MINISTRY OF ENVIRONMENT AND FORESTS, GOVERNMENT OF INDIA

BICHOM RIVER BASIN STUDY

VOLUME - I MAIN REPORT

WAPCOS LIMITED

(A GOVERNMENT OF INDIA UNDERTAKING)

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ABBREVIATIONS AND ACRONYMS

AAF	-	Annual Average Flow
amsl	-	above mean sea level
BBM	-	Building Block Methodology
BOD	-	Biochemical Oxygen Demand
BRTF	-	Border Roads Task Force
CA	-	Catchment Area
CEIA	-	Comprehensive Environmental Impact Assessment
CFRD	-	Concrete Face Rockfill Dam
COD	-	Chemical Oxygen Demand
CPCB	-	Central Pollution Control Board
DO	-	Dissolved Oxygen
DPR	-	Detailed project Report
EAC	-	Expert Appraisal Committee
EC	-	Electrical Conductivity
EF	-	Environmental Flow
EFA	-	Environmental Flow Assessment
EIA	-	Environmental Impact Assessment
EL	-	Elevation
EMP	-	Environmental Management Plan
EPRI	-	Environmental Protection Research Institute
EWR	-	Environmental Water Requirement
FRL	-	Full Reservoir Level
FSL	-	Full Supply Level
GPP	-	Gross Primary Productivity
GWhr	-	Giga Watt Hour
HEP	-	Hydro-electric Project
HFR	-	High Flow Requirement
HPL	-	Hydro-power Limited
HRT	-	Head Race Tunnel
IDC	-	Interest During Construction
IUCN	-	International Union for Conservation of Nature
IWMI	-	International Water Management Institute
LFR	-	Low Flow Requirement
MAR	-	Mean Annual Runoff
masl	-	metre above sea level
MBT	-	Main Boundary Thrust
MCM	-	Million Cubic Metre
MCT	-	Main Central Thrust
MDDL	-	Minimum Draw Down Level
MIF	-	Minimum Instream Flow
MoEF	-	Ministry of Environment and Forests
MOL	-	Minimum Operation Level
MoWR	-	Ministry of Water Resources
MU	-	Million Units
MW	-	Mega Watt
MWL	-	Maximum Water Level
NEEPCO	-	North Eastern Electric Power Corporation Limited
NPP	-	Net Primary Productivity

PFR	-	Pre-Feasibility Report
PIRR	-	Project Internal Rate of Return
PMF	-	Probable Maximum Flood
PWD	-	Public Works Department
PWW	-	Power Water Ways
TDS	-	Total Dissolved Solids
TOR	-	Terms of Reference
TRT	-	Tail Race Tunnel
WAPCOS	-	Water and Power Consultancy Services Limited

CHAPTER-1
INTRODUCTION

1.1 GENERAL

Basin study for any river basin can be defined as its ability to provide optimum support for various natural processes and allow sustainable activities undertaken by its inhabitants. The same is determined in terms of the following:

- Inventorisation and analysis of the existing resource base and its production, consumption and conservation levels.
- Determination of regional ecological fragility/sensitivity based on geo-physical, biological, socio-economic and cultural attributes.
- Review of existing and planned developments as per various developmental plans.
- Evaluation of impacts on various facets of environment due to existing and planned development.

The basin study involves assessment of stress/load due to varied activities covering, e.g. exploitation of natural resources, industrial development, population growth which lead to varying degree of impacts on various facets of environment. The basin study also envisages a broad framework of environmental action plan to mitigate the adverse impacts on environment which could be in the form of:

- preclusion of an activity
- infrastructure development
- modification in the planned activity
- implementation of set of measures for amelioration of adverse impacts.

Thus, basin study is a step beyond the EIA study, as it incorporates an integrated approach to assess the impacts due to various developmental projects. The present study basically assesses impacts on aquatic ecology due to development of various hydroelectric projects in the area to be studied as a part of the present study.

1.2 CONCEPT OF SUSTAINABLE MANAGEMENT

Implementation of any developmental project requires sustainable management of natural resources. In order to ensure sustainable management of resources, an inventory of the existing resource base and its production and consumption pattern needs to be studied. This helps in developing conservation strategies for the resources and identification of intervention areas for conservation effort. Sustainable development is also assessed by determining the carrying capacity, which defines the upper limit of growth.

Sustainable development calls for keeping life-supporting ecosystems and interrelated socio-economic systems resilient for avoiding irreversibility, and for keeping the scale and impact of human activities within supportive and assimilative capacities.

Sustainable development is a process in which the exploitation of resources, the direction of investments, and institutional changes are all made consistent with future as well as present needs. The sustainable development could be achieved through:

- Carrying capacity based developmental planning process
- Preventive environmental policy
- Structural change in economic sectors
- Enlarged and objective use of tools like
- Environmental Impact and Risk Assessment
- Environmental Audit
- Natural Resource Accounting, and
- Life Cycle Assessment.

Planning for sustainable development based on the premises of carrying capacity implies adoption of a normative, rationalist approach to planning, wherein planners subject both the ends and means of public policy to rational considerations. Sustainable development requires pragmatic management of natural resources through positive and realistic planning that balances human expectations with the ecosystems carrying capacity. It aims not only at environmental harmony, but also at long-term sustainability of the natural resource base with economic efficiency in the utilization of non-renewable resources, and structural shifts to renewable resource utilization in economic processes.

1.3 NEED FOR THE STUDY

The Basin Study for Bichom Basin in Arunachal Pradesh has been initiated at the instance of Ministry of Environment & Forests, Government of India while according prior Environmental Clearance to Dibbin hydroelectric project being developed by M/s KSK Dibbin Hydropwer Private Limited, New Delhi. Subsequently through a series of presentations, the Expert Appraisal Committee (EAC) approved the TOR for the Basin Study for Bichom Basin. The cost of the study has been shared on pro-rata basis by various project developers who propose to commission hydroelectric projects in the study area. The work for Basin study was awarded to WAPCOS Limited, a government of India undertaking under Ministry of Water Resources (MoWR).

1.4 STUDY AREA

The Basin Study will assess impacts within the Bichom river basin up to confluence of river Bichom with river Tenga. The Bichom basin map is enclosed as Figure-1.1 A total of 11 projects are envisaged in the study area to be covered in the Bichom basin. The list of the same is given in Table-1.1 and location of these projects is given in the study area map enclosed as Figure-1.2.

TABLE-1.1

Details of projects in Basin Area to be covered as a part of the study

S. No.	Project Name	Project Proponent	Levels (masl)	Capacity (MW)
1	Bichom HEP	NEEPCO	770 -	600
2	Utung HEP	KSK Dibbin HPL	1475-1325	100
3	Nazong HEP	KSK Dibbin HPL	1325-1220	60
4	Dibbin HEP	KSK Dibbin HPL	1220-1054	120
5	Dimijin HEP	KSK Dibbin HPL	1054-982	20
6	Dikhri HEP	KSK Dibbin HPL	1450-1225	15
7	Dinchang HEP	KSK Dibbin HPL	1190-800	360
8	Jameri HEP	KSK Dibbin HPL	1060-800	50
9	Dinan HEP	KSK Dibbin HPL	1450-800	10
10	Nafra HEP	Sew Energy Limited	990-780	100
11	Gongri HEP	Patel Energy Limited	1450-1250	70
	Total			**1505**

The Bichom hydroelectric project being developed by NEEPCO has already been accorded Environmental Clearance by Ministry of Environment and Forests and the project is currently under construction. Hence, the same has been excluded for the present study. Thus, a total of 10 (ten) projects listed at S.No. 2 to 11 in Table-1.1 are being covered as a part of the present study for Bichom Basin. As per the current level of investigations, these projects shall generate a total of 1245 MW of hydropower.

1.5 STATUS OF ENVIRONMENTAL CLEARANCE OF THE PROJECTS IN STUDY AREA

The status of Environmental Clearance of the projects in Basin Area to be covered as a part of the study is given in Table-1.2.

TABLE-1.2
Status of Environmental Clearance of the projects in Basin Area to be covered as a part of the study

S. No.	Project Name	Project Proponent	Status of Environmental Clearance
1	Utung HEP	KSK Dibbin HPL	Process yet to start
2	Nazong HEP	KSK Dibbin HPL	Process yet to start
3	Dibbin HEP	KSK Dibbin HPL	TOR Approved by EAC for River Valley Projects, Ministry of Environment and Forests Public Hearing conducted
4	Dimijin HEP	KSK Dibbin HPL	Process yet to start
5	Dikhri HEP	KSK Dibbin HPL	Process yet to start

S. No.	Project Name	Project Proponent	Status of Environmental Clearance
6	Dinchang HEP	KSK Dibbin HPL	Project under Appraisal for Prior Environmental Clearance (Scoping) by EAC for River Valley Projects, Ministry of Environment and Forests.
7	Jameri HEP	KSK Dibbin HPL	Process yet to start
8	Dinan HEP	KSK Dibbin HPL	Process yet to start
9	Nafra HEP	Sew Energy Limited	Project accorded Environmental Clearance by EAC for River Valley Projects, Ministry of Environment and Forests
10	Gongri HEP	Patel Energy Limited	Project accorded Environmental Clearance by EAC for River Valley Projects, Ministry of Environment and Forests

1.6 SCOPE OF WORK

In the present study emphasis is laid on terrestrial and aquatic ecology. The study envisages both primary as well as secondary data collection. The detailed Terms of Reference approved by Expert Appraisal Committee (EAC) for River Valley Projects of Ministry of Environment & Forests (MoEF) is enclosed as Annexure-I.

The key features of the Terms of Reference for the basin study are presented in the following paragraphs.

Primary data collection has been colletced for the following aspects:

- Water quality
- Aquatic ecology
- Terrestrial Ecology

Secondary data collection has been collected for the following aspects:

- Meteorology
- Water resources
- Flora
- Fauna
- Aquatic Flora and fauna

The following impacts studied as a part of the present study:

- Modification in hydrologic regime due to diversion of water for hydropower generation.
- Depth of water available in river stretches during lean season, and its assessment of its adequacy vis-à-vis various fish species.
- Length of river stretches with normal flow due to commissioning of various hydroelectric projects due to diversion of flow for hydropower generation.

- Impacts on discharge in river stretch during monsoon and lean seasons due to diversion of flow for hydropower generation.
- Impacts on water users in terms of water availability and quality
- Impacts on aquatic ecology including riverine fisheries as a result of diversion of flow for hydropower generation.
- Assessment of maintaining minimum releases of water during lean season to sustain riverine ecology, maintain water quality and meet water requirements of downstream users.
- Impacts due to loss of forests
- Impacts on rare, endangered and threatened species
- Impacts on economically important plant species
- Impacts due to increased human interferences
- Impacts due to agricultural practices.

The key outcomes of the study were to:

- provide sustainable and optimal ways of hydropower development of Lohit river, keeping in view of the environmental setting of the basin.
- Assess requirement of environmental flow during lean season with actual flow, depth and velocity at different level.

1.7 BICHOM RIVER BASIN

1.7.1 Meteorology

Climatologically, a calendar year can be divided into four seasons. The pre-monsoon lasts from March to May. The months of April and May are characterized by thundershowers. The area comes under the influence of south-west monsoons from June to August, followed by the post-monsoon season which begins from September and continues upto November. During post-monsoon season, temperatures declines noticeably and precipitation received also declines perceptibly. Winter season in the area is observed from December to March.

A meteorological station 5 km upstream of barrage site of Gongri hydroelectric has been established by the project developer to record daily meteorological data. Monthly average rainfall data from September 2007 to August 2008 was provided. The maximum rainfall during the above monitoring period was received from June to September. On the other hand, the months from January to March were the drier months. The annual rainfall received during the monitoring period was 1190 mm.

The temperature gradually rises from March to September and again starts declining from October to December. The area witnesses a humid climate as there is little variation in humidity throughout the year.

Temperature

The temperature in the study area varies with altitude. At higher altitides, temperature in the winter months goes even below the freezing point. The temperature rises gradually after February, and the month of August is the hottest month of the year, with mean monthly maximum temperature of 23°C. The temperature under monsoon season is slightly warmer than the summer season lasting from March to May. The temperature begins to drop in monsoon months. January is the coolest month of the year with the mean minimum temperature dropping up to 1°C. The average maximum and minimum temperatures at monitoring station at Bomdila are 17.71°C and 7.91°C respectively. The month wise variations in maximum and minimum temperatures are shown in Figure-1.3 and summarized in Table-1.3.

TABLE-1.3
Monthwise variations in Temperature in the study area

Month	**Temperature (°C)**	
	Maximum	**Minimum**
January	11.27	1.18
February	12.04	2.0
March	15.42	4.66
April	18.19	7.35
May	20.128	10.32
June	21.17	12.31
July	22.44	13.73
August	23.14	13.75
September	22.03	12.82
October	18.53	9.44
November	15.09	4.91
December	12.86	2.39
Average	**17.71**	**7.91**
Total		

Source: Socio-Economic Review of West Kameng District 2003

Rainfall

The rainfall is received throughout the year in the basin area. The precipitation is received in the following periods:

- Pre-monsoon
- Summer monsoon

- Monsoon
- Post-monsoon

Pre-monsoon

In Eastern-Himalayas, first pre-monsoon precipitation, mostly in form of thunderstorms, sets in by the end of March. The months of April and May are characterized with thundershowers.

Summer-monsoon

The onset of the summer-monsoon in north-eastern India lies normally between the 30th of May and the 5th of June. The southern trade winds cross the equator and move towards the extreme low-pressure region in northern India and turn into the south-west monsoon, also known as the summer monsoon.

Post-monsoon

In September the influence of the summer-monsoon begins to wane. During the post-monsoon season i.e. from September to October/November, sharp decline in temperatures is observed. The precipitation activity also declines perceptibly. Weather at this time of the year is generally pleasant. In the mornings, valleys are filled with dense fog, but at higher reaches, the sky is generally clear.

Winter-monsoon

In the north-eastern Indian mountain ranges, winter (November to February) is severe and is characterized by low temperatures (but without significant snowfall). Precipitation occurs only in conjunction with western disturbances (flat low-pressure areas). The temperatures begin to rise slowly again from February onwards.

The annual average rainfall in the basin area is of the order of 2,000 mm. A major portion of the rainfall is received under the influence of south-west monsoons during the months from April to October. The months of June and July contribute most of the rainfall. Western disturbances pass across or near the region from west to east from November to March. In association with these disturbances, precipitation is received at lower elevations and snowfall at higher elevations.

The monthly distribution of rainfall at three raingauge stations i.e. Bhalukpong, Dirang and Seppa are shown in the Table-1.4. Seppa is located in eastern as well as upper part of Kameng, whereas Bhalukpong in the lower part, Dirang is located in the Western part of Kameng catchment. The average annual rainfall at various stations varies from 992 mm to 4407 mm. The rainfall varies received at a station varies with attitude.

TABLE-1.4
Detail of average monthly rainfall at various raingauge stations

S. No.	Month	Average Monthly rainfall (mm)		
		Bhalukpong	Dirang	Seppa
1.	January	36	6	26
2.	February	55	6	39
3.	March	57	18	43
4.	April	145	60	154
5.	May	406	76	300
6.	June	795	169	446
7.	July	910	169	449
8.	August	784	205	389
9.	September	786	178	315
10.	October	359	87	174
11.	November	47	16	34
12.	December	28	3	17
Average Annual rainfall		**4407**	**992**	**2386**

The month wise variations in rainfall received in the area are shown in Figure-1.4.

Humidity

Humidity is high throughout the year. The relative humidity is close to 90% during monsoon months. However, during other months of the year, humidity is marginally lower as it ranges from about 82 to 84%. The details are given in Table-1.5. The month wise humidity variations are shown in Figure-1.5.

TABLE-1.5
Monthwise variation in humidity in the Study Area

Month	Relative Humidity (%)
January	84.24
February	83.63
March	83.14
April	83.9
May	87.31
June	89.08
July	88.46
August	88.01
September	89.58
October	88.81
November	83.65
December	82.36
Average	**86.01**

Source: Socio-Economic Review of West Kameng District 2003

Cloud Cover

During winter months, morning sky remains often obscured due to lifted fog, which withers away as the day advances. During the period from March to May, the sky generally becomes moderately clouded. Heavy cloud cover is occasionally observed. During monsoon months from June to mid-October when the hills and ridges are enveloped in cloud, generally heavy cloud cover is observed. Clear or lightly clouded skies are a common climatic feature of the Monsoon season. However, during the north-east monsoon months too, heavily clouded and overcast conditions prevail.

Special Weather Phenomena

The cyclonic storms originating from the Bay of Bengal sometimes on their way to upper Assam, affect the project area. Thunderstorms occur between February and June. Those occurring between March to May are similar to the north-westers of Bengal, and are violent. Fog appears frequently in the valleys in the monsoon and winter months.

1.7.2 Topography

The entire study area lies in the state of Arunachal Pradesh, which is situated in the north-eastern part of Himalayan region and can be divided into four distinct zones; the snow capped mountains with elevations above 5.500 m, the lower Himalayan ranges ranging between 2,000 and 3,500 m, the sub Himalayan Siwalik hills at around 700 m and the eastern Assam plains. The catchment of river Bichom stretches between the snow capped mountains and the lower Himalayan range, with elevations ranging from 1,000 m to 5,500 m. The Bichom basin is a part of Kameng basin, which is a part of Brahmputra basin. River Kameng is right bank tributary of river Brahmputra.

Gongri/Digo river valley resembles typical V-shaped valley of Himalayan terrain surrounded by denudational hills. Developments of terraces were observed at few locations along present river course on both sides of the river banks with an average elevation of about 5 to 15 m from the river bed. Development of shoals is also observed at some places along the river.

In general both the banks of the river are mostly covered with slopewash deposits with occasional bed rock outcrops. Major geodynamic features observed along the left bank of the river are dormant slide zones with slopewash deposits and potential rock fall zones.

The river Gongri/Digo originates in the western part of Kameng basin at an elevation of 4600 masl. The main tributaries of river Gongri/Digo are Saskang Rong, Pasom Rong, etc. River Gongri/Digo in its upper reaches generally flows in north-south direction, taking almost straight course. The river has very steep bed slope that is almost of order of 104 m/km in its upper reaches up to Saskang Rong diversion site. The overall river bed slope up to diversion site is 1 in 28. This river has a drop of about 3200 m from its origin upto diversion site.

1.7.3 Geomorphology

The geomorphology of the basin area shows the characteristics of the south-eastern Himalayan Foothills. The drainage pattern is characterized by a bifurcated network of tributary streams and nallas which drain steep-sided valleys. The surface is dominated by overburden which is covered by dense vegetation. Outcrops of bedrock are rather scattered and are of smaller areas. Further in the north, at higher elevations, Higher Himalayas with its rough mountainous morphology and less vegetation are observed.

1.7.4 Regional Geology

The rock sequences of the areas in the study area are principally of crystalline nature, of high metamorphic degree and are complexly folded. These petrographic sequences of Proterozoic age are attributed to the Central Himalayan or Inner Lesser Himalayan tectonic domain. The tectonic domain is limited in the south by thrust faults from the Outer Lesser Himalaya tectonic domain, with a rock succession represented by highly folded Permian Gondwana rocks (coal-bearing fossiliferous rocks) with moderately metamorphosed Paleozoic rocks of Pre-Gondwana age (phyllite, quartzite, dolomite). The Main Boundary Thrust (MBT) limits the Lesser Himalayas from the autochthonous Sub-Himalayas in the south (hills along the Brahmaputra Plain), represented by the Siwalik sedimentary rocks.

In the north, the Main Central Thrust (MCT) limits the Central or Inner Lesser Himalayan from the Higher Himalayan tectonic domain, which forms the basement of the Phanerozoic succession of the Tethys Himalaya (Tibetan Plateau). The trend or strike of the tectonic domain boundaries and the principal thrusts are WSW-ENE. A generalized succession of the different geological units existing in the Kameng District is given in Table-1.6.

TABLE-1.6

Generalized succession of different geological units of district Kameng

Age	Formation			Lithology
Mio-Pliocene	Siwalik Group		Upper	Massive brownish to grey sandy rocks, shaly sandstones with inter-calated clay
				-------------- Tectonic Contact ------------
			Middle	Reddish brown friable sandstone, Micaceous With bands of pebbly sandstones and shale
				-------------- Tectonic Contact -----------------
			Lower	Grey to chocolate coloured sandstones with a few trap rocks occurring as bands
---------------------- MAIN BOUNDARY THRUST ----------------------				
Permian	Gondwana Group			Fine to coarse grained brownish white to grey sandstones, carbonaceous shale with plant fossils of Permian age and a few thin coal bands
---------------------- TECTONIC CONTACT ----------------------				
Paleozoic (Pre-Permian)	Pre-Gondwana Group	Bichom Foromation	Upper	Slate, Phyllite, Quartzite and minor Limestone
			Lower	Diamitites of various colours, slates and sherty conglomerates with minor limestone bands
---------------------- TECTONIC CONTACT ----------------------				
Protero-zoic	Crystalline Gneissic Complex	Tenga Group		Phyllite, Quartzite and Biotite Schist
		---------------------- TECTONIC CONTACT ----------------------		
		Bomdila Group	Dirang Fm.	Schist and Quartzite
		Dibbin Project area	Bomdila gneiss	Augen gneiss, quartzite-biotite gneiss with occasional bands of Quartzite
		---------------------- TECTONIC CONTACT ----------------------		
		Sela Group	Upper	Non-foliated kyanite-Sillimenite bearing schist & gneiss with Quartz migmatites
			Lower	Granite, ambhiboilites with cale-silicate marbles and sillimenite bearing schists
---------------------- MAIN CENTRAL THRUST ----------------------				

Source: DPR Dibbin HEP, (Acharya, 1978; Kaura & Basu Roy, 1981)

1.7.5 Seismicity

Seismically the north-eastern parts of the Himalayas are one of the most active zones in the world. They are located at the tri-junction of three tectonic plates, the Indian, the Indo-Burmese and the Eurasian. These plates are constantly in collision with each other, and as a result, the rocks of this area have undergone repeated intense folding, faulting and thrusting in a highly complex way so much so that many of the rock sequences have either been eliminated or repeated. The structural pattern has at most of the times controlled the drainage pattern of the rivers. This pattern is generally elongated in a WSW to NE-SW direction but many transverse structural features have modified them.

Most Himalayan earthquakes have shallow foci (0-40 km), but there are few events with focal depth in the range of 41-70 km

As per the Seismic Zoning Map of India (IS 1893:2002), the whole of the north-east including Arunachal Pradesh has been placed in Zone V. This zone is susceptible to major earthquakes. The seismic zoning map of India is enclosed as Figure-1.6. The list of major earthquakes that have occurred in the region are given in Table-1.7.

TABLE-1.7
List of major earthquakes in the region

S. No.	Year	Month	Date	Time (Utc)	Latitude	Longitude	Ms	Mw	Depth (km)
1	1905	Feb	17	11:42	30.00	95.00	-	7.1	-
2	1906	May	12	05:50	25.00	92.00	-	6.5	-
3	1906	August	31	14:57:30	27.00	97.00	7.0	-	-
4	1908	December	12	12:54:54	26.50	97.00	7.6	-	-
5	1941	January	27	12:41:48	27.00	92.00	6.7	-	-
6	1947	July	29	13:29:25	28.50	94.00	7.5	7.3	-
7	1950	August	15	14:09:28.5	28.7	96.6	-	8.6	-
8	1950	August	15	21:42:16	25.00	95.80	8.0	-	-
9	1950	August	16	06:41:59.5	28.60	95.70	7.0	-	-
10	1950	September	13	11 :07:34.1	27.80	94.30	7.0	-	-
11	1951	March	11	14:52:20	28.70	94.20	6.5	-	-
12	1951	November	18	00:44: 10	27.70	94.60	6.7	-	-
13	1962	February	20	22:02:35	26.13	96.94	6.7	-	-
14	2000	June	7	21 :46:55	26.856	97.238	6.5	6.4	-
15	2003	August	18	09:03:02	29.547	95.562	-	5.5	29
16	2005	June	1	04: 16:48	28.871	94.59	-	5.7	18

Keeping in view that the projects are located in high seismic area and considering the past seismic events, it is emphasized that site specific studies are to be carried out by specialized agency for optimal safe design of structures. This is also mandatory as per the Model TOR formulated by Ministry of Environment and Forests (MoEF).

1.7.6 Vegetation

The state of Arunachal Pradesh is a part of Eastern Himalayan Ranges. The state falls within the Himalayan global biodiversity hotspots and is also among the 200 globally important eco-regons of the world. It harbours the world's northern-most tropical rain forest and is estimated to contain nearly 50% of the total flowering plant species in India. The diversity of topographical and climatic condition has favoured the growth of luxuriant forests, which are home to various floral and faunal species.

Arunachal has a wide altitudinal range varying from 100 m to 7,090m(amsl). There are nine wildlife reserves covering total area of 9,246 km^2. It largely covers the low and mid elevation forests. This is despite the fact the 23% of Arunachal lies above 3000 m. Only small parts of some of the existing reserves extend into high altitude zone.

Based on altitude, rainfall and dominant species composition, vegetation of the study area can be broadly classified as below:

- Temperate and sub-alpine forests at an elevation of 2800 to 4000 m.
- Sub-Tropical forests with an altitudinal variation of 900 m to 1000 m.
- Tropical forests upto an elevation of 900 m.

a) Temperate and sub-alpine coniferous forests

Temperate and sub-alpine coniferous forests occur between an elevation of 2800 m to 4000 m beyond temperate broad-leaved evergreen forests. They are found in areas which experience snowfall during winter months. The lower limit of such forests is dominated by mixed coniferous types, which include species of *Abies*, *Pinus*, *Taxus*, etc. whereas the upper limit predominantly comprises of *Abies*, *Juniperus*, *Larix*, *Picea*, *Tsuga* and *Taxus* species**.**

b) Tropical Evergreen Forests

The tropical evergreen forest extends upto an elevation of 900 m in the areas with heavy rainfall. The top canopy or the upper storey in these forests mainly consists of tall trees. Some of the commonly occurring species in these forests are *Agalaia hiemii, Atlingia excelsa, Artocarpus chama, BIschofia javanica, Bombax ceiba, Callicarpa arborea, Castanopsis indica, Dillenia indica,* etc.

The next canopy is dominated by small trees and shrubs. Some of these species observed are *Ardisia crispa, Bauhinia purpurea, Baliospermum corymbiferum, Buddleja asiatica, correa benghalensis, Oendrocnide sinuata, Illicium manipurense, Magnolia hodgsonii,* *Grewia disperma, Micromelum minutum, Oxysopra paniculata, Solanum laNum, Sambucus hookeri.* Canes, e.g. *Calamus erectus* and *Calamus leptospadix* occur in the swampy areas and form impenetrable thickets.

This forest category is dominated by densely covered lianas and epiphytes. Some of the common lianas species observed are Acacia, Bauhinia, Derris, Entada, Gnetum, Hodgsonia, Mucuna, Piper, Thunbergia, Toddalia, Vitis etc. Several species of Calamus also stretch long distances from one tree to another. Some of the common epiphytic orchids are species of Aerides, Dendrobium, Cymbidium, Eria, Oberonia, Pholidata, and the epiphytic ferns belong to Asplenium, Nephrolepis, Drymoglossum, Colysiis, etc.

The ground flora is dominated by herbaceous elements such as *Begonia roxburghii, Chima oblongifolia, Commelina sp., Derringia amaranthoides, Floscopa scandens, Oxalis comiculata, Lobelia pyramidalis,* etc.

c) Sub-tropical Forests

The sub-tropical forest in the mid-hill zone are rich in hardwood species like oak and chestnut, pine and number of medicinal plants, bamboo and orchids. Depending on the species composition, vegetation type can be further divided into two sub-types, Sub-tropical Pine Forests and Sub-tropical Broadleaved Forests.

Sub-tropical Pine Forests

Sub-tropical pine forests occur at elevations between 1000 and 1800 m. These forests are mainly represented by species *Pinus* in association with species like *Alnus nepalensis* and *Rhus javanica,* shrubby and herbaceous vegetation, viz., *Desmodium* sp., *Indigofera* sp., *Rubus* sp., etc. The moist ground adjacent to the streams are covered with the taxa mainly of Polygonaceae, Poaceae, Cyperaceae, Chenopodiaceae are very common with other taxa of restricted occurance.

Subtropical Broadleaved Forests

The top canopy is dominated by species like *Cinnamomum bejolghota, Bielschmedia pseudomicropora, Engelhardtia spicata, Castanopsis indica, Euodia trichotoma, Quercus grifftfhii, Lithocarpus fenestrata, Magnolia caveana, Michelia doltsopa, Ostodes paniculata, Sterculia guttata, Ulmus lancifolia, Acer oblongum, Schima wallichii,* etc. In valleys where higher moisture *Populus* and *Alnus* flourish. This phenomenon may be due to the weather condition alone, and that the species found on the drier slopes are probably better adapted to such conditions while those in the valley require moisture and are not able to survive in arid situation.

1.7.7 Fauna

Jhum cultivation is prevailing in the study area being covered as a part of the present study. The area under Jhum cultivation is disturbed and vast stretches of basin area do not support large scale faunal. The study area is neither potential site for wildlife sanctuary nor offer migration route to any major animal species. There is no national Park or sanctuary in the study area.

The study area provides habitation and sustenance for numerous fauna. The mountains, forests and streams, abundant food, shelter, water and large stretches of uninhabited and comparatively inaccessible country provide favorable factors for sheltering many kinds of wild animals. Earlier, this area used to harbour good wildlife. However, with increase in human interferences, and as a result of clearing of forests for *Jhum* cultivation, forests and wildlife are under threat. Wildlife is also under threat on account of pressure due to large-scale hunting in the area.

The terrestrial fauna covers a wide variety of the taxa from vertebrates and invertebrates. In the present context mammals, aves, amphibia and reptiles have been assessed from vertebrates and insects from invertebrates.

Among mammals jungle cat, mangoose and field mouse are reported. Among reptiles House Gecko is reported. Avian fauna includes Pegion, Dove, Myna, sparrow, etc.

1.7.8 Economy

Agriculture, mainly jhum, is the mainstay of the economy. Fishing and hunting, the main pastime, is a source of subsistence food. The Mijis have kitchen gardens too, wherein they use oak leaves as manure.

Even with low productivity, they are self-sufficient in foodgrains, mainly due to low population and higher landholdings. Earlier, they only knew the use of bamboo stick as an agricultural implement, but at present, iron hoes too being used.

Jhum cultivation is done in two phases. In the first phase, which takes place between January and March, a jhum plot (pam) is prepared. A plot of land is selected, trees felled, timber removed, and bushes and undergrowth put on fire. Ashes are then left on the 'pam' itself to act as manure. This phase may involve a family, a group of families, or even the entire village, depending upon the size of the pam.

In the second phase, the seeds are sown in the ash. Usually, pam is cultivated for one or two years. Then the land remains fallow from 4 to 8 years. The plots could be owned on communal basis, though the trend is moving towards individual ownership. Seeds for the succeeding harvest are selected during the preceding one, and stored in big earthen jars. The Mijis use oak leaves as manure. They raise two crops a year; the main ones being paddy, wheat, barley, maize, millet and the minor ones are pulses, potato, yam, tuber, cotton, chilly, etc. Usually, the first crop is of wheat and barley, which is sown in November and harvested in May. The second crop is of maize, millet, buck-wheat, etc., which is sown in May-June and harvested in September-October.

Food-gathering is predominantly carried out by the Miji womenfolk. Miji land has an abundance of edible plants and leaves, which the women gather in large numbers for 6 to 7 months in a year, to supplement their food resources.

They spin the yarn from short staple cotton, obtain their dyes from the jungle, and weave their fabrics on loin loom. In earlier days, when bamboo was the main industrial raw material, the Mijis lived in bamboo huts, made household utility articles from it, wore ornaments, raincoats and hats made of bamboo, and ate bamboo shoots and pickles. Also, bamboo jars were used for storing beer as well as fetching water from the village spring and the river. In the modern scenario, bamboo products are being replaced by metal utensils procured from the markets at Bomdila, Tenga and Bhalukpong.

Livestock consists of mithuns, pigs, goats and fowl. Barring the mithun, the domestic animals are kept in the basement of the dwelling. Mithuns are let loose to roam about in a state of semi-wilderness, and brought home only when bride price has to be paid or a sacrifice offered.

1.8 OUTLINE OF THE REPORT

The report is presented in two volumes listed as below:

Volume-I : Main Report

Volume-II : Annexures

The outline of Volume-I (Main Report) is given as below:

Chapter-1 covers the need for the basin study, study area to be covered as a part of the study. The scope of work and a brief profile of the study area is also summarized in the Chapter.

Chapter-2 summarizes the details of various projects proposed to be developed in the study area.

Chapter-3 outlines the methodology adopted for conducting the Basin study. The information has been collected mainly from secondary data sources. The data available in the project reports and DPRs of various projects. The secondary data was provided by various project developers.

Chapter-4 presents information on hydrological aspects of the Bichom river Basin.

Chapter-5 covers the findings of the water quality survey conducted as a part of the study. As a part of the basin study, water quality sampling was conducted once per month for six months from April 2009 to September 2009. The findings of the same have been presented in this Chapter.

Chapter-6 presents the aquatic ecological aspects of environment. The study is based on collection of data from primary as well as secondary data sources. As a part of the basin study, detailed ecological survey was conducted once per month for six months from April 2009 to September 2009. The findings of the aquatic ecological survey were analysed and ecological characteristics of the study area have been covered in this Chapter.

Chapter-7 presents the findings the terrestrial ecological survey conducted for two seasons as a part of the study. The survey was conducted in the months of April 2009 and July 2009. The information collected through secondary sources has also been presented in this chapter.

Chapter-8 : describes the anticipated positive and negative impacts as a result of the commissioning of various projects in the study area being covered within Bichom Basin. The emphasis was mainly on water environment including water availability, water quality and aquatic ecology including riverine fisheries.

Impact prediction is essentially a process to forecast the future environmental conditions of the project area that might be expected to occur as a result of commissioning of various projects in the study area. An attempt has been made to forecast future environmental conditions quantitatively to the extent possible. But for certain parameters, which cannot be quantified, qualitative assessment has been done so that planners and decision-makers are aware of their existence as well as their possible implications.

Chapter-9 presents the Environmental Flows to be released for sustaining the riverine ecology. Environment Flows have been estimated using various methods namely Tenant's Method, Index Method, Hughes and Munster Method and Building Block Methodology.

Chapter-10 delineates an Environmental Management Plan (EMP) for amelioration of anticipated adverse impacts likely to accrue on water resources, aquatic and terrestrial ecology as a result of commissioning of various projects in the study area. The approach adopted for formulation of the Environmental Management Plan (EMP) has been to maximize the positive environmental impacts and minimize the negative ones.

CHAPTER-2

DESCRIPTION OF PROJECTS IN THE STUDY AREA

2.1 GENERAL

As mentioned earlier in Chapter-1, a total of 10 projects are envisaged in the study area to be covered as a part of the Bichom basin study. The list of the projects is given as below:

- Utung hydroelectric project
- Nazong hydroelectric project
- Dibbin hydroelectric project
- Dimijin hydroelectric project
- Dikhri hydroelectric project
- Dinchang hydroelectric project
- Jameri hydroelectric project
- Dinan hydroelectric project
- Gongri hydroelectric project
- Nafra hydroelectric project

The investigations for seven of the ten projects are in preliminary stage and only Reconnaissance survey reports have been prepared. These projects are:

- Utung hydroelectric project
- Nazong hydroelectric project
- Dimijin hydroelectric project
- Dikhri hydroelectric project
- Dinchang hydroelectric project
- Jameri hydroelectric project
- Dinan hydroelectric project

For Gongri hydroelectric project, Pre-Feasibility Report (PFR) alongwith hydrological data was provided. The Detailed Project Report (DPR) were available for only two hydroelectric projects namely Dibbin and Nafra hydroelectric projects.

The description of various projects covered in the present Basin Study is given in the following:

2.2 UTUNG HYDROLELETRIC PROJECT

The catchment area intercepted at Utung hydroelectric project site is about 630 km^2. Three tributaries join river Bichom upstream of the Dibbin dam; these are the Dakhri, Dibri and Deyang, whose confluences are 1.1 km^2, 5.8 km^2 and 11.1 km^2 respectively. At the proposed Full Reservoir Level (FRL), reservoir of the Dibbin project will extend back about 3.3 km up the Bichom valley and about 2 km up the Dakhri valley.

The Utung hydroelectric project would be the upstream most project to be developed on river Bichom and would develop the highest head of the various projects which have to be studied (up to 300 m). By locating the dam a short distance downstream of the confluence of the Devang nalla and the Bichom, a total catchment area of 311 km^2 would be intercepted.

As a part of the Reconnaissance Study, various layouts were considered for the project headworks, including a dam up to 120 m height; which would provide considerable additional generating head. However, the reservoir would lie within steep and narrow valley, are the project would have a small generation capacity. The axis considered for dam is situated at a narrowing of the Bichom valley, several hundred metres downstream of the Devang confluence.

In view of the steep gradient of the upper part of the Bichom valley, it was decided to locate the head works as far upstream as possible as this could allow a considerably higher head for hydropower generation. The problem with this option is, however, the need also to make use of the inflows from the Deyang Dalla, the confluence of which is only a short distance of the dam site discussed above. The option considered was to locate the dam on this latter nallah, on the sharp curve about 2 km upstream of the confluence, where the level is estimated to be about 1750 m above mean sea level. From the reservoir so created, a pressure tunnel about 2.5 km long which leads to the surge chamber will be constructed. The inflow from the upper Bichom valley could be diverted into this reservoir by means of a separate adduction tunnel, about 2 km long. Although this option would require longer tunnels, the gain in head, and hence in energy production, could well justify the additional costs.

Power waterways and power station

The left flank of the valley is the most suitable for the location of the pressure tunnel, which would be about 2 km long and lead to a surge chamber based on a steep ridge roughly one km from the head of Nazong reservoir. At the present level of investigations, both surface as well as underground power houses are feasible. The final decision shall be made during subsequent investigations to be conducted as a part of DPR Preparation.

Electro-mechanical equipment

Depending on the dam site selected, and the reservoir storage level (i.e. dam height) the installed capacity of the Utung power plant will be in the range of 100 MW to 200 MW. In the reconnaissance site survey report, the capacity envisaged is 96 MW with two units Francis turbines. Depending on the civil design of the power house, switchyard is prepared to be located on an excavated platform near to a surface power house.

The transmission lines from the Utung power station would extend down the Bichom valley to the switchyard at the Dibbin power station, a distance of about 15 km. The project layout is enclosed as Figure-2.1. The salient features of the project are summarized in Table-2.1.

TABLE-2.1

Salient Features of Utung hydroelectric project

1. GENERAL	
State	Arunachal Pradesh
District	West Kameng
Tehsil	Nafra
Coordinates of the Dam Site	27° 29'13"N 92° 31' 32" E
Nearest rail head/Nearest Airport	Bhalukpong / Tezpur
Name of the River	Bichom River
Name of river basin	Bichom River/ Kameng River
2. HYDROLOGY	
Catchment Area upto headworks	311 km^2
Average Annual Discharge:	23.8 m^3/s
Hydraulic Design Flood (1,000 year Flood)	2211 m^3/s
PMF	4351 m^3/s
3. DAM AND RESERVOIR	
Type	Concrete Gravity Dam
Maximum height above deepest foundation (m)	38 m
Elevation of top of Dam (m)	1603 m asl
Length of Dam at crest (m)	129.7 m
Full Supply Level (FSL)	1600 m asl
Minimum Operation Level(MOL)	1590 m asl
Gross storage capacity	1.3 Mm^3
Live storage capacity	0.6 Mm^3
Dead storage capacity	0.7 Mm^3
4. SPILLWAY	
Type	Gated overflow spillway
Discharge capacity (m^3/s)	2211 m^3/s
Number of bays	3
5. POWER WATERWAYS	
Head Race Tunnel	
- Length	3600 m
- Diameter	3.6 m
- Design Discharge and Velocity	36 m^3/s and 4 m/s
Penstock	
- Length	450 m
- Diameter	3 m
- Design Discharge and Velocity	36 m^3/s and 6 m/s
6 POWERHOUSE	
Powerhouse	
- Type	Surface
- Location	Left Bichom bank, at confluence of Dibri Bru
Turbines	
- Type of turbine	Francis

- Number of units	2
- Installed capacity	96 MW
- Rated net head (m)	291.7 m
- Maximum flow through each unit	19 m^3/s
Tail Water Level	1300 masl
7 POWER BENEFITS	
Annual Design Energy (90% dependable year)	380.4 GWhr/year
Mean Annual Energy	443.0 GWhr/year
8 COST ESTIMATE	
Civil	Rs. 313.7 Crores
Electrical/ Mechanical	Rs. 97.4 Crores
Design, supervision & administration	Rs. 20.6 Crores
Sub-Total (Generation)	Rs. 431.7 Crores
I.D.C.	Rs. 46.7 Crores
Total (including initial financing charges)	Rs. 481.2 Crores

2.3 NAZONG HYDROELECTRIC PROJECT

The dam of the proposed Nazong hydroelectric project is envisaged to be located immediately downstream of the confluence of river Bichom and Dibri nalla. The elevation of the rivers at this confluence, has been estimated as 1300 masl, which is about 100 m higher than the FSL of Dibbin reservoir.

In the Reconnaissance Survey Report, two options were considered for the Nazong scheme:

- concrete gravity dam to impound a reservoir and thus to create a greater generating head
- run-of-river diversion weir for a lower head and providing little if any storage capacity

From these structures the power waterways, located in the left flank of the Bichom valley, would serve a power station located at the upstream end of Dibbin reservoir. Barn heights over the range of 40 to 120 m have been considered for the Nazong site, corresponding the gross generating heads of 80 to 160 m above FSL of Dibbin reservoir. Given the steep slope of the narrow Bichom valley, even a dam of significant height would impound a reservoir of only relatively small volume and limited regulating capacity, which would extend back only about 1.5 km upstream of the dam.

The pressure tunnel extending from the left end of the dam to the surge chamber would be about 2 km long. It will be excavated through the left flank of the valley, across the curve of the river, as this location will allow a somewhat shorter alignment for the available head.

Depending on the dam height selected, installed capacity of the Nazong power house will be in the range of 32 MW to 76 MW. In the proposed project, a surface power house with a capacity of 32 MW with 2 units of 16 MW each of Francis turbines are proposed. The transmission lines from the Nazong power station would extend down the Bichom valley to the switchyard at the Dibbin power station, a distance of about 8 km. The project layout map is enclosed as Figure-2.2 and the salient features are given in Table-2.2.

TABLE-2.2

Salient Features of Nazong hydroelectric project

1. GENERAL	
State	Arunachal Pradesh
District	West Kameng
Tehsil	Nafra
Coordinates of the Dam Site	27° 27'02"N 92° 30' 56" E
Name of the River	Bichom River
Name of river basin	Bichom River/Kameng River
2. HYDROLOGY	
Catchment Area upto headworks	391 km^2
Average Annual Discharge:	29.8 m^3/s
Hydraulic Design Flood (1,000 year Flood)	2620 m^3/s
PMF	5155 m^3/s
3. DAM AND RESERVOIR	
Type	Concrete Gravity Dam
Maximum height above deepest foundation (m)	38 m
Elevation of top of Dam (m)	1303 m asl
Length of Dam at crest (m)	131.5 m
Full Supply Level (FSL)	1300 m asl
Minimum Operation Level(MOL)	1290 m asl
Gross storage capacity	0.2 Mm^3
Live storage capacity	0.1 Mm^3
Dead storage capacity	0.1 Mm^3
4. SPILLWAY	
Type	Gated overflow spillway
Discharge capacity (m^3/s)	2620 m^3/s
Number of bays	3
5. POWER WATERWAYS	
Head Race Tunnel	
- Length	2350 m
- Diameter	4.0 m
- Design Discharge and Velocity	49 m^3/s and 4 m/s
Penstock	
- Length	100 m
- Diameter	3.25 m
- Design Discharge and Velocity	49 m^3/s and 6 m/s
6 POWERHOUSE	
Powerhouse	
- Type	Surface
- Location	Left bank of river Bichom, approx. 2.1 km

	downstream of dam site
Turbines	
- Type of turbine	Francis
- Number of units	2
- Installed capacity	32 MW
- Rated net head (m)	72.2 m
- Maximum flow through each unit	25 m^3/s
Tail Water Level	1220 m asl
7 POWER BENEFITS	
Annual Design Energy (90% dependable year)	128.2 GWhr/year
Mean Annual Energy	149.1 GWhr/year
8 COST ESTIMATE	
Civil	Rs. 254.9 Crores
Electrical/ Mechanical	Rs. 46.9 Crores
Design, supervision & administration	Rs. 15.1 Crores
Sub-Total (Generation)	Rs. 316.9 Crores
I.D.C.	Rs. 34.6 Crores
Total (including initial financing charges)	Rs. 353.5 Crores

2.4 DIBBIN HYDROELECTRIC PROJECT

The dam site of the proposed Dibbin hydroelectric Project is located in the upper reach of river Bichom just downstream of confluence of Bichom Chu with Difya with its co-ordinates at 27°27'00"N and 92°31' 16"E. The dam site is approachable through PWD road from Rupa up to Nafra and then a foot path of about 15 km up to Dibbin village. Power house site is located near Nachibin village with its co-ordinates at $27^0$26'49"N and $92^0$30'58"E. Nafra is connected to Rupa town by a PWD road. Up to Rupa town the road from Balipara is maintained by Border Roads Task Force (BRTF) of the Government of India. Balipara, in turn is connected to Tezpur on the National Highway No. 52. The nearest airport is at Tezpur located about 25 km from Balipara.

The proposed project envisages construction of:

- A gated dam 92 m high located 1 km downstream of the confluence of Dakri Bru river with Bichom river. The length of the dam will be 165.8 m consisting of 54 m of overflow section and 111.8 m of non-overflow section.
- Reservoir upstream of dam will have gross and live storage of 7.085 Mm^3 and 7.04 $Mm^{3.}$
- A spillway with 3 bays of 12.0 m width each and controlled by 3 nos. radial gates each of size 12 m x 15.53 m. Crest elevation of spillway shall be 1206.0 m.
- A head race tunnel (HRT) 5.5 m diameter and 3.97 km long.
- A surge shaft at the outlet of the head race tunnel 2.4 m diameter and 102.5 m height.
- A surface power house located 250 m upstream of confluence of Bichom Bru and Debra Bru having installation of 2 units of 60 MW each with Francis type turbine

designed for a net head of 158 m. The maximum flow through each turbine shall be 44.5 cumec.

- A tail race tunnel/channel of 150 m length to discharge the tail water of Dibbin hydro electric project into Ditch Bru

The salient features of the project are given in Table-2.3 and layout plan shown in Figure-2.3.

TABLE-2.3
Salient features of Dibbin Hydroelectric Project

LOCATION	
State	Arunachal Pradesh
District	West Kameng
Tehsil	Nafra
River	Bichomchu, tributary of Kameng river, Dokri Bru, Difya Nalla
Longitude	92° 30' 58" E
Latitude	27° 26' 49" N
Access to the project	By road from Tezpur (Assam) via Balipara Bhalukpong and Rupa
Nearest Rail head	Bhalukpong
Airport	Tezpur
HYDROLOGY	
Catchment area intercepted at Dam Site	630 sq.km
Average Annual discharge at dam site	39.6 cumec
Average annual rainfall	2800 mm
Specific runoff	1975 mm/year
Probable Maximum Flood	7300 cumec
DAM	
Type	Mass concrete gravity dam
Maximum Height above deepest foundation level	92.0 m
Elevation at top of dam	1223 m
River Bed Level	1158 m
Total length at crest	165.8 m
RESERVOIR	
Full reservoir level (FRL)	1220.0 m
Free board (m)	3.0 to FSL
Minimum Draw down level (MDDL)	1218.0 m
Gross storage capacity	7.085 Mm^3
Live storage capacity	7.040 Mm^3
Dead storage capacity	0.045 Mm^3
SPILLWAY	
Type	Gated overflow
Discharge capacity	7380 cumec
Bay Width	12 m
No. of bays	3 bays
Crest level of spillway	1206 m
HEAD RACE TUNNEL	

Size (Diameter)	5.5 m
Shape	Circular
Velocity	3.6 m/sec
Length	3970 m
SURGE SHAFT	
Diameter	Shaft : 2.4, Tank : 11.5 m
Height	Shaft: 102.5m, Tank : 71.5 m
Top Elevation	1261.5 m
Bottom Elevation	1081.0 m
POWER HOUSE	
Installed Capacity	120 MW
Units	2 x 60 MW
Type of Turbine	Francis
Design net head	158 m
Design energy (GWh/year)	370.5
Mean energy (GWh/year)	449.8
TAIL RACE TUNNEL	
Size (m)	20
Length (m)	150
FINANCIAL ASPECTS	
Total Project Cost	Rs. 767.10 crores (including IDC)
Tariff for 1st year	Rs. 5.44 per kWh
Levelised tariff	Rs. 4.45/kWh

2.5 DIMIJIN HYDROELCTRIC PROJECT

Three possible layout options for the Dimijin HEP were evaluated in the Reconnaissance Survey Report.

The dam site is proposed to be located immediately downstream of the confluence of Dimijin Nallah with river Bichom, just over 3 km above the road bridge over the Bichom, on the approach to Nafra village. The possible locations considered for the power house site include:

- On the left bank of river Bichom, directly downstream of the dam (Alternative-I)
- On the left bank alluvial terrace, below the new government rest house (PWD), about one km downstream of the Nafra road bridge (Alternative II)
- In the Bichom valley, 3 km downstream of Nafra bridge (Alternative III)

The most favourable site for alignment of dam axis of the Dimijin HEP is the sharp right-hand bend of the Bichom river, just downstream of the Dimij confluence. The steep, massive rock spur around which the river flows have been considered for construction of short river diversion tunnels and the spillway structure. The height of the proposed dam is limited by the tailwater level of the Dibbin scheme, the power station of which will be situated about 4 km further upstream. A maximum storage level of 1054 m asl has therefore been fixed for the Dimijin reservoir, which corresponds to a dam with a maximum height of about 50 m above river bed level.

In principle, the Dimijin site lends itself to the construction of a concrete-face rockfill dam (CFRD), not least because much of the required volume of rock could be obtained from excavation on the right abutment for the spillway structure. The geological reconnaissance of the site has shown that this excavated rock would be ideal as construction material for a dam of the relatively limited height required.

A membrane cut-off wall, of plastic concrete (concrete with bentonite), would be provided below the plinth, should site investigations during detailed studies show that a grout curtain in the alluvial deposits is not feasible or very expensive. This solution of a cut-off wall was adopted in a dam of similar size in river Dhauliganga.

As per the present level of investigations, the type of dam to be constructed is yet to be finalized on account of diversion of the river during the construction period and, specifically, the maximum discharge needing to be diverted. In this respect, a rockfill dam has a serious disadvantage, as it requires the river to be diverted away from the construction area during whole of the year, and the exclusion of all risk of the partially-completed dam being overtopped in the event of a large flood. A concrete dam, on the other hand, needs only to be protected during the dry season; flooding of the site during the monsoon season can be accepted and overtopping of the dam will not cause it to be destroyed or seriously damaged. This means that, only one relatively small diversion tunnel would be needed, and dimensioned to pass only dry-season flows. For a rockfill dam, however, it will be necessary to pass around the site a wet-season flood of, perhaps 50-year return period, the estimated peak discharge for such a flood at Dibbin has been estimated to be about 2000 m^3/s. This could require two tunnels, each of about 10 m diameter, and concrete lined. The effect of such tunnels on the cost of a rockfill dam would be significant although, given their short length, of about 0.5 km each, not prohibitive. However, as per the salient features outlined in the Reconnaissance Survey Report, a concrete face rockfill dam has been proposed.

The spillway on the right abutment would be designed for a 1,000 year flood, for which the peak outflow would be about 4020 m^3/s. A spillway structure similar to that designed for Dhauliganga can be assumed; this has three submerged orifices, equipped with large (8 m x 14.5°m) radial gates, discharging into a stilling basin. This spillway structure will be located in such a way that the flood flows are discharged directly into the straight reach of the river, downstream of the site.

Layouts considered for the pressure waterways and power station

Alternative I: power house adjacent to the dam

The power house could be located on the left bank of the river, at the foot of the very high and steep slope of the Bichom valley. The intake structure would be situated at the end of the dam crest so that the pressure waterways would be short (less than 200 m). Either steeply-inclined tunnels or surface steel penstocks would be possible; a surge chamber would not be required.

Bedrock crops out extensively in the steep flank of the valley and adequate foundation conditions for the power house are assured; however, it will be necessary during design to avoid excavation which extends to far into the slope, as this will create high and steep rock faces, possible needing stabilisation works.

The head developed by this variant is essentially the height of the dam, and is not expected to exceed about 45 m, corresponding to full supply level of the reservoir. Two units of about 18 MW are proposed.

Alternative II: power house near Nafra rest house

The second layout considered would harness the head across the long bend of the Bichom river, upstream of Nafra town. Over this reach of about 4 km length, the level of the Bichom drops by about 25 m, whilst a pressure: tunnel system across the bend would be little more than 2 km long.

The proposed site of the power house is the flat terrace below the road, at present used as a sports field, where the river is diverted sharply to the right by the alluvial fan on which Nafra town has been built. Above the road, the mountain slope rises steeply to over 1500 masl elevation. The layout proposed consists of a pressure tunnel (1600 m long, diameter about 5.7 m, concrete-lined) through this ridge, and a surge shaft. The single steel penstock, about 4.5 m diameter, would be constructed on the slope, adjacent to the rest house. The maximum head developed would be 74 m and an installed capacity of 65 MW (with two units) is proposed.

Alternative III: Power house south-east of Nafra town

Over a distance of about 4 km, south-east of Nafra town, river Bichom flows in a deep valley. At the end of this reach is the site proposed for the dam of the Nafra hydro power project, being developed by Sew Energy Limited. The FRL of the 96 MW Nafra scheme is about 950 masl. This reach of the river represents an additional head of about 30 m, compared to Alternative-II.

The total head of this variant, about 100 m, could be developed by a pressure waterway system through the mountains forming the left flank of the Bichom valley. The problem, however, is that this mountainous area is crossed by the lateral valley of the nalla on the alluvial fan of which Nafra town has been built, and a pressure tunnel would have to pass through or beneath this geologically problematic area, about which no information is at present available.

For this reason, alignment of the pressure waterways for Alternative-III has been shifted to the north-east, in order to allow it to pass beneath this lateral valley in bedrock at greater depth, i.e. to reduce the risk of it encountering the alluvial materials filling this valley, in which tunnelling excavation would be difficult. This increases the length of the waterway system to about 4.5 km, or 20% greater than that of a more direct but riskier alignment. This concept would, however, allow the full head between Dimijin dam and the Nafra hydroelectric project to be harnessed for power production. A possible site for the power house for Alternative III is in alluvial terrace on the left bank of the Bichom. This would be equipped with two units, each of about 40 MW under a head of 104.

The project layout map for Dimijin hydroelectric project is enclosed as Figure-2.4. The salient features of the project are given in Table-2.4.

TABLE-2.4

Salient Features of Dimijin hydroelectric project

1. GENERAL	
State	Arunachal Pradesh
District	West Kameng
Tehsil	Nafra
Coordinates of the Dam Site	27^{o} 22'27"N 92^{o} 32' 50" E
Name of the River	Bichom River
Name of river basin	Bichom River / Kameng River
2. HYDROLOGY	
Catchment Area upto headworks	691 km^2
Average Annual Discharge:	52.7 m^3/s
Hydraulic Design Flood (1,000 year Flood)	4020 m^3/s
Probable Maximum Flood (PMF)	7912 m^3/s
3. DAM AND RESERVOIR	
Type	Concrete Faced Rockfill Dam
Maximum height above deepest foundation (m)	60.5 m
Elevation of top of Dam (m)	1060.5 masl
Length of Dam at crest (m)	206m
Full Supply Level (FSL)	1054.4 masl
Minimum Operation Level(MOL)	1040 masl
Gross storage capacity	34.7 Mm^3

Live storage capacity	19.9 Mm^3
Dead storage capacity	14.8 Mm^3
4. SPILLWAY	
Type	Conduit spillway
Discharge capacity (m^3/s)	7912 m^3/s
Number of bays	3
5. POWER WATERWAYS	
Head Race Tunnel	
- Length	3900 m
- Diameter	6.1 m
- Design Discharge and Velocity	115 m^3/s and 4 m/s
Penstock	
- Length	250 m
- Diameter	5m
- Design Discharge and Velocity	115 m^3/s and 6 m/s
6 POWERHOUSE	
Powerhouse	
- Type	Surface
- Location	Left Bichom bank, d/s Nafra village
Turbines	
- Type of turbine	Francis
- Number of units	2
- Installed capacity	96 MW
- Rated net head (m)	91.8 m
- Maximum flow through each unit	58 m^3/s
Tail Water Level	950 m asl
7 POWER BENEFITS	
Annual Design Energy (90% dependable year)	331.3 GWh/year
Mean Annual Energy	383.9 GWh/year
8 COST ESTIMATE	
Civil	Rs. 490.7 Crores
Electrical/ Mechanical	Rs. 133.4 Crores
Design, supervision & administration	Rs. 31.2 Crores
Sub-Total (Generation)	Rs. 655.3 Crores
I.D.C.	Rs. 98.5 Crores
Total (including initial financing charges):	Rs. 759.1 Crores
9 ECONOMIC EVALUATION	
90% Dependable Year	
- First year tariff (including free power)	Rs. 4.43 /kwhr
- Levellised Tariff	Rs. 3.64 /kwhr

2.6 DIKHRI HYDROELECTRIC PROJECT

The Dikhri hydropower scheme would develop the head available over a distance of about 5 km along the lower reach of river Dikhri, a steep mountain torrent which drains a catchment of 190 km^2 to the north-west of Dibbin village, and which joins river Bichom, a short distance north of Dibbin village.

Two possible sites for a dam on the Lower Dikhri were identified in the reconnaissance survey report. The minimum level which can be developed along this tributary valley is 1220 masl, equal to the full supply level of Dibbin reservoir, which will extend back about 2 km up the Dikhri valley. The dam sites studied in the Reconnaissance Survey Report are briefly described in the following paragraphs:

- **Site I**: situated immediately downstream of the important nalla which flows into river Dikhri about 5 km upstream of its confluence with river Bichom (i.e. about 3.5 km upstream of the head of Dibbin reservoir, where estimated river bed level is 1370 masl).
- **Site II**: further down the Dakhri, about 1 km upstream of the head of the Dibbin reservoir (river bed level 1270 masl).

Site-I has the advantage of providing a significantly greater head whilst still harnessing a relatively large proportion of the total catchment. The gain in catchment area between sites I and II is quite small but the reduction in head is considerable. The power house would be located near head of Dibbin reservoir.

Two alternative alignments of the power water ways (PWW) were studied for alternative-I.

- Alternative-I consists of a concrete-lined pressure tunnel/shaft in the left (north) flank
- Alternative-II envisages a reinforced concrete conduit running hillside at the left (northern) flank. It is foreseen to place the access road to the dam site beside the conduit. For the short tunnel needed from dam site under Alternative-II, on the other hand, the right side of the valley would possibly be more suitable. The lengths of these two power waterway systems would be 4 km and 250 m respectively.

A concrete gravity dam with crest spillway (three bays) is proposed for both of the alternative sites and the following ranges of reservoir levels were considered for the comparative studies:

- Dam site for Alternative I: 1420 to 1480 masl (head range 200 to 260 m): installed capacity 48 to 72 MW.
- Dam site for Alternative II: 1320 to 1380 masl (head range 100 to 160 m): 24 to 48 MW.

It can be seen that for Alternative-I, about 150 m head is due to the slope of the river, while 30 to 110 m is contributed by the height of the dam. For Alternative-II, the drop in river level between dam and power house is about 50 m, and the contribution from the dam height is the same. The power house would preferably be equipped with two Francis turbine/generator units.

The transmission lines from the Dikhri power station would extend down the Bichom valley to the switchyard at the Dibbin power station, a distance of about 8 km. The project layout is enclosed as Figure-2.5 and the salient features are given in Table-2.5.

TABLE-2.5

Salient Features of Dikhri hydroelectric project

1. GENERAL	
State	Arunachal Pradesh
District	West Kameng
Tehsil	Nafra
Coordinates of the Dam Site	27° 26'45"N 92° 31' 17" E
Nearest rail head/Nearest Airport	Bhalukpong /Tezpur
Access to project site	By road from Tezpur (Assam) via Balipara, Bhalukpong and Nechiphu
Name of the River	Bichom River
Name of river basin	Dakhri River / Bichom River
2. HYDROLOGY	
Catchment Area upto headworks	190 km^2
Average Annual Discharge:	14.5 m^3/s
Hydraulic Design Flood (1,000 year Flood)	1524 m^3/s
Probable Maximum Flood (PMF)	2999 m^3/s
3. DAM AND RESERVOIR	
Type	Concrete Gravity Dam
Maximum height above deepest foundation (m)	70 m
Elevation of top of Dam (m)	1425 masl 1455 masl (maximum)
Length of Dam at crest (m)	160 m
Full Supply Level (FSL)	1420 masl 1450 masl (maximum)
Minimum Operation Level(MOL)	1410 masl
Gross storage capacity	0.9 Mm^3
Live storage capacity	0.4 Mm^3
Dead storage capacity	0.5 Mm^3
4. SPILLWAY	
Type	Gated overflow spillway
Discharge capacity (m^3/s)	1524 m^3/s
Number of bays	3
5. POWER WATERWAYS	
Head Race Tunnel	
- Length	3650 m
- Diameter	3.1 m
- Design Discharge and Velocity	29 m^3/s; 4 m/s
Penstock	
- Length	100 m
- Diameter	2.6 m
- Design Discharge and Velocity	29 m^3/s; 6 m/s

6 POWERHOUSE	
Powerhouse	
- Type	Surface
- Location	Left Dikhri bank, approximately 1.6 km upstream of confluence with Bichom river
Turbines	
- Type of turbine	Francis
- Number of units	2
- Installed capacity	48 MW
- Rated net head (m)	190 m
- Maximum flow through each unit	15 m^3/s
Tail Water Level	1220 m asl
7 POWER BENEFITS	
Annual Design Energy (90% dependable year)	173.2 GWhr/year
Mean Annual Energy	200.6 GWhr/year
8 COST ESTIMATE	
Civil	Rs. 215.04 Crores
Electrical/ Mechanical	Rs. 53.8 Crores
Design, supervision & administration	Rs. 13.44 Crores
Sub-Total (Generation)	Rs. 282.3 Crores
I.D.C.	Rs. 30.65 Crores
Total (including initial financing charges)	Rs. 314.7 Crores

2.7 DINCHANG HYDROELELCTRIC PROJECT

INTRODUCTION

The Dinchang Hydro-electric project is a run of river project envisaged with diurnal storage located on Digo river just downstream of Selari village in West Kameng district of Arunachal Pradesh. The river Digo originates in the western part of Kameng basin at en elevation of 4600 m a.s.l. Digo river is a right bank tributary of Bichom river with its confluence near Lali village.

The project is located near Bomdila town, the headquarters of West Kameng district in the state of Arunachal Pradesh, India with the diversion site near Selari village, about 25 km from Bomdila and about 365km from Guwahati, the commercial capital of Assam. Nafra town is located on the banks of Bichom river, further 30 km from Selari village. The road from Nafra town to Bichom dam is under-construction which provides access to the confluence of Bichom and Digo rivers about 10km downstream, near which the Dinchang powerhouse is proposed. The project is located on the Digo River in the West Kameng District of Arunachal Pradesh.

The Diversion Site is located about 2km downstream of Selari Bridge on the river Digo. The Diversion structure is envisaged as concrete gravity dam 190 m long & 69 m high above deepest foundation level. To care of PMF 5 nos. radial gated spillway having breast wall at top and flip bucket energy dissipating devices are proposed. The size of the gates are proposed as 10 m (w) x 14 m (H) with the crest level at 1132.50m.

For temporary diversion of the river during the construction period, a diversion tunnel is proposed on the right bank with upstream and downstream coffer dams. Intake with rashrack arrangement is proposed at left bank of the river.

Two feeder tunnels of size 4.5m x 5.5m, modified D-shaped, offtake from the intake shall lead to the de-sanding chambers. 2 nos. underground de-sanding cambers have been proposed on left bank of the river to exclude silt particles of size of o.25mm. The size of each de-sanding chamber is 210m (L) X 14m (W) X 19m (H).

Two link tunnels from the downstream end of de-sanding chambers join to form the Headrace Tunnel. The total length of the tunnel up to surge tank is about 12.15 km. A 6.4m modified horse shoe shaped section is proposed for the headrace tunnel (HRT), provided with a 300 mm thick concrete lining. Four construction adits are planned for the HRT to allow excavation to proceed unhindered on several faces simultaneously, one at the upstream end of HRT, one near the Surge shaft and two at intermediate locations.

A surge tank is provided at the downstream end of the HRT to reduce the pressure surges created due to water hammer and to limit their further transmission to HRT. Restricted orifice type Surge shaft having dia 16m and height 95m is proposed at this stage. A pressure shaft of 5.1m diameter emanates from the surge shaft and drops down to the powerhouse level where it is branched into three unit penstocks to feed the three generating units.

The underground powerhouse complex is proposed on the left bank of Digo river. The power house cavern is of 90.5m (L) x 20m (W) x 46.3m (H) size, including space for three generating units, an erection bay and a control block. The center line of machines is set at El. 793.00m. The transformer hall cavern is located 35m downstream of the Powerhouse Cavern. The transformer hall cavern is of size 94m (L) x 16m (W) x 25m (H). Three bus duct galleries are provided between the machine hall cavern and the transformer hall cavern. The bus duct galleries are 4.5m (W) and 5.5m (H), D-shaped.

Three unit tailrace tunnels are envisaged as an extension of the draft tubes. The tailrace tunnels empty into collection gallery of size 54m (L) x25m (H) with the width varying from 122m at one end to 20m at the other. Main TRT is of size 6.4m diameter and modified horse shoe shaped. The invert at the exit of TRT has been fixed at El. 799.0m tentatively. Each of the three Vertical axis Francis turbines will be rated to match the generator output of 120 MW at a rated net head of 330.46 m. The preliminary cost estimate has been carried out on the basis of component sizes as per the preliminary design computations. The total project cost is estimated to be about 2409.98 Crores (Civil works – 1066 crores, E&M Works – 450 crores, Escalation – 496.3 crores and IDC and financing charges – 397.7 crores).

The project layout of Dinchang hydroelectric power project is given in Figure-2.6 and the salient features are given in Table-2.6.

TABLE-2.6

Salient Features of Dinchang hydroelectric project

1. GENERAL	
State	Arunachal Pradesh
District	West Kameng
Tehsil	Nafra
Coordinates of the Dam Site	27° 14' 34.6" N 92° 27' 27.5" E
Nearest rail head/Nearest Airport	Bhalukpong / Tezpur
Access to project site	By road from Tezpur (Assam) via Balipara, Bhalukpong and Nechiphu
Name of the River	Digo River
Name of river basin	Bichom River/ Kameng River
2. HYDROLOGY	
Catchment Area upto headworks	1236 km^2
Rain fed area	1236 km^2
Probable Maximum Flood (PMF)	9025 m^3/s
3. DAM AND RESERVOIR	
FRL	1160 m asl
MDDL	1152 m asl
Length of Reservoir at FRL	2.05 km
Submergence Area at FRL	23.3 ha
Top of the Dam	1162 m asl
River Bed Level	1118.55 m asl
4. INTAKE (ON LEFT BANK)	
Numbers	02
Intake Crest elevation	1140.0 m asl
Nominal Discharge	144.66 m^3/s
Gate Type	Vertical lift fixed wheel type
Gate Size (wxh)	2 No., 4.5m x 5.5m
5. FEEDER TUNNELS	
Nos.	02
Size (W x H) of each tunnel	4.5 m x 5.5 m Modified D-shaped
Length	130m, 160m
6. DE-SANDING CHAMBERS	
No. & Size (LxHxW)	2 Nos., 210m x 19m x 14m
Size of Particle to be Removed	>0.25 mm
Average Discharge for each Chamber	66.3 m^3 /s
Flushing Discharge for two Chambers	24.1 m^3/s
7. HEADRACE TUNNEL	
Excavated Shape	Modified Horse shoe

Finished Size	6.4 m Diameter Modified Horse shoe
Lining type	Concrete lined
Lining thickness	300 mm
Length/Slope	12155m ; 1:264
Design Discharge	120.55 m^3/s
8. SURGE SHAFT	
Type	Underground Verticle Shaft
Diameter	16 m
HRT invert at surge shaft	1092.5 m asl
Surge shaft bottom	1102.0 m asl
Surge Shaft Top	1197.0 m a sl
Total Height	95.0
9. PRESSURE SHAFT	
Number and Diameter	1 Nos. 5.1 m dia
Length of main Pressure Shaft	474.8m (Vertical Reach 242.1 m)
Design Discharge through Pressure Shaft	120.55 m^3/s
10. UNIT PENSTOCK	
No. & Dia	3 Nos., 2.9 m
Combined Length	226.7 m
11. UNDERGROUND POWER HOUSE	
Dimensions (W x Hx L)	20m x 46.3m x 90.5m
Turbine Type	Vertical Axis Francis Turbine
Number of Units	3
Turbine Setting Elevation	793.0 m asl
Rated Discharge per Unit	40.16 m^3/s
Minimum tail water level	800 m asl
Normal tail Water Level	802 m asl
12 . UNIT TAILRACE TUNNEL	
Length	62.5m
Shape	Rectangular, 7.23m (W)x 3.81m (H)
13. TAILRACE TUNNEL	
Length	451 m
Shape	Modified Horse Shoe, 6.4 m dia
Tailrace Outfall Gate Type	Vertical lift wheel type
Tailrace Outfall Gate Size (WxH)	1 No. 6.4m x 6.4m
Hoist Type	Rope Drum Hoist
Outlet sill elevation	799.55m
14. ESTIMATED COST	
Civil works	Rs. 1066.0 Cr.
E&M works	Rs. 450.0 Cr.
Total basic cost	Rs. 1516.0 Cr.
Escalation for Civil and E&M works	Rs. 496.3 Cr.
Interest during construction & Financing Charges	Rs. 397.7 Cr.
Protest Cost including Escalation, IDC & Financial Charges	Rs. 2409.98 Cr.
Cost per MW installed	Rs. 6.69 Cr./MW
15. POWER BENEFITS	

90% dep. Energy	1445.66 MU

2.8 JAMERI HYDROELECTRIC PROJECT

From the desk studies conducted as a part of Reconnaissance Study Report, various alternatives for Jameri scheme were studied. Two possible dam sites, both situated east of village Jameri were evaluated initially. Maximum Reservoir Level (MRL) of 1055 masl, corresponding to a dam about 90 m high, were studied. The maximum storage level was governed by the need not to allow submergence upstream of the Tenga road bridge and Military camps.

Three possible power house locations were studied. Site I was located on the left bank of river Jameri and would require a pressure tunnel 3.05 km long from dam site 1 to develop a gross head of 150 m. Sites 2 and 3 were on the right bank and were connected with dam site 2, and the latter site would correspond to the maximum retention level of the reservoir formed by the diversion weir at the Kameng (Bichom) headworks. These two sites would be served by a pressure tunnel following essentially the same alignment, with that for site 2 being about 1500 m shorter. The gross head developed would be between 215 to 255 m and 245 to 285 m for sites 2 and 3 respectively.

The left bank alignment is more direct and is located at greater depth, hence, it will pass through more favourable geological conditions. The right bank tunnel would be located at shallower depth on the outside of the bend of the river, hence, it would pass through more disturbed rock formations. On the other hand, short intermediate adit(s) could be excavated to increase the number of working faces for tunnel construction.

The Jameri dam would be a concrete gravity weir with a maximum height of up to 90 m and with a gated (4-bay) spillway with radial gates and ski jump. The power intake structure would be located at the dam abutment, with an adjacent low-level sluice to allow flushing of sediment from the apron area of the intake. Directly downstream of the intake, an underground silt chamber is envisaged. Upstream of each power house location, and at an appropriate elevation, sites exist for an excavated surge shaft which would be connected with the turbines by high-pressure underground shafts or surface penstocks. The options of surface or underground power house will examined in detail during the feasibility study. The project layout is shown in Figure-2.7 and salient features are given in Table-2.7.

TABLE-2.7

Salient Features of Jameri hydroelectric project

1. GENERAL	
State	Arunachal Pradesh
District	West Kameng
Tehsil	Nafra
Latitude & Longitude (Dam Site)	27° 13'21"N 92° 38'22" E
Nearest rail head/Nearest Airport	Bhalukpong / Tezpur
Access to project site	By road from Tezpur (Assam) via Balipara, Bhalukpong and Nechiphu
Name of the River/ Tributary	Tenga River
Name of river basin	Tenga River / Kameng River
2. HYDROLOGY	
Catchment Area upto headworks	939 km^2
Average Annual Discharge:	24.1 m^3/s
Hydraulic Design Flood (1'000 year Flood)	5244 m^3/s
Safety Check Flood (PMF)	10321 m^3/s
3. DAM AND RESERVOIR	
Type	Concrete Gravity Dam
Maximum height above deepest foundation (m)	50 m
Elevation of top of Dam (m)	1020 masl
Length of Dam at crest (m)	130 m
Full Supply Level (FSL)	1015 masl 1060 masl (maximum)
Minimum Operation Level(MOL)	1005 masl
Gross storage capacity	10.6 mill m^3
Live storage capacity	6.2 mill m^3
Dead storage capacity	4.2 mill m^3
4. SPILLWAY	
Type	Gated overflow spillway
Discharge capacity (m^3/s)	5244 m^3/s
Number of bays	4
5. POWER WATERWAYS	
Head Race Tunnel	
- Length	5600 m
- Diameter	4 m
- Design Discharge and Velocity	50 m^3/s; 4 m/s
Penstock	
- Length	250 m
- Diameter	3.25 m
- Design Discharge and Velocity	50 m^3/s; 6 m/s
6 POWERHOUSE	
Powerhouse	
- Type	Surface
- Location	Right Tenga bank, about 8 km d/s of dam site

Turbines	
- Type of turbine	Francis
- Number of units	2
- Installed capacity	128 MW
- Rated net head (m)	236 m
- Maximum flow through each unit	30 m^3/s
c) Tail Water Level	770 m asl
7) POWER BENEFITS	
Annual Design Energy (90% dependable year)	294.4 GWh/year
Mean Annual Energy	401.1 GWh/year
8) COST ESTIMATE (in crores Rupees)	
Civil	Rs. 334.12 Crores
Electrical/ Mechanical	Rs. 104.88 Crores
Design, supervision & administration	Rs. 21.95 Crores
Sub-Total (Generation)	Rs. 460.95 Crores
I.D.C.	Rs. 50.44 Crores
Total (incl. initial financing charges)	Rs. 519.55 Crores
9) ECONOMIC EVALUATION	
90% Dependable Year	
- First year tariff (incl. free power)	Rs. 3.47/kwhr
- Levellised Tariff	Rs. 2.86 /kwhr

2.9 DINAN HYDROELECTRIC PROJECT

As a part of Reconnaissance studies for the project, three alternatives were considered for Dinan hydroelectric project. Alternative-I, comprises of a high dam located at the narrow section of the valley located less than 1 km upstream of the confluence with river Bichom. Dams between 70 to 110 m high, with an adjacent power house, were considered for this site. The sites for alternative-II and III are further upstream and here only low, run-of-river weirs can be developed. These weirs would divert water into high-level canals excavated along the left, south flank of the valley, which would feed penstocks and a power plant near the Bichom confluence.

Alternative-I

The dam under Alternative-I would create most of the head as the difference in elevation between the dam site and the Bichom river is only about 30 m. For dams in the range of 40 to 80 m high the gross head would be 70 to 110 m and the corresponding installed capacities shall range from 5 to 10 MW. The low power generation capacity are due not only on account of small available head but also due to rather low mean runoff from the small catchment area. On the other hand, a dam up to 80 m high, probably at best a concrete gravity structure, would be relatively expensive, although this would be compensated somewhat by the short power waterways, less than 0.5 km long.

Alternatives II and III

An alternative layout for the small power plant on the Dinang river considered under Reconnaissance Report comprises of open headrace canal excavated along the valley flank from a diversion weir (Tyrolean weir) further up the valley. At its downstream end, this canal would discharge through a small, open balancing pond with an overflow section, into a penstock feeding a power house located on the bank of river Bichom. This layout is quite common in Himalayan regions as well as in the mountains of South America and Europe. Whilst maximising the head that can be developed, the need for a high dam and/or underground waterways can be avoided. The disadvantage is that the head pond is too small so that only very limited flow regulation is possible.

The two possible sites for the diversion weir considered were about 2.0 and 5.3 km upstream of the Bichom confluence. Site 2 would be at 930 masl (head 140 m) and site 3 at 1170 masl (head 400 m). In both cases, penstock from the end of the canal to the power house would be less than 500 m in length.

The layout of Dinan hydroelectric project is given in Figure-2.8 and the salient features of the project are given in Table-2.8.

TABLE-2.8

Salient Features of Dinan hydroelectric project

1. GENERAL	
State	Arunachal Pradesh
District	West Kameng
Tehsil	Nafra
Coordinates of the Dam Site	27° 19'27"N 92° 35'51" E
Nearest rail head/Nearest Airport	Bhalukpong / Tezpur
Access to project site	By road from Tezpur (Assam) via Balipara, Bhalukpong and Nechiphu
Name of the River	Dinang River, Tributary of Bichom River
Name of river basin	Kameng River
2. HYDROLOGY	
Catchment Area upto headworks	140 km^2
Average Annual Discharge:	5.1 m^3/s
Hydraulic Design Flood (1,000 year Flood)	1216 m^3/s
Probable Maximum Flood (PMF)	2394 m^3/s
3. DAM AND RESERVOIR	
Type	Tyrolean Weir
Maximum height above deepest foundation (m)	14 m
Elevation of top of Dam (m)	1170 masl (Weir crest) 1177 masl (Platform)
Length of Dam at crest (m)	65 m
Full Supply Level (FSL)	1170 masl

	1450 masl (maximum)
Minimum Operation Level(MOL)	1170.0 masl
Gross storage capacity	-
4. SPILLWAY	
Type	Ungated ogee weir
Discharge capacity (m^3/s)	1216 m^3/s
Number of bays	1177.5 masl
5. POWER WATERWAYS	
Head Race Tunnel	
- Length	5200 m
- Diameter	2.0 X 2.0 m
- Design Discharge and Velocity	8.5 m^3/s and 4 m/s
Penstock	
- Length	600 m
- Diameter	1.4 m
- Design Discharge and Velocity	8.5 m^3/s and 6 m/s
6 POWERHOUSE	
Powerhouse	
- Type	Surface
- Location	left bank of Dinang River, near the confluence with Bichom river
Turbines	
- Type of turbine	Francis
- Number of units	2
- Installed capacity	30.5 MW
- Rated net head (m)	385 m
- Maximum flow through each unit	4.25 m^3/s
Tail Water Level	
- Maximum water level (m)	770 m asl
7 POWER BENEFITS	
Annual Design Energy (90% dependable year)	96.8 GWhr/year
Mean Annual Energy	125.9 GWhr/year
8 COST ESTIMATE	
Civil	Rs. 87.5 Crores
Electrical/ Mechanical	Rs. 28.8 Crores
Design, supervision & administration	Rs. 5.8 Crores
Sub-Total (Generation)	Rs. 122.1 Crores
I.D.C.	Rs. 13.2 Crores
Total (including initial financing charges)	Rs. 136.0 Crores

2.10 NAFRA HYDROELETCRIC PROJECT

The proposed Nafra Hydro Electric Project is a run-off-the-river scheme on the Bichom river of Kameng Basin in Arunachal Pradesh. The project construction includes a 40 m high composite dam located at latitude 27°21'15.71" N and longitude 92°33'56.66" E where the river bed level is at an elevation of 944 m above mean sea level. The water of river Bichom will be diverted through a tunnel to a surface power house on the right bank of Bichom River. The Power House site is located at Latitude 27°19'24.91" N and Longitude 92°35'25.25" E where natural ground elevation is 810m above mean sea level. Installed capacity planned for the power house is 96 MW (2 units of 48 MW each vertical Francis type Turbine designed for a net head of 173.31m).

The project site is located at Nafra village of West Kameng District in the state of Arunachal Pradesh. The site is accessible by road from Guwahati via Tezpur, Bhalukpong and Bomdila.

Tezpur is the nearest rail head and the nearest air port is located about 215 km from the project site.

Various components of the project are briefly described in the following paragraphs:

Composite Dam

The Nafra Dam location has been selected to take optimum advantage of the' topographical and geological conditions of the site. Average river bed level at the dam site is EL. 944.0. The dam with its deepest assumed excavated level at EL 944.0m is 40 m high with its top at EL 984.0. It is about 40 m above the river bed level. The rock fill dam comprises central clay core with shouldering of 200mm thick sand and gravel filters and thereafter the compacted rockfill. The u/s is protected by 1000mm thick rip rap material to safeguard against wave action/level variation. The dam with its u/s and d/s slopes of 2.5.1 and 2.1 has a top width of 10m and has been provided with 3m free board. The clay core trenches into the existing foundation clay. The top soil removal and clay stock piling work shall start immediately after mobilization and completed in a period of 10 to 11 months.

Intake Structure

The intake structure is located on right bank of the river. After establishing access to the intake structure, open excavation works will be taken up. Excavation of rock in 1:10 slope starting from top will be carried out in benches. Installation of rock bolts, shotcrete and provision of drainage holes will be carried out on the excavated slope before taking up the next benching to safeguard against disturbance in the cut slope. Excavation of Intake will take 4 months time.

Head Race Tunnel

The total length of the Nafra Hydro-Electric Project head race tunnel (HRT) is 3680 m. The tunnel will be of modified horse shoe shape profile of 5.0 m finished diameter and excavated diameter of about 5.95 m.

Surge Shaft

The restricted orifice type surge shaft will be of 10.5 m diameter and 50.0 m in height with the orifice dia. of 2.35 m. The surge shaft will also be open at the top. For carrying out construction of surge shaft, access road has been provided at the top of the shaft at EL 1005.0 m. Further an adit of 100 m length has been provided at the bottom of the shaft at EL 940.0 m.

Pressure Shaft

From the surge shaft bottom steel pressure tunnel of 3.0m dia. of about 100 m length up to valve chamber of size 16m x 8m has been provided. From valve chamber, surface penstocks of 3.0 m dia take off and terminate into power house units.

Power House

The deep seated power house proposed on the right bank of Bichom River is located on a flat terrain on terrace deposit. Elevation of the river bed at this location is around EL 800m and power house terrace is at EL 810 m. The powerhouse will be in a deep pit and sufficiently away from the river. Hence seepage is not expected to be major problem; however provision for drainage pumping shall be kept. A protection bund of suitable height around the complex has been planned to safeguard against floods up to PMF. The deepest foundation level is at EL 781.70 m.

Tailrace Arrangement

The tail race channel of 165.0 m length has been provided from the Power house up to the Bichom River. The excavation work for the tail race channel will be taken up after the excavation work for Power house is completed.

Switch Yard

An outdoor 220 KV switchyard (53 m x 42 m) has been planned on the platform near the power house at an elevation of 813 m.

The project layout is given in Figure-2.9 and the salient features are given in Table-2.9.

TABLE-2.9
Salient features of Nafra hydroelectric project

LOCATION	
State	Arunachal Pradesh
District	West Kameng
River	Bichom
River basin	Kameng
Nearest Railway Station	Bhalukpung
Nearest Airport	Tezpur

Coordinates of the Dam Site	27° 21' 15.71" N 92° 33' 56.66" E
HYDROLOGY	
Catchment area upto Dam Site	776 km^2
Average annual rainfall	3188 mm
Probable max. flood	5988 m^3/s
90% available discharge	38.43 m^3/s
Annual Inflow	1219.29 Mm^3
DAM	
Type	Composite
Max. height above river bed level	40m
River bed level	944.0 masl
Elevation of top of Dam	984.0 masl
Length of Dam at top	241 m
Freeboard	3.0 m to FRL
Width at top	10.0m
SPILLWAY	
Type	Sluice Spillway
No. and size of gates (Radial)	4 Nos x 10m wide x 12m high
Discharge capacity	5978 m^3/s
No. of bays	4 Nos.
Length of spillway	58.0m
Bay width	10.0m
Crest elevation (masl)	952.0 m
RESERVOIR and SUBMERGENCE	
Full Reservoir Level FRL (masl)	981.0 m
Maximum Water Level (masl)	982.0 m
Minimum Draw Down Level (masl)	972.0 m
Gross capacity	5.267 Mm^3
Live capacity	2.413 Mm^3
Dead storage capacity	2.854 Mm^3
Submergence area at FRL	32.67 ha
No. of villages affected	Nil
HEAD RACE TUNNEL	
Length	3.68 km
Diameter	5.0 m
Shape	Modified Horse Shoe
Design discharge	61.38 m^3/s
Design velocity	3.02 m^3/s
Invert level of intake (masl)	961.50 m
SURGE SHAFT	
Type	Restricted orifice type Surge Shaft
Surge Shaft Diameter	10.50 m
Orifice Diameter	2.35m
Height	57.00 m
Top elevation (masl)	1002.0 m
Bottom elevation (masl)	945.0 m
Gates for Penstock	2 Nos

PENSTOCK	
Type	Sub-surface penstock
Number of Pressure shaft *f* penstock	2 nos
Maximum discharge through Pressure shaft of penstock	30.69 m^3/s
Diameter of each Pressure shaft of Penstock	3.0m
Maximum velocity	4.34 m^3/s
Length of Subsurface Pressure shaft	100.0 m
Length of penstock	486.00 m
POWER HOUSE	
Type	Surface
Location	1.5 km upstream of river Digo confluence With river Bichom
Number of units	2 nos
Rated unit capacity	48MW
Installed Capacity	96MW
Maximum Gross head	184.40 m
Design net head	173.31 m
Type of turbine	Vertical Francis
Maximum flow through each unit	30.69 m^3/s
Normal Tail Water level	796.57 m (two units running at full load)
Minimum Tail Water level	794.84 m (one unit running at full load)
Speed specific and synchronous	375 rpm
Type of Switch yard	Outdoor (53 x 42 m)
POWER BENEFITS	
Peaking Capacity	96MW
Annual Energy (GWh/Yr) for 50% dependable year	491.60 MU
load factor for operation (annual/lean period) for 50% dependable year	58.46 %,30.72 %
Annual Energy (GWh/Yr) for 90% dependable year	423.95 MU
load factor for operation (annual/lean period) for 90% dependable year	50.41 %, 22.76 %
ESTIMATED COST	
Civil Works (Including gates and hoists)	Rs. 379.44 Crore
E and M Works (Including costs of transmission line to pooling station)	Rs. 149.30 Crore
Total Basic Cost	Rs. 528.74 Crore
Total cost including monitoring as per MOA	Rs. 529.27 Crore
Escalation during Construction	Rs. 73.75 Crore
Interest during Construction	Rs. 80.90 Crore
Working capital margin	Rs. 6.78 Crore
Total (Generation Works)	Rs. 690.70 Crore
Cost per MW installed	Rs. 7.19 Crore
FINANCIAL ASPECTS	
Levelized Tariff for Design Energy at 90% Dependable year	Rs. 3.53/ KWh
Project Internal Rate of Return for 3-5 Years	10.46 %

(PIRR)	
CONSTRUCTION PERIOD	36 months

Source: Detailed Project Report (DPR)-Nafra *Hydro Electric Project*

2.11 GONGRI HYDROELETCRIC PROJECT

The project envisages construction of a located 1.5 km upstream of Munna camp. The barrage height is 24 m from deepest foundation level. The power house is located at approximately 7.0 km downstream of barrage site. The site is located in a narrow gorge with good rock in abutments The proposed project envisages power generation of 90 MW. The project layout is given in Figure-2.10 and the salient features of the project are given in Table-2.10.

TABLE-2.10

Salient Features of Gongri hydroelectric Project

PROJECT LOCATION	
Location	Arunachal Pradesh
District	West Kameng
River	Gongri/Digo
Vicinity	Jhala Village
Coordinates of the Dam Site	27^o 19'12"N 92^o 23'35" E
HYDROLOGY	
Catchment area	1039 km^2
Average Discharge	72.5 m^3/s
Maximum Discharge	361.16 m^3/s
Minimum discharge	12.43 m^3/s
For 90% dependable year	
Average Discharge	53.55 m^3/s
Maximum Discharge	144.46 m^3/s
Minimum discharge	20.54 m^3/s
1 in 50 years flood Discharge	1500 m^3/s
1 in 500 years flood Discharge	950 m^3/s
RESERVOIR	
Full reservoir Level (FRL)	1455.5 masl
Min. Draw Down Level (MDDL)	1445.0 masl
Gross storage at FRL	0.48 Mm^3
Live storage	0.43 Mm^3
Length of submergence at FRL	1100 m
RIVER DIVERSION	
Diversion Arrangement	Diversion channel through one half of river
Diversion Discharge	790 m^3/s
BARRAGE-SPILLWAY	
Latitude	27^0 20 '22" N
Longitude	92^{0}18' 52" E
Top of Barrage	1456.5 masl

Stream Bed Level	1439.0 masl
Barrage Length	110 m
Barrage Foundation Level (Lowest)	1432.5 masl
Barrage Height from Foundation Level	24 m
Barrage Sill Elevation at Barrage Axis	1439.0 masl
Gate Type and Size (WxH)	5 Nos. Radial; 6.0mx7.7m
Hoist Type and Capacity	Twin Hydraulic Hoist (2x35MT)
Stop log Type and Size (WxH)	Vertical lift slide type, 6.0mx16.4m
Hoist Type and Capacity	Gantry Crane, 20MT
INTAKE (ON LEFT ABUTMENT)	
Number of Feeder Tunnels	2
Size of Feeder Tunnel (WxH)	3.5mx4.25m, Modified D-shaped
Intake well size	51.0m x 10.0m x 20.5m
Sill elevation of intake Gates	1436.0 masl
Nominal Discharge	87.0 m^3/s
No. of Trash rack bays & Trash rack size	7Nosx6.0mx13.5m
Sill level of Trash rack	1443.0m
Clear Opening between trash bars	100 mm
Trash rake panel size	6.0m (W) x 2.283m (H)
Total number of panels	42 Nos.
Intake Bulk head gate	Vertical lift fixed wheel type
Intake Bulk head Size (WxH)	2 Nos. 3.5mx4.0m
Hoist Type and Capacity	Rope Drum Hoist, 10.0M T
Intake Gate Type	Vertical lift wheel type
Intake Gate Size (WxH)	2 Nos. 3.25mx4.0m
Hoist Type and Capacity	Rope Drum Hoist, 15.0 T
FEEDER TUNNELS	
Nos. and Size (WxH) 2 Nos. Modified D	shaped 3.5mx4.25m
DESILTING CHAMBERS	
Desilting Chamber Size (LxHxW)	200mx18.7mx12m, 2Nos.
Size of Particle to be Removed	>0.25 mm
Design Discharge for each Chamber	36.25 m^3/s
Flushing Discharge for each Chamber	7.25 m^3/s
Flushing Duct Size (WxH)	1.35mx1.8m
Desilting Chambers outlet Gate Type	Vertical lift fixed wheel type
Gate Size (WxH)	2 Nos. 3.5mx4.0m
Hoist Type and Capacity	Rope Drum Hoist, 15.0 MT
Flushing Tunnel Gate Type	Vertical lift slide type
Flushing Tunnel Gate Size (WxH)	4 Nos. 1.35mx1.8m (2 Nos. Service and 2 Nos. Emergency gates)
Hoist Type and Capacity	Double acting Hydraulic Hoist, 65.0 MT
LINK TUNNELS	
Nos. and Size (WxH)	2 Nos. Modified D shaped 3.5mx4.25m
HEADRACE TUNNEL	
Shape of HRT	Modified Horse Shoe Shaped Finished Size of 5.2 m
Lining type	Concrete lined
Lining thickness	300mm

Length/Slope	7626m; 1:195
SURGE SHAFT	
Type	Underground open to the surface Restricted Orifice Vertical Shaft
Diameter	11.5 m
Orifice Area	4.51 m^2
Total Height	75 m
PRESSURE SHAFT	
Number and Diameter	1 No. and 4.0 m Thickness of Liner
Total Length of Pressure Shaft	488 m
Design Discharge through Pressure	72.50 m^3/s
PENSTOCK	
Number and Diameter	3 Nos., 2.3 m
Length of Longer Penstock	50 m
Design Discharge through each Penstock	24.17 m^3/s
SURFACE POWERHOUSE	
Latitude	27º 19' 09" N
Longitude	92º 23' 22" E
Dimensions (W X H X L)	19m x 33.6m x 68.3m
Turbine Type	Francis
Number of Units	3
Max./Min. Gross Head	203.55/187.60m
Rated Head	183.10 m
Installed Capacity	(3x30) 90 MW
EOT Crane capacity (Power House)	1 Nos. 125/ 20 MT
TAILRACE CHANNEL	
Length	40m
Channel Shape	33.1 to 19.8m (W) x12.0 to 2.4m(H)
Outlet sill elevation	1251.6 masl
SWITCH YARD	
Type	Out door
Area	(L x W) 82 m x 40.5 m
ESTIMATED COST	
Civil works	Rs. 550.67 Crores
E & M works	Rs. 180.00 Crores
Total basic cost (excl. transmission line cost)	Rs. 730.67 Crores
Escalation cost of Civil and E&M works	Rs. 141.08 Crores
Interest during construction & Financing Charges	Rs. 143.16 Crores
Total cost	Rs. 1014.91 Crores
Cost per MW installed	Rs. 8.46 Crores
POWER BENEFITS	
90% dep. Energy	591.3 MU
50% dep. Energy	682.0 MU

CHAPTER-3

METHODOLOGY ADOPTED FOR THE STUDY

3.1 GENERAL

The Basin Study is based on collection of relevant data from primary and secondary sources on environmental and baseline parameters. The parameters covered as a part of the study include meteorology, water quality, terrestrial and aquatic ecology. Based on the baseline setting and input loads due to the proposed hydroelectric projects to be developed in the study area, impacts on water resources, terrestrial and aquatic ecology have been predicted. Management measures have been recommended for amelioration of adverse impacts. The present chapter describes the methodology adopted for conducting the Basin Study for the Bichom Basin.

3.2 SAMPLING FREQUENCY

The frequency of sampling for various aspects to be covered under primary data collection as a part of the study is given as below:

- Water Quality : Once per month for six months
- Aquatic Ecology : Once per month for six months
- Terrestrial Ecology : Once per season for two seasons

3.3 PRIMARY DATA COLLECTION

As a part of the study, field studies have been conducted for water quality, aquatic and terrestrial ecology. As a part of aquatic ecology, phytoplanktons, zooplanktons, periphyton, benthic invertebrates, primary productivity, fisheries, etc. has been monitored. The methodology adopted for estimation of various parameters is given in the following sections.

3.3.1 SAMPLING STATIONS

For water quality monitoring, the following two sites were monitored at each hydroelectric project and the same are listed as below:

- Dam site
- 2000 m downstream of dam site

For aquatic ecological monitoring the following three sites were monitored at each hydroelectric project:

- 2000 m upstream of dam site
- Dam site
- 3000 m downstream of dam site

For terrestrial ecological monitoring, three sites were monitored for each hydroelectric project and are listed as below:

- Catchment area

- Submergence area
- Downstream of dam site

3.3.2 ESTIMATION OF DENSITY AND DIVERSITY OF PHYTOPLANKTON IN RIVER WATER

Phytoplanktons are the autotrophic component of the plankton community and play an important role in the primary production process in the stream ecosystems. They serve as a base of the aquatic food web, providing essential ecological function for all aquatic life. In terms of numbers, the important groups of phytoplankton comprises of diatoms, dinoflagellates, cyanobacteria, and other groups of unicellular algae. In the present study, the density and diversity of phytoplanktons in river water was studied by collecting the samples from various sites listed in Section 3.3.1.

Methodology

For enumeration of phytoplankton and zooplankton population, 100 litre composite water samples were collected from the river surface up to 60 cm depth and were filtered through a 20 µm net to make 1 litre of bulk sample. The bulk samples so collected were preserved in 5% formalin solution and were brought to the laboratory for analysis. Ten replicate water samples each of 15 ml were made out of the preserved 1 litre bulk sample and were centrifuged at 1500 rpm for 10 minutes. After centrifuging, volume of aliquot concentrate was measured. 1 ml of aliquot concentrate was used for enumeration of phytoplankton population in each replicate. A plankton chamber of 1 ml capacity was used for counting of plankton under a light microscope.

The total number of planktons present in a litre of water sample was calculated using the following formula:

$$N = (n \times v \times 100) / V$$

Where, N= Number of phytoplankton per litre

n = average number of plankton cells in 1 ml of aliquot concentrate

v = volume of plankton concentrate (aliquot)

V= volume of water from bulk sample centrifuged

3.3.3 ESTIMATION OF DENSITY AND DIVERSITY OF PERIPHYTONS IN RIVER WATER

Periphytons are a complex mixture of algae, cyanobacteria, heterotrophic microbes, and detritus that is attached to submerged surfaces in most aquatic ecosystems. They serve as an important food source for invertebrates, tadpoles, and some fish. They can also absorb contaminants; removing them from the water column and limiting their movement through the environment. The periphytons are also an important indicator of water quality; responses of this community to pollutants can be measured at a variety of scales representing physiological to community-level changes.

In the present study, periphytic algal component were sampled at various project sites. Samples of periphytic algae were collected by scraping 1 cm^2 area of the substratum on which they were growing. The scrapped algae were then put in a small container and brought to the laboratory for identification. Density of the periphytic algae has been expressed in terms of no. per cm^2.

3.3.4 ESTIMATION OF DENSITY AND DIVERSITY OF BENTHIC INVERTEBRATES IN RIVER WATER

Benthic invertebrates are organisms that live on the bottom of a water body (or in the sediment) and have no backbone. Their size spans 6 to 7 orders of magnitude and they range from microscopic, e.g. micro-invertebrates, to a few tens of centimetres or more in length, e.g. macro-invertebrates. Benthic invertebrates live either on the surface of bed forms (e.g. rock, coral or sediment - epibenthos) or within sedimentary deposits, and comprise several types of feeding groups e.g. deposit-feeders, filter-feeders, grazers and predators. The abundance, diversity, biomass and species composition of benthic invertebrates can be used as indicators of changing environmental conditions.

Construction of dams can impact the benthic invertebrates by alteration of the physical characteristics of the river which includes substratum, current velocity, food availability, water temperature, dissolved oxygen concentration, and water chemistry. Prior to commissioning of power projects on a river an enumeration of the benthic invertebrates in the proposed site is necessary. In the present study, an enumeration of benthic invertebrates was done in order to assess their composition, density and diversity in different reaches of the river.

Methodology

Benthic invertebrates were collected from the sampling stations by stirring an area of 1 m^2 and dislodging the substrate to catch the dislodged organisms in a net (0.5 mm mesh) held downstream. Three replicates were collected from each site. The species were then brought to the laboratory and sorted order-wise and were later on identified and enumerated. The identification was done under stereo-microscope to the lowest possible taxonomic levels following Pennak (1978) and Thirumalai (1989, 1994).

3.3.5 ESTIMATION OF INDICES

Phytoplankton species diversity indices were calculated using PAST. The following formulas were used in the PAST implementation.

- Simpson index = 1 - dominance (D). Measures 'evenness' of the community from 0 to 1.
- Shannon index. A diversity index taking into account the number of individuals as well as number of taxa. Varies from 0 for communities with only a single taxon to high values for communities with many taxa, each with few individuals. $\overline{H} = -\Sigma \frac{ni}{N} ln\left(\frac{ni}{N}\right)$
- Equitability. Shannon diversity divided by the logarithm of number of taxa. This measures the evenness with which individuals are divided among the taxa present.

3.3.5 DIVERSITY OF ICHTHYOFAUNA IN THE PROJECT AREA

The state of Arunachal Pradesh is the largest in terms of geographical as well as river drainage. It harbors many rivers, streams and streamlets which supports diverse fish species of which many are endemic to the region. Recently, Bagra *et al*. (2009) prepared a checklist of 213 species of fishes for Arunachal Pradesh of which 138 species were first hand collections from 35 rivers in the state. Construction of dams over these rivers can block or delay upstream fish migration and thus contribute to the decline and even the extinction of species that depend on longitudinal movements along the stream continuum during certain phases of their life cycle. Mortality resulting from fish passage through hydraulic turbines or over spillways during their downstream migration can be significant. Hence, prior to dam construction, a survey of the diversity of fish fauna is necessary.

Random sampling in selected areas of the project areas in the river basin was carried out using a cast net at morning (6:00 — 8:00) hours. The sampled fishes were identified using the taxonomic keys (Nath & Dey 2000, Bagra *et al*. 2009, Viswanath NBFGR).

3.3.5 ESTIMATION OF RIMARY PRODUCTIVITY IN RIVER WATER

Phytoplanktons are autotrophic, prokaryotic or eukaryotic algae that live near the water surface where there is sufficient light to support photosynthesis. Among the more important groups are the diatoms, cyanobacteria, dinoflagellates and coccolithophores. Phytoplanktons account for half of all photosynthetic activity on earth and contribute significantly to primary productivity process in aquatic ecosystems. Phytoplankton primary productivity is defined as the rate of organic matter production by the growth of planktonic plants.

Methodology

The primary productivity was determined by light and dark bottle method (Wetzel and Likens 1991). The water samples were collected in light and dark BOD bottles. Three replicates were maintained for each sample. The experimental bottles were kept for 6 hours in the river from where the water samples were collected. Winkler's method was used for determination of oxygen in the light and dark bottles. Following formula was used for calculation of phytoplankton primary productivity.

Gross Primary productivity (GPP) ($mgC/m^3/hr$) =

$$\frac{(O_2 \text{ content of light bottle} - O_2 \text{ content of dark bottle}) \times 0.375 \times 1000}{1.2 \times \text{Incubation hour}}$$

Net Primary productivity (NPP) ($mgC/m^3/hr$) =

$$\frac{(O_2 \text{ content of light bottle} - O_2 \text{ content of control bottle}) \times 0.375 \times 1000}{1.2 \times \text{Incubation hour}}$$

3.3.7 VEGETATION SURVEY

Considering the difficult terrain, quadrat method was used for vegetation sampling. The phyto-sociological data for trees and shrubs were collected from random quadrats of 10 x 10 m size laid at the project site. Random quadrats of 1 x 1 m size were laid for the study of herb component at each site.

During survey, number of plants of different species in each quadrat was identified and counted. The height of individual trees was estimated using an Abney level/ Binocular and the DBH of all trees having height more than 8 m was measured.

Based on the quadrat data, frequency, density and cover (basal area) of each species were calculated. The importance value index (IVI) for different tree species were determined by summing up the Relative Density, Relative Frequency and Relative Cover values. The Relative Density and Relative Frequency values were used to calculate the IVI of shrubs and herbs.

The volume of wood for trees was estimated using the data on DBH (measured at 1.5 m above the ground level) and height. The volume was estimated using the formula: $\pi r^2 h$, where r is the radius and h is the estimated height of the bole of the tree. The data on density and volume were presented in per ha basis.

Two species diversity indices viz., Shannon index of general diversity (H) and Evenness index (e) were computed using PAST software:

- Shannon index. A diversity index taking into account the number of individuals as well as number of taxa. Varies from 0 for communities with only a single taxon to high values for communities with many taxa, each with few individuals. $\bar{H} = -\Sigma \frac{ni}{N} \ln\left(\frac{ni}{N}\right)$
- Buzas and Gibson's evenness index was calculated using the formula: e^H / S, where H is the Shannon's index and S represents the number of species.

As a part of the vegetation survey, herbaria were prepared for the plants those had flowers. Rare and endangered species were identified referring to the Red Data Book of India and flora and herbarium pertaining to the rare/ endangered species of Arunachal Pradesh.

3.3.8 Water Quality

The existing data on water quality has been collected to evaluate river water quality on upstream and downstream of the project site. The water quality was monitored once per month for six months from April 2009 to September 2009. For water quality monitoring, the following two sites were monitored at each hydroelectric project and the same are listed as below:

- Dam site
- 2000 m downstream of dam site

Thus, a total of 20 sites were monitored as part of the Study. The water samples were collected from various locations in the study area and analyzed for physico-chemical parameters. The list of various parameters analysed is given in Table-3.1.

TABLE-3.1
Water quality parameters analysed as a part of the field studies

pH	Electrical Conductivity (EC)
Total Dissolved Solids (TDS)	Hardness
Chlorides	Sulphates
Phosphates	Nitrates
Sodium	Potassium
Calcium	Magnesium
Iron	Alkalinity
Copper	Lead
Zinc	Chromium
Mercury	Cadmium
Biochemical Oxygen Demand (BOD)	Chemical Oxygen Demand (COD)
Dissolved Oxygen (DO)	Phenolic compounds
Oil & grease	Total Coliform

3.4 SECONDARY DATA COLLECTION

The following reports/ documents were reviewed and the data as reported in these reports was used as basis for the present report:

- Reconnaissance survey Report for Utong hydroelectric project.
- Reconnaissance survey Report for Nazong hydroelectric project.
- Reconnaissance survey Report for Dimiju hydroelectric project.
- Reconnaissance survey Report for Dikhri hydroelectric project.
- Reconnaissance survey Report for Dinchang hydroelectric project.
- Reconnaissance survey Report for Jameri hydroelectric project.
- Reconnaissance survey Report for Dinan hydroelectric project.
- Detailed Project Report for Dibbin hydroelectric Project
- Detailed Project Report for Nafra hydroelectric project
- Pre-feasibility Report for Gongri hydroelectric project
- Hydrological Data for Gongri hydroelectric project

The meteorological data for the project area was collected from India Meteorological Department (IMD) and Project Reports. The data on geology was collected from Project Reports. For terrestrial and aquatic ecology, Secondary data as available with the Forest Department and other secondary sources was collected.

3.5 SUMMARY OF DATA COLLECTION

The summary of the data collected from various sources is outlined in Table-3.2.

TABLE-3.2

Summary of data collected from various sources

Aspect	Mode of Data collection	Parameters covered	Frequency	Source
Meteorology	Secondary	Temperature, humidity, rainfall, etc.	-	India Meteorological Department (IMD) and Project Reports
Water Resources	Secondary	Flow, Design hydrograph and design flood hydrograph	-	Project Reports
Water Quality	Primary	Physico-chemical and bacteriological parameters	Once per month for six months	Field studies
Geology	Secondary	Geological characteristics of study area	-	Project Reports
Terrestrial Ecology	Primary and secondary	Floral and faunal diversity	Two seasons	Field studies for summer and monsoon seasons.

Aspect	Mode of Data collection	Parameters covered	Frequency	Source
				Secondary data as available with the Forest Department
Aquatic Ecology	Primary and Secondary	Presence and abundance of various species	Once per month for six months	Field studies and secondary data sources

3.6 IMPACT PREDICTION

Prediction is essentially a process to forecast the future environmental conditions of the project area that might be expected to occur because of implementation of the project. Impact of project activities has been predicted using mathematical models and overlay technique (super-imposition of activity on environmental parameter). For intangible impacts qualitative assessment has been done. The following impacts were assessed as a part of the present study:

- Modification in hydrologic regime due to diversion of water for hydropower generation.
- Depth of water available in river stretches during lean season, and its assessment of its adequacy vis-à-vis various fish species.
- Length of river stretches with normal flow due to commissioning of various hydroelectric projects due to diversion of flow for hydropower generation.
- Impacts on discharge in river stretches during monsoon and lean seasons due to diversion of flow for hydropower generation.
- Impacts on water users in terms of water availability and quality
- Impacts on aquatic ecology including riverine fisheries as a result of diversion of flow for hydropower generation.
- Assessment of maintaining minimum releases of water during lean season to sustain riverine ecology, maintain water quality and meet water requirements of downstream users.
- Impacts due to loss of forests
- Impacts on rare, endangered and threatened species
- Impacts on economically important plant species
- Impacts due to increased human interferences
- Impacts due to agricultural practices.

3.7 OUTCOMES OF THE STUDY

The key outcomes of the study are:

- provision of sustainable and optimal ways of hydropower development of Bichom river, keeping in view of the environmental setting of the basin.
- assessment of requirement of environmental flow during lean season with actual flow, depth and velocity at different level.

CHAPTER 4
HYDROLOGY

4.1 INTRODUCTION

The Bichom river basin is located in the easternmost state of India, Arunachal Pradesh which shares a border with the states of Assam in the south and Nagaland in the south-east, as well as with Myanmar in the east, Bhutan in the west and Tibet in the north.

The river Bichom River is one of the principal tributaries of river Kameng, which further confluences with river Brahmaputra. River Bichom originates in the rugged mountains east of Tawang at an elevation of more than 5,500 masl. The river then flows south-eastwards in a deep and thickly-forested canyon to its confluence with the river Tenga. From this confluence the Bichom then flows eastwards to join the Kameng river itself, about 10 km south-west of the town of Seppa. The river Kameng then makes a long loop after it flows almost westwards through the southern ridges of the mountains.

At a location only a few kilometers away towards the south-east of Nechephu pass, river Kameng then turn towards south to enter the plain near the Bhaluphong town. In reach, river is also known as the Bhareli.

The Kameng Hydro-Electric Project (HEP) at present is under construction and it will develop the head across this loop of the Bichom and Kameng rivers by diverting the flow of the former river at a dam which is being built about 10 km downstream of Nafra town, the principal community of the upper Bichom valley.

At a short distance upstream from the Bichom dam, Digo river confluences with river Bichom. In terms of the catchment area, river Digo is larger than river Bichom. The catchment area of rivers Digo and Bichom at their confluence site is 1350 km^2 and 750 km^2 respectively. The Digo catchment is bounded in the east by the Bichom and in the south by river Tenga. The confluence of the Bichom and Digo rivers is essentially the lowest point considered in the Bichom basin for the present study (PÖYRY, 2008).

It is proposed to construct 10 hydropower projects on river Bichom in the study area. In the upper portion of Bichom basin (north of Nafra) Utung, Nazong, Dikhri, Dibbin and Dimijin hydroelectric projects are located. In the lower portion of Bichom basin (south of Nafra) Nafra, Dinan, Ongri/Digo, Dinchang and Jameri hydroelectric projects are located. The schematic form of salient features of these proposed projects is shown in Figure-4.1.

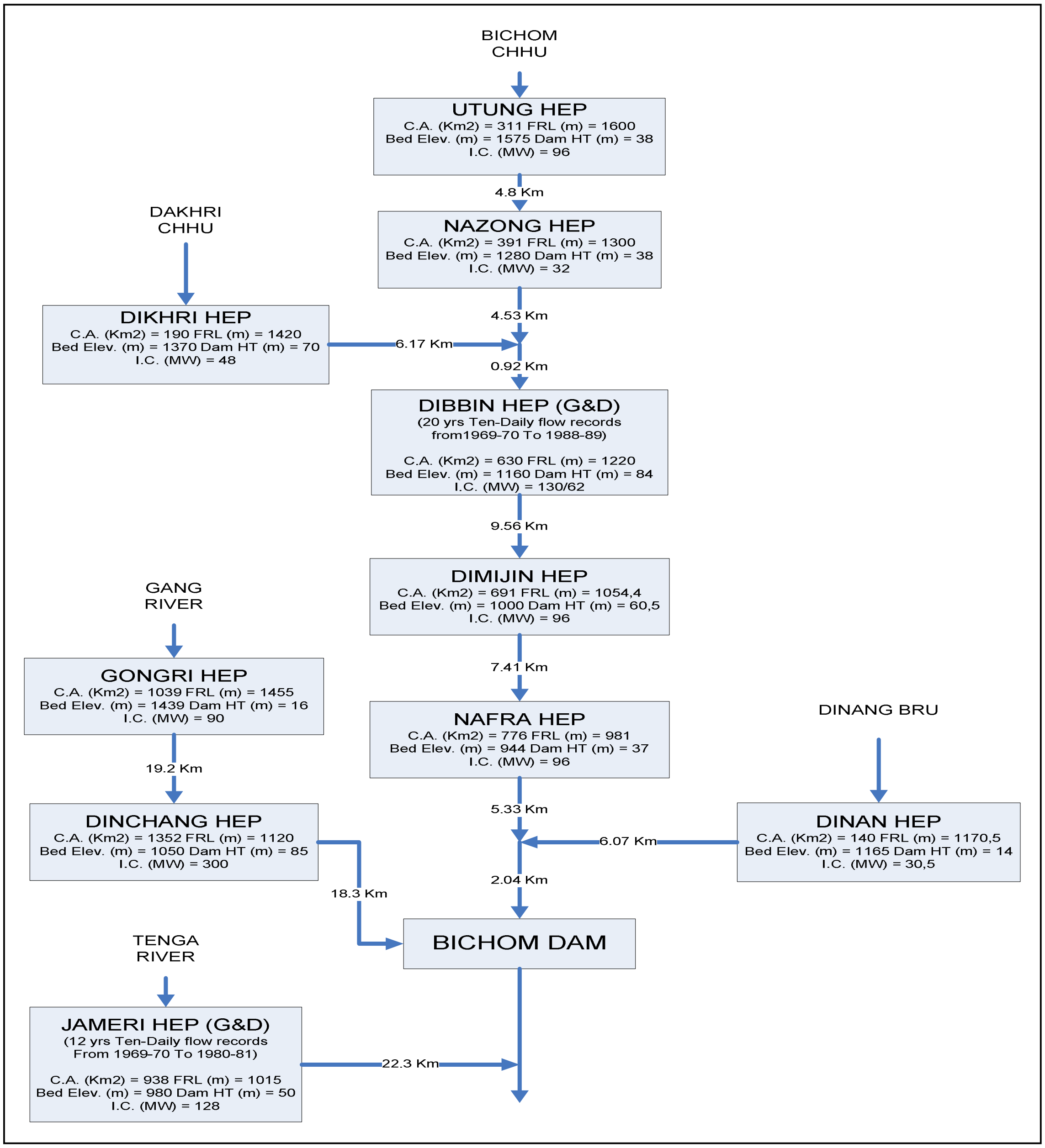


Figure-4.1: Salient features of different proposed projects in Bichom Basin

4.2 REVIEW OF AVAILABLE INFORMATION

The following reports/ documents were reviewed and the data as reported in these reports was used as basis for the present report:

- Reconnaissance Study of 7 Hydro Power Projects in West Kameng District. Utung H.E.P. (96 MW). Arunachal Pradesh, India. Volume 5. POYRY, August 2008.
- Reconnaissance Study of 7 Hydro Power Projects in West Kameng District. Nazong H.E.P. (32 MW). Arunachal Pradesh, India. Volume 6. POYRY, August 2008.
- Reconnaissance Study of 7 Hydro Power Projects in West Kameng District. Dikhri H.E.P. (48 MW). Arunachal Pradesh, India. Volume 7. POYRY, August 2008.
- Reconnaissance Study of 7 Hydro Power Projects in West Kameng District. Dibbin H.E.P. (130/62 MW). Arunachal Pradesh, India. Volume 8. POYRY, August 2008.
- Reconnaissance Study of 7 Hydro Power Projects in West Kameng District. Dimijin H.E.P. (96 MW). Arunachal Pradesh, India. Volume 9. POYRY, August 2008.
- Reconnaissance Study of 7 Hydro Power Projects in West Kameng District. Dinan H.E.P. (30,5 MW). Arunachal Pradesh, India. Volume 10. POYRY, August 2008.
- Reconnaissance Study of 7 Hydro Power Projects in West Kameng District. Dinchang H.E.P. (300 MW). Arunachal Pradesh, India. Volume 11. POYRY, August 2008.
- Reconnaissance Study of 7 Hydro Power Projects in West Kameng District. Jameri H.E.P. (128 MW). Arunachal Pradesh, India. Volume 12. POYRY, August 2008.
- Detailed project report for Nafra HE project (96 MW), SMEC INDIA, Chapter 5 Hydrology.
- Detailed project report for Gongri HE project (90 MW), Patel Engineering Limited, Chapter 3 Hydrology.

4.3 DATA AVAILABILITY

The stream inflow series were based on run-off data of river Gauging and Discharge (G&D) stations. Data were collected from three sites: Dibbin H.E.P., Bhalukpong G&D station and Jameri H.E.P. in which Ten-daily and monthly average flow is given over different periods of records. The details of data availability at the above sites are given in the following paragraphs.

Dibbin HEP

A series of Ten-Daily average flows at Dibbin dam site (C.A. 630 km^2) for a period of twenty (20) years has been determined from the analysis of the following flow records for the Bichom River:

- Bichom Dam site (C.A. 2277 km^2) for the period 1969 to 1982.
- Measured flows at Dibbin dam site during a period of eight months, between January 2005 and January 2006.

Bhalukpong G&D

No Gauge and Discharge data is available for the Ongri/Digo River, therefore flow data is taken from Bhalukpong G&D station (C.A. 10450 km^2) on the near river called Kameng and transferred by area-proportion method to Ongri/Digo River (C.A. 1039 km^2). Ten-Daily flows are available covering the period of 14 years from May 1990 to December 2004.

Jameri HEP

The inflow series for Jameri (C.A. 938 km^2) is based on the twelve (12) years time series of measured data (1969 to 1981) in which data gaps were filled using mean monthly values, since data available is on monthly bases.

4.4 DATA GENERATION

All available discharge records for stations in the region were collected and reviewed in detail. After assessment of data quality for reliability and homogeneity the following data series were selected for the generation of the inflow series in different dam sites.

Dibbin Inflow series

Final Ten-Daily inflow series at Dibbin H.E.P. covers a period of 20 years from 1969-70 to 1988-89. Following hydropower schemes are considered close to Dibbin site within areas of similar vegetation and same effective rainfall, therefore flow series generated for Dibbin site are transferred by area proportion for the Utung, Nazong, Dikhri, Dimijin, Nafra and Dinan hydroelectric projects:

Jameri Inflow series

The inflow series for Jameri H.E.P. is given on monthly basis covering a period of 12 years from 1969-70 to 1980-81. In order to transform data available on monthly to Ten-Daily basis, a multiplicative factor is applied based on Ongri/Digo inflow series. A ratio of Ten-Daily flow to Monthly flow is obtained as follows:

- Ten-Daily data available at Gongri dam site for every month is divided by monthly average flow for corresponding month

- This ratios is applied to transform monthly data available at Jameri G&D station into Ten-Daily flow series.

Ongri/Digo Inflow series

Final Ten-Daily inflow series at Gongri H.E.P. (C.A. 1039 Km^2) covers a period of 12 years from 1969-70 to 1980-81. Ten-Daily inflow data is transferred by area-proportion method to Dinchang H.E.P (C.A. 1352 Km^2) located about 19.2 km downstream of Gongri dam site along river Gang.

The schematic form of data generation at different proposed hydroelectric project sites in Bichom river basin are given in Figure-4.2.

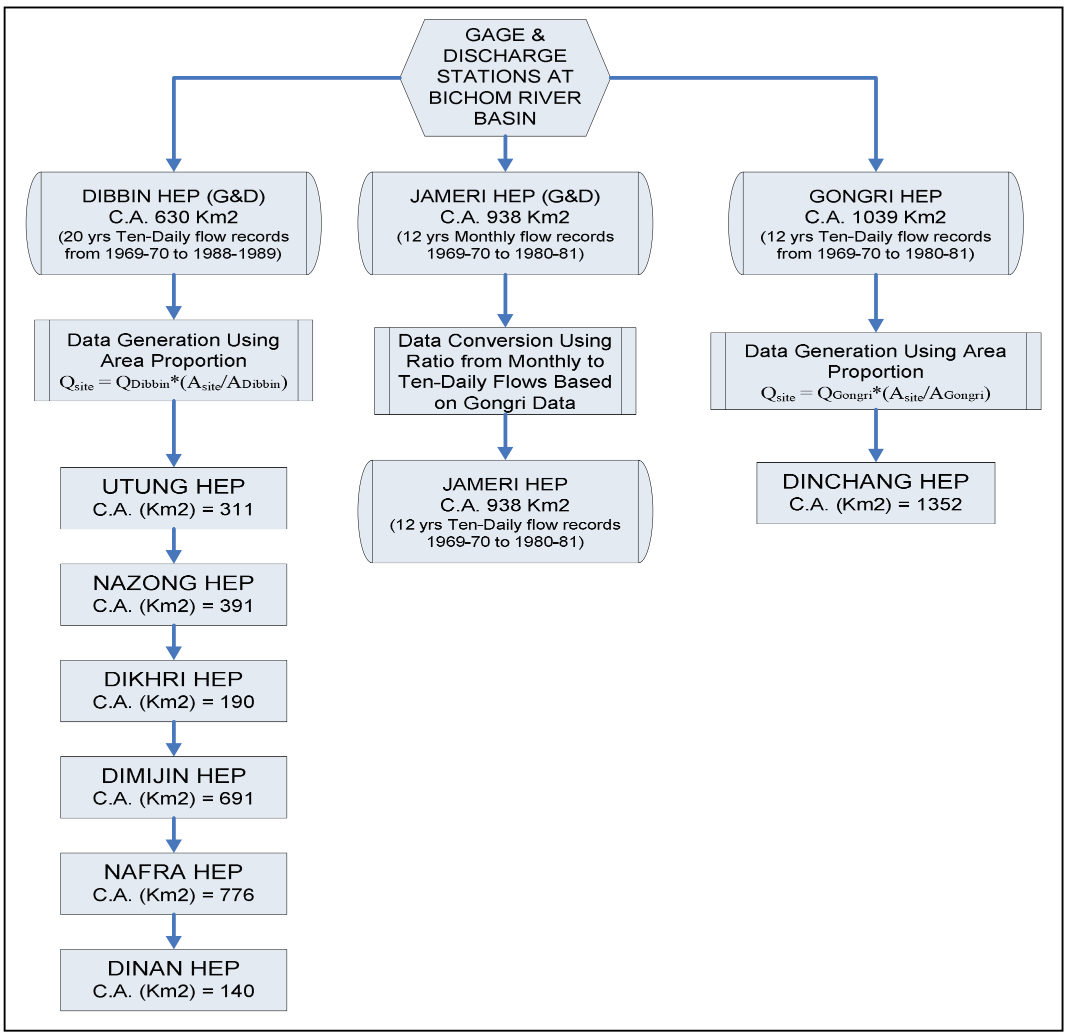


Figure-4.2: Schematic form of data generation at different proposed hydroelectric project sites in Bichom river basin

4.5 DATA ANALYSIS

Ten-Daily average flow data were carried out at different length of year for dependability analysis. For upper part of the Bichom basin which includes dam sites of Utong, Nazong, Dikhri, Dibbin, Dimijin, Nafra and Dinan hydroelectric projects, total flow records cover the period of 20 years flow records from 1969-70 to 1988-89. For lower part of Bichom basin which includes dam sites of the proposed Gongri, Dinchang and Jameri hydroelectric projects, total flow records used cover the period of 12 years from 1969-70 to 1980-81.

In all proposed sites, using Ten-Daily average flow, following is estimated:

- Monthly average, maximum, minimum, and corresponding standard deviation values are estimated.
- Annual Yield volume (MCM).
- Annual Average Flow (AAF) among total years of records in cumec.

The area-ratio for catchment area for various hydroelectric projects for which Bichom HEP Data has been used is given in Table-4.1.

TABLE-4.1

Area-ratio for catchment area for various hydroelectric projects for which Bichom HEP data has been used

S. No.	Project Name	Catchment Area (km^2)	Catchment Area Ratio
1	Utung Hydroelectric Project	311	0.494
2	Nazong Hydroelectric Project	391	0.621
3	Dikhri Hydroelectric Project	190	0.302
4	Dimijin Hydroelectric Project	691	1.097
5	Nafra Hydroelectric Project	776	1.232
6	Dinan Hydroelectric Project	140	0.223

Note: Catchment Area intercepted at Dibbin HEP site is 630 km^2.

The data for Dinchang HEP site using area-proportion method using Gongri HEP data. The catchment area intercepted at Gongri and Dinchang HEP sites are 1039 km^2 and 1352 km^2. Thus, the factor used for converting discharge data of Gongri HEP site for Dinchang HEP site has been taken as 1.302.

The flow series at Dibbin HEP site and analysis of various sets of data is given in Annexure-II. The flow series at Gongri HEP site and analysis of various sets of data is given in Annexure-III. The flow series at Jameri HEP site and analysis of various sets of data is given in Annexure-IV.

The Assessment of the 50%, 75% and 90% dependable years at Dibbin HEP site is given in Table-4.2. The flow duration curve for Dibbin HEP site is given in Figure-4.3. The hydrological flow data of Dibbin HEP is mentioned above taking into consideration the dependable years on annual basis, dependable flows for their corresponding dependable years and the flow duration curve. The hydrological data was instrumental in interpretation of the flow data for different dependable years of Utung, Nazong, Dikhri, Dimijin, Nafra, Dinan the following hydroelectric projects. The flow data was calculated by using the catchment area proportion of the HEP's.

TABLE-4.2
Assessment of the 50%, 75% and 90% dependable years at Dibbin HEP

S. No.	Year	Average Discharge (cumec)	Year	Average Discharge (cumec	Rank	% Time
1	1969-70	65.27	1981-82	79.21	1	4.76
2	1970-71	52.16	1969-70	65.27	2	9.52
3	1971-72	36.81	1973-74	61.55	3	14.29
4	1972-73	46.79	1987-88	58.84	4	19.05
5	1973-74	61.55	1985-86	56.82	5	23.81
6	1974-75	52.34	1974-75	52.34	6	28.57
7	1975-76	39.64	1970-71	52.16	7	33.33
8	1976-77	45.77	1986-87	49.97	8	38.10
9	1977-78	35.45	1972-73	46.79	9	42.86
10	1978-79	38.10	1982-83	46.77	10	47.62
11	1979-80	39.46	1988-89	46.66	11	52.38
12	1980-81	37.62	1976-77	45.77	12	57.14
13	1981-82	79.21	1984-85	44.51	13	61.90
14	1982-83	46.77	1975-76	39.64	14	66.67
15	1983-84	36.47	1979-80	39.46	15	71.43
16	1984-85	44.51	1978-79	38.10	16	76.19
17	1985-86	56.82	1980-81	37.62	17	80.95
18	1986-87	49.97	1971-72	36.81	18	85.71
19	1987-88	58.84	1983-84	36.47	19	90.48
20	1988-89	46.66	1977-78	35.45	20	95.24

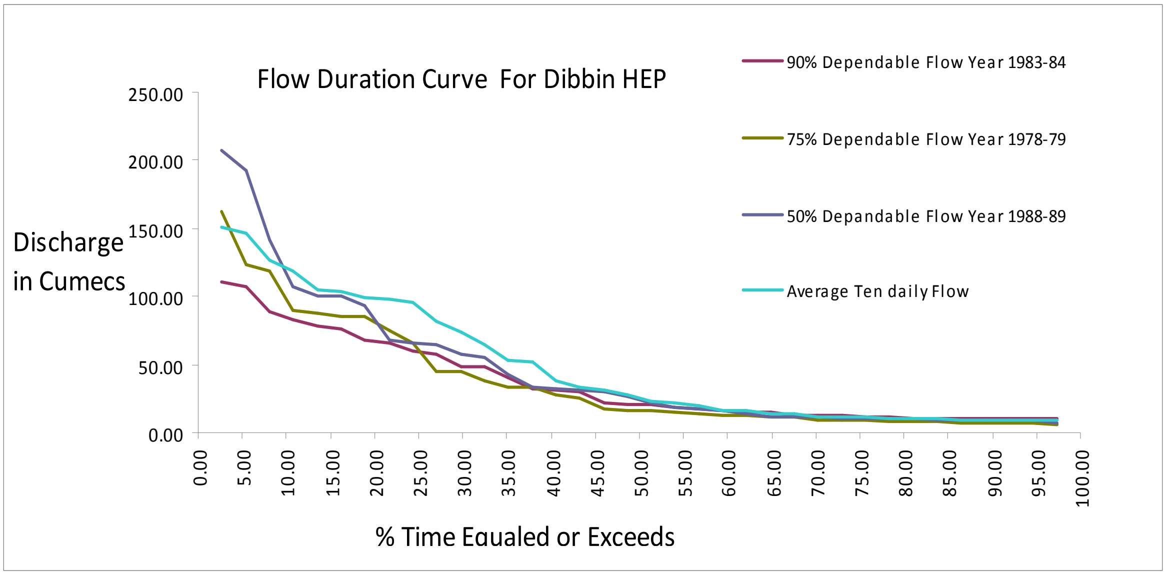


Figure-4.3 Flow Duration Curve of Dibbin HEP

The Assessment of the 50%, 75% and 90% dependable years at Gongri HEP site is given in Table-4.3. The flow duration curve for Gongri HEP site is given in Figure-4.4. The hydrological flow data of Gongri HEP is mentioned above taking into consideration the dependable years on annual basis, dependable flows for their corresponding dependable years and the flow duration curve. The hydrological data was instrumental in interpretation of the flow data for different dependable years of the Dinchang hydroelectric project. The flow data was calculated by using the catchment area proportion of the HEP's.

TABLE-4.3

Assessment of the 50%, 75% and 90% dependable years at Gongri HEP

S. No.	Year	Average discharge (cumec)	Year	Average discharge (cumec)	Rank	% Time
1	1969-70	58.46	1970-71	80.02	1	7.69
2	1970-71	80.02	1974-75	76.50	2	15.38
3	1971-72	69.11	1971-72	69.11	3	23.08
4	1972-73	52.26	1975-76	67.45	4	30.77
5	1973-74	60.61	1977-78	60.82	5	38.46
6	1974-75	76.50	1973-74	60.61	6	46.15
7	1975-76	67.45	1969-70	58.46	7	***53.85***
8	1976-77	53.47	1976-77	53.47	8	61.54
9	1977-78	60.82	1980-81	53.08	9	69.23
10	1978-79	50.52	1979-80	52.64	10	***76.92***

S. No.	Year	Average discharge (cumec)	Year	Average discharge (cumec)	Rank	% Time
11	1979-80	52.64	1972-73	52.26	11	84.62
12	1980-81	53.08	1978-79	50.52	12	***92.31***

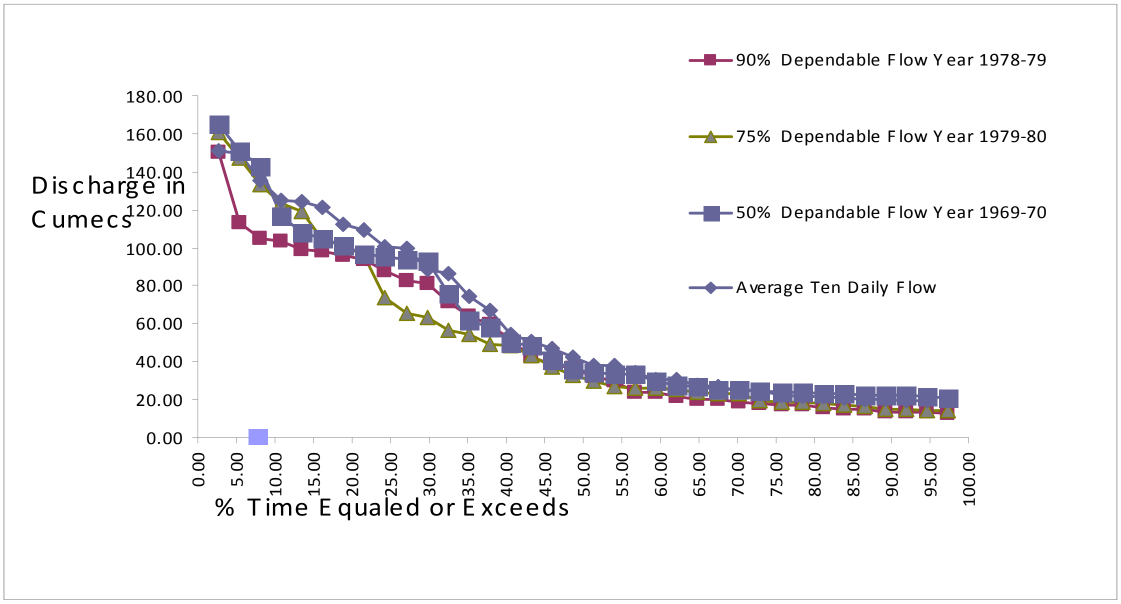


Figure 4.4 Flow Duration Curve of Gogri HEP

The Assessment of the 50%, 75% and 90% dependable years at Jameri HEP site is given in Table-4.4. The flow duration curve for Jameri HEP site is given in Figure-4.5.

TABLE-4.4

Assessment of the 50%, 75% and 90% dependable years at Jameri HEP

S. No.	Year	Average Discharge (cumec)	Year	Average Discharge (cumec)	Rank	% Time
1	1969-70	26.95	1979-80	55.46	1	7.69
2	1970-71	29.90	1970-71	29.90	2	15.38
3	1971-72	22.65	1969-70	26.95	3	23.08
4	1972-73	14.51	1977-78	24.86	4	30.77
5	1973-74	18.33	1980-81	24.70	5	38.46
6	1974-75	21.20	1971-72	22.65	6	46.15
7	1975-76	18.17	1978-79	22.44	7	53.85
8	1976-77	16.42	1974-75	21.20	8	61.54
9	1977-78	24.86	1973-74	18.33	9	69.23
10	1978-79	22.44	1975-76	18.17	10	76.92

S. No.	Year	Average Discharge (cumec)	Year	Average Discharge (cumec)	Rank	% Time
11	1979-80	55.46	1976-77	16.42	11	84.62
12	1980-81	24.70	1972-73	14.51	12	92.31

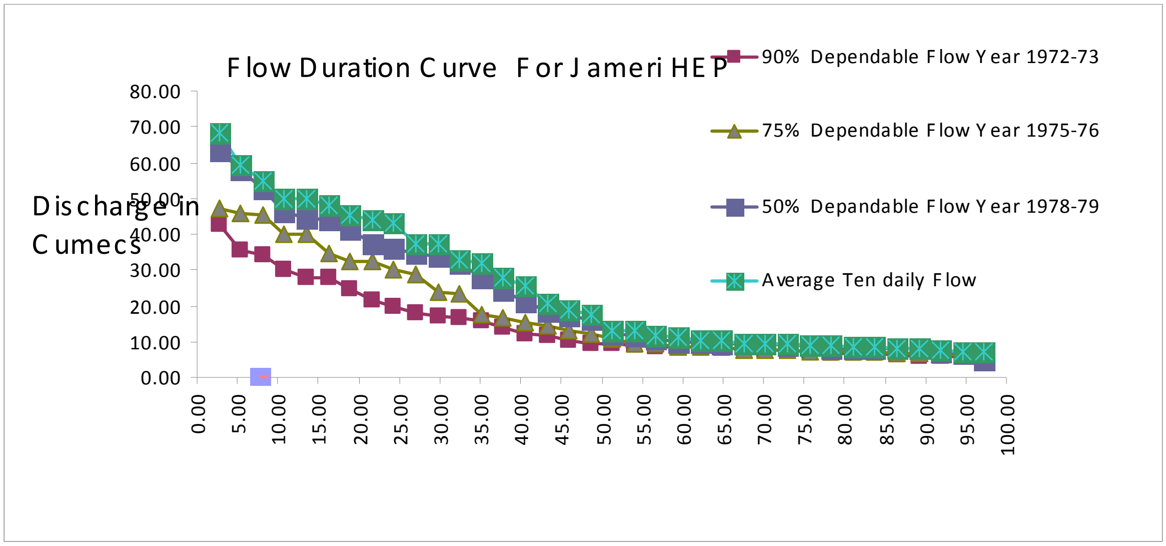


Figure-4.5 : Flow Duration Curve of Jameri HEP

4.6 DEPENDABILITY ANALYSIS

For further dependability analysis at different sites, the next analysis were done :

- 90% dependability year among corresponding years.
- 90% dependable flow from 90% dependable year.
- Flow duration curve within various flows and dependable years (Ten-Daily average basis) for each proposed site.

The summary of dependable flows at various project sites is given in Tables 4.5 to 4.14.

TABLE-4.5

Summary of different Dependable flow at Dibbin HEP (cumec)

Dibbin HEP	Q_{90}	Q_{75}	Q_{50}
Dependable Flow of 90% Dependable year 1983-84	10.20	11.90	20.80
Dependable Flow of 75% Dependable year 1978-79	6.80	8.70	16.10
Dependable Flow of 50% Dependable year 1988-89	9.23	10.24	22.15
Average Ten Daily flow	9.42	11.25	22.74

TABLE-4.6
Summary of different Dependable flow at Utung HEP (cumec)

Utung HEP	Q_{90}	Q_{75}	Q_{50}
Dependable Flow of 90% Dependable year 1983-84	5.04	5.88	10.27
Dependable Flow of 75% Dependable year 1978-79	3.36	4.28	7.95
Dependable Flow of 50% Dependable year 1988-89	4.56	5.06	10.94
Average Ten Daily flow	4.65	5.56	11.23

TABLE-4.7
Summary of different Dependable flow at Nazong HEP (cumec)

Nazong HEP	Q_{90}	Q_{75}	Q_{50}
Dependable Flow of 90% Dependable year 1983-84	6.33	7.39	12.92
Dependable Flow of 75% Dependable year 1978-79	4.22	5.40	10.00
Dependable Flow of 50% Dependable year 1988-89	5.73	6.36	13.76
Average Ten Daily flow	5.85	6.97	14.12

TABLE-4.8
Summary of different Dependable flow at Dikhri HEP (cumec)

Dikhri HEP	Q_{90}	Q_{75}	Q_{50}
Dependable Flow of 90% Dependable year 1983-84	3.08	3.59	6.28
Dependable Flow of 75% Dependable year 1978-79	2.05	2.63	4.86
Dependable Flow of 50% Dependable year 1988-89	2.79	3.09	6.69
Average Ten Daily flow	2.84	3.40	6.87

TABLE-4.9
Summary of different Dependable flow at Dimjin HEP (cumec)

Dimijin HEP	Q_{90}	Q_{75}	Q_{50}
Dependable Flow of 90% Dependable year 1983-84	11.19	13.05	22.82
Dependable Flow of 75% Dependable year 1978-79	7.46	9.54	17.66
Dependable Flow of 50% Dependable year 1988-89	10.12	11.23	24.30
Average Ten Daily flow	10.33	12.34	24.95

TABLE-4.10
Summary of different Dependable flow at Nafra HEP (cumec)

Nafra HEP	Q_{90}	Q_{75}	Q_{50}
Dependable Flow of 90% Dependable year 1983-84	12.57	14.66	25.63
Dependable Flow of 75% Dependable year 1978-79	8.38	10.72	19.83
Dependable Flow of 50% Dependable year 1988-89	11.37	12.62	27.29
Average Ten Daily flow	11.61	13.86	28.02

TABLE-4.11
Summary of different Dependable flow at Dinan HEP (cumec)

Dinan HEP	Q_{90}	Q_{75}	Q_{50}
Dependable Flow of 90% Dependable year 1983-84	2.27	2.65	4.64
Dependable Flow of 75% Dependable year 1978-79	1.52	1.94	3.59
Dependable Flow of 50% Dependable year 1988-89	2.06	2.28	4.94
Average Ten Daily flow	2.10	2.51	5.07

TABLE-4.12

Summary of different Dependable flow at Gongri HEP (cumec)

Gongri HEP	Q_{90}	Q_{75}	Q_{50}
Dependable Flow of 90% Dependable year 1978-79	13.49	17.35	32.04
Dependable Flow of 75% Dependable year 1979-80	14.80	18.85	29.52
Dependable Flow of 50% Dependable year 1969-70	21.98	23.73	34.48
Average Ten Daily flow	19.23	22.63	38.03

TABLE-4.13
Summary of different Dependable flow at Dinchang HEP (cumec)

Dinchang HEP	Q_{90}	Q_{75}	Q_{50}
Dependable Flow of 90% Dependable year 1978-79	17.56	22.59	41.72
Dependable Flow of 75% Dependable year 1979-80	19.27	24.54	38.43
Dependable Flow of 50% Dependable year 1969-70	28.62	30.90	44.89
Average Ten Daily flow	25.04	29.46	49.51

TABLE-4.14

Summary of different Dependable flow at Jameri HEP (cumec)

Jameri HEP	Q_{90}	Q_{75}	Q_{50}
Dependable Flow of 90% Dependable year 1972-73	6.00	7.07	9.28
Dependable Flow of 75% Dependable year 1975-76	6.47	7.22	10.57
Dependable Flow of 50% Dependable year 1978-79	7.00	8.79	12.20
Average Ten Daily flow	7.42	9.14	12.91

The summary of Hydrological statistical data is given in Table-4.15.

TABLE-4.15

Summary of Hydrological statistical data

Project	CA (km^2)	AAF (cumec)	Annual Yield (MCM)	Max. discharge (cumec)	Min. discharge (cumec)	Std. Dev. (cumec)
Utung HEP	311	23.96	755.73	156.5	2.62	92.48
Nazong HEP	391	30.12	950	196.73	3.29	116.25
Dikhri HEP	190	14.65	462	95.67	1.6	56.53
Dibbin HEP	630	48.51	1529.82	316.8	5.3	187.2
Dimijin HEP	691	53.21	1678.21	347.53	5.81	205.36
Nafra HEP	776	59.76	1884.74	390.3	6.53	230.63
Dinan HEP	140	10.82	341.15	70.65	1.18	41.75
Gongri HEP	1039	61.25	1932.72	221.74	13.73	163.3
Dinchang HEP	1352	79.75	2516.4	288.7	17.88	212.62
Jameri HEP	938	24.63	777.32	191.9	5.11	135.9

4.7 SUMMARY OF ANALYSIS

From hydropower development point of view, the availability of water for a given percentage of time is important. Generally, 90 % dependable flow of 90% dependable year is considered for reliable power production. The analysis has been carried out to estimate the 90 %, 75 %, and 50 % dependable years, and the corresponding 90 %, 75 %, and 5-0 dependable flows. For estimating the dependable flows at Utung, Nazong, Dikhri, Dibbin, Dimijin, Nafra and Dinan, the flow series at Dibbin is considered. From the flow series of Dibbin, the flows at other sites are estimated using area-proportion as these falls in same similar catchments. Since the flows are estimated in area-proportion, the dependable years remain same. However, the flows changes. For other sites like Dinchang and Gongri, the flow of Ongri/Digo is taken as base. Since the monthly flows are available, the ratio of ten daily to monthly flows of Dibbin are taken as base and the monthly flows of Ongri/Digo are converted in to ten-daily flows. Thereafter, the flow series at Dinchang is derived using area-proportion method. Using Ten-Daily flow series derived for Gongri HEP the 90% dependable flow corresponds to 1978-79 and these include Gongri and Dinchang. Further, availability of flow is analysed for Jameri site, and the dependable years and the dependable flows are estimated. The 90 % dependable year at Jameri site corresponds to the year 1972-73.

CHAPTER-5

WATER QUALITY

5.1 INTRODUCTION

As per the Terms of Reference, approved for the basin study, water quality monitoring is to be conducted at various locations in the study area. The frequency of monitoring shall be per month for six (6) consecutive months. The months in which monitoring was conducted are given as below:

- April 2009
- May 2009
- June 2009
- July 2009
- August 2009
- September 2009

5.2 SAMPLING SITES

As mentioned earlier, ten hydroelectric projects are proposed to be commissioned in the study area. Two sampling sites were monitored for each project. Thus, a total of twenty (20) sampling locations were covered as a part of the study. The sampling locations covered as a part of the study are listed as below:

- Dam site
- 3000 m downstream of dam site

The sampling locations covered as a part of the study are given in Figure-5.1. The drinking water quality standards are given in Annexure-V.

5.3 FINDINGS OF THE WATER QUALITY SURVEY

5.3.1 Utung Hydroelectric project

As a part of the study, water quality was monitored at the following locations:

- Dam site (W1)
- 3000 m downstream of dam site (W2)

The results of water quality survey conducted for six months for Utung hydroelectric project are given in Tables-5.1 to 5.6.

TABLE-5.1

Results of water quality monitoring for Utung hydroelectric project : April 2009

Parameter	W1	W2
pH	7.2	7.2
Electrical Conductivity, micromhos/cm	91	98
Total Dissolved Solids, mg/l	64	71
Hardness, mg/l	54	54
Chlorides, mg/l	16	18
Sulphates, mg/l	<1.0	<1.0
Phosphates, mg/l	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01
Sodium, mg/l	5.2	5.7
Potassium, mg/l	1.0	1.2
Calcium, mg/l	15.6	16.1
Magnesium, mg/l	3.5	3.3
Iron, mg/l	<0.1	<0.1
Alkalinity, mg/l	66	65
Copper, mg/l	<0.1	<0.1
Lead, mg/l	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01
BOD, mg/l	1.8	1.8
COD, mg/l	3.4	3.4
DO, mg/l	9.5	9.4
Phenolic compounds, mg/l	BDL	BDL
Oil & Grease, mg/l	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil

TABLE-5.2

Results of water quality monitoring for Utung hydroelectric project : May 2009

Parameter	W1	W2
pH	7.2	7.2
Electrical Conductivity, micromhos/cm	92	96
Total Dissolved Solids, mg/l	65	70
Hardness, mg/l	52	54
Chlorides, mg/l	16	18
Sulphates, mg/l	<1.0	<1.0
Phosphates, mg/l	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01
Sodium, mg/l	5.1	5.2
Potassium, mg/l	0.9	1.0
Calcium, mg/l	15.2	16.0
Magnesium, mg/l	3.3	3.2
Iron, mg/l	<0.1	<0.1

Parameter	W1	W2
Alkalinity, mg/l	63	66
Copper, mg/l	<0.1	<0.1
Lead, mg/l	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01
BOD, mg/l	1.8	1.8
COD, mg/l	3.4	3.4
DO, mg/l	9.5	9.5
Phenolic compounds, mg/l	BDL	BDL
Oil & Grease, mg/l	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil

TABLE-5.3

Results of water quality monitoring for Utung hydroelectric project : June 2009

Parameter	W1	W2
pH	7.1	7.1
Electrical Conductivity, micromhos/cm	88	86
Total Dissolved Solids, mg/l	64	63
Hardness, mg/l	48	49
Chlorides, mg/l	14	15
Sulphates, mg/l	<1.0	<1.0
Phosphates, mg/l	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01
Sodium, mg/l	4.5	4.5
Potassium, mg/l	0.8	0.8
Calcium, mg/l	14.1	14.3
Magnesium, mg/l	3.0	3.0
Iron, mg/l	<0.1	<0.1
Alkalinity, mg/l	59	61
Copper, mg/l	<0.1	<0.1
Lead, mg/l	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01
BOD, mg/l	1.7	1.7
COD, mg/l	3.1	3.2
DO, mg/l	9.5	9.5
Phenolic compounds, mg/l	BDL	BDL
Oil & Grease, mg/l	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil

TABLE-5.4

Results of water quality monitoring for Utung hydroelectric project : July 2009

Parameter	W1	W2
pH	7.1	7.1
Electrical Conductivity, micromhos/cm	86	85
Total Dissolved Solids, mg/l	63	65
Hardness, mg/l	47	48
Chlorides, mg/l	14	14
Sulphates, mg/l	<1.0	<1.0
Phosphates, mg/l	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01
Sodium, mg/l	4.2	4.4
Potassium, mg/l	0.7	0.8
Calcium, mg/l	14.0	14.0
Magnesium, mg/l	2.9	3.0
Iron, mg/l	<0.1	<0.1
Alkalinity, mg/l	57	59
Copper, mg/l	<0.1	<0.1
Lead, mg/l	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01
BOD, mg/l	1.6	1.5
COD, mg/l	3.0	3.0
DO, mg/l	9.5	9.5
Phenolic compounds, mg/l	BDL	BDL
Oil & Grease, mg/l	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil

TABLE-5.5

Results of water quality monitoring for Utung hydroelectric project : August 2009

Parameter	W1	W2
pH	7.1	7.1
Electrical Conductivity, micromhos/cm	86	86
Total Dissolved Solids, mg/l	63	64
Hardness, mg/l	48	48
Chlorides, mg/l	14	14
Sulphates, mg/l	<1.0	<1.0
Phosphates, mg/l	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01
Sodium, mg/l	4.1	4.4
Potassium, mg/l	0.7	0.8
Calcium, mg/l	14.1	14.1
Magnesium, mg/l	3.0	3.0
Iron, mg/l	<0.1	<0.1
Alkalinity, mg/l	59	60

Parameter	W1	W2
Copper, mg/l	<0.1	<0.1
Lead, mg/l	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01
BOD, mg/l	1.5	1.5
COD, mg/l	3.0	3.0
DO, mg/l	9.5	9.5
Phenolic compounds, mg/l	BDL	BDL
Oil & Grease, mg/l	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil

TABLE-5.6

Results of water quality monitoring for Utung hydroelectric project : September 2009

Parameter	W1	W2
pH	7.1	7.0
Electrical Conductivity, micromhos/cm	88	88
Total Dissolved Solids, mg/l	66	66
Hardness, mg/l	49	48
Chlorides, mg/l	15	14
Sulphates, mg/l	<1.0	<1.0
Phosphates, mg/l	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01
Sodium, mg/l	4.3	4.5
Potassium, mg/l	0.9	0.9
Calcium, mg/l	14.4	14.3
Magnesium, mg/l	3.1	3.1
Iron, mg/l	<0.1	<0.1
Alkalinity, mg/l	61	60
Copper, mg/l	<0.1	<0.1
Lead, mg/l	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01
BOD, mg/l	1.6	1.5
COD, mg/l	3.1	3.0
DO, mg/l	9.4	9.4
Phenolic compounds, mg/l	BDL	BDL
Oil & Grease, mg/l	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil

The pH level in the project area of Utung hydroelectric project ranged from 7.0 to 7.2 at various samples sites covered as a part of the study. The pH level indicate neutral nature of the water, and are within the permissible limit specified for meeting drinking water requirements (Refer Annexure-V).

The TDS level ranged from 63 to 71 mg/l which is well below the permissible limit of 500 mg/l specified for drinking water. The TDS level was found to be lower in monsoon season as compared to summer season. This trend was observed for various cations and anions monitored as a part of the study. This could be attributed to higher discharges in monsoon months.

The hardness level ranged from 47 to 54 mg/l indicating soft nature. The hardness level was well below the permissible limit of 200 mg/l specified for drinking water. Hardness is caused by divalent metallic cations. The principal hardness causing cations are calcium, magnesium, strontium and iron. The low levels of calcium and magnesium are mainly responsible for the soft nature of water.

Alkalinity of a water is a measure of its capacity to neutralize acids. The alkalinity of natural water is due primarily because of the salts of weak acids. The alkalinity was found to be higher than the total hardness in all the water sampling stations monitored as a part of the study, which indicates that entire hardness in the water is on account of carbonate hardness and there is no bicarbonate hardness in the water.

The chlorides level ranged from 14 to 18 mg/l, which are well below the permissible limit of 200 mg/l, specified for meeting drinking water requirements. The sulphates level at various sampling stations was less than <1.0 mg/l in various samples monitored for a period of six months as a part of the study. The sulphates was found to be well below the permissible limit of 200 mg/l specified for drinking water purposes. The concentration of nitrates and phosphates at various sampling locations was observed to below detectable limit of 0.01 mg/l.

The concentration of various cations, e.g. sodium, potassium, calcium and magnesium was observed to be quite low which is also reflected by the low TDS level. Iron was found to be well below the permissible limit of 1 mg/l specified for drinking water purposes.

The concentration of various heavy metals was found to be well below the permissible limits. The concentration of phenolic compounds and oil & grease as expected in a region with no major sources of water pollution from domestic or industrial sources was observed to be quite low.

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

The DO level ranged from 9.4 to 9.5 mg/l at various sampling locations monitored on a monthly basis for six months as a part of the study.

The Total Coliform level was nil at all the sampling sites. The DO, BOD and Total Coliform level indicate that pollution loading is well within the carrying capacity of river Bichom in the study area.

5.3.2 Nazong Hydroelectric project

As a part of the study, water quality was monitored at the following locations:

- Dam site (W3)
- 3000 m downstream of dam site (W4)

The results of water quality survey conducted for six months for Nazong hydroelectric project, are given in Tables-5.7 to 5.12.

TABLE-5.7

Results of water quality monitoring for Nazong hydroelectric project : April 2009

Parameter	W3	W4
pH	7.2	7.1
Electrical Conductivity, micromhos/cm	96	95
Total Dissolved Solids, mg/l	71	71
Hardness, mg/l	52	54
Chlorides, mg/l	17	18
Sulphates, mg/l	<1.0	<1.0
Phosphates, mg/l	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01
Sodium, mg/l	5.4	5.3
Potassium, mg/l	1.0	1.0
Calcium, mg/l	15.1	14.9
Magnesium, mg/l	3.3	3.3
Iron, mg/l	<0.1	<0.1
Alkalinity, mg/l	64	62
Copper, mg/l	<0.1	<0.1
Lead, mg/l	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01
BOD, mg/l	1.8	1.8
COD, mg/l	3.5	3.4
DO, mg/l	9.3	9.4
Phenolic compounds, mg/l	BDL	BDL
Oil & Grease, mg/l	BDL	BDL

Parameter	W3	W4
Total Coliform MPN/100 ml	Nil	Nil

TABLE-5.8

Results of water quality monitoring for Nazong hydroelectric project : May 2009

Parameter	W3	W4
pH	7.2	7.1
Electrical Conductivity, micromhos/cm	96	95
Total Dissolved Solids, mg/l	71	71
Hardness, mg/l	52	54
Chlorides, mg/l	17	18
Sulphates, mg/l	<1.0	<1.0
Phosphates, mg/l	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01
Sodium, mg/l	5.4	5.3
Potassium, mg/l	1.0	1.0
Calcium, mg/l	15.1	14.9
Magnesium, mg/l	3.3	3.3
Iron, mg/l	<0.1	<0.1
Alkalinity, mg/l	64	62
Copper, mg/l	<0.1	<0.1
Lead, mg/l	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01
BOD, mg/l	1.8	1.8
COD, mg/l	3.5	3.4
DO, mg/l	9.3	9.4
Phenolic compounds, mg/l	BDL	BDL
Oil & Grease, mg/l	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil

TABLE-5.9

Results of water quality monitoring for Nazong hydroelectric project : June 2009

Parameter	W3	W4
pH	7.1	7.1
Electrical Conductivity, micromhos/cm	88	86
Total Dissolved Solids, mg/l	64	63
Hardness, mg/l	48	49
Chlorides, mg/l	14	15
Sulphates, mg/l	<1.0	<1.0
Phosphates, mg/l	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01
Sodium, mg/l	4.5	4.5
Potassium, mg/l	0.8	0.8

Parameter	W3	W4
Calcium, mg/l	14.1	14.3
Magnesium, mg/l	3.0	3.0
Iron, mg/l	<0.1	<0.1
Alkalinity, mg/l	59	61
Copper, mg/l	<0.1	<0.1
Lead, mg/l	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01
BOD, mg/l	1.7	1.7
COD, mg/l	3.1	3.2
DO, mg/l	9.5	9.5
Phenolic compounds, mg/l	BDL	BDL
Oil & Grease, mg/l	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil

TABLE-5.10

Results of water quality monitoring for Nazong hydroelectric project : July 2009

Parameter	W3	W4
pH	7.1	7.1
Electrical Conductivity, micromhos/cm	86	85
Total Dissolved Solids, mg/l	63	65
Hardness, mg/l	47	48
Chlorides, mg/l	14	14
Sulphates, mg/l	<1.0	<1.0
Phosphates, mg/l	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01
Sodium, mg/l	4.2	4.4
Potassium, mg/l	0.7	0.8
Calcium, mg/l	14.0	14.0
Magnesium, mg/l	2.9	3.0
Iron, mg/l	<0.1	<0.1
Alkalinity, mg/l	57	59
Copper, mg/l	<0.1	<0.1
Lead, mg/l	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01
BOD, mg/l	1.6	1.5
COD, mg/l	3.0	3.0
DO, mg/l	9.5	9.5
Phenolic compounds, mg/l	BDL	BDL
Oil & Grease, mg/l	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil

TABLE-5.11

Results of water quality monitoring for Nazong hydroelectric project : August 2009

Parameter	W3	W4
pH	7.1	7.1
Electrical Conductivity, micromhos/cm	86	86
Total Dissolved Solids, mg/l	63	64
Hardness, mg/l	48	48
Chlorides, mg/l	14	14
Sulphates, mg/l	<1.0	<1.0
Phosphates, mg/l	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01
Sodium, mg/l	4.1	4.4
Potassium, mg/l	0.7	0.8
Calcium, mg/l	14.1	14.1
Magnesium, mg/l	3.0	3.0
Iron, mg/l	<0.1	<0.1
Alkalinity, mg/l	59	60
Copper, mg/l	<0.1	<0.1
Lead, mg/l	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01
BOD, mg/l	1.5	1.5
COD, mg/l	3.0	3.0
DO, mg/l	9.5	9.5
Phenolic compounds, mg/l	BDL	BDL
Oil & Grease, mg/l	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil

TABLE-5.12

Results of water quality monitoring for Nazong hydroelectric project : September 2009

Parameter	W3	W4
pH	7.1	7.1
Electrical Conductivity, micromhos/cm	88	88
Total Dissolved Solids, mg/l	66	66
Hardness, mg/l	49	48
Chlorides, mg/l	15	14
Sulphates, mg/l	<1.0	<1.0
Phosphates, mg/l	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01
Sodium, mg/l	4.3	4.5
Potassium, mg/l	0.9	0.9
Calcium, mg/l	14.4	14.3
Magnesium, mg/l	3.1	3.1

Parameter	W3	W4
Iron, mg/l	<0.1	<0.1
Alkalinity, mg/l	61	60
Copper, mg/l	<0.1	<0.1
Lead, mg/l	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01
BOD, mg/l	1.6	1.5
COD, mg/l	3.1	3.0
DO, mg/l	9.4	9.4
Phenolic compounds, mg/l	BDL	BDL
Oil & Grease, mg/l	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil

The pH level in various water samples monitored in the project area of Nazong hydroelectric project ranged from 7.1 to 7.2. The pH level indicate neutral nature of the water. The pH level in water samples was observed to be well within the permissible limit specified for meeting drinking water requirements.

The TDS level ranged from 63 to 71 mg/l which is well below the permissible limit of 500 mg/l specified for drinking water. The TDS level was found to be lower in monsoon months as compared to summer months. This trend was observed for various cations and anions monitored as a part of the study.

The hardness level ranged from 47 to 54 mg/l indicating soft nature of water. The hardness level was well below the permissible limit of 200 mg/l specified for drinking water. Hardness is caused by divalent metallic cations. The low levels of calcium and magnesium are mainly responsible for the soft nature of water. The alkalinity was found to be higher than the total hardness in all the water sampling stations monitored as a part of the study, which indicates that entire hardness in the water is on account of carbonate hardness and there is no bicarbonate hardness in the water.

The chlorides level ranged from 14 to 18 mg/l, which is well below the permissible limit specified for drinking water (200 mg/l). The sulphates level at various sampling stations was <1.0 mg/l in various samples during the monitoring period covered as a part of the study. The concentration of nitrates and phosphates at various sampling locations was observed to below detectable limit of 0.01 mg/l.

The concentration of various cations, e.g. sodium, potassium, calcium and magnesium was observed to be quite low which is also reflected by the low TDS level. Iron was found to be well below the permissible limit of 1 mg/l specified for drinking water purposes.

The concentration of various heavy metals was found to be well below the permissible limits. Concentration of phenolic compounds and oil & grease as expected in a hilly terrain with no major sources of water pollution from domestic or industrial sources was observed to be quite low.

The BOD and total coliform values are well within the permissible limits, which indicates the absence of organic pollution loading. This is mainly due to the low population density and absence of industries in the area. The low COD values also indicate the absence of chemical pollution loading in the area. The marginal quantity of pollution load which enters river Bichom, gets diluted.

The DO level ranged from 9.3 to 9.5 mg/l at various sampling locations monitored on a monthly basis for six months as a part of the study. The DO levels were close to saturation limits in water, indicating the excellent quality of water in the study area.

5.3.3 Dibbin Hydroelectric project

As a part of the study, water quality was monitored at the following locations:

- Dam site (W5)
- 3000 m downstream of dam site (W6)

The results of water quality survey conducted for six months for Dibbin hydroelectric project are given in Tables-5.13 to 5.18.

TABLE-5.13

Results of water quality monitoring for Dibbin hydroelectric project: April 2009

Parameter	W5	W6
pH	7.1	7.1
Electrical Conductivity, micromhos/cm	90	90
Total Dissolved Solids, mg/l	67	66
Hardness, mg/l	43	44
Chlorides, mg/l	14	12
Sulphates, mg/l	<1.0	<1.0
Phosphates, mg/l	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01
Sodium, mg/l	4.1	4.2
Potassium, mg/l	1.0	1.0
Calcium, mg/l	12.1	12.7
Magnesium, mg/l	3.1	3.0
Iron, mg/l	<0.1	<0.1
Alkalinity, mg/l	51	49

Parameter	W5	W6
Copper, mg/l	<0.1	<0.1
Lead, mg/l	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01
BOD, mg/l	1.8	1.9
COD, mg/l	3.5	3.7
DO, mg/l	9.3	9.2
Phenolic compounds, mg/l	BDL	BDL
Oil & Grease, mg/l	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil

TABLE-5.14

Results of water quality monitoring for Dibbin hydroelectric project: May 2009

Parameter	W5	W6
pH	7.0	7.1
Electrical Conductivity, micromhos/cm	87	88
Total Dissolved Solids, mg/l	64	65
Hardness, mg/l	42	43
Chlorides, mg/l	12	11
Sulphates, mg/l	<1.0	<1.0
Phosphates, mg/l	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01
Sodium, mg/l	4.1	4.1
Potassium, mg/l	1.0	1.0
Calcium, mg/l	11.9	12.1
Magnesium, mg/l	3.0	3.0
Iron, mg/l	<0.1	<0.1
Alkalinity, mg/l	50	50
Copper, mg/l	<0.1	<0.1
Lead, mg/l	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01
BOD, mg/l	1.8	1.8
COD, mg/l	3.5	3.6
DO, mg/l	9.1	9.1
Phenolic compounds, mg/l	BDL	BDL
Oil & Grease, mg/l	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil

TABLE-5.15

Results of water quality monitoring for Dibbin hydroelectric project: June 2009

Parameter	W5	W6
pH	7.1	7.1
Electrical Conductivity, micromhos/cm	86	86
Total Dissolved Solids, mg/l	63	63
Hardness, mg/l	41	42
Chlorides, mg/l	11	11
Sulphates, mg/l	<1.0	<1.0
Phosphates, mg/l	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01
Sodium, mg/l	4.0	4.1
Potassium, mg/l	1.0	1.0
Calcium, mg/l	11.4	12.0
Magnesium, mg/l	3.0	2.8
Iron, mg/l	<0.1	<0.1
Alkalinity, mg/l	48	50
Copper, mg/l	<0.1	<0.1
Lead, mg/l	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01
BOD, mg/l	1.8	1.7
COD, mg/l	3.5	3.5
DO, mg/l	9.0	9.0
Phenolic compounds, mg/l	BDL	BDL
Oil & Grease, mg/l	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil

TABLE-5.16

Results of water quality monitoring for Dibbin hydroelectric project: July 2009

Parameter	W5	W6
pH	7.0	7.0
Electrical Conductivity, micromhos/cm	82	82
Total Dissolved Solids, mg/l	60	61
Hardness, mg/l	39	40
Chlorides, mg/l	9	9
Sulphates, mg/l	<1.0	<1.0
Phosphates, mg/l	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01
Sodium, mg/l	2.9	2.8
Potassium, mg/l	1.0	1.0
Calcium, mg/l	11.0	11.5
Magnesium, mg/l	2.8	2.7
Iron, mg/l	<0.1	<0.1
Alkalinity, mg/l	48	48

Parameter	W5	W6
Copper, mg/l	<0.1	<0.1
Lead, mg/l	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01
BOD, mg/l	1.5	1.6
COD, mg/l	3.1	3.2
DO, mg/l	9.1	9.1
Phenolic compounds, mg/l	BDL	BDL
Oil & Grease, mg/l	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil

TABLE-5.17

Results of water quality monitoring for Dibbin hydroelectric project: August 2009

Parameter	W5	W6
pH	7.0	7.0
Electrical Conductivity, micromhos/cm	80	82
Total Dissolved Solids, mg/l	58	60
Hardness, mg/l	38	39
Chlorides, mg/l	9	9
Sulphates, mg/l	<1.0	<1.0
Phosphates, mg/l	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01
Sodium, mg/l	2.9	2.8
Potassium, mg/l	1.0	1.0
Calcium, mg/l	11.0	11.2
Magnesium, mg/l	2.6	2.7
Iron, mg/l	<0.1	<0.1
Alkalinity, mg/l	48	48
Copper, mg/l	<0.1	<0.1
Lead, mg/l	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01
BOD, mg/l	1.5	1.6
COD, mg/l	3.1	3.1
DO, mg/l	9.1	9.1
Phenolic compounds, mg/l	BDL	BDL
Oil & Grease, mg/l	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil

TABLE-5.18

Results of water quality monitoring for Dibbin hydroelectric project: September 2009

Parameter	**W5**	**W6**
pH	7.0	7.0
Electrical Conductivity, micromhos/cm	80	80
Total Dissolved Solids, mg/l	58	58
Hardness, mg/l	37	39
Chlorides, mg/l	9	9
Sulphates, mg/l	<1.0	<1.0
Phosphates, mg/l	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01
Sodium, mg/l	2.8	2.8
Potassium, mg/l	1.0	1.0
Calcium, mg/l	10.8	11.0
Magnesium, mg/l	2.5	2.6
Iron, mg/l	<0.1	<0.1
Alkalinity, mg/l	46	48
Copper, mg/l	<0.1	<0.1
Lead, mg/l	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01
BOD, mg/l	1.5	1.5
COD, mg/l	3.0	3.0
DO, mg/l	9.2	9.1
Phenolic compounds, mg/l	BDL	BDL
Oil & Grease, mg/l	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil

The pH level in the project area of Dibbin hydroelectric project was observed to be in neutral range (7.0 to 7.1) at various sampling sites covered as a part of the study. The TDS level ranged from 58 to 67 mg/l which is well below the permissible limit of 500 mg/l specified for drinking water. The TDS level was found to be lower in monsoon months as compared to summer months. This trend was observed for various cations and anions monitored as a part of the study.

The hardness level ranged from 37 to 44 mg/l indicating soft nature. The hardness level was well below the permissible limit of 200 mg/l specified for drinking water. Hardness is caused by divalent metallic cations. The low levels of calcium and magnesium are mainly responsible for the soft nature of water. The alkalinity was found to be higher than the total hardness in all the water sampling stations monitored as a part of the study, which indicates that entire hardness in the water is on account of carbonate hardness and there is no bicarbonate hardness in the water.

The chlorides level ranged from 9 to 14 mg/l, which is well below the permissible limit specified for drinking water (200 mg/l). The sulphates level at various sampling stations was <1.0 mg/l in various samples monitored for a period of six months as a part of the study. The concentration of nitrates and phosphates at various sampling locations was observed to below detectable limit of 0.01 mg/l.

The concentration of various cations, e.g. sodium, potassium, calcium and magnesium was observed to be quite low which is also reflected by the low TDS level. Iron was found to be well below the permissible limit of 1 mg/l specified for drinking water purposes.

The concentration of various heavy metals was found to be well below the permissible limits. Concentration of phenolic compounds and oil & grease as expected in a hilly terrain with no major sources of water pollution from domestic or industrial sources was observed to be quite low.

The BOD and Total coliform values are well within the permissible limits, which indicates the absence of organic pollution loading. This is mainly due to the low population density and absence of industries in the area. The low COD values also indicate the absence of chemical pollution loading in the area. The marginal quantity of pollution load which enters river Bichom, gets diluted.

The DO level ranged from 9.0 to 9.3 mg/l at various sampling locations monitored on a monthly basis for six months as a part of the study. The DO levels were close to saturation limits in water, indicating the excellent quality of water in the study area.

5.3.4 Dimijin Hydroelectric project

As a part of the study, water quality was monitored at the following locations:

- Dam site (W7)
- 3000 m downstream of dam site (W8)

The results of water quality survey conducted for six months for Dimijin hydroelectric project are given in Tables-5.19 to 5.24.

TABLE-5.19

Results of water quality monitoring for Dimijin hydroelectric project : April 2009

Parameter	W7	W8
pH	7.0	7.1
Electrical Conductivity, micromhos/cm	94	92
Total Dissolved Solids, mg/l	69	67
Hardness, mg/l	49	48

Parameter	W7	W8
Chlorides, mg/l	15	15
Sulphates, mg/l	<1.0	<1.0
Phosphates, mg/l	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01
Sodium, mg/l	5.0	5.1
Potassium, mg/l	1.1	1.0
Calcium, mg/l	13.9	13.7
Magnesium, mg/l	3.3	3.3
Iron, mg/l	<0.1	<0.1
Alkalinity, mg/l	62	61
Copper, mg/l	<0.1	<0.1
Lead, mg/l	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01
BOD, mg/l	1.8	1.8
COD, mg/l	3.5	3.5
DO, mg/l	9.2	9.2
Phenolic compounds, mg/l	BDL	BDL
Oil & Grease, mg/l	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil

TABLE-5.20

Results of water quality monitoring for Dimijin hydroelectric project : May 2009

Parameter	W7	W8
pH	7.0	7.0
Electrical Conductivity, micromhos/cm	92	91
Total Dissolved Solids, mg/l	67	67
Hardness, mg/l	47	47
Chlorides, mg/l	15	15
Sulphates, mg/l	<1.0	<1.0
Phosphates, mg/l	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01
Sodium, mg/l	5.0	5.0
Potassium, mg/l	1.1	1.1
Calcium, mg/l	13.5	13.5
Magnesium, mg/l	3.1	3.2
Iron, mg/l	<0.1	<0.1
Alkalinity, mg/l	59	60
Copper, mg/l	<0.1	<0.1
Lead, mg/l	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01

Parameter	W7	W8
BOD, mg/l	1.7	1.8
COD, mg/l	3.3	3.5
DO, mg/l	9.1	9.2
Phenolic compounds, mg/l	BDL	BDL
Oil & Grease, mg/l	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil

TABLE-5.21

Results of water quality monitoring for Dimijin hydroelectric project : June 2009

Parameter	W7	W8
pH	7.0	7.0
Electrical Conductivity, micromhos/cm	92	92
Total Dissolved Solids, mg/l	67	68
Hardness, mg/l	47	46
Chlorides, mg/l	15	15
Sulphates, mg/l	<1.0	<1.0
Phosphates, mg/l	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01
Sodium, mg/l	5.0	5.0
Potassium, mg/l	1.1	1.2
Calcium, mg/l	13.5	13.2
Magnesium, mg/l	3.1	3.1
Iron, mg/l	<0.1	<0.1
Alkalinity, mg/l	59	58
Copper, mg/l	<0.1	<0.1
Lead, mg/l	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01
BOD, mg/l	1.7	1.8
COD, mg/l	3.3	3.5
DO, mg/l	9.1	9.2
Phenolic compounds, mg/l	BDL	BDL
Oil & Grease, mg/l	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil

TABLE-5.22

Results of water quality monitoring for Dimijin hydroelectric project : July 2009

Parameter	W7	W8
pH	7.0	7.0
Electrical Conductivity, micromhos/cm	86	88
Total Dissolved Solids, mg/l	63	64
Hardness, mg/l	45	45
Chlorides, mg/l	15	14

Parameter	W7	W8
Sulphates, mg/l	<1.0	<1.0
Phosphates, mg/l	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01
Sodium, mg/l	5.0	4.9
Potassium, mg/l	1.1	1.1
Calcium, mg/l	13.1	12.9
Magnesium, mg/l	3.1	3.0
Iron, mg/l	<0.1	<0.1
Alkalinity, mg/l	57	57
Copper, mg/l	<0.1	<0.1
Lead, mg/l	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01
BOD, mg/l	1.6	1.6
COD, mg/l	3.1	3.1
DO, mg/l	9.2	9.2
Phenolic compounds, mg/l	BDL	BDL
Oil & Grease, mg/l	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil

TABLE-5.23

Results of water quality monitoring for Dimijin hydroelectric project : August 2009

Parameter	W7	W8
pH	7.0	7.0
Electrical Conductivity, micromhos/cm	85	85
Total Dissolved Solids, mg/l	62	62
Hardness, mg/l	45	45
Chlorides, mg/l	14	14
Sulphates, mg/l	<1.0	<1.0
Phosphates, mg/l	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01
Sodium, mg/l	4.9	4.9
Potassium, mg/l	1.0	1.1
Calcium, mg/l	12.9	13.0
Magnesium, mg/l	3.0	3.1
Iron, mg/l	<0.1	<0.1
Alkalinity, mg/l	57	58
Copper, mg/l	<0.1	<0.1
Lead, mg/l	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01
BOD, mg/l	1.6	1.6

Parameter	W7	W8
COD, mg/l	3.1	3.1
DO, mg/l	9.2	9.2
Phenolic compounds, mg/l	BDL	BDL
Oil & Grease, mg/l	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil

TABLE-5.24

Results of water quality monitoring for Dimijin hydroelectric project : September 2009

Parameter	W7	W8
pH	7.0	7.0
Electrical Conductivity, micromhos/cm	82	84
Total Dissolved Solids, mg/l	60	61
Hardness, mg/l	44	45
Chlorides, mg/l	12	11
Sulphates, mg/l	<1.0	<1.0
Phosphates, mg/l	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01
Sodium, mg/l	4.9	5.1
Potassium, mg/l	1.0	1.0
Calcium, mg/l	12.5	12.9
Magnesium, mg/l	3.1	3.1
Iron, mg/l	<0.1	<0.1
Alkalinity, mg/l	56	57
Copper, mg/l	<0.1	<0.1
Lead, mg/l	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01
BOD, mg/l	1.5	1.5
COD, mg/l	3.0	3.0
DO, mg/l	9.2	9.2
Phenolic compounds, mg/l	BDL	BDL
Oil & Grease, mg/l	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil

The pH level in the project area of Dimijin hydroelectric project ranged from 7.0 to 7.1 at various samples covered as a part of the study indicating neutral nature of the water.

The TDS level ranged from 60 to 69 mg/l which is well below the permissible limit of 500 mg/l specified for drinking water. The TDS level was found to be lower at all the stations in monsoon months as compared to summer months. This trend was observed for various cations and anions monitored as a part of the study. This could be attributed to higher discharge in monsoon months.

The hardness level ranged from 44 to 49 mg/l indicating soft nature. The hardness level was well below the permissible limit of 200 mg/l specified for drinking water. The alkalinity was found to be higher than the total hardness in all the water sampling stations monitored as a part of the study, which indicates that entire hardness in the water is on account of carbonate hardness and there is no bicarbonate hardness in the water.

The chlorides level ranged from 11 to 15 mg/l, which is well below the permissible limit specified for drinking water (200 mg/l). The sulphates level at various sampling stations was <1.0 mg/l in various samples monitored for a period of six months as a part of the study. The concentration of nitrates and phosphates at various sampling locations was observed to below detectable limit of 0.01 mg/l.

The concentration of various cations, e.g. sodium, potassium, calcium and magnesium was observed to be quite low which is also reflected by the low TDS level. Iron was found to be well below the permissible limit of 1 mg/l specified for drinking water purposes.

The concentration of various heavy metals was found to be well below the permissible limits. Concentration of phenolic compounds and oil & grease as expected in a hilly terrain with no major sources of water pollution from domestic or industrial sources was observed to be quite low.

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

The DO level ranged from 9.1 to 9.2 mg/l at various sampling locations monitored on a monthly basis for six months as a part of the study. The DO levels were close to saturation limits in water, indicating the excellent quality of water in the study area.

5.3.5 Dikhri Hydroelectric project

As a part of the study, water quality was monitored at the following locations:

- Dam site (W9)
- 3000 m downstream of dam site (W10)

The results of water quality survey conducted for six months for Dikhri hydroelectric project are given in Tables-5.25 to 5.30.

TABLE-5.25
Results of water quality monitoring for Dikhri hydroelectric project : April 2009

Parameter	W9	W10
pH	7.1	7.1
Electrical Conductivity, micromhos/cm	86	83
Total Dissolved Solids, mg/l	63	61

Parameter	W9	W10
Hardness, mg/l	44	44
Chlorides, mg/l	12	12
Sulphates, mg/l	<1.0	<1.0
Phosphates, mg/l	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01
Sodium, mg/l	5.0	5.0
Potassium, mg/l	1.0	1.0
Calcium, mg/l	12.5	12.7
Magnesium, mg/l	3.1	3.0
Iron, mg/l	<0.1	<0.1
Alkalinity, mg/l	56	56
Copper, mg/l	<0.1	<0.1
Lead, mg/l	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01
BOD, mg/l	1.8	1.9
COD, mg/l	3.5	3.8
DO, mg/l	9.2	9.1
Phenolic compounds, mg/l	BDL	BDL
Oil & Grease, mg/l	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil

TABLE-5.26
Results of water quality monitoring for Dikhri hydroelectric project : May 2009

Parameter	W9	W10
pH	7.0	7.1
Electrical Conductivity, micromhos/cm	86	85
Total Dissolved Solids, mg/l	63	62
Hardness, mg/l	43	44
Chlorides, mg/l	11	12
Sulphates, mg/l	<1.0	<1.0
Phosphates, mg/l	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01
Sodium, mg/l	5.0	5.0
Potassium, mg/l	1.1	1.0
Calcium, mg/l	12.4	12.5
Magnesium, mg/l	3.0	3.1
Iron, mg/l	<0.1	<0.1
Alkalinity, mg/l	55	56
Copper, mg/l	<0.1	<0.1
Lead, mg/l	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01

Parameter	W9	W10
BOD, mg/l	1.8	1.8
COD, mg/l	3.5	3.7
DO, mg/l	9.2	9.2
Phenolic compounds, mg/l	BDL	BDL
Oil & Grease, mg/l	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil

TABLE-5.27
Results of water quality monitoring for Dikhri hydroelectric project : June 2009

Parameter	W9	W10
pH	7.0	7.0
Electrical Conductivity, micromhos/cm	84	84
Total Dissolved Solids, mg/l	61	62
Hardness, mg/l	43	43
Chlorides, mg/l	10	12
Sulphates, mg/l	<1.0	<1.0
Phosphates, mg/l	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01
Sodium, mg/l	4.9	5.0
Potassium, mg/l	1.2	1.0
Calcium, mg/l	12.1	12.1
Magnesium, mg/l	3.0	3.0
Iron, mg/l	<0.1	<0.1
Alkalinity, mg/l	54	54
Copper, mg/l	<0.1	<0.1
Lead, mg/l	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01
BOD, mg/l	1.8	1.7
COD, mg/l	3.5	3.4
DO, mg/l	9.2	9.2
Phenolic compounds, mg/l	BDL	BDL
Oil & Grease, mg/l	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil

TABLE-5.28
Results of water quality monitoring for Dikhri hydroelectric project : July 2009

Parameter	W9	W10
pH	7.0	7.0
Electrical Conductivity, micromhos/cm	80	81
Total Dissolved Solids, mg/l	58	59
Hardness, mg/l	41	42
Chlorides, mg/l	9	9
Sulphates, mg/l	<1.0	<1.0

Parameter	W9	W10
Phosphates, mg/l	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01
Sodium, mg/l	4.8	4.8
Potassium, mg/l	1.0	1.0
Calcium, mg/l	11.9	12.0
Magnesium, mg/l	2.8	2.8
Iron, mg/l	<0.1	<0.1
Alkalinity, mg/l	52	53
Copper, mg/l	<0.1	<0.1
Lead, mg/l	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01
BOD, mg/l	1.6	1.6
COD, mg/l	3.2	3.1
DO, mg/l	9.3	9.3
Phenolic compounds, mg/l	BDL	BDL
Oil & Grease, mg/l	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil

TABLE-5.29

Results of water quality monitoring for Dikhri hydroelectric project : August 2009

Parameter	W9	W10
pH	7.0	7.0
Electrical Conductivity, micromhos/cm	78	80
Total Dissolved Solids, mg/l	57	58
Hardness, mg/l	39	40
Chlorides, mg/l	8.7	8.8
Sulphates, mg/l	<1.0	<1.0
Phosphates, mg/l	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01
Sodium, mg/l	4.7	4.7
Potassium, mg/l	1.0	1.0
Calcium, mg/l	11.5	11.7
Magnesium, mg/l	2.7	2.7
Iron, mg/l	<0.1	<0.1
Alkalinity, mg/l	50	51
Copper, mg/l	<0.1	<0.1
Lead, mg/l	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01
BOD, mg/l	1.6	1.6
COD, mg/l	3.2	3.1
DO, mg/l	9.2	9.3

Parameter	W9	W10
Phenolic compounds, mg/l	BDL	BDL
Oil & Grease, mg/l	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil

TABLE-5.30
Results of water quality monitoring for Dikhri hydroelectric project : September 2009

Parameter	W9	W10
pH	7.0	7.0
Electrical Conductivity, micromhos/cm	78	80
Total Dissolved Solids, mg/l	57	58
Hardness, mg/l	39	40
Chlorides, mg/l	8.7	8.7
Sulphates, mg/l	<1.0	<1.0
Phosphates, mg/l	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01
Sodium, mg/l	4.7	4.6
Potassium, mg/l	1.0	1.0
Calcium, mg/l	11.4	11.6
Magnesium, mg/l	2.6	2.7
Iron, mg/l	<0.1	<0.1
Alkalinity, mg/l	50	51
Copper, mg/l	<0.1	<0.1
Lead, mg/l	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01
BOD, mg/l	1.6	1.6
COD, mg/l	3.1	3.1
DO, mg/l	9.2	9.2
Phenolic compounds, mg/l	BDL	BDL
Oil & Grease, mg/l	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil

The pH level in the project area of Dikhri hydroelectric project ranged from 7.0 to 7.1 at various samples covered as a part of the study, which is well within the permissible limit specified for drinking water.

The TDS level ranged from 57 to 63 mg/l which is well below the permissible limit of 500 mg/l specified for drinking water. The hardness level ranged from 39 to 44 mg/l indicating soft nature. The hardness level was well below the permissible limit of 200 mg/l specified for drinking water. The alkalinity was found to be higher than the total hardness in all the water sampling stations monitored as a part of the study, which indicates that entire hardness in the water is on account of carbonate hardness and there is no bicarbonate hardness in the water.

The chlorides level ranged from 8.7 to 12 mg/l, which is well below the permissible limit specified for drinking water (200mg/l). The sulphates level at various sampling stations was <1.0 mg/l in various samples monitored for a period of six months as a part of the study. The concentration of nitrates and phosphates at various sampling locations was observed to below detectable limit of 0.01 mg/l.

The concentration of various cations, e.g. sodium, potassium, calcium and magnesium was observed to be quite low which is also reflected by the low TDS level. Iron was found to be well below the permissible limit of 1 mg/l specified for drinking water purposes.

The concentration of various heavy metals was found to be well below the permissible limits. Concentration of phenolic compounds and oil & grease as expected in a hilly terrain with no major sources of water pollution from domestic or industrial sources was observed to be quite low.

The low BOD, COD, Total coliform values alongwith high DO levels (9.1 to 9.3 mg/l) indicate the absence of pollution loading. This is mainly due to the low population density and absence of industries in the area.

5.3.6 Dinchang Hydroelectric project

As a part of the study, water quality was monitored at the following locations:

- Dam site (W11)
- 3000 m downstream of dam site (W12)

The results of water quality survey conducted for six months for Dinchang hydroelectric project are given in Tables-5.31 to 5.36.

TABLE-5.31

Results of water quality monitoring for Dinchang hydroelectric project : April 2009

Parameter	W11	W12
pH	7.0	7.0
Electrical Conductivity, micromhos/cm	83	82
Total Dissolved Solids, mg/l	61	60
Hardness, mg/l	43	44
Chlorides, mg/l	11	12
Sulphates, mg/l	<1.0	<1.0
Phosphates, mg/l	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01
Sodium, mg/l	4.5	4.7
Potassium, mg/l	1.0	1.0
Calcium, mg/l	12.2	12.3

Parameter	W11	W12
Magnesium, mg/l	3.0	3.1
Iron, mg/l	<0.1	<0.1
Alkalinity, mg/l	54	55
Copper, mg/l	<0.1	<0.1
Lead, mg/l	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01
BOD, mg/l	1.8	1.8
COD, mg/l	3.5	3.4
DO, mg/l	9.1	9.1
Phenolic compounds, mg/l	BDL	BDL
Oil & Grease, mg/l	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil

TABLE-5.32

Results of water quality monitoring for Dinchang hydroelectric project : May 2009

Parameter	W11	W12
pH	7.0	7.0
Electrical Conductivity, micromhos/cm	83	81
Total Dissolved Solids, mg/l	61	59
Hardness, mg/l	43	43
Chlorides, mg/l	11	11
Sulphates, mg/l	<1.0	<1.0
Phosphates, mg/l	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01
Sodium, mg/l	4.4	4.5
Potassium, mg/l	1.0	0.9
Calcium, mg/l	12.2	12.1
Magnesium, mg/l	3.0	3.0
Iron, mg/l	<0.1	<0.1
Alkalinity, mg/l	54	54
Copper, mg/l	<0.1	<0.1
Lead, mg/l	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01
BOD, mg/l	1.8	1.7
COD, mg/l	3.5	3.3
DO, mg/l	9.1	9.1
Phenolic compounds, mg/l	BDL	BDL
Oil & Grease, mg/l	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil

TABLE-5.33

Results of water quality monitoring for Dinchang hydroelectric project : June 2009

Parameter	W11	W12
pH	7.0	7.0
Electrical Conductivity, micromhos/cm	81	80
Total Dissolved Solids, mg/l	59	58
Hardness, mg/l	43	42
Chlorides, mg/l	11	10
Sulphates, mg/l	<1.0	<1.0
Phosphates, mg/l	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01
Sodium, mg/l	4.4	4.4
Potassium, mg/l	1.0	0.9
Calcium, mg/l	12.0	12.0
Magnesium, mg/l	3.0	2.9
Iron, mg/l	<0.1	<0.1
Alkalinity, mg/l	54	53
Copper, mg/l	<0.1	<0.1
Lead, mg/l	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01
BOD, mg/l	1.6	1.6
COD, mg/l	3.1	3.1
DO, mg/l	9.2	9.2
Phenolic compounds, mg/l	BDL	BDL
Oil & Grease, mg/l	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil

TABLE-5.34

Results of water quality monitoring for Dinchang hydroelectric project : July 2009

Parameter	W11	W12
pH	7.0	7.0
Electrical Conductivity, micromhos/cm	78	76
Total Dissolved Solids, mg/l	57	55
Hardness, mg/l	40	40
Chlorides, mg/l	10	9
Sulphates, mg/l	<1.0	<1.0
Phosphates, mg/l	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01
Sodium, mg/l	4.2	4.2
Potassium, mg/l	0.9	0.9
Calcium, mg/l	11.4	11.5
Magnesium, mg/l	2.8	2.8
Iron, mg/l	<0.1	<0.1
Alkalinity, mg/l	51	51

Parameter	W11	W12
Copper, mg/l	<0.1	<0.1
Lead, mg/l	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01
BOD, mg/l	1.5	1.6
COD, mg/l	3.0	3.1
DO, mg/l	9.2	9.2
Phenolic compounds, mg/l	BDL	BDL
Oil & Grease, mg/l	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil

TABLE-5.35

Results of water quality monitoring for Dinchang hydroelectric project : August 2009

Parameter	W11	W12
pH	7.0	7.1
Electrical Conductivity, micromhos/cm	76	76
Total Dissolved Solids, mg/l	55	55
Hardness, mg/l	40	40
Chlorides, mg/l	9	9
Sulphates, mg/l	<1.0	<1.0
Phosphates, mg/l	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01
Sodium, mg/l	4.0	4.0
Potassium, mg/l	0.8	0.8
Calcium, mg/l	11.2	11.2
Magnesium, mg/l	2.8	2.8
Iron, mg/l	<0.1	<0.1
Alkalinity, mg/l	50	50
Copper, mg/l	<0.1	<0.1
Lead, mg/l	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01
BOD, mg/l	1.5	1.5
COD, mg/l	2.9	3.0
DO, mg/l	9.2	9.2
Phenolic compounds, mg/l	BDL	BDL
Oil & Grease, mg/l	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil

TABLE-5.36

Results of water quality monitoring for Dinchang hydroelectric project : September 2009

Parameter	W11	W12
pH	7.0	7.0
Electrical Conductivity, micromhos/cm	76	75
Total Dissolved Solids, mg/l	55	55
Hardness, mg/l	40	39
Chlorides, mg/l	8	9
Sulphates, mg/l	<1.0	<1.0
Phosphates, mg/l	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01
Sodium, mg/l	4.0	4.0
Potassium, mg/l	0.9	0.8
Calcium, mg/l	11.1	11.0
Magnesium, mg/l	2.8	2.7
Iron, mg/l	<0.1	<0.1
Alkalinity, mg/l	50	49
Copper, mg/l	<0.1	<0.1
Lead, mg/l	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01
BOD, mg/l	1.5	1.5
COD, mg/l	2.9	3.0
DO, mg/l	9.2	9.2
Phenolic compounds, mg/l	BDL	BDL
Oil & Grease, mg/l	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil

The pH level in the project area of Dinchang hydroelectric project ranged from 7.0 to 7.1 at various samples covered as a part of the study. The pH level indicate neutral nature of the water and is well within the permissible limit specified for drinking water requirements.

The TDS level ranged from 55 to 61 mg/l which is well below the permissible limit of 500 mg/l specified for drinking water. The TDS level was found to be lower at all the stations in the monsoon months as compared to summer months. This trend was observed for various cations and anions monitored as a part of the study. This could be attributed to higher discharges in monsoon months.

The hardness level ranged from 39 to 44 mg/l indicating soft nature of water. The hardness level was well below the permissible limit of 200 mg/l specified for drinking water. The alkalinity was found to be higher than the total hardness in all the water sampling stations

monitored as a part of the study, which indicates that entire hardness in the water is on account of carbonate hardness and there is no bicarbonate hardness in the water.

The chlorides level ranged from 8 to 12 mg/l, which is well below the permissible limit specified for drinking water (200 mg/l). The sulphates level at various sampling stations was <1.0 mg/l in various samples monitored for a period of six months as a part of the study. The concentration of nitrates and phosphates at various sampling locations was observed to below detectable limit of 0.01 mg/l.

The concentration of various cations, e.g. sodium, potassium, calcium and magnesium was observed to be quite low which is also reflected by the low TDS level. Iron was found to be well below the permissible limit of 1 mg/l specified for drinking water purposes.

The concentration of various heavy metals was found to be well below the permissible limits. Concentration of phenolic compounds and oil & grease as expected in a hilly terrain with no major sources of water pollution from domestic or industrial sources was observed to be quite low.

The low BOD, COD and Total coliform values and near saturation level values of DO indicate the absence of pollution loading in the area. This is mainly due to the low population density and absence of industries in the area. The low COD values also indicate the absence of chemical pollution loading in the area. The marginal quantity of pollution load which enters river Bichom, gets diluted, and as a result, various parameters are well within the permissible limits.

5.3.7 Jameri Hydroelectric project

As a part of the study, water quality was monitored at the following locations:

- Dam site (W13)
- 3000 m downstream of dam site (W14)

The results of water quality survey conducted for six months for Jameri hydroelectric project are given in Tables-5.37 to 5.42.

TABLE-5.37

Results of water quality monitoring for Jameri hydroelectric project : April 2009

Parameter	**W13**	**W14**
pH	7.1	7.2
Electrical Conductivity, micromhos/cm	88	90
Total Dissolved Solids, mg/l	60	64
Hardness, mg/l	45	46
Chlorides, mg/l	14	14
Sulphates, mg/l	<1.0	<1.0
Phosphates, mg/l	<0.01	<0.01

Parameter	W13	W14
Nitrates, mg/l	<0.01	<0.01
Sodium, mg/l	5.4	5.7
Potassium, mg/l	1.1	1.6
Calcium, mg/l	12.4	12.8
Magnesium, mg/l	3.2	3.4
Iron, mg/l	<0.1	<0.1
Alkalinity, mg/l	55	57
Copper, mg/l	<0.1	<0.1
Lead, mg/l	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01
BOD, mg/l	1.9	1.8
COD, mg/l	3.7	3.4
DO, mg/l	9.0	9.0
Phenolic compounds, mg/l	BDL	BDL
Oil & Grease, mg/l	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil

TABLE-5.38

Results of water quality monitoring for Jameri hydroelectric project : May 2009

Parameter	W13	W14
pH	7.1	7.1
Electrical Conductivity, micromhos/cm	87	88
Total Dissolved Solids, mg/l	59	60
Hardness, mg/l	44	46
Chlorides, mg/l	13	14
Sulphates, mg/l	<1.0	<1.0
Phosphates, mg/l	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01
Sodium, mg/l	4.9	5.0
Potassium, mg/l	1.2	1.1
Calcium, mg/l	12.4	12.2
Magnesium, mg/l	3.2	3.4
Iron, mg/l	<0.1	<0.1
Alkalinity, mg/l	55	57
Copper, mg/l	<0.1	<0.1
Lead, mg/l	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01
BOD, mg/l	1.8	1.8
COD, mg/l	3.5	3.5
DO, mg/l	9.0	9.0

Parameter	W13	W14
Phenolic compounds, mg/l	BDL	BDL
Oil & Grease, mg/l	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil

TABLE-5.39

Results of water quality monitoring for Jameri hydroelectric project : June 2009

Parameter	W13	W14
pH	7.2	7.1
Electrical Conductivity, micromhos/cm	85	84
Total Dissolved Solids, mg/l	62	61
Hardness, mg/l	42	43
Chlorides, mg/l	9	9
Sulphates, mg/l	<1.0	<1.0
Phosphates, mg/l	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01
Sodium, mg/l	5.0	4.8
Potassium, mg/l	1.2	1.1
Calcium, mg/l	11.8	12.0
Magnesium, mg/l	3.0	3.0
Iron, mg/l	<0.1	<0.1
Alkalinity, mg/l	53	54
Copper, mg/l	<0.1	<0.1
Lead, mg/l	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01
BOD, mg/l	1.5	1.6
COD, mg/l	3.0	3.1
DO, mg/l	9.0	9.0
Phenolic compounds, mg/l	BDL	BDL
Oil & Grease, mg/l	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil

TABLE-5.40

Results of water quality monitoring for Jameri hydroelectric project : July 2009

Parameter	W13	W14
pH	7.0	7.0
Electrical Conductivity, micromhos/cm	80	80
Total Dissolved Solids, mg/l	57	56
Hardness, mg/l	40	40
Chlorides, mg/l	9	8
Sulphates, mg/l	<1.0	<1.0
Phosphates, mg/l	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01
Sodium, mg/l	4.5	4.5

Parameter	W13	W14
Potassium, mg/l	0.9	0.9
Calcium, mg/l	11.5	11.5
Magnesium, mg/l	2.8	2.8
Iron, mg/l	<0.1	<0.1
Alkalinity, mg/l	50	51
Copper, mg/l	<0.1	<0.1
Lead, mg/l	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01
BOD, mg/l	1.5	1.5
COD, mg/l	2.9	2.9
DO, mg/l	9.1	9.1
Phenolic compounds, mg/l	BDL	BDL
Oil & Grease, mg/l	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil

TABLE-5.41

Results of water quality monitoring for Jameri hydroelectric project : August 2009

Parameter	W13	W14
pH	7.2	7.2
Electrical Conductivity, micromhos/cm	78	77
Total Dissolved Solids, mg/l	57	56
Hardness, mg/l	40	39
Chlorides, mg/l	8	8
Sulphates, mg/l	<1.0	<1.0
Phosphates, mg/l	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01
Sodium, mg/l	4.1	4.4
Potassium, mg/l	0.8	0.8
Calcium, mg/l	11.2	11.2
Magnesium, mg/l	2.8	2.7
Iron, mg/l	<0.1	<0.1
Alkalinity, mg/l	50	48
Copper, mg/l	<0.1	<0.1
Lead, mg/l	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01
BOD, mg/l	1.6	1.5
COD, mg/l	3.0	3.0
DO, mg/l	9.1	9.0
Phenolic compounds, mg/l	BDL	BDL
Oil & Grease, mg/l	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil

TABLE-5.42

Results of water quality monitoring for Jameri hydroelectric project : September 2009

Parameter	**W13**	**W14**
pH	7.1	7.0
Electrical Conductivity, micromhos/cm	75	75
Total Dissolved Solids, mg/l	54	55
Hardness, mg/l	40	39
Chlorides, mg/l	8	8
Sulphates, mg/l	<1.0	<1.0
Phosphates, mg/l	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01
Sodium, mg/l	4.1	4.1
Potassium, mg/l	0.8	0.8
Calcium, mg/l	11.0	11.0
Magnesium, mg/l	2.8	2.8
Iron, mg/l	<0.1	<0.1
Alkalinity, mg/l	49	49
Copper, mg/l	<0.1	<0.1
Lead, mg/l	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01
BOD, mg/l	1.6	1.6
COD, mg/l	3.0	3.1
DO, mg/l	9.0	9.0
Phenolic compounds, mg/l	BDL	BDL
Oil & Grease, mg/l	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil

The pH level in the project area of Jameri hydroelectric project ranged from 7.0 to 7.2 at various samples covered as a part of the study. The pH level indicate neutral nature of the water and is well within the permissible limit specified for drinking water requirements.

The TDS level ranged from 54 to 64 mg/l which is well below the permissible limit of 500 mg/l specified for drinking water. The TDS level was found to be lower at all the stations in the monsoon months as compared to summer months. This trend was observed for various cations and anions monitored as a part of the study. This could be attributed to higher discharges in monsoon months.

The hardness level ranged from 39 to 46 mg/l indicating soft nature of water. The hardness level was well below the permissible limit of 200 mg/l specified for drinking water. The alkalinity was found to be higher than the total hardness in all the water sampling stations

monitored as a part of the study, which indicates that entire hardness in the water is on account of carbonate hardness and there is no bicarbonate hardness in the water.

The chlorides level ranged from 8 to 14 mg/l, which is well below the permissible limit specified for drinking water (200 mg/l). The sulphates level at various sampling stations was <0.1 mg/l in various samples monitored for a period of six months as a part of the study. The concentration of nitrates and phosphates at various sampling locations was observed to below detectable limit of 0.01 mg/l.

The concentration of various cations, e.g. sodium, potassium, calcium and magnesium was observed to be quite low which is also reflected by the low TDS level. Iron was found to be well below the permissible limit of 1 mg/l specified for drinking water purposes.

The concentration of various heavy metals was found to be well below the permissible limits. Concentration of phenolic compounds and oil & grease as expected in a hilly terrain with no major sources of water pollution from domestic or industrial sources was observed to be quite low.

The low BOD, COD and Total coliform values and near saturation level values of DO indicate the absence of pollution loading in the area. This is mainly due to the low population density and absence of industries in the area. The low COD values also indicate the absence of chemical pollution loading in the area. The marginal quantity of pollution load which enters river Bichom, gets diluted.

5.3.8 Dinan Hydroelectric project

As a part of the study, water quality was monitored at the following locations:

- Dam site (W15)
- 3000 m downstream of dam site (W16)

The results of water quality survey conducted for six months for Dinan hydroelectric project are given in Tables-5.43 to 5.48.

TABLE-5.43

Results of water quality monitoring for Dinan hydroelectric project : April 2009

Parameter	W15	W16
pH	7.2	7.2
Electrical Conductivity, micromhos/cm	86	84
Total Dissolved Solids, mg/l	63	61
Hardness, mg/l	43	45
Chlorides, mg/l	9	9
Sulphates, mg/l	<1.0	<1.0
Phosphates, mg/l	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01

Parameter	W15	W16
Sodium, mg/l	4.6	4.8
Potassium, mg/l	1.0	1.0
Calcium, mg/l	12.5	12.6
Magnesium, mg/l	3.2	3.2
Iron, mg/l	<0.1	<0.1
Alkalinity, mg/l	54	56
Copper, mg/l	<0.1	<0.1
Lead, mg/l	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01
BOD, mg/l	1.9	1.9
COD, mg/l	3.6	3.7
DO, mg/l	9.0	9.0
Phenolic compounds, mg/l	BDL	BDL
Oil & Grease, mg/l	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil

TABLE-5.44

Results of water quality monitoring for Dinan hydroelectric project : May 2009

Parameter	W15	W16
pH	7.2	7.1
Electrical Conductivity, micromhos/cm	85	85
Total Dissolved Solids, mg/l	62	61
Hardness, mg/l	44	45
Chlorides, mg/l	9	9
Sulphates, mg/l	<1.0	<1.0
Phosphates, mg/l	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01
Sodium, mg/l	4.5	4.7
Potassium, mg/l	1.1	1.0
Calcium, mg/l	12.5	12.5
Magnesium, mg/l	3.1	3.2
Iron, mg/l	<0.1	<0.1
Alkalinity, mg/l	55	57
Copper, mg/l	<0.1	<0.1
Lead, mg/l	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01
BOD, mg/l	1.8	1.8
COD, mg/l	3.5	3.4
DO, mg/l	9.0	9.1

Parameter	W15	W16
Phenolic compounds, mg/l	BDL	BDL
Oil & Grease, mg/l	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil

TABLE-5.45

Results of water quality monitoring for Dinan hydroelectric project : June 2009

Parameter	W15	W16
pH	7.1	7.1
Electrical Conductivity, micromhos/cm	82	80
Total Dissolved Solids, mg/l	60	58
Hardness, mg/l	41	42
Chlorides, mg/l	9	8
Sulphates, mg/l	<1.0	<1.0
Phosphates, mg/l	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01
Sodium, mg/l	4.5	4.4
Potassium, mg/l	0.9	0.9
Calcium, mg/l	11.9	12.0
Magnesium, mg/l	2.8	2.8
Iron, mg/l	<0.1	<0.1
Alkalinity, mg/l	51	52
Copper, mg/l	<0.1	<0.1
Lead, mg/l	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01
BOD, mg/l	1.7	1.6
COD, mg/l	3.2	3.1
DO, mg/l	9.1	9.1
Phenolic compounds, mg/l	BDL	BDL
Oil & Grease, mg/l	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil

TABLE-5.46

Results of water quality monitoring for Dinan hydroelectric project : July 2009

Parameter	W15	W16
pH	7.0	7.0
Electrical Conductivity, micromhos/cm	80	79
Total Dissolved Solids, mg/l	58	58
Hardness, mg/l	39	38
Chlorides, mg/l	8	8
Sulphates, mg/l	<1.0	<1.0
Phosphates, mg/l	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01
Sodium, mg/l	4.0	4.0

Parameter	W15	W16
Potassium, mg/l	0.8	0.8
Calcium, mg/l	11.2	11.3
Magnesium, mg/l	2.7	2.6
Iron, mg/l	<0.1	<0.1
Alkalinity, mg/l	49	48
Copper, mg/l	<0.1	<0.1
Lead, mg/l	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01
BOD, mg/l	1.5	1.5
COD, mg/l	2.9	3.0
DO, mg/l	9.2	9.2
Phenolic compounds, mg/l	BDL	BDL
Oil & Grease, mg/l	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil

TABLE-5.47

Results of water quality monitoring for Dinan hydroelectric project : August 2009

Parameter	W15	W16
pH	7.0	7.0
Electrical Conductivity, micromhos/cm	78	77
Total Dissolved Solids, mg/l	57	56
Hardness, mg/l	38	38
Chlorides, mg/l	8	8
Sulphates, mg/l	<1.0	<1.0
Phosphates, mg/l	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01
Sodium, mg/l	4.0	4.0
Potassium, mg/l	0.8	0.8
Calcium, mg/l	11.2	11.0
Magnesium, mg/l	2.6	2.7
Iron, mg/l	<0.1	<0.1
Alkalinity, mg/l	47	48
Copper, mg/l	<0.1	<0.1
Lead, mg/l	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01
BOD, mg/l	1.5	1.5
COD, mg/l	2.9	2.9
DO, mg/l	9.2	9.2
Phenolic compounds, mg/l	BDL	BDL
Oil & Grease, mg/l	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil

TABLE-5.48

Results of water quality monitoring for Dinan hydroelectric project : September 2009

Parameter	**W15**	**W16**
pH	7.0	7.0
Electrical Conductivity, micromhos/cm	75	75
Total Dissolved Solids, mg/l	55	55
Hardness, mg/l	39	39
Chlorides, mg/l	8	8
Sulphates, mg/l	<1.0	<1.0
Phosphates, mg/l	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01
Sodium, mg/l	4.1	4.0
Potassium, mg/l	0.8	0.8
Calcium, mg/l	11.0	11.0
Magnesium, mg/l	2.7	2.7
Iron, mg/l	<0.1	<0.1
Alkalinity, mg/l	48	48
Copper, mg/l	<0.1	<0.1
Lead, mg/l	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01
BOD, mg/l	1.5	1.5
COD, mg/l	2.8	2.9
DO, mg/l	9.2	9.2
Phenolic compounds, mg/l	BDL	BDL
Oil & Grease, mg/l	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil

The pH level in the project area of Dinan hydroelectric project ranged from 7.0 to 7.2 at various samples covered as a part of the study. The pH level indicate neutral nature of the water and is well within the permissible limit specified for drinking water requirements.

The TDS level ranged from 55 to 63 mg/l which is well below the permissible limit of 500 mg/l specified for drinking water. The TDS level was found to be lower at all the stations in the monsoon months as compared to summer months. This trend was observed for various cations and anions monitored as a part of the study. This could be attributed to higher discharges in monsoon months.

The hardness level ranged from 38 to 47 mg/l indicating soft nature of water. The hardness level was well below the permissible limit of 200 mg/l specified for drinking water. The alkalinity was found to be higher than the total hardness in all the water sampling stations

monitored as a part of the study, which indicates that entire hardness in the water is on account of carbonate hardness and there is no bicarbonate hardness in the water.

The chlorides level ranged from 8 to 9 mg/l, which is well below the permissible limit specified for drinking water (200 mg/l). The sulphates level at various sampling stations was <0.1 mg/l in various samples monitored for a period of six months as a part of the study. The concentration of nitrates and phosphates at various sampling locations was observed to below detectable limit of 0.01 mg/l.

The concentration of various cations, e.g. sodium, potassium, calcium and magnesium was observed to be quite low which is also reflected by the low TDS level. Iron was found to be well below the permissible limit of 1 mg/l specified for drinking water purposes.

The concentration of various heavy metals was found to be well below the permissible limits. Concentration of phenolic compounds and oil & grease as expected in a hilly terrain with no major sources of water pollution from domestic or industrial sources was observed to be quite low.

The low BOD, COD and Total coliform values and near saturation level values of DO indicate the absence of pollution loading in the area. This is mainly due to the low population density and absence of industries in the area. The low COD values also indicate the absence of chemical pollution loading in the area. The marginal quantity of pollution load which enters river Bichom is well within the carrying capacity, even for lean season discharges.

5.3.9 Gongri Hydroelectric project

As a part of the study, water quality was monitored at the following locations:

- Dam site (W17)
- 3000 m downstream of dam site (W18)

The results of water quality survey conducted for six months for Gongri hydroelectric project are

given in Tables-5.49 to 5.54.

TABLE-5.49

Results of water quality monitoring for Gongri hydroelectric project : April 2009

Parameter	**W17**	**W18**
pH	7.0	7.0
Electrical Conductivity, micromhos/cm	81	80
Total Dissolved Solids, mg/l	59	58
Hardness, mg/l	42	43
Chlorides, mg/l	10	10

Parameter	W17	W18
Sulphates, mg/l	<1.0	<1.0
Phosphates, mg/l	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01
Sodium, mg/l	4.4	4.5
Potassium, mg/l	1.0	1.0
Calcium, mg/l	12.0	12.0
Magnesium, mg/l	3.1	3.2
Iron, mg/l	<0.1	<0.1
Alkalinity, mg/l	52	53
Copper, mg/l	<0.1	<0.1
Lead, mg/l	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01
BOD, mg/l	1.8	1.9
COD, mg/l	3.5	3.6
DO, mg/l	9.1	9.1
Phenolic compounds, mg/l	BDL	BDL
Oil & Grease, mg/l	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil

TABLE-5.50

Results of water quality monitoring for Gongri hydroelectric project : May 2009

Parameter	W17	W18
pH	7.1	7.0
Electrical Conductivity, micromhos/cm	81	81
Total Dissolved Solids, mg/l	60	59
Hardness, mg/l	42	44
Chlorides, mg/l	9	10
Sulphates, mg/l	<1.0	<1.0
Phosphates, mg/l	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01
Sodium, mg/l	4.4	4.4
Potassium, mg/l	0.9	0.9
Calcium, mg/l	11.9	12.1
Magnesium, mg/l	3.0	3.1
Iron, mg/l	<0.1	<0.1
Alkalinity, mg/l	53	56
Copper, mg/l	<0.1	<0.1
Lead, mg/l	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01

Parameter	W17	W18
BOD, mg/l	1.8	1.8
COD, mg/l	3.5	3.5
DO, mg/l	9.1	9.1
Phenolic compounds, mg/l	BDL	BDL
Oil & Grease, mg/l	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil

TABLE-5.51

Results of water quality monitoring for Gongri hydroelectric project : June 2009

Parameter	W17	W18
pH	7.1	7.0
Electrical Conductivity, micromhos/cm	81	80
Total Dissolved Solids, mg/l	58	57
Hardness, mg/l	42	44
Chlorides, mg/l	9	9
Sulphates, mg/l	<1.0	<1.0
Phosphates, mg/l	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01
Sodium, mg/l	4.3	4.2
Potassium, mg/l	0.9	0.9
Calcium, mg/l	11.8	11.9
Magnesium, mg/l	2.8	2.9
Iron, mg/l	<0.1	<0.1
Alkalinity, mg/l	52	55
Copper, mg/l	<0.1	<0.1
Lead, mg/l	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01
BOD, mg/l	1.7	1.7
COD, mg/l	3.2	3.3
DO, mg/l	9.1	9.1
Phenolic compounds, mg/l	BDL	BDL
Oil & Grease, mg/l	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil

TABLE-5.52

Results of water quality monitoring for Gongri hydroelectric project : July 2009

Parameter	W17	W18
pH	7.0	7.0
Electrical Conductivity, micromhos/cm	76	75
Total Dissolved Solids, mg/l	54	53
Hardness, mg/l	39	40
Chlorides, mg/l	8	8

Parameter	W17	W18
Sulphates, mg/l	<1.0	<1.0
Phosphates, mg/l	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01
Sodium, mg/l	4.0	4.0
Potassium, mg/l	0.8	0.8
Calcium, mg/l	11.1	11.3
Magnesium, mg/l	2.6	2.6
Iron, mg/l	<0.1	<0.1
Alkalinity, mg/l	50	51
Copper, mg/l	<0.1	<0.1
Lead, mg/l	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01
BOD, mg/l	1.5	1.5
COD, mg/l	2.9	2.9
DO, mg/l	9.0	9.1
Phenolic compounds, mg/l	BDL	BDL
Oil & Grease, mg/l	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil

TABLE-5.53

Results of water quality monitoring for Gongri hydroelectric project : August 2009

Parameter	W17	W18
pH	7.0	7.0
Electrical Conductivity, micromhos/cm	74	72
Total Dissolved Solids, mg/l	52	50
Hardness, mg/l	38	37
Chlorides, mg/l	8	8
Sulphates, mg/l	<1.0	<1.0
Phosphates, mg/l	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01
Sodium, mg/l	3.9	4.0
Potassium, mg/l	0.8	0.8
Calcium, mg/l	11.0	11.0
Magnesium, mg/l	2.6	2.6
Iron, mg/l	<0.1	<0.1
Alkalinity, mg/l	47	46
Copper, mg/l	<0.1	<0.1
Lead, mg/l	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01
BOD, mg/l	1.5	1.5
COD, mg/l	2.8	2.8

Parameter	W17	W18
DO, mg/l	9.2	9.2
Phenolic compounds, mg/l	BDL	BDL
Oil & Grease, mg/l	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil

TABLE-5.54

Results of water quality monitoring for Gongri hydroelectric project : September 2009

Parameter	W17	W18
pH	7.0	7.0
Electrical Conductivity, micromhos/cm	72	72
Total Dissolved Solids, mg/l	51	50
Hardness, mg/l	37	38
Chlorides, mg/l	8	8
Sulphates, mg/l	<1.0	<1.0
Phosphates, mg/l	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01
Sodium, mg/l	3.8	4.0
Potassium, mg/l	0.8	0.8
Calcium, mg/l	10.8	11.0
Magnesium, mg/l	2.6	2.6
Iron, mg/l	<0.1	<0.1
Alkalinity, mg/l	46	48
Copper, mg/l	<0.1	<0.1
Lead, mg/l	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01
BOD, mg/l	1.5	1.5
COD, mg/l	2.8	2.9
DO, mg/l	9.2	9.2
Phenolic compounds, mg/l	BDL	BDL
Oil & Grease, mg/l	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil

The pH level in the project area of Gongri hydroelectric project ranged from 7.0 to 7.1 at various samples covered as a part of the study. The pH level indicate neutral nature of the water and is well within the permissible limit specified for drinking water requirements.

The TDS level ranged from 50 to 60 mg/l which is well below the permissible limit of 500 mg/l specified for drinking water. The TDS level was found to be lower at all the stations in the monsoon months as compared to summer months. This trend was observed for various cations and anions monitored as a part of the study. This could be attributed to higher discharges in monsoon months.

The hardness level ranged from 37 to 43 mg/l indicating soft nature of water. The hardness level was well below the permissible limit of 200 mg/l specified for drinking water. The alkalinity was found to be higher than the total hardness in all the water sampling stations monitored as a part of the study, which indicates that entire hardness in the water is on account of carbonate hardness and there is no bicarbonate hardness in the water.

The chlorides level ranged from 8 to 10 mg/l, which is well below the permissible limit specified for drinking water (200 mg/l). The sulphates level at various sampling stations was <1.0 mg/l in various samples monitored for a period of six months as a part of the study. The concentration of nitrates and phosphates at various sampling locations was observed to below detectable limit of 0.01 mg/l.

The concentration of various cations, e.g. sodium, potassium, calcium and magnesium was observed to be quite low which is also reflected by the low TDS level. Iron was found to be well below the permissible limit of 1 mg/l specified for drinking water purposes.

The concentration of various heavy metals was found to be well below the permissible limits. Concentration of phenolic compounds and oil & grease as expected in a hilly terrain with no major sources of water pollution from domestic or industrial sources was observed to be quite low.

The low BOD, COD and Total coliform values and near saturation level values of DO indicate the absence of pollution loading in the area. This is mainly due to the low population density and absence of industries in the area. The low COD values also indicate the absence of chemical pollution loading in the area. The marginal quantity of pollution load which enters river Bichom, gets diluted.

5.3.10 Nafra Hydroelectric project

As a part of the study, water quality was monitored at the following locations:

- Dam site (W19)
- 3000 m downstream of dam site (W20)

The results of water quality survey conducted for six months for Nafra hydroelectric project are

given in Tables-5.55 to 5.60.

TABLE-5.55

Results of water quality monitoring for Nafra hydroelectric project : April 2009

Parameter	W19	W20
pH	7.2	7.3

Parameter	W19	W20
Electrical Conductivity, micromhos/cm	83	75
Total Dissolved Solids, mg/l	60	62
Hardness, mg/l	45	46
Chlorides, mg/l	12	11
Sulphates, mg/l	<1.0	<1.0
Phosphates, mg/l	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01
Sodium, mg/l	4.5	4.5
Potassium, mg/l	1.0	1.0
Calcium, mg/l	12.4	12.5
Magnesium, mg/l	3.5	3.3
Iron, mg/l	<0.1	<0.1
Alkalinity, mg/l	57	57
Copper, mg/l	<0.1	<0.1
Lead, mg/l	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01
BOD, mg/l	1.8	1.8
COD, mg/l	3.6	3.6
DO, mg/l	9.1	9.1
Phenolic compounds, mg/l	BDL	BDL
Oil & Grease, mg/l	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil

TABLE-5.56

Results of water quality monitoring for Nafra hydroelectric project : May 2009

Parameter	W19	W20
pH	7.2	7.2
Electrical Conductivity, micromhos/cm	82	82
Total Dissolved Solids, mg/l	60	61
Hardness, mg/l	46	45
Chlorides, mg/l	12	13
Sulphates, mg/l	<1.0	<1.0
Phosphates, mg/l	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01
Sodium, mg/l	4.6	4.6
Potassium, mg/l	1.1	1.1
Calcium, mg/l	12.5	12.5
Magnesium, mg/l	3.3	3.4
Iron, mg/l	<0.1	<0.1
Alkalinity, mg/l	58	56
Copper, mg/l	<0.1	<0.1
Lead, mg/l	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1

Parameter	W19	W20
Chromium, mg/l	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01
BOD, mg/l	1.8	1.7
COD, mg/l	3.5	3.4
DO, mg/l	9.1	9.2
Phenolic compounds, mg/l	BDL	BDL
Oil & Grease, mg/l	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil

TABLE-5.57

Results of water quality monitoring for Nafra hydroelectric project : June 2009

Parameter	W19	W20
pH	7.1	7.2
Electrical Conductivity, micromhos/cm	82	82
Total Dissolved Solids, mg/l	59	59
Hardness, mg/l	44	43
Chlorides, mg/l	11	11
Sulphates, mg/l	<1.0	<1.0
Phosphates, mg/l	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01
Sodium, mg/l	4.5	4.6
Potassium, mg/l	0.9	0.9
Calcium, mg/l	12.4	12.2
Magnesium, mg/l	3.2	3.2
Iron, mg/l	<0.1	<0.1
Alkalinity, mg/l	56	55
Copper, mg/l	<0.1	<0.1
Lead, mg/l	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01
BOD, mg/l	1.7	1.7
COD, mg/l	3.4	3.3
DO, mg/l	9.0	9.0
Phenolic compounds, mg/l	BDL	BDL
Oil & Grease, mg/l	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil

TABLE-5.58

Results of water quality monitoring for Nafra hydroelectric project : July 2009

Parameter	W19	W20
pH	7.0	7.0
Electrical Conductivity, micromhos/cm	77	75

Parameter	W19	W20
Total Dissolved Solids, mg/l	56	54
Hardness, mg/l	40	40
Chlorides, mg/l	8	8
Sulphates, mg/l	<1.0	<1.0
Phosphates, mg/l	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01
Sodium, mg/l	4.0	4.0
Potassium, mg/l	42	41
Calcium, mg/l	11.9	11,7
Magnesium, mg/l	3.0	3.0
Iron, mg/l	<0.1	<0.1
Alkalinity, mg/l	55	53
Copper, mg/l	<0.1	<0.1
Lead, mg/l	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01
BOD, mg/l	1.7	1.6
COD, mg/l	3.3	3.2
DO, mg/l	9.1	9.1
Phenolic compounds, mg/l	BDL	BDL
Oil & Grease, mg/l	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil

TABLE-5.59

Results of water quality monitoring for Nafra hydroelectric project : August 2009

Parameter	W19	W20
pH	7.0	7.0
Electrical Conductivity, micromhos/cm	75	74
Total Dissolved Solids, mg/l	54	52
Hardness, mg/l	40	41
Chlorides, mg/l	8	8
Sulphates, mg/l	<1.0	<1.0
Phosphates, mg/l	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01
Sodium, mg/l	4.1	4.0
Potassium, mg/l	0.8	0.8
Calcium, mg/l	11.5	11.7
Magnesium, mg/l	2.8	2.7
Iron, mg/l	<0.1	<0.1
Alkalinity, mg/l	50	52
Copper, mg/l	<0.1	<0.1
Lead, mg/l	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001

Parameter	**W19**	**W20**
Cadmium, mg/l	<0.01	<0.01
BOD, mg/l	1.5	1.5
COD, mg/l	2.8	2.9
DO, mg/l	9.2	9.2
Phenolic compounds, mg/l	BDL	BDL
Oil & Grease, mg/l	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil

TABLE-5.60

Results of water quality monitoring for Nafra hydroelectric project : September 2009

Parameter	**W19**	**W20**
pH	7.0	7.0
Electrical Conductivity, micromhos/cm	74	75
Total Dissolved Solids, mg/l	54	55
Hardness, mg/l	39	38
Chlorides, mg/l	8	8
Sulphates, mg/l	<1.0	<1.0
Phosphates, mg/l	<0.01	<0.01
Nitrates, mg/l	<0.01	<0.01
Sodium, mg/l	4.0	4.0
Potassium, mg/l	0.9	0.9
Calcium, mg/l	11.4	11.2
Magnesium, mg/l	2.7	2.7
Iron, mg/l	<0.1	<0.1
Alkalinity, mg/l	50	48
Copper, mg/l	<0.1	<0.1
Lead, mg/l	<0.1	<0.1
Zinc, mg/l	<0.1	<0.1
Chromium, mg/l	<0.05	<0.05
Mercury, mg/l	<0.001	<0.001
Cadmium, mg/l	<0.01	<0.01
BOD, mg/l	1.5	1.5
COD, mg/l	2.9	2.9
DO, mg/l	9.2	9.2
Phenolic compounds, mg/l	BDL	BDL
Oil & Grease, mg/l	BDL	BDL
Total Coliform MPN/100 ml	Nil	Nil

The pH level in the project area of Nafra hydroelectric project ranged from 7.0 to 7.2 at various samples covered as a part of the study. The pH level indicate neutral nature of the water and is well within the permissible limit specified for drinking water requirements.

The TDS level ranged from 52 to 62 mg/l which is well below the permissible limit of 500 mg/l specified for drinking water. The TDS level was found to be lower at all the stations in the monsoon months as compared to summer months. This trend was observed for various cations and anions monitored as a part of the study. This could be attributed to higher discharges in monsoon months.

The hardness level ranged from 38 to 46 mg/l indicating soft nature of water. The hardness level was well below the permissible limit of 200 mg/l specified for drinking water. The alkalinity was found to be higher than the total hardness in all the water sampling stations monitored as a part of the study, which indicates that entire hardness in the water is on account of carbonate hardness and there is no bicarbonate hardness in the water.

The chlorides level ranged from 8 to 13 mg/l, which is well below the permissible limit specified for drinking water (200 mg/l). The sulphates level at various sampling stations was <1.0 mg/l in various samples monitored for a period of six months as a part of the study. The concentration of nitrates and phosphates at various sampling locations was observed to below detectable limit of 0.01 mg/l.

The concentration of various cations, e.g. sodium, potassium, calcium and magnesium was observed to be quite low which is also reflected by the low TDS level. Iron was found to be well below the permissible limit of 1 mg/l specified for drinking water purposes.

The concentration of various heavy metals was found to be well below the permissible limits. Concentration of phenolic compounds and oil & grease as expected in a hilly terrain with no major sources of water pollution from domestic or industrial sources was observed to be quite low.

The low BOD, COD and Total coliform values and near saturation level values of DO indicate the absence of pollution loading in the area. This is mainly due to the low population density and absence of industries in the area. The low COD values also indicate the absence of chemical pollution loading in the area. The marginal quantity of pollution load which enters river Bichom gets diluted and sufficient water is available even in lean season.

5.4 CONCLUSIONS

It can be concluded that water quality is quite good in the area. This is expected in an area with no major sources of water pollution. The main reasons for low pollution loading are low population density, absence of industries, low cropping intensity with minimal or no use of agro-chemicals. The pollution loading observed is well below the carrying capacity available in the river, even in the lean season.

CHAPTER-6
AQUATIC ECOLOGY

6.1 GENERAL

Implementation of any developmental project requires sustainable management of the land and water resources. In order to ensure sustainable management of resources, an inventory of the existing resource base and its production and consumption pattern must be studied. As a part of the basin study detailed ecological sampling study was conducted. The sampling was conducted once every month for a period of six months from April 2009 to September 2009.

6.2 SAMPLING SITES

As mentioned earlier about 10 projects are envisaged in the study area. In each project, three sites were monitored as a part of aquatic ecology. These are listed as below:

1. Utung hydroelectric project

- 2000 m upstream of dam site (AQ1)
- Dam site (AQ2)
- 3000 m downstream of dam site (AQ3)

2. Nazong hydroelectric project

- 2000 m upstream of dam site (AQ4)
- Dam site (AQ5)
- 3000 m downstream of dam site (AQ6)

3. Dibbin hydroelectric project

- 200 m Upstream area (AQ7)
- Damsite (AQ8)
- 3000 m damsite (AQ9)

4. Dimijin hydroelectric project

- 2000 m Upstream of dam site (AQ10)
- Dam site (AQ11)
- 3000 m downstream of dam site (AQ12)

5. Dikhri hydroelectric project

- 2000 m upstream of dam site (AQ13)
- Dam site (AQ14)
- 3000 m downstream of dam site (AQ15)

6. Dinchang hydroelectric project

- 2000 m upstream of dam site (AQ16)
- Dam site (AQ17)
- 3000 m downstream of dam site (AQ18)

7. Jameri hydroelectric project

- 2000 m upstream of dam site (AQ19)
- Dam site (AQ20)
- 3000 m downstream of dam site (AQ21)

8. Dinan hydroelectric project

- 2000 m upstream of dam site (AQ22)
- Dam site (AQ23)
- 3000 m downstream of dam site (AQ24)

9. Gongri hydroelectric project

- 2000 m upstream of dam site (AQ25)
- Dam site (AQ26)
- 3000 m downstream of dam site (AQ27)

10. Nafra hydroelectric project

- 2000 m upstream of dam site (AQ28)
- Dam site (AQ29)
- 3000 m downstream of dam site (AQ30)

The location of various sampling locations is shown in Figure-6.1.

6.3 FINDINGS OF THE AQUATIC ECOLOGICAL SURVEY

6.3.1 PHYTOPLANKTONS

Phytoplanktons are the autotrophic component of the plankton community and play an important role in the primary production process in the stream ecosystems. They serve as a base of the aquatic food web, providing essential ecological function for all aquatic life. In terms of numbers, the important groups of phytoplankton comprise of diatoms, dinoflagellates, cyanobacteria, and other groups of unicellular algae. The construction of hydroelectric stations in the mountain rivers/streams will have profound impact on the planktonic communities as the planktonic organisms pass through a regulated stream with cascades of reservoirs. The species composition of two conditions viz. lake conditions and river conditions will be different. Hence, prior to dam construction it is necessary to know the composition, density and diversity of phytoplankton. Density and diversity of phytoplankton in the river water was studied for a period of six months viz., April, May, June, July, August and September 2009 by collecting samples from various sampling locations.

Phytoplankton species, their population density at various sampling sites for different projects is given in Annexure-VI. The summary of phytoplankton density observed at various sampling stations during the sampling period is given in Table-6.1.

TABLE-6.1

Phytoplankton density at various sampling stations (No. of individuals/l)

S. No.	Project	Month					
		April 2009	May 2009	June 2009	July 2009	August 2009	September 2009
1.	Utung HEP	14-17	7-15	11-24	4-7	3-10	8-10
2.	Nazong HEP	10-16	8-19	8-13	6-13	6-11	2
3.	Dibbin HEP	2-3	1-7	2-3	6-8	2-5	2-10
4.	Dimijin HEP	3-9	1-6	1-4	3-9	3-4	4-7
5.	Dikhri HEP	2-4	5-6	1-4	5-7	4	3-7
6.	Dinchang HEP	6-7	2-4	5-6	4-9	2-4	3-5
7.	Jameri HEP	18-22	20-40	8-22	5-8	12-15	8-12
8.	Dinan HEP	8-12	8-18	7-8	7-8	5-11	3-7
9.	Gongri HEP	15-18	26-40	14-17	9-12	10-18	3-8
10.	Nafra HEP	2-5	2-7	2	2-3	2-5	2-8

- Phytoplankton density ranged from 3-24 individuals/l at various sampling stations monitored for Utung hydroelectric project.
- Phytoplankton density ranged from 2-19 individuals/l at various sampling sites monitored for Nazong hydroelectric project.
- Phytoplankton density ranged from 1-10 individuals/l at various sampling sites monitored for Dibbin hydroelectric project.
- Phytoplankton density ranged from 1-9 individuals/l at various sampling sites monitored for Dimijin hydroelectric project.
- Phytoplankton density ranged from 1-7 individuals/l at various stations monitored for Dikhri hydroelectric project.
- Phytoplankton density ranged from 5-40 individuals/l at various sampling stations monitored for Jameri hydroelectric project.
- Phytoplankton density ranged from 3-18 individuals/l at various sampling sites monitored for Dinan hydroelectric project..
- Phytoplankton density ranged from 3-40 individuals/l at various sampling sites monitored for Gongri hydroelectric project.

- Phytoplankton density ranged from 2-8 individuals/l at various sampling sites monitored for Nafra hydroelectric project.

In general, phytoplankton density was higher in the months of April and May in comparison to other months. In general, the phytoplankton density and diversity was lower in the project sites located in the higher elevations compared to that of lower elevations (Refer Table-6.1). Analysis of variance showed that total density of phytoplankton differed significantly between different projects but did not differ between different sites in each project.

The phytoplankton species in the Bichom basin belonged to three classes i.e. Bacillariophyceae, Chlorophyceae and Cyanophyceae. Some of the dominant phytoplanktons found in the Bichom river basin were *Actinastrum*, *Chlorella*, *Cymbella cistula* and *Neidium*. Members of Bacillariophyceae dominated the planktonic community in the upper reaches of the Bichom river basin such as Utung, Nazong and Dikhri.

The diversity of phytoplanktons at various sampling locations during the study period is given in Tables-6.2 to 6.7.

TABLE-6.2

Diversity of phytoplanktons at various sampling locations in April 2009

Diversity indices	**Utung**			**Nazong**			**Dibbin**		
Taxa	6	10	2	2	2	5	2	3	2
Individuals	14	17	3	3	3	10	3	3	2
Shannon's diversity	1.71	2.20	0.64	0.64	0.64	1.51	0.64	1.10	0.69
Simpson's index	0.81	0.88	0.44	0.44	0.44	0.76	0.44	0.67	0.50
Equitability	0.95	0.96	0.92	0.92	0.92	0.94	0.92	1.00	1.00
	Dimijin			**Dikhri**			**Dinchang**		
Taxa	4	6	3	2	3	2	5	7	2
Individuals	5	9	3	2	4	2	6	7	6
Shannon's diversity	1.33	1.68	1.10	0.69	1.04	0.69	1.56	1.95	0.45
Simpson's index	0.72	0.79	0.67	0.50	0.63	0.50	0.78	0.86	0.28
Equitability	0.96	0.94	1.00	1.00	0.95	1.00	0.97	1.00	0.65

	Jameri			**Dinan**		
Taxa	6	5	3	5	5	3
Individuals	22	17	18	11	12	8
Shannon's diversity	1.31	1.15	0.83	1.41	1.52	1.08
Simpson's index	0.64	0.59	0.51	0.71	0.76	0.66
Equitability	0.73	0.72	0.75	0.88	0.94	0.99
	Gongri			**Nafra**		
Taxa	9	7	4	2	4	2
Individuals	15	18	15	2	5	2
Shannon's diversity	2.12	1.67	1.24	0.69	1.33	0.69
Simpson's index	0.87	0.77	0.68	0.50	0.72	0.50
Equitability	0.96	0.86	0.89	1.00	0.96	1.00

TABLE-6.3
Diversity of phytoplanktons at various sampling locations in May 2009

Diversity indices	Utung			Nazong			Dibbin		
Taxa	4	6	4	2	7	6	2	6	1
Individuals	7	15	9	8	19	12	2	7	1
Shannon's diversity	1.28	1.68	1.15	0.69	1.91	1.58	0.69	1.75	0.00
Simpson's index	0.69	0.79	0.62	0.50	0.85	0.75	0.50	0.82	0.00
Equitability	0.92	0.93	0.83	1.00	0.98	0.88	1.00	0.98	0.00
Diversity indices	**Dimijin**			**Dikhri**			**Dinchang**		
Taxa	3	4	1	2	3	3	3	3	2
Individuals	4	6	1	5	6	5	4	3	2
Shannon's diversity	1.04	1.33	0.00	0.67	1.01	1.06	1.04	1.10	0.69
Simpson's index	0.63	0.72	0.00	0.48	0.61	0.64	0.63	0.67	0.50
Equitability	0.95	0.96	0.00	0.97	0.92	0.96	0.95	1.00	1.00

Diversity indices	Jameri			Dinan		
Taxa	11	5	10	2	5	4
Individuals	30	20	40	2	14	8
Shannon's diversity	2.13	1.44	2.04	0.69	1.33	1.32
Simpson's index	0.86	0.74	0.84	0.50	0.67	0.72
Equitability	0.89	0.90	0.88	1.00	0.83	0.95
Diversity indices	**Gongri**			**Nafra**		
Taxa	13	8	10	2	6	2
Individuals	40	26	37	2	7	2
Shannon's diversity	2.34	1.87	2.12	0.69	1.75	0.69
Simpson's index	0.89	0.83	0.86	0.50	0.82	0.50
Equitability	0.91	0.90	0.92	1.00	0.98	1.00

TABLE-6.4
Diversity of phytoplanktons at various sampling locations in June 2009

Diversity indices	Utung			Nazong			Dibbin		
Taxa	9	8	4	3	4	6	2	3	2
Individuals	24	11	19	8	8	13	3	3	2
Shannon's diversity	1.68	1.89	0.99	1.04	1.07	1.53	0.64	1.10	0.69
Simpson's index	0.71	0.81	0.56	0.63	0.56	0.72	0.44	0.67	0.50
Equitability	0.77	0.91	0.71	0.95	0.77	0.85	0.92	1.00	1.00
Diversity indices	**Dimijin**			**Dikhri**			**Dinchang**		
Taxa	2	3	1	2	3	1	4	5	2
Individuals	2	4	1	2	4	1	5	5	6
Shannon's diversity	0.69	1.04	0.00	0.69	1.04	0.00	1.33	1.61	0.45
Simpson's index	0.50	0.63	0.00	0.50	0.63	0.00	0.72	0.80	0.28
Equitability	1.00	0.95	0.00	1.00	0.95	0.00	0.96	1.00	0.65

Diversity indices	Jameri			Dinan		
Taxa	6	5	3	3	6	2
Individuals	22	8	18	8	8	7
Shannon's diversity	1.31	1.39	0.83	0.74	1.73	0.60
Simpson's index	0.64	0.69	0.51	0.41	0.81	0.41
Equitability	0.73	0.86	0.75	0.67	0.97	0.86

Diversity indices	Gongri			Nafra		
Taxa	8	6	4	2	2	2
Individuals	14	17	15	2	2	2
Shannon's diversity	2.01	1.54	1.24	0.69	0.69	0.69
Simpson's index	0.86	0.74	0.68	0.50	0.50	0.50
Equitability	0.97	0.86	0.89	1.00	1.00	1.00

TABLE-6.5
Diversity of phytoplanktons at various sampling locations in July 2009

Diversity indices	Utung			Nazong			Dibbin		
Taxa	3	4	1	4	6	3	3	3	3
Individuals	5	7	4	9	13	6	6	6	8
Shannon's diversity	1.06	1.35	0.00	1.15	1.59	1.01	1.01	1.01	0.90
Simpson's index	0.64	0.73	0.00	0.62	0.76	0.61	0.61	0.61	0.53
Equitability	0.96	0.98	0.00	0.83	0.89	0.92	0.92	0.92	0.82
Diversity indices	**Dimijin**			**Dikhri**			**Dinchang**		
Taxa	4	6	3	2	2	2	3	1	3
Individuals	6	9	3	5	5	7	6	4	9
Shannon's diversity	1.33	1.68	1.10	0.67	0.67	0.68	1.01	0.00	1.06
Simpson's index	0.72	0.79	0.67	0.48	0.48	0.49	0.61	0.00	0.64
Equitability	0.96	0.94	1.00	0.97	0.97	0.99	0.92	0.00	0.97

Diversity indices	Jameri			Dinan		
Taxa	2	2	3	3	2	3
Individuals	5	6	8	7	7	8
Shannon's diversity	0.67	0.64	0.97	0.80	0.68	1.08
Simpson's index	0.48	0.44	0.59	0.45	0.49	0.66
Equitability	0.97	0.92	0.89	0.72	0.99	0.99
Diversity indices	**Gongri**			**Nafra**		
Taxa	7	4	3	2	2	3
Individuals	12	11	9	2	2	3
Shannon's diversity	1.86	1.03	0.94	0.69	0.69	1.10
Simpson's index	0.83	0.55	0.57	0.50	0.50	0.67
Equitability	0.96	0.75	0.85	1.00	1.00	1.00

TABLE-6.6
Diversity of phytoplanktons at various sampling locations in August 2009

Diversity indices	Utung			Nazong			Dibbin		
Taxa	3	3	2	2	4	4	2	4	2
Individuals	6	10	3	8	11	6	2	5	2
Shannon's diversity	1.01	1.03	0.64	0.69	1.34	1.33	0.69	1.33	0.69
Simpson's index	0.61	0.62	0.44	0.50	0.73	0.72	0.50	0.72	0.50
Equitability	0.92	0.94	0.92	1.00	0.97	0.96	1.00	0.96	1.00
Diversity indices	**Dimijin**			**Dikhri**			**Dinchang**		
Taxa	3	2	1	2	2	3	3	2	3
Individuals	4	3	3	4	4	4	4	2	3
Shannon's diversity	1.04	0.64	0.00	0.69	0.56	1.04	1.04	0.69	1.10
Simpson's index	0.63	0.44	0.00	0.50	0.38	0.63	0.63	0.50	0.67

Equitability	0.95	0.92	0.00	1.00	0.81	0.95	0.95	1.00	1.00

Diversity indices	Jameri			Dinan		
Taxa	7	4	4	6	3	3
Individuals	15	13	12	11	10	5
Shannon's diversity	1.84	1.27	1.20	1.72	0.80	1.06
Simpson's index	0.83	0.70	0.65	0.81	0.46	0.64
Equitability	0.95	0.91	0.86	0.96	0.73	0.96
Diversity indices	**Gongri**			**Nafra**		
Taxa	7	4	4	2	4	2
Individuals	15	10	18	5	4	2
Shannon's diversity	1.77	1.28	1.22	0.50	1.39	0.69
Simpson's index	0.80	0.70	0.67	0.32	0.75	0.50
Equitability	0.91	0.92	0.88	0.72	1.00	1.00

TABLE-6.7
Diversity of phytoplanktons at various sampling locations in September 2009

Diversity indices	Utung			Nazong			Dibbin		
Taxa	5	5	3	1	2	2	1	2	3
Individuals	10	8	9	2	2	2	2	2	10
Shannon's diversity	1.51	1.39	0.85	0.00	0.69	0.69	0.00	0.69	0.90
Simpson's index	0.76	0.69	0.49	0.00	0.50	0.50	0.00	0.50	0.54
Equitability	0.94	0.86	0.77	0.00	1.00	1.00	0.00	1.00	0.82
Diversity indices	**Dimijin**			**Dikhri**			**Dinchang**		
Taxa	3	2	2	3	2	2	3	3	2
Individuals	7	5	4	6	3	7	5	3	5
Shannon's diversity	0.96	0.67	0.56	1.01	0.64	0.60	1.06	1.10	0.67
Simpson's index	0.57	0.48	0.38	0.61	0.44	0.41	0.64	0.67	0.48
Equitability	0.87	0.97	0.81	0.92	0.92	0.86	0.96	1.00	0.97

Diversity indices	Jameri			Dinan		
Taxa	5	5	3	3	2	3
Individuals	12	8	8	7	3	6
Shannon's diversity	1.42	1.39	0.74	0.96	0.64	1.01
Simpson's index	0.72	0.69	0.41	0.57	0.44	0.61
Equitability	0.88	0.86	0.67	0.87	0.92	0.92
Diversity indices	**Gongri**			**Nafra**		
Taxa	5	2	1	1	3	3
Individuals	7	8	3	2	8	8
Shannon's diversity	1.55	0.38	0.00	0.00	0.97	0.90
Simpson's index	0.78	0.22	0.00	0.00	0.59	0.53
Equitability	0.96	0.54	0.00	0.00	0.89	0.82

- The highest number of taxa observed as a part of monitoring was 11 at the monitoring station located 2000 m upstream of Jameri hydroelectric projects in the month of May 2009.

- The highest number of individuals observed was 40 at monitoring station located 3000 m downstream of Jameri hydroelectric project.
- In general, number of taxa and individuals was observed to be higher at sampling stations, in vicinity of projects located at lower elevations as compared to the projects located at higher elevations.

6.3.2 ZOOPLANKTONS

Zooplanktons are the heterotrophic component of the plankton community, and is a broad categorization spanning a range of organism sizes that includes both small protozoans and large metazoans. Through their consumption and processing of phytoplankton (and other food sources), zooplanktons play an important role in aquatic food webs, both as a resource for consumers on higher trophic levels (including fish), and as a conduit for packaging the organic material in the biological pump. Since they are typically of small size, zooplankton can respond relatively rapidly to increases in phytoplankton abundance, for instance, during the spring bloom. The construction of hydroelectric stations in the mountain rivers/streams will have profound impact on the planktonic communities as the planktonic organisms pass through a regulated stream with cascades of reservoirs. The species composition of two conditions viz. lake conditions and river conditions will be different. Hence, prior to dam construction it is necessary to know the composition, density and diversity of zooplankton. Density and diversity of phytoplankton in the river water was studied for a period of six months viz., April, May, June, July, August and September 2009 by collecting the samples from various sites outlined in Section-6.2.

Zooplankton species and their population density in different project sites are summarized in Annexure - VII. The density and diversity of zooplankton species was highest in all the sites in April and it showed decreasing trend in the months of May, June, July, August and September. Analysis of variance showed that the total density of zooplankton differed significantly between different projects and sampling periods ($p<0.05$) but did not differ significantly between different sites in each project. Zooplankton community in Bichom river basin was dominated by members of Rotifera and Cladocera. The dominant genera were *Difflugia*, *Colurella*, *Testudinella*, *Keratella* and *Polyarthra*, although their dominance varied across sites and seasons in the Bichom river basin (Annexure -VII). The summary of zooplankton density observed at various sampling locations during the study period is given in Table-6.8.

TABLE-6.8
Zooplankton Density at various sampling stations (No. of individuals/l)

S. No.	Project	Month					
		April 2009	May 2009	June 2009	July 2009	August 2009	September 2009
1.	Utung HEP	2-3	2-3	8-10	2-3	1-3	6-8
2.	Nazong HEP	2-3	3-7	7-9	1-3	3-5	1-4
3.	Dibbin HEP	19-26	13-19	12-16	6-7	5-7	2-4
4.	Dimijin HEP	6-16	3-9	7-9	3-9	3-9	1-4
5.	Dikhri HEP	10-12	5-12	6-11	4-10	3-9	4-5
6.	Dinchang HEP	10-18	5-16	9-17	4-6	3-4	2-4
7.	Jameri HEP	23-26	16-20	11-13	9-17	6-7	3-5
8.	Dinan HEP	2-6	4-9	6-12	2-4	4-9	1-3
9.	Gongri HEP	18-27	14-18	12-15	5-14	4-11	3-8
10.	Nafra HEP	6-12	4-6	5-10	3-8	3-8	1-2

- Zooplankton density ranged from 1-10 individuals/l at various sampling stations monitored for Utung hydroelectric project.
- Zooplankton density ranged from 1-9 individuals/l at various sampling sites monitored for Nazong hydroelectric project.
- Zooplankton density ranged from 2-26 individuals/l at various sampling sites monitored for Dibbin hydroelectric project.
- Zooplankton density ranged from 1-16 individuals/l at various sampling sites monitored for Dimijin hydroelectric project.
- Zooplankton density ranged from 3-12 individuals/l at various stations monitored for Dikhri hydroelectric project.
- Zooplankton density ranged from 3-26 individuals/l at various sampling stations monitored for Jameri hydroelectric project.
- Zooplankton density ranged from 1-12 individuals/l at various sampling sites monitored for Dinan hydroelectric project.
- Zooplankton density ranged from 3-27 individuals/l at various sampling sites monitored for Gongri hydroelectric project.
- Zooplankton density ranged from 1-12 individuals/l at various sampling sites monitored for Nafra hydroelectric project.

The zooplankton density and diversity was observed to be higher in the month of April, May and June as compared to other months. The diversity of zooplanktons at various sampling locations during the study period is given in Tables-6.9 to 6.14.

TABLE-6.9
Diversity of zooplanktons in the month of April 2009

Diversity indices	Utung			Nazong			Dibbin		
Taxa	2	2	1	2	1	2	7	6	6
Individuals	2	2	3	2	3	2	22	26	19
Shannon's diversity	0.69	0.69	0.00	0.69	0.00	0.69	1.72	1.60	1.61
Simpson's index	0.50	0.50	0.00	0.50	0.00	0.50	0.79	0.77	0.78
Equitability	1.00	1.00	0.00	1.00	0.00	1.00	0.88	0.89	0.90

Diversity indices	Dimijin			Dikhri			Dinchang		
Taxa	5	3	4	4	6	4	10	7	6
Individuals	16	8	6	11	10	12	16	18	10
Shannon's diversity	1.33	0.90	1.24	1.16	1.61	1.27	2.10	1.61	1.70
Simpson's index	0.69	0.53	0.67	0.64	0.76	0.69	0.84	0.75	0.80
Equitability	0.83	0.82	0.90	0.84	0.90	0.91	0.91	0.83	0.95

Diversity indices	Jameri			Dinan		
Taxa	10	8	8	3	3	2
Individuals	24	23	26	4	6	2
Shannon's diversity	2.03	1.75	1.77	1.04	1.10	0.69
Simpson's index	0.84	0.78	0.79	0.63	0.67	0.50
Equitability	0.88	0.84	0.85	0.95	1.00	1.00

Diversity indices	Gongri			Nafra		
Taxa	8	5	7	5	5	3
Individuals	19	18	27	6	12	7
Shannon's diversity	1.96	1.51	1.86	1.56	1.52	0.80
Simpson's index	0.84	0.76	0.83	0.78	0.76	0.45
Equitability	0.94	0.94	0.95	0.97	0.94	0.72

TABLE-6.10
Diversity of zooplanktons in the month of May 2009

Diversity indices	Utung			Nazong			Dibbin		
Taxa	2	2	1	2	1	2	5	4	5
Individuals	2	2	3	7	3	5	19	13	18
Shannon's diversity	0.69	0.69	0.00	0.60	0.00	0.67	1.40	1.20	1.48
Simpson's index	0.50	0.50	0.00	0.41	0.00	0.48	0.71	0.64	0.75
Equitability	1.00	1.00	0.00	0.86	0.00	0.97	0.87	0.86	0.92

Diversity indices	Dimijin			Dikhri			Dinchang		
Taxa	4	2	3	4	4	4	7	5	4
Individuals	9	3	3	11	5	12	12	16	5
Shannon's diversity	1.15	0.64	1.10	1.16	1.33	1.27	1.70	1.33	1.33
Simpson's index	0.62	0.44	0.67	0.64	0.72	0.69	0.76	0.69	0.72
Equitability	0.83	0.92	1.00	0.84	0.96	0.91	0.87	0.83	0.96

Diversity indices	Jameri			Dinan		
Taxa	8	6	6	2	2	2
Individuals	20	16	17	7	4	9
Shannon's diversity	1.72	1.33	1.56	0.60	0.69	0.64
Simpson's index	0.77	0.63	0.75	0.41	0.50	0.44
Equitability	0.83	0.74	0.87	0.86	1.00	0.92

Diversity indices	Gongri			Nafra		
Taxa	3	4	7	4	4	2
Individuals	14	15	18	4	9	6
Shannon's diversity	0.99	1.19	1.80	1.39	1.27	0.45
Simpson's index	0.60	0.64	0.81	0.75	0.69	0.28
Equitability	0.90	0.86	0.92	1.00	0.92	0.65

TABLE-6.11
Diversity of zooplanktons in the month of June 2009

Diversity indices	Utung			Nazong			Dibbin		
Taxa	3	3	3	3	3	3	6	5	5
Individuals	10	8	10	9	9	7	15	12	16
Shannon's diversity	1.03	0.97	1.03	0.94	0.85	0.96	1.64	1.56	1.39
Simpson's index	0.62	0.59	0.62	0.57	0.49	0.57	0.78	0.78	0.72
Equitability	0.94	0.89	0.94	0.85	0.77	0.87	0.92	0.97	0.86
Diversity indices	**Dimijin**			**Dikhri**			**Dinchang**		
Taxa	3	2	3	3	5	3	10	6	5
Individuals	7	7	9	6	8	11	16	17	9
Shannon's diversity	0.80	0.60	0.94	0.87	1.39	1.07	2.10	1.48	1.52
Simpson's index	0.45	0.41	0.57	0.50	0.69	0.64	0.84	0.72	0.77
Equitability	0.72	0.86	0.85	0.79	0.86	0.97	0.91	0.82	0.95

Diversity indices	Jameri			Dinan		
Taxa	8	6	6	3	3	2
Individuals	13	11	12	12	6	9
Shannon's diversity	1.89	1.59	1.58	0.92	1.10	0.64
Simpson's index	0.82	0.76	0.75	0.57	0.67	0.44
Equitability	0.91	0.89	0.88	0.84	1.00	0.92
Diversity indices	**Gongri**			**Nafra**		
Taxa	6	4	5	4	4	3
Individuals	12	12	15	5	10	7
Shannon's diversity	1.75	1.36	1.55	1.33	1.28	0.80
Simpson's index	0.82	0.74	0.77	0.72	0.70	0.45
Equitability	0.98	0.98	0.96	0.96	0.92	0.72

TABLE-6.12
Diversity of zooplanktons in the month of July 2009

Diversity indices	Utung			Nazong			Dibbin		
Taxa	2	2	1	1	1	2	3	3	3
Individuals	2	2	3	1	3	2	7	7	6
Shannon's diversity	0.69	0.69	0.00	0.00	0.00	0.69	1.00	1.08	1.01
Simpson's index	0.50	0.50	0.00	0.00	0.00	0.50	0.61	0.65	0.61
Equitability	1.00	1.00	0.00	0.00	0.00	1.00	0.91	0.98	0.92
Diversity indices	**Dimijin**			**Dikhri**			**Dinchang**		
Taxa	4	2	3	3	3	2	6	3	4
Individuals	9	3	3	10	4	4	6	4	5
Shannon's diversity	1.15	0.64	1.10	0.94	1.04	0.56	1.79	1.04	1.33
Simpson's index	0.62	0.44	0.67	0.58	0.63	0.38	0.83	0.63	0.72

Equitability	0.83	0.92	1.00	0.86	0.95	0.81	1.00	0.95	0.96

Diversity indices	Jameri			Dinan		
Taxa	7	5	5	2	2	2
Individuals	17	9	10	3	4	2
Shannon's diversity	1.68	1.43	1.56	0.64	0.69	0.69
Simpson's index	0.78	0.72	0.78	0.44	0.50	0.50
Equitability	0.86	0.89	0.97	0.92	1.00	1.00
Diversity indices	**Gongri**			**Nafra**		
Taxa	4	2	4	3	3	2
Individuals	12	5	14	3	8	6
Shannon's diversity	1.31	0.67	1.30	1.10	1.04	0.45
Simpson's index	0.71	0.48	0.70	0.67	0.63	0.28
Equitability	0.94	0.97	0.94	1.00	0.95	0.65

TABLE-6.13
Diversity of zooplanktons in the month of August 2009

Diversity indices	Utung			Nazong			Dibbin		
Taxa	2	1	1	2	1	2	2	2	2
Individuals	2	1	3	3	3	5	7	5	5
Shannon's diversity	0.69	0.00	0.00	0.64	0.00	0.67	0.60	0.67	0.67
Simpson's index	0.50	0.00	0.00	0.44	0.00	0.48	0.41	0.48	0.48
Equitability	1.00	0.00	0.00	0.92	0.00	0.97	0.86	0.97	0.97
Diversity indices	**Dimijin**			**Dikhri**			**Dinchang**		
Taxa	4	2	3	2	2	2	4	3	3
Individuals	9	3	3	9	3	4	4	4	3
Shannon's diversity	1.15	0.64	1.10	0.69	0.64	0.56	1.39	1.04	1.10
Simpson's index	0.62	0.44	0.67	0.49	0.44	0.38	0.75	0.63	0.67
Equitability	0.83	0.92	1.00	0.99	0.92	0.81	1.00	0.95	1.00

Diversity indices	Jameri			Dinan		
Taxa	6	4	4	2	2	2
Individuals	7	6	6	7	4	9
Shannon's diversity	1.75	1.24	1.33	0.60	0.69	0.64
Simpson's index	0.82	0.67	0.72	0.41	0.50	0.44
Equitability	0.98	0.90	0.96	0.86	1.00	0.92
Diversity indices	**Gongri**			**Nafra**		
Taxa	2	3	4	3	3	2
Individuals	4	7	11	3	8	6
Shannon's diversity	0.69	1.08	1.34	1.10	1.04	0.45
Simpson's index	0.50	0.65	0.73	0.67	0.63	0.28
Equitability	1.00	0.98	0.97	1.00	0.95	0.65

TABLE-6.14
Diversity of zooplanktons in the month of September 2009

Diversity indices	Utung			Nazong			Dibbin		
Taxa	2	3	2	1	1	1	2	2	3
Individuals	8	6	7	2	1	4	3	2	4
Shannon's diversity	0.66	1.01	0.60	0.00	0.00	0.00	0.64	0.69	1.04

Simpson's index	0.47	0.61	0.41	0.00	0.00	0.00	0.44	0.50	0.63
Equitability	0.95	0.92	0.86	0.00	0.00	0.00	0.92	1.00	0.95
Diversity indices	**Dimijin**			**Dikhri**			**Dinchang**		
Taxa	2	2	1	3	3	3	4	3	1
Individuals	2	4	1	4	4	5	4	4	2
Shannon's diversity	0.69	0.56	0.00	1.04	1.04	0.95	1.39	1.04	0.00
Simpson's index	0.50	0.38	0.00	0.63	0.63	0.56	0.75	0.63	0.00
Equitability	1.00	0.81	0.00	0.95	0.95	0.87	1.00	0.95	0.00

Diversity indices	**Jameri**			**Dinan**		
Taxa	4	3	2	1	1	1
Individuals	5	3	3	1	2	3
Shannon's diversity	1.33	1.10	0.64	0.00	0.00	0.00
Simpson's index	0.72	0.67	0.44	0.00	0.00	0.00
Equitability	0.96	1.00	0.92	0.00	0.00	0.00
Diversity indices	**Gongri**			**Nafra**		
Taxa	2	1	2	1	1	1
Individuals	3	3	8	1	2	1
Shannon's diversity	0.64	0.00	0.66	0.00	0.00	0.00
Simpson's index	0.44	0.00	0.47	0.00	0.00	0.00
Equitability	0.92	0.00	0.95	0.00	0.00	0.00

Highest number of taxa (10) were observed at sampling stations located 2 km upstream of Jameri and Dinchang hydroelectric project sites. Highest number of individuals (23 to 26) were observed at various monitoring stations for Jameri hydroelectric project.

6.3.3 PERIPHYTONS

Periphyton is a complex mixture of algae, cyanobacteria, heterotrophic microbes, and detritus that is attached to submerged surfaces in most aquatic ecosystems. It serves as an important food source for invertebrates, tadpoles, and some fish. It can also absorb contaminants; removing them from the water column and limiting their movement through the environment. The periphyton is also an important indicator of water quality; responses of this community to pollutants can be measured at a variety of scales representing physiological to community-level changes. Construction of concrete structures on flowing waters alter the flow and temperature regimes, hydraulics, the availability and stability of substrata, channel morphology, the riparian vegetation, and as a result, the community structure of aquatic communities. The change in flow regimes will have immense impact on the periphytic community in the stream ecosystem. Hence, prior to construction of such ubiquitous structures a preliminary assessment of the composition, density and diversity of periphytic algal community is needed. The periphytic algal components were sampled in the project sites for 6 months viz. March, April, May, July, August and September. Samples of periphytic algae were collected by scraping 1 cm^2 area of the substratum on which they were growing. The scraped algae were then put in a small container and brought to the laboratory for identification. Density of the periphytic algae was expressed in terms of cm^2.

The Periphyton densities at various sampling sites in different project sites are summarized in Annexure-VII. Periphyton communities were prominent in the months of April, May and June in the shallow, rocky and gravelly bottoms in all the project sites of Bichom river basin. However, their population became insignificant in the months of July, August and September which could be attributed to frequent flooding during these months. The common periphyton genera found in the project sites were *Nitzchia, Cymbella cistula, Hormidium, Cosmerium, Spirotaena, Gloeocapsa, Nitzchia* and *Chlorella.* Overall, 8 taxa of periphytic algae were recorded from all the sites in the Bichom river basin. Analysis of variance showed that the total density of periphytic algae did not differ significantly between different projects as well as between different sites in each project. The summary of periphyton density observed at various sampling sites is given in Table-6.15.

TABLE-6.15
Density (No. of individuals/cm^2) of periphyton at various sampling sites

S.No.	Project	Month		
		April 2009	May 2009	June 2009
1.	Utung HEP	70-160	70-140	10-70
2.	Nazong HEP	60-140	50-140	30-60
3.	Dibbin HEP	100	90-120	40-60
4.	Dimijin HEP	80-130	70-100	40-70
5.	Dikhri HEP	100-110	90-110	20-70
6.	Dinchang HEP	70-140	80-120	30
7.	Jameri HEP	30-50	70-90	20-30
8.	Dinan HEP	100-130	70-100	30-50
9.	Gongri HEP	60-100	90-120	90-120
10.	Nafra HEP	100-130	60-90	30-50

- Periphyton density ranged from 10-160 individuals/cm^2 at various sampling stations monitored for Utung hydroelectric project.
- Periphyton density ranged from 30-140 individuals/cm^2 at various sampling sites monitored for Nazong hydroelectric project.
- Periphyton density ranged from 40-120 individuals/cm^2 at various sampling sites monitored for Dibbin hydroelectric project.
- Periphyton density ranged from 40-130 individuals/cm^2 at various sampling sites monitored for Dimijin hydroelectric project.

- Periphyton density ranged from 20-110 individuals/cm^2 at various stations monitored for Dikhri hydroelectric project.
- Periphyton density ranged from 20-90 individuals/cm^2 at various sampling stations monitored for Jameri hydroelectric project.
- Periphyton density ranged from 30-130 individuals/cm^2 at various sampling sites monitored for Dinan hydroelectric project..
- Periphyton density ranged from 60-120 individuals/cm^2 at various sampling sites monitored for Gongri hydroelectric project.
- Periphyton density ranged from 30-130 individuals/cm^2 at various sampling sites monitored for Nafra hydroelectric project.

During the months of July, August and September, periphyton density could not be determined, as frequent flooding led to increase in water level and turbidity of the river water. Hence, hardly any periphyton population was found in the river. The diversity of periphytons at various sampling locations during the study period is given in Tables-6.16 to 6.18.

TABLE-6.16
Diversity of periphyton in the month of April 2009

Diversity indices	**Utung**			**Nazong**			**Dibbin**		
Taxa	4	4	4	4	4	5	5	4	4
Individuals	120	160	70	60	70	140	100	100	100
Shannon's diversity	1.20	1.28	1.28	1.33	1.28	1.44	1.51	1.33	1.17
Simpson's index	0.65	0.70	0.69	0.72	0.69	0.72	0.76	0.72	0.64
Equitability	0.86	0.92	0.92	0.96	0.92	0.89	0.94	0.96	0.84
Diversity indices	**Dimijin**			**Dikhri**			**Dinchang**		
Taxa	3	4	4	4	4	4	5	2	3
Individuals	80	90	130	100	110	100	140	100	70
Shannon's diversity	0.90	1.15	1.27	1.22	1.24	1.17	1.47	0.69	1.08
Simpson's index	0.53	0.62	0.69	0.66	0.68	0.64	0.74	0.50	0.65
Equitability	0.82	0.83	0.92	0.88	0.90	0.84	0.91	1.00	0.98

	Jameri			**Dinan**		
Taxa	2	2	2	5	3	4
Individuals	40	50	30	110	100	130
Shannon's diversity	0.56	0.50	0.64	1.41	1.03	1.27
Simpson's index	0.38	0.32	0.44	0.71	0.62	0.69
Equitability	0.81	0.72	0.92	0.88	0.94	0.92
Diversity indices	**Gongri**			**Nafra**		
Taxa	4	3	4	3	4	3
Individuals	100	90	60	100	130	100
Shannon's diversity	1.17	1.00	1.24	0.90	1.35	1.03
Simpson's index	0.64	0.59	0.67	0.54	0.73	0.62
Equitability	0.84	0.91	0.90	0.82	0.98	0.94

TABLE-6.17
Diversity of periphyton in the month of May 2009

Diversity indices	Utung			Nazong			Dibbin		
Taxa	4	3	4	4	4	4	4	3	4
Individuals	70	100	140	140	90	50	120	90	90
Shannon's diversity	1.28	0.95	1.33	1.20	1.37	1.33	1.20	1.00	1.15
Simpson's index	0.69	0.56	0.72	0.66	0.74	0.72	0.65	0.59	0.62
Equitability	0.92	0.87	0.96	0.86	0.99	0.96	0.86	0.91	0.83
Diversity indices	**Dimijin**			**Dikhri**			**Dinchang**		
Taxa	4	4	4	3	3	4	4	3	3
Individuals	70	80	100	110	90	100	120	80	100
Shannon's diversity	1.28	1.32	1.22	0.92	1.06	1.22	1.20	0.97	0.95
Simpson's index	0.69	0.72	0.66	0.56	0.64	0.66	0.65	0.59	0.56
Equitability	0.92	0.95	0.88	0.83	0.97	0.88	0.86	0.89	0.87

Diversity indices	Jameri			Dinan		
Taxa	2	2	3	4	3	3
Individuals	60	90	70	70	100	80
Shannon's diversity	0.69	0.69	1.08	1.28	1.03	1.04
Simpson's index	0.50	0.49	0.65	0.69	0.62	0.63
Equitability	1.00	0.99	0.98	0.92	0.94	0.95
Diversity indices	**Gongri**			**Nafra**		
Taxa	4	4	4	2	3	2
Individuals	120	90	110	80	90	60
Shannon's diversity	1.24	1.15	1.12	0.66	1.06	0.45
Simpson's index	0.68	0.62	0.61	0.47	0.64	0.28
Equitability	0.89	0.83	0.81	0.95	0.97	0.65

TABLE-6.18
Diversity of periphyton in the month of June 2009

Diversity indices	Utung			Nazong			Dibbin		
Taxa	2	1	2	2	2	3	6	5	5
Individuals	70	10	40	30	30	60	15	12	16
Shannon's diversity	0.60	0.00	0.56	0.64	0.64	1.01	1.64	1.56	1.39
Simpson's index	0.41	0.00	0.38	0.44	0.44	0.61	0.78	0.78	0.72
Equitability	0.86	0.00	0.81	0.92	0.92	0.92	0.92	0.97	0.86
Diversity indices	**Dimijin**			**Dikhri**			**Dinchang**		
Taxa	3	2	3	3	5	3	10	6	5
Individuals	7	7	9	6	8	11	16	17	9
Shannon's diversity	0.80	0.60	0.94	0.87	1.39	1.07	2.10	1.48	1.52
Simpson's index	0.45	0.41	0.57	0.50	0.69	0.64	0.84	0.72	0.77
Equitability	0.72	0.86	0.85	0.79	0.86	0.97	0.91	0.82	0.95

Diversity indices	Jameri			Dinan		
Taxa	8	6	6	3	3	2
Individuals	13	11	12	12	6	9
Shannon's diversity	1.89	1.59	1.58	0.92	1.10	0.64
Simpson's index	0.82	0.76	0.75	0.57	0.67	0.44

Equitability	0.91	0.89	0.88	0.84	1.00	0.92
Diversity indices	**Gongri**			**Nafra**		
Taxa	6	4	5	4	4	3
Individuals	12	12	15	5	10	7
Shannon's diversity	1.75	1.36	1.55	1.33	1.28	0.80
Simpson's index	0.82	0.74	0.77	0.72	0.70	0.45
Equitability	0.98	0.98	0.96	0.96	0.92	0.72

6.3.4 BENTHIC INVERTEBRATES

Benthic invertebrates are organisms that live on the bottom of a water body (or in the sediment) and have no backbone. Their size spans 6-7 orders of magnitude and they range from microscopic (*e.g.* microinvertebrates, <10 microns) to a few tens of centimetres or more in length (*e.g.* macroinvertebrates, >50 cm). Benthic invertebrates live either on the surface of bedforms (*e.g.* rock, coral or sediment - epibenthos) or within sedimentary deposits (infauna), and comprise several types of feeding groups e.g. deposit-feeders, filter-feeders, grazers and predators. The abundance, diversity, biomass and species composition of benthic invertebrates can be used as indicators of changing environmental conditions. Construction of dams can impact the benthic invertebrates by alteration of the physical characteristics of the river which includes substratum, current velocity, food availability, water temperature, dissolved oxygen concentration, and water chemistry. Prior to commissioning of power projects on a river an enumeration of the benthic invertebrates in the proposed site is necessary. In the present study, an enumeration of benthic invertebrates was done in order to know their composition, density and diversity in different reaches of the river.

Invertebrate species, their population density in different project sites are summarized Annexure-IX. Bichom river basin showed a high diversity of benthic invertebrates with overall 29 taxa of invertebrates belonging to 8 orders were recorded from all the project sites. Members of Ephemeroptera, Trichoptera, Plecoptera and Diptera dominated the invertebrate group in the project sites. Other orders included Coleoptera, Hemiptera, Megaloptera and Odonata. The families of macroinvertebrates included Baetidae, Chironomidae, Corixidae, Corydalidae, Dytiscidae, Ecdyonuridae, Elmidae, Ephemerellidae, Gomphidae, Gyrinidae, Heptageniidae, Hydropsychidae, Leptoceridae, Leptophlebiidae, Limoniidae, Molannidae, Nemouridae, Peltoperlidae, Perlidae, Perlodideae, Philopotamidae, Polycentropidae, Psychomyiidae, Rhagionidae, Rhyacophilidae, Simulidae, Tabanidae, Taeniopterygidae and Tipulidae. Analysis of variance showed that the total density of invertebrates differ significantly between the projects and sampling periods ($p<0.05$). However, significant differences between different sites in each project were not detected. The diversity and abundance of macroinvertebrates was higher in the months of March, April and May while it decreased in the rainy months of July, August and September. The density and abundance of macroinvertebrates in the later months decreased due to increased water flow regime which washed off the macroinvertebrates and their habitats. The summary of density of benthic invertebrates at various sampling sites is given in Table-6.19.

TABLE-6.19
Density of Benthic invertebrates at various sampling sites (No. of individuals/m^2)

S. No.	Project	Month					
		April 2009	May 2009	June 2009	July 2009	August 2009	September 2009
1.	Utung HEP	2-3	11-14	7-12	4-6	5-11	6-7
2.	Nazong HEP	2-3	9-17	7-17	5-7	6-13	7-10
3.	Dibbin HEP	19-32	11-27	15-21	1-2	7-9	4-5
4.	Dimijin HEP	15-52	13-32	11-20	2-4	6-9	4-7
5.	Dikhri HEP	10-12	5-11	5-11	1-4	2-6	2-7
6.	Dinchang HEP	10-18	5-16	8-15	2-6	2-10	3-4
7.	Jameri HEP	38-91	7-29	15-18	2-5	3-8	2-6
8.	Dinan HEP	2-6	13-16	2-7	7-8	5-11	2-6
9.	Gongri HEP	27-61	10-20	10-23	13-15	5-13	6-8
10.	Nafra HEP	6-12	2-10	2-4	2-8	4-7	3-7

- Benthic invertebrates density ranged from 2-14 individuals/m^2 at various sampling stations monitored for Utung hydroelectric project.
- Benthic invertebrates density ranged from 2-17 individuals/m^2 at various sampling sites monitored for Nazong hydroelectric project.
- Benthic invertebrates density ranged from 1-32 individuals/m^2 at various sampling sites monitored for Dibbin hydroelectric project.
- Benthic invertebrates density ranged from 2-52 individuals/m^2 at various sampling sites monitored for Dimijin hydroelectric project.
- Benthic invertebrates density ranged from 1-12 individuals/m^2 at various stations monitored for Dikhri hydroelectric project.
- Benthic invertebrates density ranged from 2-91 individuals/m^2 at various sampling stations monitored for Jameri hydroelectric project.
- Benthic invertebrates density ranged from 2-16 individuals/m^2 at various sampling sites monitored for Dinan hydroelectric project.
- Benthic invertebrates density ranged from 5-61 individuals/m^2 at various sampling sites monitored for Gongri hydroelectric project.

- Benthic invertebrates density ranged from 2-12 individuals/m^2 at various sampling sites monitored for Nafra hydroelectric project.

In general, the density of benthic invertebrates was higher in the months of April, May and June as compared to the other months. The diversity of benthic invertebrates at various sampling locations during the study period is given in Tables-6.20 to 6.25.

TABLE-6.20
Diversity of benthic invertebrates in the month of April 2009

Diversity indices	**Utung**			**Nazong**			**Dibbin**		
Taxa	2	2	1	2	1	2	7	6	6
Individuals	2	2	3	2	3	2	32	28	19
Shannon's diversity	0.69	0.69	0.00	0.69	0.00	0.69	1.54	1.56	1.61
Simpson's index	0.50	0.50	0.00	0.50	0.00	0.50	0.72	0.75	0.78
Equitability	1.00	1.00	0.00	1.00	0.00	1.00	0.79	0.87	0.90
Diversity indices	**Dimijin**			**Dikhri**			**Dinchang**		
Taxa	5	3	4	4	6	4	10	7	6
Individuals	52	26	15	11	10	12	16	18	10
Shannon's diversity	0.66	0.43	0.72	1.16	1.61	1.27	2.10	1.61	1.70
Simpson's index	0.30	0.21	0.35	0.64	0.76	0.69	0.84	0.75	0.80
Equitability	0.41	0.39	0.52	0.84	0.90	0.91	0.91	0.83	0.95

Diversity indices	**Jameri**			**Dinan**		
Taxa	10	8	8	3	3	2
Individuals	91	44	38	4	6	2
Shannon's diversity	1.23	1.42	1.59	1.04	1.10	0.69
Simpson's index	0.59	0.66	0.74	0.63	0.67	0.50
Equitability	0.53	0.68	0.76	0.95	1.00	1.00
Diversity indices	**Gongri**			**Nafra**		
Taxa	9	8	7	5	5	3
Individuals	61	42	27	6	12	7
Shannon's diversity	1.65	1.59	1.86	1.56	1.52	0.80
Simpson's index	0.76	0.74	0.83	0.78	0.76	0.45
Equitability	0.75	0.76	0.95	0.97	0.94	0.72

TABLE-6.21
Diversity of benthic invertebrates in the month of May 2009

Diversity indices	**Utung**			**Nazong**			**Dibbin**		
Taxa	5	4	3	7	4	6	1	5	4
Individuals	11	14	11	14	9	17	2	10	6
Shannon's diversity	1.41	1.33	0.93	1.81	1.15	1.68	0.00	1.36	1.24
Simpson's index	0.71	0.72	0.58	0.82	0.62	0.80	0.00	0.68	0.67
Equitability	0.88	0.96	0.85	0.93	0.83	0.94	0.00	0.84	0.90
Diversity indices	**Dimijin**			**Dikhri**			**Dinchang**		
Taxa	3	6	2	3	5	2	5	4	3
Individuals	11	27	12	5	11	6	32	21	13

Shannon's diversity	0.86	1.50	0.64	1.06	1.47	0.45	0.92	1.10	0.54
Simpson's index	0.51	0.74	0.44	0.64	0.74	0.28	0.45	0.60	0.27
Equitability	0.78	0.84	0.92	0.96	0.91	0.65	0.57	0.79	0.49

Diversity indices	**Jameri**			**Dinan**		
Taxa	9	4	9	4	6	7
Individuals	29	7	14	16	15	13
Shannon's diversity	2.00	1.28	2.05	1.37	1.68	1.63
Simpson's index	0.84	0.69	0.85	0.74	0.79	0.73
Equitability	0.91	0.92	0.93	0.99	0.93	0.84
Diversity indices	**Gongri**			**Nafra**		
Taxa	7	3	4	10	5	5
Individuals	20	10	14	16	5	5
Shannon's diversity	1.73	1.03	1.30	2.10	1.61	1.61
Simpson's index	0.80	0.62	0.70	0.84	0.80	0.80
Equitability	0.89	0.94	0.94	0.91	1.00	1.00

TABLE-6.22
Diversity of benthic invertebrates in the month of June 2009

Diversity indices	**Utung**			**Nazong**			**Dibbin**		
Taxa	3	6	3	3	6	3	5	4	4
Individuals	7	12	9	10	17	7	21	19	15
Shannon's diversity	1.08	1.71	1.00	0.95	1.69	1.08	1.06	1.12	1.24
Simpson's index	0.65	0.81	0.59	0.56	0.80	0.65	0.52	0.60	0.68
Equitability	0.98	0.95	0.91	0.87	0.94	0.98	0.66	0.81	0.89
Diversity indices	**Dimijin**			**Dikhri**			**Dinchang**		
Taxa	2	2	2	2	4	3	6	4	4
Individuals	20	11	13	5	7	11	12	15	8
Shannon's diversity	0.56	0.47	0.27	0.50	1.15	1.07	1.58	1.17	1.32
Simpson's index	0.38	0.30	0.14	0.32	0.61	0.64	0.75	0.65	0.72
Equitability	0.81	0.68	0.39	0.72	0.83	0.97	0.88	0.84	0.95

Diversity indices	**Jameri**			**Dinan**		
Taxa	5	3	4	2	1	2
Individuals	16	18	15	7	2	7
Shannon's diversity	0.91	0.73	0.86	0.68	0.00	0.68
Simpson's index	0.42	0.43	0.44	0.49	0.00	0.49
Equitability	0.56	0.66	0.62	0.99	0.00	0.99
Diversity indices	**Gongri**			**Nafra**		
Taxa	4	3	3	2	2	2
Individuals	14	23	10	3	4	2
Shannon's diversity	1.03	0.81	1.03	0.64	0.56	0.69
Simpson's index	0.54	0.51	0.62	0.44	0.38	0.50
Equitability	0.74	0.73	0.94	0.92	0.81	1.00

TABLE-6.23
Diversity of benthic invertebrates in the month of July 2009

Diversity indices	Utung			Nazong			Dibbin		
Taxa	3	3	3	2	3	3	1	2	1
Individuals	6	4	6	5	7	6	1	2	1
Shannon's diversity	1.01	1.04	1.01	0.67	0.80	1.01	0.00	0.69	0.00
Simpson's index	0.61	0.63	0.61	0.48	0.45	0.61	0.00	0.50	0.00
Equitability	0.92	0.95	0.92	0.97	0.72	0.92	0.00	1.00	0.00
Diversity indices	**Dimijin**			**Dikhri**			**Dinchang**		
Taxa	2	3	2	1	2	1	2	4	2
Individuals	3	4	2	1	4	1	2	6	2
Shannon's diversity	0.64	1.04	0.69	0.00	0.69	0.00	0.69	1.33	0.69
Simpson's index	0.44	0.63	0.50	0.00	0.50	0.00	0.50	0.72	0.50
Equitability	0.92	0.95	1.00	0.00	1.00	0.00	1.00	0.96	1.00

Diversity indices	Jameri			Dinan		
Taxa	2	2	2	3	3	3
Individuals	2	3	5	8	7	8
Shannon's diversity	0.69	0.64	0.50	1.08	1.08	1.04
Simpson's index	0.50	0.44	0.32	0.66	0.65	0.63
Equitability	1.00	0.92	0.72	0.99	0.98	0.95
Diversity indices	**Gongri**			**Nafra**		
Taxa	4	4	4	3	5	2
Individuals	15	13	14	4	8	2
Shannon's diversity	1.25	1.22	1.30	1.04	1.49	0.69
Simpson's index	0.68	0.67	0.70	0.63	0.75	0.50
Equitability	0.90	0.88	0.94	0.95	0.93	1.00

TABLE-6.24
Diversity of benthic invertebrates in the month of August 2009

Diversity indices	Utung			Nazong			Dibbin		
Taxa	3	2	1	5	2	2	2	2	2
Individuals	4	9	5	11	2	5	8	9	7
Shannon's diversity	1.04	0.69	0.00	1.47	0.69	0.67	0.38	0.64	0.60
Simpson's index	0.63	0.49	0.00	0.74	0.50	0.48	0.22	0.44	0.41
Equitability	0.95	0.99	0.00	0.91	1.00	0.97	0.54	0.92	0.86
Diversity indices	**Dimijin**			**Dikhri**			**Dinchang**		
Taxa	3	2	2	2	2	2	5	2	2
Individuals	9	8	6	3	2	6	10	2	4
Shannon's diversity	1.06	0.69	0.64	0.64	0.69	0.45	1.36	0.69	0.56
Simpson's index	0.64	0.50	0.44	0.44	0.50	0.28	0.68	0.50	0.38
Equitability	0.97	1.00	0.92	0.92	1.00	0.65	0.84	1.00	0.81

Diversity indices	Jameri			Dinan		
Taxa	3	1	4	3	3	4
Individuals	7	3	8	11	6	5
Shannon's diversity	1.08	0.00	1.21	1.09	1.10	1.33
Simpson's index	0.65	0.00	0.66	0.66	0.67	0.72

Equitability	0.98	0.00	0.88	0.99	1.00	0.96
Diversity indices	**Gongri**			**Nafra**		
Taxa	5	2	2	3	2	2
Individuals	13	5	6	6	7	4
Shannon's diversity	1.44	0.67	0.69	1.01	0.60	0.56
Simpson's index	0.73	0.48	0.50	0.61	0.41	0.38
Equitability	0.89	0.97	1.00	0.92	0.86	0.81

TABLE-6.25

Diversity of benthic invertebrates in the month of September 2009

Diversity indices	**Utung**			**Nazong**			**Dibbin**		
Taxa	3	3	2	3	3	3	2	2	2
Individuals	7	6	7	10	9	7	5	3	4
Shannon's diversity	1.08	1.01	0.60	0.95	0.97	1.08	0.67	0.64	0.69
Simpson's index	0.65	0.61	0.41	0.56	0.59	0.65	0.48	0.44	0.50
Equitability	0.98	0.92	0.86	0.87	0.88	0.98	0.97	0.92	1.00
Diversity indices	**Dimijin**			**Dikhri**			**Dinchang**		
Taxa	2	2	3	2	1	2	2	2	1
Individuals	4	5	7	7	2	7	4	3	3
Shannon's diversity	0.69	0.50	1.08	0.68	0.00	0.60	0.69	0.64	0.00
Simpson's index	0.50	0.32	0.65	0.49	0.00	0.41	0.50	0.44	0.00
Equitability	1.00	0.72	0.98	0.99	0.00	0.86	1.00	0.92	0.00

Diversity indices	**Jameri**			**Dinan**		
Taxa	2	2	1	2	2	1
Individuals	6	4	2	6	5	2
Shannon's diversity	0.64	0.69	0.00	0.69	0.67	0.00
Simpson's index	0.44	0.50	0.00	0.50	0.48	0.00
Equitability	0.92	1.00	0.00	1.00	0.97	0.00
Diversity indices	**Gongri**			**Nafra**		
Taxa	3	2	2	2	4	2
Individuals	8	7	6	3	7	3
Shannon's diversity	1.04	0.60	0.69	0.64	1.28	0.64
Simpson's index	0.63	0.41	0.50	0.44	0.69	0.44
Equitability	0.95	0.86	1.00	0.92	0.92	0.92

6.3.5 PRIMARY PRODCUTIVITY

Phytoplanktons are autotrophic, prokaryotic or eukaryotic algae that live near the water surface where there is sufficient light to support photosynthesis. Among the more important groups are the diatoms, cyanobacteria, dinoflagellates and coccolithophores. Phytoplankton accounts for half of all photosynthetic activity on Earth and contribute significantly to primary production process in aquatic ecosystems. Phytoplankton primary productivity is defined as the rate of organic matter production by the growth of planktonic plants.

The details of primary productivity for the months of April, May, June, July, August and September in different project sites are summarized in Annexure X. Gross primary production (GPP) and net primary production (NPP) show an increase in the months of April and May, and then decreases in the months of July, August and September in all the sites. The summary of primary productivity observed at various sampling sites is given in Table-6.26.

TABLE-6.26
Primary productivity at various sampling sites

	Projects		**Month**					
			April 2009	**May 2009**	**June 2009**	**July 2009**	**August 2009**	**Septem-ber 2009**
1.	Utung HEP	Gross Primary Productivity (GPP)	35.5	36.1	42.9	15.5-16.5	18.1-20.1	15.9-18.9
		Net Primary Productivity (NPP)	11.5	19.4	13.6	10.5-12.5	13.4	10.6-13.6
2.	Nazong HEP	Gross Primary Productivity (GPP)	23.0-35.5	31.2-36.1	34.2-42.3	12.5-15.5	15.1-18.1	16.5
		Net Primary Productivity (NPP)	12.5-14.2	24.4-25.6	15.6-16.2	8.5-9.5	11.4-13.4	11.2-12.2
3.	Dibbin HEP	Gross Primary Productivity (GPP)	25.0-37.5	33.4-39.1	31.2-46.9	15.0-17.5	13.4-19.1	14.3-16.9
		Net Primary Productivity (NPP)	12.5	23.4	15.6	10.5-11.5	8.4-13.4	10.6-11.6
4.	Dimijin HEP	Gross Primary Productivity (GPP)	37.5	39.1	46.9	16.5-17.5	19.1-19.5	16.9
		Net Primary Productivity (NPP)	12.5-25.0	23.4-29.1	15.6-31.3	9.0-11.0	13.4-14.1	11.3-11.6
5.	Dikhri HEP	Gross Primary Productivity (GPP)	37.5	39.1	46.9	17.5	19.1	16.9

	Projects		**Month**					
			April 2009	**May 2009**	**June 2009**	**July 2009**	**August 2009**	**Septem-ber 2009**
		Net Primary Productivity (NPP)	12.5	23.4	15.6	10.5	13.4	10.6-11.6
6.	Dinchang HEP	Gross Primary Productivity (GPP)	50.0	54.7	62.5	10.0-12.0	14.7	12.5
		Net Primary Productivity (NPP)	25.0	39.1	31.2-31.3	6.0-7.0	9.1	9.2-9.3
7.	Jameri HEP	Gross Primary Productivity (GPP)	37.5-50.0	39.1-54.7	46.9-62.5	10.0-17.5	14.7-19.5	14.5-16.9
		Net Primary Productivity (NPP)	12.5-25.0	23.4-39.1	15.6-31.3	9.5-12.0	9.1-13.4	9.3-11.6
8.	Dinan HEP	Gross Primary Productivity (GPP)	36.5	38.1-40.1	45.9-48.9	15.5-16.5	18.1-20.1	15.9-18.9
		Net Primary Productivity (NPP)	14.5-15.5	23.4	16.6-19.6	10.5-11.5	13.4	11.6-12.6
9.	Gongri HEP	Gross Primary Productivity (GPP)	32.5-35.5	35.1-38.1	60.5-61.5	12.5-15.5	15.1-18.1	15.5-16.5
		Net Primary Productivity (NPP)	14.5-17.5	21.4-23.4	32.2-33.3	7.5-9.5	9.4-12.4	11.2-13.3
10.	Nafra HEP	Gross Primary Productivity (GPP)	25.0-62.5	35.4-70.3	31.2-78.1	12.5-17.5	10.3-19.1	15.2-18.1
		Net Primary Productivity (NPP)	12.5-25.0	23.4-39.1	15.6-31.3	10.5-12.0	8.1-15.1	11.6-14.3

- Net Primary Productivity (NPP) ranged from 10.5 – 19.4 $mgC/m^2/day$ at various sampling stations monitored for Utung hydroelectric project.
- Net Primary Productivity (NPP) ranged from 8.5 – 25.6 $mgC/m^2/day$ at various sampling sites monitored for Nazong hydroelectric project.
- Net Primary Productivity (NPP) ranged from 8.4 – 23.4 $mgC/m^2/day$ at various sampling sites monitored for Dibbin hydroelectric project.
- Net Primary Productivity (NPP) ranged from 9 – 31.3 $mgC/m^2/day$ at various sampling sites monitored for Dimijin hydroelectric project.
- Net Primary Productivity (NPP) ranged from 10.5 – 23.4 $mgC/m^2/day$ at various stations monitored for Dikhri hydroelectric project.
- Net Primary Productivity (NPP) ranged from 9.1 – 39.1 $mgC/m^2/day$ at various sampling stations monitored for Jameri hydroelectric project.
- Net Primary Productivity (NPP) ranged from 10.5 – 23.4 $mgC/m^2/day$ at various sampling sites monitored for Dinan hydroelectric project..
- Net Primary Productivity (NPP) ranged from 7.5 – 33.3 $mgC/m^2/day$ at various sampling sites monitored for Gongri hydroelectric project.
- Net Primary Productivity (NPP) ranged from 8.1 – 39.1 $mgC/m^2/day$ at various sampling sites monitored for Nafra hydroelectric project.

6.3.6 TROPHIC STATUS IN BICHOM BASIN

Trophic status is a useful means of classifying water bodies and describing aquatic processes in terms of the productivity of the system. The trophic status of a water body can be determined by estimating the quantities of nitrogen and phosphorous concentration. The estimation of these two nutrients in an aquatic body is necessary as they tend to be the limiting resources and an increase in these nutrients increases the algal productivity. Algal biomass and productivity is yet another indicator of the trophic status of a water body in which lower values correspond to oligotrophic state. Vollenweider (1974) used GPP as a criteria for classifying water bodies on trophic nature as, oligotrophic (0.065 - 0.3 g $Cm^{-2}d^{-1}$), mesotrophic (0.25 – 1.0 g $Cm^{-2}d^{-1}$) and eutrophic (1.0 – 8.0 g $Cm^{-2}d^{-1}$).

In the present study, the water bodies in different project sites had low concentrations of nitrate and total phosphorous (<0.015 mg l^{-1}). Overall, phytoplankton population is also low and the community is mainly dominated by Bacillariophyceae (diatoms), although some sites had dominance of Chlorophyceae and Cyanophyceae. Periphytic algal communities can be seen in some shallow areas of the project sites, but their diversity and density is low and their distribution is restricted to some pockets only. Overall, zooplankton population is dominated by Rotiferans and Cladocerans which mostly feed on fish waste, dead bacteria, algae and small particles of food suspended in water generated from falling leaf litter from the riparian forest areas. The benthic invertebrate communities are dominated by Ephemeroptera and Plecoptera which are abundant in undisturbed habitats mainly feeding on detritus. They can be classified as grazers, scrapers and filter feeders. Some invertebrates are carnivorous feeding on larvae of other species. The GPP values for all the project sites lies within the range of 0.065 - 0.3 g $Cm^{-2}d^{-1}$ as suggested by Vollenweider (1974). Hence, based on all the above the trophic status of the project areas may be classified as oligotrophic.

6.4 DIVERSITY OF FISH FAUNA IN ARUNACHAL PRADESH

Works done on fish diversity in the state is fragmentary and limited by the following studies viz., McClelland (1839), Chaudhuri (1913), Hora (1921), Jayaram and Majumder (1964), Srivastava (1966), Choudhury and Sen (1977), Ghosh (1979), Dutta and Barman (1984, 1995), and Nath and Dey (2000). These studies mainly dealt with systematics including new records from India viz., *Amblyceps apangi* and *Amblyceps arunachalensis* (Nath and Dey 1989). Recently, Bagra *et al*. (2009) prepared a checklist of 213 species of fishes for Arunachal Pradesh of which 138 species were first hand collections from 35 rivers in the state. About 5 species are endemic to this region viz., *Amblyceps apangi*, *Amblyceps arunachalensis*, *Labeo devdevi*, *Osteacheilus neilli* and *Calisa labiosus*. The distribution of fishes in Arunachal Pradesh can be mainly attributed to altitude and topography. The higher elevations have cold water forms such as *Schizothorax* spp., *Glyptothorax* spp. etc. The foot hills and mid-elevations comprises of Mahseers such as *Acrossocheilus hexagonolepis*, *Tor tor*, *Tor putitora* which are economically important. Other species include *Labeo dero*, *Labeo pangusia*, *Clarius* sp., *Wallago attu*, *Aborichthys aor*, *Pabda* sp., *Notopterus notopterus*, *Belone cancila* etc. The state also has a large number of ornamental fishes such as: Barbs and minnows (*G. chapra*, *A. mola*, *P. ticto*, *A. morar*, *S. bacaila*), Cat fishes (*Ailia coila*, *B. tengana*, *H. hara*, *G. horal*, *M. vittatus*, *M. montanus*), Eels (*M. aculeatus*, *M. armatus*, *P. indica*), Glass fish (*C. baculis*, *C. nama*, *C. ranga*), Gourami (*C. fasciata*, *C. labiosus*), Loaches (*A. elongatus*, *A. kempi*, *N. devdevi*, *B. dario*, *B. rostrata*), Needle fish (*X. cancila*), Perches (*B. badis, N. nandus*), Snakeheads (*C. marulius*, *C. striatus*, *C. orientalis*), Puffer fish (*T. cutcutia*), Knife fish (*N. notopterus*).

ASSESSMENT OF FISH DIVERSITY IN BICHOM BASIN

The state of Arunachal Pradesh is the largest in terms of geographical as well as river drainage. It harbors many rivers, streams and streamlets which supports diverse fish species of which many are endemic to the region. Recently, Bagra *et al*. (2009) prepared a checklist of 213 species of fishes for Arunachal Pradesh of which 138 species were first hand collections from 35 rivers in the state. Construction of dams over these rivers can block or delay upstream fish migration and thus contribute to the decline and even the extinction of species that depend on longitudinal movements along the stream continuum during certain phases of their life cycle. Mortality resulting from fish passage through hydraulic turbines or over spillways during their downstream migration can be significant. Hence, prior to dam construction a survey of the diversity of fish diversity is necessary.

The sampling of fish species was done in the months of April, May, June, July, August and September. Random sampling in selected areas of the project areas in the river basin was carried out using a cast net at morning (6:00 — 8:00) hours. The sampled fishes were identified using the taxonomic keys (Nath & Dey 2000, Bagra *et al.* 2009, Talwar and Kackar, Viswanath NBFGR).

Details of fish composition in different project sites is given in Tables-6.27 to.36. The fish fauna in the Bichom river basin belonged to 7 families i.e. Cyprinidae, Bolitoridae, Cobitidae, Siluridae, Amblycipitidae, Sisoridae and Channidae. Overall, the cyprinid fishes dominated in the Bichom river basin.

TABLE-6.27
Fish composition at various sampling sites in Utung HEP

Families	Species	AQ1	AQ2	AQ3
Cyprinidae	*Schizothorax richardsonii*	×	×	×
Cyprinidae	*Neolissochilus hexagonolepis*	×	×	×
Cyprinidae	*Labeo pangusia*	×	×	×
Cyprinidae	*Tor putitora*	×	×	×
Cyprinidae	*Garra gotyla*	×	×	×

S1 – 2000 m upstream of dam site, S2 - Dam site, S3 – 3000 m downstream of dam site

TABLE-6.28
Fish composition at various sampling sites in Nazong HEP

Families	Species	AQ4	AQ5	AQ6
Cyprinidae	*Schizothorax richardsonii*	×	×	×
Cyprinidae	*Neolissochilus hexagonolepis*	×	×	×
Cyprinidae	*Labeo pangusia*	×	×	×
Cyprinidae	*Tor putitora*	×	×	×
Cyprinidae	*Garra gotyla*	×	×	×

S1 – 2000 m upstream of dam site, S2 - Dam site, S3 – 3000 m downstream of dam site

TABLE-6.29
Fish composition at various sampling sites in Dibbin HEP

Families	Species	AQ7	AQ8	AQ9
Cyprinidae	*Schizothorax richardsonii*	×	×	×
Cyprinidae	*Neolissochilus hexagonolepis*	×	×	×
Cyprinidae	*Labeo pangusia*	×	×	×
Cyprinidae	*Tor putitora*	×	×	×
Cyprinidae	*Garra gotyla*	×	×	×

S1 – 2000 m upstream of dam site, S2 - Dam site, S3 – 3000 m downstream of dam site

TABLE-6.30
Fish composition at various sampling sites in Dimijin HEP

Families	Species	AQ10	AQ11	AQ12
Cyprinidae	*Schizothorax richardsonii*	×	×	×
Cyprinidae	*Neolissochilus hexagonolepis*	×	×	×
Cyprinidae	*Labeo pangusia*	×	×	×
Cyprinidae	*Garra gotyla*	×	×	×

S1 – 2000 m upstream of dam site, S2 - Dam site, S3 – 3000 m downstream of dam site

TABLE-6.31
Fish composition at various sampling sites in Dikhri HEP

Families	Species	AQ13	AQ14	AQ15
Cyprinidae	*Schizothorax richardsonii*	×	×	×
Cyprinidae	*Neolissochilus hexagonolepis*	×	×	×
Cyprinidae	*Labeo pangusia*	×	×	×
Cyprinidae	*Tor putitora*	×	×	×
Cyprinidae	*Garra gotyla*	×	×	×

S1 – 2000 m upstream of dam site, S2 - Dam site, S3 – 3000 m downstream of dam site

TABLE-6.32
Fish composition at various sampling sites in Dinchang HEP

Families	Species	AQ16	AQ17	AQ18
Cyprinidae	*Schizothorax richardsonii*	×	×	×
Cyprinidae	*Neolissochilus hexagonolepis*	×	×	×
Cyprinidae	*Labeo pangusia*	×	×	×
Cyprinidae	*Tor putitora*	×	×	×
Cyprinidae	*Garra gotyla*	×	×	×
Siluridae	*Silurus afgana*	×	×	×
Sisoridae	*Glyptothorax sp.*	×	×	×

S1 – 2000 m upstream of dam site, S2 - Dam site, S3 – 3000 m downstream of dam site

TABLE-6.33
Fish composition at various sampling sites in Jameri HEP

Families	Species	AQ19	AQ20	AQ21
Cyprinidae	*Schizothorax richardsonii*	×	×	×
Cyprinidae	*Neolissochilus hexagonolepis*	×	×	×
Cyprinidae	*Labeo pangusia*	×	×	×

Families	Species	AQ19	AQ20	AQ21
Cyprinidae	*Chagunius chagunio*	×		
Cyprinidae	*Tor putitora*	×	×	×
Cyprinidae	*Tor tor*	×		
Cyprinidae	*Garra gotyla*	×	×	×
Cyprinidae	*Garra annandalei*	×		×
Bolitoridae	*Aborichthys elongates*	×	×	
Cobitidae	*Botia Dario*	×		
Siluridae	*Silurus afgana*	×	×	×
Amblycipitidae	*Amblyceps sp.*	×		
Sisoridae	*Glyptothorax sp.*	×	×	×
Channidae	*Channa orientalis*	×	×	×

S1 – 2000 m upstream of dam site, S2 - Dam site, S3 – 3000 m downstream of dam site

TABLE-6.34
Fish composition at various sampling sites in Dinan HEP

Families	Species	AQ22	AQ23	AQ24
Cyprinidae	*Schizothorax richardsonii*	×	×	×
Cyprinidae	*Neolissochilus hexagonolepis*	×	×	×
Cyprinidae	*Labeo pangusia*	×	×	×
Cyprinidae	*Tor putitora*	×	×	×
Cyprinidae	*Garra gotyla*	×	×	×

S1 – 2000 m upstream of dam site, S2 - Dam site, S3 – 3000 m downstream of dam site

TABLE-6.35
Fish composition at various sampling sites in Nafra HEP

Families	Species	AQ22	AQ23	AQ24
Cyprinidae	*Schizothorax richardsonii*	×	×	×
Cyprinidae	*Neolissochilus hexagonolepis*	×	×	×
Cyprinidae	*Labeo pangusia*	×	×	×
Cyprinidae	*Tor putitora*	×	×	×
Cyprinidae	*Garra gotyla*	×	×	×

S1 – 2000 m upstream of dam site, S2 - Dam site, S3 – 3000 m downstream of dam site

TABLE-6.36
Fish composition at various sampling sites in Nafra HEP

Families	Species	AQ25	AQ26	AQ27
Cyprinidae	*Schizothorax richardsonii*	×	×	×
Cyprinidae	*Neolissochilus hexagonolepis*	×	×	×
Cyprinidae	*Labeo pangusia*	×	×	×
Cyprinidae	*Tor putitora*	×	×	×
Cyprinidae	*Garra gotyla*	×	×	×

S1 – 2000 m upstream of dam site, S2 - Dam site, S3 – 3000 m downstream of dam site

CHAPTER-7
TERRESTRIAL ECOLOGY

7.1 INTRODUCTION

Arunachal Pradesh is a part of the Eastern Himalayan biodiversity hotspot, one of the 34 hotspots of the world. The state (26° 30' N and 29° 30' N latitudes and 91° 30' E and 97° 30' E longitudes) has a very wide altitudinal variation ranging from flood plain of Brahmaputra to more than 7600 m high mountain peaks. The elevational variation, associated variability in climatic and edaphic factors, phytogeographical position, and undulating topography of the state have led to formation of varied ecological diversity, and diverse and luxuriant vegetation with a rich gene pool of wild and domesticated plant species. Due to presence of numerous primitive plant species and wild relatives of cultivated plants the region is considered to be a part of the "*Cradle of flowering plants*" by Takhtajan and as a "*Centre of origin*" of important crop plants (Takhtajan 1974).

The mountainous topography of the state presents an ideal condition for the development of hydro-electric projects. Based on the size and volume of water drained, there are five major river basins in the state, namely, Kameng River Basin, Subansiri River Basin, Siang River Basin, Dibang River Basin and Lohit River Basin. The abovementioned major rivers of the state either constitute or finally drain into the Brahmaputra River. Each of these rivers has very high potential of hydro-power generation. Besides, there are many tributaries and distributaries of these rivers which also offer suitable locations for the development of hydro-electric power projects. On the other hand, more than 80% of the total geographical area of Arunachal Pradesh is covered with forest (FSI 2003). Therefore, development of hydropower projects would obviously affect the forest area of the state. Considering the importance of power in country's development, it is required to maintain a balance between the development of hydropower projects and forest conservation. As the first step of forest conservation, it is essential that the floristic survey of the proposed project sites be made in order to make an account of the plant diversity in the area and identify the species for conservation.

7.2 HISTORICAL ACCOUNT ON FLORISTIC SURVEYS IN ARUNACHAL PRADESH

A large number of European botanists and explorers visited the area in the early 19^{th} century (Buchanan-Hamilton 1820, Roxburgh 1820-1824, Griffith 1847, Hooker 1854, 1872-1897, Hooker and Thompson 1855, Clarke 1889, Burkill 1924-1925, 1965, Kingdom Ward 1929, 1960). Lieutenant R. Wilcox and Captain Bedford visited the *Mishmi Hills* in Arunachal Pradesh during their survey of Assam and the neighboring countries for geographic discoveries in the North East Frontier (1825-1828). However, it was W. Griffith (1847) who made botanical explorations for the first time and the '*Flora of Mishimee Hills'* was based on his collections made during October-December, 1836. After that Thomas J. Booth made horticultural explorations during 1840-1850 from *Bisnath* (Assam) to the '*Daphla Hills*' in the southeastern corner of Bhutan and described a few Rhododendrons from the area. However, Robinson (1841) gave the first kind of floristic account of the region. Further, Hooker (1854 and 1906) presented a detailed account on the vegetation and flora of the region. In the 20th century, the floristic explorations gained momentum which resulted in publication of some important floristic accounts of the region such as *Botany of Abor Expedition* by I.H. Burkill (1924-25), *Botanical Expedition in the Mishmi Hills* by Kingdom Ward (1929-1931), *A Sketch of the Vegetation of Aka Hills* by N.L. Bor (1938), *Lohit Valley* by Kingdom Ward (1953) and, *The Flora of Aka Hills* by K.P. Biswas (1941) based on the collections of N.L. Bor (1931-1934). Lately, Kanjilal *et al*. (1934-1940) published the regional *Flora of Assam* in 5 volumes, containing the firsthand account of the vegetation of Assam.

For extensive floristic explorations in the northeast region, the Botanical Survey of India was reorganized and the Eastern Circle was established at Shillong in December, 1955. To enable further explorations in Arunachal Pradesh, a Field Station was established at Itanagar in July 1977. Since then, several floristic accounts on Arunachal Pradesh were published viz., Panigrahi and Naik (1961), Rao and Panigrahi (1961), Panigrahi (1965, 1966), Rao and Joseph (1965), Panigrahi and Joseph (1966), Sastry (1966), Panigrahi and Kar (1967), Joseph (1968, 1975, 1981), Rao and Ahuja (1969), Sahni (1969), Rao (1972), Rao and Deori (1980), Hajra (1970, 1973, 1976), Rao and Murti (1990), Rao (1994). *A contribution to the Flora of Namdapha, Arunachal Pradesh* (Chauhan *et al*. 1996), *Materials for the Flora of Arunachal Pradesh*, Vol. 1 (ed. Hajra *et al*. 1996), Orchidaceae of Arunachal Pradesh (Checklist) (Chowdhery and Pal 1997), and Orchid Flora of Arunachal Pradesh (Chowdhery 1998) are some of the contributions made towards the floristic accounts of Arunachal Pradesh. Haridasan (1997) and Haridasan *et al.* (1998) gave a brief account of the flora of Dibang valley and Lohit districts of Arunachal Pradesh.

7.3 FOREST TYPES IN ARUNACHAL PRADESH

Champion and Seth (1968), Rao and Panigrahi (1961), Sahni (1981), Rao and Hajra (1986) are some prominent workers who studied the forest and vegetation of Arunachal Pradesh. Rao (1972) categorized the vegetation of Arunachal Pradesh into the following types:

- Tropical
- Sub-tropical
- Temperate
- Sub-alpine
- Alpine based

Recently, Kaul and Haridasan (1987) classified the forest and identified 6 major types within 4 climatic categories and compared them with the classical types of Champion and Seth (1968). The forest types of Arunachal Pradesh can be classified into:

1. Tropical Forests
    i. Tropical evergreen forests
    ii. South Bank Tropical Wet Evergreen Dipterocarpus Forests
    iii. North Bank Tropical Evergreen Nahor-Jutuli Forests
    iv. Tropical Semi-Evergreen Forests
    v. Low Hills and Plains Semi-Evergreen Forests
    vi. Riverine Semi-Evergreen Forests
2. Sub-tropical Forests
3. Pine Forests
4. Temperate Forests
    i. Temperate broad leaved forests
    ii. Temperate conifer forests
5. Alpine Forests
6. Degraded Forests
    i. Bamboo forests
    ii. Grasslands

According to Champion and Seth (1968) classification the forest types of Arunachal Pradesh can be categorized as:

1. Assam valley tropical evergreen forests (IB/C1)
2. Upper Assam valley tropical evergreen forests (IB/C2)
3. Assam alluvial plains semi-evergreen forests (2B/C1a)
4. Sub Himalayan light alluvial semi-evergreen forests (2B/C1/S1)
5. East Himalayan moist deciduous forests (3C/C3B)
6. Eastern hollock forests (3/1S2)
7. East Himalayan subtropical forests (8B/C1)
8. Assam subtropical pine forests (9/C2)
9. East Himalayan wet temperate forests (11B/C1)
10. Lauraceae forests (11B/C1a)
11. Bak Oak forests (11B/C1b)
12. High level Oak forests (11B/C1c)
13. Naga hill temperate forests (11B/C2)
14. East Himalayan mixed coniferous forests (12/C3a)
15. *Abies delavayi* forests (12/C3b)
16. East Himalayan sub-alpine birch/fir forests (14/C2)
17. Alpine pastures (15/C3)

18. Dry alpine scrub (16/C1)
19. Dwarf juniper scrub (16/E1)

7.4 FLORISTIC DIVERSITY OF ARUNACHAL PRADESH

Arunachal Pradesh accounts for 2.5% of the total geographical area of the country and contains more than 23.5% of the flowering plants of India. 76.9% families of India are represented in Arunachal Pradesh. Chowdhery *et al*. (1996) enumerated 4,117 species of angiosperms belonging to 1295 genera and 192 families from the state against 17,500 species in 2984 genera and 247 families in India. Out of these 2,986 species belonging to 970 genera and 165 families are of dicots and 1,131 species under 325 genera belonging to 27 families are of monocots. There are about 41 monotypic families. Among the dicots, the monotypic herbaceous families, Balsaminaceae, Begoniaceae, are represented by 33 species of *Impatiens* and 19 species of *Begonia* respectively. While, the monotypic families representing the tree species like Aceraceae and Symplocaceae are represented by 15 species of *Acer* and 13 species of *Symplocos* respectively. The monotypic families of the monocots are Dioscoreaceae and Smilacaceae. They are represented by 25 species of *Dioscorea* and 19 species of *Smilax* respectively. Pteridophytes also form a significant feature of the vegetation in the state. Out of 1020 species of ferns occurring in India, 452 species are recorded from Arunachal Pradesh (Baishya 1999). The diversity of fern allies like *Selaginella* and *Lycopodium* are best represented in this region.

The family Orchidaceae is a highly evolved groups of plants with 1,229 species belonging to 184 genera in India (Singh and Chauhan 1999) out of which 545 species belonging to 122 genera are reported from Arunachal Pradesh (Chowdhery 1998), of which 20 species are endemic to the state (Hegde 1998). Among all the described species of orchids from Arunachal Pradesh, 17 species are saprophytes, 138 species are terrestrials and 383 species are epiphytes. Some of the dominant genera are *Bulbophyllum*, *Calanthe*, *Cymbidium*, *Dendrobium* and *Eria*.

Bamboos are also a dominant group of plants in the state. 23 genera and 120 species are so far known from India (Biswas 1998) of which 17 genera and 89 species are represented in the northeast India (Haridasan 2000). 26 species belonging to 9 genera of bamboo occur in Arunachal Pradesh. Some of the important genera are: *Bambusa* (4 species), *Dendrocalamus* (6 species), *Schizostachyum* (7 species) and *Chimonocalamus* (2 species).

Among Gymnosperms, out of 48 species belonging to 15 genera and 8 families native in India 24 species in 13 genera are found in Arunachal Pradesh. Some of the cultivated species of gymnosperms include *Agathis robusta*, *Araucaria columnaris*, *Cryptomeria japonica*, *Taxodium disticum* and *Thuja orientalis*. *Amentotaxus assamicus* is endemic to Arunachal Pradesh.

The state abounds in quite a large number of primitive flowering plants and many species of Annonaceae, Piperaceae and Lauraceae do not occur in other parts of India except Northeast region, Eastern Himalaya, Assam and Burma. Some of the primitive genera are *Magnolia*, *Alnus*, *Betula*, *Holboellia*, *Exbucklandia* etc.

The physiographic features along with its geological history have contributed to high endemism in this relatively young mountain system. The occurrence of endemics, determined by biogeographic provinces, unique ecosystems, and topographical and climatological interfaces, is suggestive of biogeography, center of speciation, and adaptive evolution of the biota of this region. Out of 17,500 described species of flowering plants, over 5000 species belonging to 140 genera and 47 families are endemic to India. It is estimated that *ca* 3,500 endemic species occur in northeast India. Chowdhery (1999) provides a list of 238 endemic taxa from Arunachal Pradesh.

7.5 FOREST TYPES IN BICHOM BASIN

Bichom basin is rich in plant diversity. The major forest types surveyed in the Bichom river basin including the upstream area are:

- Subtropical semi-evergreen forests
- Subtropical oak forests
- Secondary forests
- Plantation forests
- Bamboo plantations
- Subtropical pine forests
- Subtropical mixed pine forests
- Tropical evergreen forests

Subtropical semi-evergreen forests

These are essentially evergreen and dense in nature and are restricted along a narrow belt on both the sides of the river. The trees are usually evergreen in nature with some deciduous elements. Patches of this forest type can be seen on both sides of the river dominated by tree species such as *Engelhardtia spicata*, *Macaranga denticulata. Castanopsis* spp., *Quercus griffithii*, *Drymicarpus racemosus*, *Acer laevigatum, Albizzia sp., Rhus acuminata, Rhus javanica, Castanopsis* spp., *Quercus griffithii*, *Myrica esculenta, Alangium begonifolia*, *Phyllanthus embelica, Toona ciliata, Schima wallichii* etc. The shrub layer includes species like *Eupatorium odoratum*, *Plectranthus striatus, Debregessia longifolia.* The herbaceous layer consists of *Drymaria cordata, Oplismenus* sp, *Pilea umbrosa.* etc.

Such forests are seen all along the river valley and are found in the areas of Dibbin, Dikhri, Dimijin, Dinan, Nafra, Nazong, and Utung.

Sub-tropical oak forests

These are essentially dense in nature and must have developed in abandoned jhum lands. The dominant species in this type of forest is *Quercus griffithii*. *Lyonia ovalifolia*, *Rhododendron* sp. and *Myrica esculenta* are the other associated species. The shrub layer is rich and includes species like *Eupatorium odoratum*, *Plectranthus striatus, Mesea indiaca* etc. The herbaceous layer consists of *Agenetia indica, Begonia* sp., *Cyanotis vaga*, *Lygodium flexuosum*, *Ophiopogon intermedius*, *Pilea* sp., *Symethea ciliata* etc. Such forests are seen all along the river valley and are found in the areas in the vicinity of Dibbin, Dikhri, Nazong and Utung hydroelectric projects.

Secondary forests

These are forests that have regenerated in abandoned jhum lands. They have lesser species diversity and are formed of secondary successional species. The density of plants is low and structure is less complex. The secondary forests are dominated by fast growing tree species like *Macaranga denticulata* and *Quercus griffithii* and *Musa* species. The herbaceous flora of these forests is mostly of weedy nature. These types of forests are seen along the right bank of the river in all the project sites.

Plantation forests

Along the road sides in Jameri, plantations of *Juglans regia* and *Bombax cieba* have been observed. In the upstream as well as near the proposed dam site in Nazong HEP, especially on the right bank, thick growth of *Phyllostachys manii* plantation and *Alnus napalensis* have been observed.

Bamboo plantations

In the downstream area of Dikhri and Utung HEP, especially on the right bank thick growth of *Phyllostachys manii* plantation has been observed.

Sub-tropical pine forests

These are essentially dense as well as sparse in nature at some places and must have developed in abandoned jhum lands. *Pinus* sp. is the dominant species. *Callicarpa arborea, Rhus acuminata* and *Rhus javanica* are the other associated species in the forests. This forest is common along Dinchang, Nafra, Dinan, Dimijin and on the way to Dibbin project site.

Sub-tropical mixed pine forests

These forests are dominated by *Pinus* sp. *Quercus griffithii*, *Quercus sp.,* and *Castanopsis spp.* The other associated tree species includes *Engelhardtia spicata*, *Rhus javanica* etc and commonly seen in all the project sites upto Dibbin.

Tropical evergreen forests

The vertical stratification in these types of forests is clearly distinguishable into emergent, canopy and sub-canopy tree layers, shrub layer and ground flora. The tropical climatic conditions have favored growth of a multitude of plants making these forests resource rich. Patches of primary undisturbed evergreen forests are seen especially in the both the river banks in Jameri, which are dominated by tree species such as *Ficus* sp*., Duabanga grandriflora*, *Terminalia myriocarpa*, *Pandanus odoratissima* etc. The shrub layer includes species like *Acacia pennata, Acacia pruinescen, Boehmeria longifolia, Boehmeria macrophylla, Calamas erectus, Calamus leptospadix, Clerodendron coolebrokianum* and *Debregessia longifolia.* The herbaceous layer consists of *Begonia* sp., *Cyanotis vaga*, *Lygodium flexuosum*, *Ophiopogon intermedius*, *Pilea* sp., *Symethea ciliata* etc. Some species found in the study area are important from conservation point of view such as *Lagerstroemia muniticarpa* which is globally an endangered category of species. Plants of economic importance such as timber, medicinal, edible fruits were common e.g., *Pandanus* species is a fiber yielding tree species.

7.6 VEGETATION PATTERN IN THE BASIN AREA

The vegetation particularly along both the banks in Jameri, Utung, Nazong, and Dikhri is relatively undisturbed. However, there are patches of forests which show evidences that they have been recently cleared for cultivation. The river banks in Nafra, Dimijin, Gongri/Digo, Dinan, and Dinchang are relatively degraded. Human settlements and jhum fields are often seen along both the banks. In some of the areas which had long fallow period usually in little remote areas had trees like *Macaranga denticulata* and bamboo species which essentially are pioneer species. Such tree species are good for fuel wood purpose. A few fodder trees such as *Ficus* spp. were seen along the roadside. Beside this, bamboo species and *Musa* sp. were also found in these jhum fallows. The forest at the disturbed area shows stunted growth and the trees showed three distinct strata viz., canopy layer of trees with 10m height, shrub layer and the ground layer. However, undisturbed primary forest of the area had distinct stratification. At places emergent trees of isolated trees followed by a thick canopy, subcanopy and undercanopy layers was observed. The canopy cover of forests at Dam site and Upstream area in Jameri, Utung, Nazong, and Dikhri hydroelectric projects is >70% (dense forest) whereas, in Nafra, Dimijin, Gongri, Dinan, Dibbin and Dinchang hydroelectric projects, forests have <40% canopy cover (open forest).

7.7 FINDINGS OF FIELD STUDIES

The vegetation and floristic survey in the Bichom basin was done for ten project sites listed as below:

- Utung HEP
- Nazong HEP
- Dibbin HEP
- Dimijin HEP
- Dikhri HEP
- Dinching HEP
- Jameri HEP
- Dinan HEP
- Nafra HEP
- Gongri HEP

The monitoring was done for two seasons, i.e., summer season (April 2009) and monsoon season (August 2009).

The sampling was done within 1 km of the riverbed. Considering the difficult terrain, quadrat method was used for vegetation sampling. The phytosociological data for trees and shrubs were collected from random quadrats of 10 x 10 m size laid at the project site. Random quadrats of 1 x 1 m size were laid for the study of herb component at each site. The sampling locations for terrestrial ecological survey are shown in Figure-7.1.
During the survey, number of plants of different species in each quadrat was identified and counted. The height of individual trees was estimated using an Abney level/ Binocular and the DBH of all trees having girth of more than 16 cm were measured.

Based on the quadrat data, frequency, density and cover (basal area) of each species were calculated. The importance value index (IVI) for different tree species were determined by summing up the Relative Density, Relative Frequency and Relative Cover values. The Relative Density and Relative Frequency values were used to calculate the IVI of shrubs and herbs. IVI represent the contribution that a species makes to the community in respect of: (a) the number of plants within the quadrats (abundance), (b) its influence on the other species through its shading, competition or aggressiveness (dominance), and (c) its contribution to the community through its distribution (frequency). Thus, the index is purely a measure of the contribution of a species to that vegetation in which it is present, regardless of whether the ground is completely covered or very sparsely covered.

The volume of wood for trees was estimated using the data on DBH (measured at 1.5 m above the ground level) and height. The volume was estimated using the formula: $\pi r^2 h$, where r is the radius and h is the estimated height of the bole of the tree. The data on density and volume were presented in per ha basis.

To assess diversity of floral elements and numerical structure of the plant community in the study sites, different diversity indices were used. 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. Two species diversity indices viz., Shannon index of general diversity (H) 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.

$$\bar{H} = -\Sigma \frac{ni}{N} ln\left(\frac{ni}{N}\right)$$

Buzas and Gibson's evenness index was calculated using the formula: 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.

During the vegetation survey, herbaria were prepared for the plants that had flowers and fruits. Rare and endangered species were identified referring to the Red Data Book of India and other available literature, flora and herbarium pertaining to the rare/ endangered species of Arunachal Pradesh.

7.8 PLANT DIVERISTY AT VARIOUS SITES

7.8.1 Utung hydroelectric project

The following sampling sites were monitored as a part of the vegetation survey for Utung hydroelectric project:

- Catchment area (T1)
- Submergence area (T2)
- Downstream area (T3)

The findings of the vegetation survey at various sampling sites are given in Annexure-XI. The summary of the findings of vegetation survey are given in Table-7.1. The diversity indices of various floral species are given in Table-7.2.

TABLE -7.1

Density (No./ha) of various floral species at various sampling sites in Utung HEP

S.No.	Sampling site	Trees	Shrubs	Herbs	
				Summer	Monsoon
1.	Catchment area	795	3685	80050	130900
2.	Submergence area	640	3425	78400	156000
3.	Downstream area	500	5715	64200	141400

Note: Summer Season- April 2009, Monsoon season- August 2009

TABLE-7.2

Species Diversity Indices for different vegetation components in Utung HEP

Vegetation component	Diversity Indices	
	Shannon's Diversity Index (H)	Evenness Index (e)
Catchment area		
Trees	2.94	0.79
Shrubs	2.27	0.54
Herbs	1.83 (April), 2.24 (August)	0.37 (April), 0.43 (August)
Submergence Area		
Trees	2.71	0.84
Shrubs	2.30	0.55
Herbs	2.05 (April), 2.31 (August)	0.35 (April), 0.37 (August)
Downstream area		

Trees	2.67	0.80
Shrubs	2.41	0.51
Herbs	2.48 (April), 2.55 (August)	0.54 (April), 0.53 (August)

Note: Summer Season- April 2009, Monsoon season- August 2009

In the catchment area, twenty four tree species were recorded. The tree density was high (795 individuals /ha). *Brassiopsis glomerulata* was the dominant tree species followed by *Castanopsis purpurella*. Eighteen shrub and 22 herbs including climbers were recorded from the site. *Piper* sp. and *Plectranthus striatus* dominated the shrub layer while *Elatostemma sessile* and *Pilea umbrosa* were dominant in the herb layer. In general, species diversity was high and Shannon's Index for all three components (trees, shrubs and herbs) was more than 2 in the forests studied. The evenness index ranged from 0.43-0.79.

In the submergence area, eighteen species of trees represented by 640 individuals were recorded in this forest. There were 18 shrubs and 27 herbs including climbers that were recorded from the site. *Eupatorium odoratum* and *Piper* sp. were the dominant shrub species whereas, *Elatostemma sessile* and *Pilea umbrosa* were the dominant herb species. Shannon's diversity index for all three components i.e., trees, shrubs and herbs was more than 2 and evenness index ranged from 0.37-0.84.

The downstream site had 18 tree species represented by 500 individuals/ha. *Quercus griffithii* was the dominant species followed by *Engelhardtia spicata*. There were 22 shrubs and 24 herbs including climbers that were recorded from the site. *Piper* sp. and *Plectranthus striatus* dominated the shrub layer whereas, *Drymaria cordata* and *Nephrolepis cordifolia* dominated the herb layer. The Shannon's diversity index was more than 2 and the evenness index ranged from 0.51-0.8 for all tree, shrub and herb components.

The tree and shrubs did not show any difference in terms of composition and diversity while there was a slight increase in the diversity of herbaceous component in all the sites.

7.8.2 Nazong hydroelectric project

The following sampling sites were monitored as a part of the vegetation survey for Nazong hydroelectric project:

- Catchment area (T4)
- Submergence area (T5)
- Downstream area (T6)

The findings of the vegetation survey at various sampling sites are given in Annexure-XII. The summary of the findings of vegetation survey are given in Table-7.3. The diversity indices of various floral species are given in Table-7.4.

TABLE-7.3

Density (No./ha) of various floral species at various sampling sites in Nazong HEP

S.No.	Sampling site	Trees	Shrubs	Herbs	
				Summer	Monsoon
1.	Catchment area	605	4965	93200	158000
2.	Submergence area	615	3670	60300	95300
3.	Downstream	685	4540	50350	89150

Note: Summer Season- April 2009, Monsoon season- August 2009

TABLE-7.4
Species Diversity Indices for different vegetation components in Nazong HEP

Vegetation component	Diversity Indices	
	Shannon's Diversity Index (H)	Evenness Index (e)
Catchment area		
Trees	2.74	0.71
Shrubs	2.24	0.59
Herbs	2.15 (April), 2.30 (August)	0.48 (April), 0.43 (August)
Submergence area		
Trees	2.46	0.53
Shrubs	2.50	0.68
Herbs	1.82 (April), 2.38 (August)	0.33 (April), 0.35 (August)
Downstream area		
Trees	1.20	0.56
Shrubs	2.01	0.41
Herbs	2.30 (April), 2.64 (August)	0.43 (April), 0.48 (August)

Note: Summer Season- April 2009, Monsoon season- August 2009

In the catchment area, six tree species were recorded. The tree density was 605 individuals /ha. *Quercus griffithii* with 365 individuals / ha was the dominant species followed by *Rhododendron* sp. (110 individuals /ha). Sixteen shrub and 23 herbs including climbers were recorded from the site. *Indigofera* sp. and *Plectranthus striatus* dominated the shrub layer while *Imperata cylindrica and Opliomenus sp.* were dominant in the herb layer. In general, species diversity was high and the Shannon's Index for all three components (tree, shrub and herb) was more than 2 in the forests studied. The evenness index ranged from 0.43-0.71.

In the submergence area, twenty two species of trees represented by 615 individuals/ha were recorded in this forest. *Alnus nepalensis* and *Macaranga denticulata* are the dominant tree species. There were 18 shrubs and 32 herbs including climbers that were recorded from the site. *Eupatorium odoratum* and *Plectranthus striatus* were the dominant shrub species whereas, the herb layer was dominated by *Pilea umbrosa* and *Nephrolepis cordifolia.* Shannon's diversity index for all three components i.e., tree, shrub and herb was more than 2 and evenness index ranged from 0.35-0.68.

The downstream site had 22 tree species represented by 685 individuals /ha. *Alnus nepalensis* and *Castanopsis purpurella* were the dominant species. There were 18 shrubs and 28 herbs including climbers that were recorded from the site. *Eupatorium odoratum* and *Plectranthus striatus* dominated the shrub layer whereas, *Pilea umbrosa and Rhynoglossum obliqum* dominated the herb layer. The Shannon's diversity index ranged from 1.2-2.64 for all tree, shrub and herb components and the evenness index ranged from 0.41-0.56.

The tree and shrubs did not show any difference in terms of composition and diversity while there was a slight increase in the diversity of herbaceous component in all the sites.

7.8.3 Dibbin hydroelectric project

The following sites were monitored as a part of the Terrestrial Ecological Survey for Dibbin Hydroelectric Project:

- Catchment area (T7)
- Submergence area (T8)
- Downstream area (T9)

The number of species encountered during the vegetation survey at various sampling sites are given in Annexure-XIII. The summary of the findings of vegetation survey are given in Table-7.5. The diversity indices of various vegetation components are given in Table-7.6.

TABLE-7.5

Density of various floral species at various sampling sites covered in Dibbin HEP (No. /ha)

Sl. No.	Sampling site	Trees	Shrubs	Herbs	
				Summer	Monsoon
1.	Catchment area	590	3715	64300	103550
2.	Submergence area	555	4080	76800	105550
3.	Downstream	695	3155	63850	103700

Note: Summer Season- April 2009, Monsoon season- August 2009

TABLE-7.6
Species Diversity Indices for different vegetation components in Dibbin hydroelectric project

Vegetation component	Diversity Indices	
	Shannon's Diversity Index (H)	Evenness Index (e)
Catchment area		
Trees	2.03	0.35
Shrubs	1.92	0.40
Herbs	2.73 (April), 2.79 (August)	0.57 (April), 0.52 (August)
Submergence area		
Trees	2.36	0.71
Shrubs	1.90	0.39
Herbs	2.52 (April), 2.59 (August)	0.52 (April), 0.51 (August)
Downstream		
Trees	1.95	0.32
Shrubs	2.59	0.67
Herbs	2.44 (April), 2.64 (August)	0.52 (April), 0.50 (August)

Note: Summer Season- April 2009, Monsoon season- August 2009

The dam site is located near Dibbin village. The submergence is confined to narrow strips along the river on account of steep slopes on both the sides. In the catchment area, twenty two tree species were recorded in this forest with a density of 590 individuals /ha. *Quercus griffithii* (300 individuals/ha) and *Lyonia ovalifolia* (50 individuals/ha) were the dominant tree species. Seventeen shrub and 31 herbs including climbers were recorded from the site. *Eupatorium odoratum* and *Plectranthus striatus* dominated the shrub layer while *Drymaria cordata* and *Oplismenus* sp. were dominant in the herb layer. In general, species diversity was high and the Shannon's Index for all three components (tree, shrub and herb) was more than 1.9 in the forests studied. The evenness index ranged from 0.35-0.52.

In the submergence area, fifteen species of trees were represented by 555 individuals/ha. There were 17 shrubs and 26 herbs including climbers that were recorded from the site. *Eupatorium odoratum* and *Plectranthus striatus* were the dominant shrub species whereas, *Pilea umbrosa* and *Drymaria cordata* were the dominant herb species. Shannon's diversity index for all three components i.e., tree, shrub and herb was more than 1.9 and evenness index ranged from 0.5-0.71.

The downstream site had 22 tree species represented by 695 individuals /ha. *Musa* sp. and Bamboo species were the dominant species. There were 20 shrubs and 28 herbs including climbers that were recorded from the site. *Debregessia longifolia* and *Plectranthus striatus* dominated the shrub layer whereas, *Urtica dioca* and *Opliomenus* sp. dominated the herb layer.

The tree and shrubs did not show any difference in terms of composition and diversity while there was a slight increase in the diversity of herbaceous component in all the sites.

7.8.4 Dimijin hydroelectric project

The following sampling sites were covered as a part of the terrestrial ecological survey for Dimijin hydroelectric project:

- Catchment area (T10)
- Submergence area (T11)
- Downstream area (T12)

The findings of the vegetation survey at various sampling sites are given in Annexure-XIV. The summary of the findings of vegetation survey are given in Table-7.7. The diversity indices of various vegetation components are given in Table-7.8.

TABLE-7.7

Density (No./ha) of various floral species at various sampling sites of Dimijin HEP

S.No.	Sampling site	Trees	Shrubs	Herbs	
				Summer	Monsoon
1.	Catchment area	445	107500	26400	44200
2.	Submergence area	315	4070	29250	32000
3.	Downstream	345	950	41200	53750

Note: Summer Season- April 2009, Monsoon season- August 2009

TABLE-7.8
Species Diversity Indices for different vegetation components in Dimijin HEP

Vegetation component	Diversity Indices	
	Shannon's Diversity Index (H)	**Evenness Index (e)**
Submergence Area		
Trees	2.47	0.85
Shrubs	1.88	0.39
Herbs	1.92 (April), 2.03 (August)	0.62 (April), 0.54 (August)
Catchment Area		
Trees	0.50	0.41
Shrubs	1.37	0.56
Herbs	1.11 (April), 0.84 (August)	0.51 (April), 0.33 (August)
Downstream Area		
Trees	0.46	0.53
Shrubs	0.97	0.38
Herbs	1.15 (April), 1.07 (August)	0.45 (April), 0.36 (August)

Note: Summer Season- April 2009, Monsoon season- August 2009

Four tree species represented by 445 individuals /ha were recorded in the catchment area site. *Pinus* sp. was the dominant tree species. Seven shrub and 7 herbs were recorded from the site. *Eupatorium odoratum* and *Plectranthus striatus* dominated the shrub layer while *Imperata cylindrica, Borreria articularis* and *Nephrolepis cordifolia* were dominant in the herb layer. In general, species diversity was high and the Shannon's Index for all three components (tree, shrub and herb) ranged from 0.5-1.37 in the forests studied. The evenness index ranged from 0.33-0.56.

In the submergence area, fourteen species of trees represented by a low density of 315 individuals/ha were recorded in this forest. There were 17 shrubs and 14 herbs including climbers that were recorded from the site. *Artemesia nilagirica* and *Piper* sp. were the dominant shrub species whereas, *Ageratum conyzoides* and *Pilea umbrosa* dominated the herb layer. Shannon's diversity index for all three components i.e., tree, shrub and herb ranged from 1.88-2.47 and evenness index ranged from 0.39-0.85.

The downstream site had 3 tree species with a low density of 345 individuals /ha. *Pinus* sp. was the dominant tree species in the site. There were 7 shrubs and 8 herbs that were recorded from the site. *Artemesia nilagirica* and *Eupatorium odoratum* dominated the shrub layer whereas, *Imperata cylindrica* and *Nephrolepis cordifolia* dominated the herb layer. The Shannon's diversity index for trees, shrubs and herbs ranged from 0.46-1.07 and the evenness index ranged from 0.36-0.53 for all tree, shrub and herb components.

The tree and shrubs did not show any difference in terms of composition and diversity while there was a slight increase in the diversity of herbaceous component in all the sites.

7.8.5 Dikhri hydroelectric project

The following sampling sites were monitored at various locations in the Dikhri hydroelectric project:

- Catchment area (T13)
- Submergence area (T14)
- Downstream area (T15)

The findings of the vegetation survey at various sampling sites are given in Annexure-XV. The summary of the findings of vegetation survey are given in Table-7.9. The diversity indices of various floral species are given in Table-7.10.

TABLE-7.9

Density (No. /ha) of various floral species at various sampling sites covered in Dikhri HEP

S.No.	Sampling site	Trees	Shrubs	Herbs	
				Summer	Monsoon
1.	Catchment Area	605	7635	41300	86900
2.	Submergence Area	530	4465	68250	95900
3.	Downstream area	515	4985	81250	142250

Note: Summer Season- April 2009, Monsoon season- August 2009

TABLE-7.10
Species Diversity Indices for different vegetation components in Dikhri HEP

Vegetation component	Diversity Indices	
	Shannon's Diversity Index (H)	Evenness Index (e)
Catchment Area		
Trees	3.06	0.74
Shrubs	2.15	0.37
Herbs	2.50 (April), 2.76 (August)	0.58 (April), 0.59 (August)
Submergence Area		
Trees	2.80	0.82
Shrubs	2.40	0.46
Herbs	2.43 (April), 2.62 (August)	0.60 (April), 0.65 (August)
Downstream area		
Trees	2.56	0.76
Shrubs	2.07	0.42
Herbs	2.38 (April), 2.69 (August)	0.43 (April), 0.47 (August)

Note: Summer Season- April 2009, Monsoon season- August 2009

Twenty nine tree species were recorded in the catchment area. The tree density was low (605 individuals /ha). *Engelhardtia spicata* was the dominant tree species with 75 individuals /ha followed by *Lyonia ovalifolia* and *Quercus griffithii* with 55 individuals/ ha each. Twenty three shrub and 27 herbs including climbers were recorded from the site. *Piper sp.* and *Plectranthus striatus* dominated the shrub layer while *Pilea umbrosa* and *Drymaria cordata* were dominant in the herb layer. In general, species diversity was high and the Shannon's Index for all three components (tree, shrub and herb) was more than 2 in the forests studied. The evenness index ranged from 0.37-0.74.

In the submergence area, twenty species of trees represented by 530 individuals/ha were recorded. *Drymicarpus racemosus* and *Brassiopsis glomerulata* represented by 60 and 55 individuals /ha were the dominant tree species. There were 24 shrubs and 21 herbs including climbers that were recorded from the site. *Piper* sp. and *Indigofera sp.* were the dominant shrub species whereas, *Pilea umbrosa* and *Nephrolepis cordifolia* were the dominant herb species. Shannon's diversity index for all three components i.e., tree, shrub and herb was more than 2 and evenness index ranged from 0.46-0.82.

The downstream site had 17 tree species represented by 515 individuals /ha. *Castanopsis purpurella* (80 individuals/ha) was the dominant species followed by *Juglans regia* and *Quercus griffithii* with 60 individuals/ha each. There were 19 shrubs and 31 herbs including climbers that were recorded from the site. *Urena lobata* and *Indigofera* sp. dominated the shrub layer whereas, *Drymaria cordata* and *Nephrolepis cordifolia* dominated the herb layer. The Shannon's diversity index was more than 2 and evenness index ranged from 0.42-0.76 for all tree, shrub and herb components.

The tree and shrubs did not show any difference in terms of composition and diversity while there was a slight increase in the diversity of herbaceous component in all the sites.

7.8.6 Dinchang hydroelectric project

The following sampling sites were monitored as a part of the vegetation survey for Dinchang hydroelectric project:

- Catchment area (T16)
- Submergence area (T17)
- Downstream area (T18)

The findings of the vegetation survey at various sampling sites are given in Annexure-XVI. The summary of the findings of vegetation survey are given in Table-7.11. The diversity indices of various floral species are given in Table-7.12.

TABLE-7.11

Density (No./ha) of various floral species at various sampling sites in Dinchang HEP

S.No.	Sampling site	Trees	Shrubs	Herbs	
				Summer	Monsoon
1.	Catchment area	450	965	59950	96250
2.	Submergence area	520	1930	31600	59900
3.	Downstream area	320	1200	42050	66500

Note: Summer Season- April 2009, Monsoon season- August 2009

TABLE-7.12

Species Diversity Indices for different vegetation components in Dinchang HEP

Vegetation component	Diversity Indices	
	Shannon's Diversity Index (H)	Evenness Index (e)
Catchment Area		
Trees	1.49	0.49
Shrubs	1.89	0.60
Herbs	1.31(April), 1.47 (August)	0.25(April), 0.27 (August)
Submergence area		
Trees	1.11	0.76
Shrubs	0.71	0.29
Herbs	1.98(April), 1.98 (August)	0.48(April), 0.48 (August)
Downstream area		
Trees	1.42	0.46
Shrubs	2.31	0.63
Herbs	2.01(April), 2.00 (August)	0.58(April), 0.39 (August)

Note: Summer Season- April 2009, Monsoon season- August 2009

Nine tree species were recorded in the catchment area. The tree density was low (450 individuals /ha). *Pinus* sp. and *Pinus wallichiana* were the dominant tree species. Eleven shrub and 16 herbs including climbers were recorded from the site. *Eupatorium odoratum* and *Urena lobata* dominated the shrub layer while *Imperata cylindrica* and *Commelina paludosa* were dominant in the herb layer. The Shannon's Index for all three components (tree, shrub and herb) ranged from 1.47-1.89 in the forests studied. The evenness index ranged from 0.27-0.60.

In the submergence area, nine species of trees represented by 520 individuals were recorded. There were 16 shrubs and 19 herbs including climbers that were recorded from the site. *Indigofera* sp. and *Eupatorium odoratum* were the dominant shrub species whereas, *Imperata cylindrica* and *Drymaria cordata* were the dominant herb species. Shannon's diversity index for all three components i.e., tree, shrub and herb ranged from 0.71-1.98 and the evenness index ranged from 0.29-0.76.

The downstream site had 9 tree species represented by 320 individuals /ha. *Pinus* sp. was the dominant species followed by *Quercus* sp. There were 7 shrubs and 15 herbs including climbers that were recorded from the site. *Indigofera* sp. followed by *Eupatorium odoratum* and *Boehmeria longifolia* dominated the shrub layer whereas, the herb layer was dominated by grasses. The Shannon's diversity index ranged from 1.42-2.31 for trees, shrubs and herbs and the evenness index ranged from 0.39-0.63.

The tree and shrubs did not show any difference in terms of composition and diversity while there was a slight increase in the diversity of herbaceous component in all the sites.

7.8.7 Jameri hydroelectric project

The following sampling sites were monitored as a part of the vegetation survey for Jameri hydroelectric project:

- Catchment area (T19)
- Submergence area (T20)
- Downstream area (T21)

The findings of the vegetation survey at various sampling sites are given in Annexure-XVII. The summary of the findings of vegetation survey are given in Table-7.13. The diversity indices of various floral species are given in Table-7.14.

TABLE-7.13

Density (No./ha) of various floral species at various sampling sites in Jameri HEP

S.No.	Sampling site	Trees	Shrubs	Herbs	
				Summer	Monsoon
1.	Catchment area	845	5715	56000	75350
2.	Submergence area	1225	3105	34250	53300
3.	Downstream area	525	5035	49600	63850

Note: Summer Season- April 2009, Monsoon season- August 2009

TABLE-7.14

Species Diversity Indices for different vegetation components in Jameri HEP

Vegetation component	**Diversity Indices**	
	Shannon's Diversity Index (H)	**Evenness Index (e)**
Catchment area		
Trees	2.20	0.60
Shrubs	1.46	0.36
Herbs	2.32 (April), 2.43 (August)	0.60 (April), 0.67 (August)
Submergence area		
Trees	2.55	0.61
Shrubs	1.77	0.39
Herbs	2.17 (April), 2.26 (August)	0.63 (April), 0.56 (August)
Downstream area		
Trees	2.78	0.64
Shrubs	1.61	0.38
Herbs	1.96 (April), 2.17 (August)	0.55 (April), 0.51 (August)

Note: Summer Season- April 2009, Monsoon season- August 2009

In the catchment area, fifteen tree species were recorded. The tree density was high (845 individuals /ha). *Musa* sp., bamboo species were the dominant species. Twelve shrub and 17 herbs including climbers were recorded from the site. *Artemesia nilagirica* and *Eupatorium adenophorum* dominated the shrub layer while *Imperata cylindrica* and *Saccharum spontaneum* were dominant in the herb layer. The Shannon's Index for all three components (tree, shrub and herb) ranged from 1.46-2.23 in the forests studied. The evenness index ranged from 0.36-0.67 for most of the components.

In the submergence site, twenty one species of trees represented by 1225 individuals were recorded. There were 15 shrubs and 17 herbs that were recorded from the site. *Rhynchotecium sp.* and *Piper* sp. were the dominant shrub species whereas *Selaginella sp.* and *Elatostemma sessile* were the dominant herb species.Shannon's diversity index for all three components i.e., tree, shrub and herb ranged from 1.77-2.55 and evenness index ranged from 0.39-0.61.

The submergence area had 25 tree species represented by 525 individuals /ha. *Pandanus odoratissima* and *Alnus nepalensis* with 105 and 75 individuals/ha were the dominant species. There were 13 shrubs and 17 herbs were recorded from the site. *Piper* sp. and *Rhynchotecium* sp. dominated the shrub layer whereas, *Elatostemma sessile* and *Pilea umbrosa* dominated the herb layer. The Shannon's diversity index for trees, shrubs and herbs ranged from 1.61-2.78 and the evenness index ranged from 0.38-0.64.

The tree and shrubs did not show any difference in terms of composition and diversity while there was a slight increase in the diversity of herbaceous component in all the sites.

7.8.8 Dinan hydroelectric project

The following sampling sites were covered as a part of the ecological survey for Dinan hydroelectric project:

- Catchment area (T22)
- Submergence area (T23)
- Downstream area (T24)

The findings of the vegetation survey at various sampling sites are given in Annexure-XVIII. The summary of the findings of vegetation survey are given in Table-7.15. The diversity indices of various floral species are given in Table-7.16.

TABLE-7.15

Density (No./ha) of various floral species at various sampling sites of Dinan HEP

S. No.	Sampling site	Trees	Shrubs	Herbs	
				Summer	Monsoon
1.	Catchment area	610	2875	40850	71300
2.	Submergence area	460	3020	63850	102300
3.	Downstream area	535	3460	62700	114700

Note: Summer Season- April 2009, Monsoon season- August 2009

TABLE-7.16

Species Diversity Indices for different vegetation components in Dinan HEP

Vegetation component	Diversity Indices	
	Shannon's Diversity Index (H)	Evenness Index (e)
Catchment area		
Trees	2.08	0.50
Shrubs	2.49	0.63
Herbs	2.34 (April), 2.55 (August)	0.49 (April), 0.65 (August)
Submergence area		
Trees	1.95	0.64
Shrubs	2.22	0.51
Herbs	1.70 (April), 2.34 (August)	1.25 (April), 0.41 (August)
Downstream area		
Trees	1.45	0.71
Shrubs	2.28	0.57
Herbs	2.11 (April), 2.23 (August)	0.44 (April), 0.33 (August)

Note: Summer Season- April 2009, Monsoon season- August 2009

Sixteen tree species were recorded in the catchment area. The tree density was high (610 individuals /ha). *Quercus griffithii and Myrica esculenta* with 240 and 90 individuals /ha were the dominant tree species. Nineteen shrub and 25 herbs including climbers were recorded from the site. *Indigofera* sp. and *Boehmeria longifolia* dominated the shrub layer while *Pilea umbrosa* and *Nephrolepis cordifolia* were dominant in the herb layer. In general, species diversity was high and the Shannon's Index for all three components (tree, shrub and herb) was more than 2 in the forests studied. The evenness index ranges from 0.50-0.63 for most of the components.

In the submergence area, six tree species of trees represented by 460 individuals were recorded. There were 17 shrubs and 28 herbs including climbers that were recorded from the site. *Indigofera* sp. and *Urena lobata* were the dominant shrub species whereas, *Imperata cylindrica* and *Nephrolepis cordifolia* were the dominant herb species. Shannon's diversity index for all three components i.e., tree, shrub and herb was more than 1.95 and evenness index ranges from 0.41-0.64.

The downstream site had 11 tree species represented by 535 individuals /ha. *Pinus* sp. (210 individuals/ha) and *Quercus* sp*.* (75 individuals/ha) were the dominant tree. There were 18 shrubs and 25 herbs including climbers that were recorded from the site. *Artemesia nilagirica* and *Urena lobata* dominated the shrub layer whereas, *Imperata cylindrica* and *Ageratum conyzoides* dominated the herb layer. The Shannon's diversity index from 1.45-2.28 for trees, shrubs and herbs and evenness index ranged from 0.33-0.71 for all tree, shrub and herb components.

The tree and shrubs did not show any difference in terms of composition and diversity while there was a slight increase in the diversity of herbaceous component in all the sites.

7.8.9 Nafra hydroelectric project

The following sampling sites were monitored as a part of the vegetation survey for Nafra hydroelectric project:

- Catchment area (T25)
- Submergence area (T26)
- Downstream area (T27)

The findings of the vegetation survey at various sampling sites are given in Annexure-XIX. The summary of the findings of vegetation survey are given in Table-7.17. The diversity indices of various floral species are given in Table-7.18.

TABLE-7.17

Density (No./ha) of various floral species at various sampling sites in Nafra HEP

S.No.	Sampling site	Trees	Shrubs	Herbs	
				Summer	Monsoon
1.	Catchment area	610	2365	34800	52550
2.	Submergence area	210	5995	39600	56200
3.	Downstream area	285	2360	32000	53750

Note: Summer Season- April 2009, Monsoon season- August 2009

TABLE-7.18

Species Diversity Indices for different vegetation components in Nafra HEP

Vegetation component	Diversity Indices	
	Shannon's Diversity Index (H)	Evenness Index (e)
Catchment area		
Trees	1.99	0.61
Shrubs	1.45	0.47
Herbs	1.52 (April), 1.74 (August)	0.42 (April), 0.47 (August)
Submergence area		
Trees		1.00
Shrubs	1.27	0.71
Herbs	1.52 (April), 0.98 (August)	0.46 (April), 0.53 (August)
Downstream area		
Trees	1.34	0.64
Shrubs	0.91	0.23
Herbs	0.99 (April), 1.51 (August)	0.67 (April), 0.41 (August)

Note: Summer Season- April 2009, Monsoon season- August 2009

In the catchment area, twelve tree species were recorded. The tree density was high (610 individuals /ha). *Pinus wallichiana* was the dominant tree species followed by *Macaranga denticulata*. Nine shrub and 12 herbs were recorded from the site. *Ageratum conyzoides* and *Eupatorium conyzoides* dominated the shrub layer while *Imperata cylindrica* and *Nephrolepis cordifolia* were dominant in the herb layer. In general, Shannon's Index for all three components (tree, shrub and herb) ranged from 1.45-1.99 in the forests studied. The evenness index ranged from 0.47-0.61.

In the submergence area, six species of trees represented by 210 individuals/ha were recorded. There were 11 shrubs and 11 herbs that were recorded from the site. *Artimesia nilagirica* and *Eupatorium odoratum* were the dominant shrub species whereas, *Imperata cylindrica and Paspallum* sp. were the dominant herb species. Shannon's diversity index for all three components i.e., tree, shrub and herb was more than ranged from 0-1.27 and evenness index ranged from 0.53-1.00.

The downstream site was dominated by *Pinus* sp. and had a density of 285 individuals /ha. There were 5 shrubs and 5 herbs species that were recorded from the site. *Urena lobata* and *Artimesia nilagirica* dominated the shrub layer whereas, *Imperata cylindrica and Kyllinga* sp. dominated the herb layer. The Shannon's diversity index ranged from 0.91-1.51 and evenness index ranged from 0.23-0.64 for all tree, shrub and herb components.

The tree and shrubs did not show any difference in terms of composition and diversity while there was a slight increase in the diversity of herbaceous component in all the sites.

7.8.10 Gongri hydroelectric project

The various sampling sites were covered as a part of the vegetation survey for Gongri hydroelectric project sites are:

- Catchment area (T28)
- Submergence area (T29)
- Downstream area (T30)

The findings of the vegetation survey at various sampling sites are given in Annexure-XX. The summary of the findings of vegetation survey are given in Table-7.19. The diversity indices of various floral species are given in Table-7.20.

TABLE-7.19

Density (No./ha) of various floral species at various sampling sites of Gongri HEP

S.No.	Sampling site	Trees	Shrubs	Herbs	
				Summer	Monsoon
1.	Catchment area	430	1140	38350	63950
2.	Submergence area	205	3615	38100	56050
3.	Downstream area	520	1090	28950	51900

Note: Summer Season- April 2009, Monsoon season- August 2009

TABLE-7.20

Species Diversity Indices for different vegetation components in Gongri HEP

Vegetation component	Shannon's Diversity Index (H)	Evenness Index (e)
Catchment area		
Trees	1.83	0.78
Shrubs	2.19	0.59
Herbs	1.95 (April), 2.01 (August)	0.47 (April), 0.44 (August)
Submergence area		
Trees	0.00	1.00
Shrubs	2.10	0.58
Herbs	2.20 (April), 1.88 (August)	0.56 (April), 0.50 (August)
Downstream area		
Trees	1.87	0.81
Shrubs	2.03	0.51
Herbs	1.86 (April), 2.12 (August)	0.58 (April), 0.44 (August)

Note: Summer Season- April 2009, Monsoon season- August 2009

In the catchment area, eight tree species were recorded in this forest. The tree density was low (430 individuals /ha). *Rhus javanica* and *Quercus* sp. were the dominant tree species. Fifteen shrub and 17 herbs including climbers were recorded from the site. *Eupatorium adenophorum* and *Artimesia nilagirica* dominated the shrub layer while *Imperata cylindrica* and *Nephrolepis cordifolia* were dominant in the herb layer. In general, species diversity was high and the Shannon's Index for all three components (tree, shrub and herb) ranged from 1.83-2.19 in the forests studied. The evenness index ranged from 0.44-0.78 for most of the components.

In the submergence area, eight species of trees represented by 250 individuals/ha were recorded in this forest. There were 15 shrubs and 19 herbs that were recorded from the site. *Artimesia nilagirica* and *Plectranthus striatus* were the dominant shrub species whereas, the herb layer was dominated by grasses. Shannon's diversity index for all three components i.e., tree, shrub and herb ranged from 0-2.10 and the evenness index ranged from 0.5-1.00.

The downstream site represents pure Pine forest with a density of 520 individuals /ha. There were 14 shrubs and 13 herbs including climbers that were recorded from the site. *Eupatorium adenophorum* and *Artimesia nilagirica* dominated the shrub layer while *Imperata cylindrica* and *Commelina paludosa* were dominant in the herb layer. The Shannon's diversity index for trees, shrubs and herbs ranged from 1.87-2.12 and the evenness index ranged from 0.44-0.81.

The tree and shrubs did not show any difference in terms of composition and diversity while there was a slight increase in the diversity herbaceous component in all the sites.

7.9 ESTIMATED WOOD VOLUME IN THE PROJECT SITES

The estimated volume of wood at various sampling sites is given in Table-7.21. The details are given in Annexure-XXI.

TABLE-7.21
Estimated wood volume at various sampling sites

Sampling site	Wood Volume (m^3/ha)
Utung Hydroelectric Project	
Catchment area	324.12
Submergence area	171.12
Downstream area	150.48
Nazong Hydroelectric Project	
Catchment area	367.61
Submergence area	173.99
Downstream area	176.71
Dibbin Hydroelectric Project	
Catchment area	230.09
Submergence area	39.66
Dam site	66.97
Dimijin Hydroelectric Project	
Catchment area	53.97
Submergence area	79.35
Downstream area	29.01
Dikhri Hydroelectric Project	
Catchment area	514.93
Submergence area	109.44
Downstream area	88.95
Dinchang Hydroelectric Project	
Catchment area	36.46
Submergence area	69.99
Downstream area	25.45
Jameri Hydroelectric Project	
Catchment area	107.57
Submergence area	47.88
Downstream area	200.39

Sampling site	Wood Volume (m^3/ha)
Dinan Hydroelectric Project	
Catchment area	181.26
Submergence area	51.33
Downstream area	81.82
Nafra Hydroelectric Project	
Catchment area	38.05
Submergence area	6.83
Gongri Hydroelectric Project	
Catchment area	0.68
Submergence area	20.25
Downstream area	167.27

- In Utung Hydroelectric Project, the estimated volume of wood present in sampling site at catchment area was maximum (324.12 m^3/ha) followed by sampling site in submergence area (171.12 m^3/ha).
- In Nazong Hydroelectric Project, the estimated volume of wood present in sampling site at catchment area was maximum (367.61 m^3/ha) followed by sampling site at downstream area (176.71 m^3/ha).
- In Dibbin Hydroelectric Project, the estimated volume of wood present in sampling site at catchment area was maximum (230.09 m^3/ha) followed by sampling site at submergence area (66.97 m^3/ha).
- In Dimijin Hydroelectric Project, the estimated volume of wood present at various sampling sites ranged from 29.01 m^3/ha to 79.35 m^3/ha.
- The estimated volume of wood present in forest in Dikhri Hydroelectric Project was low (88.95 m^3/ha) at downstream area and high in sampling site at catchment area (514.93 m^3/ha).
- In Dinchang Hydroelectric Project, the estimated volume of wood present ranged from 25.45 m^3/ha to 69.99 m^3/ha.
- In Jameri Hydroelectric Project, the estimated volume of wood present in sampling site at submergence area forest was maximum (200.39 m^3/ha) followed by sampling site at catchment area (107.57 m^3/ha).
- The estimated volume of wood present in Dinan Hydroelectric Project, was maximum in sampling site at catchment area area (105.28 m^3/ha) followed by sampling site at downstream area (81.82 m^3/ha).

- In Nafra Hydroelectric Project, the estimated volume of wood present in sampling site at catchment area was maximum (38.05 m^3/ha) followed by sampling site at submergence area (6.83 m^3/ha).
- In Gongri Hydroelectric Project, the estimated volume of wood present in forest at sampling site at catchment area was lowest (0.68 m^3/ha) and highest in sampling site at downstream area (167.27 m^3/ha).

7.10 ECONOMICALLY IMPORTANT PLANTS

The forests in Arunachal Pradesh are endowed with many useful plant species viz., timber yielding species, medicinal plants, bamboos, rattans, wild ornamental plants, etc. The state can be termed as a repository of medicinal plants (Haridasan *et al*. 1996). The indigenous people in the state live in close association with the forests and have accumulated a vast treasure of knowledge related to utilization of plants. This knowledge of medicinal plants is becoming a potential source of information for the pharmaceutical industries. The list of economically important plant species observed at various sampling sites in the area of various hydroelectric projects is given in Table-7.22.

TABLE-7.22
List of Economically important plant species observed at various sampling sites

S. No.	Species	Uses
I.	**Utung Hydroelectric Project**	
1	*Clerodendron colebrookianum*	Leafy vegetable
2	*Costos speciosus*	Medicinal
3	*Ficus roxburghii*	Fodder, fruits edible
4	*Macaranga denticulate*	Fuel
5	*Nephrolepis cordifolia*	Medicinal
6	*Rubus* sp.	Edible
7	*Schima khasiana*	Timber
8	*Spondias pinnata*	Fruits edible
9	*Myrica esculenta*	Fruits edible
II.	**Nazong Hydroelectric Project**	
1	*Clerodendron colebrookianum*	Leafy vegetable
2	*Costos speciosus*	Medicinal
3	*Ficus roxburghii*	Fodder, fruits edible
4	*Macaranga denticulate*	Fuel
5	*Nephrolepis cordifolia*	Medicinal
6	*Rubus* sp.	Edible
7	*Schima khasiana*	Timber
III.	**Dibbin Hydroelectric Project**	

S. No.	Species	Uses
1	*Clerodendron colebrookianum*	Leafy vegetable
2	*Costos speciosus*	Medicinal
3	*Ficus roxburghii*	Fodder, fruits edible
4	*Macaranga denticulate*	Fuel
5	*Nephrolepis cordifolia*	Medicinal
6	*Rubus* sp.	Edible
7	*Schima khasiana*	Timber
8.	*Toona ciliate*	Timber
IV.	**Dimijin Hydroelectric Project**	
1	*Pinus* sp.	Timber
2	*Schima wallichii*	Timber
3	*Toona ciliate*	Timber
4	*Clerodendron colebrookianum*	Leafy vegetable
5	*Nephrolepis cordifolia*	Medicinal
6	*Rubus* sp.	Edible
V.	**Dikhri Hydroelectric Project**	
1	*Clerodendron colebrookianum*	Leafy vegetable
2	*Costos speciosus*	Medicinal
3	*Ficus roxburghii*	Fodder, fruits edible
4	*Macaranga denticulate*	Fuel
5	*Nephrolepis cordifolia*	Medicinal
6	*Rubus* sp.	Edible
7	*Schima khasiana*	Timber
8	*Juglans regia*	Fruits edible
9	*Myrica esculenta*	Fruits edible
VI.	**Dinchang Hydroelectric Project**	
1	*Clerodendron colebrookianum*	Leafy vegetable
2	*Ficus roxburghii*	Fodder, fruits edible
3	*Nephrolepis cordifolia*	Medicinal
4	*Rubus* sp.	Edible
VII.	**Jameri Hydroelectric Project**	
1	*Clerodendron colebrookianum*	Leafy vegetable
2	*Ficus cunia*	Fodder
3	*Macaranga denticulate*	Fuel
4	*Nephrolepis cordifolia*	Medicinal
5	*Pandanus odoratissima*	Fiber
6	*Rubus* sp.	Edible
7	*Terminalia myriocarpa*	Timber
VIII.	**Dinan Hydroelectric Project**	
1	*Ficus roxburghii*	Fodder, fruits edible
2	*Nephrolepis cordifolia*	Medicinal
3	*Rubus* sp.	Edible

S. No.	Species	Uses
4	*Schima khasiana*	Timber
5	*Myrica esculenta*	Fruits edible
IX.	**Nafra Hydroelectric Project**	
1	*Pinus* sp.	Timber
2	*Schima wallichii*	Timber
3	*Toona ciliate*	Timber
4	*Clerodendron colebrookianum*	Leafy vegetable
5	*Nephrolepis cordifolia*	Medicinal
6	*Rubus* sp.	Edible
X.	**Gongri Hydroelectric Project**	
1	*Macaranga denticulata*	Fuel
2	*Nephrolepis cordifolia*	Medicinal
3	*Rubus* sp.	Edible
4	*Juglans regia*	Edible fruits

About 9 economically important plant species were recorded from the study area in Utung. Plants of economic importance such as fuelwood (*Lyonia ovalifolia*, *Macaranga denticulata*, *Quercus* spp.), medicinal (*Nephrolepis cordifolia*) and edible fruits (*Castanopsis purpurella, Myrica esculenta, Spondias pinnata*) yielding tree species were seen commonly here and there at the project site. The names of edible and economically important and wild crop relative plants found during the survey have been listed in Table-7.22.

About 7 economically important plant species were recorded from the study area in Nazong. Plants of economic importance such as fuelwood (*Macaranga denticulata*, *Quercus* spp.), medicinal (*Nephrolepis cordifolia*) and edible fruits (*Castanopsis purpurella, Myrica esculenta*) yielding tree species were seen commonly here and there at the project site. The names of edible and economically important and wild crop relative plants found during the survey have been listed in Table -7.22.

About 8 economically important plant species were recorded from the study area in Dibbin. Plants of economic importance such as fuelwood (*Lyonia ovalifolia*, *Macaranga denticulata*), medicinal (*Nephrolepis cordifolia*) and edible fruits (*Castanopsis purpurella*) yielding tree species were seen commonly here and there at the project site. The names of edible and economically important and wild crop relative plants found during the survey have been listed in Table-7.22.

About 6 economically important plant species were recorded from the study area in Dimijin. Plants of economic importance such as timber/fuel wood (*Pinus* sp., *Schima wallichii, Toona ciliata*) and medicinal (*Nephrolepis cordifolia*) yielding tree species were seen commonly here and there at the project site. The names of edible and economically important and wild crop relative plants found during the survey have been listed in Table-7.22.

About 9 economically important plant species were recorded from the study area in Dikhri. Plants of economic importance such as fuelwood (*Lyonia ovalifolia*, *Macaranga denticulata*, *Quercus* spp.), medicinal (*Nephrolepis cordifolia*) and edible fruits (*Castanopsis purpurella, Myrica esculenta, Juglans regia*) yielding tree species were seen commonly here and there at the project site. The names of edible and economically important and wild crop relative plants found during the survey have been listed in Table-7.22.

About 4 economically important plant species were recorded from the study area in Dinchang. Plants of economic importance such as timber/fuelwood (*Quercus* spp.) and medicinal (*Nephrolepis cordifolia*) yielding tree species were seen commonly here and there at the project site. The names of edible and economically important and wild crop relative plants found during the survey have been listed in Table-7.22.

About 7 economically important plant species were recorded from the study area in Jameri. Plants of economic importance such as timber (*Terminalia myriocarpa*), medicinal (*Nephrolepis cordifolia*) and edible fruits (*Juglans regia*) and *Pandanus odoratissima* a fiber yielding tree species were seen commonly here and there at the project site. The names of edible and economically important and wild crop relative plants found during the survey have been listed in Table-7.22.

About 5 economically important plant species were recorded from the study area in Dinan. Plants of economic importance such as timber/fuelwood (*Schima khasiana, Quercus* spp.), medicinal (*Nephrolepis cordifolia*) and edible fruits (*Castanopsis purpurella, Myrica esculenta*) yielding tree species were seen commonly here and there at the project site. The names of edible and economically important and wild crop relative plants found during the survey have been listed in Table-7.22.

About 6 economically important plant species were recorded from the study area in Nafra. Plants of economic importance such as timber/fuel wood (*Pinus* sp., *Schima wallichii, Toona ciliata*) and medicinal (*Nephrolepis cordifolia*) yielding tree species were seen commonly here and there at the project site. The names of edible and economically important and wild crop relative plants found during the survey have been listed in Table-7.22.

About 4 economically important plant species were recorded from the study area in Gongri. Plants of economic importance such as timber/ fuelwood (*Quercus* spp., *Macaranga denticulata*), medicinal (*Nephrolepis cordifolia*) and edible fruits (*Juglans regia*) yielding tree species were seen commonly here and there at the project site. The names of edible and economically important and wild crop relative plants found during the survey have been listed in Table-7.22.

7.11 FLORA UNDER THREATENED CATEGORY

During the course of survey, only one species i.e., *Lagerstroemia muniticarpa* classified as endangered plant species as per IUCN Red list.

7.12 FAUNA

The wildlife in the project area has been listed based on the observation during the field visit and information collected from the local people as shown in Table-7.23.

TABLE-7.23
List of wildlife in project area along with their common names

Common Name	Zoological name
Mammals	
Leopard	*Panthera Pardus*
Wild Dog	*Cuon Alpinus*
Wild Cat	*Felis chaus*
Himalayan Black Bear	*Selenarctos thibetanus*
Assamese Monkey	*Macaca assamensis*
Wild pig	*Sus scrofa*
Bay bamboo rat	*Cannomys badius*
Small Indian civet	*Viverricula indica*
Indian grey mongoose	*Herpestes edwardsii*
Crab eating mongoose	*Herpestes urva*
Jungle cat	*Felis chaus*
Leopard cat	*Felis bengalensis*
Reptiles	
Brown-spotted pitviper	*Protobothrops mucrosquamatus*
Jerdon's pitviper	*Protobothrops jerdoni*
Mountain pitviper	*Ovophis monticola*
Yellow bellied worm-snake	*Trachischium tenuiceps*
Lizard Monitor	*Varanus bengalensis*
Sikkim Sunskink	*Scinella sikimmensis*
Stremside forest skink	*Sphenomorphus maculates*
Three Striped Roofed turtle	*Kachuga dhangoka*
Assam Saw-back turtle	*Kachuga sylhetensis*

Common Name	Zoological name
Cat snake	*Boiga orchea*
Amphibians	
Common bufo	*Bufo melanostictus*
Hyla	*Microhyla ornats*
Butterflies	
Golden birdwing	*Triodes aeacus*
Common windmill	*Atrrphaneura polyeuctes*
Paris peacock	*Papilio paris*
Lime butterfly	*P.demoleus demoleus*
Red halen	*P. halenus*
Common mormon	*P. polytes*
Common mime	*Chilasa clytia clytia*
Common blue bottle	*Graphium serpedon*
Great zebra	*Paranticopsis xenocles xenocles*
Redbase jezebel	*Delias pasithoe*
Indian cabbage white	*Artogeia canidia*
Chocolate albatross	*Appias lyncida*
Yellow orangetip	*Ixias pyrene*
Spot puffin	*Appias lalage*
Common grass yellow	*Eurema hecabe*
Three spot grass yellow	*E. blanda*
Plain tiger	*Danaus chrysippus*
Common tiger	*D. genutia*
Glassy tiger	*Parantica aglea*
Striped blue crow	*Euploea mulciber*
Red lacewing	*Cethosia biblis*
Indian fritillary	*Argyreus hyperbius*
Painted lady	*Vanessa cardui*
Lemon pansy	*Junonia lemonias*
Grey pansy	*J. atlitus*
Chocolate soldier	*J. iphita*
Peacock pansy	*J. almana*
Himalayan jester	*Symbrenthia hypselis*
Orange oakleaf	*Kallima inachus*
Common sailor	*Neptis hylas*
Sullied sailor	*N. soma soma*
Green commodore	*Sumalia daraxa daraxa*
Palliednawab	*Polyura arja*
Black prince	*Rohana parisatis parisatis*
Common evening brown	*Meanitis leda*
Plain bush brown	*Mycalesis malsarida*
Common three ring	*Ypthima asterope mahraatta*
Eastern fivering	*Ypthima similes similis*
Common plamfly	*Elymnias hypermnestra*
Golden sapphire	*Heliophorus bramah*
Green sapphire	*H. androcles*
Common pierrot	*Castalius rosimon*

Common Name	Zoological name
Avi-fauna	
Broad-billed Warbler	*Abroscopus hodgsonii*
Black-faced Warbler	*Abroscopus schisticeps*
Black-throated Tit	*Aegithalos concinnus*
Common Iora	*Aegithina tiphia*
Fire-tailed Sunbird	*Aethopyga ignicauda*
Rufous-winged Fulvetta	*Alcippe castaneceps*
Olive-backed Pipit	*Anthus hodgsonii*
Upland Pipit	*Anthus sylvanus*
House Swift	*Apus affinis*
Golden Eagle	*Aquila chrysaetos*
Yellow-breasted Greenfinch	*Carduelis spinoides*
Dark-rumped Rosefinch	*Carpodacus edwardsii*
Dark-breasted Rosefinch	*Carpodacus nipalensis*
White-browed Rosefinch	*Carpodacus thura*
Rusty-flanked Treecreeper	*Certhia nipalensis*
White-capped Water Redstart	*Chaimarrornis leucocephalus*
Emerald Dove	*Chalcophaps indica*
Speckled Wood Pigeon	*Columba hodgsonii*
Snow Pigeon	*Columba leuconota*
Hill Pigeon	*Columba rupestris*
Large-billed Crow	*Corvus macrorhynchos*
Grey-headed Canary Flycatcher	*Culicicapa ceylonensis*
Cutia	*Cutia nepalensis*
Pale blue Flycatcher	*Cyornis rubeculoides*
Asian House Martin	*Delichon dasypus*
Grey Treepie	*Dendrocitta formosae*
Darjeeling Woodpecker	*Dendrocopos darjellensis*
Stripebreasted Woodpecker	*Dendrocopus atratus*
Crimsonbreasted Woodpecker	*Dendrocopus cathpharius*
Yellow-bellied Flowerpecker	*Dicaeum melanoxanthum*
Spangled Drongo	*Dicrurus hottentotus*
Black Drongo	*Dicrurus macrocercus*
Lesser Racket-tailed Drongo	*Dicrurus remifer*
Mountain Imperial Pigeon	*Ducula badia*
Rock Bunting	*Emberiza cia*
Little Forktail	*Enicurus scouleri*
Verditer Flycatcher	*Eumyias thalassina*
Oriental Hobby	*Falco severus*
Slaty-blue Flycatcher	*Ficedula hodgsonii*
Red-throated Flycatcher	*Ficedula parva*
Ultramarine Flycatcher	*Ficedula superciliaris*
Black-faced Laughing Thrush	*Garrulax affinis*
White-throated Laughing Thrush	*Garrulax albogularis*
Chestnut-crowned Laughing Thrush	*Garrulax erythrocephalus*
White-crested Laughing Thrush	*Garrulax leucopholus*
Streaked Laughing Thrush	*Garrulax lineatus*

Common Name	Zoological name
Lesser Necklaced Laughing Thrush	*Garrulax monileger*
Spotted Laughing Thrush	*Garrulax ocellatus*
Rufous-necked Laughing Thrush	*Garrulax ruficollis*
Striated Laughing Thrush	*Garrulax striatus*
Eurasian Jay	*Garrulus glandarius*
Lammergeier	*Gypaetus barbatus*
Eurasian Griffon	*Gyps fulvus*
Himalayan Griffon	*Gyps himalayensis*
Scarlet Finch	*Haematospiza sipahi*
Bar-winged Flycatcher Shrike	*Hemipus picatus*
Rufous Sibia	*Heterophasia capistrata*
Grey Sibia	*Heterophasia gracilis*
Long-tailed Sibia	*Heterophasia picaoides*
Black Bulbul	*Hypsipetes leucocephalus*
Blood Pheasant	*Ithaginis cruentus*
Long-tailed Shrike	*Lanius schach*
Grey-backed Shrike	*Lanius tephronotus*
Silver-eared Mesia	*Leiothrix argentauris*
Red-billed Leiothrix	*Leiothrix lutea*
Plain Mountain Finch	*Leucosticte nemoricola*
Himalayan Monal	*Lophophorus impejanus*
Golden-throated Barbet	*Megalaima franklinii*
Great Barbet	*Megalaima virens*
Red-tailed Minla	*Minla ignotincta*
Chestnut-tailed Minla	*Minla strigula*
Chestnut-bellied Rock Thrush	*Monticola rufiventris*
White Wagtail	*Motacilla alba*
Grey Wagtail	*Motacilla cinerea*
Yellow Wagtail	*Motacilla flava*
Asian Brown Flycatcher	*Muscicapa dauurica*
Ferruginous Flycatcher	*Muscicapa ferruginea*
Spot-winged Grosbeak	*Mycerobas melanozanthos*
Blue Whistling Thrush	*Myophonus caeruleus*
Fire-tailed Myzornis	*Myzornis pyrrhoura*
Streaked Wren Babbler	*Napothera brevicaudata*
Brown Hawk Owl?	*Ninox scutulata*
Spotted Nutcracker	*Nucifraga caryocatactes*
Coal Tit	*Parus ater*
Grey-crested Tit	*Parus dichrous*
Great Tit	*Parus major*
Green-backed Tit	*Parus monticolus*
Rufous-vented Tit	*Parus rubidiventris*
Black-lored Tit	*Parus xanthogenys*
Eurasian Tree Sparrow	*Passer montanus*
Long-tailed Minivet	*Pericrocotus ethologus*
Scarlet Minivet	*Pericrocotus flammeus*
Whitewinged Redstart	*Phoenicurus erythrogaster*

Common Name	**Zoological name**
Blue fronted Redstart	*Phoenicurus frontalis*
Black Redstart	*Phoenicurus ochruros*
Tickell's Leaf Warbler	*Phylloscopus affinis*
Eastern Crowned Warbler	*Phylloscopus coronatus*
Yellow-browed Warbler	*Phylloscopus inornatus*
Buff-barred Warbler	*Phylloscopus pulcher*
Blyth's leaf Warbler	*Phylloscopus reguloides*
Streak-breasted Scimitar Babbler	*Pomatorhinus ruficollis*
Hill Prinia	*Prinia atrogularis*
Alpine Accentor	*Prunella collaris*
Rufous-breasted Accentor	*Prunella strophiata*
White-browed Shrike Babbler	*Pteruthius flaviscapis*
Green Shrike Babbler	*Pteruthius melanotis*
Red-vented Bulbul	*Pycnonotus cafer*
Yellow-billed Chough	*Pyrrhocorax graculus*
Red-billed Chough	*Pyrrhocorax pyrrhocorax*
Gold-naped Finch	*Pyrrhoplectes epauletta*
Grey-headed Bullfinch	*Pyrrhula erythaca*
Red-headed Bullfinch	*Pyrrhula erythrocephala*
Goldcrest	*Regulus regulus*
White-browed Fantail	*Rhipidura aureola*
Yellow-bellied Fantail	*Rhipidura hypoxantha*
Plumbeous Water Redstart	*Rhyacornis fuliginosus*
Grey Bushchat	*Saxicola ferrea*
White-spectacled Warbler	*Seicercus affinis*
Golden-spectacled Warbler	*Seicercus burkii*
Chestnut-crowned Warbler	*Seicerus castaniceps*
Grey-hooded Warbler	*Seicerus xanthoschistos*
Chestnut-bellied Nuthatch	*Sitta castanea*
Beautiful Nuthatch	*Sitta formosa*
White-tailed Nuthatch	*Sitta himalayensis*
Crested Serpent Eagle	*Spilornis cheela*
Spotted Dove	*Streptopelia chinensis*
Oriental Turtle Dove	*Streptopelia orientalis*
Golden Bush Robin	*Tarsiger chrysaeus*
Rufous-breasted Bush Robin	*Tarsiger hyperythrus*
Common Woodshrike	*Tephrodornis pondicerianus*
Orange-breasted Green Pigeon	*Treron bicincta*
Pompadour Green Pigeon	*Treron pompadora*
Wedge-tailed Green Pigeon	*Treron sphenura*
Wood Sandpiper	*Tringa glareola*
Winter Wren	*Troglodytes troglodytes*

CHAPTER-8
PREDICTION OF IMAPCTS

8.1 INTRODUCTION

Prediction is essentially a process to forecast the future environmental conditions of the project area that might be expected to occur because of implementation of the project. Impact of project activities has been predicted using mathematical models and overlay technique (super-imposition of activity on environmental parameter). For intangible impacts qualitative assessment has been done.

8.2 LENGTH OF RIVER WITH NORMAL FLOW

The biggest impact on hydrologic regime is on account of change in the free flowing condition of the river.

The following projects are envisaged on river Bichom:

- Utong HEP
- Nazong HEP
- Dibbin HEP
- Dimijin HEP
- Nafra HEP

The following projects are envisaged on river Gongri/Digo:

- Gongri HEP
- Khuitam HEP
- Dinchang HEP

On following rivers, one hydroelectric project is proposed:

- River Dikhri - Dikhri HEP
- River Dinang - Dinan HEP
- River Tenga - Jameri HEP

With the construction of the proposed 5 (five) hydroelectric projects, free flowing river stretch on river Bichom shall be available for a stretch of about 32.5 km, as the FRL of the downstream project extends upto the tail race of the upstream project. Thus, the projects in its present configuration would convert the free flowing river into a series of river stretch with reduced or no flow downstream of dam site upto tail race disposal site followed by reservoir of the next project in the cascade development.

With the construction of the Gongri, Khuitam and Dinchang hydroelectric projects, river stretch for a length of about 28.25 km will be affected. There is a gap of 0.36 km between the TWL of Gongri HEP and tip of the reservoir of Khuitam HEP. Likewise, there is a gap of 0.87 km in the TWL of Khuitam HEP and tip of the FRL of Dinchang HEP. To develop free flow between Khuitam and Dinchang HEPs, it is recommended that either FRL of Dinchang HEP be reduced or dam site be shifted downstream or a combination of both be adopted in the project planning.

On river Dikhri, the free flow will be obstructed for a stretch of 5.5 km between dam site and tail race disposal site. For a stretch of 0.8 km downstream of tail race disposal of Dikhri HEP, there free flow will be observed upto confluence with river Bichom. The details are given in Figure-8.1.

The Dinan HEP site is located at a distance of about 6 km from the confluence of river Dinang with river Bichom. The tail race disposal site is envisaged about 5.8 km downstream of the Dikhri HEP site. Thus, a free flow stretch of only 0.2 km is available from the tail race disposal site to the confluence of river Dinang with river Bichom. The details are shown in Figure-8.1.

The Jamerii HEP site is located at a distance of about 22 km from the confluence of river Tenga with river Bichom. The tail race disposal site is envisaged about 5.6 km downstream of the Jameri HEP site. Thus, a free flow stretch of 17 km is available from the tail race disposal site to the confluence of river Tenga with river Bichom. The details are shown in Figure-8.1. Thus, it can be concluded that river Tenga has sufficient stretch of free flow downstream of dam site.

8.3 MODIFICATION IN HYDROLOGIC REGIME

The discharge for 90% dependable year for various hydroelectric project proposed in the study area is given in Table-8.1. The number of units likely to operate for hydro power generation in various months for 90% dependable year is given in Table-8.2.

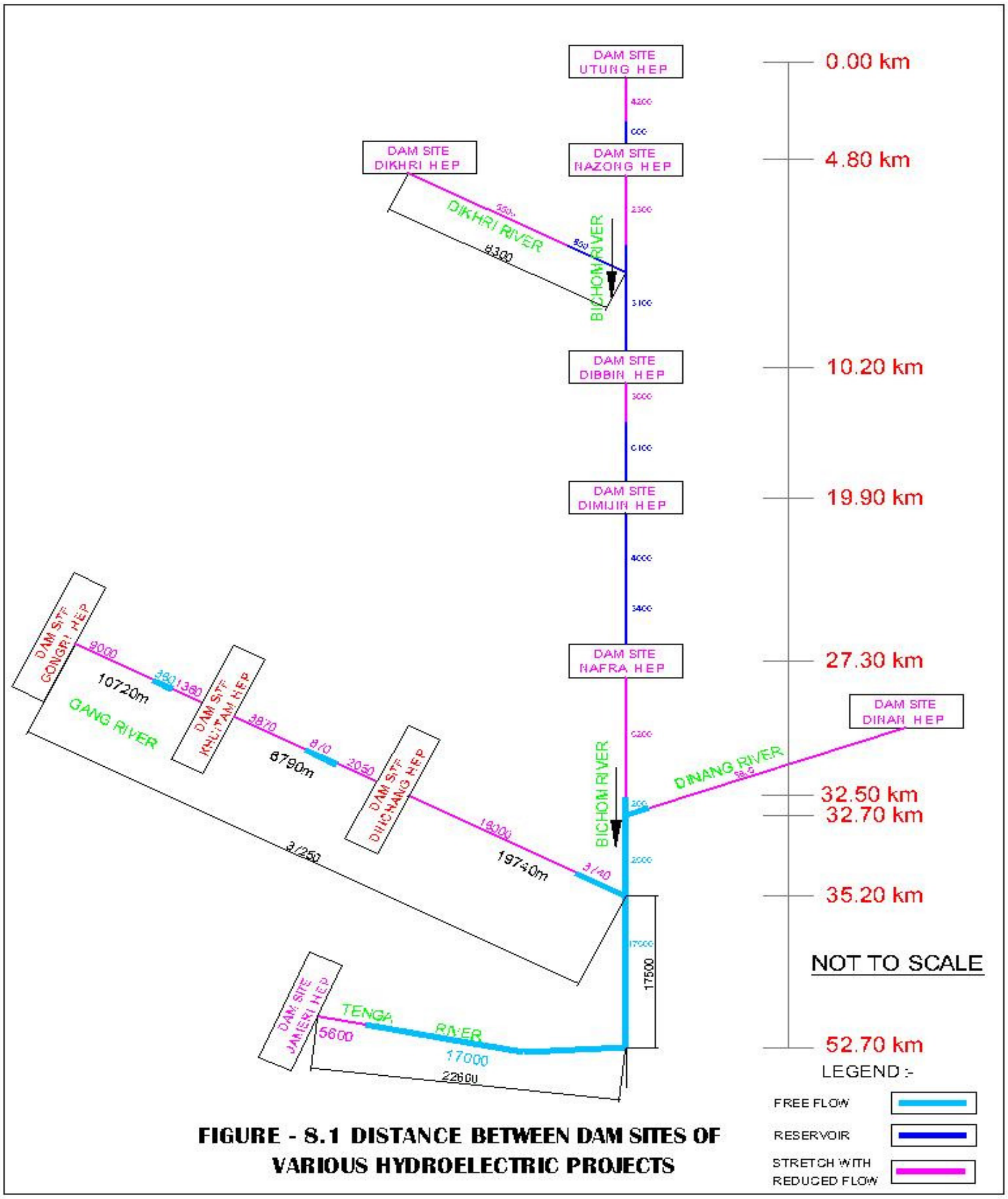


FIGURE - 8.1 DISTANCE BETWEEN DAM SITES OF VARIOUS HYDROELECTRIC PROJECTS

TABLE-8.1
Discharge for 90% dependable year for various Hydroelectric Projects

Month		Utung HEP	Nazong HEP	Dibbin HEP	Dimijin HEP	Dikhri HEP	Dinchang HEP	Jameri HEP	Dinan HEP	Gongri HEP	Nafra HEP
June	I	15.9	19.9	32.1	35.2	9.7	83.2	14.1	7.2	63.9	39.5
	II	23.9	30.0	48.3	53.0	14.6	122.1	17.2	10.8	93.8	59.5
	III	32.4	40.7	65.6	72.0	19.8	146.9	18.1	14.6	112.8	80.8
July	I	37.7	47.4	76.4	83.8	23.1	127.8	21.5	17.0	98.1	94.1
	II	38.8	48.8	78.6	86.2	23.7	129.1	28.0	17.5	99.2	96.8
	III	54.5	68.5	110.3	121.0	33.3	134.5	35.4	24.6	103.3	135.9
August	I	53.0	66.6	107.3	117.7	32.4	195.8	42.7	23.9	150.4	132.2
	II	29.6	37.2	59.9	65.7	18.1	125.3	27.7	13.4	96.2	73.8
	III	40.7	51.2	82.4	90.4	24.9	93.2	30.2	18.4	71.6	101.5
September	I	43.7	54.9	88.4	97.0	26.7	114.4	33.9	19.7	87.8	108.9
	II	33.5	42.2	67.9	74.5	20.5	136.8	24.7	15.1	105.0	83.7
	III	28.6	35.9	57.8	63.4	17.5	105.7	19.8	12.9	81.2	71.2
October	I	23.9	30.1	48.4	53.1	14.6	107.1	16.8	10.8	82.3	59.6
	II	19.8	24.9	40.1	44.0	12.1	77.2	15.8	8.9	59.3	49.4
	III	15.1	18.9	30.5	33.5	9.2	66.5	12.1	6.8	51.1	37.6
November	I	8.8	11.1	17.9	19.6	5.4	55.4	11.5	4.0	42.5	22.1
	II	10.5	13.2	21.3	23.4	6.4	50.8	10.2	4.7	39.0	26.2
	III	10.7	13.5	21.7	23.8	6.6	47.6	9.3	4.8	36.5	26.7
December	I	5.8	7.3	11.8	12.9	3.6	38.8	9.0	2.6	29.8	14.5
	II	5.9	7.4	11.9	13.1	3.6	31.4	8.6	2.7	24.1	14.7
	III	5.1	6.4	10.3	11.3	3.1	28.2	8.3	2.3	21.6	12.7
January	I	5.1	6.5	10.4	11.4	3.1	24.4	8.0	2.3	18.7	12.8
	II	5.0	6.3	10.2	11.2	3.1	22.6	8.0	2.3	17.3	12.6
	III	7.2	9.0	14.5	15.9	4.4	20.6	7.5	3.2	15.8	17.9
February	I	8.2	10.2	16.5	18.1	5.0	19.6	5.7	3.7	15.1	20.3
	II	6.4	8.0	12.9	14.2	3.9	19.5	6.5	2.9	15.0	15.9
	III	5.0	6.3	10.2	11.2	3.1	17.9	7.5	2.3	13.7	12.6
March	I	7.3	9.2	14.8	16.2	4.5	17.0	6.1	3.3	13.1	18.2
	II	6.5	8.2	13.1	14.4	4.0	16.8	6.5	2.9	12.9	16.1
	III	4.8	6.1	9.8	10.8	3.0	17.6	6.7	2.2	13.5	12.1

Month		Utung HEP	Nazong HEP	Dibbin HEP	Dimijin HEP	Dikhri HEP	Dinchang HEP	Jameri HEP	Dinan HEP	Gongri HEP	Nafra HEP
April	I	5.3	6.6	10.7	11.7	3.2	22.0	6.2	2.4	16.9	13.2
	II	5.2	6.5	10.5	11.5	3.2	26.5	5.4	2.3	20.3	12.9
	III	6.0	7.5	12.1	13.3	3.7	26.5	6.0	2.7	20.4	14.9
May	I	8.7	10.9	17.5	19.2	5.3	31.3	7.1	3.9	24.0	21.6
	II	10.3	12.9	20.8	22.8	6.3	22.8	8.7	4.6	17.5	25.6
	III	15.6	19.6	31.5	34.6	9.5	41.7	9.3	7.0	32.0	38.8

TABLE-8.2

Number of turbines likely to operate for various Hydroelectric Projects for 90% dependable year

Month		Utung HEP	Nazong HEP	Dibbin HEP	Dimijin HEP	Dikhri HEP	Dinchang HEP	Jameri HEP	Dinan HEP	Gongri HEP	Nafra HEP
June	I	-	-	-	-	-	3	-	1	3	1
	II	1	1	1	-	1	3	-	2	3	2
	III	1	1	1	1	1	3	-	2	3	2
July	I	2	1	1	1	1	3	-	2	3	2
	II	2	2	1	1	1	3	1	2	3	2
	III	2	2	2	2	2	3	1	2	3	2
August	I	2	2	2	2	2	3	1	2	3	2
	II	1	1	1	1	1	3	1	2	3	2
	III	2	2	1	1	1	3	1	2	3	2
September	I	2	2	1	1	1	3	1	2	3	2
	II	1	1	1	1	1	3	-	2	3	2
	III	1	1	1	1	1	3	-	2	3	2
October	I	1	1	1	1	1	3	-	2	3	1
	II	1	1	-	1	1	3	-	2	3	1
	III	-	-	-	-	-	2	-	1	2	1
November	I	-	-	-	-	-	2	-	1	2	-
	II	-	-	-	-	-	2	-	1	2	-
	III	-	-	-	-	-	2	-	1	2	-
December	I	-	-	-	-	-	2	-	-	1	-
	II	-	-	-	-	-	1	-	-	1	-

Month		Utung HEP	Nazong HEP	Dibbin HEP	Dimijin HEP	Dikhri HEP	Dinchang HEP	Jameri HEP	Dinan HEP	Gongri HEP	Nafra HEP
	III	-	-	-	-	-	1	-	-	1	-
January	I	-	-	-	-	-	1	-	-	1	-
	II	-	-	-	-	-	1	-	-	-	-
	III	-	-	-	-	-	1	-	-	-	-
February	I	-	-	-	-	-	-	-	-	-	-
	II	-	-	-	-	-	-	-	-	-	-
	III	-	-	-	-	-	-	-	-	-	-
March	I	-	-	-	-	-	-	-	-	-	-
	II	-	-	-	-	-	-	-	-	-	-
	III	-	-	-	-	-	-	-	-	-	-
April	I	-	-	-	-	-	-	-	-	-	-
	II	-	-	-	-	-	1	-	-	1	-
	III	-	-	-	-	-	1	-	-	1	-
May	I	-	-	-	-	-	1	-	-	1	-
	II	-	-	-	-	-	-	-	1	1	-
	III	-	-	-	-	-	1	-	1	1	1

Utung Hydroelectric Project

In Utung hydroelectric project, discharge for 90% dependable year is higher than the rated discharge (38 cumec) for a period about 70 days from 1st July to 10th September. The project envisages generation of 96 MW hydropower using 2 turbines of 48 MW capacity each. Thus, in for a period from 1st July to 10th September, both the turbines can be operated. and pre-project level of discharge will be maintained in river Bichom downstream of tail race disposal to dam of Nazong hydro-electric project. In lean season, i.e. from November discharge in 90% dependable year cannot operate even one turbine. If peaking power is to be generated then the reservoir needs to be filled upto FRL. This can result in drying of river stretch downstream of tail race disposal site to dam site of Nazong hydroelectric project. The drying of river stretch to fill the reservoir upto FRL for peaking power will last even upto 1 day after which there will continuous flow equivalent to rated discharge of 38 cumec for few hours. Even, if peaking power is not attained and higher number of turbines are operated (based on optimization of power generation with respect to cost) can result in drying up of river stretch followed by continuous flow of rated discharge. The rated discharge could be 6 to 7 times of the lean season flow in a 90% dependable year.

Nazong Hydroelectric Project

In Nazong hydroelectric project, discharge for 90% dependable year is higher than the rated discharge (50 cumec) for a period about 60 days from 11th July to 10th September. The project envisages generation of 32 MW hydropower using 2 turbines of 16 MW capacity each. Thus, in for a period from 10th July to 10th September, both the turbines can be operated. and pre-project level of discharge will be maintained in river Bichom downstream of tail race disposal to dam of Dibbin hydro-electric project. In lean season, i.e. from November discharge in 90% dependable year cannot operate even one turbine. If peaking power is to be generated then the reservoir needs to be filled upto FRL. This can result in drying of river stretch downstream of tail race disposal site to dam site of Dibbin hydroelectric project. The drying of river stretch to fill the reservoir upto FRL for peaking power will last even upto 1 day after which there will continuous flow equivalent to rated discharge of 50 cumec for few hours. Even, if peaking power is not attained and higher number of turbines are operated (based on optimization of power generation with respect to cost) can result in drying up of river stretch followed by continuous flow of rated discharge. The rated discharge could be 5 to 8 times of the lean season flow in a 90% dependable year.

Dibbin Hydroelectric Project

In Dibbin hydroelectric project, discharge for 90% dependable year is higher than the rated discharge (98 cumec) for a period about 20 days from 21st July to 10th August. The project envisages generation of 130 MW hydropower using 2 turbines of 60 MW capacity each. Thus, in for a period from 21st July to 10th August, both the turbines can be operated and pre-project level of discharge will be maintained in river Bichom downstream of tail race disposal to dam of Dimijin hydro-electric project. In the following periods one turbine can operate in 90% dependable year:

- 11th June to 20th July
- 11th August to 10th October

In lean season, i.e. from October-November to May discharge in 90% dependable year cannot operate even one turbine. If peaking power is to be generated then the reservoir needs to be filled upto FRL. This can result in drying of river stretch downstream of tail race disposal site to dam site of Dimijin hydroelectric project. The drying of river stretch to fill the reservoir upto FRL for peaking power will last even upto 2 days after which there will continuous flow equivalent to rated discharge of 98 cumec for few hours. Even, if peaking power is not attained and higher number of turbines are operated (based on optimization of power generation with respect to cost) can result in drying up of river stretch followed by continuous flow of rated discharge. The rated discharge could be 3 to 8 times of the lean season flow in a 90% dependable year.

Dimijin Hydroelectric Project

In Dimijin hydroelectric project, discharge for 90% dependable year is higher than the rated discharge (116 cumec) for a period about 20 days from 21st July to 10th August. The project envisages generation of 130 MW hydropower using 2 turbines of 65 MW capacity each. Thus, in for a period from 21st July to 10th August, both the turbines can be operated. and pre-project level of discharge will be maintained in river Bichom downstream of tail race disposal to dam of Nafra hydro-electric project. In the following periods, one turbine can operate in 90% dependable year:

- 21st June to 10th July
- 21st August to 20th October

In lean season, i.e. from October to May-June, discharge in 90% dependable year cannot operate even one turbine. If peaking power is to be generated then the reservoir needs to be filled upto FRL. This can result in drying of river stretch downstream of tail race disposal site to dam site of Nafra hydroelectric project. The drying of river stretch to fill the reservoir upto FRL for peaking power will last even up to 2 days after which there will continuous flow equivalent to rated discharge of 116 cumec for few hours. Even, if peaking power is not attained and higher number of turbines are operated (based on optimization of power generation with respect to cost) can result in drying up of river stretch followed by continuous flow of rated discharge. The rated discharge could be more than 10 times the lean season flow in a 90% dependable year.

Nafra Hydroelectric Project

In Nafra hydroelectric project, discharge for 90% dependable year is higher than the rated discharge (61.38 cumec) for a period about 110 days from 11th June to 30th September. The project envisages generation of 96 MW hydropower using 2 turbines of 48 MW capacity each. Thus, in for a period from 11th June to 30th September, both the turbines can be operated. and pre-project level of discharge will be maintained in river Bichom downstream of tail race disposal site. In the following periods, one turbine can operate in 90% dependable year:

- 21st May to 10th June
- 1st October to 31st October

In lean season, i.e. from November to April-May, discharge in 90% dependable year cannot operate even one turbine. If peaking power is to be generated then the reservoir needs to be filled upto FRL. This can result in drying of river stretch downstream of tail race disposal site to dam site of Nafra hydroelectric project. The drying of river stretch to fill the reservoir upto FRL for peaking power will last even up to 2 days after which there will continuous flow equivalent to rated discharge of 61.38 cumec for few hours. Even, if peaking power is not attained and higher number of turbines are operated (based on optimization of power generation with respect to cost) can result in drying up of river stretch followed by continuous flow of rated discharge. The rated discharge could be more than 2 to 3 times the lean season flow in a 90% dependable year.

Dikhri Hydroelectric Project

In Dikhri hydroelectric project, discharge for 90% dependable year is higher than the rated discharge (30 cumec) for a period about 20 days from 21st July to 10th August. The project envisages generation of 48 MW hydropower using 2 turbines of 24 MW capacity each. Thus, in for a period from 21st July to 10th August, both the turbines can be operated. and pre-project level of discharge will be maintained in river Dikhri downstream of tail race disposal site. In the following periods, one turbine can operate in 90% dependable year:

- 21st June to 10th July
- 21st August to 20th October

In lean season, i.e. from October to May-June, discharge in 90% dependable year cannot operate even one turbine. If peaking power is to be generated then the reservoir needs to be filled upto FRL. This can result in drying of river stretch downstream of tail race disposal site to confluence of river Dikhri with river Bichom, i.e. for a stretch of about 6.3 km. The drying of river stretch to fill the reservoir upto FRL for peaking power will last even up to 2 days after which there will continuous flow equivalent to rated discharge of 30 cumec for few hours. Even, if peaking power is not attained and higher number of turbines are operated (based on optimization of power generation with respect to cost) can result in drying up of river stretch followed by continuous flow of rated discharge. The rated discharge could be 5 to 10 times the lean season flow in a 90% dependable year.

Dinan Hydroelectric Project

In Dinan hydroelectric project, discharge for 90% dependable year is higher than the rated discharge (8.5 cumec) for a period about 130 days from 11th June to 20th October. The project envisages generation of 30 MW hydropower using 2 turbines of 15 MW capacity each. Thus, in for a period from 11th June to 20th October, both the turbines can be operated. and pre-project level of discharge will be maintained in river Dinang downstream of tail race disposal site. In the following periods, one turbine can operate in 90% dependable year:

- 21st October to 30th November
- 11th May to 10th June

In lean season, i.e. from December to May-June, discharge in 90% dependable year cannot operate even one turbine. If peaking power is to be generated then the reservoir needs to be filled upto FRL. This can result in drying of river stretch downstream of tail race disposal site to confluence of river Dinang with river Bichom, i.e. for a stretch of about 6 km. The drying of river stretch to fill the reservoir upto FRL for peaking power will last even up to 2 days after which there will continuous flow equivalent to rated discharge of 8.5 cumec for few hours. Even, if peaking power is not attained and higher number of turbines are operated (based on optimization of power generation with respect to cost) can result in drying up of river stretch followed by continuous flow of rated discharge. The rated discharge could be 2 to 3.5 times the lean season flow in a 90% dependable year.

Gongri Hydroelectric Project

In Gongri hydroelectric project, discharge for 90% dependable year is higher than the rated discharge (56.1 cumec) for a period about 140 days from 1st June to 20th October. The project envisages generation of 90 MW hydropower using 3 turbines of 30 MW capacity each. Thus, in for a period from 1st June to 20th October, all three turbines can be operated. and pre-project level of discharge will be maintained in river Gongri/Digo downstream of tail race disposal to dam of Dinchang hydro-electric project. In the period from 21st October to 30th November, two turbines can operate in 90% dependable year:

In the following peroid, one turbine can operate in 90% dependable year:

- 1st December to 10th January
- 11th April to 31st May

In lean season, i.e. from January to April, discharge in 90% dependable year cannot operate even one turbine. If peaking power is to be generated then the reservoir needs to be filled upto FRL. This can result in drying of river stretch downstream of tail race disposal site to dam site of Nafra hydroelectric project. The drying of river stretch to fill the reservoir upto FRL for peaking power will last even up to 1 day after which there will continuous flow equivalent to rated discharge of 56.1 cumec for few hours. Even, if peaking power is not attained and higher number of turbines are operated (based on optimization of power generation with respect to cost) can result in drying up of river stretch followed by continuous flow of rated discharge. The rated discharge could be more than 3 to 4 times the lean season flow in a 90% dependable year.

Dinchang Hydroelectric Project

In Dinchang hydroelectric project, discharge for 90% dependable year is higher than the rated discharge (82 cumec) for a period about 140 days from Ist June to 20th October. The project envisages generation of 300 MW hydropower using 3 turbines of 100 MW capacity each. Thus, in for a period from Ist June to 20th October, all the three turbines can be operated. and pre-project level of discharge will be maintained in river Gongri/Digo downstream of tail race disposal site. In the period from 21st October to 10th December, two turbines can operate in 90% dependable year. Likewise, from 11th December to 31st January, one turbine can operate in 90% dependable year.

In lean season, i.e. from February to May, discharge in 90% dependable year cannot operate even one turbine. If peaking power is to be generated then the reservoir needs to be filled upto FRL. This can result in drying of river stretch downstream of tail race disposal site to confluence of river Gongri/Digo with river Bichom. The drying of river stretch to fill the reservoir upto FRL for peaking power will last for few hours, after which there will continuous flow equivalent to rated discharge of 30 cumec for few hours. Even, if peaking power is not attained and higher number of turbines are operated (based on optimization of power generation with respect to cost) can result in drying up of river stretch followed by continuous flow of rated discharge. The rated discharge could be 2 to 3 times the lean season flow in a 90% dependable year.

Jameri Hydroelectric Project

The project envisages generation of 30 MW hydropower using 2 turbines of 15 MW capacity each with a rated discharge of 60 cumec. In Jameri hydroelectric project, discharge for 90% dependable year is sufficient to run one turbine for a period about 90 days from 11th July to 10th September. In remaining months, i.e. from September to June, discharge in 90% dependable year cannot operate even one turbine. If peaking power is to be generated then the reservoir needs to be filled upto FRL. This can result in drying of river stretch downstream of tail race disposal site to confluence of river Tenga with river Bichom, i.e. for a stretch of about 22.6 km. The drying of river stretch to fill the reservoir upto FRL for peaking power will last even up to 3 days after which there will continuous flow equivalent to rated discharge of 60 cumec for few hours. Even, if peaking power is not attained and higher number of turbines are operated (based on optimization of power generation with respect to cost) can result in drying up of river stretch followed by continuous flow of rated discharge. The rated discharge could be 7 to 10 times the lean season flow in a 90% dependable year.

8.4 IMPACTS ON AQUATIC ECOLOGY DUE TO MODIFICATION OF FLOW REGIME

As mentioned earlier in section 8.3, the commissioning of a hydroelectric project, significantly affects the hydrologic regime. The proposed hydroelectric projects in the basin area too will have similar impacts on hydrologic regime, with a corresponding impact on riverine ecology including fisheries. At the present level of investigations, all the projects will divert water for hydropower generation through HRT, which will outfall back into the river at tail race disposal site. As mentioned earlier, reservoir of downstream of project would extend upto tail race disposal of upstream project. Thus, there will be a dry stretch downstream of diversion structure upto tail race disposal site after which there will be a reservoir of the downstream project. Thus, there will be complete disruption of pre-project free flowing hydrologic regime.

The free flowing water regime of river Bichom will be completely disturbed over a stretch of about 36 km. The six dams will store water to enable peaking power generation. As a result, barring for a period from June-July to September-October, when discharge is higher than the river Bichom is rated discharge, will have dry stretch from few hours to upto few days for generation of peaking power. This storage period will result in drying up of the river, downstream of the dam site upto the reservoir of next downstream project in cascade development. The dry period will be followed by a wet or flow period with uniform flow corresponding to the number of units/turbines generating hydropower in the stretches with river flow. Thus, the riverine ecology will be severely affected on account of modification in hydrologic regime. This change can have significant impact on the riverine fisheries affecting physiological readiness to migrate, mature and spawn.

Likewise, stretches of river Gongri/Digo, Dinang, Dikhri and Tenga too will be disturbed on account of diversion of water for hydropower generation. The projects will convey the water to the power house sites through Head Race Tunnel (HRT), which will outfall into the river through Tail Race Tunnel (TRT). Thus, there will be significant reduction in flows in the stretch downstream of dam site to tail race disposal sites.

The dry phase in the river stretch will result in stranding of fish in temporary pools. Similarly, drying of the river bed will lead to exposure of spawning substrates resulting in exposure and desiccation of fish eggs as well. The increased discharge especially in the lean season on account of flow of rated discharge will sweep the larvae past their suitable habitat.

The presence of variety of species makes it impossible to consider flow needs individually, it is convenient to operate at some level of aggregation, the most convenient of which is a simple behavioural, ecological or functional guild structure. Ecological guilds have been defined differently in various parts of the world. Regier, Welcomme, Steedman & Henderson (1989) proposed an early classification based on the traditional South East Asian usage for tropical systems, and Bain, Finn and Booke (1988) developed a classification of functional groupings for US rivers. Aarts, Van den Brink and Nienhuis (2004) summarize the classification for major European rivers. The combined elements of these together with some of Balon's (1975) reproductive guilds to illustrate the way in which each of the guilds responds to characteristic changes in the river that result from changes in flow is given in Table-8.3. The three main groups of fish and their sub-groups respond to changes to natural hydrographs that result from increased control over water in very different ways, which generally favour eurytopic species at the expense of the limnophilic and rheophilic ones.

TABLE – 8.3
Response of the main behavioural guilds to changes in flow regimes.

Behavioural guild	**Typical behaviour**		**Reaction to changes in hydrograph**
	General	**Specific**	
Black fish – limnophilic species	• Floodplain residents move little between floodplain pools, swamps and inundated floodplain. • Repeat breeders with specialised reproductive behaviour. • Predominantly polyphils, nest builders, parental carers or live bearers. • Tolerant of low dissolved oxygen or anoxia (auxiliary breathing adaptations)	**A** • Tolerant of low dissolved oxygen tensions only	• Tend to disappear when floodplain disconnected and desiccated through poldering and levee construction. • May increase in number in shallow, isolated wetlands, rice-fields and drainage ditches.
		A. B • Tolerant of Complete Anoxia	• Persist in residual floodplain water bodies • Principal component of rice field and ditch faunas

Behavioural guild	Typical behaviour		Reaction to changes in hydrograph
	General	Specific	
White fish – rheophilic species	• Long distance migrants • One breeding season a year • Intolerant of low oxygen.	**B. A** • Main channel residents not entering floodplain • Predominantly psammophils, lithophils or pelagophils. • Often have drifting eggs and larvae	• Tend to disappear when river dammed to prevent migration, • When timing of flood inappropriate to their breeding seasonality and • If flow excessive or too slow for the needs of drifting larvae.
		C. B • Use floodplain for breeding, nursery grounds and feeding of juvenile and adult fish • Predominantly phytophils • Usually spawn at floodplain margin or on floodplain; sometimes have drifting eggs and larvae	• Tend to disappear when river dammed to prevent migration, • Damaged when access to floodplain denied to developing fry and juveniles.
Grey fish – eurytopic species	• Tolerant of low dissolved oxygen • Repeat breeders • Predominantly phytophils but some nesters or parental carers • Short distance migrants often with local populations.	**D. A** • Occupy main channel generally benthic	• Able to adapt behaviourally to altered hydrograph • Generally increase in number as other species decline • Impacted negatively to flows that change depositional siltation processes and alter the nature of the bottom

Behavioural guild	Typical behaviour		Reaction to changes in hydrograph
	General	Specific	
		E. B • Occupy riparian vegetation	• Able to adapt behaviourally to altered hydrograph • Generally increase in number as other species decline • Impacted negatively by flows and management that changes riparian structure
		F. C • Occupy larger and better oxygenated floodplain water bodies	• Sensitive to isolation of floodplain water body but can colonise river if flow slowed sufficiently • Often form basic colonisers of reservoirs and dams

Based on the categorization of fisheries in Table-8.3, various fish species reported in the study area can be categorized as White fish – rheophilic species, on account of their response to change in hydrologic regime. These responses are listed as below:

- Tend to disappear when river dammed to prevent migration,
- When timing of flood inappropriate to their breeding seasonality and
- If flow excessive or too slow for the needs of drifting larvae.
- Tend to disappear when river dammed to prevent migration,
- Damaged when access to floodplain denied to developing fry and juveniles.

As rivers change in response to human efforts to control flow they pass through a series of stages that can be characterized according to the degree of modification. The degree of modification is summarized in Table-8.4.

TABLE - 8.4

Characteristics of various developmental stages of a river, impacts on flood regimes and form of lowland rivers

Development stage	Flood regime	State of river channel	State of floodplain	Human habitation
Unmodified	Natural hydrograph with seasonal alternation of flood and dry seasons. Water quality is good	Freely meandering or anastomosing often with islands. Diverse	Usually forested interspersed with floodplain water bodies.	Migratory human settlement in temporary camps, on high ground only or in stilt houses
Slightly modified	Natural hydrograph with seasonal alternation of flood and dry seasons. Water quality is good	Freely meandering or anastomosing often with islands. Obstructions removed from channel. Some simplification of channels. Diverse	Some forests usually savannah with floodplain grasses	Human settlement in temporary camps on floodplain, villages on levees or stilt houses.
Modified	Natural hydrograph persists in many reaches of river but can be locally modified below dams with reduced amplitude and duration of seasonal floods. Can also be modified around poldered areas. Water quality affected around settlements.	Locally regulated with some damming and leveeing but with some reaches still relatively unregulated. Tendency to suppress branches in favour of a single main channel. Some backwaters persist.	Floodplain partially modified, deforested: floodplain water bodies sometimes isolated. Local poldering and flood control structures	Human settlement beginning to intensify on artificially constructed mounds or areas protected by flood defences.
Highly modified	Hydrograph completely modified suppressing and altering	Often heavily dammed sometimes in cascades: Fully regulated and	Floodplain dry or completely controlled with extensive drainage and	Heavy human settlement of whole former floodplain area.

Development stage	Flood regime	State of river channel	State of floodplain	Human habitation
	timing of flood peaks and quantity of water in system. Water quality often severely reduced in whole river	channelised often with revetted banks and dredged navigation channels, Backwaters eliminated. Habitat diversity low.	irrigation canals. Off channel water bodies largely eliminated or isolated Maybe heavily poldered	

On completion of the proposed hydroelectric projects in the basin, would render river Bichom as highly modified, on account of:

- Hydrographs getting completely modified
- Modification of floods including suppression and alteration of flood peaks.
- Conversion of free flowing stretch of river into reservoir.

However, no major impact on water quality is anticipated on account of modification in hydrologic regime, as there are no major sources of water pollution in the study area.

The modification of downstream river flow characteristics (regime) by an impoundment can have a variety of negative effects upon fish species. These include:

- loss of stimuli for migration
- loss of migration routes and spawning grounds
- decreased survival of eggs and juveniles
- diminished food production.

Regulation of stream flow during the migratory period can alter the seasonal and daily dynamics of migration. Regulation of a river can lead to a sharp decrease in a migratory population, or even to its complete elimination.

8.5 IMPACTS ON FISHERIES DUE TO FLUCTUATIONS IN WATER LEVEL

Variable flow regime resulting from operation of hydroelectric power-dams can have significant consequences for fish fauna : daily 2 m to 3 m fluctuation of Colorado river-levels below the Glen Canyon dam may have contributed to the decline in endemic fish (Petts, 1988). The native species have been replaced by the introduced species and spawning of the native species is restricted to tributaries. The fluctuations of water-level and velocities due to power demand can lead to adverse effects on fish namely:

- inhibition of spawning behaviour
- juveniles could be swept downstream by high flows
- sudden reductions in flow could leave eggs or juveniles stranded (Petts, 1988).

Walker *et al*. (1979) related the disappearance of *Tandanus tandanus* in the Murray river, Australia to short-term fluctuations in water level caused by reservoir releases in response to downstream water user requirements. In the proposed hydroelectric projects, releases on account of peaking power requirement shall result in fluctuations in water level. This could result in significant reduction in native species. Althouogh, experimental data on the impacts on fish species present in river Bichom is not available, but it can be concluded that daily fluctuation in water level will have significant adverse impacts on fisheries.

8.6 IMPACTS ON FISH MIGRATION

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 environments for the main phases of their life cycle which are reproduction, production of juveniles, growth and sexual maturation. The species has to move from one environment to another in order to survive. The fish composition in the project area are represented by potadromous species i.e. the species which occur only in freshwater system and their reproduction and feeding zones are separated by distances that could vary from few meters to hundreds of kilometers.

The building of a dam generally has a major impact on fish populations: migrations and other fish movements can be stopped or delayed, the quality, quantity and accessibility of their habitat, which plays an important role in population sustainability. Fish can suffer major damage during their transit through hydraulic turbines or over spillways. Changes in discharge regime or water quality can also have indirect impacts on fish species. Increased upstream and downstream predation on migratory fish is also linked to dams, fish being delayed and concentrated due to the presence of the dam and the habitat becoming more favourable to certain predatory species. One of the major effects of the construction of a dam on fish populations is the decline of migratory fish species. The dam prevents migration between feeding and breeding zones. The effect can become severe, leading to the extinction of species, where no spawning grounds are present in the river or its tributary downstream of the dam.

The impact of river valley projects has been extensively studied for river Bees as a result of damming at pong and Pandoh under the Beas-Sutlej Link Project. Sehgal and Sar (1989) and Sehgal (1990) have found subtle and irreversible changes in abiotic and biotic parameters. The migratory routes of *Tor putitora* and *Schizothorax richardsonii* have been obstructed due to construction of various dams. These species which were migrating to higher elevation, were obstructed. *Schizothorax richardsonii* which used to migrate from higher reaches to lower reaches was unable to do so on account of construction of dam at Pandoh. The contribution of *Schizothorax richardsonii* in the river Beas reduced from 10.2 –

13.5% between Mandi and Nodomn towns prior to construction of project reduced to 0.5 – 1% after project.

The commissioning of the proposed hydroelectric projects would seriously impede the migratory route of fisheries. The migration characteristics of various fish species observed in the study area is given in Table-8.5.

TABLE-8.5

Migration distance, spawning season and spawning substrate of some of the fish species

Family	Species	Migration distance	Spawning season	Spawning substrate
Cyprinidae	*Schizothorax richardsonii*	Short to Mid	Aug-Sep	Gravelly substrate
Cyprinidae	*Neolissochilus hexagonolepis*	Short to Mid	May-July	Gravelly substrate
Cyprinidae	*Labeo pangusia*	Short to Mid	May -July	Gravelly substrate
Cyprinidae	*Chagunius chagunio*	Short to Mid	May-June	Gravelly substrate
Cyprinidae	*Tor putitora*	Long	Sep -Oct	Gravelly substrate
Cyprinidae	*Tor tor*	Long	Sep -Oct	Gravelly substrate
Cyprinidae	*Garra gotyla*	Short to Mid	May - Jul	Gravelly substrate
Cyprinidae	*Garra annandalei*	Short to Mid	Jul - Aug	Gravelly substrate
Bolitoridae	*Aborichthys elongatus*	Short	May – Jul	Gravelly substrate
Cobitidae	*Botia Dario*	Short	Jun - Aug	Gravelly substrate
Siluridae	*Silurus afgana*	Short	Jun -Aug	Gravelly substrate
Amblycipitidae	*Amblyceps sp.*	Short	Jun-Aug	Gravelly substrate
Sisoridae	*Glyptothorax sp.*	Short	May- Jul	Gravelly substrate
Channidae	*Channa orientalis*	Short	Jun- Aug	Gravelly substrate

The species *Schizothorax richardsonii* and *Neolissochilus hexagonolepis* migrate from lower elevation to higher elevation in summer months and return to lower elevation in winter months. These species were observed at various sampling locations of all the ten hydroelectric projects proposed to be developed in the study area.

The dam of Nafra hydroelectric project would block the upward migratory movement of various fish species in winter season on river Bichom. Thus, migration of species *Schizothorax richardsonii* and *Neolissochilus hexagonolepis* river stretch would be affected for a length of about 27 km due to obstruction to migration created by the dam of Nafra hydroelectric project. Similarly, Utung hydroelectric project, would impede the downward movement of migratory fish species in summer season. It is likely that the migration of fish species namely, *Schizothorax richardsonii* and *Neolissochilus hexagonolepis* in the stretch of about 33 km would be severely affected on account of construction of the proposed hydroelectric projects on river Bichom. Likewise, migration of fish species from tributaries, e.g., Gongri/Digo and Dikhri to river Bichom, would be severely affected on account of creation of reservoirs due to construction of proposed hydroelectric projects. Thus, the project will lead to significant adverse impact on migratory fish species. The fish migration would be observed in the following stretches:

River Bichom

- Upstream of dam site of Utung hydroelectric project
- Downstream of tail race disposal site of Nafra hydroelectric project

River Gongri/Digo

- Upstream of dam site of Gongri hydroelectric project
- Downstream of tail race disposal site of Dinchang hydroelectric project

River Dikhri

- Upstream of dam site of Dikhri hydroelectric project

River Dinang

- Upstream of dam site of Dinan hydroelectric project

River Tenga

- Upstream of dam site of Jameri hydroelectric project
- Downstream of tail race disposal site of Jameri hydroelectric project.

The affected stretch in the case of Jameri HEP would be about 5.6 km. The distance between confluence of Tenga with Bichom and tail race disposal site of Jameri hydroelectric project is about 16 km.

The following fish species migrate to lower elevation in summer months and undertake the reverse journey in winter months:

- *Labeo pangusia*
- *Chagunius chagunio*
- *Tor putitora*
- *Tor tor*
- *Garra gotyla*
- *Garra annandalei*

The presence of the above fish species in areas in vicinity to various projects is given in Table-8.6.

TABLE-8.6

Presence of the above fish species in areas in vicinity to various projects

S. No.	Project Name	*Labeo pangusia*	*Chagunius chagunio*	*Tor putitora*	*Tor tor*	*Garra gotyla*	*Garra annandalei*
1	Utung HEP	×		×		×	
2	Nazong HEP	×		×		×	
3	Dibbin HEP	×		×		×	
4	Dimijin HEP	×				×	
5	Dikhri HEP	×		×		×	
6	Dinchang HEP	×		×		×	
7	Jameri HEP	×	×	×	×	×	×
8	Dinan HEP	×		×		×	
9	Nafra HEP	×		×		×	×
10	Gongri HEP	×		×		×	×

The following species were observed in the vicinity of all the projects to be commissioned in the Study Area:

- *Labeo pangusia*
- *Tor putitora*
- *Garra gotyla*

The construction of various projects would impede the migratory movement of *Labeo pangusia, Tor putitora* and *Garra gotyla*. The fish migration would be restricted only in the following stretches:

River Bichom

- Upstream of dam site of Utung hydroelectric project
- Downstream of tail race disposal site of Nafra hydroelectric project

River Gongri/Digo

- Upstream of dam site of Gongri hydroelectric project
- Downstream of tail race disposal site of Dinchang hydroelectric project

River Dikhri

- Upstream of dam site of Dikhri hydroelectric project

River Dinang

- Upstream of dam site of Dinan hydroelectric project

River Tenga

- Upstream of dam site of Jameri hydroelectric project
- Downstream of tail race disposal site of Jameri hydroelectric project.

The affected stretch in the case of Jameri HEP would be about 5.6 km. The distance between confluence of Tenga with Bichom and tail race disposal site of Jameri hydroelectric project is about 16 km.

The migration of various fish species would be severely affected and their number would decrease significantly.

The following species were observed in the vicinity of only Jameri hydroelectric project:

- *Chagunius chagunio*
- *Tor tor*
- *Garra annandalei*

The migration of *Chagunius chagunio, Tor tor, Garra annandalei* would be severely affected and their number would decrease significantly. . However, the affected stretch in the case of Jameri HEP would be about 5.6 km. The distance between confluence of Tenga with Bichom and tail race disposal site of Jameri hydroelectric project is about 17.6 km.

8.7 IMPACTS ON FISHERIES DUE TO HYDRAULIC TURBINES

Fish can suffer major damage during their transit through hydraulic turbines or over spillways. Fish passing through hydraulic turbines are subject to various forms of stress likely to cause high mortality i.e., probability of shocks from moving or stationary parts of the turbine (guide vanes, vanes or blades on the wheel), sudden acceleration or deceleration, very sudden variations in pressure and cavitation. Passage through spillways may be a direct cause of injury or mortality, or an indirect cause (increased susceptibility of disorientated or shocked fish to predation). Mortality in migrating fishes could be due to shearing effects, abrasion against spillway surfaces, turbulence in the stilling basin at the base of the dam, sudden variations in velocity and pressure as the fish hits the water, physical impact against energy dissipators.

Fish passing through hydraulic turbines are subject to various forms of stress likely to cause high mortality: probability of shocks from moving or stationary parts of the turbine (guide vanes, vanes or blades on the wheel), sudden acceleration or deceleration, very sudden variations in pressure and cavitation. The impacts of hydraulic turbines on snow trout, , Mahaseer etc. have not been studied. However, numerous experiments have been conducted in various countries (USA, Canada, Sweden, Netherlands, Germany and France), mainly on juvenile salmonids and less frequently on clupeids and eels, to determine the mortality rate due to their passage through the main types of turbine (Bell, 1981; Monten, 1985; Eicher, 1987; Larinier and Dartiguelongue, 1989; EPRI, 1992).

The mortality rate for juvenile salmonids in Francis and Kaplan turbines varies greatly, depending on the properties of the wheel (diameter, speed of rotation, etc), their conditions of operation, the head, and the species and size of the fish concerned. The mortality rate varies from under 5% to over 90% in Francis turbines. On an average, it is lower in Kaplan turbines, from under 5% to approximately 20%. The difference between the two types of turbines is due to the fact that Francis turbines are generally installed under higher heads.

The mortality rate may be 4 to 5 times higher than in juvenile salmonids, reaching a minimum of 10% to 20% in large low-head turbines (as against a few per cent in juvenile salmonids). (Desrochers, 1994; Hadderingh and Bakker, 1998; Monten, 1985; Larinier and Dartiguelongue, 1989). Similar impacts, i.e. fish mortality is anticipated in the proposed hydroelectric projects as well. However, in absence of experimental data, quantification of impacts on this account cannot be made.

8.8 IMPACTS ON FEEDING BIOLOGY AND GROWTH RATES OF FISH SPECIES

Studies on Golden Mahaseers in rivers Alaknanda, Nayar and Saung in Uttarakhand have seen that in extensively regulated river stretches of river Ganga, Mahaseer was found to consume relatively lesser animal matter (40-100%) as compared to fish species in free flowing rivers, e.g. Nayar (72.1 – 89.8%) or Saung (74.3 – 90%). Insects generally occur as macrozoobenthic community, the density of which was found to be lower in rivers with regulated flows. However, the food habits did not get altered to the extent of showing a shift from carnivorous to omnivorous diet. Similar impacts are envisaged in the study area as well. The fish species in the river with regulated flow will be forced to eat higher percentage of plant matter, as a result of decrease in macro-zoobenthic community.

Another impact envisaged is that large sized fish species which are potential brooders may migrate in the tributaries for breeding. Thus, large sized fish may become virtually absent in the breeding season from the regulated stretches of river flows.

8.9 IMPACTS DUE TO LOSS OF FORESTS

At the present level of investigation, the total land to be acquired for the project is not available. The density of trees in the submergence area of various hydroelectric projects is given in Table-8.7.

TABLE-8.7
Density of trees and wood volume in submergence area of various Hydroelectric projects in the study area

S. No.	Project Name	Tree Density (no./ha)	Wood Volume (m^3/ha)
1	Utung HEP	640	171.12
2	Nazong HEP	615	173.99
3	Dibbin HEP	555	39.66
4	Dimijin HEP	315	79.35
5	Dikhri HEP	530	109.44
6	Dinchang HEP	520	69.99
7	Jameri HEP	1225	47.88
8	Dinan HEP	460	51.33
9	Nafra HEP	210	6.83
10	Gongri HEP	205	20.25

The tree density is highest in the submergence area of Jameri HEP. The density of trees is lowest in submergence area of Nafra and Gongri hydroelectric projects. The wood volume was highest in the submergence area of Dikhri HEP. The wood volume was lowest in the submergence area of Nafra HEP.

8.10 IMPACTS ON ECONOMICALLY IMPORTANT PLANTS

The forests in Arunachal Pradesh are endowed with many useful plant species viz., timber yielding species, medicinal plants, bamboos, rattans, wild ornamental plants, etc. The state can be termed as a repository of medicinal plants (Haridasan *et al*. 1996). The indigenous people in the state live in close association with the forests and have accumulated a vast treasure of knowledge related to utilization of plants. This knowledge of medicinal plants is becoming a potential source of information for the pharmaceutical industries. The density of various economically important plant species in the submergence area of various hydroelectric projects is given in Table-8.8.

TABLE-8.8
List of Economically important plant species observed at various sampling sites

S. No.	Species	Use	Type of flora	Density at dam site (no./ha)
I	**Utung Hydroelectric Project**			
1	*Clerodendron colebrookianum*	Leafy vegetable	Shrub	170
2	*Costos speciosus*	Medicinal	Herb	150
3	*Ficus roxburghii*	Fodder, fruits edible	Tree	15
4	*Macaranga denticulate*	Fuel	Tree	40
5	*Nephrolepis cordifolia*	Medicinal	Herb	24250
6	*Rubus* sp.	Edible	Shrub	15
7	*Schima khasiana*	Timber	Tree	20
II	**Nazong Hydroelectric Project**			
1	*Clerodendron colebrookianum*	Leafy vegetable	Shrub	55
2	*Costos speciosus*	Medicinal	Herb	300
3	*Ficus roxburghii*	Fodder, fruits edible	Tree	15
4	*Macaranga denticulate*	Fuel	Tree	120
5	*Nephrolepis cordifolia*	Medicinal	Herb	20
6	*Schima khasiana*	Timber	Tree	5
III	**Dibbin Hydroelectric Project**			
1	*Clerodendron colebrookianum*	Leafy vegetable	Shrub	45
2	*Costos speciosus*	Medicinal	Herb	550
3	*Ficus roxburghii*	Fodder, fruits edible	Tree	15
4	*Macaranga denticulate*	Fuel	Tree	120
5	*Nephrolepis cordifolia*	Medicinal	Herb	6250
6	*Rubus* sp.	Edible	Shrub	35
7	*Schima khasiana*	Timber	Tree	5
IV	**Dimijin Hydroelectric Project**			
1	*Schima wallichii*	Timber	Tree	30
2	*Toona ciliate*	Timber	Tree	45
3	*Clerodendron colebrookianum*	Leafy vegetable	Shrub	375
4	*Nephrolepis cordifolia*	Medicinal	Herb	2400
V	**Dikhri Hydroelectric Project**			
1	*Clerodendron colebrookianum*	Leafy vegetable	Shrub	300

S. No.	Species	Use	Type of flora	Density at dam site (no./ha)
2	*Costos speciosus*	Medicinal	Herb	400
3	*Ficus roxburghii*	Fodder, fruits edible	Tree	15
4	*Macaranga denticulate*	Fuel	Tree	35
5	*Nephrolepis cordifolia*	Medicinal	Herb	14750
6	*Rubus* sp.	Edible	Shrub	45
7	*Schima khasiana*	Timber	Tree	10
8	*Juglans regia*	Fruits edible	Tree	60
VI	**Dinchang Hydroelectric Project**			
1	*Clerodendron colebrookianum*	Leafy vegetable	Shrub	30
2	*Ficus roxburghii*	Fodder, fruits edible	Tree	5
3	*Nephrolepis cordifolia*	Medicinal	Herb	1250
VII	**Jameri Hydroelectric Project**			
1	*Clerodendron colebrookianum*	Leafy vegetable	Shrub	100
2	*Ficus cunia*	Fodder	Tree	75
3	*Macaranga denticulate*	Fuel	Tree	105
4	*Nephrolepis cordifolia*	Medicinal	Herb	3200
VIII	**Dinan Hydroelectric Project**			
1	*Nephrolepis cordifolia*	Medicinal	Herb	7200
2	*Rubus* sp.	Edible	Shrub	45
IX	**Nafra Hydroelectric Project**			
1	*Pinus* sp.	Timber	Tree	100
2	*Schima wallichii*	Timber	Tree	10
3	*Nephrolepis cordifolia*	Medicinal	Herb	2250
4	*Rubus* sp.	Edible	Shrub	10
X	**Gongri Hydroelectric Project**			
1	*Nephrolepis cordifolia*	Medicinal	Herb	5400
2	*Rubus* sp.	Edible	Shrub	25
3	*Juglans regia*	Edible fruits	Tree	30

About 7 economically important plant species were recorded from the submergence area of Utung HEP. Plants of economic importance such as fuelwood (*Lyonia ovalifolia*, *Macaranga denticulata*, *Quercus* spp.), medicinal (*Nephrolepis cordifolia*) and edible fruits (*Rubus* sp.) yielding floral species were commonly observed in the submergence area.

About 6 economically important plant species were recorded from the submergence area of Nazong HEP. Plants of economic importance such as fuel wood (*Ficus roxburghii*, *Quercus* spp.), medicinal (*Nephrolepis cordifolia*) and edible fruits (*Castanopsis purpurella, Myrica esculenta*) yielding floral species were commonly observed in the submergence area.

About 7 economically important plant species were recorded from the submergence area of Dibbin HEP. Plants of economic importance such as fuelwood (*Macaranga denticulata*), medicinal (*Nephrolepis cordifolia, Castos speciosus*) yielding floral species were commonly observed in the submergence area.

About 4 economically important plant species were recorded from the submergence area of Dimijin HEP. Plants of economic importance such as timber/fuel wood (*Schima wallichii, Toona ciliata*) and medicinal (*Nephrolepis cordifolia*) yielding floral species were commonly observed in the submergence area.

About 8 economically important plant species were recorded from the submergence area of Dikhri HEP. Plants of economic importance such as fuelwood (*Macaranga denticulate)*, medicinal (*Nephrolepis cordifolia*) and edible fruits *(Juglans regia*) yielding floral species were commonly observed in the submergence area.

About 3 economically important plant species were recorded from the submergence area of Dinchang HEP. Plants of economic importance such as Fodder (*Ficus roxburghii*) and medicinal (*Nephrolepis cordifolia*) yielding floral species were commonly observed in the submergence area.

About 4 economically important plant species were recorded from the submergence area of Jameri HEP. Plants of economic importance such as Fodder (*Ficus cussia*), medicinal (*Nephrolepis cordifolia*) yielding floral species were commonly observed in the submergence area.

About 2 economically important plant species were recorded from the submergence area of Dinan HEP. Plants of medicinal (*Nephrolepis cordifolia*) and edible fruits (*Rubus* spp.) yielding floral species were commonly observed in the submergence area.

About 2 economically important plant species were recorded from the submergence area of Nafra HEP. Plants of economic importance such as timber/fuel wood (*Pinus* sp.) and medicinal (*Nephrolepis cordifolia*) yielding floral species were commonly observed in the submergence area.

About 3 economically important plant species were recorded from the submergence in Gongri HEP. Plants of economic importance such as medicinal (*Nephrolepis cordifolia*) and edible fruits (*Juglans regia*) yielding floral species were commonly observed in the submergence area.

8.11 FLORA UNDER THREATENED CATEGORY

During the course of survey, only one species i.e., *Lagerstroemia muniticarpa* classified as endangered plant species as per IUCN Red list was found near the dam site of Jameri HEP. The density of *Lagerstroemia muniticarpa* at this site was 45 trees/ha.

8.12 IMPACTS ON WILDLIFE

The land acquisition for various project appurtenances could lead to adverse impacts on wildlife. Effects needs to be made for identification of non-location specific project requirements lead to minimum impacts on flora and fauna. The sites selected for various project appurtenances, e.g. project colony, labour camps, muck disposal sites, roads, waste disposal sites, etc. should be:

- Free from dense vegetation
- Away from wildlife habitats including breeding sites
- Water holes for wildlife
- Away from river banks

The various hydroelectric projects are not expected to adversely affect the migratory routes of wildlife, because river Bichom itself acts barrier to wildlife movement in pre-project plans. Thus, there is no wildlife movement across river Bichom, even in the pre-project phase itself. The impacts due to blasting is another source of adverse impacts on wildlife during construction phase of any hydroelectric project. Similar adverse impacts are anticipated in the proposed projects as well. Thus, appropriate measures need to be implemented as a part of Environmental Management Plan to be prepared as a part of the EIA study.

8.13 IMPACTS ON TERRESTRIAL FLORA DUE TO INCREASED HUMAN INTERFERENCES

The direct impact of construction activity of any water resource project in a Himalayan terrain is generally limited in the vicinity of the construction sites only. About 1000-1200 including technical staff, workers and other group of people are likely to congregate in the area during the project construction phase of each project. Thus, it can be assumed that about 4000 persons are likely to congregate in the area during construction phase. Though, it is possible that all the projects may not get constructed at the same time. 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 a total increase in population by about 4000 which would require fuel.

*	Average fuel wood consumption	:	20 kg pcd
*	Average population size over project construction phase	:	4000
*	Average consumption per day	:	800 quintals/day

or 292000 quintals/year

* For a construction period of 4 years : 1168000 quintals or 93440 m^3.
* One tree produces about 2.5 m^3 of wood, thus, about 38000 lakh tree will be cut to meet the fuelwood requirements to the labour population, over a construction phase of 4 years.

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.

CHAPTER-9

ASSESSMENT OF ENVIRONMENTAL FLOWS

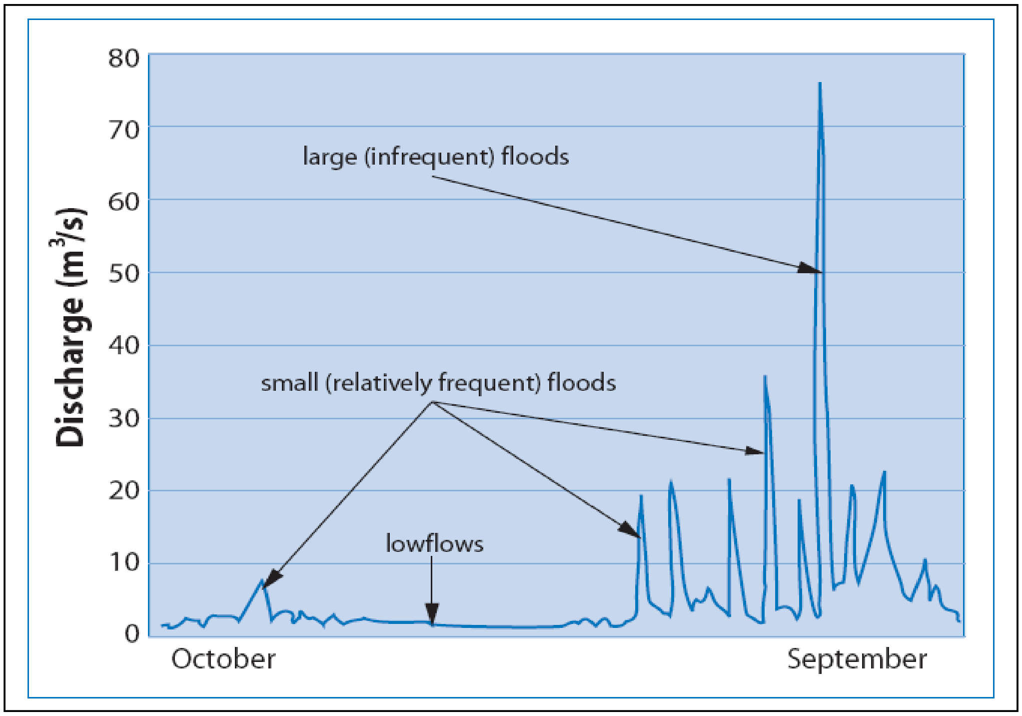
9.1 INTRODUCTION

Environmental Flows (EF) are the flows of water in rivers that are necessary to maintain aquatic ecosystems. In other words, a flow regime in the river, capable of sustaining a complex set of aquatic habitats and ecosystem processes are referred to as environmental flow. The EF is designed to maintain or upgrade a river in desired, agreed or pre-determined status referred to as an "environmental management class" ranging from A (Negligible modification from natural condition) to F (Critically modified ecosystem).

The process for determining or estimating EF is termed as Environmental Flow Assessment (EFA) and there are more than 200 techniques suggested in literature for the same. EFA techniques determine the volume and temporal distribution of EF. The difficulty of estimation EF values lies in the lack of understanding the relationship between river flow and the multiple components of river ecology and the scarcity of data concerned to these relationships. For example, required river flow conditions are available only for a target fish species in a given river basin and this information is very specific and not applicable under different circumstances. Different types of flows with different amount of discharge are spread through dry and wet seasons. This fact plays a very important issue in the interaction of river flow with the surrounded ecosystem. According, to flow, regime of a river can be divided into:

- ***Low flows*** (Base flow): this occurs through out the year and is more in the wet season than in the dry season and defines if river flow through out the year. The delayed flow that reaches a stream essentially as groundwater flow is also called base flow. In the annual hydrograph of a perennial stream the base flow is easily recognized as the slowly decreasing flow of the stream in rainless periods.
- ***Small floods***: they are small in size, (as compared with high floods) a few number per year and they have a small period of time (days or weeks) (Refer Figure-9.1).
- ***Large floods***: they are infrequently and the timing is very short (hours or days) (Refer Figure-9.1).

Figure-9.1: Typical Annual Hydrograph of daily flows in a river



Identification of these flow components and the understanding the ecosystem consequences of their loss or modification are one of the main objectives of Environmental Flow Assessment (EFA).

Further, flows in most of the river are being modified through impoundments such as dams and weirs, abstractions for agriculture, industrial and domestic supply, hydropower, drainage return flows and through structures for flood control. These interventions have had significant impacts, reducing the total flow of many rivers and affecting both; the seasonality of flows and the size and frequency of floods. In many cases, these modifications have adversely affected the river ecosystem, including the people living near the river banks. The river ecosystem includes both the channel and the floodplain. Regulations of river flows reduce or eliminate the linkage between the river and its floodplain margins.

With this background, it is important to recognize the importance of different flows in the river ecosystem. According to Brown (2003), flow in rivers is generally needed for various purposes such as to:

- maintain river flow conditions like flow velocity, water depth and acceptable turbidity levels, making it possible for the river purify itself (dilution of effluents and waste water).
- maintain low flow which support livelihood of the people (people who use the river for drinking, washing, bathing, fishing, recreation and tourism, etc).

- sustain both terrestrial and aquatic ecosystem. For example, low flow provides water to wild animals, maintain soil-moisture in the banks, etc. Small floods stimulate spawning in fish and allow passage for migratory fish and germination of seeds on river banks. Large floods deposits nutrients on the banks and distribute seeds.
- recharge groundwater and aquifers by large floods, which maintain the perennial nature of rivers acting as source of water during dry season. Further, large floods flush sediments and natural obstructions in the river course and maintain a sufficient deep channel for navigation.
- preserve estuarine conditions: low flows maintain the required salt-freshwater balance and prevented the incursion of salinity. Large floods maintain links with the by scouring estuaries.

In general, flows enabling the river to play its role in the cultural and spiritual live of the people. This is very important in Indian context as some religious festivals reduce the quality and quantity of flow.

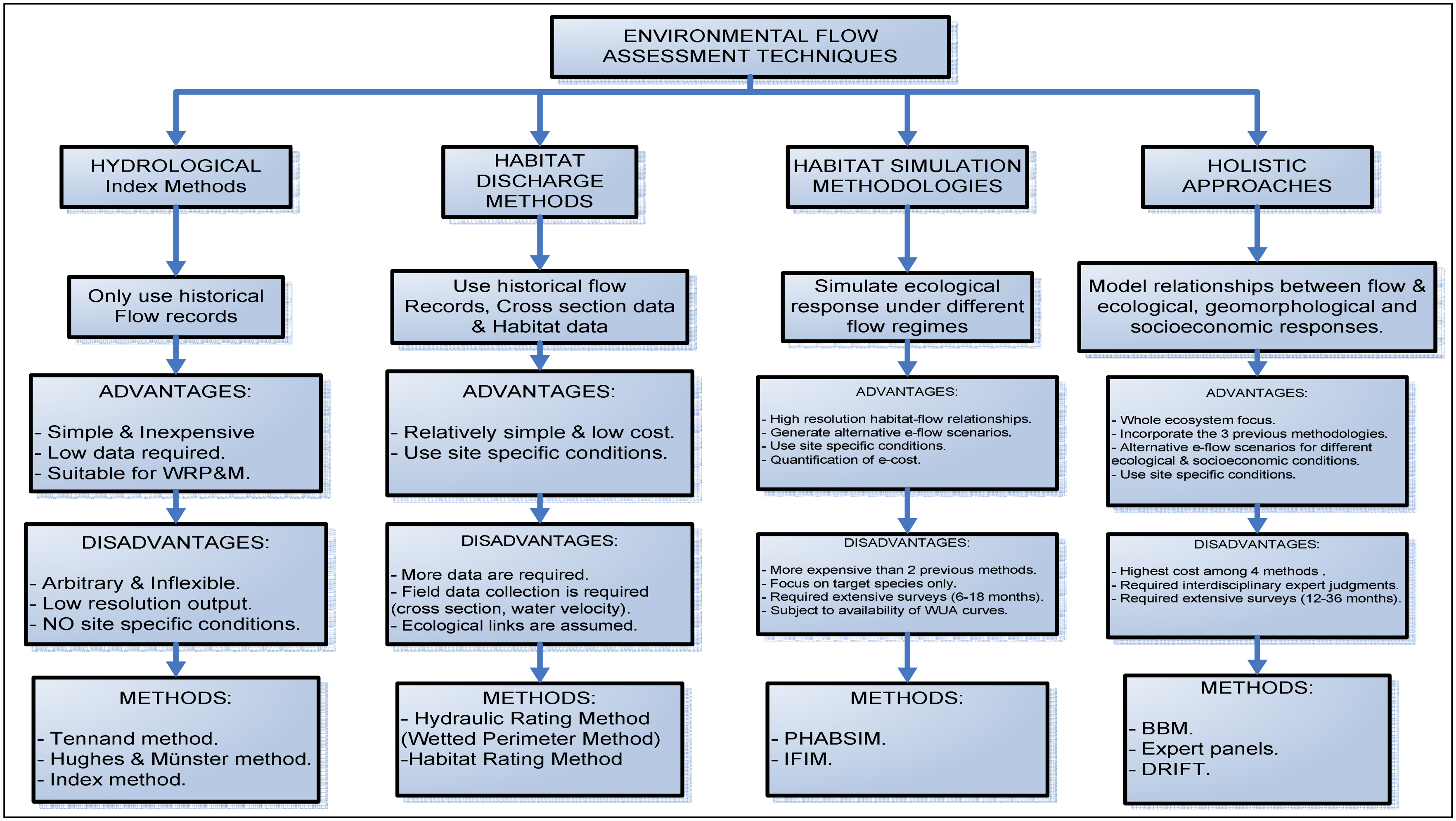
9.2 ENVIRONMENTAL FLOW ASSESSMENT TECHNIQUES.

In a recent review of international environmental flows assessment, Tharme (2003) recorded 207 different methods within 44 countries. Broadly, these can be divided into four categories:

- **Hydrological Index Methods** (or rule of thumb, threshold, or standard setting, desktop methods, or flow duration curve methods)
- **Habitat Discharge Methods** (hydraulic rating or habitat rating methods)
- **Habitat Simulation Methods**
- **Holistic Approach**

Figure 9.2 summarizes these methodologies with respective advantages and disadvantages.

Figure-9.2 Environmental Flow Assessment (EFA) Techniques



9.3 SELECTION OF APPROPIATE TECHNIQUE

The appropriate technique for a particular project will depend on specific conditions, listed as below:

- availability and quality of data.
- location and extend of the study area.
- prevailing time and financial constraints.
- level of confidence required in the final output.

In general, a project-specific flow assessment for large or controversial projects, which are likely to call for considerable negotiation and tradeoffs between environment and development issues, require a more comprehensive approach as compared to flow assessment for coarse-scale planning, where a single number might suffice (Brown, 2006). Most of the data and understanding required for interactive approaches (Habitat simulation and Holistic methodologies) have to be acquired on site by site basis, considerably adding to the time, funding and expertise required for a flow assessment. Probably because of this, most applications have used prescriptive approaches (Hydrological and Hydraulic methodologies). This study is based on hydrologic and hydraulic based methodologies. The above referred methods are briefly described in the following paragraphs.

1. Hydrological Index Methods

These are the simplest and most widespread EFA methods. They are often referred to as desk-top or look-up table methods and they rely primarily on historical flow records; usually long-term virgin or naturalized, historical monthly or daily flow records, to derive EF recommendations (IWMI, 2007). Hydrological Index Methods provide a relatively rapid, non-resource intensive, but low resolution estimate of environmental flows. The methods are most appropriate at the planning level of water resources development, or in low controversy situations where they may be used as preliminary estimates. Hydrological Index methods may be used as tools within habitat simulation, holistic or combination environmental flow methodologies. They have been applied in developed and developing countries (IWMI, 2007).

Environmental flow is usually given as a percentage of average annual flow or as a percentile from the flow duration curve, on an annual, seasonal or monthly basis. The most frequently used methods under this category are:

(i) Tennant Method

This method was developed by Donald Tennant in Montana region in USA through several field observations and measurements. The Tennant study used 58 cross sections from 11 streams in Montana, Nebraska and Wyoming (Mann, 2006). The technique utilizes only the Average Annual Flow (AAF) for the stream. It then states that certain flows relate to the qualitative fish habitat rating, which is used to define the flow needed to protect fish habitat, expressed in tabular form. Tennant concluded that 10% of AAF is the minimum for short term fish survival, 30% of AAF is considered to be able to sustain fair survival conditions and 60% of AAF is excellent to outstanding habitat (Tennant, 1975). The details are given in Table-9.1.

TABLE-9.1
Instream flow for fish, wildlife & recreation. Source: Tennant 1975

Description of Survival conditions	**Recommended base flow regimes**	
	October- March	**April –September**
Flushing or Maximum	200% of AAF	
Optimum range	60% - 100% of AAF	
Outstanding	40%	60%
Excellent	30%	50%
Good	20%	40%
Fair or Degrading	10%	30%
Poor or Minimum	10%	10%
Severe degradation	10% of AAF to zero flow	

(ii) Hughes & Münster Method

Under this method, the Environmental Water Requirement (EWR) values are based on the time series of monthly river flows. So, computation of the long-term mean annual runoff (MAR) is required. This methodology is based in the concept of aquatic ecology that the conservation of aquatic ecosystem should be considered in the context of the natural variability of flow regime (Smakhtin, 2004). In this methodology, the EWR is the summation of Low Flow Requirements (LFR) and High Flow Requirements (HFR). Mathematically, it is written as:

EWR = LFR + HFR

LFR is believed to approximate the minimum requirement of water of the fish and other aquatic species throughout the year. HFR is important for river channel maintenance, as a stimulus for processes such as migration and spawning, for wetland flooding and recruitment of riparian vegetation (Smakhtin, 2004). LFR is assumed to be equal to the monthly flow which is exceeded 90% of the time (Q_{90}) and HFR is taken from Table-9.2 which it is approximate by a set of thresholds linked to the different LFR levels (Smakhtin, 2004).

TABLE-9.2
Estimation of environmental high-flow requirement (HFR)

Low Flow Req. (Q_{90})	HFR	Comment
If $Q_{90} < 10\%$ AAF	Then HFR = 20% AAF	Basins with very variable flow regimes. Most of the flow occurs as flood events during short wet season
If 10% MAR ≤ $Q_{90} < 20\%$ AAF	Then HFR = 15% AAF	
If 20% MAR ≤ $Q_{90} < 30\%$ AAF	Then HFR = 7% AAF	
If $Q_{90} \geq 30\%$ AAF	Then HFR = 0	Very stable flow regimes. Flow is consistent throughout the year. Low-flow requirement is the primary component.

Source: Smakhtin, 2004

In reliable flowing rivers with high baseflow contribution (and consequently high LFR), HFR is low. In the other hand, in highly variable rivers, baseflow contributions are normally low (and consequently LFR is low) and the total environmental requirement is dominated by high HFR (Smakhtin, 2004).

(iii) Index Method

This method defined the value of the Minimum Instream Flow (MIF) that must be maintained downstream water diversion in order to maintain vital conditions of ecosystem functionality and quality (Maran, 2007). Based on Q_{355} (the flow not exceeded more than 355 days per year) this means that, on average, the natural flow is less than Q_{355} value only for 10 days in a year (Maran, 2007).

MIF = Ka*Kb*Kc* Q_{355}

where:

- Ka is corrective coefficient for different environmental sensitive of the interested river stretch [0.7 to 1.0]
- Kb = implementation factor [0.25 to 1.0]
- Kc is corrective coefficient to account for different level of protection due to the naturalistic value of the interested area [1.0 to 1.5].

The concept of "environmental sensitive" is linked with Flow Duration Curve (FDC). When the slope of the FDC is flat, for example when $Q_{90} \geq 30\%$ AAF, the flow in the river is very stable thought the year, and the ecosystem is getting used to have a constant rate of flow in the river most of the time. This type of ecosystem is more sensitive to any change in river flow regime and the value of K_a will be taken as 1 (one). On other hand, when the FDC slope is steep, say $Q_{90} < 10\%$ AAF, the river flow is very unstable and present high extreme values (floods and droughts). Under this condition, ecosystem is getting used to water scarcity during some periods of the year, therefore this ecosystem is less sensitive to changes in flow regime, because the river naturally present a wide variability in flow regime. In this case, the value of K_a can be taken as 0.7.

The implementation factor refers to upgrade a degraded river condition, in which the quantity of water in the river is very low, due the abstractions made for different purposes (domestic, industrial, agriculture, etc.). The recovery of natural conditions of the river flow must to be done gradually, because another uses of water will be affected. In this case, the value of K_b could be 0.25. In the case of no significant abstractions, the value of K_b will be 1.

The K_c factor increases the value of MIF, for protection of special conditions in the river ecosystem like naturalistic and tourism values, fisheries development and medicinal or religious issues.

(iv) Building Block Method

The Building Block Method (BBM) is essentially a prescriptive approach, designed to construct a flow regime for maintaining a river in a predetermined condition. The objective of BBM is to determine ecologically acceptable, modified flow regimes for impounded rivers and other situations where flows are regulated (Arthington, 1998). An environmental flow regime is then constructed (month by month basis) through separate consideration of different components of the flow regime. Each component of flow being specified in terms of magnitude, time of year, duration and rate of rise and fall of flood flows. Each flow component is intended to achieve a particular ecological, geo-morphological or water-quality objective (Brown, 2006).

The BBM is holistic, but issues such as water quality and the flow requirements of water-dependent wildlife require more development and stronger linkages into the methodology. The BBM has advanced the field of environmental flow assessment in an entirely new direction, being an holistic methodology that addresses the health (structure and functioning) of all components of the riverine ecosystem, rather than focusing on selected species as do many similarly resource-intensive international methodologies.

2. Hydraulic Rating Method

Hydraulic Rating Method (HRM) is combined desktop-field methods requiring limited hydrological, hydraulic modeling and ecological data and expertise. Like previous method, HRM also use the hydrological record and link this data to simple cross-section data in the river of interest. This method uses the relationship between the flow of the river (discharge) and simple hydraulic characteristic such as water depth, velocity or wetted perimeter to calculate an acceptable flow.

These methods are an improvement on hydrological index methods, since they require measurement of the river channel and so are more sensitive than the desktop approaches to differences between rivers. The number of measurements taken and field visits made will depend on the level of confidence required for the study. Cross-sections are placed at a river site where maintenance of flow is most critical or where instream hydraulic habitat is most responsive to flow reduction, and thus potentially most limiting to the aquatic biota.

9.4 ENVIRONMENTAL WATER REQUIREMENTS IN BICHOM BASIN

(i) Tennant Method

Assume that fair and degrading conditions are prevailing in the basin. Hence EF is 10% of Annual Average Flow (AAF) for the period Oct. to March and 30 % for the period April to September for different years which represents the 90% dependable year of entire Ten-Daily flow series at different proposed dam sites. Table-9.3 summarizes the results for each proposed site in Bichom River basin.

TABLE-9.3
Environmental Water Requirements using Tennant Method

Project	90% dep. yr	AAF of 90% dep. Yr (cumecs)	EWR (cumecs) (Oct-Mar) 0.1*col 3	EWR (cumecs) (Apr-Sep) 0.3*col 3
(1)	(2)	(3)	(4)	(5)
Utung	1983-84	18.02	1.80	5.41
Nazong	1983-84	22.65	2.27	6.80
Dikhri	1983-84	11.01	1.10	3.30
Dibbin	1983-84	36.47	3.65	10.94
Dimijin	1983-84	40.00	4.00	12.00
Nafra	1983-84	44.93	4.49	13.48
Dinan	1983-84	8.13	0.81	2.44
Gongri	1978-79	50.52	5.05	15.16
Dinchang	1976-77	65.78	6.58	19.73
Jameri	1972-73	14.51	1.45	4.35

(ii) Hughes & Münster Method (H&M)

The EWR = LFR + HFR.

LFR = $Q_{90\%}$ dependable flow of 90% dependable year.

HFR are taken from table 3.2, when the ratio of $Q_{90\%}$ / AAF is between 20% and 30% the value of HFR is taken as 7% of AAF. When the ratio of $Q_{90\%}$ / AAF is more than 30% the components of high flows are negligible. Computations are shown in Table-9.4.

TABLE-9.4
Environmental Water Requirements using Hughes & Münster method.

Project	90% Dep. Year	AAF of 90% dep. yr (cumecs)	Q90 of 90% dep. yr (cumecs)	% Q90/AAF (Col4)/(Col3)	HFR (cumecs) 0.07*Col3	EWR (cumecs) Col4+Col6
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Utung	1983-84	18.02	5.04	27.97	1.2614	6.30
Nazong	1983-84	22.65	6.33	27.95	1.5855	7.92
Dikhri	1983-84	11.01	3.08	27.97	0.7707	3.85
Dibbin	1983-84	36.47	10.20	27.97	2.5529	12.75
Dimijin	1983-84	40	11.19	27.98	2.8	13.99
Nafra	1983-84	44.93	12.57	27.98	3.1451	15.72
Dinan	1983-84	8.13	2.27	27.92	0.5691	2.84

Gongri	1978-79	50.52	13.49	26.70	3.5364	17.03
Dinchang	1976-77	65.78	17.56	26.70	4.6046	22.16
Jameri	1972-73	14.51	6.00	41.35	0	6.00

(iii) Index Method

Assumptions taken in computations:

Ka = 1.0 River ecology is very sensitive.

Kb = 1.0 River flows are in natural state, therefore any implementation factor is NOT required.

Kc = 1.5 considering high naturalistic values in Bichom river basin.

Q355 correspond to Q equaled or exceeded 98% of the time. This value is taken from flow duration curve for different years which represents the 90% dependable year.

$$MIF = Q_{355}*Ka*Kb*Kc$$

Table-9.5 summarizes the results of EWR using Index Method.

TABLE-9.5
Environmental Water Requirements using Index method

Project	**90% dep. yr**	**Q_{355} of 90% dep. yr (cumecs)**	**EWR (cumecs)**
Utung	1983-84	4.84	7.26
Nazong	1983-84	6.06	9.09
Dikhri	1983-84	2.96	4.44
Dibbin	1983-84	9.8	14.7
Dimijin	1983-84	10.75	16.125
Nafra	1983-84	12.07	18.105
Dinan	1983-84	2.18	3.27
Gongri	1978-79	12.87	19.305
Dinchang	1976-77	16.76	25.14
Jameri	1972-73	5.39	8.085

(iv) Building Block Method

The BBM methodology assesses the requirements, which needs to be fulfilled throughout the year for estimation of Environmental flows. The requirements considered are:

- Irrigation water requirements
- Drinking water requirements
- Flow required to sustain riverine ecology including fisheries

Irrigation and drinking water requirements

The proposed project is located in an area with low population density with no major sources of pollution. The major source of water for meeting irrigation and drinking requirements in the project area are rivers or nallahs which flow adjacent to the habitations. The water is conveyed to the point of consumption. Thus, no water is abstracted form river Bichom.

Flow required to sustain riverine ecology including fisheries

The BBM methodology used in this study constructs a synthetic hydrograph which must satisfy the water requirements in the river for maintaining a desired condition. The hydrograph simulates the natural conditions in the river to fulfill the different flow regimes present throughout the year. The identification and incorporation of these important flow characteristics will help to maintain the river's channel structure, diversity of the physical biotopes and processes. Four main seasons are identified along the year:

Season I: This season is considered as high flow season, influenced by monsoon. It covers the months from May to September in which the proposed minimum flow is taken as 30% of average flow for the corresponding period (10 daily flows).

Season II: This season is considering like average season and it corresponds to transition period between wet and dry period. It covers the month of October in which the proposed minimum flow is taken as 20% of average flow for corresponding period.

Season III: This season is considering as low flow, lean or dry season. It covers the months from November to March in which the proposed minimum flow is taken as 15% of average flow for corresponding period (10 daily flows).

Season IV: This season is considering like average season and it corresponds to transition period between dry and wet period. It covers the month of April in which the proposed minimum flow is taken as 20% of average flow for corresponding period.

The proposed minimum flows have been estimated for two cases:

1. Using Ten-Daily Average Flows for Average flow series at various proposed dam sites (Refer Tables-9.6 to 9.15).
2. For 90% dependable year at various proposed dam sites (Refer Tables-9.16 to 9.25).

TABLE-9.6

Proposed Minimum Flows for Average Ten-Daily Flow at Utung HEP

Season	Month	Ten daily	%	Average	Environmental Flow
	May	I	30	10.94	3.28
		II	30	15.24	4.57
		III	30	16.38	4.91
S	June	I	30	26.03	7.81
E		II	30	36.59	10.98
A		III	30	48.77	14.63
S	July	I	30	48.37	14.51
O		II	30	62.68	18.80
N		III	30	74.81	22.44
	August	I	30	72.02	21.61
I		II	30	58.46	17.54
		III	30	52.03	15.61
	September	I	30	51.27	15.38
		II	30	47.23	14.17
		III	30	40.16	12.05
Season I Average values			30	**44.07**	**13.22**

Season	Month	Ten daily	%	Average	Environmental Flow
	October	I	20	32.05	6.41
II		II	20	25.73	5.15
		III	20	19.06	3.81
Season II Average values			20	**25.61**	5.12
	November	I	15	13.61	2.04
SEASON III		II	15	11.23	1.68
		III	15	9.84	1.48
	December	I	15	8.15	1.22
		II	15	6.82	1.02
		III	15	5.81	0.87
	January	I	15	5.56	0.83
		II	15	5.06	0.76
		III	15	4.85	0.73
	February	I	15	4.48	0.67
		II	15	4.56	0.68
		III	15	4.67	0.70
	March	I	15	4.65	0.70
		II	15	4.8	0.72
		III	15	5.23	0.78
Season III Average values			15	**6.62**	0.99
	April	I	20	5.93	1.19
IV		II	20	6.63	1.33
		III	20	8.11	1.62
Season IV Average values			20	**6.89**	1.38

TABLE-9.7

Proposed Minimum Flows for Average Ten-Daily Flow at Nazong HEP

Seasons	Month	Ten daily	%	Average	Environmental Flow
	May	I	30	13.75	4.13
		II	30	19.16	5.75
		III	30	20.59	6.18
S	June	I	30	32.72	9.82
E		II	30	46	13.80
A		III	30	61.31	18.39
S	July	I	30	60.81	18.24
O		II	30	78.79	23.64
N		III	30	94.04	28.21
	August	I	30	90.54	27.16
I		II	30	73.5	22.05
		III	30	65.41	19.62
	September	I	30	64.45	19.34
		II	30	59.37	17.81
		III	30	50.49	15.15
Season I Average values			30	**55.39**	**16.62**
	October	I	20	40.28	8.06
II		II	20	32.34	6.47
		III	20	23.96	4.79

Seasons	Month	Ten daily	%	Average	Environmental Flow
Season II Average values			20	**32.19**	**6.44**
	November	I	15	17.11	2.57
S E A S O N III		II	15	14.12	2.12
		III	15	12.36	1.85
	December	I	15	10.24	1.54
		II	15	8.57	1.29
		III	15	7.3	1.10
	January	I	15	6.99	1.05
		II	15	6.36	0.95
		III	15	6.09	0.91
	February	I	15	5.63	0.84
		II	15	5.73	0.86
		III	15	5.88	0.88
	March	I	15	5.85	0.88
		II	15	6.04	0.91
		III	15	6.58	0.99
Season III Average values			15	**8.32**	**1.25**
	April	I	20	7.46	1.49
IV		II	20	8.34	1.67
		III	20	10.19	2.04
Season IV Average values			20	**8.66**	**1.73**

TABLE-9.8

Proposed Minimum Flows for Average Ten-Daily Flow at Dikhri HEP

Seasons	Month	Ten daily	%	Average	Environmental Flow
	May	I	30	6.69	2.01
		II	30	9.32	2.80
		III	30	10.02	3.01
S	June	I	30	15.91	4.77
E		II	30	22.37	6.71
A		III	30	29.81	8.94
S	July	I	30	29.57	8.87
O		II	30	38.32	11.50
N		III	30	45.73	13.72
	August	I	30	44.03	13.21
I		II	30	35.74	10.72
		III	30	31.81	9.54
	September	I	30	31.34	9.40
		II	30	28.87	8.66
		III	30	24.55	7.37
Season I Average values			30	**26.94**	**8.08**
	October	I	20	19.59	3.92
II		II	20	15.73	3.15
		III	20	11.65	2.33
Season II Average values			20	**15.66**	**3.13**
	November	I	15	8.32	1.25
S		II	15	6.87	1.03
E		III	15	6.01	0.90

Seasons	Month	Ten daily	%	Average	Environmental Flow
A S O N III	December	I	15	4.98	0.75
		II	15	4.17	0.63
		III	15	3.55	0.53
	January	I	15	3.4	0.51
		II	15	3.09	0.46
		III	15	2.96	0.44
	February	I	15	2.74	0.41
		II	15	2.79	0.42
		III	15	2.86	0.43
	March	I	15	2.84	0.43
		II	15	2.94	0.44
		III	15	3.2	0.48
Season III Average values			15	**4.05**	**0.61**
IV	April	I	20	3.63	0.73
		II	20	4.05	0.81
		III	20	4.96	0.99
Season IV Average values			20	**4.21**	**0.84**

TABLE-9.9
Proposed Minimum Flows for Average Ten-Daily Flow at Dibbin HEP

Seasons	Month	Ten daily	%	Average	Min. Flow
S E A S O N I	May	I	30	22.15	6.65
		II	30	30.85	9.26
		III	30	33.16	9.95
	June	I	30	52.69	15.81
		II	30	74.07	22.22
		III	30	98.72	29.62
	July	I	30	97.92	29.38
		II	30	126.88	38.06
		III	30	151.44	45.43
	August	I	30	145.79	43.74
		II	30	118.35	35.51
		III	30	105.33	31.60
	September	I	30	103.79	31.14
		II	30	95.6	28.68
		III	30	81.31	24.39
Season I Average values			30	**89.20**	**26.76**
II	October	I	20	64.87	12.97
		II	20	52.08	10.42
		III	20	38.58	7.72
Season II Average values			20	**51.84**	**10.37**
S E A S O N III	November	I	15	27.55	4.13
		II	15	22.74	3.41
		III	15	19.91	2.99
	December	I	15	16.49	2.47
		II	15	13.81	2.07
		III	15	11.76	1.76
	January	I	15	11.25	1.69
		II	15	10.24	1.54
		III	15	9.81	1.47

Seasons	Month	Ten daily	%	Average	Min. Flow
	February	I	15	9.06	1.36
		II	15	9.23	1.38
		III	15	9.46	1.42
	March	I	15	9.42	1.41
		II	15	9.72	1.46
		III	15	10.59	1.59
Season III Average values			15	**13.40**	**2.01**
	April	I	20	12.01	2.40
IV		II	20	13.43	2.69
		III	20	16.41	3.28
Season IV Average values			20	**13.95**	**2.79**

TABLE-9.10
Proposed Minimum Flows for Average Ten-Daily Flow at Dimijin HEP

Seasons	Month	Ten daily	%	Average	Min. Flow
SEASON I	May	I	30	24.3	7.29
		II	30	33.85	10.16
		III	30	36.38	10.91
	June	I	30	57.8	17.34
		II	30	81.25	24.38
		III	30	108.3	32.49
	July	I	30	107.42	32.23
		II	30	139.19	41.76
		III	30	166.12	49.84
	August	I	30	159.93	47.98
		II	30	129.83	38.95
		III	30	115.54	34.66
	September	I	30	113.85	34.16
		II	30	104.87	31.46
		III	30	89.19	26.76
Season I Average values			30	**97.85**	**29.36**
II	October	I	20	71.16	14.23
		II	20	57.13	11.43
		III	20	42.32	8.46
Season II Average values			20	**56.87**	11.37
SEASON III	November	I	15	30.22	4.53
		II	15	24.94	3.74
		III	15	21.84	3.28
	December	I	15	18.09	2.71
		II	15	15.14	2.27
		III	15	12.9	1.94
	January	I	15	12.34	1.85
		II	15	11.24	1.69
		III	15	10.76	1.61
	February	I	15	9.94	1.49
		II	15	10.13	1.52
		III	15	10.38	1.56
	March	I	15	10.33	1.55

Seasons	Month	Ten daily	%	Average	Min. Flow
		II	15	10.66	1.60
		III	15	11.62	1.74
Season III Average values			15	**14.70**	**2.21**
IV	April	I	20	13.18	2.64
		II	20	14.73	2.95
		III	20	18	3.60
Season IV Average values			20	**15.30**	3.06

TABLE-9.11
Proposed Minimum Flows for Average Ten-Daily Flow at Nafra HEP

Seasons	Month	Ten daily	%	Average	Min.Flow
SEASON I	May	I	30	27.29	8.19
		II	30	38.01	11.40
		III	30	40.86	12.26
	June	I	30	64.91	19.47
		II	30	91.25	27.38
		III	30	121.62	36.49
	July	I	30	120.64	36.19
		II	30	156.32	46.90
		III	30	186.57	55.97
	August	I	30	179.61	53.88
		II	30	145.81	43.74
		III	30	129.76	38.93
	September	I	30	127.86	38.36
		II	30	117.78	35.33
		III	30	100.17	30.05
Season I Average values			30	**109.90**	**32.97**
II	October	I	20	79.92	15.98
		II	20	64.16	12.83
		III	20	47.53	9.51
Season II Average values			20	**63.87**	**12.77**
SEASON III	November	I	15	33.94	5.09
		II	15	28.01	4.20
		III	15	24.53	3.68
	December	I	15	20.32	3.05
		II	15	17.01	2.55
		III	15	14.49	2.17
	January	I	15	13.86	2.08
		II	15	12.62	1.89
		III	15	12.09	1.81
	February	I	15	11.17	1.68
		II	15	11.37	1.71
		III	15	11.66	1.75
	March	I	15	11.6	1.74
		II	15	11.98	1.80
		III	15	13.05	1.96
Season III Average values			15	**16.51**	**2.48**

IV	April	I	20	14.8	2.96
		II	20	16.54	3.31
		III	20	20.22	4.04
Season IV Average values			20	**17.19**	**3.44**

TABLE-9.12

Proposed Minimum Flows for Average Ten-Daily Flow at Dinan HEP

Seasons	Month	Ten daily	%	Average	Min.Flow
SEASON I	May	I	30	4.94	1.48
		II	30	6.88	2.06
		III	30	7.4	2.22
	June	I	30	11.75	3.53
		II	30	16.52	4.96
		III	30	22.01	6.60
	July	I	30	21.84	6.55
		II	30	28.29	8.49
		III	30	33.77	10.13
	August	I	30	32.51	9.75
		II	30	26.39	7.92
		III	30	23.49	7.05
	September	I	30	23.14	6.94
		II	30	21.32	6.40
		III	30	18.13	5.44
Season I Average values			30	**19.89**	**5.97**
II	October	I	20	14.47	2.89
		II	20	11.61	2.32
		III	20	8.6	1.72
Season II Average values			20	**11.56**	**2.31**
SEASON III	November	I	15	6.14	0.92
		II	15	5.07	0.76
		III	15	4.44	0.67
	December	I	15	3.68	0.55
		II	15	3.08	0.46
		III	15	2.62	0.39
	January	I	15	2.51	0.38
		II	15	2.28	0.34
		III	15	2.19	0.33
	February	I	15	2.02	0.30
		II	15	2.06	0.31
		III	15	2.11	0.32
	March	I	15	2.1	0.32
		II	15	2.17	0.33
		III	15	2.36	0.35
Season III Average values			15	**2.99**	**0.45**
IV	April	I	20	2.68	0.54
		II	20	2.99	0.60
		III	20	3.66	0.73
Season IV Average values			20	**3.11**	**0.62**

TAVBLE-9.13
Proposed Minimum Flows for Average Ten-Daily Flow at Gongri HEP

Seasons	Month	Ten daily	%	Average	Min. Flow
SEASON I	May	I	30	37.83	11.35
		II	30	46.8	14.04
		III	30	50.72	15.22
	June	I	30	74.44	22.33
		II	30	86.51	25.95
		III	30	100.39	30.12
	July	I	30	109.14	32.74
		II	30	135.18	40.55
		III	30	150.8	45.24
	August	I	30	149.72	44.92
		II	30	123.88	37.16
		III	30	124.82	37.45
	September	I	30	121.54	36.46
		II	30	112.62	33.79
		III	30	100.02	30.01
Season I Average values			30	**101.63**	**30.49**
II	October	I	20	88.35	17.67
		II	20	66.83	13.37
		III	20	54.23	10.85
Season II Average values			20	**69.80**	**13.96**
SEASON III	November	I	15	42.18	6.33
		II	15	38.03	5.70
		III	15	33.89	5.08
	December	I	15	30.24	4.54
		II	15	26.77	4.02
		III	15	24.79	3.72
	January	I	15	22.63	3.39
		II	15	21.32	3.20
		III	15	20.3	3.05
	February	I	15	19.14	2.87
		II	15	19.15	2.87
		III	15	20.78	3.12
	March	I	15	19.23	2.88
		II	15	20.12	3.02
		III	15	21.21	3.18
Season III Average values			15	**25.32**	**3.80**
IV	April	I	20	24.43	4.89
		II	20	27.67	5.53
		III	20	30.71	6.14
Season IV Average values			20	**27.60**	**5.52**

TABLE-9.14
Proposed Minimum Flows for Average Ten-Daily Flow at Dinchang HEP

Seasons	Month	Ten daily	%	Average	Min.Flow
SEASON I	May	I	30	49.25	14.78
		II	30	60.94	18.28
		III	30	66.03	19.81
	June	I	30	96.93	29.08
		II	30	112.64	33.79
		III	30	130.7	39.21
	July	I	30	142.11	42.63
		II	30	176.01	52.80
		III	30	196.34	58.90
	August	I	30	194.94	58.48
		II	30	161.29	48.39
		III	30	162.51	48.75
	September	I	30	158.24	47.47
		II	30	146.63	43.99
		III	30	130.23	39.07
Season I Average values			30	**132.32**	**39.70**
II	October	I	20	115.03	23.01
		II	20	87.01	17.40
		III	20	70.61	14.12
Season II Average values			20	**90.88**	**18.18**
SEASON III	November	I	15	54.91	8.24
		II	15	49.51	7.43
		III	15	44.13	6.62
	December	I	15	39.37	5.91
		II	15	34.85	5.23
		III	15	32.27	4.84
	January	I	15	29.47	4.42
		II	15	27.76	4.16
		III	15	26.43	3.96
	February	I	15	24.92	3.74
		II	15	24.94	3.74
		III	15	27.05	4.06
	March	I	15	25.04	3.76
		II	15	26.2	3.93
		III	15	27.62	4.14
Season III Average values			15	**32.96**	**4.94**
IV	April	I	20	31.81	6.36
		II	20	36.02	7.20
		III	20	39.99	8.00
Season IV Average values			20	**35.94**	**7.19**

TABLE-9.15
Proposed Minimum Flows for Average Ten-Daily Flow at Jameri HEP

Seasons	Month	Ten daily	%	Average	Min. Flow
SEASON I	May	I	30	9.42	2.83
		II	30	11.62	3.49
		III	30	12.91	3.87
	June	I	30	27.79	8.34
		II	30	31.7	9.51
		III	30	37.23	11.17
	July	I	30	49.83	14.95
		II	30	59.28	17.78
		III	30	68.12	20.44
	August	I	30	54.94	16.48
		II	30	45.57	13.67
		III	30	48.21	14.46
	September	I	30	49.76	14.93
		II	30	44.05	13.22
		III	30	37.39	11.22
Season I Average values			30	**39.19**	**11.76**
II	October	I	20	43.2	8.64
		II	20	32.7	6.54
		III	20	25.46	5.09
Season II Average values			20	**33.78**	**6.76**
SEASON III	November	I	15	20.9	3.14
		II	15	18.8	2.82
		III	15	17.52	2.63
	December	I	15	12.91	1.94
		II	15	11.29	1.69
		III	15	10.42	1.56
	January	I	15	10.23	1.53
		II	15	9.6	1.44
		III	15	9.14	1.37
	February	I	15	8.6	1.29
		II	15	8.64	1.30
		III	15	9.27	1.39
	March	I	15	7.16	1.07
		II	15	7.42	1.11
		III	15	7.92	1.19
Season III Average values			15	**11.32**	**1.70**
IV	April	I	20	7.09	1.42
		II	20	8.23	1.65
		III	20	8.99	1.80
Season IV Average values			20	**8.10**	**1.62**

TABLE-9.16
Proposed Minimum Flows for 90% Dependable year at Utung HEP

Seasons	Month	Ten daily	%	Flow	Min. Flow
SEASON I	May	I	30	8.65	2.60
		II	30	10.28	3.08
		III	30	15.56	4.67
	June	I	30	15.86	4.76
		II	30	23.86	7.16
		III	30	32.41	9.72
	July	I	30	37.74	11.32
		II	30	38.83	11.65
		III	30	54.49	16.35
	August	I	30	53.01	15.90
		II	30	29.59	8.88
		III	30	40.71	12.21
	September	I	30	43.67	13.10
		II	30	33.54	10.06
		III	30	28.55	8.57
Season I Average values			30	**31.12**	**9.34**
II	October	I	20	23.91	4.78
		II	20	19.81	3.96
		III	20	15.07	3.01
Season II Average values			20	**19.60**	**3.92**
SEASON III	November	I	15	8.84	1.33
		II	15	10.52	1.58
		III	15	10.72	1.61
	December	I	15	5.83	0.87
		II	15	5.88	0.88
		III	15	5.09	0.76
	January	I	15	5.14	0.77
		II	15	5.04	0.76
		III	15	7.16	1.07
	February	I	15	8.15	1.22
		II	15	6.37	0.96
		III	15	5.04	0.76
	March	I	15	7.31	1.10
		II	15	6.47	0.97
		III	15	4.84	0.73
Season III Average values			15	**6.83**	**1.02**
IV	April	I	20	5.29	1.06
		II	20	5.19	1.04
		III	20	5.98	1.20
Season IV Average values			20	**5.48**	**1.10**

TABLE-9.17
Proposed Minimum Flows for 90% Dependable year at Nazong HEP

Seasons	Month	Ten daily	%	Flow	Min. Flow
SEASON I	May	I	30	10.87	3.26
		II	30	12.92	3.88
		III	30	19.56	5.87
	June	I	30	19.93	5.98
		II	30	29.99	9.00
		III	30	40.74	12.22
	July	I	30	47.44	14.23
		II	30	48.81	14.64
		III	30	68.5	20.55
	August	I	30	66.63	19.99
		II	30	37.2	11.16
		III	30	51.17	15.35
	September	I	30	54.9	16.47
		II	30	42.17	12.65
		III	30	35.89	10.77
Season I Average values			30	**39.11**	**11.73**
II	October	I	20	30.06	6.01
		II	20	24.9	4.98
		III	20	18.94	3.79
Season II Average values			20	**24.63**	**4.93**
SEASON III	November	I	15	11.12	1.67
		II	15	13.23	1.98
		III	15	13.48	2.02
	December	I	15	7.33	1.10
		II	15	7.39	1.11
		III	15	6.4	0.96
	January	I	15	6.46	0.97
		II	15	6.33	0.95
		III	15	9	1.35
	February	I	15	10.25	1.54
		II	15	8.01	1.20
		III	15	6.33	0.95
	March	I	15	9.19	1.38
		II	15	8.14	1.22
		III	15	6.09	0.91
Season III Average values			15	**8.58**	**1.29**
IV	April	I	20	6.64	1.33
		II	20	6.52	1.30
		III	20	7.51	1.50
Season IV Average values			20	**6.89**	**1.38**

TABLE-9.18
Proposed Minimum Flows for 90% Dependable year at Dikhri HEP

Seasons	Month	Ten daily	%	Flow	Min. Flow
SEASON I	May	I	30	5.29	1.59
		II	30	6.28	1.88
		III	30	9.51	2.85
	June	I	30	9.69	2.91
		II	30	14.59	4.38
		III	30	19.81	5.94
	July	I	30	23.07	6.92
		II	30	23.74	7.12
		III	30	33.31	9.99
	August	I	30	32.4	9.72
		II	30	18.09	5.43
		III	30	24.88	7.46
	September	I	30	26.7	8.01
		II	30	20.51	6.15
		III	30	17.46	5.24
Season I Average values			30	**19.02**	**5.71**
II	October	I	20	14.62	2.92
		II	20	12.11	2.42
		III	20	9.21	1.84
Season II Average values			20	**11.98**	**2.40**
SEASON III	November	I	15	5.41	0.81
		II	15	6.43	0.96
		III	15	6.55	0.98
	December	I	15	3.56	0.53
		II	15	3.59	0.54
		III	15	3.11	0.47
	January	I	15	3.14	0.47
		II	15	3.08	0.46
		III	15	4.38	0.66
	February	I	15	4.98	0.75
		II	15	3.9	0.59
		III	15	3.08	0.46
	March	I	15	4.47	0.67
		II	15	3.96	0.59
		III	15	2.96	0.44
Season III Average values			15	**4.17**	**0.63**
IV	April	I	20	3.23	0.65
		II	20	3.17	0.63
		III	20	3.65	0.73
Season IV Average values			20	**3.35**	**0.67**

TABLE-9.19

Proposed Minimum Flows for 90% Dependable year at Dibbin HEP

Seasons	Month	Ten daily	%	Flow	Min. Flow
SEASON I	May	I	30	17.5	5.25
		II	30	20.8	6.24
		III	30	31.5	9.45
	June	I	30	32.1	9.63
		II	30	48.3	14.49
		III	30	65.6	19.68
	July	I	30	76.4	22.92
		II	30	78.6	23.58
		III	30	110.3	33.09
	August	I	30	107.3	32.19
		II	30	59.9	17.97
		III	30	82.4	24.72
	September	I	30	88.4	26.52
		II	30	67.9	20.37
		III	30	57.8	17.34
Season I Average values			30	**62.99**	**18.90**
II	October	I	20	48.4	9.68
		II	20	40.1	8.02
		III	20	30.5	6.10
Season II Average values			20	**39.67**	**7.93**
SEASON III	November	I	15	17.9	2.69
		II	15	21.3	3.20
		III	15	21.7	3.26
	December	I	15	11.8	1.77
		II	15	11.9	1.79
		III	15	10.3	1.55
	January	I	15	10.4	1.56
		II	15	10.2	1.53
		III	15	14.5	2.18
	February	I	15	16.5	2.48
		II	15	12.9	1.94
		III	15	10.2	1.53
	March	I	15	14.8	2.22
		II	15	13.1	1.97
		III	15	9.8	1.47
Season III Average values			15	**13.82**	**2.07**
IV	April	I	20	10.7	2.14
		II	20	10.5	2.10
		III	20	12.1	2.42
Season IV Average values			20	**11.10**	**2.22**

TABLE-9.20
Proposed Minimum Flows for 90% Dependable year at Dimijin HEP

Seasons	Month	Ten daily	%	Flow	Min. Flow
SEASON I	May	I	30	19.2	5.76
		II	30	22.82	6.85
		III	30	34.56	10.37
	June	I	30	35.21	10.56
		II	30	52.99	15.90
		III	30	71.96	21.59
	July	I	30	83.81	25.14
		II	30	86.22	25.87
		III	30	121	36.30
	August	I	30	117.71	35.31
		II	30	65.71	19.71
		III	30	90.39	27.12
	September	I	30	96.97	29.09
		II	30	74.49	22.35
		III	30	63.41	19.02
Season I Average values			30	**69.10**	**20.73**
II	October	I	20	53.09	10.62
		II	20	43.99	8.80
		III	20	33.46	6.69
Season II Average values			20	**43.51**	**8.70**
SEASON III	November	I	15	19.64	2.95
		II	15	23.37	3.51
		III	15	23.8	3.57
	December	I	15	12.94	1.94
		II	15	13.05	1.96
		III	15	11.3	1.70
	January	I	15	11.41	1.71
		II	15	11.19	1.68
		III	15	15.91	2.39
	February	I	15	18.1	2.72
		II	15	14.15	2.12
		III	15	11.19	1.68
	March	I	15	16.24	2.44
		II	15	14.37	2.16
		III	15	10.75	1.61
Season III Average values			15	**15.16**	**2.27**
IV	April	I	20	11.74	2.35
		II	20	11.52	2.30
		III	20	13.27	2.65
Season IV Average values			20	**12.18**	**2.44**

TABLE-9.21
Proposed Minimum Flows for 90% Dependable year at Nafra HEP

Seasons	Month	Ten daily	%	Flow	Min.Flow
SEASON I	May	I	30	21.56	6.47
		II	30	25.63	7.69
		III	30	38.81	11.64
	June	I	30	39.55	11.87
		II	30	59.51	17.85
		III	30	80.82	24.25
	July	I	30	94.12	28.24
		II	30	96.84	29.05
		III	30	135.89	40.77
	August	I	30	132.19	39.66
		II	30	73.8	22.14
		III	30	101.52	30.46
	September	I	30	108.91	32.67
		II	30	83.65	25.10
		III	30	71.21	21.36
Season I Average values			30	**77.60**	**23.28**
II	October	I	20	59.63	11.93
		II	20	49.4	9.88
		III	20	37.58	7.52
Season II Average values			20	**48.87**	**9.77**
SEASON III	November	I	15	22.05	3.31
		II	15	26.24	3.94
		III	15	26.73	4.01
	December	I	15	14.54	2.18
		II	15	14.66	2.20
		III	15	12.69	1.90
	January	I	15	12.81	1.92
		II	15	12.57	1.89
		III	15	17.86	2.68
	February	I	15	20.33	3.05
		II	15	15.89	2.38
		III	15	12.57	1.89
	March	I	15	18.23	2.73
		II	15	16.14	2.42
		III	15	12.07	1.81
Season III Average values			15	**17.03**	**2.55**
IV	April	I	20	13.18	2.64
		II	20	12.94	2.59
		III	20	14.91	2.98
Season IV Average values			20	**13.68**	**2.74**

TABLE-9.22
Proposed Minimum Flows for 90% Dependable year at Dinan HEP

Seasons	Month	Ten daily	%	Flow	Min.Flow
SEASON I	May	I	30	3.9	1.17
		II	30	4.64	1.39
		III	30	7.02	2.11
	June	I	30	7.16	2.15
		II	30	10.77	3.23
		III	30	14.63	4.39
	July	I	30	17.04	5.11
		II	30	17.53	5.26
		III	30	24.6	7.38
	August	I	30	23.93	7.18
		II	30	13.36	4.01
		III	30	18.38	5.51
	September	I	30	19.71	5.91
		II	30	15.14	4.54
		III	30	12.89	3.87
Season I Average values			20	**14.05**	**4.22**
II	October	I	20	10.79	2.16
		II	20	8.94	1.79
		III	20	6.8	1.36
Season II Average values			20	**8.85**	**1.77**
SEASON III	November	I	15	3.99	0.60
		II	15	4.75	0.71
		III	15	4.84	0.73
	December	I	15	2.63	0.39
		II	15	2.65	0.40
		III	15	2.3	0.35
	January	I	15	2.32	0.35
		II	15	2.27	0.34
		III	15	3.23	0.48
	February	I	15	3.68	0.55
		II	15	2.88	0.43
		III	15	2.27	0.34
	March	I	15	3.3	0.50
		II	15	2.92	0.44
		III	15	2.19	0.33
Season III Average values			15	**3.08**	**0.46**
IV	April	I	20	2.39	0.48
		II	20	2.34	0.47
		III	20	2.7	0.54
Season IV Average values			20	**2.48**	**0.50**

TABLE-9.23
Proposed Minimum Flows for 90% dependable Year at Gongri HEP

Seasons	Month	Ten daily	%	Flow	Min. Flow
SEASON I	May	I	30	24.05	7.22
		II	30	17.53	5.26
		III	30	32.04	9.61
	June	I	30	63.89	19.17
		II	30	93.75	28.13
		III	30	112.83	33.85
	July	I	30	98.14	29.44
		II	30	99.16	29.75
		III	30	103.32	31.00
	August	I	30	150.37	45.11
		II	30	96.23	28.87
		III	30	71.59	21.48
	September	I	30	87.84	26.35
		II	30	105.04	31.51
		III	30	81.18	24.35
Season I Average values			30	**82.46**	**24.74**
II	October	I	20	82.29	16.46
		II	20	59.29	11.86
		III	20	51.06	10.21
Season II Average values			20	**64.22**	**12.84**
	November	I	15	42.54	6.38
		II	15	39.04	5.86
		III	15	36.52	5.48
SEASON III	December	I	15	29.83	4.47
		II	15	24.12	3.62
		III	15	21.62	3.24
	January	I	15	18.71	2.81
		II	15	17.35	2.60
		III	15	15.81	2.37
	February	I	15	15.08	2.26
		II	15	14.98	2.25
		III	15	13.72	2.06
	March	I	15	13.07	1.96
		II	15	12.87	1.93
		III	15	13.49	2.02
Season III Average values			15	**21.92**	**3.29**
IV	April	I	20	16.9	3.38
		II	20	20.34	4.07
		III	20	20.38	4.08
Season IV Average values			20	**19.21**	**3.84**

TABLE-9.24
Proposed Minimum Flows for 90% dependable Year at Dinchang HEP

Seasons	Month	Ten daily	%	Flow	Min.Flow
SEASON I	May	I	30	31.31	9.39
		II	30	22.82	6.85
		III	30	41.72	12.52
	June	I	30	83.19	24.96
		II	30	122.07	36.62
		III	30	146.9	44.07
	July	I	30	127.78	38.33
		II	30	129.11	38.73
		III	30	134.53	40.36
	August	I	30	195.78	58.73
		II	30	125.3	37.59
		III	30	93.2	27.96
	September	I	30	114.36	34.31
		II	30	136.76	41.03
		III	30	105.7	31.71
Season I Average values			30	**107.37**	**32.21**
II	October	I	20	107.14	21.43
		II	20	77.2	15.44
		III	20	66.48	13.30
Season II Average values			20	**83.61**	**16.72**
SEASON III	November	I	15	55.38	8.31
		II	15	50.83	7.62
		III	15	47.56	7.13
	December	I	15	38.84	5.83
		II	15	31.41	4.71
		III	15	28.16	4.22
	January	I	15	24.36	3.65
		II	15	22.58	3.39
		III	15	20.59	3.09
	February	I	15	19.63	2.94
		II	15	19.5	2.93
		III	15	17.86	2.68
	March	I	15	17.01	2.55
		II	15	16.75	2.51
		III	15	17.56	2.63
Season III Average values			15	**28.54**	**4.28**
IV	April	I	20	22	4.40
		II	20	26.48	5.30
		III	20	26.53	5.31
Season IV Average values			20	**25.01**	**5.00**

TABLE-9.25
Proposed Minimum Flows for 90% dependable Year at Jameri HEP

Seasons	Month	Ten daily	%	Flow	Min. Flow
SEASON I	May	I	30	7.07	2.12
		II	30	8.69	2.61
		III	30	9.31	2.79
	June	I	30	14.07	4.22
		II	30	17.22	5.17
		III	30	18.12	5.44
	July	I	30	21.49	6.45
		II	30	28.03	8.41
		III	30	35.44	10.63
	August	I	30	42.75	12.83
		II	30	27.72	8.32
		III	30	30.21	9.06
	September	I	30	33.94	10.18
		II	30	24.69	7.41
		III	30	19.85	5.96
Season I Average values			30	**22.57**	**6.77**
II	October	I	20	16.79	3.36
		II	20	15.76	3.15
		III	20	12.06	2.41
Season II Average values			20	**14.87**	**2.97**
SEASON III	November	I	15	11.47	1.72
		II	15	10.21	1.53
		III	15	9.28	1.39
	December	I	15	9	1.35
		II	15	8.56	1.28
		III	15	8.33	1.25
	January	I	15	8	1.20
		II	15	7.97	1.20
		III	15	7.49	1.12
	February	I	15	5.75	0.86
		II	15	6.52	0.98
		III	15	7.52	1.13
	March	I	15	6.05	0.91
		II	15	6.53	0.98
		III	15	6.68	1.00
Season III Average values			15	**7.96**	**1.19**
IV	April	I	20	6.19	1.24
		II	20	5.39	1.08
		III	20	6	1.20
Season IV Average values			20	**5.86**	**1.17**

9.5 ESTIMATION OF STAGE-DISCHARGE RELATIONSHIP

In Bichom basin, cross section data was available at different locations downstream of for only Gongri hydroelectric project, and no stage discharge relationship was available. Therefore the first step was to generate a synthetic form of normal depth discharge relationship. Since, only cross section area (A) and corresponding wetted perimeter (P) is available at different stages; the discharges were obtained using Manning's equation. The water depths were taken in the intervals of 0.5 m, ranging between 0.5 m to 3.0 meters. Therefore, a relation between normal depth and discharge is obtained at three different project sites, where the cross section of the river is available at different length along the river channel. Assumptions taken in Manning's equation are:

- *Steady uniform flow condition.*

  The critical period of analysis in this project occurs during dry season, when rainfall is not expected and runoff can be taken as zero, therefore, additional discharge from lateral inflow for a selected reach is zero, seepage is negligible, and discharge is assumed to be steady, and uniform.

- *One-dimensional analysis.*

  In one-dimensional analysis, the mean velocity is used as a representative velocity for the entire cross section and is defined on the basis of the longitudinal component. Hence, the velocities in the other than the main direction of flow are not considered.

Manning's equation can be written in terms of discharge as:

$$Q = \frac{1}{n} A R^{2/3} S^{1/2}$$

where:

Q is the discharge (m3/s).
n is the roughness coefficient (dimensionless).
A is the area of the cross section perpendicular to flow (m2).
R is the hydraulic radius in meters (R=A/P).
S is the slope of the river bed.

The selection of *n* value was done by tables using a description of the river conditions "in situ". According with Chow, the roughness coefficient for a natural minor stream (top width at flood stage < 100 ft), mountain river stream, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high stages. River bed conforms of boulders, cobbles and few boulders range from [0.03-0.05]. Therefore, the analysis has been carried out for Manning's n as 0.03, 0.04, and 0.05. Three different curves of Water Depth vs. Discharge were obtained for each dam site analyzed..

The normal depth relationship w.r.t. to discharge was available only for Gongri hydroelectric project. The stage-discharge relationship at various distances downstream of dam site for Gongri HEP is given in Table-9.26.

TABLE-9.26
Stage discharge relationship at various distances downstream of dam site for Gongri HEP

Distance downstream of the dam site(m)	Stage-discharge relationship		
	n=0.03	n=0.04	n=0,05
200	$Q=46.674y^{2.2288}$	$Q=35.066.674y^{2.2288}$	$Q=28.8054y^{2.2288}$
400	$Q=23.29y^{1.9955}$	$Q=17.472.y^{1.9955}$	$Q=13.978y^{1.9955}$
600	$Q=18.241y^{2.404}$	$Q=13.681y^{2.404}$	$Q=10.945y^{2.404}$
800	$Q=25.06y^{2.0814}$	$Q=19.395y^{2.0814}$	$Q=15.1011y^{2.0814}$
1000	$Q=17.195y^{2.1801}$	$Q=13.897y^{2.1801}$	$Q=10.317y^{2.1801}$

The depth of flows for various percentages of Environmental flows in Lean season for n=0.03, n=0.04 and n=0.05 at a distance of 200 m downstream of dam site of Gongri HEP is given in Tables-9.27 to 9.29.

TABLE-9.27
Depth of flows at 200m downstream of dam site (For n=0.03)

Month		Discharge for 90% DY (cumec)	Environmental Flows (cumec)			Depth of flows (m)		
			15%	20%	25%	15%	20%	25%
November	I	42.54	6.38	8.51	10.65	0.41	0.47	0.51
	II	39.04	5.85	7.81	9.76	0.39	0.45	0.50
	III	36.52	5.48	7.30	9.13	0.38	0.43	0.48
December	I	29.83	4.48	5.97	7.46	0.35	0.40	0.44
	II	24.12	3.62	4.82	6.03	0.32	0.36	0.40
	III	21.62	3.24	4.32	5.41	0.30	0.34	0.38
January	I	18.71	2.81	3.74	4.68	0.28	0.32	0.36
	II	17.35	2.60	3.47	4.34	0.27	0.31	0.34
	III	15.81	2.37	3.16	3.95	0.26	0.30	0.33
February	I	15.08	2.26	3.02	3.77	0.26	0.29	0.32
	II	14.98	2.25	3.00	3.75	0.26	0.29	0.32
	III	13.72	2.06	2.74	3.43	0.25	0.28	0.31
March	I	13.07	1.96	2.61	3.27	0.24	0.27	0.30
	II	12.87	1.93	2.57	3.22	0.24	0.27	0.30
	III	13.49	2.02	2.70	3.37	0.24	0.28	0.31
Average		**21.92**	**3.29**	**4.38**	**5.48**	**0.30**	**0.35**	**0.38**

TABLE-9.28
Depth of flows at 200m downstream of dam site (For n=0.04)

Month		Discharge for 90% DY (cumec)	Environmental Flows (cumec)			Depth of flows (m)		
			15%	20%	25%	15%	20%	25%
November	I	42.54	6.38	8.51	10.65	0.47	0.53	0.59
	II	39.04	5.85	7.81	9.76	0.45	0.51	0.56
	III	36.52	5.48	7.30	9.13	0.44	0.50	0.55
December	I	29.83	4.48	5.97	7.46	0.40	0.45	0.50
	II	24.12	3.62	4.82	6.03	0.36	0.41	0.45
	III	21.62	3.24	4.32	5.41	0.34	0.39	0.43
January	I	18.71	2.81	3.74	4.68	0.32	0.37	0.41

Month		Discharge for 90% DY (cumec)	Environmental Flows (cumec)			Depth of flows (m)		
			15%	20%	25%	15%	20%	25%
	II	17.35	2.60	3.47	4.34	0.31	0.35	0.39
	III	15.81	2.37	3.16	3.95	0.30	0.34	0.38
February	I	15.08	2.26	3.02	3.77	0.29	0.33	0.37
	II	14.98	2.25	3.00	3.75	0.29	0.33	0.37
	III	13.72	2.06	2.74	3.43	0.28	0.32	0.35
March	I	13.07	1.96	2.61	3.27	0.27	0.31	0.35
	II	12.87	1.93	2.57	3.22	0.27	0.31	0.34
	III	13.49	2.02	2.70	3.37	0.28	0.32	0.35
Average		**21.92**	**3.29**	**4.38**	**5.48**	**0.35**	**0.39**	**0.44**

TABLE-9.29
Depth of flows at 200m downstream of dam site (For n=0.05)

Month		Discharge for 90% DY (cumec)	Environmental Flows (cumec)			Depth of flows (m)		
			15%	20%	25%	15%	20%	25%
November	I	42.54	6.38	8.51	10.65	0.51	0.58	0.64
	II	39.04	5.85	7.81	9.76	0.49	0.56	0.62
	III	36.52	5.48	7.30	9.13	0.47	0.54	0.60
December	I	29.83	4.48	5.97	7.46	0.43	0.49	0.55
	II	24.12	3.62	4.82	6.03	0.39	0.45	0.50
	III	21.62	3.24	4.32	5.41	0.38	0.43	0.47
January	I	18.71	2.81	3.74	4.68	0.35	0.40	0.44
	II	17.35	2.60	3.47	4.34	0.34	0.39	0.43
	III	15.81	2.37	3.16	3.95	0.33	0.37	0.41
February	I	15.08	2.26	3.02	3.77	0.32	0.36	0.40
	II	14.98	2.25	3.00	3.75	0.32	0.36	0.40
	III	13.72	2.06	2.74	3.43	0.31	0.35	0.38
March	I	13.07	1.96	2.61	3.27	0.30	0.34	0.38
	II	12.87	1.93	2.57	3.22	0.30	0.34	0.37
	III	13.49	2.02	2.70	3.37	0.30	0.35	0.38
Average		**21.92**	**3.29**	**4.38**	**5.48**	**0.38**	**0.43**	**0.47**

The depth of flows for various percentages of Environmental flows in Lean season for n=0.03, n=0.04 and n=0.05 at a distance of 400 m downstream of dam site of Gongri HEP is given in Tables-9.30 to 9.32.

TABLE-9.30
Depth of flows at 400m downstream of dam site (For n=0.03)

Month		Discharge for 90% DY (cumec)	Environmental Flows (cumec)			Depth of flows (m)		
			15%	20%	25%	15%	20%	25%
November	I	42.54	6.38	8.51	10.65	0.52	0.60	0.68
	II	39.04	5.85	7.81	9.76	0.50	0.58	0.65
	III	36.52	5.48	7.30	9.13	0.48	0.56	0.63
December	I	29.83	4.48	5.97	7.46	0.44	0.51	0.57

Month		Discharge for 90% DY (cumec)	Environmental Flows (cumec)			Depth of flows (m)		
			15%	20%	25%	15%	20%	25%
	II	24.12	3.62	4.82	6.03	0.39	0.45	0.51
	III	21.62	3.24	4.32	5.41	0.37	0.43	0.48
January	I	18.71	2.81	3.74	4.68	0.35	0.40	0.45
	II	17.35	2.60	3.47	4.34	0.33	0.39	0.43
	III	15.81	2.37	3.16	3.95	0.32	0.37	0.41
February	I	15.08	2.26	3.02	3.77	0.31	0.36	0.40
	II	14.98	2.25	3.00	3.75	0.31	0.36	0.40
	III	13.72	2.06	2.74	3.43	0.30	0.34	0.38
March	I	13.07	1.96	2.61	3.27	0.29	0.33	0.37
	II	12.87	1.93	2.57	3.22	0.29	0.33	0.37
	III	13.49	2.02	2.70	3.37	0.29	0.34	0.38
Average		**21.92**	**3.29**	**4.38**	**5.48**	**0.37**	**0.43**	**0.48**

TABLE-9.31
Depth of flows at 400m downstream of dam site (For n=0.04)

Month		Discharge for 90% DY (cumec)	Environmental Flows (cumec)			Depth of flows (m)		
			15%	20%	25%	15%	20%	25%
November	I	42.54	6.38	8.51	10.65	0.60	0.70	0.78
	II	39.04	5.85	7.81	9.76	0.58	0.67	0.75
	III	36.52	5.48	7.30	9.13	0.56	0.65	0.72
December	I	29.83	4.48	5.97	7.46	0.51	0.58	0.65
	II	24.12	3.62	4.82	6.03	0.45	0.52	0.59
	III	21.62	3.24	4.32	5.41	0.43	0.50	0.56
January	I	18.71	2.81	3.74	4.68	0.40	0.46	0.52
	II	17.35	2.60	3.47	4.34	0.39	0.44	0.50
	III	15.81	2.37	3.16	3.95	0.37	0.42	0.47
February	I	15.08	2.26	3.02	3.77	0.36	0.41	0.46
	II	14.98	2.25	3.00	3.75	0.36	0.41	0.46
	III	13.72	2.06	2.74	3.43	0.34	0.40	0.44
March	I	13.07	1.96	2.61	3.27	0.33	0.39	0.43
	II	12.87	1.93	2.57	3.22	0.33	0.38	0.43
	III	13.49	2.02	2.70	3.37	0.34	0.39	0.44
Average		**21.92**	**3.29**	**4.38**	**5.48**	**0.43**	**0.50**	**0.56**

TABLE-9.32
Depth of flows at 400m downstream of dam site (For n=0.05)

Month		Discharge for 90% DY (cumec)	Environmental Flows (cumec)			Depth of flows (m)		
			15%	20%	25%	15%	20%	25%
November	I	42.54	6.38	8.51	10.65	0.68	0.78	0.87
	II	39.04	5.85	7.81	9.76	0.65	0.75	0.84
	III	36.52	5.48	7.30	9.13	0.63	0.72	0.81
December	I	29.83	4.48	5.97	7.46	0.57	0.65	0.73
	II	24.12	3.62	4.82	6.03	0.51	0.59	0.66
	III	21.62	3.24	4.32	5.41	0.48	0.56	0.62
January	I	18.71	2.81	3.74	4.68	0.45	0.52	0.58

Month		Discharge for 90% DY (cumec)	Environmental Flows (cumec)			Depth of flows (m)		
			15%	20%	25%	15%	20%	25%
	II	17.35	2.60	3.47	4.34	0.43	0.50	0.56
	III	15.81	2.37	3.16	3.95	0.41	0.47	0.53
February	I	15.08	2.26	3.02	3.77	0.40	0.46	0.52
	II	14.98	2.25	3.00	3.75	0.40	0.46	0.52
	III	13.72	2.06	2.74	3.43	0.38	0.44	0.49
March	I	13.07	1.96	2.61	3.27	0.37	0.43	0.48
	II	12.87	1.93	2.57	3.22	0.37	0.43	0.48
	III	13.49	2.02	2.70	3.37	0.38	0.44	0.49
Average		**21.92**	**3.29**	**4.38**	**5.48**	**0.48**	**0.56**	**0.63**

The depth of flows for various percentages of Environmental flows in Lean season for n=0.03, n=0.04 and n=0.05 at a distance of 600 m downstream of dam site of Gongri HEP is given in Tables-9.33 to 9.35.

TABLE-9.33
Depth of flows at 600m downstream of dam site (For n=0.03)

Month		Discharge for 90% DY (cumec)	Environmental Flows (cumec)			Depth of flows (m)		
			15%	20%	25%	15%	20%	25%
November	I	42.54	6.38	8.51	10.65	0.65	0.73	0.80
	II	39.04	5.85	7.81	9.76	0.62	0.70	0.77
	III	36.52	5.48	7.30	9.13	0.61	0.68	0.75
December	I	29.83	4.48	5.97	7.46	0.56	0.63	0.69
	II	24.12	3.62	4.82	6.03	0.51	0.58	0.63
	III	21.62	3.24	4.32	5.41	0.49	0.55	0.60
January	I	18.71	2.81	3.74	4.68	0.46	0.52	0.57
	II	17.35	2.60	3.47	4.34	0.44	0.50	0.55
	III	15.81	2.37	3.16	3.95	0.43	0.48	0.53
February	I	15.08	2.26	3.02	3.77	0.42	0.47	0.52
	II	14.98	2.25	3.00	3.75	0.42	0.47	0.52
	III	13.72	2.06	2.74	3.43	0.40	0.45	0.50
March	I	13.07	1.96	2.61	3.27	0.40	0.45	0.49
	II	12.87	1.93	2.57	3.22	0.39	0.44	0.49
	III	13.49	2.02	2.70	3.37	0.40	0.45	0.50
Average		**21.92**	**3.29**	**4.38**	**5.48**	**0.49**	**0.55**	**0.61**

TABLE-9.34
Depth of flows at 600m downstream of dam site (For n=0.04)

Month		Discharge for 90% DY (cumec)	Environmental Flows (cumec)			Depth of flows (m)		
			15%	20%	25%	15%	20%	25%
November	I	42.54	6.38	8.51	10.65	0.73	0.82	0.90
	II	39.04	5.85	7.81	9.76	0.70	0.79	0.87
	III	36.52	5.48	7.30	9.13	0.68	0.77	0.85
December	I	29.83	4.48	5.97	7.46	0.63	0.71	0.78
	II	24.12	3.62	4.82	6.03	0.58	0.65	0.71

Month		Discharge for 90% DY (cumec)	Environmental Flows (cumec)			Depth of flows (m)		
			15%	20%	25%	15%	20%	25%
	III	21.62	3.24	4.32	5.41	0.55	0.62	0.68
January	I	18.71	2.81	3.74	4.68	0.52	0.58	0.64
	II	17.35	2.60	3.47	4.34	0.50	0.57	0.62
	III	15.81	2.37	3.16	3.95	0.48	0.54	0.60
February	I	15.08	2.26	3.02	3.77	0.47	0.53	0.58
	II	14.98	2.25	3.00	3.75	0.47	0.53	0.58
	III	13.72	2.06	2.74	3.43	0.45	0.51	0.56
March	I	13.07	1.96	2.61	3.27	0.45	0.50	0.55
	II	12.87	1.93	2.57	3.22	0.44	0.50	0.55
	III	13.49	2.02	2.70	3.37	0.45	0.51	0.56
Average		**21.92**	**3.29**	**4.38**	**5.48**	**0.55**	**0.62**	**0.68**

TABLE-9.35
Depth of flows at 600m downstream of dam site (For n=0.05)

Month		Discharge for 90% DY (cumec)	Environmental Flows (cumec)			Depth of flows (m)		
			15%	20%	25%	15%	20%	25%
November	I	42.54	6.38	8.51	10.65	0.80	0.90	0.99
	II	39.04	5.85	7.81	9.76	0.77	0.87	0.95
	III	36.52	5.48	7.30	9.13	0.75	0.85	0.93
December	I	29.83	4.48	5.97	7.46	0.69	0.78	0.85
	II	24.12	3.62	4.82	6.03	0.63	0.71	0.78
	III	21.62	3.24	4.32	5.41	0.60	0.68	0.75
January	I	18.71	2.81	3.74	4.68	0.57	0.64	0.70
	II	17.35	2.60	3.47	4.34	0.55	0.62	0.68
	III	15.81	2.37	3.16	3.95	0.53	0.60	0.65
February	I	15.08	2.26	3.02	3.77	0.52	0.58	0.64
	II	14.98	2.25	3.00	3.75	0.52	0.58	0.64
	III	13.72	2.06	2.74	3.43	0.50	0.56	0.62
March	I	13.07	1.96	2.61	3.27	0.49	0.55	0.60
	II	12.87	1.93	2.57	3.22	0.49	0.55	0.60
	III	13.49	2.02	2.70	3.37	0.50	0.56	0.61
Average		**21.92**	**3.29**	**4.38**	**5.48**	**0.61**	**0.68**	**0.75**

The depth of flows for various percentages of Environmental flows in Lean season for n=0.03, n=0.04 and n=0.05 at a distance of 800 m downstream of dam site of Gongri HEP is given in Tables-9.36 to 9.38.

TABLE-9.36
Depth of flows at 800m downstream of dam site (For n=0.03)

Month		Discharge for 90% DY (cumec)	Environmental Flows (cumec)			Depth of flows (m)		
			15%	20%	25%	15%	20%	25%
November	I	42.54	6.38	8.51	10.65	0.52	0.60	0.66
	II	39.04	5.85	7.81	9.76	0.50	0.57	0.64
	III	36.52	5.48	7.30	9.13	0.48	0.55	0.62

Month		Discharge for 90% DY (cumec)	Environmental Flows (cumec)			Depth of flows (m)		
			15%	20%	25%	15%	20%	25%
December	I	29.83	4.48	5.97	7.46	0.44	0.50	0.56
	II	24.12	3.62	4.82	6.03	0.39	0.45	0.50
	III	21.62	3.24	4.32	5.41	0.37	0.43	0.48
January	I	18.71	2.81	3.74	4.68	0.35	0.40	0.45
	II	17.35	2.60	3.47	4.34	0.34	0.39	0.43
	III	15.81	2.37	3.16	3.95	0.32	0.37	0.41
February	I	15.08	2.26	3.02	3.77	0.31	0.36	0.40
	II	14.98	2.25	3.00	3.75	0.31	0.36	0.40
	III	13.72	2.06	2.74	3.43	0.30	0.35	0.38
March	I	13.07	1.96	2.61	3.27	0.29	0.34	0.38
	II	12.87	1.93	2.57	3.22	0.29	0.34	0.37
	III	13.49	2.02	2.70	3.37	0.30	0.34	0.38
Average		**21.92**	**3.29**	**4.38**	**5.48**	**0.38**	**0.43**	**0.48**

TABLE-9.37
Depth of flows at 800m downstream of dam site (For n=0.04)

Month		Discharge for 90% DY (cumec)	Environmental Flows (cumec)			Depth of flows (m)		
			15%	20%	25%	15%	20%	25%
November	I	42.54	6.38	8.51	10.65	0.59	0.67	0.75
	II	39.04	5.85	7.81	9.76	0.56	0.65	0.72
	III	36.52	5.48	7.30	9.13	0.54	0.63	0.70
December	I	29.83	4.48	5.97	7.46	0.49	0.57	0.63
	II	24.12	3.62	4.82	6.03	0.45	0.51	0.57
	III	21.62	3.24	4.32	5.41	0.42	0.49	0.54
January	I	18.71	2.81	3.74	4.68	0.40	0.45	0.50
	II	17.35	2.60	3.47	4.34	0.38	0.44	0.49
	III	15.81	2.37	3.16	3.95	0.36	0.42	0.47
February	I	15.08	2.26	3.02	3.77	0.36	0.41	0.46
	II	14.98	2.25	3.00	3.75	0.36	0.41	0.45
	III	13.72	2.06	2.74	3.43	0.34	0.39	0.44
March	I	13.07	1.96	2.61	3.27	0.33	0.38	0.42
	II	12.87	1.93	2.57	3.22	0.33	0.38	0.42
	III	13.49	2.02	2.70	3.37	0.34	0.39	0.43
Average		**21.92**	**3.29**	**4.38**	**5.48**	**0.43**	**0.49**	**0.54**

TABLE-9.38
Depth of flows at 800m downstream of dam site (For n=0.05)

Month		Discharge for 90% DY (cumec)	Environmental Flows (cumec)			Depth of flows (m)		
			15%	20%	25%	15%	20%	25%
November	I	42.54	6.38	8.51	10.65	0.66	0.76	0.84
	II	39.04	5.85	7.81	9.76	0.63	0.73	0.81
	III	36.52	5.48	7.30	9.13	0.61	0.71	0.79
December	I	29.83	4.48	5.97	7.46	0.56	0.64	0.71
	II	24.12	3.62	4.82	6.03	0.50	0.58	0.64
	III	21.62	3.24	4.32	5.41	0.48	0.55	0.61

Month		Discharge for 90% DY (cumec)	Environmental Flows (cumec)			Depth of flows (m)		
			15%	20%	25%	15%	20%	25%
January	I	18.71	2.81	3.74	4.68	0.45	0.51	0.57
	II	17.35	2.60	3.47	4.34	0.43	0.49	0.55
	III	15.81	2.37	3.16	3.95	0.41	0.47	0.53
February	I	15.08	2.26	3.02	3.77	0.40	0.46	0.51
	II	14.98	2.25	3.00	3.75	0.40	0.46	0.51
	III	13.72	2.06	2.74	3.43	0.38	0.44	0.49
March	I	13.07	1.96	2.61	3.27	0.37	0.43	0.48
	II	12.87	1.93	2.57	3.22	0.37	0.43	0.48
	III	13.49	2.02	2.70	3.37	0.38	0.44	0.49
Average		**21.92**	**3.29**	**4.38**	**5.48**	**0.48**	**0.55**	**0.61**

The depth of flows for various percentages of Environmental flows in Lean season for n=0.03, n=0.04 and n=0.05 at a distance of 1000 m downstream of dam site of Gongri HEP is given in Tables-9.39 to 9.41.

TABLE-9.39
Depth of flows at 1000m downstream of dam site (For n=0.03)

Month		Discharge for 90% DY (cumec)	Environmental Flows (cumec)			Depth of flows (m)		
			15%	20%	25%	15%	20%	25%
November	I	42.54	6.38	8.51	10.65	0.63	0.72	0.80
	II	39.04	5.85	7.81	9.76	0.61	0.70	0.77
	III	36.52	5.48	7.30	9.13	0.59	0.68	0.75
December	I	29.83	4.48	5.97	7.46	0.54	0.62	0.68
	II	24.12	3.62	4.82	6.03	0.49	0.56	0.62
	III	21.62	3.24	4.32	5.41	0.47	0.53	0.59
January	I	18.71	2.81	3.74	4.68	0.44	0.50	0.55
	II	17.35	2.60	3.47	4.34	0.42	0.48	0.53
	III	15.81	2.37	3.16	3.95	0.40	0.46	0.51
February	I	15.08	2.26	3.02	3.77	0.39	0.45	0.50
	II	14.98	2.25	3.00	3.75	0.39	0.45	0.50
	III	13.72	2.06	2.74	3.43	0.38	0.43	0.48
March	I	13.07	1.96	2.61	3.27	0.37	0.42	0.47
	II	12.87	1.93	2.57	3.22	0.37	0.42	0.46
	III	13.49	2.02	2.70	3.37	0.37	0.43	0.47
Average		**21.92**	**3.29**	**4.38**	**5.48**	**0.47**	**0.53**	**0.59**

TABLE-9.40
Depth of flows at 1000m downstream of dam site (For n=0.04)

Month		Discharge for 90% DY (cumec)	Environmental Flows (cumec)			Depth of flows (m)		
			15%	20%	25%	15%	20%	25%
November	I	42.54	6.38	8.51	10.65	0.70	0.80	0.88
	II	39.04	5.85	7.81	9.76	0.67	0.77	0.85
	III	36.52	5.48	7.30	9.13	0.65	0.74	0.82
December	I	29.83	4.48	5.97	7.46	0.59	0.68	0.75

Month		Discharge for 90% DY (cumec)	Environmental Flows (cumec)			Depth of flows (m)		
			15%	20%	25%	15%	20%	25%
	II	24.12	3.62	4.82	6.03	0.54	0.62	0.68
	III	21.62	3.24	4.32	5.41	0.51	0.59	0.65
January	I	18.71	2.81	3.74	4.68	0.48	0.55	0.61
	II	17.35	2.60	3.47	4.34	0.46	0.53	0.59
	III	15.81	2.37	3.16	3.95	0.44	0.51	0.56
February	I	15.08	2.26	3.02	3.77	0.43	0.50	0.55
	II	14.98	2.25	3.00	3.75	0.43	0.49	0.55
	III	13.72	2.06	2.74	3.43	0.42	0.48	0.53
March	I	13.07	1.96	2.61	3.27	0.41	0.46	0.51
	II	12.87	1.93	2.57	3.22	0.40	0.46	0.51
	III	13.49	2.02	2.70	3.37	0.41	0.47	0.52
Average		**21.92**	**3.29**	**4.38**	**5.48**	**0.52**	**0.59**	**0.65**

TABLE-9.41
Depth of flows at 1000m downstream of dam site (For n=0.05)

Month		Discharge for 90% DY (cumec)	Environmental Flows (cumec)			Depth of flows (m)		
			15%	20%	25%	15%	20%	25%
November	I	42.54	6.38	8.51	10.65	0.80	0.92	1.01
	II	39.04	5.85	7.81	9.76	0.77	0.88	0.97
	III	36.52	5.48	7.30	9.13	0.75	0.85	0.95
December	I	29.83	4.48	5.97	7.46	0.68	0.78	0.86
	II	24.12	3.62	4.82	6.03	0.62	0.71	0.78
	III	21.62	3.24	4.32	5.41	0.59	0.67	0.74
January	I	18.71	2.81	3.74	4.68	0.55	0.63	0.70
	II	17.35	2.60	3.47	4.34	0.53	0.61	0.67
	III	15.81	2.37	3.16	3.95	0.51	0.58	0.64
February	I	15.08	2.26	3.02	3.77	0.50	0.57	0.63
	II	14.98	2.25	3.00	3.75	0.50	0.57	0.63
	III	13.72	2.06	2.74	3.43	0.48	0.54	0.60
March	I	13.07	1.96	2.61	3.27	0.47	0.53	0.59
	II	12.87	1.93	2.57	3.22	0.46	0.53	0.59
	III	13.49	2.02	2.70	3.37	0.47	0.54	0.60
Average		**21.92**	**3.29**	**4.38**	**5.48**	**0.59**	**0.68**	**0.75**

9.6 CONCLUSIONS

The environmental flow for Bichom basin has been estimated using the hydrologic methods. The results are summarized in Table-9.42.

TABLE-9.42
Summary of Environmental Water Requirements for different techniques

Project	Tennant Method (cumecs)		H&M Method	Index Method
	Oct-Mar	Apr-Sep	(cumecs)	(cumecs)
Utung HEP	1.80	5.41	6.30	7.26

Nazong HEP	2.27	6.80	7.92	9.09
Dikhri HEP	1.10	3.30	3.85	4.44
Dibbin HEP	3.65	10.94	12.75	14.70
Dimijin HEP	4.00	12.00	13.99	16.13
Nafra HEP	4.49	13.48	15.72	18.11
Dinan HEP	0.81	2.44	2.84	3.27
Gongri HEP	5.05	15.16	17.03	19.31
Dinchang HEP	6.58	19.73	22.16	25.14
Jameri HEP	1.45	4.35	6.00	8.09

As per Building Block Method, the minimum flow requirements based on average flows has been estimated. The results are summarized in Table-9.43.

TABLE-9.43
Summary of Environmental Water Requirements as per Building Block Method

Project	Season I	Season II	Season III	Season IV
	May-September	October	November to March	April
Utung HEP	9.34	3.92	1.02	1.10
Nazong HEP	11.73	4.93	1.29	1.38
Dikhri HEP	5.71	2.40	0.63	0.67
Dibbin HEP	18.90	7.93	2.07	2.22
Dimijin HEP	20.73	8.70	2.27	2.44
Nafra HEP	23.28	9.77	2.55	2.74
Dinan HEP	4.22	1.77	0.46	0.50
Gongri HEP	24.74	12.84	3.29	3.84
Dinchang HEP	32.21	16.72	4.28	5.00
Jameri HEP	6.77	2.97	1.19	1.17

However, it may be noted depth of water available at various locations nees to eb checked, whether it is sufficient for sustenance of riverine fisheries. This can only be carried out, if the sectional details are available. In the present basin study, sectional details were available only for Gongri HEP. As per the stage –discharge analysisi for the Gongri HEP, the following can be concluded:

- For 15% of releases as Environmental flows in lean season, the depth of water available at various cross-sections downstream of dam site was 0.3 (n=0.03) to 0.61 m (n=0.05).
- For 20% of releases as Environmental flows in lean season, the depth of water available at various cross-sections downstream of dam site was 0.35 (n=0.03) to 0.68 m (n=0.05).
- For 25% of releases as Environmental flows in lean season, the depth of water available at various cross-sections downstream of dam site was 0.38 (n=0.03) to 0.75 m (n=0.05).

Thus, it is recommended that a minimum of 20% of releases as Environmental flows in lean season be always maintained or sustenance of riverine fisheries. For other projects in the basin, 20% of flow in four consecutive months in lean season will be released as Environmental Flow always needs to be maintained.

A scientific study can also be conducted to assess the downstream requirement of water to decide Environmental Flow for maintaining the aquatic ecology and water quality of river. However, if the site specific study, assesses that Environmental Flow is less than 20% in four consecutive months in lean season, then a minimum of 20% of flow in four consecutive months in lean season always needs to be maintained.

CHAPTER-10

ENVIRONMENTAL MANAGEMENT PLAN

10.1 INTRODUCTION

The aim of the Environmental Management Plan (EMP) is to ensure that the impacts due to stress/load on the ecosystem are ameliorated to the extent possible. The most reliable way to achieve the above objective is to incorporate the management plan into the overall planning and implementation of the proposed hydroelectric projects in the study area.

10.2 MANAGEMENT PLAN FOR FISHERIES

Various measures outlined for sustenance of riverine fisheries are described in the following paragraphs.

10.2.1 Release of minimum flow

The Building Block Methodology has been used in the present study to formulate a synthetic hydrograph which must satisfy the water requirements in the river for maintaining a desired condition. The hydrograph simulates the natural conditions in the river to fulfill the different flow regimes present through out the year. The identification and incorporation of these important flow characteristics will help to maintain the river's channel structure, diversity of the physical biotopes and processes. As outlined in Chapter-9, four main seasons have been identified in a calendar. These are listed as below:

Season I: This season is considered as high flow season influenced by monsoon. It covers the months from May to September. The minimum flow during this period is assumed as 30% of average flow (10 daily or monthly).

Season II: This season is considered as average flow period. It covers the month of October in which the proposed minimum flow is taken as 20% of average flow. This period is a transitional period between the wet and dry period.

Season III: This season is considered as low or lean or dry flow season. It covers the months from November to March. The proposed minimum flow is taken as 15% of average flow during this period.

Season IV: This season is considered as average flow period and is same as that of season II. It cover the month of April in which the proposed minimum flow is taken as 20% of average flow. This period is a transitional period between the dry and wet period.

The release of minimum flows on the basis of average flow during 20 years data and on the basis of flow during the 90 % dependable year has been estimated in Chapter-9 of this report. The proposed Minimum Flow on the basis of average flow during 20 years data for various hydroelectric projects is given in Table-10.1.

TABLE-10.1
Summary of Environmental Water Requirements as per Building Block Method

Project	Season I May-September	Season II October	Season III November to March	Season IV April
Utung HEP	9.34	3.92	1.02	1.10
Nazong HEP	11.73	4.93	1.29	1.38
Dikhri HEP	5.71	2.40	0.63	0.67
Dibbin HEP	18.90	7.93	2.07	2.22
Dimijin HEP	20.73	8.70	2.27	2.44
Nafra HEP	23.28	9.77	2.55	2.74
Dinan HEP	4.22	1.77	0.46	0.50
Gongri HEP	24.74	12.84	3.29	3.84
Dinchang HEP	32.21	16.72	4.28	5.00
Jameri HEP	6.77	2.97	1.19	1.17

It is recommended that a minimum of 20% of releases as Environmental flows in lean season be always maintained or sustenance of riverine fisheries. For other projects in the basin, 20% of flow in four consecutive months in lean season will be released as Environmental Flow always needs to be maintained.

A scientific study can also be conducted to assess the downstream requirement of water to decide Environmental Flow for maintaining the aquatic ecology and water quality of river. However, if the site specific study, assesses that Environmental Flow is less than 20% in four consecutive months in lean season, then a minimum of 20% of flow in four consecutive months in lean season always needs to be maintained.

10.2.3 Management plan for sustenance of fish species

Based on the field studies, the following migratory fish species are observed in the study area:

- *Schizothorax richardsonii*
- *Neolissochilus hexagonolepis*
- *Labeo pangusia*
- *Chagunius chagunio*
- *Tor putitora*
- *Tor tor*
- *Garra gotyla*
- *Garra annandalei*
- *Aborichthys elongatus*
- *Botia Dario*
- *Silurus afgana*
- *Amblyceps sp.*
- *Glyptothorax sp.*
- *Channa orientalis*

The species *Schizothorax richardsonii* and *Neolissochilus hexagonolepis* migrate from lower elevation to higher elevation in summer months and return to lower elevation in winter months. These species were observed at various sampling locations of all the ten hydroelectric projects proposed to be developed in the study area.

The dam of Nafra hydroelectric project would block the upward migratory movement of various fish species in winter season on river Bichom. Thus, migration of species *Schizothorax richardsonii* and *Neolissochilus hexagonolepis* river stretch would be affected for a length of about 27 km due to obstruction to migration created by the dam of Nafra hydroelectric project. Similarly, Utung hydroelectric project, would impede the downward movement of migratory fish species in summer season. It is likely that the migration of fish species namely, *Schizothorax richardsonii* and *Neolissochilus hexagonolepis* in the stretch of about 33 km would be severely affected on account of construction of the proposed hydroelectric projects on river Bichom. Likewise, migration of fish species from tributaries, e.g., Gongri/Digo and Dikhri to river Bichom, would be severely affected on account of creation of reservoirs due to construction of proposed hydroelectric projects. Thus, the project will lead to significant adverse impact on migratory fish species. As a result of development of various projects, fish migration would be observed in the following stretches:

River Bichom

- Upstream of dam site of Utung hydroelectric project
- Downstream of tail race disposal site of Nafra hydroelectric project

River Gongri/Digo

- Upstream of dam site of Gongri hydroelectric project
- Downstream of tail race disposal site of Dinchang hydroelectric project

River Dikhri

- Upstream of dam site of Dikhri hydroelectric project

River Dinang

- Upstream of dam site of Dinan hydroelectric project

River Tenga

- Upstream of dam site of Jameri hydroelectric project
- Downstream of tail race disposal site of Jameri hydroelectric project.

The affected stretch in the case of Jameri HEP would be about 5.6 km. The distance between confluence of Tenga with Bichom and tail race disposal site of Jameri hydroelectric project is about 16 km.

The following fish species migrate to lower elevation in summer months and undertake the return journey in winter months:

- *Labeo pangusia*

- *Chagunius chagunio*
- *Tor putitora*
- *Tor tor*
- *Garra gotyla*
- *Garra annandalei*

The presence of the above fish species in areas in vicinity to various projects is given in Table-10.2.

TABLE-10.2
Presence of the above fish species in areas in vicinity to various projects

S. No.	Project Name	*Labeo pangusia*	*Chagunius chagunio*	*Tor putitora*	*Tor tor*	*Garra gotyla*	*Garra annandalei*
1	Utung HEP	×		×		×	
2	Nazong HEP	×		×		×	
3	Dibbin HEP	×		×		×	
4	Dimijin HEP	×				×	
5	Dikhri HEP	×		×		×	
6	Dinchang HEP	×		×		×	
7	Jameri HEP	×	×	×	×	×	×
8	Dinan HEP	×		×		×	
9	Nafra HEP	×		×		×	×
10	Gongri HEP	×		×		×	×

The following species were observed in the vicinity of all the projects to be commissioned in the Study Area:

- *Labeo pangusia*
- *Tor putitora*
- *Garra gotyla*

The construction of various projects would impede the migratory movement of *Labeo pangusia, Tor putitora* and *Garra gotyla*. As a result of commissioning of various projects, fish migration would be restricted only in the following stretches:

River Bichom

- Upstream of dam site of Utung hydroelectric project
- Downstream of tail race disposal site of Nafra hydroelectric project

River Gongri/Digo

- Upstream of dam site of Gongri hydroelectric project
- Downstream of tail race disposal site of Dinchang hydroelectric project

River Dikhri

- Upstream of dam site of Dikhri hydroelectric project

River Dinang

- Upstream of dam site of Dinan hydroelectric project

River Tenga

- Upstream of dam site of Jameri hydroelectric project
- Downstream of tail race disposal site of Jameri hydroelectric project.

The affected stretch in the case of Jameri HEP would be about 5.6 km. The distance between confluence of Tenga with Bichom and tail race disposal site of Jameri hydroelectric project is about 16 km.

The migration of various fish species would be severely affected and their number would decrease significantly.

The following species were observed in the vicinity of only Jameri hydroelectric project:

- *Chagunius chagunio*
- *Tor tor*
- *Garra annandalei*

The migration of *Chagunius chagunio, Tor tor, Garra annandalei* would be severely affected and their number would decrease significantly. . However, the affected stretch in the case of Jameri HEP would be about 5.6 km. The distance between confluence of Tenga with Bichom and tail race disposal site of Jameri hydroelectric project is about 17.6 km.

It is proposed to construct separate hatcheries for various fish species to be stocked in the reservoirs in the study area. These hatcheries can be developed by the Department of Fisheries, state government of Arunachal Pradesh. 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).

It is proposed to stock the reservoirs of all the projects with fingerlings of the following species:

- *Schizothorax richardsonii*
- *Neolissochilus hexagonolepis*
- *Labeo pangusia*
- *Tor putitora*
- *Garra gotyla*

It is proposed to stock the reservoirs of the following projects with fingerlings of *Garra annandalei*:

- Jameri hydroelectric project
- Nafra hydroelectric project

- Gongri hydroelectric project

It is proposed to stock the reservoir of Jameri Hydroelectric project with fingerlings of *Tor tor* and *Chagunius chagunio.*

The cost for fisheries development shall be shared amongst all the various hydro-electric projects proposed to be developed in the study area.

A Steering Committee of the project would be constituted for the monitoring of the project as listed in Table-10.3.

TABLE-10.3
Steering Committee constituted for the monitoring of fisheries development

S. No.	Officer	Position
1	Secretary (Fisheries) to the Government of Arunchal Pradesh	Chairman
2	Representative of District Collector	Member
3	Representative of Department of Power, state government of Arunachal Pradesh	Member
4	Nominated representative of local public	Member
5	Nominated representative of proponents of various hydroelectric projects	Member
6	Assistant Director of Fisheries, state government of Arunachal Pradesh	Member Secretary

The main task of the Committee shall be to:

- review of the progress of fisheries development project
- consideration of the need for any mid-course change in the project component.

10.3 CONSERVATION OF THREATENED FLORA

During the course of survey, only one species i.e., *Lagerstroemia muniticarpa* classified as endangered plant species as per IUCN Red list was found near the dam site of Jameri HEP. The density of *Lagerstroemia muniticarpa* at this site was 45 trees/ha. A detailed study is recommended as a part of the CEIA study of Jameri hydroelectric project to ascertain the impacts on *Lagerstoremia muniticarpa* and suggest appropriate management measures on this account.

10.4 ENVIRONMENTAL MANAGEMENT DURING CONSTRUCTION PHASE

Provision of Free Fuel to Labour Population

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

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

As a part of tender document for the contractor, it should be made mandatory to:

- make a clause mandatory in the contract of every contractor involved in project construction to provide supply of fuel to their labourers, so that trees are not cut for meeting their fuel demands.
- establish LPG godown within the project area for providing LPG cylinder to run community kitchens.
- establish kerosene oil depot near project area with the help of state government to ensure proper supply of kerosene oil.

Control of Air Pollution

The following measures are recommended to control air pollution to minimize impacts on the vegetation in the area:

- 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.

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-10.4, and are recommended to be followed.

TABLE-10.4

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 needs to followed by the contractor operating the DG sets.

Technical Specifications for Acoustic Enclosure of DG set

The acoustic enclosure will be of free standing, floor mounting type integral with the DG set. The enclosure will be provided with rugged heavy-duty structural steel base frame with chequered plate flooring on which the DG set is to be mounted. The enclosure will be prefabricated factory – built and modular in construction, so that it can be easily assembled at site around the DG set. The enclosure will consist of acoustically treated panels housed in rugged steel frames, which will be bolted together to from the body of the enclosure. Sliding doors will be provided, on either side, which will also be acoustically treated, thereby providing easy access to the DG set while minimizing the operating space requirements. The construction of the acoustic enclosure will be such that with both the acoustic doors open on the either side, full access is available to the engine and attenuator. For fresh air inlet into the system a parallel baffle air inlet silencer will be provided.

Additionally, to augment the fresh air inlet requirements, a forced air ventilation duct with associated silencer will be provided above the alternator. For hot air discharge, an acoustic discharge plenum will be provided in front of the engine radiator, for discharge of hot air into the surroundings through a parallel baffle air outlet silencer. The enclosure will have suitable openings in the roof module for exhaust piping. Acoustic enclosure Designed to meet stringent MoEF/ CPCB norms of 75 dBA at 1mtr at 75% load under free field conditions.

Design Features of Acoustic Enclosure:

- Silencer suitably optimized to meet stringent sound emission standards laid down by MoEF / CPCB
- Base rail with integral fuel tank (285 liters capacity) is provided with drain plug, air vent, inlet and outlet connection, level indicator, manhole etc.
- 2 x 12 V dry, uncharged batteries with connecting leads and terminals Acoustic enclosure
- Specially designed to meet stringent MoEF/ CPCB norms of 75 dBA @ 1 m at 75% load under free field conditions
- Designed to have optimum serviceability

- Air inlet louvers specially designed to operate at rated load even at 50^0C air inlet temperature
- Powder coated for long lasting service life and superior finish wWith UV resistant powder coating, can withstand extreme environments
- Use of stainless steel hardware - Insulation material meets exacting IS 8183 specs for better attenuation

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. 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 spoils 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 employed for this purpose.

Noise Control

The noise control measures are essential to minimize the adverse impacts on faunal population of the area.

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 to 100 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.

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 s distance of 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 to attenuate noise level by atleast 25 dB(A).
- Efforts will 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.

10.5 RECOMMENDATIONS

The following recommendations have been made as a part of the study for environmental conservation:

- It is recommended to drop Dimijin (20 MW) Hydroelectric project. This will ensure free flow for a stretch of about 10.1 km of river Bichom, between tail end of reservoir of Nafra and tail race disposal site of Dibbin hydroelectric project.
- It is recommended to drop Nazong 60 (MW) Hydroelectric project. This will ensure free flow for a stretch of about 4.8 km of river Bichom, between tail end of reservoir of Dibbin hydroelectric project and tail race disposal site of Utung hydroelectric project.
- It is recommended to drop Dikhri (15 MW) Hydroelectric project. This will ensure free flow for a stretch of about 6.3 km of river Dikhri between tail race disposal site of Dikhri hydroelectric project and its confluence with river Bichom. Thus, it is recommended that no project be developed on river Dikhri.
- It is recommended to drop Dinan (10MW) hydroelectric project. This will ensure free flow for a stretch of about 6 km of river Dinang between tail race disposal site of Dinan hydroelectric project and its confluence with river Bichom. Thus, it is recommended that no project be developed on river Dinang.

The above steps will reduce power generation by 105 MW (i.e. 16.3% of 645 MW), but will lead to following benefits:

- Free flow of about 15.1 km in two stretches will be available over a stretch of 32.5 km on river Bichom. The details are given in Figure-10.1.
- Free flow of about 6.3 km on river Dikhri in the stretch downstream of the dam site of the proposed Dikhri hydroelectric project upto its confluence with river Bichom. The details are given in Figure-10.1.
- Free flow of about 6 km on river Dinang in the stretch downstream of the dam site of the proposed Dinan hydroelectric project upto its confluence with river Bichom. The details are given in Figure-10.1.

On river Gongri /Digo, the following three hydroelectric projects are proposed:

- Gongri hydroelectric project
- Khuitam hydroelectric project
- Dinchang hydroelectric project

To develop free flow for adequate length on river Gongri /Digo between Gongri, Khuitam and Dinchang HEPs, following measures are recommended for incorporation in the project planning:

- FRL of Dinchang HEP be reduced
- Dam site of Dinchang HEP be shifted downstream
- Combination of above measures.

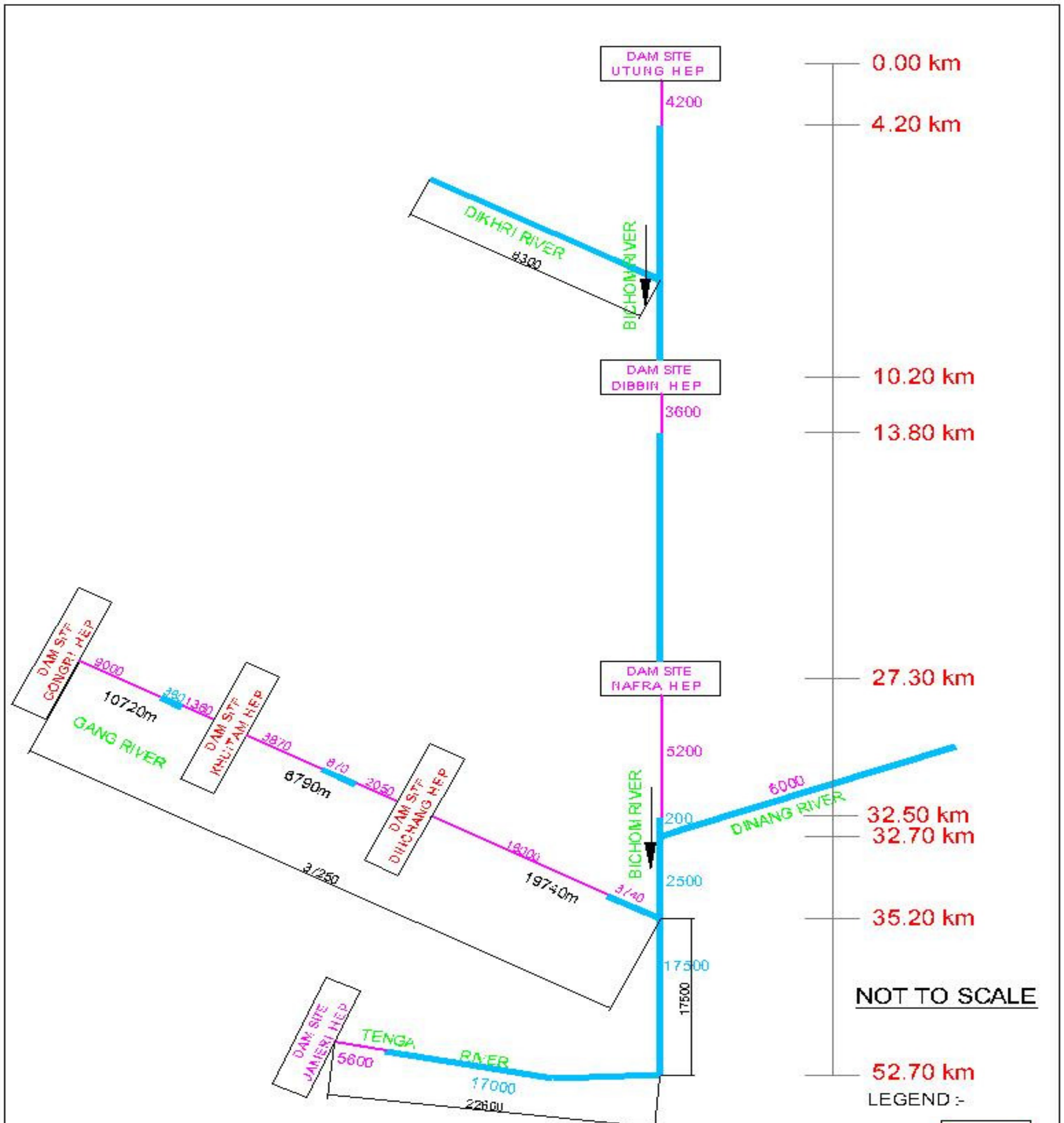


FIGURE - 10.1 DISTANCE BETWEEN DAM SITES OF VARIOUS HYDROELECTRIC PROJECTS (AFTER RECOMMENDATIONS)

MINISTRY OF ENVIRONMENT AND FORESTS, GOVERNMENT OF INDIA

BICHOM RIVER BASIN STUDY

VOLUME - II ANNEXURES

WAPCOS LIMITED
(A GOVERNMENT OF INDIA UNDERTAKING)
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ANNEXURE-I

TERMS OF REFERNCE FOR CONDUCTING THE BASIN STUDY PROPOSAL FOR CONDUCTING THE BASIN STUDY

1. INTRODUCTION

Basin study for any river basin can be defined as its ability to provide optimum support for various natural processes and allow sustainable activities undertaken by its inhabitants. The same is determined in terms of the following:

- Inventorisation and analysis of the existing resource base and its production, consumption and conservation levels.
- Determination of regional ecological fragility/sensitivity based on geo-physical, biological, socio-economic and cultural attributes.
- Review of existing and planned developments as per various developmental plans.
- Evaluation of impacts on various facets of environment due to existing and planned development.

The study involves assessment of stress/load due to varied activities covering, e.g. exploitation of natural resources, industrial development, population growth which lead to varying degree of impacts on various facets of environment. The basin study also envisages a broad framework of environmental action plan to mitigate the adverse impacts on environment which could be in the form of:

- preclusion of an activity
- infrastructure development
- modification in the planned activity
- implementation of set of measures for amelioration of adverse impacts.

Thus, basin study is a step beyond the EIA, as it incorporates an integrated approach to assess the impacts due to various developmental projects.

2. STUDY AREA

The Study Area to be covered as a part of the Basin Study for Bichom Basin is enclosed as Figure-1. The study shall be based on secondary as well as primary data collection .

3. PROJECTS ENVISAGED IN BICHOM BASIN

A total of 11 projects are envisaged in the study area to be covered in the Bichom basin. The list of the same is given in Table-1 and location of these projects is given in the study area map.

TABLE-1
Details of projects in Basin Area to be covered

S. No.	Project Name	Project Proponent	Levels (masl)	Capacity (MW)
1	Bichom HEP	NEEPCO	770 -	600
2	Utung HEP	KSK Dibbin HPL	1475-1325	100
3	Nazong HEP	KSK Dibbin HPL	1325-1220	60
4	Dibbin HEP	KSK Dibbin HPL	1220-1054	130
5	Dimijin HEP	KSK Dibbin HPL	1054-982	20
6	Dikhri HEP	KSK Dibbin HPL	1450-1225	15
7	Dinching HEP	KSK Dibbin HPL	1190-800	90
8	Jameri HEP	KSK Dibbin HPL	1060-800	50
9	Dinan HEP	KSK Dibbin HPL	1450-800	10
10	Nafra HEP	Sew Energy Limited	990-780	100
11	Gongri HEP	Patel Energy Limited	1450-1250	70
	Total			**1245**

The Bichom hydroelectric project being developed by NEEPCO has already been accorded Environmental Clearance by Ministry of Environment and Forests and is currently under construction. However, the other projects listed in Table-1 are in different stages of Environmental Clearance.

4. DATA COLLECTION

In the present study emphasis will be laid on terrestrial and aquatic ecology**.** The estimation of supportive capacity of the basin would involve the preparation of the existing scenario i.e., the preparation of detailed database of the basin. This would be accomplished through the steps outlined in following sections.

4.1 Meteorology

Information on various meteorological aspects is proposed to be collected form India Meteorological Department (IMD) for meteorological stations located within the basin area or in vicinity to the basin boundary. The information on various aspects such as rainfall, temperature, wind, humidity, etc. will be collected.

4.2 Water Resources

As a part of the study, the information on following aspects is proposed to be collected:

- Review of drainage characteristics of the basin, including various surface water bodies like rivers and lakes.
- Data collection and review of past studies/reports/data etc.
- Review of existing water sharing agreements for meeting various need-based existing and future demands viz. municipal, irrigation, power generation and industrial.
- Analysis of all past assessment of the water availability and assessing the water availability, as per updated data for the system as a whole and at

existing ongoing/proposed project locations on annual/monsoon/non-monsoon and monthly basis.
- Estimation of sediment load at various points in the basin based on available secondary data.
- Identification of perennial sources of water and their designated usages

4.3 Water Quality

As a part of the Studies, secondary data in proposal to be collected for water quality in the study area. In addition to above, information on human settlement, sewage generated and mode of collection, conveyance, treatment and disposal of sewage shall also be collected as a part of the present study.

Water quality monitoring is proposed be conducted at 20 locations in the study area. The frequency of sampling shall be once per month for 6 months. The various parameters to be monitored include :

- pH
- Dissolved Oxygen (DO)
- Electrical Conductivity (EC)
- Total Suspended Solids (TSS)
- Total Dissolved Solids (TDS)
- Total Alkalinity
- Total Hardness
- Biochemical Oxygen Demand (BOD)
- Chemical Oxygen Demand (COD)
- Nitrates
- Chlorides
- Sulphates
- Phosphates
- Sodium
- Calcium
- Magnesium
- Potassium
- Iron
- Manganese
- Zinc
- Cadmium
- Lead
- Copper
- Mercury
- Total Chromium
- Total Coliform

4.4 Flora

The following data will be collected from various secondary sources for river Bichom and its tributaries in the basin area:

- Characterization of forest types in the study area and extent of each forest type.
- Information on general vegetation pattern and floral diversity
- Presence of economically important species in the basin area.
- Presence of Rare, Endangered and Threatened floral species as per the categorization Botanical Survey of India's Red Data list in the basin area.
- Presence of endemic floral species found in the basin area, if any shall be assessed as a part of the basin study.
- Location of wild life sanctuaries, national parks, biosphere reserves if any, in the study area

As a part of the Study, it is proposed to conduct primary data collection field studies to collect information on terrestrial ecology. It is proposed to conduct sampling at 20 locations in the study area. The frequency of sampling shall be for two season, one of which shall be rainy season.

The following information is proposed to be covered as a part of the EIA Study:

- Identification of forest type and density, bio-diversity in the study area.
- Preparation of comprehensive checklist of flora (Angiosperms, Gymnosperms, Lichens, Pteridophytes, Bryophytes, Fungi, Algae etc;) with Botanical and local name.
- Importance value index of the dominant vegetation at various sampling locations
- Frequency, Abundance and density of each species of Trees, Shrubs and Herbs at representative sampling sites will be estimated.
- Identification and listing of Rare/Endangered species.
- Identification and listing of plants of genetically, biologically, economical and medicinal importance.
- Major forest produce, if any and dependence of locals on the same in the forests observed in the study area.

In addition, based on the published literature including various research papers, the information on forest types, presence of various species, biological diversity, etc. shall be collected for the study area.

4.6 Fauna

The following data will be collected from various secondary sources for the study area:

- Inventory of Birds (resident, migratory), land animals including mammals, reptiles, amphibians, fishes, etc. reported and surveyed in the basin area shall be prepared.
- Presence of Rare, Endangered and Threatened faunal species as per the categorization of IUCN Red Data list and as per different schedules of Indian Wildlife Protection Act, 1972 in the basin area.
- Presence of endemic faunal species found in the basin area, if any shall be assessed as a part of the Basin Study.
- Existence of barriers and corridors for wild animals, if any in the basin area shall be covered as a part of the study.

- Identification of threats to wildlife in the region
- Presence of National Park, Sanctuary, Biosphere, Reserve Forest etc. in the basin area shall be assessed.

During ecological survey, identification of faunal species will be carried out simultaneously. Indirect observations of mammals will be carried out by identification of tracks, droppings (scal), claw marks and calls, etc. The listing of faunal species by direct observation techniques will be carried out. The detailed list of faunal species will be formulated based on forest records and published literature.

4.7 Aquatic flora and fauna

The following data will be collected from various secondary sources for river Bichom and its tributaries in the basin area:

- presence of major fish species
- inventory of migratory fish species
- migratory routes of various fish species
- presence of major breeding and spawning sites.

As a part of the Study, it is proposed to conduct primary data collection field studies to collect information on aquatic ecology and fisheries. The sampling shall be conducted at 20 locations to identify the aquatic flora and fauna of the water bodies in the study area. The density and diversity of phytoplankton, zooplankton shall be estimated. In addition, primary productivity shall be monitored at various locations to be covered as a part of the study.

The diversion of water for hydropower generation leads to reduction in flows downstream of the dam site up to disposal of tail race outfall. This leads to adverse impacts on riverine ecology. The dam could also act as a barrier for migration of fishes. The data on prevailing fish species will be collected from the Fisheries Department. To augment the existing data, a fisheries survey will be conducted at 20 locations in the study area. The survey will be conducted once per month for six months. The details of the monitoring work proposed to be carried out are as follows:

- Assessment of biotic resources with special reference to primary productivity, zooplanktons, phytoplanktons, benthos, macrophytes, macro-invertebrates and fishes in the study area.
- Population densities and diversities of phytoplanktons, zooplanktons benthos, macrophytes, macro-invertebrates and fish shall be estimated. Diversity indices of these ecological groups will also be calculated separately.
- fish composition
- migratory route of migratory fishes
- Spawning & breeding grounds of fish species, if any, shall be identified

5. IMPACTS DUE TO HYDROPOWER DEVELOPMENT

As mentioned earlier, impacts on terrestrial and aquatic ecology shall only be studied as a part of the present studies. The scenario to be considered for assessment in the present study shall be based on the hydropower projects to be commissioned as listed in Table-1.

The key aspects to be covered are listed as below:

- Modification in hydrologic regime due to diversion of water for hydropower generation.
- Depth of water available in river stretches during lean season, and its assessment of its adequacy vis-à-vis various fish species.
- Length of river stretches with normal flow due to commissioning of various hydroelectric projects due to diversion of flow for hydropower generation.
- Impacts on discharge in river stretches during monsoon and lean seasons due to diversion of flow for hydropower generation.
- Impacts on water users in terms of water availability and quality
- Impacts on aquatic ecology including riverine fisheries as a result of diversion of flow for hydropower generation.
- Assessment of maintaining minimum releases of water during lean season to sustain riverine ecology, maintain water quality and meet water requirements of downstream users.
- Impacts due to loss of forests
- Impacts on rare, endangered and threatened species
- Impacts on economically important plant species
- Impacts due to increased human interferences
- Impacts due to agricultural practices.

7. OUTCOMES OF THE STUDY

The key outcomes of the study shall be to :

- provide sustainable and optimal ways of hydropower development of Bichom river, keeping in view of the environmental setting of the basin.
- assess requirement of environmental flow during lean season with actual flow, depth and velocity at different level.

ANNEXURE-II

Flow series at Dibbin HEP

			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Month	**Days**	Ten Daily	1969-70	1970-71	1971-72	1972-73	1973-74	1974-75	1975-76	1976-77	1977-78	1978-79	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89
June	10	I	77.5	73.3	35.9	40.4	75.5	34.3	74.9	56.8	51.2	7.2	45.2	21.2	152.3	21.6	32.1	88.8	56.1	32.5	47.0	29.9
	10	II	55.7	105.2	44.0	130.0	53.9	77.8	78.7	58.0	76.9	33.7	56.8	42.4	213.8	33.2	48.3	106.7	58.2	58.0	92.1	58.0
	10	III	118.1	122.7	45.4	73.2	62.8	85.8	108.8	50.7	90.8	85.6	86.8	72.0	309.2	140.7	65.6	83.9	77.5	98.4	96.7	99.7
July	10	I	109.8	134.0	59.0	49.0	106.6	89.7	99.3	92.0	73.4	87.3	83.2	79.7	163.7	142.0	76.4	69.3	93.6	117.5	125.9	107.0
	10	II	221.9	127.1	81.0	59.2	217.7	144.6	100.9	100.2	82.4	85.5	120.0	107.8	295.7	93.8	78.6	74.0	118.9	141.8	145.2	141.3
	11	III	218.1	105.0	112.9	108.4	218.5	184.6	50.2	155.6	101.8	162.0	116.7	115.1	316.8	189.2	110.3	83.9	141.7	132.2	197.8	207.9
August	10	I	238.4	120.3	114.8	147.7	195.9	118.8	129.1	96.0	113.9	75.2	133.2	98.5	269.8	150.0	107.3	81.8	192.8	142.7	197.4	192.2
	10	II	159.1	143.7	65.0	131.1	87.8	88.5	127.3	98.2	67.4	90.2	101.3	122.4	200.5	126.7	59.9	106.0	200.0	165.9	126.1	99.9
	11	III	137.4	118.2	81.3	86.8	165.8	92.9	129.5	119.9	48.9	123.0	95.4	107.8	104.8	127.1	82.4	73.3	110.9	118.4	89.8	92.9
September	10	I	77.8	94.6	114.7	88.1	127.1	135.0	112.7	80.1	77.5	119.2	78.5	95.8	151.0	86.3	88.4	87.3	152.1	105.2	136.5	67.8
	10	II	88.3	74.7	71.1	91.0	138.8	151.1	61.7	97.9	76.1	66.1	85.9	87.9	130.5	89.8	67.9	72.3	127.3	102.4	166.8	64.4
	10	III	128.9	80.2	57.0	63.8	114.0	99.0	43.2	128.7	69.0	45.3	67.8	38.6	87.2	61.8	57.8	60.7	125.4	116.0	116.2	65.5
October	10	I	107.1	82.4	37.0	58.8	110.7	97.9	12.8	77.3	52.2	45.4	33.4	30.0	73.2	42.4	48.4	66.7	98.3	55.1	113.1	55.2
	10	II	58.3	56.4	34.7	46.6	94.2	69.7	11.5	49.0	38.4	25.5	34.3	20.8	71.2	50.2	40.1	66.3	111.1	53.1	67.0	43.2
	11	III	71.1	39.3	24.5	33.5	64.3	47.8	10.1	34.5	29.5	17.5	24.7	19.8	44.2	31.4	30.5	61.7	64.8	38.4	51.4	32.6
November	10	I	38.0	35.3	20.4	30.2	42.7	33.1	9.7	26.4	25.5	13.7	17.0	14.1	22.0	25.1	17.9	51.7	34.5	29.6	38.0	26.0
	10	II	35.1	28.2	17.8	24.4	35.3	29.0	11.1	20.5	23.2	11.8	14.4	11.3	16.6	18.2	21.3	33.9	36.2	21.8	27.4	17.2
	10	III	27.9	23.4	15.8	23.0	27.7	23.3	10.9	17.6	20.6	15.5	12.2	8.8	15.3	15.3	21.7	32.6	27.3	12.9	27.5	18.9
			1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**

Month	Days	Ten Daily	1969-70	1970-71	1971-72	1972-73	1973-74	1974-75	1975-76	1976-77	1977-78	1978-79	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89
December	10	I	21.2	20.3	13.6	28.5	24.1	21.0	9.7	16.8	15.6	11.1	9.8	10.1	12.3	14.2	11.8	30.5	18.2	11.6	18.0	11.4
	10	II	18.9	17.1	12.5	17.0	20.9	17.5	8.8	13.7	12.3	9.0	8.5	8.6	10.7	11.6	11.9	21.4	14.7	11.0	19.8	10.2
	11	III	17.9	15.6	12.3	14.6	17.6	15.4	11.3	10.7	10.6	8.7	7.7	7.1	9.1	9.3	10.3	18.3	8.5	8.8	14.0	7.4
January	10	I	18.9	14.4	11.8	13.6	11.7	12.9	9.7	9.7	8.9	9.0	7.6	9.0	7.5	12.6	10.4	12.8	6.2	10.6	16.5	11.3
	10	II	16.1	13.2	11.4	12.6	10.9	11.7	9.2	9.2	7.9	7.2	7.0	8.3	6.7	8.9	10.2	8.6	5.2	14.0	16.3	10.2
	11	III	15.7	12.1	10.7	12.1	10.5	10.2	8.1	8.6	7.2	6.8	6.8	7.1	6.4	7.5	14.5	8.8	5.9	12.6	14.8	9.8
February	10	I	12.5	11.8	9.9	12.2	10.2	9.7	7.0	8.1	6.9	6.3	6.6	6.8	5.5	7.9	16.5	7.5	6.9	9.8	10.1	9.1
	10	II	11.8	10.5	11.8	11.2	10.1	11.1	6.8	9.3	6.7	6.8	7.0	6.3	5.2	9.7	12.9	8.2	7.3	10.2	12.5	9.2
	8	III	11.7	11.2	14.7	14.0	11.1	10.8	6.9	8.6	5.9	8.3	7.1	6.9	5.3	8.0	10.2	6.5	8.3	12.8	11.5	9.5
March	10	I	11.5	11.8	11.3	13.4	9.9	9.7	7.2	9.2	5.7	8.4	5.7	7.1	6.7	6.0	14.8	9.1	8.9	10.2	12.3	9.4
	10	II	12.6	14.0	12.0	13.6	9.8	8.8	7.3	8.8	5.7	8.1	8.9	9.1	9.5	5.5	13.1	10.0	11.0	7.2	9.7	9.7
	11	III	13.7	15.3	13.8	14.1	10.4	11.6	8.2	8.3	5.9	12.1	6.4	7.5	18.4	7.1	9.8	11.0	8.3	8.8	10.6	10.6
April	10	I	16.3	15.1	17.5	18.5	13.2	11.5	15.1	10.1	8.7	12.8	10.8	8.6	12.8	8.7	10.7	12.0	7.1	8.2	10.5	12.0
	10	II	23.1	16.6	15.3	19.3	9.2	12.7	14.5	16.2	10.5	16.1	18.1	9.1	12.4	11.7	10.5	11.3	7.4	11.3	9.8	13.4
	10	III	26.8	20.9	18.3	29.9	11.4	19.1	15.2	18.8	11.7	16.2	17.1	12.2	16.6	17.3	12.1	11.6	10.7	16.0	9.9	16.4
May	10	I	32.0	19.6	24.7	37.1	13.8	19.6	25.8	18.7	10.8	27.7	17.9	40.9	22.0	22.2	17.5	23.1	19.5	18.1	9.8	22.1
	10	II	37.8	33.9	28.5	48.1	20.5	27.4	29.2	38.8	8.5	38.4	21.6	51.2	20.8	32.9	20.8	47.4	26.9	34.4	19.1	30.9
	11	III	45.6	34.5	35.0	62.6	32.2	29.8	40.2	50.4	5.9	33.4	31.4	34.6	15.2	23.2	31.5	37.6	30.8	33.6	22.6	33.2
Mean			64.79	52.00	36.59	46.60	61.02	52.04	39.52	45.37	35.39	37.67	39.24	37.35	78.91	46.36	36.23	44.35	56.63	49.75	58.60	46.26
Max			238.40	143.70	114.80	147.70	218.50	184.60	129.50	155.60	113.90	162.00	133.20	122.40	316.80	189.20	110.30	106.70	200.00	165.90	197.80	207.90
Min.			11.50	10.50	9.90	11.20	9.20	8.80	6.80	8.10	5.70	6.30	5.70	6.30	5.20	5.50	9.80	6.50	5.20	7.20	9.70	7.40

50%, 75% and 90% flows of 90% dependable year (1983-1984) flow at DIBBIN HEP

Month	Ten Daily	Days	A.V. (CumecDay)	A.V. (Cumecs)	Ten Daily	A.V. (Cumecs)	**Rank**	**% Time**
JUN	I 06	10	321.00	32.10	III 07	110.30	1	2.70
	II 06	10	483.00	48.30	I 08	107.30	2	5.41
	III 06	10	656.00	65.60	I 09	88.40	3	8.11
JUL	I 07	10	764.00	76.40	III 08	82.40	4	10.81
	II 07	10	786.00	78.60	II 07	78.60	5	13.51
	III 07	11	1213.30	110.30	I 07	76.40	6	16.22
AUG	I 08	10	1073.00	107.30	II 09	67.90	7	18.92
	II 08	10	599.00	59.90	III 06	65.60	8	21.62
	III 08	11	906.40	82.40	II 08	59.90	9	24.32
SEP	I 09	10	884.00	88.40	III 09	57.80	10	27.03
	II 09	10	679.00	67.90	I 10	48.40	11	29.73
	III 09	10	578.00	57.80	II 06	48.30	12	32.43
OCT	I 10	10	484.00	48.40	II 10	40.10	13	35.14
	II 10	10	401.00	40.10	I 06	32.10	14	37.84
	III 10	11	335.50	30.50	III 05	31.50	15	40.54
NOV	I 11	10	179.00	17.90	III 10	30.50	16	43.24
	II 11	10	213.00	21.30	III 11	21.70	17	45.95
	III 11	10	217.00	21.70	II 11	21.30	18	48.65
DEC	I 12	10	118.00	11.80	II 05	20.80	19	51.35
	II 12	10	119.00	11.90	I 11	17.90	20	54.05
	III 12	11	113.30	10.30	I 05	17.50	21	56.76
JAN	I 01	10	104.00	10.40	I 02	16.50	22	59.46
	II 01	10	102.00	10.20	I 03	14.80	23	62.16
	III 01	11	159.50	14.50	III 01	14.50	24	64.86
FEB	I 02	10	165.00	16.50	II 03	13.10	25	67.57
	II 02	10	129.00	12.90	II 02	12.90	26	70.27
	III 02	8	81.60	10.20	III 04	12.10	27	72.97
MAR	I 03	10	148.00	14.80	II 12	11.90	28	75.68
	II 03	10	131.00	13.10	I 12	11.80	29	78.38
	III 03	11	107.80	9.80	I 04	10.70	30	81.08
APR	I 04	10	107.00	10.70	II 04	10.50	31	83.78
	II 04	10	105.00	10.50	I 01	10.40	32	86.49
	III 04	10	121.00	12.10	III 12	10.30	33	89.19
MAY	I 05	10	175.00	17.50	II 01	10.20	34	91.89
	II 05	10	208.00	20.80	III 02	10.20	35	94.59
	III 05	11	346.50	31.50	III 03	9.80	36	97.30

50%, 75% and 90% flows of 75% dependable year (1978-1979) flow at DIBBIN HEP

Month	Ten Daily	Days	A.V. (CumecDay)	A.V. (Cumecs)	Ten Daily	A.V. (Cumecs)	**Rank**	**% Time**
JUN	I 06	10	72.00	7.20	III 07	162.00	1	2.70
	II 06	10	337.00	33.70	III 08	123.00	2	5.41
	III 06	10	856.00	85.60	I 09	119.20	3	8.11
JUL	I 07	10	873.00	87.30	II 08	90.20	4	10.81
	II 07	10	855.00	85.50	I 07	87.30	5	13.51
	III 07	11	1782.00	162.00	III 06	85.60	6	16.22
AUG	I 08	10	752.00	75.20	II 07	85.50	7	18.92
	II 08	10	902.00	90.20	I 08	75.20	8	21.62
	III 08	11	1353.00	123.00	II 09	66.10	9	24.32
SEP	I 09	10	1192.00	119.20	I 10	45.40	10	27.03
	II 09	10	661.00	66.10	III 09	45.30	11	29.73
	III 09	10	453.00	45.30	II 05	38.40	12	32.43
OCT	I 10	10	454.00	45.40	II 06	33.70	13	35.14
	II 10	10	255.00	25.50	III 05	33.40	14	37.84
	III 10	11	192.50	17.50	I 05	27.70	15	40.54
NOV	I 11	10	137.00	13.70	II 10	25.50	16	43.24
	II 11	10	118.00	11.80	III 10	17.50	17	45.95
	III 11	10	155.00	15.50	III 04	16.20	18	48.65
DEC	I 12	10	111.00	11.10	II 04	16.10	19	51.35
	II 12	10	90.00	9.00	III 11	15.50	20	54.05
	III 12	11	95.70	8.70	I 11	13.70	21	56.76
JAN	I 01	10	90.00	9.00	I 04	12.80	22	59.46
	II 01	10	72.00	7.20	III 03	12.10	23	62.16
	III 01	11	74.80	6.80	II 11	11.80	24	64.86
FEB	I 02	10	63.00	6.30	I 12	11.10	25	67.57
	II 02	10	68.00	6.80	II 12	9.00	26	70.27
	III 02	8	66.40	8.30	I 01	9.00	27	72.97
MAR	I 03	10	84.00	8.40	III 12	8.70	28	75.68
	II 03	10	81.00	8.10	I 03	8.40	29	78.38
	III 03	11	133.10	12.10	III 02	8.30	30	81.08
APR	I 04	10	128.00	12.80	II 03	8.10	31	83.78
	II 04	10	161.00	16.10	I 06	7.20	32	86.49
	III 04	10	162.00	16.20	II 01	7.20	33	89.19
MAY	I 05	10	277.00	27.70	III 01	6.80	34	91.89
	II 05	10	384.00	38.40	II 02	6.80	35	94.59
	III 05	11	367.40	33.40	I 02	6.30	36	97.30

50%, 75% and 90% flows of 50% dependable year (1988-1989) flow at DIBBIN HEP

Month	Ten Daily	Days	A.V. (CumecDay)	A.V. (Cumecs)	Ten Daily	A.V. (Cumecs)	**Rank**	**% Time**
JUN	I 06	10	299.00	29.90	III 07	207.90	1	2.70
	II 06	10	580.00	58.00	I 08	192.20	2	5.41
	III 06	10	997.00	99.70	II 07	141.30	3	8.11
JUL	I 07	10	1070.00	107.00	I 07	107.00	4	10.81
	II 07	10	1413.00	141.30	II 08	99.90	5	13.51
	III 07	11	2286.90	207.90	III 06	99.70	6	16.22
AUG	I 08	10	1922.00	192.20	III 08	92.90	7	18.92
	II 08	10	999.00	99.90	I 09	67.80	8	21.62
	III 08	11	1021.90	92.90	III 09	65.50	9	24.32
SEP	I 09	10	678.00	67.80	II 09	64.40	10	27.03
	II 09	10	644.00	64.40	II 06	58.00	11	29.73
	III 09	10	655.00	65.50	I 10	55.20	12	32.43
OCT	I 10	10	552.00	55.20	II 10	43.20	13	35.14
	II 10	10	432.00	43.20	III 05	33.16	14	37.84
	III 10	11	358.60	32.60	III 10	32.60	15	40.54
NOV	I 11	10	260.00	26.00	II 05	30.85	16	43.24
	II 11	10	172.00	17.20	I 06	29.90	17	45.95
	III 11	10	189.00	18.90	I 11	26.00	18	48.65
DEC	I 12	10	114.00	11.40	I 05	22.15	19	51.35
	II 12	10	102.00	10.20	III 11	18.90	20	54.05
	III 12	11	81.40	7.40	II 11	17.20	21	56.76
JAN	I 01	10	112.53	11.25	III 04	16.41	22	59.46
	II 01	10	102.42	10.24	II 04	13.43	23	62.16
	III 01	11	107.92	9.81	I 04	12.01	24	64.86
FEB	I 02	10	90.63	9.06	I 12	11.40	25	67.57
	II 02	10	92.32	9.23	I 01	11.25	26	70.27
	III 02	8	75.71	9.46	III 03	10.59	27	72.97
MAR	I 03	10	94.16	9.42	II 01	10.24	28	75.68
	II 03	10	97.21	9.72	II 12	10.20	29	78.38
	III 03	11	116.54	10.59	III 01	9.81	30	81.08
APR	I 04	10	120.11	12.01	II 03	9.72	31	83.78
	II 04	10	134.26	13.43	III 02	9.46	32	86.49
	III 04	10	164.11	16.41	I 03	9.42	33	89.19
MAY	I 05	10	221.47	22.15	II 02	9.23	34	91.89
	II 05	10	308.53	30.85	I 02	9.06	35	94.59
	III 05	11	364.79	33.16	III 12	7.40	36	97.30

50%, 75% and 90% average ten daily flow at DIBBIN HEP

Month	Ten Daily	Days	A.V. (CumecDay)	A.V. (Cumecs)	Ten Daily	A.V. (Cumecs)	**Rank**	**% Time**
JUN	I 06	10	526.85	52.69	III 07	151.44	1	2.70
	II 06	10	740.70	74.07	I 08	145.79	2	5.41
	III 06	10	987.20	98.72	II 07	126.88	3	8.11
JUL	I 07	10	979.20	97.92	II 08	118.35	4	10.81
	II 07	10	1268.80	126.88	III 08	105.33	5	13.51
	III 07	11	1665.79	151.44	I 09	103.79	6	16.22
AUG	I 08	10	1457.90	145.79	III 06	98.72	7	18.92
	II 08	10	1183.50	118.35	I 07	97.92	8	21.62
	III 08	11	1158.58	105.33	II 09	95.60	9	24.32
SEP	I 09	10	1037.85	103.79	III 09	81.31	10	27.03
	II 09	10	956.00	95.60	II 06	74.07	11	29.73
	III 09	10	813.05	81.31	I 10	64.87	12	32.43
OCT	I 10	10	648.70	64.87	I 06	52.69	13	35.14
	II 10	10	520.80	52.08	II 10	52.08	14	37.84
	III 10	11	424.38	38.58	III 10	38.58	15	40.54
NOV	I 11	10	275.45	27.55	III 05	33.16	16	43.24
	II 11	10	227.35	22.74	II 05	30.85	17	45.95
	III 11	10	199.10	19.91	I 11	27.55	18	48.65
DEC	I 12	10	164.90	16.49	II 11	22.74	19	51.35
	II 12	10	138.05	13.81	I 05	22.15	20	54.05
	III 12	11	129.36	11.76	III 11	19.91	21	56.76
JAN	I 01	10	112.53	11.25	I 12	16.49	22	59.46
	II 01	10	102.42	10.24	III 04	16.41	23	62.16
	III 01	11	107.92	9.81	II 12	13.81	24	64.86
FEB	I 02	10	90.63	9.06	II 04	13.43	25	67.57
	II 02	10	92.32	9.23	I 04	12.01	26	70.27
	III 02	8	75.71	9.46	III 12	11.76	27	72.97
MAR	I 03	10	94.16	9.42	I 01	11.25	28	75.68
	II 03	10	97.21	9.72	III 03	10.59	29	78.38
	III 03	11	116.54	10.59	II 01	10.24	30	81.08
APR	I 04	10	120.11	12.01	III 01	9.81	31	83.78
	II 04	10	134.26	13.43	II 03	9.72	32	86.49
	III 04	10	164.11	16.41	III 02	9.46	33	89.19
MAY	I 05	10	221.47	22.15	I 03	9.42	34	91.89
	II 05	10	308.53	30.85	II 02	9.23	35	94.59
	III 05	11	364.79	33.16	I 02	9.06	36	97.30

ANNEXURE-III
Flow Series at Gongri HEP

Month	**Days**	Ten Daily	1969-70	1970-71	1971-72	1972-73	1973-74	1974-75	1975-76	1976-77	1977-78	1978-79	1979-80	1980-81
June	10	I	93.34	96.00	94.95	50.46	56.86	116.47	61.23	78.84	80.10	63.89	48.09	53.10
	10	II	75.96	76.32	124.95	61.76	140.74	78.18	93.14	104.05	75.55	93.75	42.93	70.84
	10	III	100.91	135.21	141.67	64.96	97.38	83.26	109.53	116.73	68.76	112.83	73.45	99.94
July	10	I	93.97	128.48	150.90	76.72	73.29	123.57	105.47	123.11	113.07	98.14	123.55	99.45
	10	II	164.90	223.79	144.91	100.07	79.27	203.43	142.42	129.17	110.42	99.16	103.92	120.74
	11	III	142.90	221.74	125.48	126.54	121.21	219.74	201.97	71.65	170.30	103.32	160.78	143.95
August	10	I	104.90	237.74	139.07	140.43	157.05	214.97	140.07	128.00	115.63	150.37	118.67	149.78
	10	II	95.13	170.26	159.98	91.05	156.47	111.64	112.45	146.77	118.52	96.23	96.17	131.83
	11	III	116.41	152.79	136.45	99.24	89.63	168.92	104.77	151.23	142.15	71.59	147.24	117.38
September	10	I	151.04	99.50	115.70	132.36	84.50	153.20	158.51	140.03	98.68	87.84	133.44	103.63
	10	II	107.87	109.86	96.10	96.27	119.23	157.60	164.90	86.43	114.71	105.04	101.06	92.36
	10	III	96.69	146.01	101.92	77.39	85.19	127.66	121.67	69.33	135.47	81.18	65.29	92.48
October	10	I	61.70	125.62	122.85	57.24	81.13	136.77	119.72	34.43	116.80	82.29	63.59	58.08
	10	II	50.13	79.44	87.76	53.74	67.72	117.92	86.18	27.87	72.09	59.29	49.14	50.63
	11	III	41.05	91.74	58.48	41.13	52.65	88.31	69.76	22.93	56.32	51.06	32.40	44.98
November	10	I	33.60	56.99	53.71	35.76	47.71	63.81	52.39	19.63	40.86	42.54	26.56	32.56
	10	II	34.48	53.62	45.19	31.86	40.90	54.52	46.41	20.31	39.15	39.04	23.03	27.82
	10	III	33.66	44.78	39.03	28.94	35.01	45.14	39.57	23.03	31.24	36.52	24.93	24.86
December	10	I	29.73	36.20	35.04	25.48	33.58	40.53	36.13	19.35	30.13	29.83	25.94	20.92
	10	II	27.27	33.11	30.67	24.23	32.28	36.17	31.62	18.50	26.28	24.12	18.85	18.11
	11	III	25.38	31.76	28.48	23.61	27.40	32.48	28.72	21.84	21.58	21.62	17.67	16.93
January	10	I	24.45	30.38	26.74	22.70	25.72	23.08	24.81	20.01	20.02	18.71	19.09	15.87
	10	II	23.15	29.15	25.06	22.60	24.25	21.67	22.93	19.31	18.83	17.35	16.13	15.42

	11	III	23.64	28.66	23.40	21.26	23.40	20.81	20.78	17.47	18.29	15.81	14.94	15.11
Month	**Days**	Ten Daily	1969-70	1970-71	1971-72	1972-73	1973-74	1974-75	1975-76	1976-77	1977-78	1978-79	1979-80	1980-81
February	10	I	22.07	23.93	22.93	19.97	23.77	20.60	19.63	15.47	17.31	15.08	14.16	14.72
	10	II	22.24	23.01	20.88	22.66	21.87	20.08	21.12	14.88	19.01	14.98	14.38	14.76
	8./9	III	21.63	22.75	21.46	26.15	26.15	22.14	22.58	14.93	17.60	13.72	17.17	15.37
March	10	I	21.03	22.26	22.12	21.73	25.15	19.87	19.65	15.56	18.24	13.07	18.54	13.56
	10	II	23.73	24.06	25.83	23.43	26.24	19.95	18.50	15.94	18.99	12.87	14.80	17.12
	11	III	22.94	25.79	27.28	24.00	25.93	20.67	21.84	15.52	17.68	13.49	24.09	15.34
April	10	I	21.98	29.45	27.56	32.53	29.61	24.52	20.63	26.48	18.54	16.90	23.07	21.89
	10	II	25.58	38.65	30.17	28.29	30.59	19.46	25.51	28.06	26.43	20.34	29.52	29.42
	10	III	26.60	43.25	35.14	31.54	45.79	21.92	29.43	24.73	33.93	20.38	26.22	29.64
May	10	I	35.55	49.74	34.68	38.87	55.36	36.78	35.47	43.45	31.99	24.05	37.21	30.81
	10	II	58.23	56.61	48.88	47.77	67.73	36.25	42.15	42.62	52.66	17.53	54.63	36.59
	11	III	48.11	65.03	53.80	51.18	53.42	35.92	43.53	51.85	72.13	32.04	56.87	44.74
Mean			58.39	79.55	68.87	52.05	60.67	76.06	67.09	53.32	60.54	50.44	52.15	52.80
Max			164.90	237.74	159.98	140.43	157.05	219.74	201.97	151.23	170.30	150.37	160.78	149.78
Min.			21.03	22.26	20.88	19.97	21.87	19.46	18.50	14.88	17.31	12.87	14.16	13.56

0%, 75% and 90% flows of 90% dependable year (1978-1979) flow at GONGRI HEP

Month	Ten Daily	Days	A.V. (CumecDay)	A.V. (Cumecs)	Ten Daily	A.V. (Cumecs)	**Rank**	**% Time**
JUN	I 06	10	638.93	63.89	I 08	150.37	1	2.70
	II 06	10	937.55	93.75	III 06	112.83	2	5.41
	III 06	10	1128.26	112.83	II 09	105.04	3	8.11
JUL	I 07	10	981.38	98.14	III 07	103.32	4	10.81
	II 07	10	991.62	99.16	II 07	99.16	5	13.51
	III 07	11	1136.56	103.32	I 07	98.14	6	16.22
AUG	I 08	10	1503.67	150.37	II 08	96.23	7	18.92
	II 08	10	962.33	96.23	II 06	93.75	8	21.62
	III 08	11	787.45	71.59	I 09	87.84	9	24.32
SEP	I 09	10	878.35	87.84	I 10	82.29	10	27.03
	II 09	10	1050.39	105.04	III 09	81.18	11	29.73
	III 09	10	811.83	81.18	III 08	71.59	12	32.43
OCT	I 10	10	822.92	82.29	I 06	63.89	13	35.14
	II 10	10	592.93	59.29	II 10	59.29	14	37.84
	III 10	11	561.66	51.06	III 10	51.06	15	40.54
NOV	I 11	10	425.38	42.54	I 11	42.54	16	43.24
	II 11	10	390.39	39.04	II 11	39.04	17	45.95
	III 11	10	365.25	36.52	III 11	36.52	18	48.65
DEC	I 12	10	298.31	29.83	III 05	32.04	19	51.35
	II 12	10	241.23	24.12	I 12	29.83	20	54.05
	III 12	11	237.87	21.62	II 12	24.12	21	56.76
JAN	I 01	10	187.12	18.71	I 05	24.05	22	59.46
	II 01	10	173.46	17.35	III 12	21.62	23	62.16
	III 01	11	173.96	15.81	III 04	20.38	24	64.86
FEB	I 02	10	150.77	15.08	II 04	20.34	25	67.57
	II 02	10	149.76	14.98	I 01	18.71	26	70.27
	III 02	8	109.76	13.72	II 05	17.53	27	72.97
MAR	I 03	10	130.68	13.07	II 01	17.35	28	75.68
	II 03	10	128.68	12.87	I 04	16.90	29	78.38
	III 03	11	148.36	13.49	III 01	15.81	30	81.08
APR	I 04	10	169.01	16.90	I 02	15.08	31	83.78
	II 04	10	203.38	20.34	II 02	14.98	32	86.49
	III 04	10	203.77	20.38	III 02	13.72	33	89.19
MAY	I 05	10	240.48	24.05	III 03	13.49	34	91.89
	II 05	10	175.28	17.53	I 03	13.07	35	94.59
	III 05	11	352.44	32.04	II 03	12.87	36	97.30

50%, 75% and 90% of 75% dependable year (1979-1980) flow at GONGRI HEP

Month	Ten Daily	Days	A.V. (CumecDay)	A.V. (Cumecs)	Ten Daily	A.V. (Cumecs)	**Rank**	**% Time**
JUN	I 06	10	480.94	48.09	III 07	160.78	1	2.70
	II 06	10	429.28	42.93	III 08	147.24	2	5.41
	III 06	10	734.50	73.45	I 09	133.44	3	8.11
JUL	I 07	10	1235.55	123.55	I 07	123.55	4	10.81
	II 07	10	1039.24	103.92	I 08	118.67	5	13.51
	III 07	11	1768.58	160.78	II 07	103.92	6	16.22
AUG	I 08	10	1186.67	118.67	II 09	101.06	7	18.92
	II 08	10	961.65	96.17	II 08	96.17	8	21.62
	III 08	11	1619.67	147.24	III 06	73.45	9	24.32
SEP	I 09	10	1334.37	133.44	III 09	65.29	10	27.03
	II 09	10	1010.62	101.06	I 10	63.59	11	29.73
	III 09	10	652.92	65.29	III 05	56.87	12	32.43
OCT	I 10	10	635.88	63.59	II 05	54.63	13	35.14
	II 10	10	491.45	49.14	II 10	49.14	14	37.84
	III 10	11	356.40	32.40	I 06	48.09	15	40.54
NOV	I 11	10	265.62	26.56	II 06	42.93	16	43.24
	II 11	10	230.30	23.03	I 05	37.21	17	45.95
	III 11	10	249.30	24.93	III 10	32.40	18	48.65
DEC	I 12	10	259.36	25.94	II 04	29.52	19	51.35
	II 12	10	188.48	18.85	I 11	26.56	20	54.05
	III 12	11	194.34	17.67	III 04	26.22	21	56.76
JAN	I 01	10	190.85	19.09	I 12	25.94	22	59.46
	II 01	10	161.28	16.13	III 11	24.93	23	62.16
	III 01	11	164.37	14.94	III 03	24.09	24	64.86
FEB	I 02	10	141.63	14.16	I 04	23.07	25	67.57
	II 02	10	143.81	14.38	II 11	23.03	26	70.27
	III 02	9	154.53	17.17	I 01	19.09	27	72.97
MAR	I 03	10	185.36	18.54	II 12	18.85	28	75.68
	II 03	10	148.03	14.80	I 03	18.54	29	78.38
	III 03	11	264.98	24.09	III 12	17.67	30	81.08
APR	I 04	10	230.71	23.07	III 02	17.17	31	83.78
	II 04	10	295.17	29.52	II 01	16.13	32	86.49
	III 04	10	262.17	26.22	III 01	14.94	33	89.19
MAY	I 05	10	372.14	37.21	II 03	14.80	34	91.89
	II 05	10	546.25	54.63	II 02	14.38	35	94.59
	III 05	11	625.55	56.87	I 02	14.16	36	97.30

50%, 75% and 90% flows of 50% dependable year (1969-1970) flow at GONGRI HEP

Month	Ten Daily	Days	A.V. (CumecDay)	A.V. (Cumecs)	Ten Daily	A.V. (Cumecs)	**Rank**	**% Time**
JUN	I 06	10	933.43	93.34	II 07	164.90	1	2.70
	II 06	10	759.63	75.96	I 09	151.04	2	5.41
	III 06	10	1009.15	100.91	III 07	142.90	3	8.11
JUL	I 07	10	939.75	93.97	III 08	116.41	4	10.81
	II 07	10	1648.98	164.90	II 09	107.87	5	13.51
	III 07	11	1571.86	142.90	I 08	104.90	6	16.22
AUG	I 08	10	1049.03	104.90	III 06	100.91	7	18.92
	II 08	10	951.33	95.13	III 09	96.69	8	21.62
	III 08	11	1280.52	116.41	II 08	95.13	9	24.32
SEP	I 09	10	1510.36	151.04	I 07	93.97	10	27.03
	II 09	10	1078.74	107.87	I 06	93.34	11	29.73
	III 09	10	966.87	96.69	II 06	75.96	12	32.43
OCT	I 10	10	617.04	61.70	I 10	61.70	13	35.14
	II 10	10	501.32	50.13	II 05	58.23	14	37.84
	III 10	11	451.50	41.05	II 10	50.13	15	40.54
NOV	I 11	10	336.04	33.60	III 05	48.11	16	43.24
	II 11	10	344.77	34.48	III 10	41.05	17	45.95
	III 11	10	336.63	33.66	I 05	35.55	18	48.65
DEC	I 12	10	297.30	29.73	II 11	34.48	19	51.35
	II 12	10	272.69	27.27	III 11	33.66	20	54.05
	III 12	11	279.16	25.38	I 11	33.60	21	56.76
JAN	I 01	10	244.53	24.45	I 12	29.73	22	59.46
	II 01	10	231.55	23.15	II 12	27.27	23	62.16
	III 01	11	260.07	23.64	III 04	26.60	24	64.86
FEB	I 02	10	220.66	22.07	II 04	25.58	25	67.57
	II 02	10	222.36	22.24	III 12	25.38	26	70.27
	III 02	8	173.02	21.63	I 01	24.45	27	72.97
MAR	I 03	10	210.33	21.03	II 03	23.73	28	75.68
	II 03	10	237.32	23.73	III 01	23.64	29	78.38
	III 03	11	252.29	22.94	II 01	23.15	30	81.08
APR	I 04	10	219.80	21.98	III 03	22.94	31	83.78
	II 04	10	255.81	25.58	II 02	22.24	32	86.49
	III 04	10	266.01	26.60	I 02	22.07	33	89.19
MAY	I 05	10	355.47	35.55	I 04	21.98	34	91.89
	II 05	10	582.31	58.23	III 02	21.63	35	94.59
	III 05	11	529.19	48.11	I 03	21.03	36	97.30

50%, 75% and 90% flows for average ten daily flow at GONGRI HEP

Month	Ten Daily	Days	A.V. (CumecDay)	A.V. (Cumecs)	Ten Daily	A.V. (Cumecs)	**Rank**	**% Time**
JUN	I 06	10	744.44	74.44	III 07	150.80	1	2.70
	II 06	10	865.14	86.51	I 08	149.72	2	5.41
	III 06	10	1003.87	100.39	II 07	135.18	3	8.11
JUL	I 07	10	1091.44	109.14	III 08	124.82	4	10.81
	II 07	10	1351.84	135.18	II 08	123.88	5	13.51
	III 07	11	1658.78	150.80	I 09	121.54	6	16.22
AUG	I 08	10	1497.23	149.72	II 09	112.62	7	18.92
	II 08	10	1238.75	123.88	I 07	109.14	8	21.62
	III 08	11	1372.99	124.82	III 06	100.39	9	24.32
SEP	I 09	10	1215.36	121.54	III 09	100.02	10	27.03
	II 09	10	1126.20	112.62	I 10	88.35	11	29.73
	III 09	10	1000.23	100.02	II 06	86.51	12	32.43
OCT	I 10	10	883.52	88.35	I 06	74.44	13	35.14
	II 10	10	668.26	66.83	II 10	66.83	14	37.84
	III 10	11	596.58	54.23	III 10	54.23	15	40.54
NOV	I 11	10	421.76	42.18	III 05	50.72	16	43.24
	II 11	10	380.27	38.03	II 05	46.80	17	45.95
	III 11	10	338.94	33.89	I 11	42.18	18	48.65
DEC	I 12	10	302.38	30.24	II 11	38.03	19	51.35
	II 12	10	267.69	26.77	I 05	37.83	20	54.05
	III 12	11	272.67	24.79	III 11	33.89	21	56.76
JAN	I 01	10	226.32	22.63	III 04	30.71	22	59.46
	II 01	10	213.20	21.32	I 12	30.24	23	62.16
	III 01	11	223.29	20.30	II 04	27.67	24	64.86
FEB	I 02	10	191.36	19.14	II 12	26.77	25	67.57
	II 02	10	191.55	19.15	III 12	24.79	26	70.27
	III 02	8	166.20	20.78	I 04	24.43	27	72.97
MAR	I 03	10	192.32	19.23	I 01	22.63	28	75.68
	II 03	10	201.23	20.12	II 01	21.32	29	78.38
	III 03	11	233.33	21.21	III 03	21.21	30	81.08
APR	I 04	10	244.29	24.43	III 02	20.78	31	83.78
	II 04	10	276.67	27.67	III 01	20.30	32	86.49
	III 04	10	307.12	30.71	II 03	20.12	33	89.19
MAY	I 05	10	378.29	37.83	I 03	19.23	34	91.89
	II 05	10	468.03	46.80	II 02	19.15	35	94.59
	III 05	11	557.89	50.72	I 02	19.14	36	97.30

ANNEXURE-IV
Flow series at JAMERI HEP

Month	**Days**	Ten Daily	1969-70	1970-71	1971-72	1972-73	1973-74	1974-75	1975-76	1976-77	1977-78	1978-79	1979-80	1980-81
June	10	I	47.05	52.31	28.69	14.07	22.54	34.44	9.38	20.70	37.12	35.77	10.00	21.45
	10	II	38.29	41.59	37.76	17.22	55.78	23.12	14.27	27.32	35.01	52.48	8.93	28.61
	10	III	50.86	73.68	42.81	18.12	38.60	24.62	16.78	30.65	31.86	63.16	15.27	40.36
July	10	I	49.36	58.91	52.37	21.49	22.20	44.51	23.83	39.65	42.56	43.82	147.47	51.84
	10	II	86.61	102.61	50.29	28.03	24.01	73.27	32.18	41.60	41.56	44.28	124.04	62.94
	11	III	75.05	101.67	43.55	35.44	36.71	79.15	45.63	23.08	64.10	46.14	191.90	75.04
August	10	I	47.66	75.26	43.32	42.75	50.99	54.15	40.22	34.22	37.00	58.14	112.95	62.62
	10	II	43.22	53.90	49.83	27.72	50.80	28.12	32.28	39.23	37.92	37.21	91.53	55.11
	11	III	52.88	48.37	42.50	30.21	29.10	42.55	30.08	40.43	45.49	27.68	140.15	49.07
September	10	I	67.07	29.11	32.50	33.94	20.47	35.83	45.26	33.74	39.49	34.73	184.94	40.08
	10	II	47.91	32.15	26.99	24.69	28.88	36.86	47.08	20.83	45.90	41.53	140.07	35.72
	10	III	42.94	42.72	28.62	19.85	20.64	29.85	34.74	16.71	54.21	32.10	90.49	35.77
October	10	I	38.17	45.95	48.77	16.79	25.13	31.02	39.98	16.87	45.89	33.77	147.36	28.68
	10	II	31.02	29.05	34.84	15.76	20.98	26.74	28.78	13.65	28.32	24.33	113.89	25.00
	11	III	25.39	33.55	23.22	12.06	16.31	20.03	23.30	11.23	22.13	20.96	75.09	22.21
November	10	I	17.06	21.60	21.67	11.47	15.55	16.04	17.38	8.69	22.14	18.60	60.77	19.80
	10	II	17.51	20.32	18.23	10.21	13.33	13.71	15.39	8.99	21.21	17.07	52.69	16.92
	10	III	17.09	16.97	15.75	9.28	11.41	11.35	13.13	10.19	16.92	15.97	57.03	15.12
December	10	I	12.82	13.26	13.58	9.00	12.08	11.02	12.07	7.13	17.88	12.20	18.32	15.61
	10	II	11.76	12.13	11.88	8.56	11.61	9.83	10.57	6.81	15.59	9.87	13.31	13.51
	11	III	10.94	11.64	11.04	8.33	9.86	8.83	9.60	8.04	12.80	8.85	12.48	12.63
Month	**Days**	Ten Daily	1969-70	1970-71	1971-72	1972-73	1973-74	1974-75	1975-76	1976-77	1977-78	1978-79	1979-80	1980-81
January	10	I	9.83	10.02	10.32	8.00	8.97	8.59	8.50	6.42	13.38	11.86	13.29	13.62

	10	II	9.31	9.62	9.67	7.97	8.46	8.06	7.85	6.20	12.58	11.00	11.23	13.23
	11	III	9.51	9.45	9.03	7.49	8.16	7.75	7.12	5.61	12.22	10.02	10.40	12.96
February	10	I	8.58	9.56	9.08	5.75	7.38	7.17	6.71	5.29	11.71	9.66	9.57	12.76
	10	II	8.64	9.19	8.27	6.52	6.79	6.99	7.22	5.09	12.86	9.60	9.72	12.79
	8./9	III	8.40	9.08	8.50	7.52	8.12	7.71	7.72	5.11	11.91	8.79	11.60	13.32
March	10	I	7.18	7.88	7.28	6.05	6.59	6.42	6.47	4.87	8.90	8.00	9.98	6.25
	10	II	8.10	8.52	8.50	6.53	6.87	6.45	6.09	4.99	9.26	7.88	7.97	7.89
	11	III	7.83	9.13	8.98	6.68	6.79	6.68	7.19	4.85	8.63	8.25	12.97	7.07
April	10	I	7.06	9.17	7.10	6.19	6.29	6.55	5.41	7.52	6.63	6.64	9.16	7.34
	10	II	8.22	12.04	7.77	5.39	6.49	5.20	6.69	7.96	9.46	7.98	11.72	9.87
	10	III	8.54	13.47	9.05	6.00	9.72	5.86	7.72	7.02	12.14	8.00	10.41	9.94
May	10	I	9.22	10.60	7.81	7.07	10.41	6.66	7.10	18.28	9.93	7.00	10.71	8.23
	10	II	15.10	12.06	11.01	8.69	12.74	6.56	8.43	17.93	16.34	5.10	15.73	9.78
	11	III	12.47	13.86	12.12	9.31	10.04	6.50	8.71	21.81	22.39	9.32	16.37	11.95
Mean			26.91	29.73	22.57	14.45	18.35	21.06	18.08	16.35	24.82	22.44	54.99	24.59
Max			86.61	102.61	52.37	42.75	55.78	79.15	47.08	41.60	64.10	63.16	191.90	75.04
Min.			7.06	7.88	7.10	5.39	6.29	5.20	5.41	4.85	6.63	5.10	7.97	6.25

50%, 75% and 90% flows of 90% dependable year (1972-1973) flow at JAMERI HEP

Month	Ten Daily	Days	A.V. (CumecDay)	A.V. (Cumecs)	Ten Daily	A.V. (Cumecs)	**Rank**	**% Time**
JUN	I 06	10	140.71	14.07	I 08	42.75	1	2.70
	II 06	10	172.24	17.22	III 07	35.44	2	5.41
	III 06	10	181.16	18.12	I 09	33.94	3	8.11
JUL	I 07	10	214.89	21.49	III 08	30.21	4	10.81
	II 07	10	280.30	28.03	II 07	28.03	5	13.51
	III 07	11	389.87	35.44	II 08	27.72	6	16.22
AUG	I 08	10	427.48	42.75	II 09	24.69	7	18.92
	II 08	10	277.17	27.72	I 07	21.49	8	21.62
	III 08	11	332.30	30.21	III 09	19.85	9	24.32
SEP	I 09	10	339.45	33.94	III 06	18.12	10	27.03
	II 09	10	246.88	24.69	II 06	17.22	11	29.73
	III 09	10	198.47	19.85	I 10	16.79	12	32.43
OCT	I 10	10	167.87	16.79	II 10	15.76	13	35.14
	II 10	10	157.61	15.76	I 06	14.07	14	37.84
	III 10	11	132.70	12.06	III 10	12.06	15	40.54
NOV	I 11	10	114.66	11.47	I 11	11.47	16	43.24
	II 11	10	102.15	10.21	II 11	10.21	17	45.95
	III 11	10	92.80	9.28	III 05	9.31	18	48.65
DEC	I 12	10	89.97	9.00	III 11	9.28	19	51.35
	II 12	10	85.56	8.56	I 12	9.00	20	54.05
	III 12	11	91.68	8.33	II 05	8.69	21	56.76
JAN	I 01	10	80.00	8.00	II 12	8.56	22	59.46
	II 01	10	79.67	7.97	III 12	8.33	23	62.16
	III 01	11	82.44	7.49	I 01	8.00	24	64.86
FEB	I 02	10	57.45	5.75	II 01	7.97	25	67.57
	II 02	10	65.19	6.52	III 02	7.52	26	70.27
	III 02	8	60.19	7.52	III 01	7.49	27	72.97
MAR	I 03	10	60.52	6.05	I 05	7.07	28	75.68
	II 03	10	65.28	6.53	III 03	6.68	29	78.38
	III 03	11	73.53	6.68	II 03	6.53	30	81.08
APR	I 04	10	61.92	6.19	II 02	6.52	31	83.78
	II 04	10	53.85	5.39	I 04	6.19	32	86.49
	III 04	10	60.02	6.00	I 03	6.05	33	89.19
MAY	I 05	10	70.72	7.07	III 04	6.00	34	91.89
	II 05	10	86.92	8.69	I 02	5.75	35	94.59
	III 05	11	102.45	9.31	II 04	5.39	36	97.30

50%, 75% and 90% flows of 75% dependable year (1975-1976) flow at JAMERI HEP

Month	Ten Daily	Days	A.V. (CumecDay)	A.V. (Cumecs)	Ten Daily	A.V. (Cumecs)	**Rank**	**% Time**
JUN	I 06	10	93.82	9.38	II 09	47.08	1	2.70
	II 06	10	142.73	14.27	III 07	45.63	2	5.41
	III 06	10	167.84	16.78	I 09	45.26	3	8.11
JUL	I 07	10	238.30	23.83	I 08	40.22	4	10.81
	II 07	10	321.79	32.18	I 10	39.98	5	13.51
	III 07	11	501.98	45.63	III 09	34.74	6	16.22
AUG	I 08	10	402.16	40.22	II 08	32.28	7	18.92
	II 08	10	322.84	32.28	II 07	32.18	8	21.62
	III 08	11	330.87	30.08	III 08	30.08	9	24.32
SEP	I 09	10	452.57	45.26	II 10	28.78	10	27.03
	II 09	10	470.83	47.08	I 07	23.83	11	29.73
	III 09	10	347.40	34.74	III 10	23.30	12	32.43
OCT	I 10	10	399.84	39.98	I 11	17.38	13	35.14
	II 10	10	287.82	28.78	III 06	16.78	14	37.84
	III 10	11	256.29	23.30	II 11	15.39	15	40.54
NOV	I 11	10	173.78	17.38	II 06	14.27	16	43.24
	II 11	10	153.95	15.39	III 11	13.13	17	45.95
	III 11	10	131.28	13.13	I 12	12.07	18	48.65
DEC	I 12	10	120.74	12.07	II 12	10.57	19	51.35
	II 12	10	105.69	10.57	III 12	9.60	20	54.05
	III 12	11	105.58	9.60	I 06	9.38	21	56.76
JAN	I 01	10	84.97	8.50	III 05	8.71	22	59.46
	II 01	10	78.53	7.85	I 01	8.50	23	62.16
	III 01	11	78.30	7.12	II 05	8.43	24	64.86
FEB	I 02	10	67.10	6.71	II 01	7.85	25	67.57
	II 02	10	72.22	7.22	III 04	7.72	26	70.27
	III 02	9	69.48	7.72	III 02	7.72	27	72.97
MAR	I 03	10	64.66	6.47	II 02	7.22	28	75.68
	II 03	10	60.87	6.09	III 03	7.19	29	78.38
	III 03	11	79.06	7.19	III 01	7.12	30	81.08
APR	I 04	10	54.13	5.41	I 05	7.10	31	83.78
	II 04	10	66.94	6.69	I 02	6.71	32	86.49
	III 04	10	77.23	7.72	II 04	6.69	33	89.19
MAY	I 05	10	70.96	7.10	I 03	6.47	34	91.89
	II 05	10	84.33	8.43	II 03	6.09	35	94.59
	III 05	11	95.80	8.71	I 04	5.41	36	97.30

50%, 75% and 90% flows of 50% dependable year (1978-1979) flow at JAMERI HEP

Month	Ten Daily	Days	A.V. (CumecDay)	A.V. (Cumecs)	Ten Daily	A.V. (Cumecs)	**Rank**	**% Time**
JUN	I 06	10	357.67	35.77	III 06	63.16	1	2.70
	II 06	10	524.84	52.48	I 08	58.14	2	5.41
	III 06	10	631.59	63.16	II 06	52.48	3	8.11
JUL	I 07	10	438.21	43.82	III 07	46.14	4	10.81
	II 07	10	442.78	44.28	II 07	44.28	5	13.51
	III 07	11	507.50	46.14	I 07	43.82	6	16.22
AUG	I 08	10	581.41	58.14	II 09	41.53	7	18.92
	II 08	10	372.09	37.21	II 08	37.21	8	21.62
	III 08	11	304.47	27.68	I 06	35.77	9	24.32
SEP	I 09	10	347.29	34.73	I 09	34.73	10	27.03
	II 09	10	415.32	41.53	I 10	33.77	11	29.73
	III 09	10	320.99	32.10	III 09	32.10	12	32.43
OCT	I 10	10	337.73	33.77	III 08	27.68	13	35.14
	II 10	10	243.34	24.33	II 10	24.33	14	37.84
	III 10	11	230.51	20.96	III 10	20.96	15	40.54
NOV	I 11	10	185.96	18.60	I 11	18.60	16	43.24
	II 11	10	170.67	17.07	II 11	17.07	17	45.95
	III 11	10	159.67	15.97	III 11	15.97	18	48.65
DEC	I 12	10	122.05	12.20	I 12	12.20	19	51.35
	II 12	10	98.69	9.87	I 01	11.86	20	54.05
	III 12	11	97.32	8.85	II 01	11.00	21	56.76
JAN	I 01	10	118.61	11.86	III 01	10.02	22	59.46
	II 01	10	109.95	11.00	II 12	9.87	23	62.16
	III 01	11	110.27	10.02	I 02	9.66	24	64.86
FEB	I 02	10	96.62	9.66	II 02	9.60	25	67.57
	II 02	10	95.97	9.60	III 05	9.32	26	70.27
	III 02	8	70.33	8.79	III 12	8.85	27	72.97
MAR	I 03	10	79.98	8.00	III 02	8.79	28	75.68
	II 03	10	78.76	7.88	III 03	8.25	29	78.38
	III 03	11	90.80	8.25	III 04	8.00	30	81.08
APR	I 04	10	66.35	6.64	I 03	8.00	31	83.78
	II 04	10	79.85	7.98	II 04	7.98	32	86.49
	III 04	10	80.00	8.00	II 03	7.88	33	89.19
MAY	I 05	10	69.97	7.00	I 05	7.00	34	91.89
	II 05	10	51.00	5.10	I 04	6.64	35	94.59
	III 05	11	102.54	9.32	II 05	5.10	36	97.30

50%, 75% and 90% flows of average ten daily flow series at JAMERI HEP

Month	Ten Daily	Days	A.V. (CumecDay)	A.V. (Cumecs)	Ten Daily	A.V. (Cumecs)	**Rank**	**% Time**
JUN	I 06	10	277.92	27.79	III 07	68.12	1	2.70
	II 06	10	316.97	31.70	II 07	59.28	2	5.41
	III 06	10	372.31	37.23	I 08	54.94	3	8.11
JUL	I 07	10	498.34	49.83	I 07	49.83	4	10.81
	II 07	10	592.85	59.28	I 09	49.76	5	13.51
	III 07	11	749.34	68.12	III 08	48.21	6	16.22
AUG	I 08	10	549.39	54.94	II 08	45.57	7	18.92
	II 08	10	455.74	45.57	II 09	44.05	8	21.62
	III 08	11	530.30	48.21	I 10	43.20	9	24.32
SEP	I 09	10	497.64	49.76	III 09	37.39	10	27.03
	II 09	10	440.50	44.05	III 06	37.23	11	29.73
	III 09	10	373.86	37.39	II 10	32.70	12	32.43
OCT	I 10	10	431.99	43.20	II 06	31.70	13	35.14
	II 10	10	326.98	32.70	I 06	27.79	14	37.84
	III 10	11	280.02	25.46	III 10	25.46	15	40.54
NOV	I 11	10	208.97	20.90	I 11	20.90	16	43.24
	II 11	10	187.98	18.80	II 11	18.80	17	45.95
	III 11	10	175.18	17.52	III 11	17.52	18	48.65
DEC	I 12	10	129.14	12.91	I 12	12.91	19	51.35
	II 12	10	112.87	11.29	III 05	12.91	20	54.05
	III 12	11	114.62	10.42	II 05	11.62	21	56.76
JAN	I 01	10	102.33	10.23	II 12	11.29	22	59.46
	II 01	10	95.98	9.60	III 12	10.42	23	62.16
	III 01	11	100.59	9.14	I 01	10.23	24	64.86
FEB	I 02	10	86.01	8.60	II 01	9.60	25	67.57
	II 02	10	86.40	8.64	I 05	9.42	26	70.27
	III 02	8	74.18	9.27	III 02	9.27	27	72.97
MAR	I 03	10	71.56	7.16	III 01	9.14	28	75.68
	II 03	10	74.20	7.42	III 04	8.99	29	78.38
	III 03	11	87.13	7.92	II 02	8.64	30	81.08
APR	I 04	10	70.88	7.09	I 02	8.60	31	83.78
	II 04	10	82.32	8.23	II 04	8.23	32	86.49
	III 04	10	89.90	8.99	III 03	7.92	33	89.19
MAY	I 05	10	94.18	9.42	II 03	7.42	34	91.89
	II 05	10	116.23	11.62	I 03	7.16	35	94.59
	III 05	11	141.96	12.91	I 04	7.09	36	97.30

ANNEXURE-V
Drinking water quality standards

Characteristics	***Acceptable**	****Cause for Rejection**
Turbidity (units on JTU scale)	2.5	10
Colour (Units on platinum cobalt scale)	5.0	25
Taste and Odour	Unobjectionable	Unobjectionable
pH	7.0 to 8.5	<6.5 or >9.2
Total Dissolved Solids (mg/l)	500	1500
Total hardness (mg/l) (as $CaCO_3$)	200	600
Chlorides as CD (mg/l)	200	1000
Sulphates (as SO_4)	200	400
Fluorides (as F) (mg/l)	1.0	1.5
Nitrates (as NO_3) (mg/l)	45	45
Calcium (as Ca) (mg/l)	75	200
Magnesium (as Mg) (mg/l) If there are 250 mg/l of sulphates, Mg content can be increased to a maximum of 125 mg/l with the reduction of sulphates at the rate of 1 unit per every 2.5 units of sulphates	30	150
Iron (as Fe) (mg/l)	0.1	1.0
Manganese (as Mn) (mg/l)	0.05	0.5
Copper (as Cu) (mg/l)	0.05	1.5
Zinc (as Zn) (mg/l)	5.0	15.0
Phenolic compounds (as phenol) (mg/l)	0.001	0.002
Anionic detergents (as MBAS) (mg/l)	0.2	1.0
Mineral Oil (mg/l)	0.01	0.3
Toxic materials		
Arsenic (as As) (mg/l)	0.05	0.05
Cadmium (as Cd) (mg/l)	0.01	0.01
Chromium (as hexaalent Cr) (mg/l)	0.05	0.05
Cyanides (as CN) (mg/l)	0.05	0.05
Lead (as Pb) (mg/l)	0.1	0.1
Selenium (as Se) (mg/l)	0.01	0.01
Mercury (total as Hg) (mg/l)	0.001	0.001
Polynuclear aromatic hydrocarbons (PAH)	0.2 µg/l	0.2 µg/l

Notes :-

*1. The figures indicated under the column `Acceptable' are the limits upto which water is generally acceptable to the consumers

**2 Figures in excess of those mentioned under `Acceptable render the water not acceptable, but still may be tolerated in the absence of alternative and better source but upto the limits indicated under column "Cause for Rejection" above which are supply will have to be rejected.

ANNEXURE-VI

DENSITY OF PHYTOPLANKTONS AT VARIOUS SAMPLING SITES

Density of phytoplankton (l^{-1}) in Jameri, Dibbin and Dimijin in April 2009

Class	Taxa	Jameri			Dibbin			Dimijin		
		S1	S2	S3	S1	S2	S3	S1	S2	S3
Bacillariophyceae	*Cymbella cistula*	-	-	-	1	1	-	-	-	-
	Fragillaria sp. sp.	-	-	-	-	-	-	2	1	1
	Mastogloia denseii	-	-	-	-	-	-	-	3	-
	Neidium affinis	-	-	-	-	-	-	1	-	1
Chlorophyceae	*Actinastrum hantzschii*	5	4	6	2	1	1	-	-	-
	Closterium abruptum	-	-	-	-	-	-	1	2	-
	Penium simplex	2	1	1	-	-	-	-	-	-
Cyanophyceae	*Anabaena oscillarioides*	-	-	-	-	-	-	-	1	-
	Gloeothece sp.	-	1	-	-	-	-	-	-	-
	Lyngbya birgei	1	-	-	-	-	-	-	1	-
	Oscillatoria acuminata	-	-	-	-	-	-	1	-	1
	Unidentified	-	-	-	-	-	-	-	1	-
	Spirulina caldaria	1	1	-	-	-	-	-	-	-
	Synechocystis sp.	12	10	11	-	1	1	-	-	-
Total		22	17	18	3	3	2	5	9	3

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Density of phytoplankton (l^{-1}) in Dinchang, Nafra and Dikhri in April 2009

Class	Taxa	Dinchang			Nafra			Dikhri		
		S1	S2	S3	S1	S2	S3	S1	S2	S3
Bacillariophyceae	*Acnanthes* sp.	-	-	-	-	-	-	1	-	-
	Cymbella cistula	1	-	-	-	1	1	-	1	-
	Gomphonema geminatum	-	-	-	-	-	-	-	-	1
Chlorophyceae	*Actinastrum hantzschii*	1	1	1	-	-	-	1	2	1
	Closteriopsis longissima	-	1	-	-	-	-	-	-	-
	Closterium abruptum	1	-	-	1	-	1	-	-	-
	Chlorella vulgaris	2	1	5	-	1	-	-	-	-
	Penium simplex	-	1	-	-	-	-	-	-	-
Cyanophyceae	*Anabaena oscillarioides*	-	-	-	1	-	-	-	-	-
	Oscillatoria acuminata	1	1	-	-	2	-	-	-	-
	Unidentified	-	1	-	-	1	-	-	-	-
	Synechocystis sp.	-	1	-	-	-	-	-	1	-
Total		6	7	6	2	5	2	2	4	2

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Density of phytoplankton (l^{-1}) in Dinan and Gongri in April 2009

Class	Taxa	Dinan			Gongri		
		S1	S2	S3	S1	S2	S3
Bacillariophyceae	*Acnanthes* sp.	5	-	-	-	-	-
	Ceratoneis arcus	-	-	-	3	-	5
	Cymbella cistula	-	3	3	-	2	-
	Fragillaria sp. sp.	-	-	-	2	-	-
	Gomphonema geminatum	2	-	-	-	4	6
	Mastogloia denseii	-	-	-	2	-	-
	Neidium affinis	2	-	-	-	2	-
	Navicula radiosa	-	-	-	2	1	3
	Melosira ambigua	-	4	3	2	-	-
	Tabellaria fenestrata	-	-	-	-	7	-
	Surrirella sp.	-	-	-	1	-	-
	Atthiya zachariasi	-	-	-	-	1	-
Chlorophyceae	*Closterium abruptum*	1	-	2	-	-	-
	Chlorella vulgaris	-	2	-	-	-	-
Cyanophyceae	*Anabaena oscillarioides*	1	-	-	-	-	1
	Gloeothece sp.	-	-	-	1	-	-
	Lyngbya birgei	-	-	-	1	-	-
	Microcystis sp.	-	-	-	1	-	-
	Oscillatoria acuminata	-	2	-	-	1	-
	Unidentified	-	1	-	-	-	-
Total		11	12	8	15	18	15

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Density of phytoplankton (l^{-1}) in Utung and Nazong in April 2009

Class	Genus	Utung			Nazong		
		S1	S2	S3	S1	S2	S3
Bacillariophyceae	*Acnanthes* sp.	-	1	-	-	-	-
	Ceratoneis arcus	-	2	-	-	-	-
	Cymbella cistula	2	2	-	-	-	-
	Fragillaria sp.	-	-	-	5	5	3
	Gomphonema geminatum	-	-	4	-	-	-
	Mastogloia denseii	-	-	-	-	2	-
	Neidium affinis	-	-	-	3	-	3
	Navicula radiosa	-	-	4	-	-	-
	Melosira ambigua	2	-	-	-	-	-
	Tabellaria fenestrata	-	-	-	2	1	2
	Atthiya zachariasi	-	-	-	-	3	-
	Amphora ovalis	-	-	-	1	-	1
Chlorophyceae	*Actinastrum hantzschii*	2	1	3	-	-	-
	Closteriopsis longissima	-	2	-	-	-	-
	Closterium abruptum	1	-	-	1	2	-
	Chlorella sp.	4	3	5	-	-	-
	Penium simplex	-	3	-	-	-	-
Cyanophyceae	*Anabaena oscillarioides*	-	-	-	-	1	-
	Lyngbya birgei	-	-	-	-	1	-
	Oscillatoria acuminata	3	1	-	1	-	1
	Scytonema sp.	-	1	-	-	1	-

Class	Genus	Utung			Nazong		
		S1	S2	S3	S1	S2	S3
	Synechocystis sp.	-	1	-	-	-	-
Total		14	17	16	13	16	10

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Density of phytoplankton (l^{-1}) in Jameri, Dibbin and Dimijin in May 2009

Class	Taxa	Jameri			Dibbin			Dimijin		
		S1	S2	S3	S1	S2	S3	S1	S2	S3
Bacillariophyceae	*Cymbella cistula*	7	-	11	1	1	-	-	-	-
	Fragillaria sp. sp.	-	7	-	-	-	-	1	-	-
	Gomphonema geminatum	4	-	-	-	-	-	-	-	-
	Mastogloia denseii	-	5	5	-	2	-	-	-	-
	Navicula radiosa	5	-	-	-	-	-	-	1	-
	Neidium affinis	-	2	-	-	-	-	-	-	-
	Synedra sp.	2	1	6	-	-	-	-	-	-
Chlorophyceae	*Chlorella vulgaris*	5	-	1	1	1	1	-	1	-
	Closteriopsis longissima	-	-	4	-	-	-	-	-	-
	Closterium abruptum	1	-	-	-	1	-	2	2	1
	Cylindrocystis sp.	1	-	-	-	-	-	-	-	-
	Penium simplex	-	5	-	-	-	-	-	-	-
	Spirogyra varians	-	-	6	-	-	-	-	-	-
	Triploceros sp.	1	-	-	-	-	-	-	-	-
	Unidentified-2	2	-	-	-	-	-	-	-	-
Cyanophyceae	*Lyngbya birgei*	1	-	1	-	1	-	1	-	-
	Oscillatoria acuminata	1	-	1	-	-	-	-	-	-
	Phormidium ambiguum	-	-	2	-	-	-	-	-	-
	Unidentified	-	-	3	-	1	-	-	2	-
Total		30	20	40	2	7	1	4	6	1

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Density of phytoplankton (l^{-1}) in Dinchang, Nafra and Dikhri in May 2009

Class	Taxa	Dinchang			Nafra			Dikhri		
		S1	S2	S3	S1	S2	S3	S1	S2	S3
Bacillariophyceae	*Cocconeis placentula*	-	-	-	-	1	1	-	-	-
	Cymbella cistula	-	-	-	-	-	-	2	-	1
	Fragillaria sp.	1	1	1	-	1	-	-	-	-
	Mastogloia denseii	-	-	-	-	-	-	-	1	2
	Navicula radiosa	2	-	1	-	-	-	-	-	-
	Neidium affinis	-	-	-	-	1	-	-	-	-
	Synedra sp.	-	-	-	-	1	-	-	-	-
Chlorophyceae	*Chlorella vulgaris*	-	-	-	-	-	-	3	2	2
	Closteriopsis longissima	-	-	-	1	-	-	-	-	-
	Closterium abruptum	-	-	-	-	-	-	-	3	-
	Cylindrocystis sp.	-	-	-	-	-	1	-	-	-
	Spirogyra varians	-	-	-	1	-	-	-	-	-
	***Unidentified**-2*	-	-	-	-	1	-	-	-	-
Cyanophyceae	*Lyngbya birgei*	-	1	-	-	-	-	-	-	-
	Oscillatoria acuminata	-	1	-	-	-	-	-	-	-
	Unidentified	1	-	-	-	2	-	-	-	-

Class	Taxa	Dinchang			Nafra			Dikhri		
		S1	S2	S3	S1	S2	S3	S1	S2	S3
Total		4	3	2	2	7	2	5	6	5

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Density of phytoplankton (l^{-1}) in Dinan and Gongri in May 2009

Class	Taxa	Dinan			Gongri		
		S1	S2	S3	S1	S2	S3
Bacillariophyceae	*Cocconeis placentula*	-	-	-	-	-	-
	Cymbella cistula	3	-	2	6	-	2
	Fragillaria sp. sp.	-	2	-	-	3	-
	Gomphonema geminatum	1	-	-	4	-	-
	Mastogloia denseii	-	3	3	-	4	4
	Navicula radiosa	5	-	-	5	-	-
	Neidium affinis	-	1	-	-	1	-
	Synedra sp.	2	1	2	2	1	6
	Pinnularia nobilis	-	-	-	-	-	-
	Melosira ambigua	2	-	1	6	-	8
	Tabellaria fenestrata	-	7	-	-	7	-
	Surrirella sp.	1	-	-	5	-	-
	Atthiya zachariasi	1	-	-	-	4	4
	Amphora ovalis	2	-	-	5	-	-
Chlorophyceae	*Chlorella vulgaris*	-	-	-	-	1	-
	Closteriopsis longissima	-	-	-	-	-	3
	Closterium abruptum	-	-	-	1	-	-
	Cylindrocystis sp.	-	-	-	1	-	-
	Penium simplex	-	-	-	-	5	-
	Spirogyra varians	-	-	-	-	-	6
	Triploceros sp.	1	-	-	1	-	-
	***Unidentified**-2*	-	-	-	2	-	-
Cyanophyceae	*Lyngbya birgei*	-	-	-	1	-	1
	Oscillatoria acuminata	-	-	-	1	-	1
	Phormidium ambiguum	-	-	-	-	-	2
	Unidentified	-	-	-	-	-	-
Total		18	14	8	40	26	37

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Density of phytoplankton (l^{-1}) in Utung and Nazong in May 2009

Class	Genus	Utung			Nazong		
		S1	S2	S3	S1	S2	S3
Bacillariophyceae	*Cocconeis*	-	-	5	-	-	5
	Cymbella cistula	-	-	-	4	2	-
	Fragillaria sp.	2	-	2	-	-	2
	Mastogloia denseii	-	-	1	-	3	-
	Navicula	-	1	-	-	-	-
	Neidium affinis	-	2	-	-	-	1
	Synedra	-	-	-	-	-	2
	Pinnularia	-	-	-	-	-	1
	Melosira ambigua	-	-	-	4	4	1
	Tabellaria fenestrata	3	5	-	-	-	-
	Atthiya zachariasi	-	-	-	-	3	-

Class	Genus	Utung			Nazong		
		S1	S2	S3	S1	S2	S3
	Amphora ovalis	-	3	-	-	-	-
Chlorophyceae	*Closterium abruptum*	1	2	1	-	2	-
Cyanophyceae	*Lyngbya birgei*	1	-	-	-	3	-
	Scytonema sp.	-	2	-	-	2	-
Total		7	15	9	8	19	12

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Density of phytoplankton (l^{-1}) in Jameri, Dibbin and Dimijin in June 2009

Class	Taxa	Jameri			Dibbin			Dimijin		
		S1	S2	S3	S1	S2	S3	S1	S2	S3
Bacillariophyceae	*Cymbella cistula*	-	-	-	1	1	-	-	-	-
	Neidium affinis	-	-	-	-	-	-	1	-	1
Chlorophyceae	*Actinastrum hantzschii*	5	4	6	2	1	1	-	-	-
	Closteriopsis longissima	1	-	-	-	-	-	-	-	-
	Closterium abruptum	-	-	-	-	-	-	1	2	-
	Penium simplex	2	1	1	-	-	-	-	-	-
Cyanophyceae	*Anabaena oscillarioides*	-	-	-	-	-	-	-	1	-
	Gloeothece sp.	-	1	-	-	-	-	-	-	-
	Lyngbya birgei	1	-	-	-	-	-	-	1	-
	Spirulina caldaria	1	1	-	-	-	-	-	-	-
	Synechocystis sp.	12	1	11	-	1	1	-	-	-
Total		22	8	18	3	3	2	2	4	1

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Density of phytoplankton (l^{-1}) in Dinchang, Nafra and Dikhri in June 2009

Class	Taxa	Dinchang			Nafra			Dikhri		
		S1	S2	S3	S1	S2	S3	S1	S2	S3
Bacillariophyceae	*Acnanthes* sp.	-	-	-	-	-	-	1	-	-
	Cymbella cistula	1	-	-	-	1	1	-	1	-
Chlorophyceae	*Actinastrum hantzschii*	1	1	1	-	-	-	1	2	1
	Closteriopsis longissima	-	1	-	-	-	-	-	-	-
	Closterium abruptum	1	-	-	1	-	1	-	-	-
	Chlorella vulgaris	2	1	5	-	1	-	-	-	-
	Penium simplex	-	1	-	-	-	-	-	-	-
Cyanophyceae	*Anabaena oscillarioides*	-	-	-	1	-	-	-	-	-
	Synechocystis sp.	-	1	-	-	-	-	-	1	-
Total		5	5	6	2	2	2	2	4	1

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Density of phytoplankton (l^{-1}) in Dinan and Gongri in June 2009

Class	Taxa	Dinan			Gongri		
		S1	S2	S3	S1	S2	S3
Bacillariophyceae	*Ceratoneis arcus*	-	-	-	3	-	5
	Cymbella cistula	-	-	-	-	2	-
	Neidium affinis	6	-	5	2	-	-
	Navicula radiosa	1	2	-	-	4	6
	Pinnularia nobilis	-	-	2	2	-	-
	Melosira ambigua	-	-	-	-	2	-

Class	Taxa	Dinan			Gongri		
		S1	S2	S3	S1	S2	S3
	Tabellaria fenestrata	-	1	-	2	1	3
	Atthiya zachariasi	-	1	-	2	-	-
	Amphora ovalis	-	-	-	-	7	-
Chlorophyceae	*Actinastrum hantzschii*	-	-	-	1	-	-
	Closteriopsis longissima	-	-	-	-	1	-
	Closterium abruptum	1	2	-	-	-	-
Cyanophyceae	*Anabaena oscillarioides*	-	1	-	-	-	-
	Lyngbya birgei	-	1	-	-	-	-
	Spirulina caldaria	-	-	-	-	-	1
	Synechoccus sp.	-	-	-	1	-	-
	Synechocystis sp.	-	-	-	1	-	-
Total		8	8	7	14	17	15

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Density of phytoplankton (l^{-1}) in Utung and Nazong in June 2009

Class	Genus	Utung			Nazong		
		S1	S2	S3	S1	S2	S3
Bacillariophyceae	*Acnanthes*	-	-	-	-	-	6
	Cymbella cistula	-	-	-	4	5	2
	Neidium affinis	-	-	-	-	-	2
	Navicula radiosa	-	-	-	2	-	-
	Pinnularia	-	-	-	-	1	-
	Melosira ambigua	2	1	1	-	-	1
	Surrirella	-	1	-	-	-	-
	Atthiya zachariasi	1	-	-	-	-	-
	Amphora ovalis	1	1	-	-	-	-
Chlorophyceae	*Actinastrum hantzschii*	3	4	6	2	1	1
	Closteriopsis longissima	1	-	-	-	-	-
	Penium simplex	2	1	1	-	-	-
Cyanophyceae	*Gloeothece* sp.	-	1	-	-	-	-
	Lyngbya birgei	1	-	-	-	-	-
	Spirulina	1	1	-	-	-	-
	Synechocystis sp.	12	1	11	-	1	1
Total		24	11	19	8	8	13

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Density of phytoplankton (l^{-1}) in Jameri, Dibbin and Dimijin in July 2009

Class	Taxa	Jameri			Dibbin			Dimijin		
		S1	S2	S3	S1	S2	S3	S1	S2	S3
Bacillariophyceae	*Acnanthes* sp.	-	-	-	-	-	5	-	-	-
	Ceratoneis arcus	-	-	4	-	-	-	-	-	-
	Cymbella cistula	-	-	-	2	3	-	-	-	-
	Unidentifed-1	-	-	-	-	-	2	2	1	1
	Unidentified-2	-	-	3	-	1	-	-	-	-
	Melosira ambigua	-	2	-	3	2	1	-	-	-
	Tabellaria fenestrata	-	-	1	-	-	-	2	1	1
	Atthiya zachariasi	-	-	-	-	-	-	-	3	-
	Amphora ovalis	-	-	-	1	-	-	1	-	1

Class	Taxa	Jameri			Dibbin			Dimijin		
		S1	S2	S3	S1	S2	S3	S1	S2	S3
Chlorophyceae	*Closteriopsis longissima*	3	-	-	-	-	-	-	-	-
	Closterium abruptum	-	-	-	-	-	-	1	2	-
Cyanophyceae	*Anabaena oscillarioides*	-	-	-	-	-	-	-	1	-
	Gloeothece sp.	-	4	-	-	-	-	-	-	-
	Unidentified-3	2	-	-	-	-	-	-	1	-
Total		5	6	8	6	6	8	6	9	3

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Density of phytoplankton (l^{-1}) in Dinchang, Nafra and Dikhri in July 2009

Class	Taxa	Dinchang			Nafra			Dikhri		
		S1	S2	S3	S1	S2	S3	S1	S2	S3
Bacillariophyceae	*Acnanthes* sp.	-	-	4	-	-	-	2	-	-
	Cymbella cistula	1	-	-	-	1	1	-	3	-
	Unidentified-1	-	-	2	-	-	-	3	-	3
	Melosira ambigua	3	-	-	-	1	1	-	2	-
	Unidentified-2	-	-	3	-	-	-	-	-	4
Chlorophyceae	*Closteriopsis longissima*	-	4	-	-	-	-	-	-	-
	Closterium abruptum	2	-	-	1	-	1	-	-	-
Cyanophyceae	*Anabaena oscillarioides*	-	-	-	1	-	-	-	-	-
Total		6	4	9	2	2	3	5	5	7

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Density of phytoplankton (l^{-1}) in Dinan and Gongri in July 2009

Class	Taxa	Dinan			Gongri		
		S1	S2	S3	S1	S2	S3
Bacillariophyceae	*Acnanthes* sp.	5	-	-	-	-	-
	Ceratoneis arcus	-	-	-	3	-	5
	Cymbella cistula	-	3	3	-	2	-
	Fragillaria sp.	-	-	-	2	-	-
	Unidentified-1	-	-	-	2	1	3
	Melosira ambigua	-	4	3	2	-	-
	Tabellaria fenestrata	-	-	-	-	7	-
	Unidentified-2	-	-	-	1	-	-
	Atthiya zachariasi	-	-	-	-	1	-
Chlorophyceae	*Closterium abruptum*	1	-	2	-	-	-
Cyanophyceae	*Anabaena oscillarioides*	1	-	-	-	-	1
	Gloeothece sp.	-	-	-	1	-	-
	Lyngbya birgei	-	-	-	1	-	-
Total		7	7	8	12	11	9

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Density of phytoplankton (l^{-1}) in Utung and Nazong in July 2009

Class	Taxa	Utung			Nazong		
		S1	S2	S3	S1	S2	S3
Bacillariophyceae	*Acnanthes* sp.	-	1	-	-	-	-
	Ceratoneis arcus	-	2	-	-	-	-
	Cymbella cistula	2	2	-	-	-	-
	Fragillaria sp.	-	-	-	5	5	3

Class	**Taxa**	**Utung**			**Nazong**		
		S1	**S2**	**S3**	**S1**	**S2**	**S3**
	Navicula radiosa	-	-	4	-	-	-
	Melosira ambigua	2	-	-	-	-	-
	Tabellaria fenestrata	-	-	-	2	1	2
	Atthiya zachariasi	-	-	-	-	3	-
	Amphora ovalis	-	-	-	1	-	1
Chlorophyceae	*Closteriopsis longissima*	-	2	-	-	-	-
	Closterium abruptum	1	-	-	1	2	-
Cyanophyceae	*Anabaena oscillarioides*	-	-	-	-	1	-
	Lyngbya birgei	-	-	-	-	1	-
Total		5	7	4	9	13	6

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Density of phytoplankton (l^{-1}) in Jameri, Dibbin and Dimijin in August 2009

Class	**Taxa**	**Jameri**			**Dibbin**			**Dimijin**		
		S1	**S2**	**S3**	**S1**	**S2**	**S3**	**S1**	**S2**	**S3**
Bacillariophyceae	*Cymbella cistula*	2	-	3	1	1	-	-	-	-
	Fragillaria sp.	-	3	-	-	-	-	1	-	-
	Synedra sp.	2	1	6	-	-	1	-	-	-
	Melosira ambigua	3	-	1	1	1	1	-	-	-
	Tabellaria fenestrata	-	4	-	-	-	-	1	-	-
	Unidentified-1	4	-	-	-	-	-	-	-	-
	Unidentified-2	-	5	2	-	2	-	-	-	-
	Amphora ovalis	2	-	-	-	-	-	-	1	-
Chlorophyceae	*Closterium abruptum*	1	-	-	-	1	-	2	2	3
	Cylindrocystis sp.	1	-	-	-	-	-	-	-	-
Total		15	13	12	2	5	2	4	3	3

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Density of phytoplankton (l^{-1}) in Dinchang, Nafra and Dikhri in August 2009

Class	**Taxa**	**Dinchang**			**Nafra**			**Dikhri**		
		S1	**S2**	**S3**	**S1**	**S2**	**S3**	**S1**	**S2**	**S3**
Bacillariophyceae	*Cymbella cistula*	-	-	-	-	-	-	2	-	1
	Fragillaria sp.	1	1	1	-	1	-	-	-	-
	Synedra sp.	-	-	-	-	1	-	-	-	-
	Pinnularia nobilis	-	-	-	-	1	1	-	-	-
	Melosira ambigua	-	-	-	4	-	-	2	-	1
	Tabellaria fenestrata	1	1	1	-	1	-	-	-	-
	Atthiya zachariasi	-	-	-	1	-	-	-	1	2
	Amphora ovalis	2	-	1	-	-	-	-	-	-
Chlorophyceae	*Closterium abruptum*	-	-	-	-	-	-	-	3	-
	Cylindrocystis sp.	-	-	-	-	-	1	-	-	-
Total		4	2	3	5	4	2	4	4	4

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Density of phytoplankton (l^{-1}) in Dinan and Gongri in August 2009

Class	**Taxa**	**Dinan**			**Gongri**		
		S1	**S2**	**S3**	**S1**	**S2**	**S3**
Bacillariophyceae	*Cymbella cistula*	3	-	2	1	-	2
	Fragillaria sp.	-	2	-	-	3	-
	Synedra sp.	2	1	2	2	1	6
	Melosira ambigua	2	-	1	2	-	8
	Unidentified-1	-	7	-	-	2	-
	Unidentified-2	1	-	-	3	-	-
	Atthiya zachariasi	1	-	-	-	4	2
	Amphora ovalis	2	-	-	5	-	-
Chlorophyceae	*Closterium abruptum*	-	-	-	1	-	-
	Cylindrocystis sp.	-	-	-	1	-	-
Total		11	10	5	15	10	18

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Density of phytoplankton (l^{-1}) in Utung and Nazong in August 2009

Class	**Taxa**	**Utung**			**Nazong**		
		S1	**S2**	**S3**	**S1**	**S2**	**S3**
Bacillariophyceae	*Cymbella cistula*	-	-	-	4	2	-
	Fragillaria sp. sp.	2	-	2	-	-	2
	Synedra sp.	-	-	-	-	-	2
	Pinnularia nobilis	-	-	-	-	-	1
	Melosira ambigua	-	-	-	4	4	1
	Unidentified-1	3	5	-	-	-	-
	Atthiya zachariasi sp.	-	-	-	-	3	-
	Amphora ovalis	-	3	-	-	-	-
Chlorophyceae	*Closterium abruptum*	1	2	1	-	2	-
Total		6	10	3	8	11	6

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Density of phytoplankton (l^{-1}) in Jameri, Dibbin and Dimijin in September 2009

Class	Taxa	**Jameri**			**Dibbin**			**Dimijin**		
		S1	**S2**	**S3**	**S1**	**S2**	**S3**	**S1**	**S2**	**S3**
Bacillariophyceae	*Tabellaria fenestrata*	-	-	-	-	-	-	4	2	3
	Unidentified-1	-	1	-	-	-	6	-	-	-
	Atthiya zachariasi	1	-	-	-	-	3	-	3	-
	Amphora ovalis	1	1	-	-	-	-	2	-	1
Chlorophyceae	*Actinastrum hantzschii*	5	4	6	2	1	-	-	-	-
	Penium simplex	2	1	1	-	-	-	1	-	-
Cyanophyceae	*Synechocystis* sp.	3	1	1	-	1	1	-	-	-
Total		12	8	8	2	2	10	7	5	4

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Density of phytoplankton (l^{-1}) in Dinchang, Nafra and Dikhri in September 2009

Class	Taxa	Dinchang			Nafra			Dikhri		
		S1	S2	S3	S1	S2	S3	S1	S2	S3
Bacillariophyceae	*Tabellaria fenestrata*	1	-	-	2	4	-	1	-	-
	Unidentified-1	2	-	2	-	-	5	-	-	-
	Atthiya zachariasi	-	-	-	-	-	-	2	-	2
Chlorophyceae	*Actinastrum hantzschii*	2	1	3	-	3	-	3	2	5
	Penium simplex	-	1	-	-	-	2	-	-	-
Cyanophyceae	*Synechoccus sp.*	-	-	-	-	1	-	-	-	-
	Synechocystis sp.	-	1	-	-	-	1	-	1	-
Total		5	3	5	2	8	8	6	3	7

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Density of phytoplankton (l^{-1}) in Dinan and Gongri in September 2009

Class	Taxa	Dinan			Gongri		
		S1	S2	S3	S1	S2	S3
Bacillariophyceae	*Tabellaria fenestrata*	-	1	-	2	1	3
	Atthiya zachariasi	4	2	2	2	-	-
	Amphora ovalis	-	-	-	-	7	-
Chlorophyceae	*Actinastrum hantzschii*	-	-	-	1	-	-
	Penium simplex	2	-	3	-	-	-
Cyanophyceae	*Synechoccus sp.*	-	-	-	1	-	-
	Synechocystis sp.	1	-	1	1	-	-
Total		7	3	6	7	8	3

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Density of phytoplankton (l^{-1}) in Utung and Nazong in September 2009

Class	Taxa	Utung			Nazong		
		S1	S2	S3	S1	S2	S3
Bacillariophyceae	*Unidentified-1*	-	1	-	-	-	-
	Atthiya zachariasi	1	-	-	-	-	-
	Amphora ovalis	1	1	-	-	-	-
Chlorophyceae	*Actinastrum hantzschii*	3	4	6	2	1	1
	Penium simplex	2	1	1	-	-	-
Cyanophyceae	*Synechocystis* sp.	3	1	2	-	1	1
Total		10	8	9	2	2	2

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

ANNEXURE-VII

DENSITY OF ZOOPLNAKTONS AT VARIOUS SAMPLING SITES

Density of zooplankton (l^{-1}) in Jameri, Dibbin and Dimijin in April 2009

Taxa	Jameri			Dibbin			Dimijin		
	S1	S2	S3	S1	S2	S3	S1	S2	S3
Difflugia	6	9	5	8	7	3	2	1	1
Polyarthra	1	-	2	4	9	6	5	2	1
Testudinella	3	1	2	3	2	1	-	-	-
Ceriodaphnia	-	-	-	3	2	1	-	-	-
Cyclops	1	4	1	1	4	-	-	-	-
Moina	-	-	-	1	-	3	-	-	-
Arcella	-	-	-	2	2	5	-	-	-
Colurella	1	1	1	-	-	-	-	-	-
Brachionus	5	3	9	-	-	-	7	5	3
Unidentified-3	1	-	-	-	-	-	-	-	-
Filinia	4	3	5	-	-	-	1	-	-
Lecane	1	1	-	-	-	-	-	-	1
Trichocerca	1	1	1	-	-	-	1	-	-
Total	24	23	26	22	26	19	16	8	6

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Density of zooplankton (l^{-1}) in Dinchang, Nafra and Dikhri in April 2009

Taxa	Dinchang			Nafra			Dikhri		
	S1	S2	S3	S1	S2	S3	S1	S2	S3
Difflugia	-	1	1	1	2	-	5	2	1
Keratella	1	2	-	-	-	-	-	-	-
Polyarthra	1	-	1	-	-	-	4	1	3
Testudinella	1	-	-	-	-	-	1	1	-
Ceriodaphnia	2	1	3	2	3	1	-	1	-
Cyclops	-	-	-	-	-	-	-	4	-
Moina	2	5	-	1	-	-	-	-	3
Arcella	-	-	-	-	-	-	1	1	5
Colurella	5	7	2	-	1	-	-	-	-
Unidentified-4	1	-	1	1	4	5	-	-	-
Bosmina	1	-	2	-	-	-	-	-	-
Bosminopsis	1	1	-	-	-	-	-	-	-
Unidentified-3	-	-	-	-	-	1	-	-	-
Filinia	-	-	-	1	2	-	-	-	-
Trichocerca	1	1	-	-	-	-	-	-	-
Total	16	18	10	6	12	7	11	10	12

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Density of zooplankton (l^{-1}) in Dinan and Gongri in April 2009

Taxa	Dinan			Gongri		
	S1	S2	S3	S1	S2	S3
Difflugia	2	-	-	5	6	6
Keratella	-	-	-	2	-	3
Polyarthra	-	-	-	2	-	6
Testudinella	-	-	-	3	3	2
Ceriodaphnia	1	2	-	3	2	2
Cyclops	-	-	-	1	5	-
Moina	-	-	-	1	-	3
Arcella	-	-	-	2	2	5
Unidentified-4	-	2	1	-	-	-
Unidentified-3	-	-	1	-	-	-
Filinia	1	2	-	-	-	-
Total	4	6	2	19	18	27

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Density of zooplanktons (l^{-1}) in Utung and Nazong in April 2009

Taxa	Utung			Nazong		
	S1	S2	S3	S1	S2	S3
Difflugia	1	1	3	-	3	1
Testudinella	-	1	-	1	-	-
Brachionus	-	-	-	1	-	-
Trichocerca	1	-	-	-	-	1
	2	**2**	**3**	**2**	**3**	**2**

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Density of zooplankton (l^{-1}) in Jameri, Dibbin and Dimijin in May 2009

Taxa	Jameri			Dibbin			Dimijin		
	S1	S2	S3	S1	S2	S3	S1	S2	S3
Difflugia	8	9	6	8	7	3	2	1	1
Polyarthra	1	-	2	5	2	6	5	2	1
Testudinella	3	1	2	3	2	1	-	-	-
Moina	-	-	-	1	-	3	-	-	-
Arcella	-	-	-	2	2	5	-	-	-
Colurella	1	1	1	-	-	-	-	-	-
Unidentified-3	1	-	-	-	-	-	-	-	-
Filinia	4	3	5	-	-	-	1	-	-
Lecane	1	1	-	-	-	-	-	-	1
Trichocerca	1	1	1	-	-	-	1	-	-
Total	20	16	17	19	13	18	9	3	3

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Density of zooplankton (l^{-1}) in Dinchang, Nafra and Dikhri in May 2009

Taxa	Dinchang			Nafra			Dikhri		
	S1	**S2**	**S3**	**S1**	**S2**	**S3**	**S1**	**S2**	**S3**
Difflugia	-	1	1	1	2	-	5	2	1
Keratella	1	2	-	-	-	-	-	-	-
Polyarthra	1	-	1	-	-	-	4	1	3
Testudinella	1	-	-	-	-	-	1	1	-
Moina	2	5	-	1	-	-	-	-	3
Arcella	-	-	-	-	-	-	1	1	5
Colurella	5	7	2	-	1	-	-	-	-
Unidentified-4	1	-	1	1	4	5	-	-	-
Unidentified-3	-	-	-	-	-	1	-	-	-
Filinia	-	-	-	1	2	-	-	-	-
Trichocerca	1	1	-	-	-	-	-	-	-
Total	12	16	5	4	9	6	11	5	12

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Density of zooplankton (l^{-1}) in Dinan and Gongri in May 2009

Taxa	Dinan			Gongri		
	S1	**S2**	**S3**	**S1**	**S2**	**S3**
Difflugia	2	-	-	7	8	5
Keratella	-	-	-	-	2	-
Polyarthra	-	-	-	2	2	3
Testudinella	-	-	-	-	3	2
Moina	-	-	-	5	-	-
Arcella	-	-	-	-	-	1
Colurella	-	-	-	-	-	1
Unidentified-4	-	2	6	-	-	-
Unidentified-3	-	-	3	-	-	-
Filinia	5	2	-	-	-	4
Trichocerca	-	-	-	-	-	2
Total	7	4	9	14	15	18

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Density of zooplanktons (l^{-1}) in Utung and Nazong in May 2009

Taxa	Utung			Nazong		
	S1	**S2**	**S3**	**S1**	**S2**	**S3**
Difflugia	1	1	3	-	3	3
Testudinella	-	1	-	5	-	-
Colurella	-	-	-	2	-	-
Trichocerca	1	-	-	-	-	2
Total	**2**	**2**	**3**	**7**	**3**	**5**

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Density of zooplanktons (l^{-1}) in Jameri, Dibbin and Dimijin in June 2009

Taxa	Jameri			Dibbin			Dimijin		
	S1	S2	S3	S1	S2	S3	S1	S2	S3
Polyarthra	1	-	2	5	2	6	5	5	5
Testudinella	3	1	2	3	2	1	-	-	-
Ceriodaphnia	-	-	-	3	2	1	-	-	-
Cyclops	1	4	1	1	4	-	-	-	3
Moina	-	-	-	1	-	3	-	2	-
Arcella	-	-	-	2	2	5	-	-	-
Colurella	1	1	1	-	-	-	-	-	-
Unidentified-3	1	-	-	-	-	-	-	-	-
Filinia	4	3	5	-	-	-	1	-	-
Lecane	1	1	-	-	-	-	-	-	1
Trichocerca	1	1	1	-	-	-	1	-	-
Total	13	11	12	15	12	16	7	7	9

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Density of zooplanktons (l^{-1}) in Dinchang, Nafra and Dikhri in June 2009

Taxa	Dinchang			Nafra			Dikhri		
	S1	S2	S3	S1	S2	S3	S1	S2	S3
Keratella	1	2	-	-	-	-	-	-	-
Polyarthra	1	-	1	-	-	-	4	1	3
Testudinella	1	-	-	-	-	-	1	1	-
Ceriodaphnia	2	1	3	2	3	1	-	1	-
Cyclops	-	-	-	-	-	-	-	4	-
Moina	2	5	-	1	-	-	-	-	3
Arcella	-	-	-	-	-	-	1	1	5
Colurella	5	7	2	-	1	-	-	-	-
Unidentified-4	1	-	1	1	4	5	-	-	-
Bosmina	1	-	2	-	-	-	-	-	-
Bosminopsis	1	1	-	-	-	-	-	-	-
Unidentified-3	-	-	-	-	-	1	-	-	-
Filinia	-	-	-	1	2	-	-	-	-
Trichocerca	1	1	-	-	-	-	-	-	-
Total	16	17	9	5	10	7	6	8	11

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Density of zooplanktons (l^{-1}) in Dinan and Gongri in June 2009

Taxa	Dinan			Gongri		
	S1	S2	S3	S1	S2	S3
Keratella	-	-	-	2	3	5
Polyarthra	-	-	-	2	-	2
Testudinella	-	-	-	2	-	-
Ceriodaphnia	5	2	-	3	2	-
Moina	-	-	-	2	4	-
Arcella	6	-	-	-	-	2
Colurella	-	-	-	-	3	3
Unidentified-4	-	2	6	-	-	-
Unidentified-3	-	-	3	-	-	-
Filinia	1	2	-	-	-	-
Trichocerca	-	-	-	1	-	3
Total	12	6	9	12	12	15

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Density of zooplanktons (l^{-1}) in Utung and Nazong in June 2009

Taxa	Utung			Nazong		
	S1	S2	S3	S1	S2	S3
Keratella	-	-	5	-	-	-
Polyarthra	-	-	-	-	6	-
Testudinella	-	4	-	5	-	-
Cyclops	-	-	3	-	2	1
Moina	-	3	-	3	-	-
Arcella	2	-	-	-	-	2
Bdelloid	-	1	-	-	1	-
Bosmina	-	-	-	1	-	-
Bosminopsis	3	-	2	-	-	-
Trichocerca	5	-	-	-	-	4
Total	**10**	**8**	**10**	**9**	**9**	**7**

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Density of zooplankton (l^{-1}) in Jameri, Dibbin and Dimijin in July 2009

Taxa	Jameri			Dibbin			Dimijin		
	S1	S2	S3	S1	S2	S3	S1	S2	S3
Difflugia	6	4	2	3	3	3	2	1	1
Polyarthra	1	-	2	1	2	2	5	2	1
Testudinella	3	1	2	3	2	1	-	-	-
Epistylis	1	-	-	-	-	-	-	-	-
Filinia	4	2	3	-	-	-	1	-	-
Unidentified-a	1	1	-	-	-	-	-	-	1
Unidentified-b	1	1	1	-	-	-	1	-	-
Total	17	9	10	7	7	6	9	3	3

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Density of zooplankton (l^{-1}) in Dinchang, Nafra and Dikhri in July 2009

Taxa	Dinchang			Nafra			Dikhri		
	S1	S2	S3	S1	S2	S3	S1	S2	S3
Difflugia	-	1	1	1	2	-	5	2	1
Keratella	1	2	-	-	-	-	-	-	-
Polyarthra	1	-	1	-	-	-	4	1	3
Testudinella	1	-	-	-	-	-	1	1	-
Bdelloid	1	-	1	1	4	5	-	-	-
Bosmina	1	-	2	-	-	-	-	-	-
Epistylis	-	-	-	-	-	1	-	-	-
Filinia	-	-	-	1	2	-	-	-	-
Unidentified-b	1	1	-	-	-	-	-	-	-
Total	6	4	5	3	8	6	10	4	4

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Density of zooplankton (l^{-1}) in Dinan and Gongri in July 2009

Taxa	Dinan			Gongri		
	S1	S2	S3	S1	S2	S3
Difflugia	2	-	-	5	2	3
Keratella	-	-	-	2	-	3
Polyarthra	-	-	-	2	-	6
Testudinella	-	-	-	3	3	2
Bdelloid	-	2	1	-	-	-
Epistylis	-	-	1	-	-	-
Filinia	1	2	-	-	-	-
Total	3	4	2	12	5	14

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Density of zooplankton (l^{-1}) in Utung and Nazong in July 2009

Taxa	Utung			Nazong		
	S1	S2	S3	S1	S2	S3
Difflugia	1	1	3	-	3	1
Testudinella	-	1	-	1	-	-
***Unidentified**-b*	1	-	-	-	-	1
Total	2	2	3	1	3	2

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Density of zooplankton (l^{-1}) in Jameri, Dibbin and Dimijin in August 2009

Taxa	Jameri			Dibbin			Dimijin		
	S1	S2	S3	S1	S2	S3	S1	S2	S3
Difflugia	2	1	2	2	3	3	2	1	1
Keratella	-	-	-	-	-	-	-	-	-
Polyarthra	1	-	2	5	2	2	5	2	1
Bdelloid	-	-	-	-	-	-	-	-	-
Epistylis	1	-	-	-	-	-	-	-	-
Filinia	1	3	1	-	-	-	1	-	-
Unidentified-a	1	1	-	-	-	-	-	-	1
Unidentified-b	1	1	1	-	-	-	1	-	-
Total	7	6	6	7	5	5	9	3	3

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Density of zooplankton (l^{-1}) in Dinchang, Nafra and Dikhri in August 2009

Taxa	Dinchang			Nafra			Dikhri		
	S1	S2	S3	S1	S2	S3	S1	S2	S3
Difflugia	-	1	1	1	2	-	5	2	1
Keratella	1	2	-	-	-	-	-	-	-
Polyarthra	1	-	1	-	-	-	4	1	3
Bdelloid	1	-	1	1	4	5	-	-	-
Epistylis	-	-	-	-	-	1	-	-	-
Filinia	-	-	-	1	2	-	-	-	-
Unidentified-b	1	1	-	-	-	-	-	-	-
Total	4	4	3	3	8	6	9	3	4

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Density of zooplankton (l^{-1}) in Dinan and Gongri in August 2009

Taxa	Dinan			Gongri		
	S1	S2	S3	S1	S2	S3
Difflugia	2	-	-	2	3	2
Keratella	-	-	-	-	2	-
Polyarthra	-	-	-	2	2	3
Bdelloid	-	2	6	-	-	-
Epistylis	-	-	3	-	-	-
Filinia	5	2	-	-	-	4
Trichocerca	-	-	-	-	-	2
Total	7	4	9	4	7	11

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Density of zooplankton (l^{-1}) in Utung and Nazong in August 2009

Taxa	Utung			Nazong		
	S1	S2	S3	S1	S2	S3
Difflugia	1	1	3	2	3	3
Epistylis	-	-	-	1	-	-
Trichocerca	1	-	-	-	-	2
Total	2	1	3	3	3	5

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Density of zooplanktons (l^{-1}) in Jameri, Dibbin and Dimijin in September 2009

Taxa	Jameri			Dibbin			Dimijin		
	S1	S2	S3	S1	S2	S3	S1	S2	S3
Keratella	-	-	-	1	1	1	-	3	-
Bosmina	-	-	-	-	-	2	-	-	-
Bosminopsis	-	-	-	-	-	-	-	-	-
Epistylis	1	-	-	2	-	-	-	1	-
Filinia	2	1	2	-	-	1	1	-	-
Unidentified-a	1	1	-	-	1	-	-	-	1
Unidentified-b	1	1	1	-	-	-	1	-	-
Total	5	3	3	3	2	4	2	4	1

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Density of zooplanktons (l^{-1}) in Dinchang, Nafra and Dikhri in September 2009

Taxa	Dinchang			Nafra			Dikhri		
	S1	**S2**	**S3**	**S1**	**S2**	**S3**	**S1**	**S2**	**S3**
Keratella	1	2	-	-	-	-	2	2	3
Bosmina	1	-	2	-	-	-	-	-	-
Bosminopsis	1	1	-	-	-	-	-	1	-
Epistylis	-	-	-	-	-	1	1	1	1
Filinia	-	-	-	1	2	-	-	-	1
Unidentified-a	-	-	-	-	-	-	1	-	-
Unidentified-b	1	1	-	-	-	-	-	-	-
Total	4	4	2	1	2	1	4	4	5

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Density of zooplanktons (l^{-1}) in Dinan and Gongri in September 2009

Taxa	Dinan			Gongri		
	S1	**S2**	**S3**	**S1**	**S2**	**S3**
Keratella	-	-	-	2	3	5
Bosmina	-	-	-	-	-	-
Bosminopsis	-	-	-	-	-	-
Epistylis	-	-	3	-	-	-
Filinia	1	2	-	-	-	-
Lecane	-	-	-	-	-	-
Unidentified-b	-	-	-	1	-	3
Total	1	2	3	3	3	8

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Density of zooplanktons (l^{-1}) in Utung and Nazong in September 2009

Taxa	Utung			Nazong		
	S1	**S2**	**S3**	**S1**	**S2**	**S3**
Keratella	-	-	5	-	-	-
Bosmina	-	3	-	2	-	-
Bosminopsis	3	-	2	-	-	-
Epistylis	-	2	-	-	1	-
Filinia	-	1	-	-	-	-
Unidentified-a	-	-	-	-	-	-
Unidentified-b	5	-	-	-	-	4
Total	8	6	7	2	1	4

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

ANNEXURE-VIII

DENSITY OF PERIPHYTONS AT VARIOUS SAMPLING SITES

Periphyton density (cm^{-2}) in Jameri, Dibbin and Dimijin in April 2009

Taxa	Jameri			Dibbin			Dimijin		
	S1	S2	S3	S1	S2	S3	S1	S2	S3
Nitzchia	30	10	20	30	20	10	-	10	20
Cymbella cistula	-	-	-	30	20	10	50	20	20
Hormidium	10	40	10	10	40	-	20	-	-
Cosmerium	-	-	-	10	-	30	-	50	30
Spirotaena	-	-	-	20	20	50	10	-	-
Gloeocapsa	-	-	-	-	-	-	-	10	60
Total	40	50	30	100	100	100	80	90	130

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Periphyton density (cm^{-2}) in Dinchang, Nafra and Dikhri in April 2009

Taxa	Dinchang			Nafra			Dikhri		
	S1	S2	S3	S1	S2	S3	S1	S2	S3
Nitzchia	40	-	-	-	-	-	50	30	10
Cymbella cistula	20	50	20	60	30	30	-	10	10
Hormidium	-	-	-	-	-	-	20	20	-
Cosmerium	20	50	-	30	40	-	20	-	30
Spirotaena	-	-	-	-	20	20	10	50	50
Gloeocapsa	50	-	30	10	40	50	-	-	-
Chlorella	10	-	20	-	-	-	-	-	-
Total	140	100	70	100	130	100	100	110	100

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Periphyton density (cm^{-2}) in Dinan and Gongri in April 2009

Taxa	Dinan			Gongri		
	S1	S2	S3	S1	S2	S3
Nitzchia	50	-	30	50	50	30
Cymbella cistula	10	50	60	30	20	10
Hormidium	20	-	-	-	-	-
Cosmerium	20	20	20	10	20	-
Gloeocapsa	10	30	20	10	-	10
Chlorella sp.	-	-	-	-	-	10
Total	110	100	130	100	90	60

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Periphyton density (cm^{-2}) in Utung and Nazong in April 2009

Genus	Utung			Nazong		
	S1	S2	S3	S1	S2	S3
Nitzchia	30	40	10	10	20	30
Cymbella cistula	60	-	10	-	-	60
Hormidium	-	70	-	20	10	-
Cosmerium	20	-	30	20	10	20
Spirotaena	-	30	-	-	-	20
Gloeocapsa	10	20	20	10	30	-
Chlorella	-	-	-	-	-	10
Total	**120**	**160**	**70**	**60**	**70**	**140**

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Periphyton density (cm^{-2}) in Jameri, Dibbin and Dimijin in May 2009

Taxa	Jameri			Dibbin			Dimijin		
	S1	S2	S3	S1	S2	S3	S1	S2	S3
Nitzchia	30	50	20	30	20	50	30	30	50
Cymbella cistula	-	-	-	60	20	10	-	-	20
Hormidium	30	40	30	10	50	20	20	20	20
Gloeocapsa	-	-	-	20	-	-	10	20	10
Chlorella sp.	-	-	20	-	-	10	10	10	-
Total	60	90	70	120	90	90	70	80	100

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Periphyton density (cm^{-2}) in Dinchang, Nafra and Dikhri in May 2009

Taxa	Dinchang			Nafra			Dikhri		
	S1	S2	S3	S1	S2	S3	S1	S2	S3
Nitzchia	30	-	-	-	20	-	40	20	20
Cymbella cistula	20	40	60	30	30	10	-	30	50
Hormidium	-	30	-	-	-	-	60	40	-
Gloeocapsa	60	-	20	50	40	50	-	-	10
Chlorella sp.	10	10	20	-	-	-	10	-	20
Total	120	80	100	80	90	60	110	90	100

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Periphyton density (cm^{-2}) Dinan and Gongri in May 2009

Taxa	Dinan			Gongri		
	S1	S2	S3	S1	S2	S3
Nitzchia	20	50	40	40	50	60
Cymbella cistula	10	20	-	50	20	30
Hormidium	10	-	20	-	10	-
Gloeocapsa	-	30	20	20	-	10
Chlorella sp.	30	-	-	10	10	10
Total	70	100	80	120	90	110

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Periphyton density (cm^{-2}) Utung and Nazong in May 2009

Genus	Utung			Nazong		
	S1	S2	S3	S1	S2	S3
Nitzchia	30	60	40	50	20	10
Cymbella cistula	20	-	50	60	20	10
Hormidium	10	20	-	20	-	-
Gloeocapsa	10	20	30	-	30	20
Chlorella	-	-	20	10	20	10
Total	**70**	**100**	**140**	**140**	**90**	**50**

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Periphyton density (cm^{-2}) in Jameri, Dibbin and Dimijin in June 2009

Taxa	Jameri			Dibbin			Dimijin		
	S1	S2	S3	S1	S2	S3	S1	S2	S3
Nitzchia	30	10	20	30	20	10	20	30	20
Spirotaena	-	-	-	20	20	50	-	-	20
Gloeocapsa	-	-	-	-	-	-	20	10	-
Chlorella sp.	-	-	-	-	-	-	-	-	30
Total	30	10	20	50	40	60	40	40	70

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Periphyton density (cm^{-2}) in Dinchang, Nafra and Dikhri in June 2009

Taxa	Dinchang			Nafra			Dikhri		
	S1	S2	S3	S1	S2	S3	S1	S2	S3
Nitzchia	10	10	-	20	-	-	10	10	20
Spirotaena	-	-	-	-	-	-	10	10	50
Gloeocapsa	10	20	10	10	40	50	-	-	-
Chlorella sp.	10	-	20	-	-	-	20	-	-
Total	30	30	30	30	40	50	40	20	70

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Periphyton density (cm^{-2}) in Dinan and Gongri in June 2009

Taxa	Dinan			Gongri		
	S1	S2	S3	S1	S2	S3
Nitzchia	10	30	10	50	60	50
Spirotaena	-	-	30	10	-	30
Gloeocapsa	10	20	10	30	20	-
Chlorella sp.	10	-	-	-	10	40
Total	30	50	50	90	90	120

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Periphyton density (cm^{-2}) in Utung and Nazong in June 2009

Genus	Utung			Nazong		
	S1	S2	S3	S1	S2	S3
Nitzchia	50	10	30	10	10	20
Spirotaena	-	-	-	-	-	30
Gloeocapsa	20	-	-	-	20	-
Chlorella	-	-	10	20	-	10
Total	**70**	**10**	**40**	**30**	**30**	**60**

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

ANNEXURE-IX

DENSITY OF INVERTEBRATES AT VARIOUS SAMPLING SITES

Density of invertebrates (m^{-2}) in Jameri, Dibbin and Dimijin in April 2009

Order	Families	Jameri			Dibbin			Dimijin		
		S1	S2	S3	S1	S2	S3	S1	S2	S3
Ephemeroptera	Baetidae	26	10	15	8	7	3	2	1	1
	Heptageniidae	1	-	2	14	11	6	5	2	1
	Leptophlebiidae	3	1	2	3	2	1	-	-	-
Plecoptera	Nemouridae	-	-	-	3	2	1	-	-	-
	Perlidae	1	4	1	1	4	-	-	-	-
	Taeniopterygidae	-	-	-	1	-	3	-	-	-
Trichoptera	Leptoceridae	-	-	-	2	2	5	-	-	-
	Molannidae	1	1	1	-	-	-	-	-	-
Diptera	Chironomidae	52	23	11	-	-	-	43	23	12
	Rhagionidae	1	-	-	-	-	-	-	-	-
	Simulidae	4	3	5	-	-	-	1	-	-
	Tabaenidae	1	1	-	-	-	-	-	-	1
	Tipulidae	1	1	1	-	-	-	1	-	-
Total		91	44	38	32	28	19	52	26	15

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Density of invertebrates (m^{-2}) in Dinchang, Nafra and Dikhri in April 2009

Order	Families	Dinchang			Nafra			Dikhri		
		S1	S2	S3	S1	S2	S3	S1	S2	S3
Ephemeroptera	Baetidae	-	1	1	1	2	-	5	2	1
	Ecdyonuridae	1	2	-	-	-	-	-	-	-
	Heptageniidae	1	-	1	-	-	-	4	1	3
	Leptophlebiidae	1	-	-	-	-	-	1	1	-
Plecoptera	Nemouridae	2	1	3	2	3	1	-	1	-
	Perlidae	-	-	-	-	-	-	-	4	-
	Taeniopterygidae	2	5	-	1	-	-	-	-	3
Trichoptera	Leptoceridae	-	-	-	-	-	-	1	1	5
	Molannidae	5	7	2	-	1	-	-	-	-
	Philopotamidae	1	-	1	1	4	5	-	-	-
	Psychomyiidae	1	-	2	-	-	-	-	-	-
Odonata	Gomphidae	1	1	-	-	-	-	-	-	-
Diptera	Rhagionidae	-	-	-	-	-	1	-	-	-
	Simulidae	-	-	-	1	2	-	-	-	-
	Tipulidae	1	1	-	-	-	-	-	-	-
Total		16	18	10	6	12	7	11	10	12

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Density of invertebrates (m^{-2}) in Dinan and Gongri in April 2009

Order	Families	Dinan			Gongri		
		S1	S2	S3	S1	S2	S3
Ephemeroptera	Baetidae	2	-	-	16	5	6
	Heptageniidae	-	-	-	2	-	3
	Leptophlebiidae	-	-	-	13	2	3
Plecoptera	Nemouridae	1	2	-	-	-	-
	Perlidae	-	-	-	2	14	-
Trichoptera	Molannidae	-	-	-	-	1	2
	Philopotamidae	-	2	1	-	-	-
Diptera	Chironomidae	-	-	-	21	15	5
	Rhagionidae	-	-	1	1	-	-
	Simulidae	1	2	-	4	3	2
	Tabaenidae	-	-	-	1	1	-
	Tipulidae	-	-	-	1	1	6
Total		4	6	2	61	42	27

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Density of invertebrates (m^{-2}) in Utung and Nazong in April 2009

Order	Family	Utung			Nazong		
		S1	S2	S3	S1	S2	S3
Ephemeroptera	Baetidae	1	1	3	-	3	1
	Leptophlebiidae	-	1	-	1	-	-
Diptera	Chironomidae	-	-	-	1	-	-
	Tipulidae	1	-	-	-	-	1
Total		**2**	**2**	**3**	**2**	**3**	**2**

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Density of benthic invertebrates (m^{-2}) in Jameri, Dibbin and Dimijin in May 2009

Order	Families	Jameri			Dibbin			Dimijin		
		S1	S2	S3	S1	S2	S3	S1	S2	S3
Ephemeroptera	Baetidae	5	1	2	3	8	4	2	1	1
	Ecdyonuridae	2	-	1	-	-	-	-	-	-
	Ephemerellidae	-	-	-	7	10	8	5	4	1
	Heptageniidae	-	-	-	-	1	-	-	-	-
	Leptophlebiidae	2	1	1	-	1	-	-	-	-
Plecoptera	Nemouridae	-	-	-	-	3	-	-	-	-
	Perlodideae	-	-	-	-	4	-	-	-	-
Trichoptera	Hydropsychidae	5	-	4	1	-	-	-	-	-
	Philopotamidae	8	3	2	-	-	-	-	-	-
	Polycentropidae	2	2	1	-	-	-	-	-	-
	Psychomyiidae	-	-	1	-	-	-	-	-	-
Diptera	Chironomidae	2	-	1	-	-	-	23	12	11
	Limoniidae	2	-	-	-	-	-	-	-	-
Coleoptera	Dytiscidae	-	-	-	-	-	-	1	4	-
	Elmidae	1	-	-	-	-	-	-	-	-
Megaloptera	Corydalidae	-	-	1	-	-	-	1	-	-
Total		29	7	14	11	27	12	32	21	13

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Density of benthic invertebrates (m^{-2}) in Dinchang, Nafra and Dikhri in May 2009

Order	Families	Dinchang			Nafra			Dikhri		
		S1	S2	S3	S1	S2	S3	S1	S2	S3
Ephemeroptera	Baetidae	-	1	1	2	1	1	2	3	-
	Ecdyonuridae	1	-	-	-	-	-	-	-	5
	Ephemerellidae	1	-	-	-	-	-	2	1	1
	Heptageniidae	1	-	1	-	-	-	-	-	-
	Leptophlebiidae	2	1	-	-	1	-	-	4	-
Plecoptera	Nemouridae	-	-	-	-	-	-	-	1	-
	Perlidae	2	1	-	-	-	-	-	-	-
	Perlodideae	-	-	-	-	-	-	-	2	-
Trichoptera	Hydropsychidae	-	-	1	-	2	3	1	-	-
	Philopotamidae	5	-	-	-	5	1	-	-	-
	Polycentropidae	1	-	-	-	-	-	-	-	-
	Psychomyiidae	1	1	-	-	-	-	-	-	-
	Rhyacophilidae	1	-	1	-	-	-	-	-	-
Diptera	Chironomidae	-	-	-	-	1	1	-	-	-
	Limoniidae	-	-	1	-	-	-	-	-	-
Megaloptera	Corydalidae	1	1	-	-	-	-	-	-	-
Total		16	5	5	2	10	6	5	11	6

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Density of benthic invertebrates (m^{-2}) in Dinan and Gongri in May 2009

Order	Families	Dinan			Gongri		
		S1	S2	S3	S1	S2	S3
Ephemeroptera	Baetidae	5	3	6	6	5	6
	Ecdyonuridae	-	2	1	3	3	3
	Ephemerellidae	-	-	1	-	2	-
	Heptageniidae	-	-	-	-	-	-
	Leptophlebiidae	-	5	1	1	-	2
Plecoptera	Nemouridae	4	-	-	1	-	-
	Perlidae	4	-	-	1	-	-
Trichoptera	Hydropsychidae	-	2	2	5	-	3
	Philopotamidae	3	2	1	3	-	-
	Rhyacophilidae	-	-	-	-	-	-
Diptera	Chironomidae	-	1	1	-	-	-
	Limoniidae	-	-	-	-	-	-
Coleoptera	Dytiscidae	-	-	-	-	-	-
Megaloptera	Corydalidae	-	-	-	-	-	-
Total		16	15	13	20	10	14

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Density of invertebrates (m^{-2}) in Utung and Nazong in May 2009

Order	Family	Utung			Nazong		
		S1	S2	S3	S1	S2	S3
Ephemeroptera	Baetidae	5	2	5	-	5	4
	Ecdyonuridae	-	-	-	3	-	2
	Ephemerellidae	2	5	5	2	-	-
	Heptageniidae	-	-	-	2	-	5
	Leptophlebiidae	-	-	-	1	2	-
Plecoptera	Perlidae	-	-	-	1	1	-
Trichoptera	Hydropsychidae	-	-	-	-	-	3
	Philopotamidae	-	-	-	4	-	-
	Rhyacophilidae	-	-	-	-	-	1
Diptera	Chironomidae	2	3	1	-	-	-
	Limoniidae	-	-	-	-	-	2
Coleoptera	Dytiscidae	1	4	-	-	-	-
Megaloptera	Corydalidae	1	-	-	1	1	-
Total		11	14	11	14	9	17

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Density of invertebrates (m^{-2}) in Jameri, Dibbin and Dimijin in June 2009

Order	Families	Jameri			Dibbin			Dimijin		
		S1	S2	S3	S1	S2	S3	S1	S2	S3
Ephemeroptera	Heptageniidae	1	-	2	14	11	6	5	2	1
Plecoptera	Nemouridae	-	-	-	3	2	1	-	-	-
	Perlidae	1	4	1	1	4	-	-	-	-
	Taeniopterygidae	-	-	-	1	-	3	-	-	-
Trichoptera	Leptoceridae	-	-	-	2	2	5	-	-	-
	Molannidae	1	1	1	-	-	-	-	-	-
Diptera	Chironomidae	12	13	11	-	-	-	15	9	12
	Rhagionidae	1	-	-	-	-	-	-	-	-
Total		16	18	15	21	19	15	20	11	13

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Density of invertebrates (m^{-2}) in Dinchang, Nafra and Dikhri in June 2009

Order	Families	Dinchang			Nafra			Dikhri		
		S1	S2	S3	S1	S2	S3	S1	S2	S3
Ephemeroptera	Ecdyonuridae	1	2	-	-	-	-	-	-	-
	Heptageniidae	1	-	1	-	-	-	4	1	3
Plecoptera	Nemouridae	2	1	3	2	3	1	-	1	-
	Perlidae	-	-	-	-	-	-	-	4	-
	Taeniopterygidae	2	5	-	1	-	-	-	-	3
Trichoptera	Leptoceridae	-	-	-	-	-	-	1	1	5
	Molannidae	5	7	2	-	1	-	-	-	-
	Psychomyiidae	1	-	2	-	-	-	-	-	-
Diptera	Rhagionidae	-	-	-	-	-	1	-	-	-
Total		12	15	8	3	4	2	5	7	11

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Density of invertebrates (m^{-2}) in Dinan and Gongri in June 2009

Order	Families	Dinan			Gongri		
		S1	S2	S3	S1	S2	S3
Plecoptera	Nemouridae	4	2	-	-	-	-
	Perlidae	-	-	-	2	14	-
Trichoptera	Leptoceridae	3	-	4	-	-	-
	Molannidae	-	-	-	-	1	2
Diptera	Chironomidae	-	-	-	9	8	5
	Rhagionidae	-	-	3	1	-	-
Total		7	2	7	14	23	10

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Density of invertebrates (m^{-2}) in Utung and Nazong in June 2009

Order	Family	Utung			Nazong		
		S1	S2	S3	S1	S2	S3
Ephemeroptera	Baetidae	-	3	-	-	2	-
	Ecdyonuridae	-	2	-	-	-	-
	Heptageniidae	3	2	5	6	4	-
Plecoptera	Peltoperlidae	-	-	2	-	4	-
	Perlidae	2	3	2	2	4	2
	Perlodideae	2	-	-	2	-	2
Diptera	Chironomidae	-	1	-	-	2	-
Megaloptera	Corydalidae	-	1	-	-	1	3
Total		7	12	9	10	17	7

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Density of invertebrates (m^{-2}) in Jameri, Dibbin and Dimijin in July 2009

Order	Families	Jameri			Dibbin			Dimijin		
		S1	S2	S3	S1	S2	S3	S1	S2	S3
Ephemeroptera	Baetidae	1	2	-	1	1	-	-	-	-
	Leptophlebiidae	-	1	1	-	1	-	1	2	1
Plecoptera	Peltoperlidae	1	-	-	-	-	-	-	-	-
Diptera	Tabanidae	-	-	4	-	-	1	2	1	-
Coleoptera	Gyrinidae	-	-	-	-	-	-	-	1	1
Total		2	3	5	1	2	1	3	4	2

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Density of invertebrates (m^{-2}) in Dinchang, Nafra and Dikhri in July 2009

Order	Families	Dinchang			Nafra			Dikhri		
		S1	S2	S3	S1	S2	S3	S1	S2	S3
Ephemeroptera	Baetidae	1	2	-	-	-	-	-	-	-
	Heptageniidae	1	2	-	-	3	1	1	-	1
	Leptophlebiidae	-	-	-	1	2	-	-	-	-
Plecoptera	Perlidae	-	-	-	1	1	1	-	2	-
Hemiptera	Corixidae	-	-	-	-	1	-	-	-	-
Diptera	Chironomidae	-	1	1	2	1	-	-	2	-
Megaloptera	Corydalidae	-	1	1	-	-	-	-	-	-
Total		2	6	2	4	8	2	1	4	1

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Density of invertebrates (m^{-2}) in Dinan and Gongri in July 2009

Order	Families	Dinan			Gongri		
		S1	S2	S3	S1	S2	S3
Ephemeroptera	Baetidae	-	-	-	7	5	6
	Ecdyonuridae	-	-	-	-	-	-
	Heptageniidae	3	-	-	2	-	3
	Leptophlebiidae	-	-	2	4	2	3
Plecoptera	Peltoperlidae	-	-	2	-	-	-
	Perlidae	3	3	-	2	5	-
	Perlodideae	-	-	-	-	-	-
Diptera	Chironomidae	2	2	4	-	1	2
Megaloptera	Corydalidae	-	2	-	-	-	-
Total		8	7	8	15	13	14

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Density of invertebrates (m^{-2}) in Utung and Nazong in July 2009

Order	Families	Utung			Nazong		
		S1	S2	S3	S1	S2	S3
Ephemeroptera	Ecdyonuridae	2	1	2	-	1	2
Plecoptera	Perlidae	3	2	-	-	-	3
	Taeniopterygidae	-	-	3	2	5	-
Trichoptera	Leptoceridae	1	-	-	-	-	-
	Molannidae	-	1	1	-	1	1
Diptera	Rhagionidae	-	-	-	3	-	-
Total		6	4	6	5	7	6

Density of benthic invertebrates (m^{-2}) in Jameri, Dibbin and Dimijin in August 2009

Order	Families	Jameri			Dibbin			Dimijin		
		S1	S2	S3	S1	S2	S3	S1	S2	S3
Ephemeroptera	Ecdyonuridae	2	-	1	-	-	-	-	-	-
	Ephemerellidae	-	-	-	7	6	5	4	4	4
Plecoptera	Nemouridae	-	-	-	-	3	-	-	-	-
	Perlidae	-	-	-	-	-	2	-	-	-
Trichoptera	Hydropsychidae	3	-	4	1	-	-	-	-	2
	Philopotamidae	2	3	2	-	-	-	-	-	-
Coleoptera	Dytiscidae	-	-	-	-	-	-	2	4	-
Megaloptera	Corydalidae	-	-	1	-	-	-	3	-	-
Total		7	3	8	8	9	7	9	8	6

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Density of benthic invertebrates (m^{-2}) in Dinchang, Nafra and Dikhri in August 2009

Order	Families	Dinchang			Nafra			Dikhri		
		S1	S2	S3	S1	S2	S3	S1	S2	S3
Ephemeroptera	Ecdyonuridae	1	-	-	3	-	-	-	-	5
	Ephemerellidae	1	-	-	-	-	-	2	1	1
Plecoptera	Nemouridae	-	-	1	-	-	-	-	1	-
	Perlidae	2	1	-	2	-	-	-	-	-

Trichoptera	Hydropsychidae	-	-	3	1	2	3	1	-	-
	Philopotamidae	5	-	-	-	5	1	-	-	-
Coleoptera	Dytiscidae	-	-	-	-	-	-	-	-	-
Megaloptera	Corydalidae	1	1	-	-	-	-	-	-	-
Total		10	2	4	6	7	4	3	2	6

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Density of benthic invertebrates (m^{-2}) in Dinan and Gongri in August 2009

Order	Families	Dinan			Gongri		
		S1	**S2**	**S3**	**S1**	**S2**	**S3**
Ephemeroptera	Ecdyonuridae	-	2	1	3	3	3
	Ephemerellidae	-	-	1	-	2	-
Plecoptera	Nemouridae	4	-	-	1	-	-
	Perlidae	4	-	-	1	-	-
Trichoptera	Hydropsychidae	-	2	2	5	-	3
	Philopotamidae	3	2	1	3	-	-
Coleoptera	Dytiscidae	-	-	-	-	-	-
Megaloptera	Corydalidae	-	-	-	-	-	-
Total		11	6	5	13	5	6

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Density of benthic invertebrates (m^{-2}) in Utung and Nazong in August 2009

Order	Families	Utung			Nazong		
		S1	**S2**	**S3**	**S1**	**S2**	**S3**
Ephemeroptera	Ecdyonuridae	-	2	1	3	3	3
	Ephemerellidae	-	-	1	-	2	-
Plecoptera	Nemouridae	4	-	-	1	-	-
	Perlidae	4	-	-	1	-	-
Trichoptera	Hydropsychidae	-	2	2	5	-	3
	Philopotamidae	3	2	1	3	-	-
Coleoptera	Dytiscidae	-	-	-	-	-	-
Megaloptera	Corydalidae	-	-	-	-	-	-
Total		11	6	5	13	5	6

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Density of invertebrates (m^{-2}) in Jameri, Dibbin and Dimijin in September 2009

Order	Families	Jameri			Dibbin			Dimijin		
		S1	**S2**	**S3**	**S1**	**S2**	**S3**	**S1**	**S2**	**S3**
Ephemeroptera	Heptageniidae	4	-	-	-	-	2	-	-	-
	Leptophlebiidae	-	2	2	3	2	-	2	4	3
Plecoptera	Perlidae	-	-	-	-	-	2	2	-	2
	Perlodideae	-	2	-	2	-	-	-	1	2
Hemiptera	Corixidae	2	-	-	-	1	-	-	-	-
Megaloptera	Corydalidae	-	-	-	-	-	-	-	-	-
Total		6	4	2	5	3	4	4	5	7

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Density of invertebrates (m^{-2}) in Dinchang, Nafra and Dikhri in September 2009

Order	Families	Dinchang			Nafra			Dikhri		
		S1	S2	S3	S1	S2	S3	S1	S2	S3
Ephemeroptera	Heptageniidae	2	2	-	-	3	2	3	-	5
	Leptophlebiidae	-	-	-	1	2	-	-	-	-
Plecoptera	Perlidae	2	-	-	2	1	1	-	2	2
	Perlodideae	-	-	-	-	-	-	-	-	-
Hemiptera	Corixidae	-	-	-	-	1	-	4	-	-
Megaloptera	Corydalidae	-	1	3	-	-	-	-	-	-
Total		4	3	3	3	7	3	7	2	7

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Density of invertebrates (m^{-2}) in Dinan and Gongri in September 2009

Order	Families	Dinan			Gongri		
		S1	S2	S3	S1	S2	S3
Ephemeroptera	Heptageniidae	3	-	-	2	-	3
	Leptophlebiidae	-	-	2	4	2	3
Plecoptera	Perlidae	3	3	-	2	5	-
	Perlodideae	-	-	-	-	-	-
Hemiptera	Corixidae	-	-	-	-	-	-
Megaloptera	Corydalidae	-	2	-	-	-	-
Total		6	5	2	8	7	6

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Density of invertebrates (m^{-2}) in Utung and Nazong in September 2009

Order	Families	Utung			Nazong		
		S1	S2	S3	S1	S2	S3
Ephemeroptera	Heptageniidae	3	2	5	6	4	-
	Leptophlebiidae	-	-	-	-	-	-
Plecoptera	Perlidae	2	3	2	2	4	2
	Perlodideae	2	-	-	2	-	2
Hemiptera	Corixidae	-	-	-	-	-	-
Megaloptera	Corydalidae	-	1	-	-	1	3
Total		7	6	7	10	9	7

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

ANNEXURE-X

PRIMARY PRODCUTIVITY AT VARIOUS SAMPLING SITES

Primary productivity in different project sites in the month of April 2009

Primary productivity	Jameri			Nafra			Dibbin		
	S1	S2	S3	S1	S2	S3	S1	S2	S3
Gross Primary (mgC/m3/day)	37.5	37.5	50.0	25.0	62.5	37.5	25.0	37.5	25.0
Net Primary (mgC/m3/day)	12.5	12.5	25.0	12.5	25.0	25.0	12.5	12.5	12.5
	Dimijin			Dinchang			Dikhri		
	S1	S2	S3	S1	S2	S3	S1	S2	S3
Gross Primary (mgC/m3/day)	37.5	37.5	37.5	50.0	50.0	50.0	37.5	37.5	37.5
Net Primary (mgC/m3/day)	12.5	25.0	25.0	25.0	25.0	25.0	12.5	12.5	12.5

	Dinan			Gongri		
	S1	S2	S3	S1	S2	S3
Gross Primary (mgC/m3/day)	36.5	35.5	36.5	32.5	33.5	35.5
Net Primary (mgC/m3/day)	15.5	14.5	15.5	17.5	14.5	15.5
	Utung			Nazong		
	S1	S2	S3	S1	S2	S3
Gross Primary (mgC/m3/day)	35.5	35.5	35.5	23.0	35.5	24.2
Net Primary (mgC/m3/day)	11.5	11.5	11.5	12.5	12.5	14.2

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Primary productivity in different project sites in the month of May 2009

Primary productivity	Jameri			Nafra			Dibbin		
	S1	S2	S3	S1	S2	S3	S1	S2	S3
Gross Primary (mgC/m3/day)	39.1	39.1	54.7	35.4	70.3	39.1	33.4	39.1	34.4
Net Primary (mgC/m3/day)	23.4	23.4	39.1	23.4	39.1	29.1	23.4	23.4	23.4
	Dimijin			Dinchang			Dikhri		
	S1	S2	S3	S1	S2	S3	S1	S2	S3
Gross Primary (mgC/m3/day)	39.1	39.1	39.1	54.7	54.7	54.7	39.1	39.1	39.1
Net Primary (mgC/m3/day)	23.4	29.1	29.1	39.1	39.1	39.1	23.4	23.4	23.4

	Dinan			Gongri		
	S1	S2	S3	S1	S2	S3
Gross Primary (mgC/m3/day)	38.1	39.1	40.1	36.1	35.1	38.1
Net Primary (mgC/m3/day)	23.4	23.4	23.4	21.4	23.4	22.4
	Utung			Nazong		
	S1	S2	S3	S1	S2	S3
Gross Primary (mgC/m3/day)	36.1	36.1	36.1	36.1	31.2	31.2
Net Primary (mgC/m3/day)	19.4	19.4	19.4	24.4	25.6	24.8

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Primary productivity in different project sites in the month of June 2009

Primary productivity	Jameri			Nafra			Dibbin		
	S1	S2	S3	S1	S2	S3	S1	S2	S3
Gross Primary (mgC/m3/day)	46.9	46.9	62.5	31.2	78.1	46.9	31.2	46.9	31.3
Net Primary (mgC/m3/day)	15.6	15.6	31.3	15.6	31.3	31.2	15.6	15.6	15.6
	Dimijin			**Dinchang**			**Dikhri**		
	S1	**S2**	**S3**	**S1**	**S2**	**S3**	**S1**	**S2**	**S3**
Gross Primary (mgC/m3/day)	46.9	46.9	46.9	62.5	62.5	62.5	46.9	46.9	46.9
Net Primary (mgC/m3/day)	15.6	31.3	31.3	31.3	31.2	31.2	15.6	15.6	15.6

	Dinan			Gongri		
	S1	S2	S3	S1	S2	S3
Gross Primary (mgC/m3/day)	45.9	48.9	46.9	60.5	61.5	61.5
Net Primary (mgC/m3/day)	16.6	19.6	17.6	33.3	35.2	32.2
	Utung			**Nazong**		
	S1	**S2**	**S3**	**S1**	**S2**	**S3**
Gross Primary (mgC/m3/day)	42.9	42.9	42.9	34.2	42.3	35.4
Net Primary (mgC/m3/day)	13.6	13.6	13.6	15.6	16.2	15.8

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Primary productivity in different project sites in the month of July 2009

Primary productivity	Jameri			Nafra			Dibbin		
	S1	S2	S3	S1	S2	S3	S1	S2	S3
Gross Primary (mgC/m3/day)	17.5	17.5	10.0	15.0	12.5	17.5	15.0	17.5	15.0
Net Primary (mgC/m3/day)	9.5	10.5	12.0	10.5	12.0	12.0	11.5	11.5	10.5
	Dimijin			**Dinchang**			**Dikhri**		
	S1	**S2**	**S3**	**S1**	**S2**	**S3**	**S1**	**S2**	**S3**
Gross Primary (mgC/m3/day)	17.5	16.5	17.5	10.0	12.0	12.0	17.5	17.5	17.5
Net Primary (mgC/m3/day)	10.5	9.0	11.0	7.0	6.0	7.0	10.5	10.5	10.5

	Dinan			Gongri		
	S1	S2	S3	S1	S2	S3
Gross Primary (mgC/m3/day)	16.5	15.5	16.5	12.5	13.5	15.5
Net Primary (mgC/m3/day)	10.5	11.5	10.5	7.5	9.5	9.5
	Utung			**Nazong**		
	S1	**S2**	**S3**	**S1**	**S2**	**S3**
Gross Primary (mgC/m3/day)	16.5	15.5	16.5	12.5	13.5	15.5
Net Primary (mgC/m3/day)	12.5	11.5	10.5	9.5	8.5	9.5

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Primary productivity in different project sites in the month of August 2009

Primary productivity	**Jameri**			**Nafra**			**Dibbin**		
	S1	**S2**	**S3**	**S1**	**S2**	**S3**	**S1**	**S2**	**S3**
Gross Primary (mgC/m3/day)	19.1	19.5	14.7	15.4	10.3	19.1	13.4	19.1	14.4
Net Primary (mgC/m3/day)	13.4	13.4	9.1	9.4	8.1	15.1	9.5	13.4	8.4
	Dimijin			**Dinchang**			**Dikhri**		
	S1	**S2**	**S3**	**S1**	**S2**	**S3**	**S1**	**S2**	**S3**
Gross Primary (mgC/m3/day)	19.1	19.5	19.1	14.7	14.7	14.7	19.1	19.1	19.1
Net Primary (mgC/m3/day)	13.4	14.1	14.1	9.1	9.1	9.1	13.4	13.4	13.4

	Dinan			**Gongri**		
	S1	**S2**	**S3**	**S1**	**S2**	**S3**
Gross Primary (mgC/m3/day)	18.1	19.1	20.1	16.1	15.1	18.1
Net Primary (mgC/m3/day)	13.4	13.4	13.4	11.4	9.4	12.4
	Utung			**Nazong**		
	S1	**S2**	**S3**	**S1**	**S2**	**S3**
Gross Primary (mgC/m3/day)	18.1	19.1	20.1	16.1	15.1	18.1
Net Primary (mgC/m3/day)	13.4	13.4	13.4	11.4	13.4	12.4

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

Primary productivity in different project sites in the month of September 2009

Primary productivity	**Jameri**			**Nafra**			**Dibbin**		
	S1	**S2**	**S3**	**S1**	**S2**	**S3**	**S1**	**S2**	**S3**
Gross Primary (mgC/m3/day)	16.9	16.9	14.5	15.2	18.1	16.9	15.2	16.9	14.3
Net Primary (mgC/m3/day)	11.6	10.6	9.3	11.6	14.3	12.2	11.6	11.6	10.6
	Dimijin			**Dinchang**			**Dikhri**		
	S1	**S2**	**S3**	**S1**	**S2**	**S3**	**S1**	**S2**	**S3**
Gross Primary (mgC/m3/day)	16.9	16.9	16.9	12.5	12.5	12.5	16.9	16.9	16.9
Net Primary (mgC/m3/day)	11.6	11.3	11.3	9.3	9.2	9.2	11.6	10.6	11.6

	Dinan			**Gongri**		
	S1	**S2**	**S3**	**S1**	**S2**	**S3**
Gross Primary (mgC/m3/day)	15.9	18.9	16.9	16.5	15.5	16.5
Net Primary (mgC/m3/day)	11.6	12.6	11.6	13.3	11.2	12.2
	Utung			**Nazong**		
	S1	**S2**	**S3**	**S1**	**S2**	**S3**
Gross Primary (mgC/m3/day)	15.9	18.9	16.9	16.5	16.5	16.5
Net Primary (mgC/m3/day)	10.6	13.6	12.6	11.3	11.2	12.2

S1 - Upstream of dam site, **S2** - Dam site, **S3** - Downstream of dam site

ANNEXURE-XI

Community characteristics of the vegetation at various sampling locations at different sites in Utung HEP

A. Upstream

Species	**Frequency (%)**	**Density ha^{-1}**	**Basal area (m^2ha^{-1})**	**IVI**
Trees				
Brassiopsis glomerulata	70	105	0.49	27.17
Castanopsis purpurella	45	70	3.54	26.66
Castanopsis sp	10	20	2.26	10.54
Cinnamomum obtusifolia	10	10	0.33	3.96
Drymicarpus racemosus	35	65	3.27	23.51
Elaeocarpus sp	15	15	1.09	7.60
Engelherdtia spicata	45	55	5.58	30.42
Grewia sp	20	35	0.49	9.35
Lithocarpus fenestrata	30	45	4.07	22.28
Lyonia ovalifolia	10	10	0.08	3.28
Macaranga denticulata	5	10	0.79	4.35
Macropanax disperma	40	55	0.47	15.42
Myrica esculenta	20	30	1.51	11.55
Oroxylum sp.	15	20	0.75	7.29
Pithicellobium monodelphium	15	15	0.21	5.16
Quercus griffithii	40	65	5.74	31.21
Rhododendron arboreum	20	35	1.42	11.91
Rhus acuminata	15	15	0.45	5.82
Saurauria nepalensis	20	30	0.28	8.16
Prunus acuminata	15	15	0.07	4.78
Schfellera hypoleuca	15	20	0.12	5.55
Schima khasiana	15	20	1.25	8.66
Spondias pinnata	10	10	0.89	5.52
Talauma hodgsonii	20	25	1.12	9.85

Shrubs	**Frequency (%)**	**Density ha^{-1}**	**IVI**
Clerodendron coolebrokianum	35	90	7.55

Shrubs	**Frequency (%)**	**Density ha^{-1}**	**IVI**
Debregessia longifolia	40	80	8.01
Desmodium sp	15	15	2.60
Ilex sp	50	185	12.32
Indigofera sp	40	385	16.29
Inula cappa	45	335	15.66
Mesea indica	60	220	14.73
Oxospora paniculata	65	355	19.12
Piper sp	40	1065	34.74
Plectranthus sp	70	585	26.09
Polygola axillata	30	40	5.47
Rubus ellipticus	40	55	7.33
Rubus sp	15	20	2.73
Smilax sp	15	30	3.00
Solanum nigrum	35	105	7.96
Solanum xanthocarpum	35	55	6.60
Vernonia volkemerifolia	25	30	4.46
Zanthoxylum sp	30	35	5.33

Herbs (April)	**Frequency (%)**	**Density ha^{-1}**	**IVI**
Polygonum capitatum	55	1250	9.59
Drymeria cordata	10	400	1.96
Elsoltzia blanda	40	2000	8.34
Rhynoglossum obliquim	10	250	1.77
Pilea umbrosa	100	21500	41.46
Elatostemma sessile	95	25900	46.22
Nephralepis cordifolia	90	9250	24.69
Polypodium sp	35	700	5.98
Ophiopogon intermidus	25	350	4.09
Panax sp	10	200	1.71
Begonia sp	30	400	4.88
Thysolena maxima	20	1200	4.42
Trichosanthes sp	15	200	2.44
Oplimanus sp	75	12450	26.50
Selaginella sp	10	2450	4.52
Commelina pedulosa	55	1450	9.84
Paris polyphylla	10	100	1.58
Herbs (August)	**Frequency (%)**	**Density ha^{-1}**	**IVI**
Aeginetia indica	30	2250	4.76
Anthogonium gracile	20	650	2.53
Begonia sp	65	4850	10.30
Chirita articifolia	40	1700	5.36
Chirita pumila	30	450	3.39
Commelina paludosa	55	3700	8.41
Costos speciosus	20	200	2.18
Drymeria cordata	70	8150	13.33
Elatostemma sessile	95	35450	36.73

Elsoltzia blanda	40	2350	5.86
Nephralepis cordifolia	90	9700	16.55
Ophiopogon intermedius	25	400	2.84
Oplismenus sp	75	21000	23.66
Panax sp	50	1400	6.15
Paris polyphylla	15	200	1.68
Pilea umbrosa	100	26850	30.66
Polygonum capitatum	55	1750	6.92
Polypodium sp	35	850	4.20
Rhynoglossum obliquim	35	1950	5.04
Selaginella sp	5	5250	4.52
Thysanolaena maxima	20	1600	3.25
Trichosanthes sp	15	200	1.68

B. Damsite

Species	Frequency (%)	Density ha^{-1}	Basal area (m^2ha-^{1})	IVI
Trees				
Brassiopsis glomerulata	50	80	0.27	25.07
Castanopsis sp	35	45	3.03	32.41
Drymicarpus racemosus	15	20	1.06	12.61
Engelherdtia spicata	65	100	3.54	50.55
Euvodia sp	20	25	0.19	9.41
Ficus roxburghii	10	15	0.28	6.18
Grewia sp	15	30	0.16	8.93
Lithocarpus fenestrata	35	40	1.67	23.69
Macaranga denticulata	30	40	1.69	22.71
Myrica esculenta	15	25	0.27	8.76
Oroxylum sp	15	15	0.13	6.40
Pithicellobium monodelphium	15	15	0.07	6.04
Quercus griffithii	45	65	2.10	32.33
Rhus acuminata	15	20	0.71	10.55
Rhus javanica	20	35	0.14	10.66
Schfellera hypoleuca	25	30	0.14	11.02
Schima khasiana	20	20	1.09	13.8

				9
Syzygium tetragonum	10	20	0.59	8.79

Shrubs	**Frequency (%)**	**Density ha^{-1}**	**IVI**
Boehmeria longifolia	60	385	20.26
Boehmeria macrophylla	10	45	2.82
Buddleja asiatica	35	55	6.87
Clerodendron coolebrokianum	40	170	10.98
Debregessia longifolia	20	25	3.74
Eupatorium odoratum	55	760	30.46
Indigofera sp	75	325	20.77
Mesea indica	50	55	9.12
Oxospora paniculata	35	85	7.74
Piper sp	50	405	19.34
Plectranthus striatus	50	290	15.99
Rubus ellipticus	20	20	3.59
Rubus sp	15	15	2.69
Smilax sp	15	25	2.99
Solanum nigrum	35	80	7.60
Solanum xanthocarpum	35	50	6.72
Urena lobata	55	625	26.52
Vernonia volkemerifolia	10	10	1.80
Herbs (April)	**Frequency (%)**	**Density ha^{-1}**	**IVI**
Polygonum capitatum	90	3900	15.74
Drymeria cordata	25	700	3.88
Gynura cusimba	25	500	3.63
Elsoltzia blanda	45	3500	9.84
Strepcillium volubile	40	600	5.55
Pilea umbrosa	90	19250	35.27
Elatostemma sessile	95	12250	26.96
Urtica dioca	10	400	1.71
Nephralepis cordifolia	100	24250	42.83
Polypodium sp	15	250	2.11
Ophiopogon intermidus	35	450	4.76
Panax sp	10	150	1.39
Begonia sp	10	200	1.45
Thysolena maxima	15	900	2.94
Trichosanthes sp	20	200	2.65
Oplimanus sp	40	5000	11.15
Selaginella sp	10	1750	3.42
Commelina pedulosa	55	2000	9.13
Cyanotis voga	50	1200	7.51
Paris polyphylla	15	250	2.11
Aechyranthes aspera	15	500	2.43
Rubia cordifolia	15	200	2.05

Herbs (August)	**Frequency (%)**	**Density ha^{-1}**	**IVI**
Achyranthes aspera	15	600	1.72
Anthogonium gracile	35	1050	3.78
Begonia sp	45	4450	6.85
Chirita articifolia	70	1050	6.90
Chirita pumila	30	500	2.99
Commelina paludosa	55	3700	7.26
Costos speciosus	10	150	0.99
Cyanotis voga	50	1700	5.53
Drymeria cordata	85	25550	23.93
Elatostemma sessile	95	31550	28.67
Elsoltzia blanda	45	3950	6.53
Gynura cusimba	25	350	2.45
Nephralepis cordifolia	100	26100	25.62
Ophiopogon intermedius	35	450	3.40
Oplismenus sp	40	7550	8.40
Panax sp	20	600	2.16
Paris polyphylla	15	350	1.56
Pilea umbrosa	90	29600	26.97
Polygonum capitatum	90	4550	10.92
Polypodium sp	15	400	1.59
Rhynoglossum obliquim	50	5500	7.97
Rubia cordifolia	15	400	1.59
Selaginella sp	10	3300	3.00
Strepcillium volubile	40	1050	4.23
Thysanolaena maxima	15	1050	2.01
Trichosanthes sp	20	250	1.94
Urtica dioca	10	250	1.05

C. Downstream

Species	**Frequency (%)**	**Density ha^{-1}**	**Basal area (m^2ha^{-1})**	**IVI**
Trees				
Alnus nepalensis	10	20	0.55	10.13
Brassiopsis glomerulata	10	15	0.09	6.45
Castanopsis sp	15	25	1.48	17.97
Drymicarpus racemosus	15	25	1.12	15.88
Engelherdtia spicata	30	55	3.47	39.85
Euvodia sp	20	20	0.21	11.10
Ficus roxburghii	15	20	0.66	12.24
Grewia sp	30	45	0.29	19.52

Lithocarpus penetrata	5	10	0.86	8.45
Lyonia ovalifolia	40	50	0.46	24.41
Macaranga denticulata	15	20	0.49	11.25
Myrica esculenta	10	15	0.61	9.44
Quercus griffithii	50	90	5.20	62.72
Quercus sp	10	15	0.31	7.74
Rhus javanica	25	35	0.13	15.09
Saurauria nepalensis	5	5	0.04	2.68
Schfellera hypoleuca	25	25	0.24	13.75
Schima khasiana	10	10	1.11	11.35

Shrubs	**Frequency (%)**	**Density ha^{-1}**	**IVI**
Boehmeria longifolia	25	240	7.88
Boehmeria macrophylla	20	180	6.09
Buddleja asiatica	15	30	2.73
Clerodendron coolebrokianum	40	150	8.51
Debregessia longifolia	45	60	7.67
Eupatorium odoratum	30	515	13.42
Hydranga aspera	10	15	1.73
Indigofera sp	65	485	18.05
Inula cappa	20	235	7.05
Mesea indica	40	200	9.38
Oxospora paniculata	65	280	14.46
Piper sp	25	1645	32.46
Plectranthus striatus	45	770	20.09
Polygola axillata	20	45	3.73
Rubus ellipticus	35	75	6.46
Rubus sp	20	35	3.55
Smilax sp	20	50	3.82
Solanum nigrum	30	45	5.20
Solanum xanthocarpum	20	30	3.47
Todaelia asiatica	5	10	0.91
Urena lobata	45	525	15.80
Vernonia volkemerifolia	40	95	7.54

Herbs (April)	**Frequency (%)**	**Density ha^{-1}**	**IVI**
Polygonum sp.	15	600	2.81
Polygonum capitatum	75	2700	13.58
Drymeria cordata	10	500	2.03
Gynura cusimba	25	700	4.22
Imperata cylindrica	30	6050	13.17
Nephralepis cordifolia	95	17000	38.35
thalictrum foliolosum	10	250	1.64
Borreria articularis	65	6200	17.78

Bidens pilosa	35	2250	7.88
Achyranthus aspera	65	2250	11.63
Begonia sp	10	250	1.64
Ophiopogon intermidus	35	600	5.31
Oplimanus sp (grass)	50	7900	18.56
Paspallum sp	30	5500	12.32
Carex sp	40	500	5.78
Smithia ciliata	30	1400	5.93
Commelina pedulosa	45	1950	8.66
Crassocephalum crepeoides	20	1200	4.37
Medinila sp	20	250	2.89
Thysolena maxima	30	3900	9.82
Cyanotis voga	55	2050	10.07
Rubia cordifolia	10	200	1.56

Herbs (August)	**Frequency (%)**	**Density ha^{-1}**	**IVI**
Achyranthus aspera	70	3650	8.94
Anthogonium gracile	50	1700	5.75
Begonia sp	65	1050	6.65
Bidens pilosa	35	4300	6.22
Borreria articularis	65	9900	12.91
Carex sp	50	1000	5.25
Commelina paludosa	45	6500	8.69
Crassocephalum crepezoides	20	800	2.38
Cyanotis voga	55	7050	9.99
Drymeria cordata	70	33550	30.09
Gynura cusimba	25	450	2.59
Hedychium sp.	15	200	1.51
Imperata cylindrica	30	12000	11.21
Melastoma sp	20	400	2.10
Nephralepis cordifolia	95	19250	22.25
Ophiopogon intermedius	45	600	4.52
Oplismenus sp	50	14800	15.01
Paspallum sp	30	9100	9.16
Polygonum capitatum	75	4000	9.65
Polygonum sp.	40	1500	4.70
Rubia cordifolia	25	550	2.66
Smithia ciliata	30	2050	4.18
Thalictrum foliolosum	65	2550	7.71
Thysanolaena maxima	30	4450	5.87

ANNEXURE-XII

Community characteristics of the vegetation at various sampling locations at different sites in Nazong HEP

A. Upstream

Species	Frequency (%)	Density ha^{-1}	Basal area (m^2ha^{-1})	IVI
Trees				
Castanopsis purpurella	25	30	0.80	15.60
Engelhertia spicata	15	25	0.62	10.83
Lyonia ovalifolia	60	65	0.25	32.72
Quercus griffithii	100	365	44.53	191.33
Rhododendron arboreum	75	110	0.49	46.01
Rhus javanica	5	10	0.03	3.51

Shrubs	Frequency (%)	Density ha^{-1}	IVI
Boehmeria longifolia	40	520	16.77
Boehmeria macrophylla	15	45	3.27
Buddleja asiatica	20	90	4.96
Clerodendron coolebrokianum	45	95	9.00
Debregessia longifolia	50	150	10.90
Eupatorium odoratum	30	490	14.59
Indigofera sp	60	1130	32.21
Inula cappa	70	510	21.30
Mesea indica	45	135	9.81
Piper sp	30	115	7.04
Plectranthus sp	85	980	33.12
Rubus ellipticus	20	25	3.65
Smilax sp	20	30	3.75
Solanum nigrum	30	90	6.54
Solanum xanthocarpum	25	35	4.64
Urena lobata	50	525	18.45

Herbs (April)	Frequency (%)	Density ha^{-1}	IVI
Polygonum sp	50	600	5.52
Polygonum capitatya	100	5250	15.39
Gynura cusimbua	50	700	5.63
Imperata cylidrica	95	28400	39.74
Nephralepis cordifolia	95	10400	20.43
Thalictrum foliosum	90	1700	10.60
Borreria articularis	70	7000	14.34
Achyranthus aspera	40	1300	5.30

Herbs (April)	Frequency (%)	Density ha^{-1}	IVI
Begonia sp	35	350	3.79
Ophiopogon intermidus	40	500	4.44
Opliomenus sp(grass)	75	17800	26.42
Paspalum sp	35	2800	6.42
Carex sp	30	400	3.36
Smithia ciliata	35	1250	4.76
Commelina paledosa	50	1900	6.92
Crassocephalum crepiides	40	1200	5.19
Medinila sp	45	900	5.36
Thysonalena maxima	50	10750	16.41

Herbs (August)	Frequency (%)	Density ha^{-1}	IVI
Achyranthus aspera	40	1100	3.96
Aeginetia indica	45	8200	8.86
Anemone vitifolia	10	150	0.91
Anthogonium gracile	60	2300	6.35
Begonia sp	35	550	3.21
Borreria articularis	70	7550	10.49
Carex sp	30	450	2.73
Commelina paludosa	50	7450	8.80
Crassocephalum crepizoides	40	1900	4.47
Drymaria cordata	65	6950	9.70
Gynura cusimbua	50	1050	4.75
Hedychium sp	15	150	1.32
Imperata cylindrica	95	48000	38.13
Melastoma sp	45	1150	4.40
Nephrolepis cordifolia	95	11350	14.94
Ophiopogon intermedius	40	750	3.74
Opliomenus sp	75	33450	27.29
Paspalum sp	35	4250	5.55
Polygonum capitata	100	4850	11.23
Polygonum sp	55	1350	5.34
Smithia ciliata	35	1150	3.58
Thalictrum foliosum	90	3550	9.59
Thysanolaena maxima	50	10350	10.63

B. Damsite

Species	Frequency (%)	Density ha^{-1}	Basal area (m^2ha-^{1})	IVI
Trees				
Alnus nepalensis	30	160	6.39	63.06
Betula alnoides	5	5	0.37	4.05
Brassiopsis glomerulata	15	20	3.24	21.99

Species	**Frequency (%)**	**Density ha^{-1}**	**Basal area (m^2ha^{-1})**	**IVI**
Castanopsis purpurella	45	80	4.61	47.68
Castanopsis purpurella	15	15	1.48	13.73
Drymicarpus racemosus	15	20	1.02	12.63
Eleocarpus sp	5	5	0.57	4.92
Engelhardtia spicata	15	20	1.56	14.89
Euvodia sp	5	10	0.18	4.08
Ficus roxburghii	15	15	0.15	8.14
Grewia sp	10	10	0.12	5.50
Lithocarpus penetrata	5	15	0.35	5.59
Macaranga denticulata	25	120	0.06	28.22
Oroxylum sp.	10	10	0.12	5.53
Pithicellobium monodelphium	5	10	0.09	3.69
Prunus acuminata	5	5	0.02	2.57
Quercus griffithii	15	20	1.55	14.87
Quercus sp	15	30	0.75	13.13
Rhus acuminata	10	10	0.38	6.63
Scfellera hypoleuca	20	25	0.25	11.90
Schima khasiana	5	5	0.44	4.35
Syzygium tetragonum	5	5	0.08	2.86

Shrubs	**Frequency (%)**	**Density ha^{-1}**	**IVI**
Boehmeria longifolia	70	385	19.35
Boehmeria macrophylla	45	375	15.91
Clerodendron coolebrokianum	40	55	6.56
Clerodendron viscosum	15	15	2.31
Debregessia longifolia	50	85	8.65
Eupatorium odoratum	30	495	17.29
Indigofera sp	50	175	11.10
Inula cappa	55	125	10.37
Mesea indica	50	115	9.46
Oxospora paniculata	85	310	19.21
Piper sp	35	420	15.87
Plectranthus sp	80	595	26.34
Rubus ellipticus	20	20	3.08
Smilax sp	5	15	1.04
Solanum nigrum	40	110	8.06
Solanum xanthocarpum	40	55	6.56
Urena lobata	60	280	15.22
Vernonia volkemerifolia	20	40	3.62

Herbs (April)	**Frequency (%)**	**Density ha^{-1}**	**IVI**
Polygonum sp.	15	250	3.09
Polygonum	60	1500	13.20

Herbs (April)	**Frequency (%)**	**Density ha^{-1}**	**IVI**
capitatum			
Elsoltzia blanda	30	2400	9.34
Pilea umbrosa	70	27000	57.28
Elatostemma sessile	70	6000	22.45
Gynura cusimba	35	1700	9.07
Urtica dioca	10	1350	4.02
Nephralepis cordifolia	70	12900	33.89
Polypodium sp	60	1200	12.70
Ophiopogon intermidus	10	250	2.20
Carex sp	5	100	1.06
Balanophora dioca	5	250	1.31
Panax sp	10	150	2.03
Medinila sp	15	300	3.18
Begonia sp	40	1600	9.80
Opliomenus sp(grass)	30	2550	9.59
Tetrastigma serrulatum	5	100	1.06
Costos speciosus	10	300	2.28
Achyranthus aspera	10	400	2.45

Herbs (August)	**Frequency (%)**	**Density ha^{-1}**	**IVI**
Achyranthus aspera	5	200	0.82
Aegenitia indica	10	2250	3.57
Anemone vitifolia	20	800	3.26
Anthogonium gracile	55	2150	8.92
Balanophora dioca	5	300	0.92
Begonia sp	35	4800	9.28
Carex sp	5	200	0.82
Chirita articifolia	25	500	3.55
Chirita pumilaa	20	500	2.95
Costos speciosus	10	200	1.42
Dioscorea bulbulifora	5	50	0.66
Drymeria cordata	45	5700	11.44
Elatostemma sessile	70	7400	16.25
Elsoltzia blanda	30	2150	5.89
Gynura cusimba	35	1600	5.92
Hedychium (white)	10	200	1.42
Hedychium densiflora	5	100	0.71
Medinila sp	15	300	2.13
Nephralepis cordifolia	70	14400	23.60
Ophiopogon intermidus	10	250	1.47
Opliomenus	30	4900	8.78

sp(grass)			
Panax sp	35	2550	6.92
Pilea umbrosa	70	34000	44.16
Polygonum capitatum	60	1750	9.11
Polygonum white	15	450	2.29
Polypodium sp	60	1500	8.85
Rhynoglossum obliquim	15	1800	3.71
Strepcilirium volubile	15	300	2.13
Tetrastigma serrulatum	5	150	0.76
Thalictrum foliosum	25	2350	5.50
Urtica dioca	10	1500	2.79

C. Downstream

Species	**Frequency (%)**	**Density ha^{-1}**	**Basal area (m^2ha-^{1})**	**IVI**
Trees				
Engelhardtia spicata	50	80	3.95	43.26
Alnus nepalensis	45	105	2.30	37.45
Betula alnoides	5	5	0.19	2.88
Brassiopsis glomerulata	15	20	0.06	6.76
Castanopsis purpurella	65	90	2.72	42.07
Drymicarpus racemosus	20	30	0.71	12.66
Ficus roxburghii	15	15	0.27	7.08
Ficus sp	5	5	2.10	12.45
Grewia sp.	20	40	0.49	13.02
Lithocarpus fenestrata	25	30	0.76	14.07
Lyonia ovalifolia	10	15	0.10	5.03
Macaranga denticulata	20	45	1.41	18.34
Oroxylum sp.	15	20	0.23	7.59
Pithicellobium monodelphium	5	10	0.07	3.01
Prunus acuminata	5	5	0.03	2.06
Quercus griffithii	30	45	3.32	30.25
Rhododendron arboreum	10	25	0.35	7.74
Rhus acuminata	10	10	0.06	4.13
Rhus javanica	15	40	0.01	9.43
Schfellera hypoleuca	25	35	0.19	11.9

				3
Schima khasiana	10	10	0.58	6.70
Syzygium tetragonum	5	5	0.03	2.06

Shrubs	**Frequency (%)**	**Density ha^{-1}**	**IVI**
Boehmeria longifolia	40	115	7.83
Boehmeria macrophylla	10	25	1.88
Buddleja asiatica	15	20	2.43
Clerodendron coolebrokianum	45	120	8.60
Debregessia longifolia	50	85	8.49
Desmodium sp	15	25	2.54
Eupatorium odoratum	100	1390	43.86
Indigofera sp	45	55	7.17
Inula cappa	85	245	16.65
Mesea indica	45	80	7.72
Piper sp	50	445	16.42
Plectranthus striatus	100	1170	39.02
Rubus ellipticus	20	30	3.31
Rubus sp	10	15	1.65
Smilax sp	20	30	3.31
Solanum nigrum	25	95	5.40
Solanum xanthocarpum	10	10	1.54
Urena lobata	70	585	22.16

Herbs (April)	**Frequency (%)**	**Density ha^{-1}**	**IVI**
Polygonum sp.	40	1000	7.83
Polygonum capitatum	55	2450	12.90
Elsoltzia blanda	55	8700	25.31
Rhynoglossum obliquim	15	600	3.38
Pilea umbrosa	70	14250	38.52
Elatostemma sessile	60	3750	16.21
Drymeria cordata	40	1700	9.22
Gynura cusimba	10	500	2.45
Urtica dioca	25	2000	7.62
Nephralepis cordifolia	65	8900	27.17
Polypodium sp	55	1000	10.02
Ophiopogon intermidus	20	350	3.61
Carex sp	15	250	2.69
Panax sp	5	100	0.93
Begonia sp	40	600	7.03
Paris polyphylla	10	150	1.76
Costos speciosus	15	150	2.49
Bidens pilosa	20	900	4.71
Crassocephalum conyzoides	10	600	2.65
Borreria articularis	15	900	3.98

Opliomenus sp(grass)	10	250	1.96
Achyranthus aspera	10	500	2.45
Thalictrum foliosum	25	750	5.14

Herbs (August)	**Frequency (%)**	**Density ha^{-1}**	**IVI**
Achyranthus aspera	10	600	1.69
Aeginetia indica	20	4800	7.41
Anemone vitifolia	15	300	1.86
Anthogonium gracile	65	3250	10.24
Begonia sp	30	1200	4.39
Bidens pilosa	20	1900	4.16
Borreria articularis	15	700	2.31
Carex sp	15	400	1.97
Chirita articifolia	45	800	5.47
Costos speciosus	15	200	1.75
Crassocephalum crepezoides	10	350	1.41
Drymaria cordata	70	11800	20.34
Elatostemma sessile	55	4100	10.18
Elsoltzia blanda	55	9400	16.13
Gynura cusimba	10	350	1.41
Hedychium sp.	25	300	2.87
Nephrolepis cordifolia	65	9250	16.97
Ophiopogon intermedius	20	400	2.48
Opliomenus sp	35	1250	4.96
Panax sp	10	250	1.30
Paris polyphylla	10	150	1.18
Pilea umbrosa	70	15850	24.89
Polygonum capitatum	55	2950	8.89
Polygonum sp	40	1150	5.35
Polypodium sp	55	900	6.59
Rhynchoglossum obliquum	55	12100	19.16
Strepcilirium volubile	50	700	5.86
Thalictrum foliosum	20	1500	3.71
Urtica dioca	25	2250	5.06

ANNEXURE-XIII

Community characteristics of the vegetation at various sampling locations at different sites in Dibbin HEP

A. Upstream

Species	Frequency (%)	Density ha^{-1}	Basal area ($m^2 ha^{-1}$)	IVI
Tree				
Alnus nepalensis	5	5	0.40	4.23
Betula alnoides	5	5	0.08	2.97
Brassiopsis glomerulata	15	30	0.09	10.82
Castanopsis perpurella	25	30	0.72	16.90
Castanopsis sp	5	10	0.80	6.70
Cephalotaxus sp	5	5	0.02	2.70
Drymicarpus racemosus	10	15	0.69	8.88
Engelherdtia spicata	30	40	5.47	39.42
Ficus roxburghii	5	5	0.06	2.86
Grewia sp	5	10	0.08	3.81
Lithocarpus fenestrata	5	10	0.86	6.94
Lyonia ovalifolia	35	50	0.24	21.95
Macaranga denticulata	5	10	0.05	3.69
Macropanax disperma	10	10	0.12	5.75
Oroxylum sp	5	10	0.07	3.76
Pithicellobium monodelphium	5	5	0.02	2.70
Prunus acuminata	5	5	0.01	2.68
Quercus griffithii	70	300	14.66	134.63
Rhus acuminata	5	5	0.08	2.97
Rhus javanica	5	5	0.01	2.68
Schfellera sp	10	15	0.17	6.81
Syzygium tetragonum	10	10	0.22	6.17

Shrubs	Frequency (%)	Density ha^{-1}	IVI
Boehmeria longifolia	20	35	3.88
Buddlegia asiatica	10	15	1.87
Clerodendron coolebrokianum	20	105	5.77
Debregessia longifolia	55	80	10.24
Desmodium sp	30	40	5.49
Eupatorium odoratum	100	1185	46.60
Indigofera sp	25	40	4.75
Inula cappa	35	110	8.11
Mesea indica	45	85	8.91
Piper sp	40	195	11.13
Plectranthus striatus	100	1120	44.85
Rubus ellipticus	30	40	5.49
Rubus sp	30	35	5.35

Smilax sp	10	10	1.74
Solanum nigrum	40	120	9.11
Solanum xanthocarpum	5	5	0.87
Urena lobata	85	495	25.82

Herbs (April)	**Frequency (%)**	**Density ha^{-1}**	**IVI**
Achyranthus aspera	25	750	3.29
Balanophora dioca	5	300	0.89
Begonia sp	50	700	5.34
Borreria articularis	70	4850	13.50
Carex sp	30	500	3.33
Costos speciosus	15	200	1.59
Drymeria cordata	25	750	3.29
Elatostemma sessile	80	4900	14.43
Elstoltzia blanda	65	4800	13.00
Gynura cusimba	80	1200	8.67
Hedychium sp	10	250	1.24
Hedyotis sp	20	800	2.95
Imperata cylindrica	25	4300	8.82
Leucus ciliata	10	700	1.94
Nephralepis cordifolia	90	10100	23.37
Ophiopogon intermidus	55	800	5.93
Opliomenus sp(grass)	85	9000	21.23
Panax sp	20	500	2.48
Paris polyphylla	30	300	3.02
Pilea umbrosa	80	5350	15.13
Plantago major	20	500	2.48
Polygonum capitata	80	2500	10.70
Polygonum white	50	1400	6.43
Polypodium sp	70	1700	8.60
Rhynoglossum obliquim	15	900	2.68
Trictosanthes sp	15	200	1.59
Urtica dioca	55	6050	14.09

Herbs (August)	**Frequency (%)**	**Density ha^{-1}**	**IVI**
Achyranthus aspera	25	800	2.48
Aegenitia indica	10	900	1.55
Anthogonium gracile	60	1150	5.22
Balanophora dioca	5	300	0.63
Begonia sp	50	900	4.29
Borreria articularis	70	5500	10.11
Carex sp	30	500	2.54
Chirita pumila	40	500	3.22
Chirita urticifolia	85	1700	7.46
Costos speciosus	15	200	1.22
Drymeria cordata	85	17400	22.63
Elatostemma sessile	80	5850	11.13
Elstoltzia blanda	60	5300	9.23

Gynura cusimba	80	2550	7.94
Hedgotis sp	15	800	1.80
Hedychium sp	10	100	0.78
Imperata cylindrica	25	5450	6.98
Leucus ciliata	10	900	1.55
Nephralepis cordifolia	90	10600	16.40
Ophiopogon intermidus	55	700	4.44
Opliomenus sp(grass)	85	14850	20.16
Panax sp	20	750	2.09
Paris polyphylla	30	350	2.39
Pilea umbrosa	75	8850	13.68
Plantago major	20	600	1.95
Polygonum capitata	75	3050	8.08
Polygonum white	80	2900	8.28
Polypodium sp	70	1800	6.53
Rhynoglossum obliquim	35	1750	4.09
Trictosanthes sp	15	200	1.22
Urtica dioca	55	6350	9.90

B. Submergence

Species	**Frequency (%)**	**Density ha^{-1}**	**Basal area (m^2ha^{-1})**	**IVI**
Trees				
Alnus nepalensis	10	10	0.14	6.50
Castanopsis perpurella	60	105	1.58	55.78
Engelherdtia spicata	35	55	1.23	34.99
Erythrina stricta	10	15	0.10	6.99
Lyonia ovalifolia	35	40	0.26	21.16
Macaranga denticulata	15	85	2.04	43.45
Musa sp	25	75	0.94	32.18
Pithicellobium monodelphium	5	5	0.05	2.99
Quercus griffithii	35	45	1.43	35.53
Rhododendron sp.	40	55	0.55	28.71
Rhus acuminata	15	15	0.11	8.70
Rhus javanica	15	25	0.08	10.14
Schfellera sp	10	10	0.09	6.00
Schima khasiana	5	5	0.02	2.65
Syzigium tetragonum	5	10	0.07	4.22

Shrubs	**Frequency (%)**	**Density ha^{-1}**	**IVI**
Acacia pinnata	25	60	5.17
Clerodendron coolebrokianum	35	45	6.29
Clerodendron viscosum	20	25	3.58
Debregessia longifolia	40	55	7.27

Shrubs	**Frequency (%)**	**Density ha^{-1}**	**IVI**
Desmodium sp	15	20	2.71
Eupatorium odoratum	75	1355	44.32
Indigofera sp	40	60	7.40
Inula cappa	30	115	7.26
Melatostoma sp	20	40	3.94
Mesea indica	45	95	9.00
Oxospora paniculata	90	300	20.69
Piper sp	25	310	11.30
Plectranthus sp	75	1335	43.83
Rubus ellipticus	30	35	5.30
Solanum nigrum	35	75	7.02
Solanum xanthocarpum	20	20	3.45
Urena lobata	55	135	11.46

Herbs (April)	**Frequency (%)**	**Density ha^{-1}**	**IVI**
Achyranthus aspera	35	1200	5.64
Begonia sp	20	250	2.54
Borreria articularis	70	2800	11.91
Carex sp	15	250	2.00
Costos speciosus	35	400	4.39
Dioscorea sp	5	100	0.69
Drymeria cordata	15	700	2.71
Elatostemma sessile	50	7500	17.12
Elstoltzia blanda	20	1400	4.34
Gynura cusimba	25	900	4.10
Nephralepis cordifolia	90	5250	17.90
Ophiopogon intermidus	20	200	2.46
Opliomenus sp(grass)	35	5250	11.99
Pilea umbrosa	90	14250	32.00
Polygonum capitata	60	3250	11.54
Polygonum white	40	600	5.24
Polypodium sp	55	1250	7.87
Pouzolzia hirta	75	5250	16.29
Rhynoglossum obliquim	40	2250	7.82
Rubia cordifolia	40	450	5.01
Trictosanthes sp	10	150	1.31
Urtica dioca	85	10200	25.11

Herbs (August)	**Frequency (%)**	**Density ha^{-1}**	**IVI**
Achyranthus aspera	35	1900	4.82
Ariosema sp	25	300	2.44
Begonia sp	20	400	2.10
Borreria articularis	65	4050	9.44
Carex sp	15	250	1.53
Chirita pumila	35	500	3.49
Chirita urticifolia	45	1300	5.11

Herbs (August)	Frequency (%)	Density ha^{-1}	IVI
Costos speciosus	35	550	3.54
Dioscorea sp	5	100	0.53
Drymeria cordata	70	14500	19.77
Elatostemma sessile	50	9150	12.98
Elstoltzia blanda	20	1450	3.10
Gynura cusimba	25	1200	3.29
Nephralepis cordifolia	85	6250	13.25
Ophiopogon intermidus	20	250	1.96
Oplismenus sp*(*grass*)*	40	10550	13.44
Pilea umbrosa	90	16100	23.01
Polygonum capitata	75	4100	10.35
Polygonum white	40	750	4.16
Polypodium sp	50	1500	5.73
Pouzolzia hirta	75	8250	14.28
Rhynoglossum obliquim	55	6450	10.85
Rubia cordifolia	35	450	3.44
Trictosanthes sp	10	150	1.00
Urtica dioca	80	14100	20.26
Viola sikkimensis	60	1000	6.12

C. Damsite

Species	Frequency (%)	Density ha^{-1}	Basal area ($m^2ha\text{-}^1$)	IVI
Trees				
Aralia thompsonii	5	10	0.03	3.81
Bamboo	5	85	0.44	18.02
Betula alnoides	5	5	0.32	5.55
Brassiopsis glomerata	10	10	0.03	5.96
Castanopsis sp	10	15	0.31	9.03
Cephalotaxus sp	5	5	0.01	2.95
Chukressia tubularis	5	5	0.44	6.52
Drymicarpus racemosus	30	40	3.32	46.36
Engelherdtia spicata	5	5	0.19	4.48
Itea macrophylla	5	5	0.01	2.95
Lithocarpus penetrata	5	5	0.14	4.05
Litsea sp	5	5	0.05	3.28
Macaranga denticulata	10	10	0.42	9.23
Macropanax disperma	5	5	0.02	3.02
Malvaceae (type)	5	10	0.48	7.61
Melia sp	5	5	1.75	17.54

Musa sp	20	125	1.54	39.39
Ostodes paniculata	5	5	0.06	3.38
Prunus sp	10	10	0.37	8.80
Schfellera hypoculasp	10	15	0.32	9.08
Toona ciliata	5	5	0.32	5.55
Wallichiana (fern)	65	310	1.34	83.47

Shrubs	**Frequency (%)**	**Density ha^{-1}**	**IVI**
Acacia pinnata	40	60	7.10
Artemesia nilagirica	50	335	17.11
Boehmeria longifolia	50	280	15.37
Boehmeria macrophylla	55	370	18.87
Clerodendron coolebrokianum	45	60	7.75
Debregessia sp	70	470	23.99
Eupatorium odoratum	55	310	16.97
Indigofera sp	50	110	9.98
Inula cappa	5	40	1.92
Litsea citrata	20	25	3.39
Mesea indica	45	110	9.33
Oxospora paniculata	45	65	7.90
Piper sp	25	195	9.43
Plectranthus sp	60	345	18.73
Rubus ellipticus	20	25	3.39
Rubus sp	10	10	1.62
Solanum nigrum	15	60	3.85
Solanum xanthocarpum	20	30	3.55
Urena lobata	75	235	17.19
Vernonia volmesifolia	15	20	2.58

Herbs (April)	**Frequency (%)**	**Density ha^{-1}**	**IVI**
Achyranthus aspera	35	500	4.22
Bamboo grass	15	9250	13.57
Begonia sp	40	600	4.86
Borreria articularis	50	2500	8.36
Carex sp	20	400	2.56
Costos speciosus	20	200	2.30
Cyclea bristata	15	200	1.79
Dioscorea sp	25	250	2.88
Drymeria cordata	20	400	2.56
Elatostemma sessile	45	3900	9.67
Elstoltzia blanda	45	3500	9.15
Gynura cusimba	25	700	3.46
Nephralepis cordifolia	80	9200	20.14
Ophiopogon intermidus	15	250	1.86
Opliomenus sp(grass)	65	7750	16.72

Herbs (April)	**Frequency (%)**	**Density ha^{-1}**	**IVI**
Pilea umbrosa	55	10100	18.76
Polygonum capitata	70	4900	13.52
Polygonum white	60	1000	7.42
Polypodium sp	40	1500	6.03
Pouzolzia hirta	80	3900	13.24
Rhynoglossum obliquim	30	600	3.84
Rubia cordifolia	45	750	5.57
Trictosanthes sp	10	150	1.22
Urtica dioca	75	14300	26.27

Herbs (August)	**Frequency (%)**	**Density ha^{-1}**	**IVI**
Achyranthus aspera	35	600	3.64
Ariosema sp	20	250	1.99
Bamboo grass	15	10400	11.34
Begonia sp	40	700	4.17
Borreria articularis	50	2600	6.87
Carex sp	25	450	2.62
Chirita pumila	40	600	4.07
Chirita urticifolia	45	850	4.75
Costos speciosus	20	250	1.99
Cyclea bristata	15	200	1.50
Dioscorea sp	20	250	1.99
Drymeria cordata	55	10600	15.03
Elatostemma sessile	40	4550	7.88
Elstoltzia blanda	45	3950	7.74
Gynura cusimba	25	700	2.86
Nephralepis cordifolia	80	9400	16.05
Ophiopogon intermidus	15	200	1.50
Opliomenus sp(grass)	65	12750	17.97
Pilea umbrosa	55	12100	16.47
Polygonum capitata	75	5700	12.05
Polygonum white	65	1300	6.93
Polypodium sp	45	1600	5.47
Pouzolzia hirta	80	5700	12.48
Rhynoglossum obliquim	30	1650	4.21
Rubia cordifolia	45	700	4.61
Trictosanthes sp	10	150	1.02
Urtica dioca	75	15300	21.30
Viola sikkimensis	15	200	1.50

ANNEXURE-XIV

Community characteristics of the vegetation at various sampling locations at different sites in Dimijin HEP

A. Upstream

Species	Frequency (%)	Density ha^{-1}	Basal area (m^2ha^{-1})	IVI
Trees				
Callicarpa arborea	10	15	0.06	11.19
Castanopsis purpurella	25	30	0.13	25.85
Pinus sp	100	390	6.75	252.85
Rhus acuminata	10	10	0.07	10.16

Shrubs	Frequency (%)	Density ha^{-1}	IVI
Buddleja asiatica	10	2500	6.25
Desmodium sp	20	3500	11.10
Eupatorium odoratum	55	61000	78.31
Indigofera sp	70	9000	35.82
Plectranthus striatus	30	18500	28.97
Rubus sp	40	5500	20.80
Rubus ellipticus	30	7500	18.74

Herbs (April)	Frequency (%)	Density ha^{-1}	IVI
Imperata cylindrica	100	17950	99.24
Borreria articularis	60	2400	27.84
Lygodium flexus	55	750	20.03
Crossocephalum crepezoides	10	900	6.53
Bidens pilosa	25	1900	15.01
Nephrolepis cordifolia	70	2500	31.34

Herbs (August)	Frequency (%)	Density ha^{-1}	IVI
Bidens pilosa	20	1700	9.91
Borreria articularis	55	2850	23.11
Crassocephalum crepezoides	10	750	4.73
Imperata cylindrica	100	34950	109.38
Lygodium flexus	55	800	18.48
Nephrolepis cordifolia	70	2800	27.55
Oxalis sp	20	350	6.85

B. Damsite

Species	Frequency (%)	Density ha^{-1}	Basal area ($m^2 ha^{-1}$)	IVI
Trees				
Acer laevigatum	5	5	0.19	5.82
Alangium chinensis	20	20	0.08	14.82
Albizzia sp	15	15	0.34	14.47
Alnus nepalensis	15	20	0.26	15.08
Bauhinia sp	10	10	0.03	7.27
Callicarpa arborea	15	15	0.08	11.39
Dysoxylon gobara	10	10	0.12	8.45
Ficus sp	35	50	3.95	76.55
Glochidium sp	25	40	0.18	24.24
Grewia sp	20	25	0.16	17.36
Litsea sp	15	15	0.12	11.85
Rhus acuminata	15	15	0.22	13.10
Schima wallichii	25	30	1.04	31.51
Toona ciliata	40	45	1.55	48.07

Shrubs	Frequency (%)	Density ha^{-1}	IVI
Artemesia nilagirica	80	2015	60.47
Boehmeria longifolia	40	50	6.71
Boehmeria platyphylla	30	110	6.81
Buddleja asiatica	25	35	4.28
Clerodendron coolebrokianum	70	375	18.80
Desmodium sp	25	30	4.16
Eupatorium odoratum	35	235	10.57
Indigofera sp	60	115	11.04
Inula cappa	60	150	11.90
Mesea indica	65	135	12.22
Piper v	45	515	18.82
Rubus ellipticus	40	50	6.71
Senecio sp	45	80	8.13
Solanum nigrum	40	75	7.32
Solanum xanthocarpum	20	20	3.23
Woodfordia sp	30	50	5.34
Zanthoxylum v	20	30	3.48

Herbs (April)	Frequency (%)	Density ha^{-1}	IVI
Begonia sp	40	600	10.84
Paderia foetida	50	900	14.07
Pilea umbrosa	50	6200	32.19
Ageratum conyzoides	55	8500	41.15
Crassocephalum crepezoides	40	2250	16.48

Herbs (April)	Frequency (%)	Density ha^{-1}	IVI
Saccharum sp	60	5200	30.96
Hedyotis scandens	30	400	7.96
Stephania sp	5	50	1.27
Nephrolepis cordifolia	65	2400	22.49
Drycrenepteris lineries	20	2250	12.09
Achyranthes aspera	40	500	10.50

Herbs (August)	Frequency (%)	Density ha^{-1}	IVI
Achyranthes aspera	40	650	9.87
Ageratum conyzoides	55	9100	39.22
Alocasia sp	10	250	2.74
Arisaema sp	20	250	4.70
Begonia sp	45	750	11.17
Crassocephalum crepezoides	40	2100	14.41
Drycrenepteris linearies	20	2300	11.11
Hedyotis scandens	30	450	7.29
Nephrolepis cordifolia	65	2500	20.56
Oxalis sp	20	350	5.02
Paderia foetida	50	1000	12.93
Pilea umbrosa	50	6550	30.27
Saccharum spontaneum	60	5700	29.58
Stephania sp	5	50	1.14

C. Downstream

Species	Frequency (%)	Density ha^{-1}	Basal area (m^{2}ha-^{1})	IVI
Trees				
Callicarpa arborea	10	10	0.11	13.15
Pinus sp	100	300	3.63	255.72
Rhus javanica	25	35	0.10	31.17

Shrubs	Frequency (%)	Density ha^{-1}	IVI
Artemesia nilagirica	90	690	111.76
Boehmeria longifolia	30	35	16.73
Buddleja asiatica	10	15	5.93
Eupatorium odoratum	40	140	32.13
Rubus ellipticus	20	25	11.33
Solanum nigrum	15	15	8.10
Woodfordia sp	25	30	14.03

Herbs (April)	Frequency (%)	Density ha^{-1}	IVI
Imperata cylindrica	100	26000	90.13
Borreria articularis	75	4250	30.59
Lygodium flexus	45	500	13.38

Crassocephalum crepezoides	20	600	6.86
Bidens pilosa	30	1750	12.36
Nephrolepis cordifolia	75	7500	38.47
Potentilla sp	25	600	8.21
Herbs (August)	**Frequency (%)**	**Density ha^{-1}**	**IVI**
Bidens pilosa	30	1550	10.38
Borreria articularis	75	4850	27.77
Crassocephalum crepezoides	20	400	5.74
Imperata cylindrica	100	36500	92.91
Lygodium flexus	45	650	12.46
Nephrolepis cordifolia	75	8500	34.56
Oxalis sp	30	750	8.90
Potentilla sp	25	550	7.27

ANNEXURE-XV

Community characteristics of the vegetation at various sampling locations at different sites in Dikhri HEP

A. Upstream

Species	Frequency (%)	Density (ha^{-1})	BA (m^2ha^{-1})	IVI
Trees				
Alnus nepalensis	5	10	0.67	4.21
Betula alnoides	10	10	0.69	5.34
Brassiopsis glomerulata	20	35	0.22	10.67
Castanopsis purpurella	5	15	1.00	5.75
Castanopsis sp	35	50	4.85	26.51
Cyathea gigantea	5	5	0.07	2.08
Drymicarpus racemosus	5	5	0.40	2.79
Engelherdtia spicata	60	75	7.52	41.95
Ficus roxburghii	5	5	0.24	2.45
Ficus sp	5	5	2.29	6.91
Grewia sp	20	35	0.42	11.10
Juglans regia	5	10	0.48	3.80
Lithocarpus fenestrata	15	15	3.37	13.11
Lyonia ovalifolia	35	55	0.44	17.74
Macaranga denticulata	10	10	0.33	4.58
Macropanax disperma	10	15	0.13	4.96
Michelia sp	20	30	12.57	36.71
Myrica esculenta	15	15	0.38	6.60
Prunus accuminata	10	10	0.24	4.37
Quercus griffithii	35	55	4.38	26.32
Quercus sp	20	25	0.85	10.38
Rhododendron arboreum	15	20	0.92	8.62
Rhus javanica	25	30	0.12	10.72
Saurauria nepalensis	10	10	0.13	4.13
Schfellera hypoleuca	10	10	0.12	4.11
Schima khasiana	15	15	2.22	10.61
Talauma hodgsonii	5	5	0.78	3.62
Viburnum sp	15	15	0.07	5.93
Wendlendia sp	10	10	0.03	3.92

Shrubs	Frequency (%)	Density (ha^{-1})	IVI
Boehmeria longifolia	20	80	4.30
Boehmeria macrophylla	30	110	6.32
Clerodendron coolebrokianum	20	155	5.28
Clerodendron viscosum	25	55	4.79
Debregessia longifolia	25	75	5.05
Desmodium sp	15	20	2.70
Eupatorium odoratum	15	210	5.19

Shrubs	**Frequency (%)**	**Density (ha^{-1})**	**IVI**
Hydranga aspera	10	10	1.76
Ilex sp	35	365	10.47
Indigofera sp	10	380	6.60
Inula cappa	10	285	5.36
Mesea indica	70	630	19.63
Oxospora paniculata	65	565	17.97
Piper sp	55	2975	47.91
Plectranthus striatus	65	1170	25.89
Polygola arillata	10	25	1.95
Rubus ellipticus	10	25	1.95
Rubus sp	20	25	3.58
Smilax sp	15	30	2.83
Solanum nigrum	15	20	2.70
Solanum xanthocarpum	25	30	4.46
Urena lobata	25	335	8.45
Vernonia volkemerifolia	25	60	4.85

Herbs (April)	**Frequency (%)**	**Density (ha^{-1})**	**IVI**
Polygonum white	35	900	7.73
Polygonum capitatum	30	1150	7.55
Thalictrum foliosum	30	400	5.73
Elsoltzia blanda	35	2100	10.64
Strepcilirium volubile	30	400	5.73
Rhynoglossum obliquim	10	200	2.07
Pilea umbrosa	70	7850	30.12
Elatostemma sessile	20	500	4.39
Elatostemma disectum	20	2250	8.62
Drymeria cordata	10	600	3.04
Gynura cusimba	20	250	3.78
Urtica dioca	20	2000	8.02
Nephralepis cordifolia	90	7250	31.84
Polypodium sp	35	1050	8.10
Ophiopogon intermidus	20	400	4.14
Carex sp	25	350	4.82
Begonia sp	15	1300	5.53
Thysolena maxima	20	5200	15.77
Opliomenus sp.	70	2600	17.41
Selaginella sp	20	4450	13.95
Costos speciosus	5	100	1.04

Herbs (August)	**Frequency (%)**	**Density (ha^{-1})**	**IVI**
Anemone vitifolia	10	400	1.60
Anthogonium gracile	55	2400	9.05
Begonia sp	15	1800	3.79
Carex sp	25	550	3.49
Chirita articifolia	30	1300	4.92

Herbs (August)	Frequency (%)	Density (ha^{-1})	IVI
Chirita pumilaa	30	500	4.00
Costos speciosus	5	150	0.74
Drymaria cordata	20	9700	13.45
Elatostemma disectum	25	4900	8.50
Elatostemma sessile	15	950	2.81
Elsoltzia blanda	35	1750	6.01
Globba clarkeii	90	6250	17.48
Gynura cusimba	20	400	2.75
Hedychium sp.	20	500	2.86
Nephralepis cordifolia	90	8850	20.47
Ophiopogon intermedius	20	650	3.03
Opliomenus sp.	60	9900	18.25
Pilea umbrosa	60	14400	23.43
Polygonum capitatum	30	2650	6.48
Polygonum sp	30	1850	5.56
Polypodium sp	40	1350	6.12
Rhynchoglossum obliquum	30	1150	4.75
Selaginella sp	20	5150	8.21
Strepcilirium volubile	30	600	4.12
Thalictrum foliosum	30	700	4.23
Thysanolaena maxima	20	5700	8.84
Urtica dioca	20	2400	5.05

B. Damsite

Species	Frequency (%)	Density (ha^{-1})	BA (m^2ha^{-1})	IVI
Trees				
Alnus nepalensis	10	10	0.45	7.73
Brassiopsis glomerulata	25	55	0.22	18.70
Castanopsis purpurella	15	15	0.31	9.08
Castanopsis sp	30	50	2.83	37.31
Drymicarpus racemosus	40	60	2.65	40.64
Engelherdtia spicata	30	40	2.73	34.71
Erythrina stricta	5	5	0.05	2.66
Ficus roxburghii	10	15	0.26	7.35
Grewia sp	15	25	0.23	10.39
Lithocarpus fenestrata	5	5	0.19	3.66
Macaranga denticulata	20	35	0.98	18.86
Quercus griffithii	15	15	1.09	14.51
Quercus sp	25	35	0.39	16.09
Rhus javanica	20	20	0.08	9.77
Saurauria nepalensis	25	40	0.19	15.66
Schfellera hypoleuca	25	25	0.19	12.77
Schima khasiana	10	10	0.94	11.19
Viburnum sp	10	15	0.05	5.86
Wallichiana (fern)	25	40	0.40	17.12

Wendlendia sp	10	15	0.06	5.98

Shrubs	**Frequency (%)**	**Density (ha^{-1})**	**IVI**
Ardisia sp	10	15	1.92
Boehmeria longifolia	20	80	4.97
Boehmeria macrophylla	5	20	1.24
Celestrus sp	5	5	0.91
Clerodendron coolebrokianum	50	300	14.66
Clerodendron viscosum	20	60	4.52
Debregessia longifolia	25	35	4.75
Eupatorium adenophorum	20	220	8.10
Hydranga aspera	20	55	4.41
Ilex sp	30	165	8.46
Indigofera sp	45	945	28.31
Inula cappa	25	340	11.58
Mesea indica	55	180	12.76
Mussanda roxburghii	10	20	2.04
Oxospora paniculata	20	100	5.41
Piper sp	45	955	28.53
Plectranthus striatus	70	670	26.12
Polygola arillata	10	45	2.60
Psychotria sp	10	10	1.81
Rubus ellipticus	35	45	6.56
Schefellera venulosa	5	15	1.13
Solanum nigrum	45	85	9.05
Solanum xanthocarpum	15	25	2.94
Vernonia volkemerifolia	35	75	7.24

Herbs (April)	**Frequency (%)**	**Density (ha^{-1})**	**IVI**
Polygonum white	35	750	5.59
Polygonum capitatum	55	2400	10.57
Strepcilirium volubile	70	1250	10.81
Rhynoglossum obliquim	10	250	1.65
Cyanotis voga	35	1050	6.03
Commelina pedulosa	35	1750	7.05
Pilea umbrosa	70	16000	32.49
Elatostemma sessile	65	2250	11.63
Drymeria cordata	25	2000	6.14
Urtica dioca	30	2000	6.78
Nephralepis cordifolia	65	14250	29.21
Polypodium sp	70	2700	12.93
Ophiopogon intermidus	50	700	7.44
Thysolena maxima	20	3500	7.69
Oplimanus sp (grass)	50	4250	12.64
Selaginella sp	15	2700	5.88
Costos speciosus	15	200	2.22
Saccharum spontaneum	50	6800	16.37

Phyrnium pubinerve	15	3400	6.90

Herbs (August)	Frequency (%)	Density (ha^{-1})	IVI
Chirita articifolia	35	1350	5.13
Commelina pedulosa	40	2000	6.34
Costos speciosus	30	400	3.61
Cyanotis voga	30	4600	7.99
Drymaria cordata	55	6400	12.52
Elatostemma sessile	65	2900	9.94
Globba clarkeii	20	650	2.81
Nephrolepis cordifolia	65	14750	22.30
Ophiopogon intermedius	50	900	6.26
Oplimanus sp	50	5100	10.64
Phyrnium pubinerve	15	3500	5.25
Pilea umbrosa	70	21200	29.55
Polygonum capitatum	55	2800	8.77
Polygonum sp	35	1050	4.82
Polypodium sp	70	3400	10.99
Rhynchoglossum obliquum	70	6550	14.28
Saccharum spontaneum	50	7800	13.45
Selaginella sp	15	3200	4.93
Strepcilirium volubile	70	1600	9.12
Thysanolaena maxima	20	3650	5.93
Urtica dioca	30	2100	5.38

C. Downstream

Species	Frequency (%)	Density (ha^{-1})	BA (m^2ha^{-1})	IVI
Trees				
Alnus nepalensis	10	10	0.07	5.85
Castanopsis purpurella	40	80	2.63	51.25
Cyathea gigantea	5	5	0.08	3.32
Drymicarpus racemosus	10	20	0.86	14.53
Engelherdtia spicata	20	40	0.43	18.06
Ficus roxburghii	25	30	0.56	18.95
Grewia sp	5	5	0.25	4.76
Juglans regia	35	60	1.31	34.45
Lithocarpus fenestrata	40	50	1.76	38.03
Macaranga denticulata	10	35	0.90	17.80
Prunus accuminata	5	10	0.05	4.05
Quercus griffithii	25	60	1.32	31.19
Rhus accuminata	30	35	0.86	24.14
Rhus javanica	20	40	0.12	15.45
Saurauria nepalensis	10	20	0.13	8.36
Taoluma hadgosonii	5	5	0.32	5.32

Wallichiana (fern)	5	10	0.10	4.49

Shrubs	**Frequency (%)**	**Density (ha^{-1})**	**IVI**
Boehmeria longifolia	25	270	10.62
Boehmeria macrophylla	10	110	4.29
Clerodendron coolebrokianum	40	135	11.04
Debregessia longifolia	15	275	8.64
Eupatorium odoratum	40	480	17.96
Hydranga aspera	5	15	1.34
Indigofera sp	60	675	26.04
Inula cappa	15	180	6.74
Mesea indica	20	115	6.47
Mussanda roxburghii	10	15	2.38
Oxospora paniculata	55	110	13.66
Plectranthus striatus	10	220	6.50
Rubus ellipticus	30	90	8.06
Rubus sp	20	30	4.77
Smilax sp	15	20	3.53
Solanum nigrum	20	40	4.97
Solanum xanthocarpum	20	25	4.67
Urena lobata	35	2115	49.72
Vernonia volkemerifolia	35	65	8.60

Herbs (April)	**Frequency (%)**	**Density (ha^{-1})**	**IVI**
Polygonum white	35	600	5.53
Polygonum capitatum	55	1050	8.83
Elsoltzia blanda	30	1400	5.83
Strepcilirium volubile	45	500	6.78
Rhynoglossum obliquim	10	200	1.62
Pilea umbrosa	35	6050	12.24
Elatostemma sessile	20	1350	4.40
Elatostemma disectum	35	2900	8.36
Drymeria cordata	20	1400	4.46
Gynura cusimba	10	200	1.62
Urtica dioca	10	2250	4.14
Nephralepis cordifolia	80	19250	34.65
Polypodium sp	35	1050	6.09
Ophiopogon intermidus	15	200	2.30
Carex sp	15	150	2.24
Begonia sp	5	50	0.75
Thysolena maxima	65	19300	32.66
Trichosanthes sp	10	150	1.55
Oplimanus sp	70	6800	17.96
Selaginella sp	5	2250	3.45
Costos speciosus	10	100	1.49
Saccharum spontaneum	50	5650	13.80

Commelina pedulosa	30	5400	10.76
Cyanotis voga	20	1250	4.28
Bidens pilosa	15	1750	4.21

Herbs (August)	**Frequency (%)**	**Density (ha^{-1})**	**IVI**
Anthogonium gracile	30	1550	4.21
Begonia sp	5	150	0.63
Bidens pilosa	15	1450	2.58
Carex sp	15	150	1.67
Chirita articifolia	40	950	4.83
Chirita pumila	30	950	3.79
Commelina pedulosa	30	10050	10.19
Costos speciosus	10	150	1.15
Cyanotis voga	20	5150	5.70
Drymaria cordata	45	21950	20.12
Elatostemma disectum	30	5750	7.17
Elatostemma sessile	20	2350	3.74
Elsoltzia blanda	30	1100	3.90
Globba clarkeii	70	2550	9.08
Gynura cusimba	10	100	1.11
Hedychium densiflorum	10	150	1.15
Hedychium sp	10	100	1.11
Nephralepis cordifolia	80	20550	22.78
Ophiopogon intermedius	15	200	1.70
Oplismenus sp	70	14000	17.13
Pilea umbrosa	35	9800	10.54
Polygonum capitatum	50	3400	7.60
Polygonum sp	30	1650	4.28
Polypodium sp	35	1350	4.59
Rhynoglossum obliquim	40	2150	5.68
Saccharum spontaneum	50	6750	9.95
Selaginella sp	5	4800	3.90
Strepcilirium volubile	45	550	5.07
Thysanolaena maxima	65	19800	20.69
Trichosanthes sp	10	150	1.15
Urtica dioca	10	2500	2.80

ANNEXURE-XVI

Community characteristics of the vegetation at various sampling locations at different sites in Dinchang HEP

A. Upstream

Species	Frequency (%)	Density ha^{-1}	Basal area ($m^2 ha^{-1}$)	IVI
Trees				
Callicarpa arborea	10	15	0.15	10.17
Castanopsis sp	15	20	0.73	23.41
Engelhertia spicata	5	5	0.16	5.97
Pinus sp	75	185	4.13	144.11
Pinus wallichiana	75	160	0.32	73.57
Quercus griffithi	10	10	0.08	7.98
Quercus sp	25	30	0.20	20.88
Rhus javanica	10	20	0.08	10.13
Wendlendia sp	5	5	0.03	3.82

Shrubs	Frequency (%)	Density ha^{-1}	IVI
Boehmeria longifolia	40	50	13.97
Buddleja asiatica	25	35	9.12
Debregessia longifolia	25	25	8.09
Desmodium sp	20	25	6.99
Eupatorium odoratum	80	395	58.52
Indigofera sp	60	125	26.14
Rubus ellipticus	25	25	8.09
Rubus sp	20	25	6.99
Sida rhomboidifolia	55	95	21.93
Smilax sp	25	30	8.60
Urena lobata	80	135	31.57

Herbs (April)	Frequency (%)	Density ha^{-1}	IVI
Imperata cylindrica	100	42250	84.46
Opliomenus sp	50	2500	11.16
Hedyotis sp	45	450	7.04
Smithia ciliata	30	400	4.86
Commelina pedulosa	60	2550	12.65
Cyanotis voga	65	1450	11.51
Pouzolzia hirta	45	1750	9.21
Carex sp	15	200	2.43
Rubia cordifolia	35	400	5.56

Leucas ciliata	50	750	8.24
Nephralepis cordifolia	75	3000	15.49
Polygonum capitata	55	1450	10.11
Polypodium sp	20	500	3.63
Borreria articularis	45	800	7.63
Saccharum spontaneum	25	1500	6.00

Herbs (August)	**Frequency (%)**	**Density ha^{-1}**	**IVI**
Borreria articularis	45	650	6.41
Carex sp	15	250	2.17
Commelina paludosa	55	6250	13.50
Cyanotis vaga	55	2900	10.02
Drymeria cordata	85	7300	18.41
Hedyotis sp	45	650	6.41
Imperata cylindrica	100	61600	76.74
Leucas ciliata	50	650	7.04
Nephralepis cordifolia	75	3500	13.19
Opliomenus sp	50	5500	12.08
Polygonum capitata	55	2250	9.34
Polypodium sp	20	500	3.07
Pouzolzia hirta	45	1650	7.45
Rubia cordifolia	35	400	4.87
Saccharum spontaneum	25	1600	4.85
Smithia ciliata	30	600	4.45

B. Damsite

Species	**Frequency (%)**	**Density ha^{-1}**	**Basal area (m^{2}ha-^{1})**	**IVI**
Trees				
Engelhardtia spicata	10	10	0.49	11.60
Eurya acuminata	10	10	0.05	6.81
Ficus cunea	10	20	0.19	10.24
Ficus roxburghii	5	5	0.05	3.67
Macaranga denticulata	20	20	0.28	15.59
Pinus sp	75	295	5.50	149.07
Quercus griffithi	60	90	2.09	66.12
Quercus sp	30	50	0.46	27.66
Rhus javanica	10	20	0.10	9.25

Shrubs	**Frequency (%)**	**Density ha^{-1}**	**IVI**
Artemesia nilagirica	25	135	11.09
Boehmeria longifolia	35	75	9.62
Buddleja asiatica	25	30	5.65

Shrubs	**Frequency (%)**	**Density ha^{-1}**	**IVI**
Clerodendron coolebrokianum	25	30	5.65
Debregessia longifolia	45	70	11.00
Eupatorium odoratum	80	285	27.88
Indigofera sp	80	565	42.39
Inula coppa	60	170	18.64
Mesea indica	35	45	8.07
Oxospora paniculata	35	55	8.59
Piper sp	20	170	12.09
Rubus ellipticus	20	25	4.57
Rubus sp	20	20	4.31
Sida rhomboidifolia	35	135	12.73
Smilax sp	10	15	2.42
Urena lobata	60	105	15.28

Herbs (April)	**Frequency (%)**	**Density ha^{-1}**	**IVI**
Bamboo grass	50	9250	38.12
Imperat cylindrica	40	10500	40.31
Oplimanus sp	15	800	5.19
Hedyotis sp	50	700	11.06
Pilea umbrosa	35	1200	9.99
Commelina pedulosa	60	1800	16.32
Cyanotis voga	55	1750	15.27
Carex sp	40	500	8.66
Ophiopogon intermidus	15	200	3.29
Rubia cordifolia	20	250	4.33
Nephralepis cordifolia	30	1250	9.27
Leucus ciliata	25	300	5.37
Polygonum capitatum	75	1800	18.97
Polypodium sp	25	300	5.37
Borreria articularis	30	1000	8.47

Herbs (August)	**Frequency (%)**	**Density ha^{-1}**	**IVI**
*Bamboo grass (*common name*)*	50	10050	24.24
Begonia sp	10	150	1.74
Borreria articularis	30	1100	6.31
Carex sp	40	650	7.06
Commelina paludosa	55	3800	14.55
Cyanotis voga	55	2650	12.63
Drymaria cordata	65	12550	30.65
Hedychium sp	15	200	2.57
Hedyotis scandens	50	750	8.71
Imperata cylindrica	40	20500	40.19
Leucus ciliata	25	300	4.23

Melastoma sp	20	250	3.40
Nephrolepis cordifolia	30	1050	6.23
Ophiopogon intermedius	15	250	2.66
Opliomenus sp	15	600	3.24
Pilea umbrosa	35	1400	7.56
Polygonum capitatum	75	3100	16.37
Polypodium sp	25	300	4.23
Rubia cordifolia	20	250	3.40

C. Downstream

Species	**Frequency (%)**	**Density ha^{-1}**	**Basal area (m^{2}ha^{-1})**	**IVI**
Trees				
Pinus sp	80	170	1.66	141.19
Quercus griffithi	45	70	1.52	87.34
Quercus sp	50	70	0.50	62.36
Wendlendia sp	10	10	0.02	9.20

Shrubs	**Frequency (%)**	**Density ha^{-1}**	**IVI**
Boehmeria longifolia	35	50	20.83
Debregessia longifolia	35	45	20.42
Eupatorium odoratum	20	50	13.69
Indigofera sp	85	1005	124.23
Rubus ellipticus	15	20	8.81
Rubus sp	15	20	8.81
Urena lobata	5	10	3.21

Herbs (April)	**Frequency (%)**	**Density ha^{-1}**	**IVI**
Bamboo grass	75	10050	37.92
Imperata cylindrica	60	7950	30.12
Opliomenus sp	40	2450	13.30
Hedyotis sp	25	300	5.39
Elatostemma sessile	35	7250	23.78
Pilea umbrosa	25	3600	13.23
Commelina pedulosa	40	1200	10.33
Cyanotis voga	25	600	6.10
Medinila sp	25	350	5.51
Carex sp	20	250	4.33
Ophiopogon intermidus	35	550	7.85
Rubia cordifolia	50	500	10.53
Nephralepis	80	7000	31.60

cordifolia			

Herbs (August)	Frequency (%)	Density ha^{-1}	IVI
Bamboo grass (common name)	75	18750	42.21
Carex sp	20	300	4.19
Commelina paludosa	25	1700	7.23
Cyanotis voga	25	800	5.88
Elatostemma sessile	35	9700	21.13
Fragaria sp	10	250	2.25
Hedychium white	15	150	3.03
Hedyotis scandens	25	300	5.12
Imperata cylindrica	60	11900	29.11
Melastoma sp	20	300	4.19
Nephrolepis cordifolia	75	9500	28.30
Ophiopogon intermedius	35	600	7.44
Opliomenus sp	45	8100	20.59
Pilea umbrosa	15	3400	7.92
Rubia cordifolia	55	750	11.41

ANNEXURE-XVII

Community characteristics of the vegetation at various sampling locations at different sites in Jameri HEP

A. Upstream

Species	**Frequency (%)**	**Density ha^{-1}**	**Basal area (m^2ha^{-1})**	**IVI**
Trees				
Alangium begonifolia	5	5	0.17	3.71
Albizzia sp	5	5	0.02	2.77
Bamboo sp	10	150	0.42	24.49
Musa sp	15	165	1.76	36.67
Bombax cieba	20	35	3.52	34.21
Callicarpa arborea	20	25	0.34	13.42
Castanopsis purpurella	5	5	0.25	4.25
Cyathea gigantea	5	10	0.17	4.29
Duabanga grandiflora	25	75	0.63	23.16
Ficus cunea	15	40	0.46	13.82
Juglans regia	45	150	6.65	77.59
Pandanus odoratissima	10	15	0.29	7.72
Pinus sp	35	125	0.92	35.08
Quercus griffithii	10	10	0.38	7.71
Rhus javanica	15	30	0.21	11.12

Shrubs	**Frequency (%)**	**Density ha^{-1}**	**IVI**
Acacia pinnata	50	105	11.45
Artemesia nilagirica	80	3200	71.38
Boehmeria longifolia	55	310	16.00
Boehmeria platyphylla	5	60	2.01
Debregessia longifolia	40	75	9.00
Eupatorium adenophorum	70	890	29.03
Plectranthus striatus	60	385	18.28
Rubus sp	55	70	11.80
Rubus sp	15	20	3.23
Thunbergia sp	10	15	2.19
Urena lobata	70	575	23.52
Vernonia volkemerifolia	10	10	2.10

Herbs (April)	**Frequency (%)**	**Density ha^{-1}**	**IVI**
Polygonum capitata	30	800	7.61
Ageratum conyzoides	40	2400	12.53

Herbs (April)	**Frequency (%)**	**Density ha^{-1}**	**IVI**
Thysolaena maxima	35	2000	10.79
Nephrolepis cordifolia	25	1900	8.55
Barreria articularis	20	700	5.37
Pouzolzia hirta	35	600	8.29
Elatostemma sessile	35	6050	18.02
Pilea umbrosa	35	6000	17.93
Drymeria cordata	10	600	3.13
Commelina pedulosa	20	1200	6.27
Cyanotis voga	20	1050	6.00
Imperata cylindrica	40	9600	25.39
Saccharum spontaneum	55	10050	29.29
Discrenepteris lineries	20	1250	6.36
Bamboo grass	20	10600	23.05
Centella asiatica	30	1050	8.06
Carex sp	15	150	3.36

Herbs (August)	**Frequency (%)**	**Density ha^{-1}**	**IVI**
Ageratum conyzoides	30	2500	9.20
Bamboo grass (Common name)	20	14050	22.57
Borreria articularis	20	950	5.18
Carex sp	15	200	3.21
Centella asiatica	30	1800	8.27
Commelina paludosa	20	1550	5.98
Cyanotis voga	20	1450	5.85
Dricrenopteris lineries	20	3950	9.16
Drymaria cordata	45	5250	15.79
Elatostemma sessile	35	7400	16.68
Imperata cylindrica	40	11900	23.64
Nephrolepis cordifolia	25	2050	7.62
Pilea umbrosa	35	7200	16.42
Polygonum capitata	30	1300	7.61
Pouzolzia hirta	35	1000	8.19
Saccharum spontaneum	55	10750	25.05
Thysanolaena maxima	35	2050	9.58

B. Submergence

Trees	**Frequency (%)**	**Density ha^{-1}**	**Basal area (m^2ha-^{1})**	**IVI**
Alangium begonifolia	20	35	0.19	8.02
Albizzia chinensis	20	30	0.56	10.68
Alnus nepalensis	15	20	0.28	6.63
Musa sp	40	245	1.68	41.05
Beilschmedia	10	10	0.22	4.47

Trees	**Frequency (%)**	**Density ha^{-1}**	**Basal area (m^2ha^{-1})**	**IVI**
assamica				
Brassiopsis glomerulata	30	95	0.28	15.50
Callicarpa arborea	25	30	0.36	9.93
Castanopsis purpurella	15	20	0.32	7.00
Duabanga grandiflora	15	15	0.15	5.20
Engelhardtia spicata	25	30	1.08	15.84
Ficus cunea	50	75	0.76	21.47
Lithocarpus fenestrata	15	15	0.10	4.74
Macaranga denticulata	60	105	2.30	38.28
Ostodes paniculata	5	10	0.06	2.24
Pandanus odoratissima	60	165	1.39	35.72
Rhus accuminata	15	15	0.11	4.87
Rhus javanica	35	60	0.27	13.50
Schefllera hypoleuca	15	15	0.11	4.88
Syzygium tetragonum	10	15	0.09	3.82
Toona ciliata	25	25	0.75	12.75
Wallichiana (fern)	45	195	1.14	33.41

Shrubs	**Frequency (%)**	**Density ha^{-1}**	**IVI**
Ardisia griffithii	30	35	6.90
Boehmeria macrophylla	45	470	23.79
Calamus sp	50	215	16.54
Clerodendron coolebrokianum	40	100	10.91
Daphne popuaryae	35	40	8.02
Ficus hirta	10	15	2.41
Ligustrum sp	50	75	12.03
Piper sp	90	970	48.55
Plectranthus striatus	25	35	5.93
Rhynchotecium sp	55	1025	43.59
Rubus ellipticus	15	20	3.53
Smilax sp	35	45	8.18
Solanum nigrum	20	30	4.81
Solanum xanthocarpum	10	10	2.25
Vernonia volkemerifolia	10	20	2.57

Herbs (April)	**Frequency (%)**	**Density ha^{-1}**	**IVI**
Equisetum sp.	25	5000	20.55

Elatostemma sessile	35	7900	31.40
pilea umbrosa	45	2800	18.89
Selaginella sp.	25	6050	23.62
Nephrolepis cordifolia	40	3050	18.43
Thysolaena maxima	20	900	7.39
Commelina paludosca	35	1750	13.44
Polygonum capitata	65	1200	18.98
Carex sp.	15	200	4.16
Ophiopogon intermedius	10	100	2.67
Stephenia sp.	10	100	2.67
Cyanotis vaga	45	1200	14.22
Saccharum spontanum	25	3700	16.76
Paderia foetida	25	300	6.83

Herbs (August)	**Frequency (%)**	**Density ha^{-1}**	**IVI**
Ariosema sp	15	150	3.37
Carex sp	15	300	3.66
Commelina paludosa	35	3300	13.41
Costos speciosus	20	350	4.78
Cyanotis vaga	40	1600	11.25
Drymaria cordata	25	3500	11.72
Elatostemma sessile	35	11500	28.79
Equisetum sp	25	5400	15.29
Nephrolepis cordifolia	40	3200	14.25
Ophiopogon intermedius	20	300	4.69
Paederia foetida	25	400	5.91
Pilea umbrosa	45	3900	16.60
Polygonum capitata	65	1950	17.06
Saccharum spontaneum	25	4000	12.66
Selaginella sp	25	12550	28.70
Stephenia sp	10	100	2.25
Thysanolaena maxima	20	800	5.62

C. Damsite

Species	**Frequency (%)**	**Density ha^{-1}**	**Basal area ($m^2ha\text{-}^1$)**	**IVI**
Trees				
Albizzia chinensis	5	5	0.08	2.78
Alnus nepalensis	15	75	2.59	29.63
Beilschmedia assamica	10	15	0.82	9.28
Brassiopsis glomerulata	15	15	0.16	8.01
Caseria glomerulata	5	5	0.05	2.66
Castanopsis purpurella	10	10	0.13	5.45

Castanopsis tribuloides	5	5	1.02	6.71
Dysoxylon gobara	15	35	0.22	12.07
Engelhardtia spicata	10	10	0.59	7.34
Ficus cunea	25	35	1.54	20.59
Ficus sp	5	5	2.10	11.26
Ficus sp	5	5	0.57	4.85
Lagerstromia muniticarpa	30	45	5.04	38.66
Lithocarpus penetrata	10	10	0.04	5.07
Macaranga denticulata	20	25	1.04	15.07
Ostodes paniculata	10	10	0.03	5.00
Pandanas odoratissima	40	105	1.10	36.57
Persea odoratissima	20	25	0.47	12.72
Plectocomia assamicus	10	10	0.11	5.37
Quercus grifithii	15	20	0.31	9.57
Rhus accuminata	20	20	0.13	10.33
Schima wallichii	10	10	1.82	12.52
Syzygium tetragonum	5	5	0.02	2.54
Terminalia myriocarpa	5	5	0.03	2.58
Toona ciliata	15	15	3.83	23.39

Shrubs	**Frequency (%)**	**Density ha^{-1}**	**IVI**
Ardisia griffithii	20	35	4.70
Boehmeria macrophylla	55	845	27.78
Calamus sp	65	450	21.94
Daphnae popuaryae	30	55	7.09
Ficus hirta	15	20	3.40
Ligustrum sp	45	70	10.39
Piper sp	80	1880	53.34
Plectranthus striatus	80	190	19.77
Rhynchotecium	65	1420	41.20
Smilax sp	20	35	4.70
Solanum nigrum	5	10	1.20
Solanum xanthocarpum	5	5	1.10
Vernonia volkemerifolia	15	20	3.40

Herbs (April)	**Frequency (%)**	**Density ha^{-1}**	**IVI**
Equisetum sp.	30	6050	19.26
Elatostemma sessile	55	14250	41.67
pilea umbrosa	55	10700	34.51
Selaginella sp.	20	5550	15.90

Nephrolepis cordifolia	55	5650	24.33
Thysolaena maxima	45	3500	17.64
Commelina paludosca	35	1050	10.35
Polygonum capitata	55	900	14.76
Drymaria cordata	10	700	3.76
Carex sp.	10	200	2.76
Ophiopogon intermedius	20	300	5.31
Stephenia sp.	10	150	2.66
Cyanotis vaga	25	600	7.09

Herbs (August)	**Frequency (%)**	**Density ha^{-1}**	**IVI**
Alocassia sp	5	150	1.23
Ariosema v	15	200	3.28
Carex sp	10	250	2.37
Commelina paludosa	35	2550	10.92
Costos speciosus	15	150	3.21
Cyanotis vaga	25	1800	7.77
Drymaria cordata	45	3550	14.47
Elatostemma sessile	55	16000	35.95
Equisetum sp	30	6550	16.20
Nephrolepis cordifolia	55	5650	19.74
Ophiopogon intermedius	20	400	4.59
Pilea umbrosa	55	13800	32.50
Polygonum capitata	50	2050	13.11
Potentilla fulgens	15	300	3.44
Selaginella sp	20	6650	14.38
Stephenia sp	10	150	2.22
Thysanolaena maxima	45	3650	14.63

ANNEXURE-XVIII

Community characteristics of the vegetation at various sampling locations at different sites in Dinan HEP

A. Upstream

Species	Frequency (%)	Density ha^{-1}	Basal area (m^2ha^{-1})	IVI
Trees				
Aralia thompsonii	5	5	0.02	2.38
Castanopsis purpurella	30	35	1.78	21.91
Engelherdtia spicata	5	10	1.05	7.40
Eurya acuminata	5	5	0.05	2.52
Ficus roxburghii	5	5	0.09	2.68
Lyonia ovalifolia	25	35	0.26	14.24
Myrica esculenta	70	90	5.51	57.99
Pithicellobium monodelphium	15	20	0.27	8.85
Quercus griffithii	80	240	11.48	109.75
Quercus sp	25	40	1.12	18.55
Rhododendron arboreum	20	50	1.07	18.49
Rhus javanica	5	5	0.01	2.36
Saurauria nepalensis	5	10	0.05	3.33
Schima khasiana	5	10	1.17	7.89
Syzigium tetragonum	30	40	0.64	18.10
Wallichiana (fern)	5	10	0.10	3.53

Shrubs	Frequency (%)	Density ha^{-1}	IVI
Artemesia nilagirica	25	275	12.73
Boehmeria longifolia	70	480	25.56
Boehmeria macrophylla	30	70	6.23
Buddlega asiatica	15	30	2.94
Daphnae sp	50	110	10.16
Debregessia longifolia	65	215	15.71
Desmodium sp	45	80	8.48
Indigofera sp	75	515	27.41
Inula cappa	25	75	5.77
Melastoma sp	40	55	6.98
Mesea indica	75	140	14.36
Plectranthus strlatus	75	435	24.62
Rubus ellipticus	25	30	4.21
Rubus sp	20	30	3.58
Schefllera wallichiana	10	10	1.61
*Silam (*local name)	40	150	10.28

Solanum nigrum	40	80	7.85
Solanum xanthocarpum	20	20	3.23
Urena lobata	45	75	8.30

Herbs (April)	**Frequency (%)**	**Density ha^{-1}**	**IVI**
Polygonum sp.	30	300	4.76
Polygonum white	30	500	5.25
Polygonum capitata	70	3350	17.60
Nephrolepis cordifolia	80	10650	36.81
Leucas cilita	25	250	3.97
Trichosanthes sp.	25	250	3.97
Rubia cordifolia	35	450	5.80
Impereta cylindrica	40	6000	20.06
Polypodium sp.	20	300	3.42
Ophiopogon intermedius	30	400	5.01
Carex sp.	25	400	4.33
Paderia foetida	20	350	3.54
Pilea umbrosa	80	6050	25.55
Begonia sp.	10	150	1.71
Thysonolena maxima	35	2400	10.57
Drymaria cordata	15	1050	4.58
Crossocephalum crepezoides	10	400	2.32
Commelina paludosa	50	2550	12.95
Cyanotis vaga	50	1450	10.26
Scrutellaria discolor	10	200	1.83
Bidens pilosa	55	3400	15.71

Herbs (August)	**Frequency (%)**	**Density ha^{-1}**	**IVI**
Aegenetia indica	35	3200	8.13
Ariosema sp.	15	200	1.84
Begonia sp.	10	150	1.25
Bidens pilosa	55	2550	9.31
Carex sp.	25	450	3.24
Commelina paludosa	50	5400	12.78
Crossocephalum crepezoides	10	250	1.39
Cyanotis vaga	45	4900	11.56
Drymaria cordata	75	6200	16.51
Globba Clarkii	65	2800	10.70
Hedychium sp.	20	600	2.92
Impereta cylindrica	40	7550	14.76
Leucas cilita	25	450	3.24
Nephrolepis cordifolia	80	11800	24.88
Ophiopogon intermedius	30	450	3.76
Paderia foetida	15	300	1.98

Herbs (August)	**Frequency (%)**	**Density ha^{-1}**	**IVI**
Pilea umbrosa	80	13700	27.55
Polygonum capitata	70	4850	14.09
Polygonum sp	30	450	3.76
Polygonum sp	30	550	3.90
Polypodium sp	20	350	2.57
Rubia cordifolia	35	450	4.28
Scrutellaria discolor	40	800	5.29
Thysanolaena maxima	35	2500	7.15
Trichosanthes sp.	25	400	3.17

B. Damsite

Species	**Frequency (%)**	**Density ha^{-1}**	**Basal area (m^2ha^{-1})**	**IVI**
Trees				
Calamus sp.	5	5	0.01	3.48
Castanopsis purpurella	70	155	1.75	88.37
Myrica esculenta	50	95	4.39	101.86
Quercus griffithii	45	145	0.99	64.85
Rhododendron arboreum	15	20	0.06	11.85
Syzygium tetragonum	40	40	0.23	29.56

Shrubs	**Frequency (%)**	**Density ha^{-1}**	**IVI**
Artemesia nilagirica	45	295	16.02
Buddlega asiatica	50	385	19.69
Daphnae sp	30	50	5.82
Debregessia longifolia	45	65	8.40
Desmodium sp	20	50	4.43
Indigofera sp	95	890	42.66
Inula cappa	45	130	10.55
Melastoma sp	30	50	5.82
Mesea indica	60	185	14.46
Plectranthus striatus	80	205	17.90
Rubus sp	15	20	2.75
Rubus sp	30	45	5.66
Schfellera wallichiana	10	10	1.72
Silam (local name)	45	165	11.71
Solanum nigrum	25	50	5.13
Solanum xanthocarpum	20	30	3.77
Urena lobata	75	395	23.50

Herbs (April)	**Frequency (%)**	**Density ha^{-1}**	**IVI**
Polygonum sp	35	400	5.39
Polygonum sp.	35	500	5.54

Herbs (April)	**Frequency (%)**	**Density ha^{-1}**	**IVI**
Polygonum capitata	40	900	6.85
Nephrolepis cordifolia	85	6750	22.14
Leucas cilita	40	600	6.38
Trichosanthes sp.	20	200	3.03
Rubia cordifolia	55	700	8.58
Impereta cylindrica	75	37050	68.23
Polypodium sp.	25	300	3.87
Ophiopogon intermedius	20	250	3.11
Carex sp.	20	250	3.11
Paderia foetida	25	350	3.95
Elatostemma sessile	50	5550	15.49
Begonia sp.	20	500	3.50
Thysonolena maxima	20	1900	5.70
Drymaria cordata	10	700	2.46
Crossocephalum crepezoides	10	700	2.46
Commelina paludosa	30	1200	5.96
Cyanotis vaga	30	600	5.02
Ainsliaea sp.	25	650	4.42
Ageratum conyzoides	50	3400	12.13
Pilea umbrosa	15	400	2.67

Herbs (August)	**Frequency (%)**	**Density ha^{-1}**	**IVI**
Aeginetia indica	45	1650	5.46
Ageratum conyzoides	35	3700	6.61
Ainsliaea sp	95	3150	11.20
Anemone vitifolia	65	1250	6.78
Ariosema sp	5	150	0.57
Begonia sp	50	700	4.96
Carex sp	20	250	1.95
Commelina paludosa	50	3850	8.04
Crossocephalum crepezoides	25	550	2.67
Cyanotis vaga	30	3450	5.94
Drymaria cordata	50	8300	12.39
Elatostemma sessile	40	6850	10.11
Globba Clarkii	45	4250	8.00
Hedychium sp.	20	1000	2.69
Impereta cylindrica	75	46050	51.42
Leucas cilita	40	450	3.86
Nephrolepis cordifolia	85	7200	14.30
Ophiopogon intermedius	20	250	1.95
Paderia foetida	40	600	4.01
Pilea umbrosa	15	600	1.87
Polygonum capitata	40	1000	4.40
Polygonum sp	35	600	3.58

Polygonum sp	35	500	3.48
Polypodium sp.	25	600	2.72
Rubia cordifolia	55	1000	5.68
Scrutellaria discolor	85	2400	9.61
Thysanolaena maxima	20	1700	3.37
Trichosanthes sp.	25	250	2.38

C. Downstream

Species	**Frequency (%)**	**Density ha^{-1}**	**Basal area (m^{2}ha^{-1})**	**IVI**
Trees				
Brassiopsis glomerulata	10	15	0.05	6.71
Castanopsis purpurella	20	40	0.76	21.04
Engelherdtia spicata	10	15	0.66	12.06
Eurya acuminata	15	15	0.06	8.49
Lyonia ovalifolia	25	25	0.18	14.85
Pinus sp	75	210	5.24	111.13
Quercus griffithii	35	60	1.58	37.19
Quercus sp	50	75	1.21	41.86
Saurauria nepalensis	5	15	0.05	4.98
Schfellera hypoleuca	5	15	0.07	5.13
Schima khasiana	40	50	1.53	36.55

Shrubs	**Frequency (%)**	**Density ha^{-1}**	**IVI**
Artemesia nilagirica	70	735	30.83
Buddleja asiatica	35	85	7.25
Daphne sp	35	70	6.82
Debregessia longifolia	65	315	18.01
Desmodium sp	55	100	10.42
Indigofera sp	85	605	29.13
Inula cappa	35	90	7.40
Melastoma sp	15	20	2.63
Mesea indica	45	95	8.91
Plectranthus sp	70	385	20.72
Rubus sp	25	35	4.44
Rubus ellipticus	30	40	5.27
Rubus sp	20	25	3.46
Rubus sp	10	10	1.66
Silam (local name)	15	45	3.36
Solanum nigrum	30	60	5.84
Solanum xanthocarpum	15	15	2.49
Urena lobata	75	730	31.37

Herbs (April)	**Frequency (%)**	**Density ha^{-1}**	**IVI**
Polygonum sp	65	700	9.24
Polygonum sp.	60	700	8.62
Polygonum capitata	80	4300	16.86
Nephrolepis cordifolia	60	7250	19.06
Leucas cilita	15	500	2.67
Rubia cordifolia	25	500	3.92
Polypodium sp.	25	350	3.68
Ophiopogon intermedius	20	300	2.98
Carex sp.	10	150	1.49
Paderia foetida	35	400	5.01
Elatostemma sessile	50	6000	15.82
Begonia sp.	10	100	1.41
Drymaria cordata	25	1400	5.36
Saccharum spontaneum	55	7500	18.84
Crossocephalum crepezoides	20	700	3.62
Imperata cylindrica	70	22500	44.64
Commelina paludosa	50	1550	8.72
Cyanotis vaga	55	1400	9.11
Ageratum conyzoides	70	6400	18.96

Herbs (August)	**Frequency (%)**	**Density ha^{-1}**	**IVI**
Aeginetia indica	30	1650	4.42
Ageratum conyzoides	65	17050	21.33
Ainsliaea sp	45	950	5.31
Begonia sp	20	300	2.25
Carex sp	10	150	1.13
Commelina paludosa	50	2950	7.55
Crossocephalum crepezoides	25	850	3.23
Cyanotis vaga	55	2500	7.65
Drymaria cordata	40	11150	13.70
Elatostemma sessile	50	9550	13.30
Globba Clarkii	30	1000	3.86
Hedychium sp.	15	200	1.67
Imperata cylindrica	70	33400	36.08
Leucas cilita	20	650	2.56
Lilium sp	5	50	0.54
Nephrolepis cordifolia	50	10200	13.87
Ophiopogon intermedius	15	150	1.62
Paderia foetida	30	650	3.55
Polygonum capitata	75	7450	13.96
Polygonum sp	60	1150	6.97
Polygonum sp	55	1250	6.56
Polypodium sp.	25	350	2.79
Rubia cordifolia	25	550	2.97

Saccharum spontaneum	55	8250	12.67
Scrutellaria discolor	85	2300	10.46

ANNEXURE-XIX

Community characteristics of the vegetation at various sampling locations at different sites in Nafra HEP

A. Upstream

Species	Frequency (%)	Density ha^{-1}	Basal area ($m^2 ha^{-1}$)	IVI
Trees				
Alangium begonifolia	15	25	0.09	9.96
Callicarpa arborea	30	50	0.63	26.11
Castanopsis purpurella	10	10	0.04	5.27
Ficus sp	5	5	0.44	8.44
Grewia sp	50	75	0.50	34.58
Macaranga denticulata	55	80	1.61	52.37
Phyllanthus embelica	20	40	0.17	15.08
Pinus sp	15	20	0.09	9.20
Pinus wallichiana	75	235	1.19	78.10
Rhus acuminata	15	15	0.28	10.96
Schima wallichii	10	15	0.50	12.42
Toona ciliata	25	40	1.68	37.56

Shrubs	Frequency (%)	Density ha^{-1}	IVI
Artemisia nilagirica	75	1105	67.27
Boehmeria longifolia	35	45	11.49
Colquhounia coccinea	50	210	22.58
Eupatorium odoratum	75	670	48.88
Melastoma sp	20	75	8.65
Rubus ellipticus	20	25	6.54
Solanum nigrum	20	35	6.96
Solanum xanthocarpum	10	10	3.16
Woodfordia sp	60	190	24.47

Herbs (April)	Frequency (%)	Density ha^{-1}	IVI
Periploca sp	25	300	7.62
Paderia foetida	50	1000	16.39
Imperata cylindrica	85	19300	78.43
Lygodium flexus	10	200	3.28
Gynura sp	15	200	4.63
Paspallum sp	25	2250	13.22
Nephrolepis cordifolia	30	5000	22.48
Ageratum conyzoides	60	3450	26.13

Drymeria cordifolia	10	500	4.14
Borreria articularis	35	1200	12.91
Bidens pilosa	25	1400	10.78
Herbs (August)	**Frequency (%)**	**Density ha^{-1}**	**IVI**
Ageratum conyzoides	55	4000	19.57
Bidens pilosa	25	2200	9.62
Borreria articularis	35	2300	11.99
Drymeria cordifolia	55	6100	23.56
Gynura cusimba	15	250	3.74
Imperata cylindrica	85	25500	67.00
Lygodium flexus	40	700	10.03
Nephrolepis cordifolia	30	5550	17.08
Oxalis sp	20	350	5.01
Paederia foetida	50	1400	13.53
Paspallum sp	25	3900	12.86
Periploca callosa	25	300	6.01

B. Damsite

Species	Frequency (%)	Density ha^{-1}	Basal area (m^{2}ha-^{1})	IVI
Trees				
Engelhardtia spicata	10	10	0.28	27.22
Macaranga denticulata	15	15	0.23	30.63
Pinus sp	70	100	0.70	135.23
Rhus acuminata	10	10	0.07	15.38
Rhus javanica	30	65	0.21	63.25
Schima wallichii	10	10	0.29	28.11

Shrubs	Frequency (%)	Density ha^{-1}	IVI
Artemesia nilagirica	100	4660	99.47
Boehmeria longifolia	60	90	14.54
Colquhounia coccinea	35	255	11.86
Eupatorium odoratum	55	535	20.88
Indigofera sp	50	110	12.70
Melastoma sp	10	10	2.34
Rubus ellipticus	10	10	2.34
Solanum nigrum	25	30	5.94
Solanum xanthocarpum	10	20	2.51
Urena lobata	70	220	18.89
Woodfordia sp	35	55	8.53

Herbs (April)	Frequency (%)	Density ha^{-1}	IVI

Herbs (April)	**Frequency (%)**	**Density ha^{-1}**	**IVI**
Periploca sp	25	300	5.43
Paderia foetida	60	1700	15.51
Imperata cylindrica	80	22550	71.90
Lygodium flexus	60	700	12.98
Gynura sp	40	600	8.99
Paspallum sp	70	5050	25.84
Nephrolepis cordifolia	60	2150	16.64
Ageratum conyzoides	45	2800	15.48
Borreria articularis	55	1350	13.69
Bidens pilosa	40	2400	13.54
Herbs (August)	**Frequency (%)**	**Density ha^{-1}**	**IVI**
Ageratum conyzoides	45	3800	14.66
Borreria articularis	55	1700	12.67
Bidens pilosa	40	3100	12.53
Gynura cusimba	40	500	7.91
Imperata cylindrica	80	31550	70.17
Lygodium flexus	60	800	11.95
Nephrolepis cordifolia	60	2250	14.53
Oxalis sp	35	700	7.39
Paderia foetida	60	2200	14.44
Paspallum sp	70	9300	28.83
Periploca callosa	25	300	4.92

C. Downstream

Species	**Frequency (%)**	**Density ha^{-1}**	**Basal area (m^2ha-^{1})**	**IVI**
Trees				
Pinus sp	100	285	1.29	300.00

Shrubs	**Frequency (%)**	**Density ha^{-1}**	**IVI**
Artemesia nilagirica	65	1135	54.56
Eupatorium odoratum	65	1025	51.57
Indigofera sp	55	160	24.36
Solanum nigrum	25	40	10.18
Urena lobata	65	1310	59.33

Herbs (April)	**Frequency (%)**	**Density ha^{-1}**	**IVI**
Borreria articularis	55	1200	20.67
Imperata cylindrica	100	20600	95.14
Paspallum sp	80	5050	40.40
Kyllinga sp	90	5150	43.79

Herbs (August)	**Frequency (%)**	**Density ha^{-1}**	**IVI**
Borreria articularis	55	1300	17.91
Imperata cylindrica	100	35350	93.94
Kyllinga sp	90	9550	43.12

Oxalis sp	30	450	9.29
Paspallum sp	80	7100	35.74

ANNEXURE-XX

Community characteristics of the vegetation at various sampling locations at different sites in Gongri HEP

A. Upstream

Species	Frequency (%)	Density ha^{-1}	Basal area ($m^2 ha^{-1}$)	IVI
Trees				
Engelherdtia spicata	25	30	0.17	22.31
Macaranga denticulate	20	15	0.09	13.75
Pinus sp	35	45	0.14	28.07
Pinus wallichiana	35	45	0.17	29.27
Quercus griffithii	25	30	0.32	28.54
Quercus sp	55	70	0.66	61.95
Rhus javanica	70	160	0.73	90.68
Schima khasiana	30	35	0.18	25.48

Shrubs	Frequency (%)	Density ha^{-1}	IVI
Artimesia nilagirica	45	250	32.27
Boehmeria longifolia	30	35	9.97
Buddleja asiatica	25	30	8.38
Debregessia longifolia	25	30	8.38
Eupatorium adenophorum	50	350	42.20
Indigofera sp	50	75	18.07
Inula cappa	35	85	15.50
Oxospora paniculata	15	15	4.76
Plectranthus striatus	40	85	16.65
Rubus ellipticus	25	35	8.82
Rubus sp	15	25	5.64
Rubus sp	15	15	4.76
Smilax sp	15	20	5.20
Solanum nigrum	25	30	8.38
Urena lobata	25	60	11.01

Herbs (April)	Frequency (%)	Density ha^{-1}	IVI
Bamboo grass	40	4300	17.99
Nephralepis cordifolia	65	10150	37.48
Rubia cordifolia	20	200	3.91
Imperata cylindrical	65	12900	44.65
Paspalum sp	55	2800	16.62
Leucas ciliate	35	350	6.84
Carex sp	20	400	4.43

Herbs (April)	Frequency (%)	Density ha^{-1}	IVI
Cyanotis voga	65	1200	14.15
Commelina pedulosa	35	1200	9.06
Polygonum capitata	60	900	12.52
polypodium sp	25	400	5.28
Borreria articularis	45	1000	10.23
Thysolaena maxima	25	1800	8.93
Pilea umbrosa	10	450	2.87
Fragaria sp	25	300	5.02

Herbs (August)	Frequency (%)	Density ha^{-1}	IVI
Anemone vitifolia	20	250	3.47
Bamboo grass (common name)	40	4800	13.66
Borreria articularis	50	1200	9.57
Carex sp	20	450	3.78
Commelina paludosa	35	2300	8.98
Cyanotis voga	65	3150	14.93
Drymaria cordata	35	4100	11.80
Fragaria sp	25	700	4.94
Imperata cylindrica	65	25450	49.80
Leucas ciliata	35	700	6.48
Nephrolepis cordifolia	65	11650	28.22
Paspalum sp	55	5200	16.59
Pilea umbrosa	10	350	2.09
Polygonum capitata	60	1100	10.95
Polypodium sp	25	400	4.47
Rubia cordifolia	20	350	3.62
Thysanolaena maxima	25	1800	6.66

B. Damsite

Species	Frequency (%)	Density ha^{-1}	Basal area (m^2ha^{-1})	IVI
Trees				
Albizzia sp	35	55	0.67	67.41
Callicarpa arborea	10	15	0.15	17.67
Grewia sp	5	5	0.09	8.13
Juglans regia	30	30	1.34	71.58
Macaranga	15	15	0.50	30.76
Pinus sp	20	20	0.09	24.60
Quercus sp	15	15	0.36	26.82
Rhus javanica	35	50	0.26	53.14

Shrubs	**Frequency (%)**	**Density ha^{-1}**	**IVI**
Artemisia nilagirica	75	1340	47.41
Boehmeria longifolia	75	330	19.47
Buddleja asiatica	20	25	3.45
Debregessia longifolia	70	210	15.46
Eupatorium adenophorum	60	290	16.30
Indigofera sp	85	455	24.31
Inula cappa	60	130	11.87
Oxospora paniculata	25	30	4.28
Plectranthus striatus	65	480	22.24
Rubus ellipticus	40	50	6.90
Rubus sp	20	25	3.45
Smilax sp	25	30	4.28
Solanum nigrum	20	50	4.14
Solanum xanthocarpum	15	20	2.62
Urena lobata	70	150	13.80

Herbs (April)	**Frequency (%)**	**Density ha^{-1}**	**IVI**
Fagopyrum dibotrys	20	1200	6.38
Dicrepopteris linearis	35	9000	8.01
Bamboo grass	95	5100	28.71
Nephralepis cordifolia	80	4900	25.76
Rubia cordifolia	20	350	4.14
Imperat cylindrica	65	12900	44.34
Leucus ciliata	20	300	4.01
Carex sp	20	400	4.28
Cyanotis voga	25	2400	10.33
Commelina pedulosa	40	2000	11.70
Polygonum capitatum	60	2250	15.58
Polypodium sp	30	750	6.81
Borreria articularis	40	1200	9.60
Thysolaena maxima	25	1900	9.02
Pilea umbrosa	35	1400	9.32
Fragaria sp	10	150	2.01

Herbs (August)	**Frequency (%)**	**Density ha^{-1}**	**IVI**
Anemone vitifolia	10	150	1.87
Bamboo grass (common name)	70	6100	22.08
Borreria articularis	40	1350	8.81
Carex sp	20	400	3.91
Commelina paludosa	35	3050	11.04
Cyanotis voga	25	3600	10.42
Dricrenopteris linearis	35	900	7.21
Drymaria cordata	15	1850	5.70
Fagopyrum dibotrys	20	1700	6.23

Herbs (August)	Frequency (%)	Density ha^{-1}	IVI
Fragaria sp	10	250	2.05
Hedychium sp	10	100	1.78
Imperata cylindrica	65	23350	52.06
Leucus ciliata	20	400	3.91
Nephrolepis cordifolia	80	5400	22.43
Pilea umbrosa	35	1950	9.08
Polygonum capitatum	60	2550	14.15
Polypodium sp	30	800	6.23
Rubia cordifolia	20	350	3.82
Thysanolaena maxima	25	1800	7.21

C. Downstream

Species	Frequency (%)	Density ha^{-1}	Basal area ($m^2 ha^{-1}$)	IVI
Trees				
Pinus sp	100	520	19.68	300.00

Shrubs	Frequency (%)	Density ha^{-1}	IVI
Artimisia nilagirica	35	175	23.27
Boehmeria longifolia	20	25	6.42
Buddleja asiatica	15	15	4.47
Debregessia longifolia	25	35	8.37
Eupatorium adenophorum	100	425	59.61
Indigofera sp	35	45	11.34
Inula cappa	45	70	15.70
Plectranthus striatus	50	80	17.65
Rubus ellipticus	30	50	10.77
Rubus sp	30	40	9.86
Rubus sp	25	25	7.45
Smilax sp	25	35	8.37
Solanum nigrum	25	30	7.91
Urena lobata	25	40	8.82

Herbs (April)	Frequency (%)	Density ha^{-1}	IVI
Bamboo grass	50	2500	18.16
Nephralepis cordifolia	50	3500	21.61
Rubia cordifolia	10	100	2.25
Imperat cylindrica	70	10750	50.47
Gnaphalium sp	70	1250	17.65
Leucus ciliata	25	250	5.63
Carex sp	15	250	3.72
Cyanotis voga	50	1350	14.19
Commelina pedulosa	70	5700	33.02
Polygonum capitatum	60	1200	15.57

Borreria articularis	55	2100	17.73

Herbs (August)	**Frequency (%)**	**Density ha^{-1}**	**IVI**
Bamboo grass (common name)	50	2750	13.63
Borreria articularis	55	2500	13.98
Carex sp	15	250	2.98
Commelina paludosa	70	5450	22.17
Cyanotis voga	55	2350	13.69
Drymeria cordata	45	5050	17.23
Fragaria sp	15	200	2.89
Gnaphalium sp	70	3750	18.89
Imperata cylindrica	70	23250	56.46
Leucus ciliata	25	400	4.94
Nephrolepis cordifolia	50	3850	15.75
Polygonum capitatum	60	1900	13.66
Rubia cordifolia	20	200	3.72

ANNEXURE-XXI

Estimated volume of wood at sampling sites in the project area of various hydroelectric projects in the study area

1. Estimated volume of wood (m^3/ha) at different sampling sites for Utung HEP

Species	Upstream	Damsite	Downstream
Alnus nepalensis	0.00	0.00	7.73
Castanopsis purpurella	28.29	0.00	0.00
Castanopsis sp	22.58	36.35	11.86
Cinnamomum sp	2.60	0.00	0.00
Drymicarpus racemosus	26.20	10.61	10.64
Eleocarpus sp	10.92	0.00	0.00
Engelherdtia spicata	67.00	42.43	41.62
Grewia sp	3.90	0.00	0.00
Lithocarpus penetrata	40.70	18.37	10.36
Lyonia ovalifolia	0.00	0.00	0.00
Macaranga denticulata	9.52	20.27	5.90
Macropanax disperma	0.00	0.00	0.00
Myrica esculenta	12.11	2.14	4.85
Oroxylum sp	6.01	0.00	0.00
Quercus griffithii	45.95	16.83	44.18
Rhododendron arboreum	11.34	0.00	0.00
Rhus acuminata	3.58	7.07	0.00
Schima khasiana	13.72	12.00	13.33
Spondias pinnata	10.73	0.00	0.00
Talauma hodgsonii	8.99	0.00	0.00
Syzygium tetragonum	0.00	5.05	0.00
Total	**324.12**	**171.12**	**150.48**

2. Estimated volume of wood (m^3/ha) at different sampling sites for Nazong HEP

Species	Upstream	Dam site	Downstream
Alnus nepalensis	0.00	63.85	25.32
Betula alnoides	0.00	4.40	2.34
Castanopsis purpurella	6.39	36.91	21.76
Engelhardtia spicata	5.00	15.57	47.43
Quercus griffithii	356.22	12.41	26.53
Castanopsis sp.	0.00	14.75	0.00
Drymicarpus racemosus	0.00	8.17	5.71
Eleocarpus sp	0.00	5.73	0.00
Euvodia sp	0.00	1.45	0.00
Lithocarpus fenestrata	0.00	2.77	7.61

Macaranga denticulata	0.00	0.53	16.90
Rhus acuminata	0.00	3.06	0.50
Schima khasiana	0.00	4.38	5.76
Ficus sp.	0.00	0.00	16.83
Total	**367.61**	**173.99**	**176.71**

3. Estimated volume of wood (m^3/ha) at different sampling sites for Dibbin HEP

Species	Upstream	Submergence	Dam site
Alnus nepalensis	4.77	1.10	
Betula alnoides	0.67		3.22
Castanopsis perpurella	5.75		
Castanopsis sp	8.03		
Chukressia tubularis			4.38
Drymicarpus racemosus	5.51		26.59
Engelherdtia spicata	71.07	9.85	1.66
Lithocarpus penetrata	8.63		1.15
Macaranga denticulata	0.41	16.32	4.01
Melia sp			17.54
Prunus sp			2.97
Quercus griffithii	124.57	11.48	
Rhus acuminata	0.67	0.91	
Schfellera hypoculasp			2.55
Toona ciliata			2.90
Total	**230.09**	**39.66**	**66.97**

4. Estimated volume of wood (m^3/ha) at different sampling sites for Dimijin HEP

Species	Upstream	Dam site	Downstream
Acer laevigatum		1.66	
Albizzia sp		2.86	
Alnus nepalensis		2.05	
Dysoxylon gobara		1.00	
Ficus sp		45.42	
Litsea sp		0.95	
Pinus sp	53.97		29.01
Rhus acuminata		1.78	
Schima wallichii		8.88	
Toona ciliata		14.77	
Total	**53.97**	**79.35**	**29.01**

5. Estimated volume of wood (m^3/ha) at different sampling sites for Dikhri HEP

Species	Upstream	Damsite	Downstream
Alnus nepalensis	8.03	4.49	
Betula alnoides	7.19		
Castanopsis purpurella	8.49	2.51	22.38
Castanopsis sp	58.22	22.61	
Drymicarpus racemosus	4.57	21.17	7.74
Engelherdtia spicata	90.24	27.25	3.41
Ficus roxburghii	1.94		
Ficus sp	27.49		
Grewia sp	3.37		
Juglans regia	4.82		11.79
Lithocarpus fenestrata	40.44	1.56	14.98
Macaranga denticulata	3.83	9.79	7.67
Michelia sp	169.67		
Myrica esculenta	3.03		
Prunus accuminata	1.91		
Quercus griffithii	37.27	8.73	10.54
Rhododendron arboreum	7.40		
Rhus acuminata			7.77
Schfellera hypoleuca	1.03		
Schima khasiana	26.64	11.32	
Talauma hodgsonii	9.35		2.68
Total	**514.93**	**109.44**	**88.95**

6. Estimated volume of wood (m^3/ha) at different sampling sites for Dinchang HEP

Species	Upstream	Damsite	Downstream
Engelhertia spicata	1.34	4.17	
Pinus sp	35.12	46.71	13.27
Macaranga denticulata		2.39	
Quercus griffithii		16.73	12.18
Total	**36.46**	**69.99**	**25.45**

7. Estimated volume of wood (m^3/ha) at different sampling sites for Jameri HEP

Species	Upstream	Submergence	Damsite
Albizzia chinensis		4.77	0.64
Alnus nepalensis		2.35	24.62
Bombax cieba	45.72		
Beilschmedia assamica		1.79	6.97
Castanopsis purpurella	2.29	2.58	
Castanopsis tribuloides			8.65
Duabanga grandiflora		1.30	
Engelhardtia spicata		9.18	5.56
Ficus sp			21.04
Ficus sp			4.87
Juglans regia	56.51		
Lagerstromia muniticarpa			47.91
Macaranga denticulata		19.51	9.84
Persea odoratissima			3.79
Quercus griffithii	3.05		2.45
Rhus accuminata			1.06
Schima wallichii			22.77
Toona ciliata		**6.40**	**40.22**
Total	**107.57**	**47.88**	**200.39**

8. Estimated volume of wood (m^3/ha) at different sampling sites for Dinan HEP

Species	Upstream	Damsite	Downstream
Castanopsis purpurella	15.14	14.02	6.07
Engelherdtia spicata	10.54		5.62
Myrica esculenta	46.86	37.30	
Pinus sp			44.51
Quercus griffithii	91.86		12.66
Schima khasiana	11.74		12.97
Syzigium tetragonum	5.12		
Total	181.26	51.33	81.82

9. Estimated volume of wood (m^3/ha) at different sampling sites for Nafra HEP

Species	Upstream	Damsite
Engelhardtia spicata		2.35
Ficus sp	3.73	
Macaranga denticulata	13.69	1.99
Rhus acuminata	2.38	
Schima wallichii	3.97	
Toona ciliata	14.28	
Schima wallichii		2.49
Total	**38.05**	**6.83**

10. Estimated volume of wood (m^3/ha) at different sampling sites for Nafra HEP

Species	**Upstream**	**Dam site**	**Downstream**
Albizzia sp		5.35	
Macaranga denticulata	0.68	4.21	
Juglans regia		10.70	
Pinus sp			167.27
Total	**0.68**	**20.25**	**167.27**

N

LEGEND:-

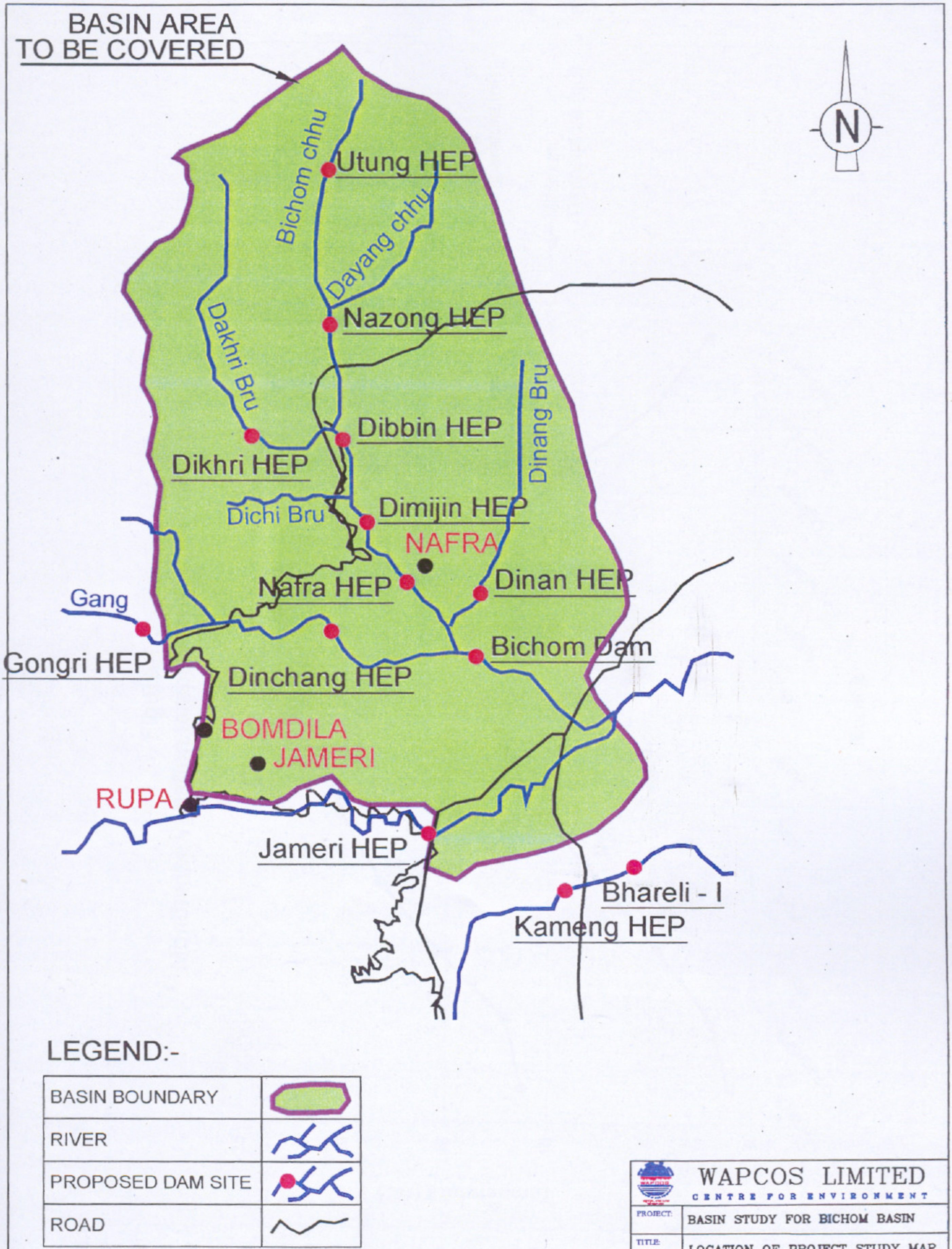
RIVER	
ROAD	
STATE BOUNDARY	
PROPOSED DAM SITE	

WAPCOS LIMITED
CENTRE FOR ENVIRONMENT

PROJECT: STUDY FOR BICHOM BASIN

TITLE: LOCATION OF VARIOUS HEDROELETRIC PROJECT

FIG. NO. 1.1



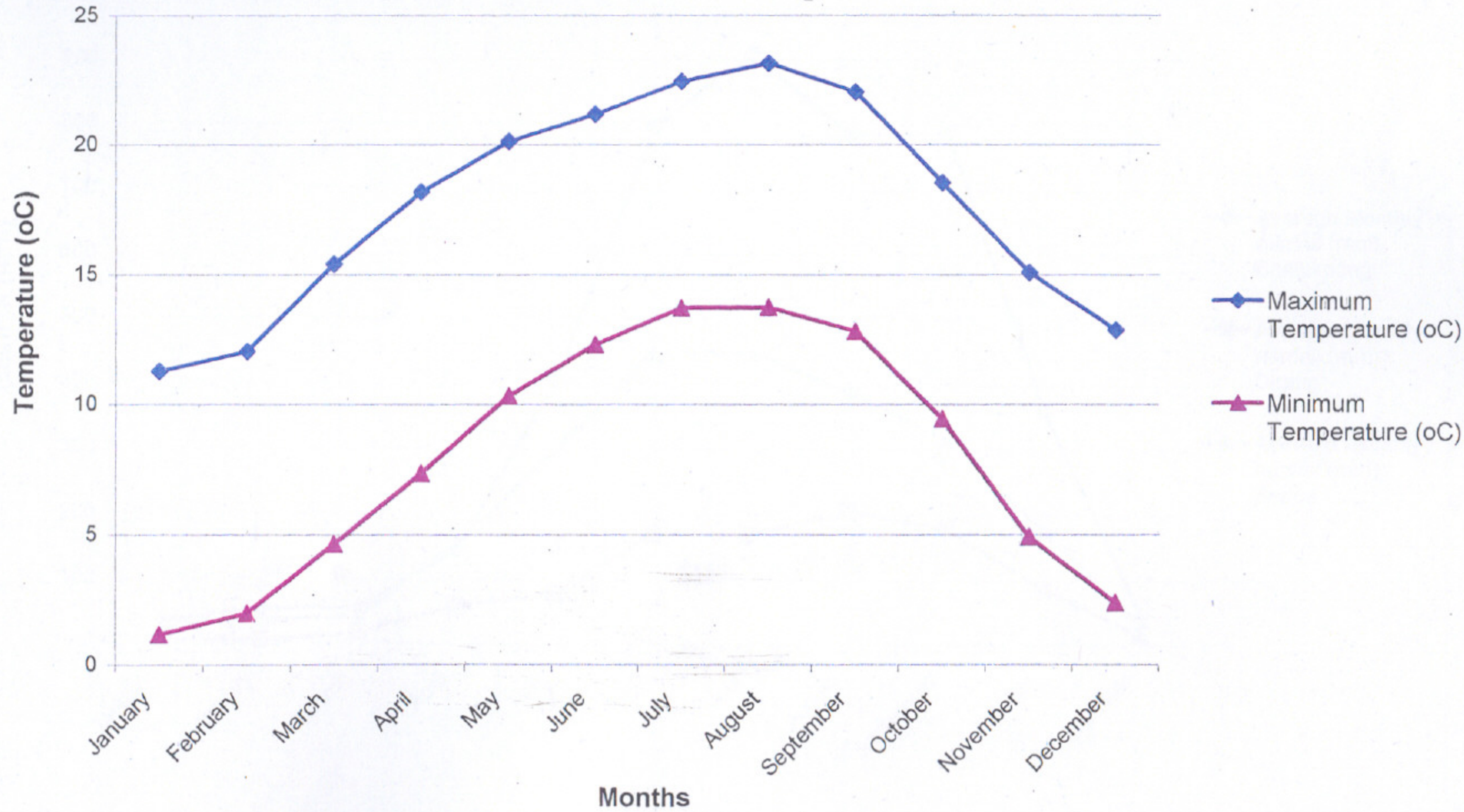
WAPCOS LIMITED
CENTRE FOR ENVIRONMENT

PROJECT: BASIN STUDY FOR BICHOM BASIN

TITLE: LOCATION OF PROJECT STUDY MAP

FIG. NO. 1.2

Figure-1.3
Monthwise variation temperature in the study area



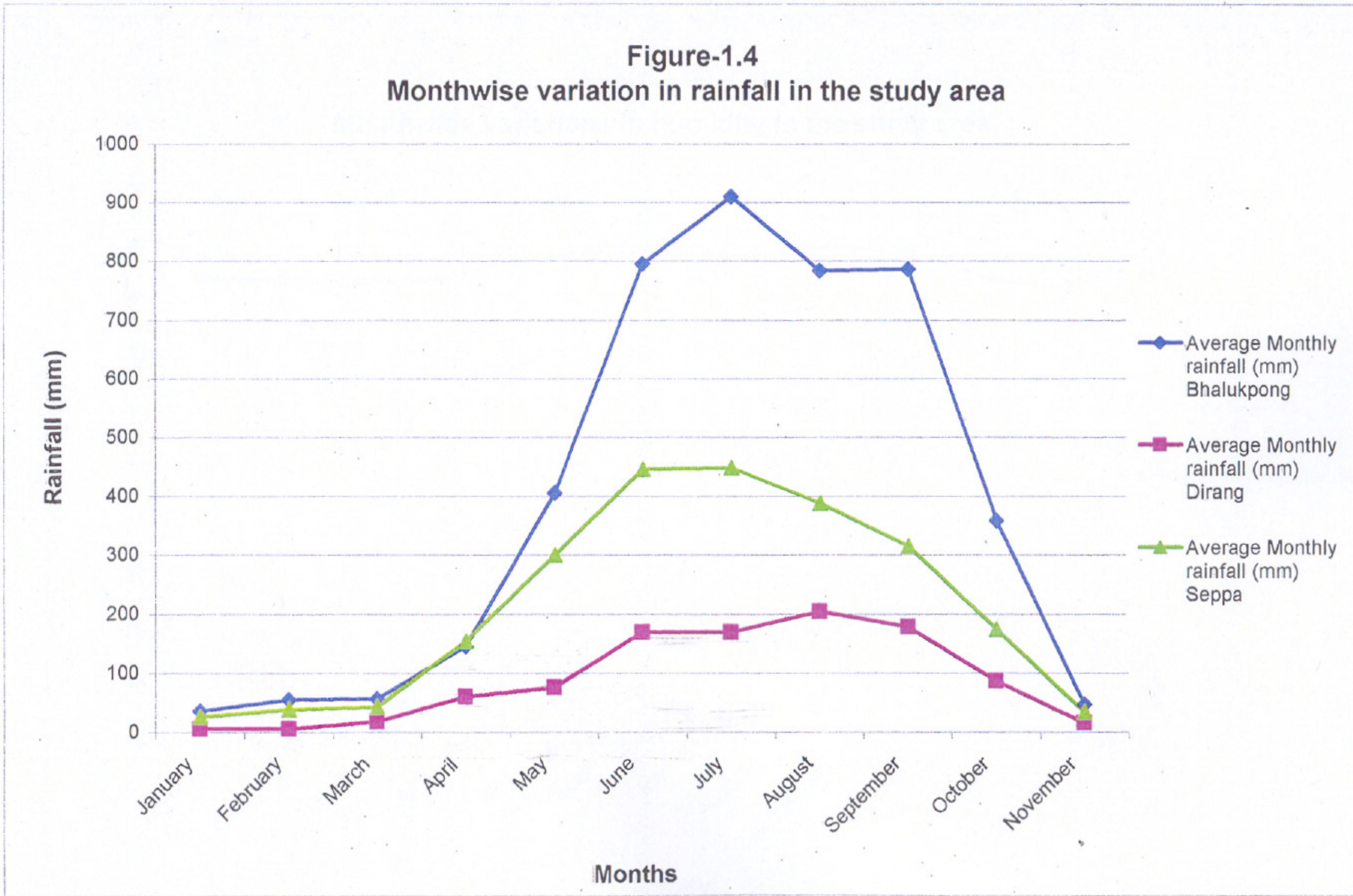
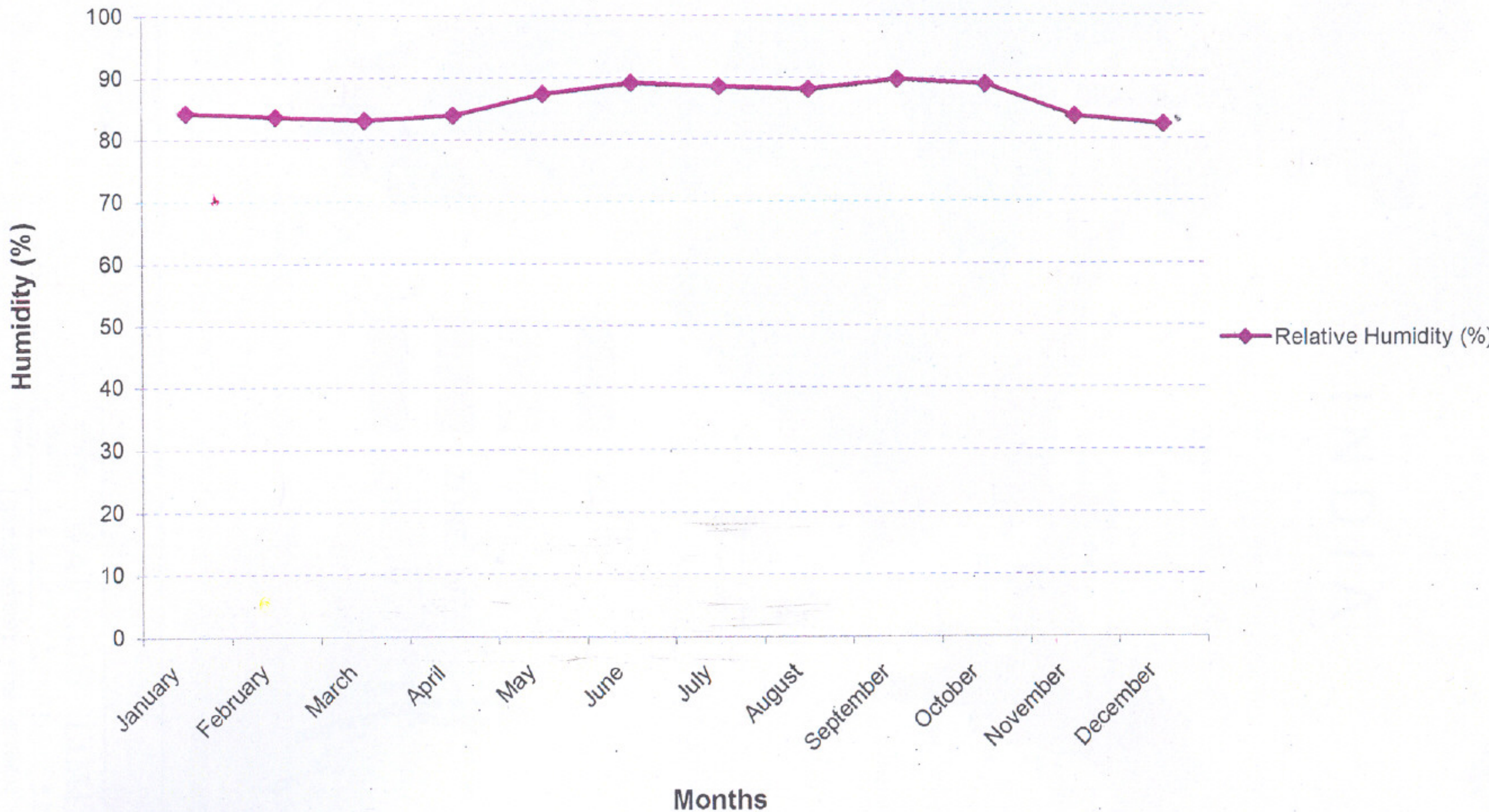
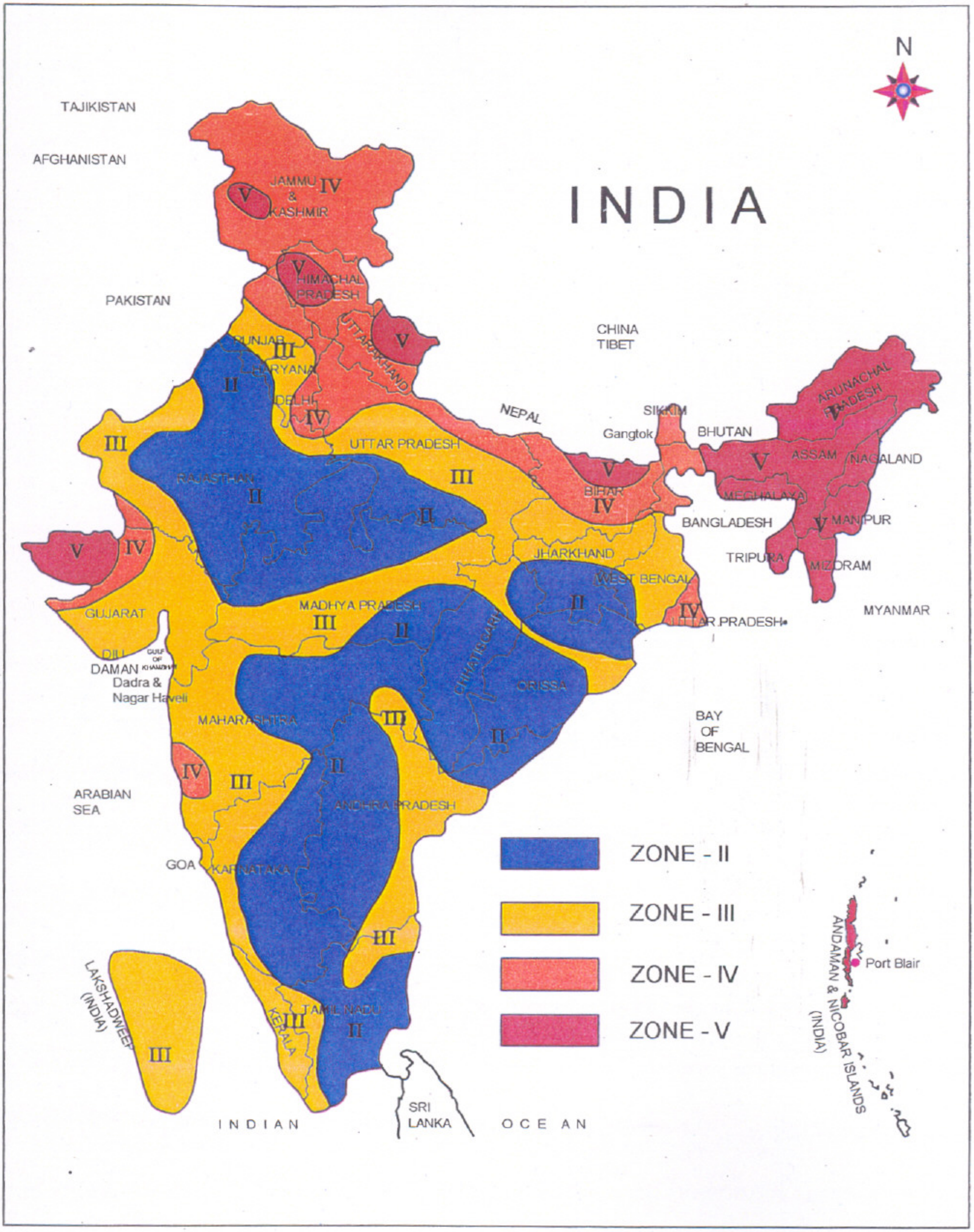


Figure-1.4
Monthwise variation in rainfall in the study area
1000
900
800
700
600
500
400
300
200
100
0
Rainfall (mm)
January
February
March
April
May
June
July
August
September
October
November
Months
Average Monthly rainfall (mm) Bhalukpong
Average Monthly rainfall (mm) Dirang
Average Monthly rainfall (mm) Seppa

Figure-1.5

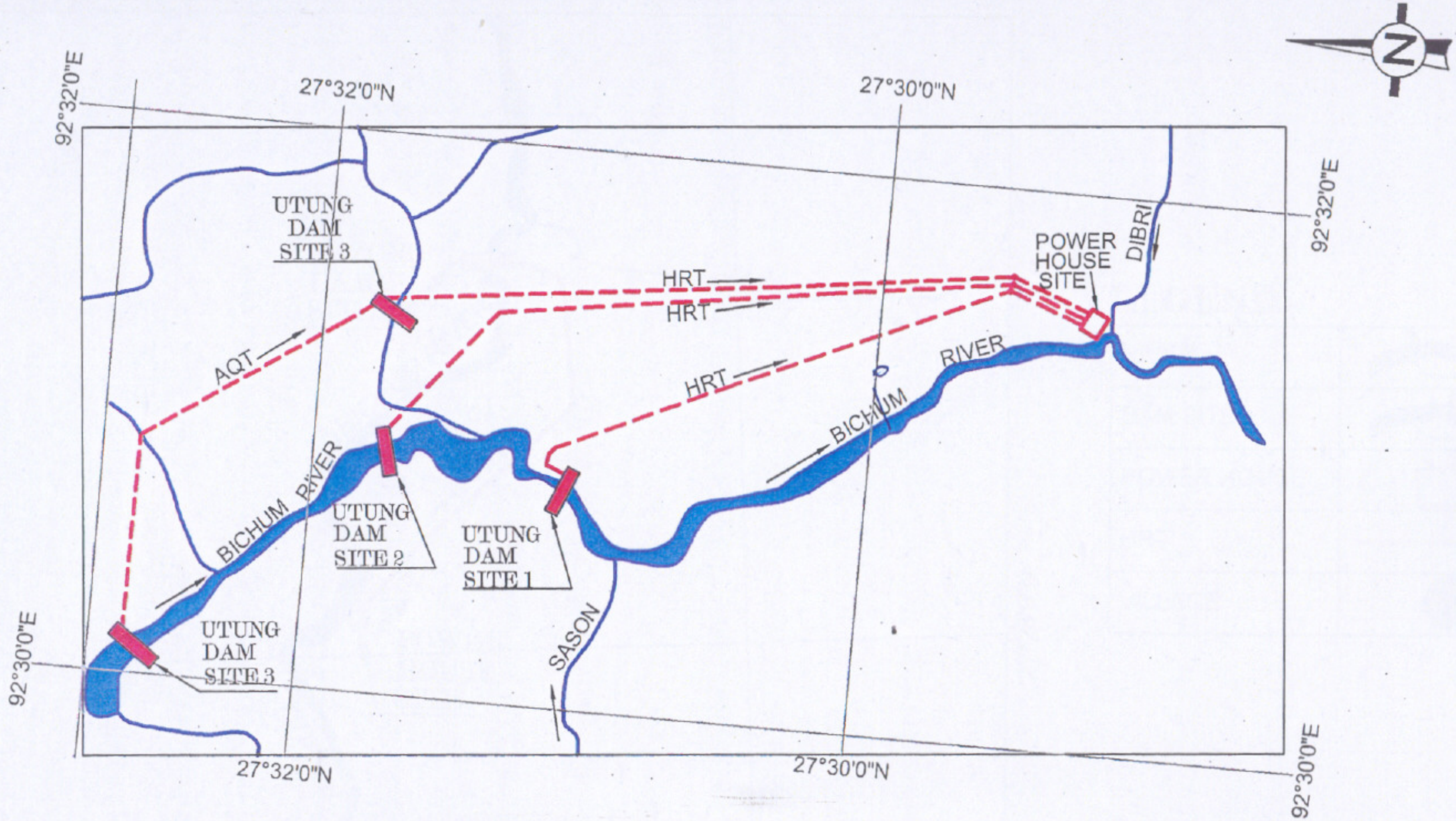
Monthwise variations in humidity in the study area





WAPCOS LIMITED
CENTRE FOR ENVIRONMENT

PROJECT:	BASIN STUDY FOR BICHOM BASIN
TITLE:	SESIMIC ZONING OF INDIA MAP
	FIG. NO. 1.6



LEGEND:-

- RIVER
- DAM SITE
- POWER HOUSE
- HRT
- HRT

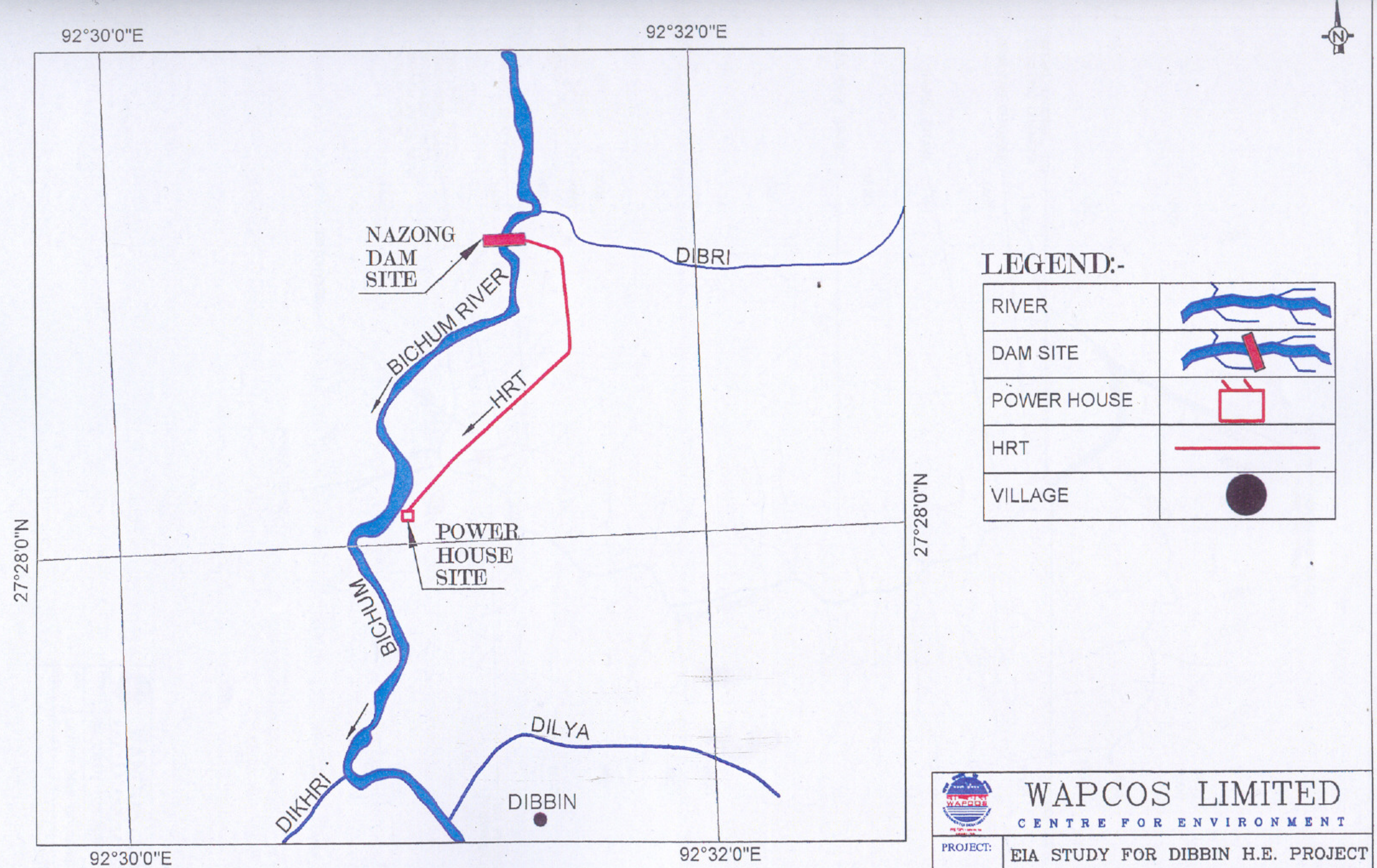
WAPCOS LIMITED

CENTRE FOR ENVIRONMENT

PROJECT: EIA STUDY FOR DIBBIN H.E. PROJECT

TITLE: LAYOUT MAP OF UTUNG DAM SITE

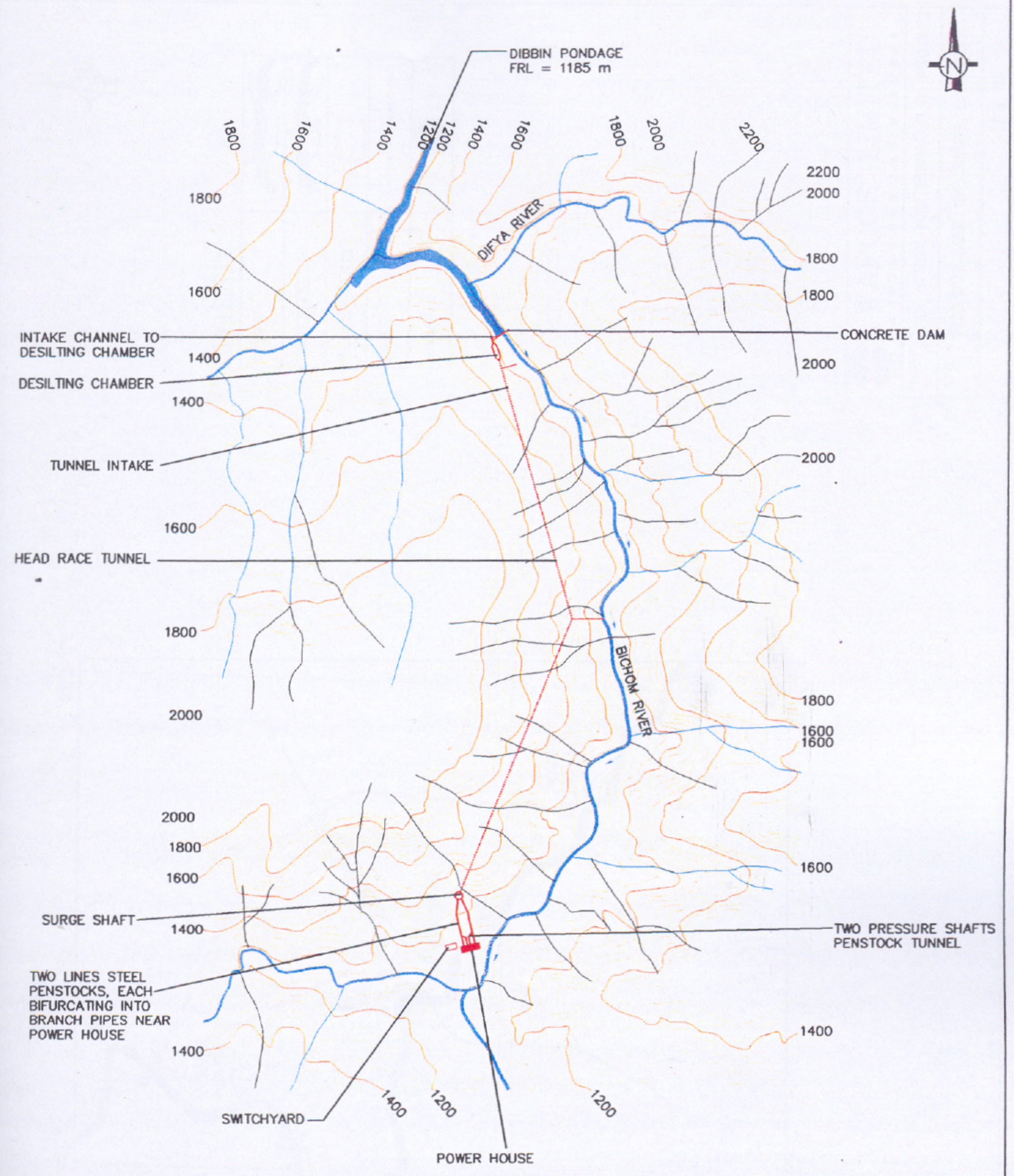
FIG. NO. 2.1



WAPCOS LIMITED

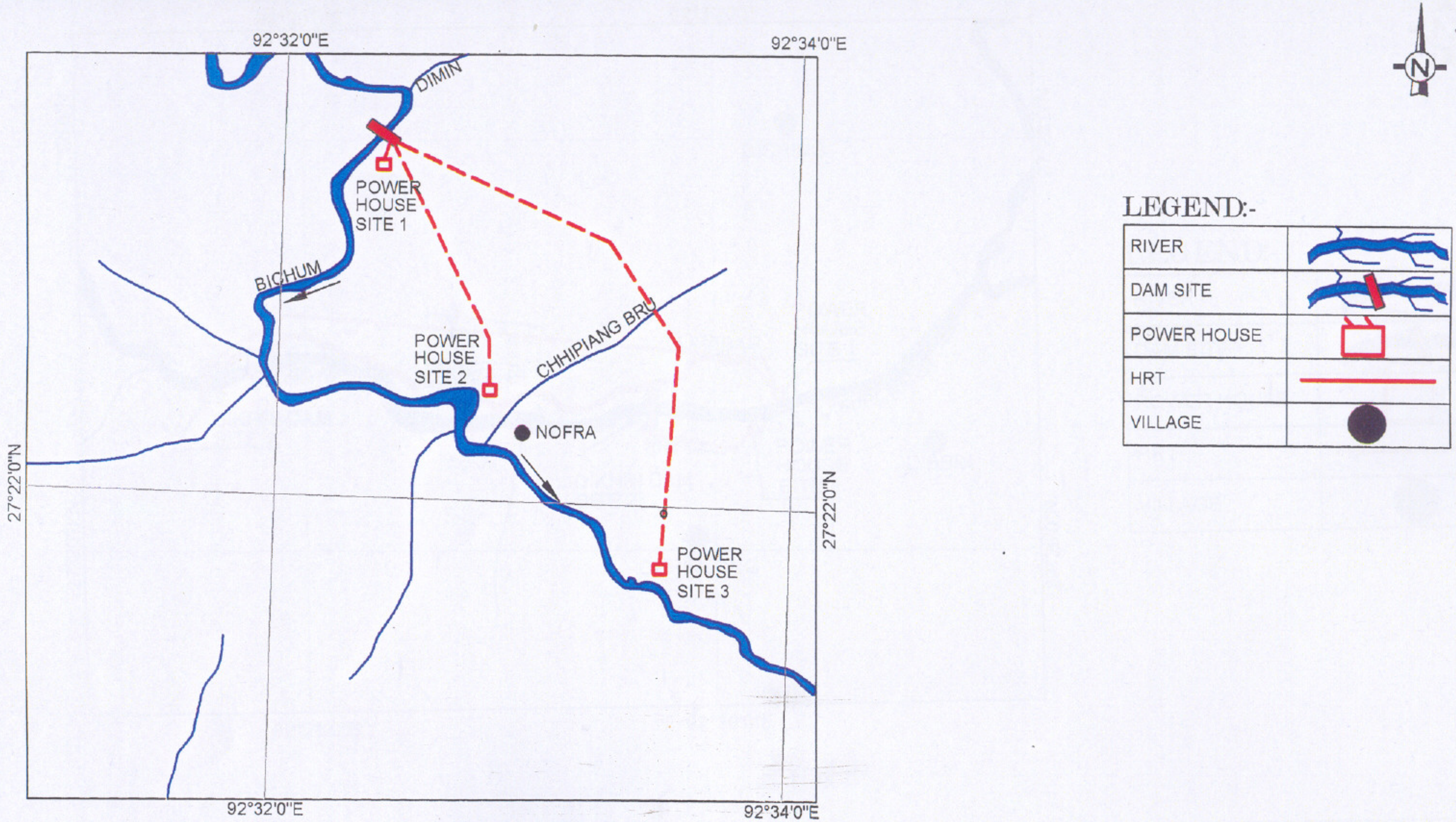
CENTRE FOR ENVIRONMENT

PROJECT:	EIA STUDY FOR DIBBIN H.E. PROJECT
TITLE:	LAYOUT MAP OF NAZONG DAM SITE
	FIG. NO. 2.2



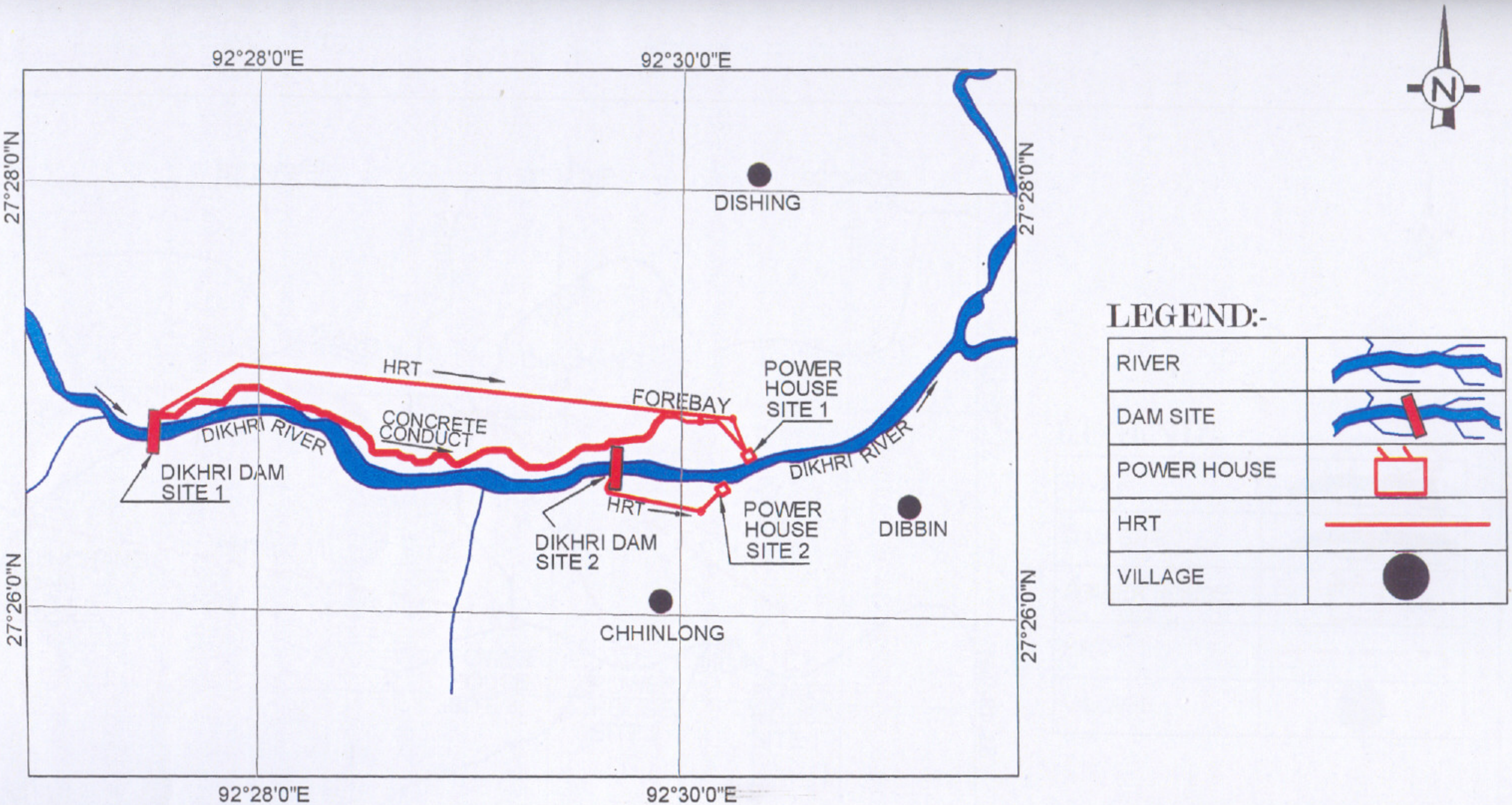
WAPCOS LIMITED
CENTRE FOR ENVIRONMENT

PROJECT:	EIA STUDY FOR DIBBIN H.E. PROJECT
TITLE:	LAYOUT MAP OF DIBBIN DAM SITE
	FIG. NO. 2.3



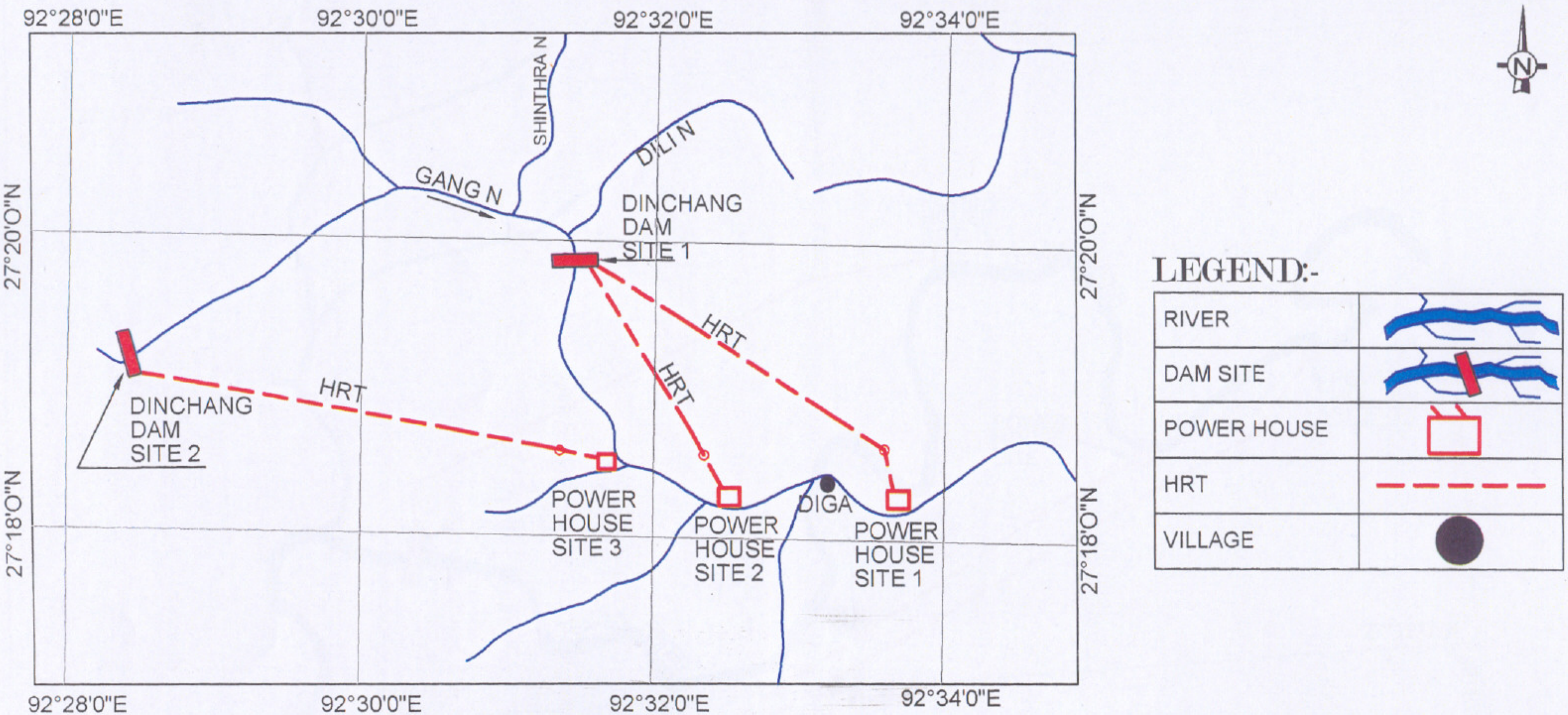
WAPCOS LIMITED
CENTRE FOR ENVIRONMENT

PROJECT:	EIA STUDY FOR DIBBIN H.E. PROJECT
TITLE:	LAYOUT MAP OF DIMJIN DAM SITE
	FIG. NO. 2.4



WAPCOS LIMITED
CENTRE FOR ENVIRONMENT

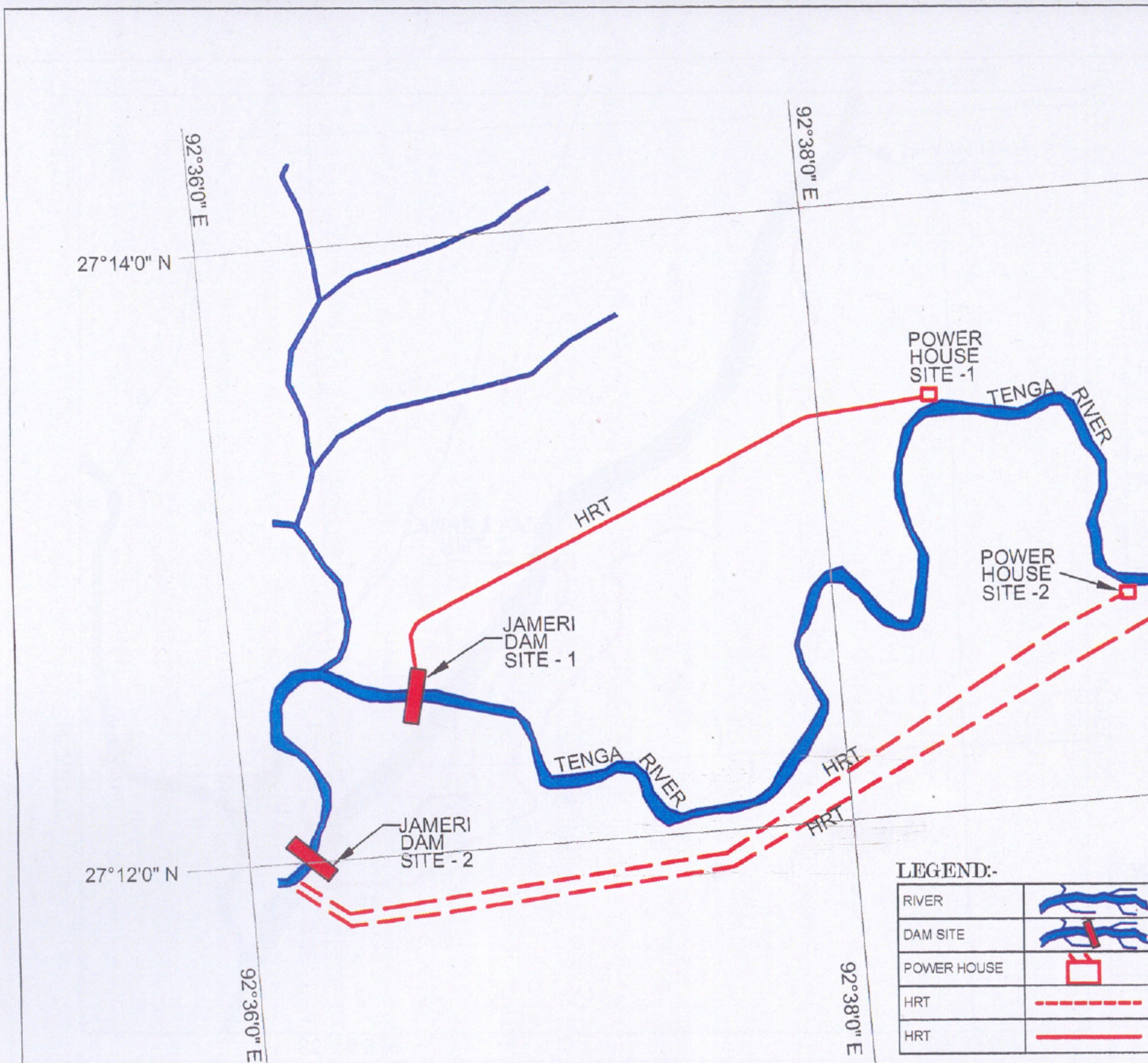
PROJECT:	EIA STUDY FOR DIBBIN H.E. PROJECT
TITLE:	LAYOUT MAP OF DIKHRI DAM SITE
	FIG. NO. 2.5



WAPCOS LIMITED

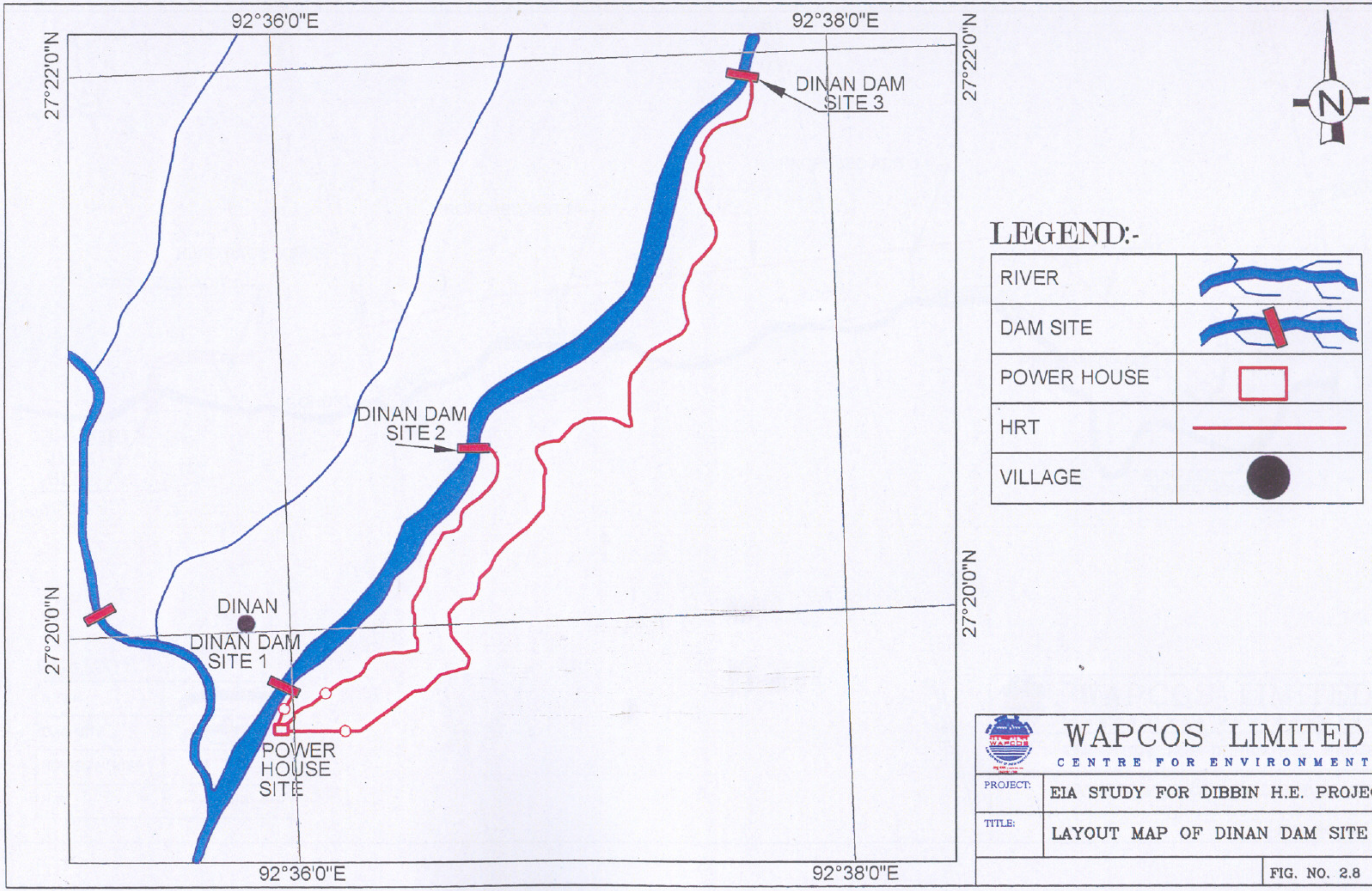
CENTRE FOR ENVIRONMENT

PROJECT:	EIA STUDY FOR DIBBIN H.E. PROJECT
TITLE:	LAYOUT MAP OF DINCHANG DAM SITE
	FIG. NO. 2.6



WAPCOS LIMITED
CENTRE FOR ENVIRONMENT

PROJECT:	EIA STUDY FOR DIBBIN H.E. PROJECT
TITLE:	LAYOUT MAP OF JAMERI DAM SITE
	FIG. NO. 2.7



LEGEND:-

RIVER	
DAM SITE	
POWER HOUSE	
HRT	
VILLAGE	

WAPCOS LIMITED
CENTRE FOR ENVIRONMENT

PROJECT: EIA STUDY FOR DIBBIN H.E. PROJECT

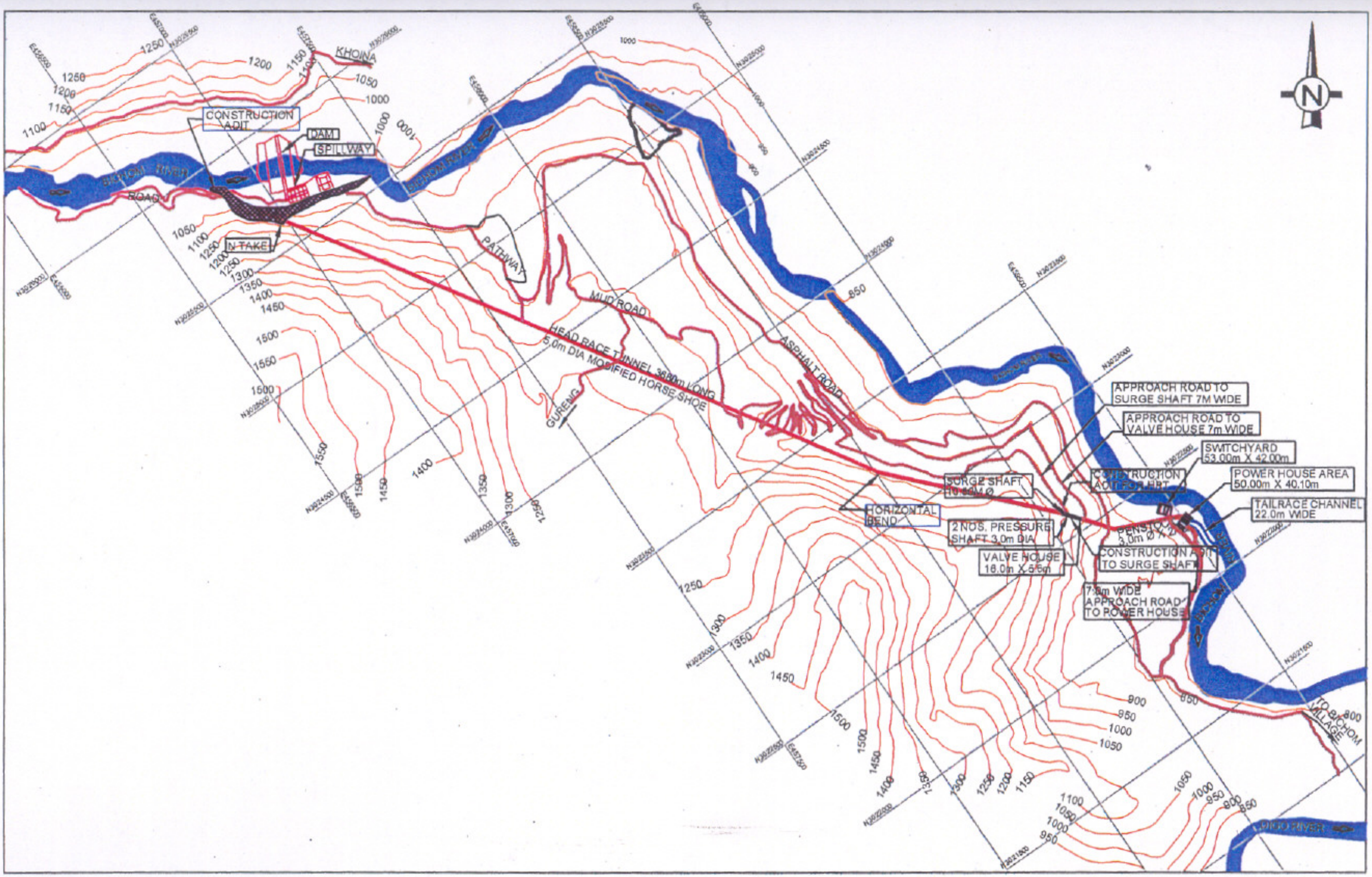
TITLE: LAYOUT MAP OF DINAN DAM SITE

FIG. NO. 2.8

WAPCOS LIMITED

CENTRE FOR ENVIRONMENT

PROJECT:	EIA STUDY FOR DIBBIN H.E. PROJECT
TITLE:	LAYOUT MAP OF GONGRI DAM SITE
	FIG. NO. 2.9



LEGEND :-

CONTOUR	
DAM SITE	
ROAD	

WAPCOS LIMITED
CENTRE FOR ENVIRONMENT

PROJECT: BICHOM BASIN H.E. NAFRA PROJECT

TITLE: LAYOUT PLAN NAFRA DAM

FIG. NO. 2.10

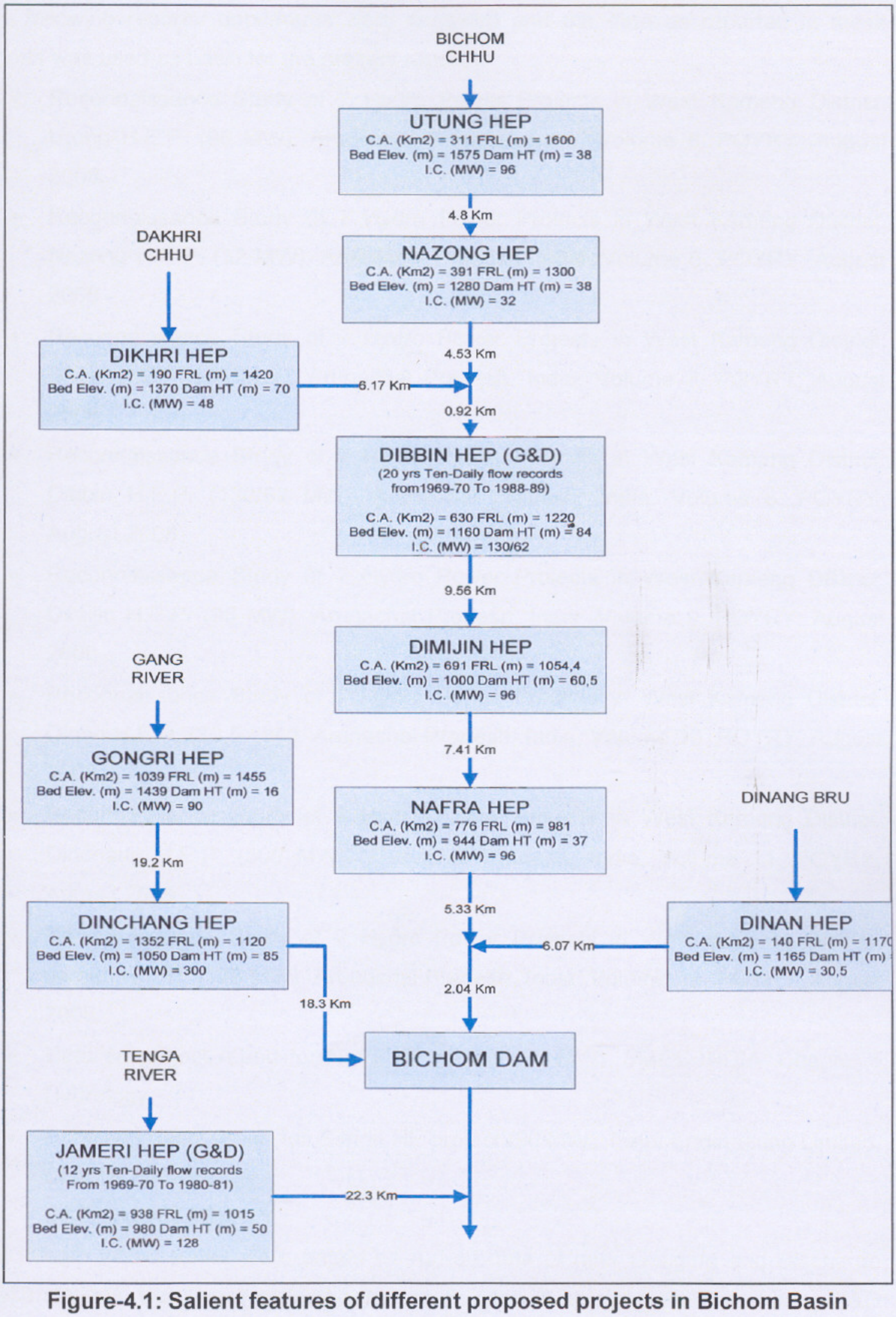


Figure-4.1: Salient features of different proposed projects in Bichom Basin

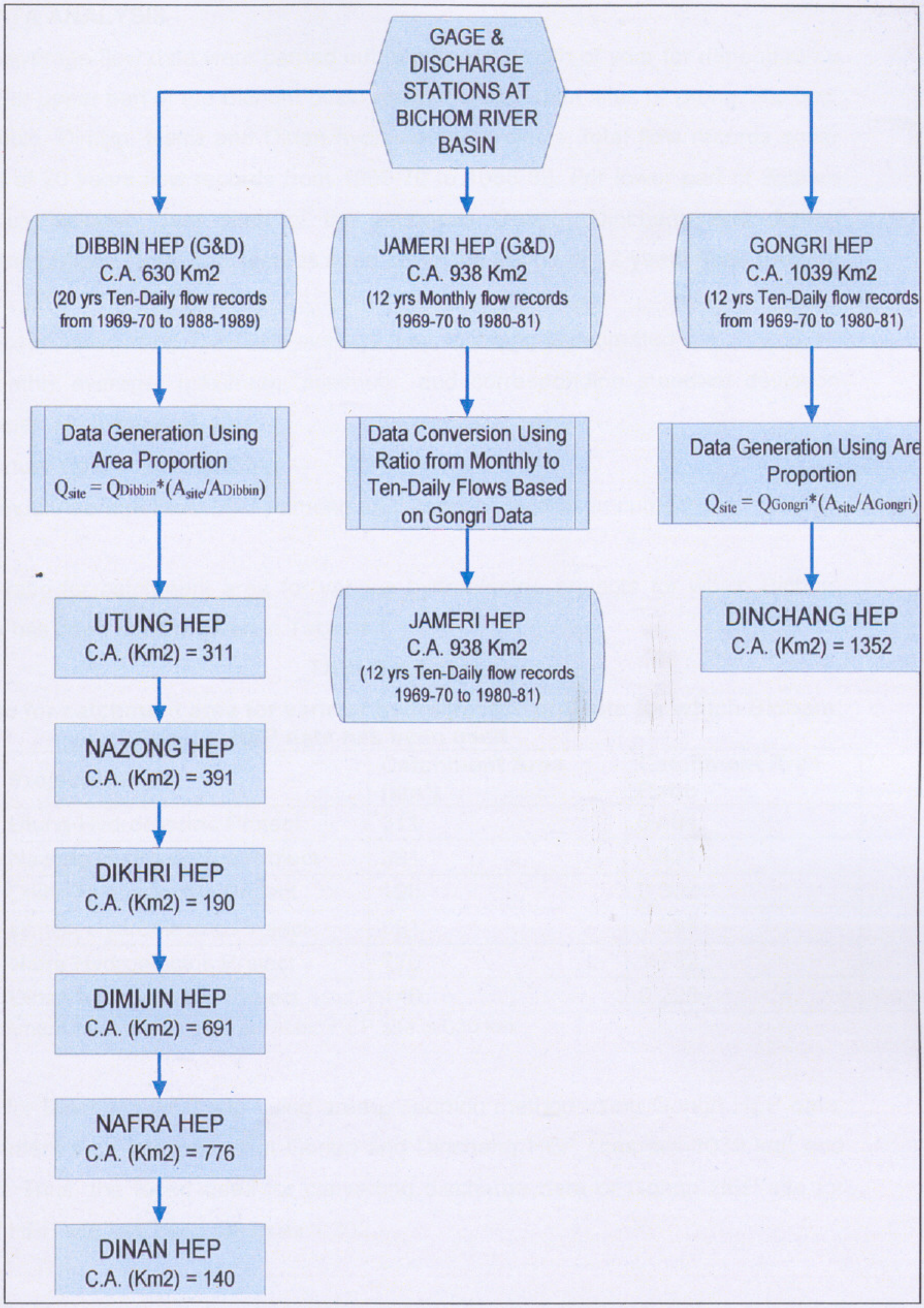


Figure-4.2: Schematic form of data generation at different proposed hydroelectric project sites in Bichom river basin

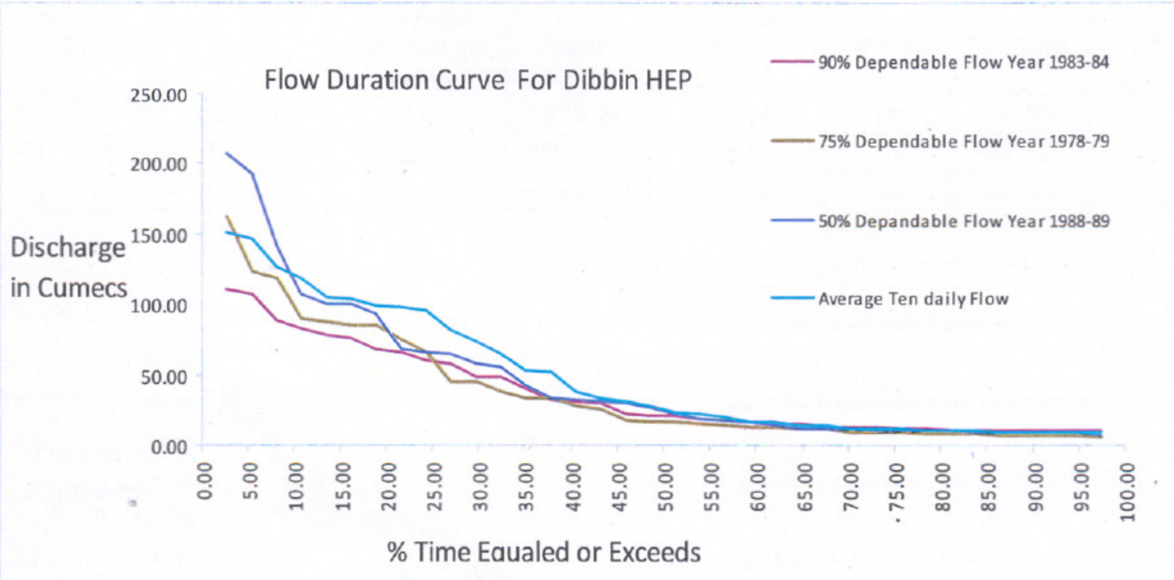


Figure-4.3 Flow Duration Curve of Dibbin HEP

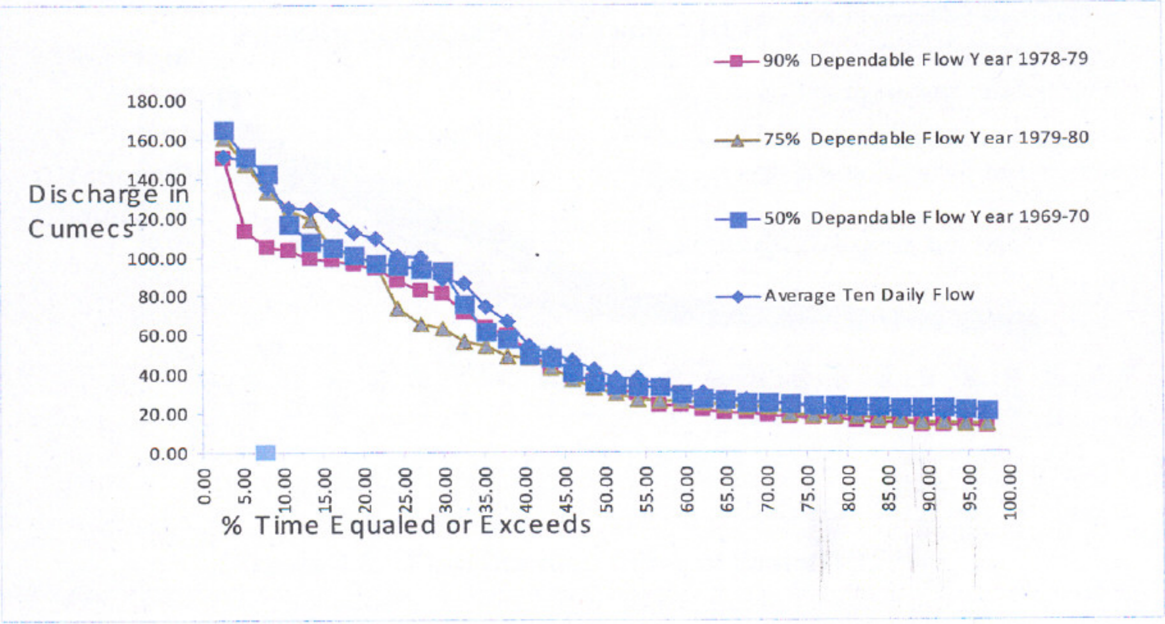


Figure 4.4 Flow Duration Curve of Gogri HEP

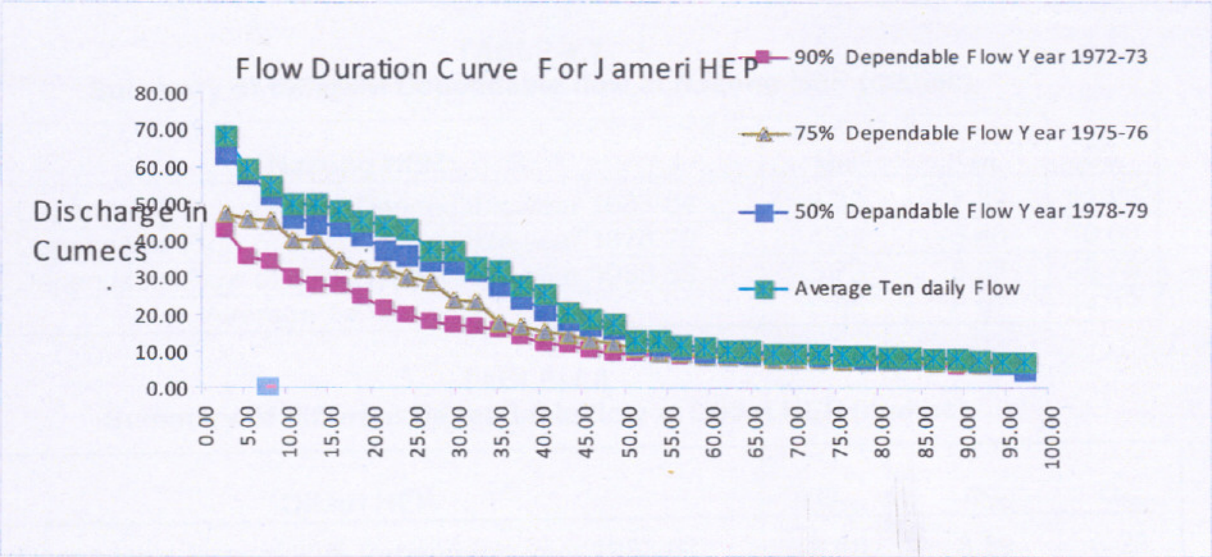
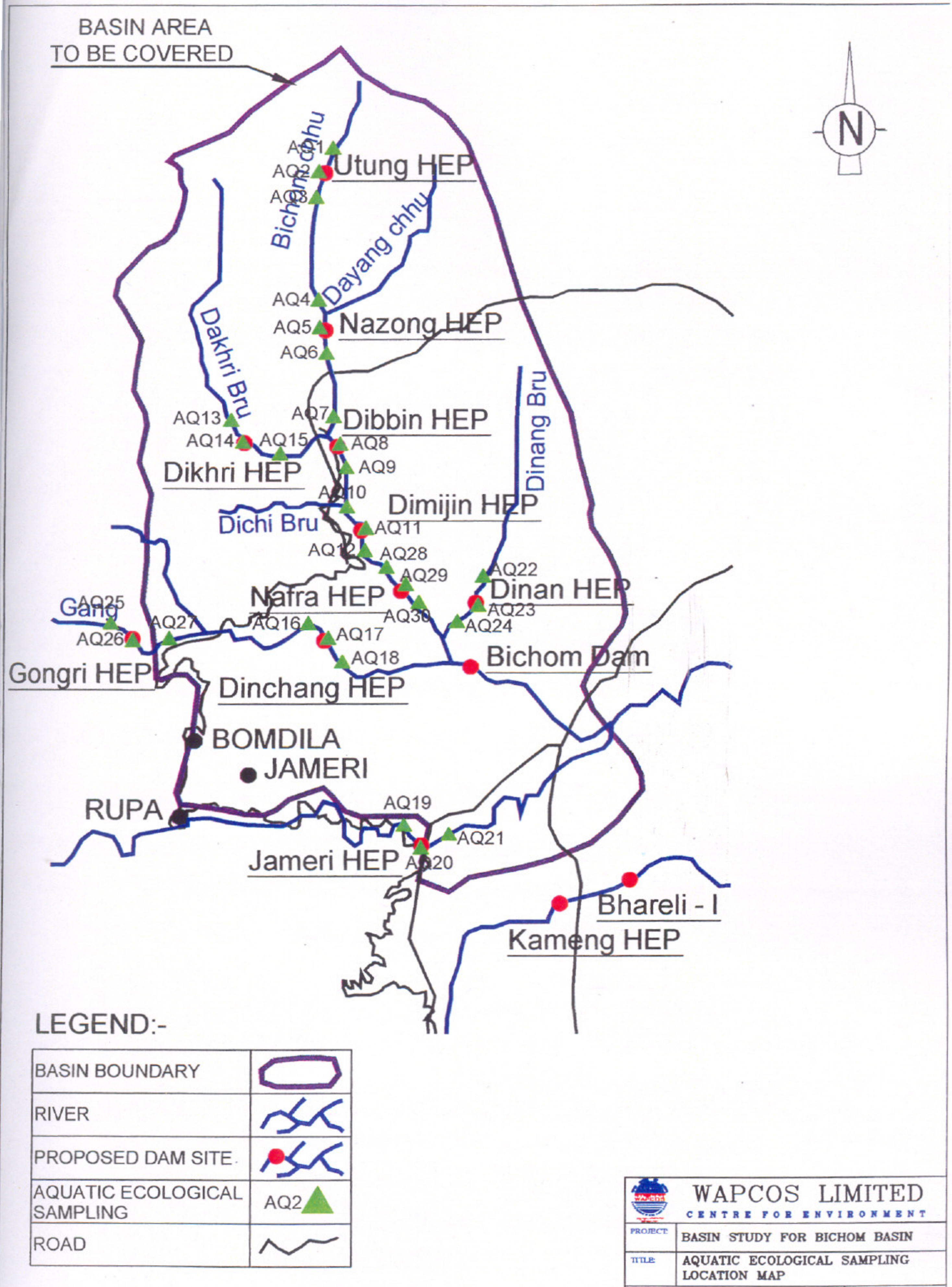


Figure-4.5 : Flow Duration Curve of Jameri HEP

WAPCOS LIMITED
CENTRE FOR ENVIRONMENT

PROJECT:	BASIN STUDY FOR BICHOM BASIN
TITLE:	WATER SAMPLING LOCATION MAP

FIG. NO. 5.1



WAPCOS LIMITED
CENTRE FOR ENVIRONMENT

PROJECT: BASIN STUDY FOR BICHOM BASIN

TITLE: AQUATIC ECOLOGICAL SAMPLING LOCATION MAP

FIG. NO. 6.1

WAPCOS LIMITED
CENTRE FOR ENVIRONMENT

PROJECT:	BASIN STUDY FOR BICHOM BASIN
TITLE:	TERRESTRIAL ECOLOGICAL SAMPLING LOCATION MAP
	FIG. NO. 7.1