Technical Series: D
तकनीकी श्रृंखला: डी

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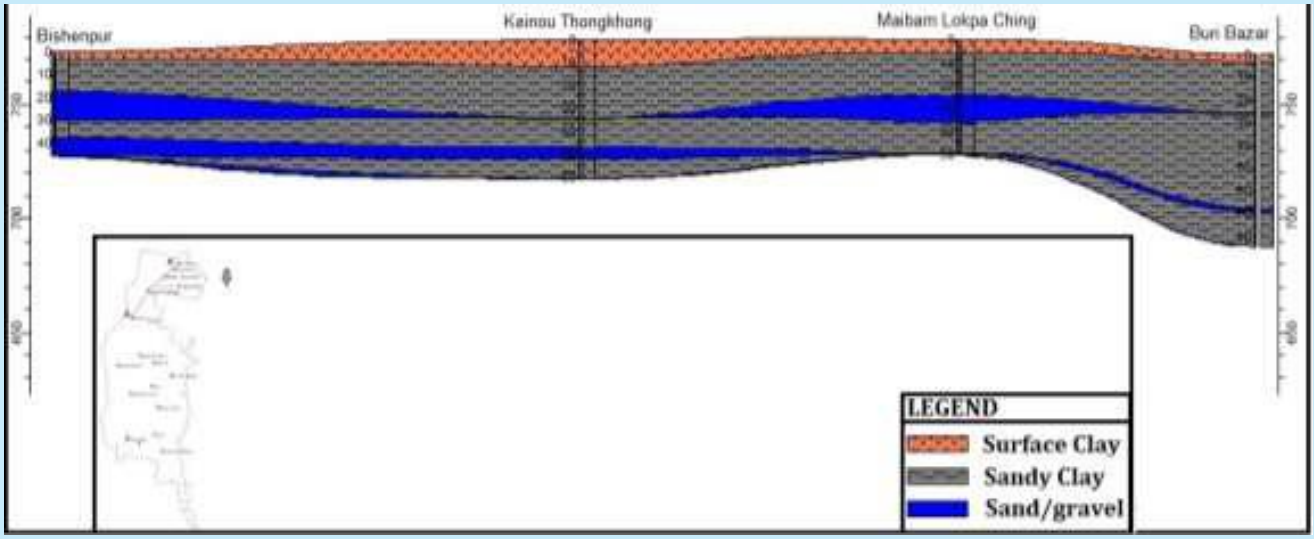
No. 12/2017-18

GOVERNMENT OF INDIA
भारत सरकार
MINISTRY OF JAL SHAKTI
जल शक्ति मंत्रालय
DEPARTMENT OF WATER RESOURCES, RD & GR
जल संसाधन, नदी विकास और गंगा संरक्षण विभाग
CENTRAL GROUND WATER BOARD
केंद्रीय भूमि जल बोर्ड

AQUIFER MAPPING AND MANAGEMENT PLAN OF BISHNUPUR DISTRICT, MANIPUR

ANNUAL ACTION PLAN, 2017-18



NORTH EASTERN REGION
उत्तरपूर्वी क्षेत्र
GUWAHATI
गुवाहाटी

GOVERNMENT OF INDIA

MINISTRY OF JAL SHAKTI, DEPARTMENT OF WATER RESOURCES, RIVER DEVELOPMENT & GANGA REJUVENATION

REPORT
ON

"AQUIFER MAPPING AND MANAGEMENT PLAN OF BISHNUPUR DISTRICT, MANIPUR"

(AAP 207-18)

By
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CENTRAL GROUND WATER BOARD
NORTH EASTERN REGION
GUWAHATI

Preface

Under National Aquifer Mapping and Management Plan (NAQUIM) program, Central Ground Water Board, North Eastern Region, Guwahati, Assam has carried out aquifer mapping and management plan in Bishnupur district of Manipur. The objective was to understand the aquifer system down to the depth of 300 meters, decipher the aquifer geometry, its characteristics, quantity, quality and formulate a complete sustainable and effective management plan for ground water development.

A multi-disciplinary approach of geology, geophysics, hydrology and chemistry was adopted to achieve the objectives of the study. A management plan was made with emphasis on irrigation for agriculture.

This report elaborates the different aquifer system prevailing in the study area, its characteristics and also provides the different scientific data which will help in proposing plans to achieve drinking water security, irrigation facilities etc. through sustainable ground water development.

The groundwater management plan was made with an emphasis in providing irrigation facilities through ground water development as agriculture is the main means of livelihood of the people in the district.

The study of the Aquifer mapping and management plan of Bishnupur district was carried out under the guidance and supervision of Regional Director, CGWB, NER, Guwahati, Technical Secretary to RD, CGWB, NER, Guwahati and Nodal officer, NAQUIM, NER who has helped in all the aspects of technical inputs and report preparation.

I hope this report will help the stake holders, planners, policy makers, professionals, academicians and researchers dealing with water resources or ground water resources management.

Acknowledgement

I would like to acknowledge all the below mentioned for their help and support in all aspects related to this work.

At the outset, I would like to extend my heartfelt gratitude to Shri. G L Meena, Regional Director, CGWB, NER, Guwahati for his support and guidance during the course of study.

I render my sincere thanks to my supervisor Shri Tapan Chakraborty, Nodal officer of NAQUIM, NER and Shri Biplap Ray, HOO, CGWB, NER, Guwahati for their support, technical input, encouragement during the year.

Sincere thanks to Dr. D. J. Khound, Scientist-B for the technical inputs and guidance in preparation of report.

I would like to thank all the officers and staff of the Regional Chemical laboratory, NER, Guwahati for analysing the ground water samples and providing the data. I thank all the Engineers and Drilling staff of CGWB, Division VII, Guwahati for their contribution in ground water exploratory drilling activities in the study area.

I would also like to thank State Government officials of Irrigation Department, Minor Irrigation Department, Water Resources Department, Public Health Engineering Department, Statistical Department and Agricultural Department for providing the data and necessary information of the district.

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ABBREVIATION

AAP	Annual Action Plan
AMP	Aquifer Management Plan
AQM	Aquifer Mapping
BIS	Bureau of Indian Standards
BDL	Below detectable level
BCM	Billion Cubic Metres
CGWB	Central Ground Water Board
DGM	Directorate of Geology and Mining
DTWL	Depth to water table
DW	Dug Well
°C	Degree Celsius
EC	Electrical Conductivity
EW	Exploratory Well
GEC	Ground water Estimation Committee
GL	Ground Level
GIS	Geographic Information System
GSI	Geological Survey of India
Ha	Hectare
Ham	Hectare meter
IMD	Indian Meteorological Department
IPD	Investigation & Planning Division
Km	Kilometre
LPM	Litres per minute
LPS	Litres per second
m	Metre
MASTEC	Manipur Science and Technology Council
Magl	Meter above ground level
mbgl	Meters below ground level
MCM	Million Cubic Meter
Mm	Milli meter
mg/l	milligram/litre
mamsl	Metre above mean sea level
MP	Measuring Point
MID	Minor Irrigation Department
µS/cm	Microsimens/centimetre
NAQUIM	National Aquifer Mapping and Management Plan
NER	North Eastern Region
OW	Observation Well
PHED	Public Health & Engineering Department
Ppm	Parts per million equivalents to mg/l
Pz	Piezometer
Sq.Km	Square Kilometre
SWL	Static water level
TDS	Total dissolved solid
TW	Tube Well
VES	Vertical Electrical Sounding
WRD	Water Resources Department

EXECUTIVE SUMMARY

Aquifer Mapping studies and Management Plan has been carried out in Imphal West district, Manipur under National Aquifer Mapping and Management Plan (NAQUIM) programme with an objective to know the different aquifer system prevailing in the study area, decipher the vertical and lateral extend of the aquifer down to the depth of 300 m, its characteristic, quantity as well as quality so as to bring a complete sustainable and effective aquifer management plan for ground water resources development in the district. This study has been done through multi-disciplinary approach so as to achieve the desired objectives.

Bishnupur district with its headquarter at Bishnupur (27 Km from Imphal) stretched between 93.43 º E and 93.53 º E Longitudes and 24.18 º N and 24.44 º N Latitudes with the total geographical area of 496 Sq. Km falls under the Survey of India topo sheet Nos. 83 H/13, H/14, 83L/15. It is bounded on the North by Imphal West District, on the South by Churachandpur District, on the East by Imphal and Thoubal Districts. The original name of Bishnupur was Lumlangdong (now Lamangdong). Bishnupur is popularly known as the 'land of dancing deer'.

Physiographically, the district may be divided into three main parts i.e. (i). Valley or alluvial plain area, (ii) area under water or wetland / lakes and (iii) area covered under Hillocks and Forest. Alluvial plains cover majority of the district area with a flat gentle regional slope towards Loktak Lake. The district is a part of the centrally located intermontane valley, i.e., Imphal valley of Manipur. Hillocks and forests, having an area of about 34.12 acres, constitute rest of the district. Some of the worth mentioning hillocks are Lokpaching, Loukoiching, Sendra, Khongjaingambaching, Thangaching etc.

The district enjoys sub-tropical humid climate. Average annual rainfall in the area is 1455.542 mm. About 60 to 65 % of the annual precipitation is received during south-west monsoon from June to September. The average annual rainfall for last 5 years in Bishnupur district is 1455.542 mm (as per IMD, data) and annual monsoon rainfall is 970.738 mm and non-monsoon is 484.804 mm.

Groundwater in the deeper aquifers occurs under sub-artesian and artesian conditions. Discharge of the tube wells constructed by State government ranged from 0.6 to 4 m3/hr. Considering the clayey nature of formation in the top aquifer, groundwater development is not considered promising on a large scale either in irrigation or water supply. Hydrogeological studies revealed that the valley area is underlined by a thin veneer of alluvial deposits, which is largely clayey in nature, underlined by rocks of Tertiary age. Since the upper formations are mainly silty and clayey, dug wells/open wells have poor yield prospects. However, the deeper zone, consisting of sandstones of Tertiary age, forms good aquifers which are under semi confined conditions. Auto flow conditions are also observed in the study area with a discharge range of 0.5 to 4.0 m3/hr.

To study ground water regime of aquifers, depth to water level from the established 20 nos. of key observation wells have been monitored seasonally during pre-monsoon and post-monsoon of 2017-18. Pre-monsoon water level in Bishnupur block ranges from 2.3 to 7.7 mbgl and it varies from 1.24 to 5.54 mbgl in Moirang block. The post monsoon water level in Bishnupur block varies from 1.47 to 6.9 mbgl and it varies from 1.1 to 5.11 mbgl in

Moirang block. Pre monsoon ad post monsoon water level fluctuation in the district ranges from 0.2 to 2.66 m.

The ground water quality is within permissible limit except for concentration of iron, which is found to be beyond permissible limit in certain pockets. As per dynamic ground water resource of the district, net ground water availability is 7346.23 ham and stage of ground water extraction is 1.09%. The existing current annual gross ground water extraction for all uses is 81.14 ham of which 57.19 ham is the current annual gross ground water extraction for irrigation use and 23.95 ham is the current gross ground water extraction for domestic use. Based on the stages and development and long-term water level trend analysis the district can be categorized under safe category.

Groundwater related problems of the district so far been identified **is emanation of gas w**hile construction of deep tube wells and existence of clayey deposit down to a depth range of 30 to 50 mbgl which invites problem for construction of tube wells. As such utmost care has to be taken during construction of tube wells so that any untoward incident can be averted.

Other groundwater related issues found in the district are low stage of ground water extraction, irrigation through ground water is not practice in large scale by individual villagers due to small land holding, high cost for construction and running of a well compared to production outcome. Another major obstacle in accelerating groundwater irrigation is the absence of power supply in most of the cultivated/cultivable area and meagre irrigational infrastructure and in major parts of the study area.

As per groundwater quality analysis data, it was found that groundwater in the district has found higher concentration of iron, which needs to be treated before consumption.

The district is having meagre irrigation facility. If an irrigation plan is made to develop 60% of the balance dynamic groundwater resources available, then 4407.72 ham of groundwater resources is available in the district for future irrigation uses. A total of 1468 tube wells can be constructed in the district for groundwater irrigation.

Development of rainwater harvesting for the drinking water supply is also one of the appropriate measures for solving the scarcity of potable water as it involves relatively low cost, less time for implementation and provides almost entirely safe drinking water which does not require costly purification and treatment process.

Rooftop rainwater harvesting is yet to be exploited in the district. The district is facing acute drinking water shortage as the government's water supply facilities fully depends on the rivers and which are generally remain dry during the dormant season. Rooftop rainwater can be one of the best options to stored quality water for use during the dormant months.

During the water crisis period, there are many other private traders who supply the drinking at much higher price, which increases hardship to the common people. Groundwater resources are not yet exploited in Manipur, so groundwater can be one of the options for supplies of water during non-rainy months and same groundwater can be recharged during the monsoon months.

AQUIFER MAPPING STUDY REPORT OF BISNUPUR DISTRICT, MANIPUR

1.0 INTRODUCTION

Aquifer mapping is a process wherein a combination of geologic, geophysical, hydrologic and chemical field and laboratory analyses are applied to characterize the quantity, quality and sustainability of ground water in aquifers.

An area of 496 sq km covering total area of Bishnupur district of Manipur has been undertaken as part of the National Aquifer Mapping Programme during the year 2017-18 by Central Ground Water Board, North Eastern Region, Guwahati.

1.1 Objectives

The objective of the study can be defined as follows:

(i) to define the aquifer geometry, type of aquifers, ground water regime behaviours, hydraulic characteristics and geochemistry of aquifer systems on 1:50,000 scale and
(ii) existing scenario of groundwater regime in shallow/deep aquifer
(iii) to work out a management plan for sustainable development of ground water.

1.2 Scope of the Study

This study was carried out to obtain an updated picture of groundwater occurrence, availability; its utilisation and also prevailing status of water quality with reference to the previous studies.

An accurate and comprehensive picture of the groundwater of the district may be generated by hydrogeological studies through groundwater exploration, geophysical and hydrochemical studies. The output of the study will enable robust groundwater management plans at the appropriate scale to be devised and implemented for this common-pool resource. This will help achieving drinking water security, improved irrigation facility and sustainability in water resources development in the rural as well as urban areas. This study is also important for planning suitable adaptation strategies to meet climate change in the area.

Therefore, hydrogeological information can be gathered in the entire study area (i.e., Bishnupur district). Similarly scope of exploration and use of geophysical technique to gather subsurface information can also be carried out.

1.3 Approach and Methodology

The approach is to identify the principal aquifers and to conceptualize the aquifer system. This will help to formulate an aquifer management plan. Finally, the scientific knowledge will be disseminated to farmers, state government and stake holders.

The methodology can be illustrated as follows:

(i) **Data compilation and data gap analysis**: The preliminary works consisted of collection and review of all existing hydrogeological and exploration data of CGWB and State Groundwater Departments. All data were plotted in the base map on GIS Platform (MapInfo-6.5 using Projection category longitude/latitude (Indian for Pakistan, India, Bangladesh, Nepal projection). On the basis of available data, data gaps were identified.

(ii) **Data Generation:** Efforts were made to fill the data gaps by multiple activities such as exploratory drilling, geophysical techniques, hydro-geochemical analysis, water level monitoring, yield tests and soil infiltration studies. The structure contours of the study area have been matched across the existing map boundaries (geological, hydrogeological) of the Manipur Valley. New data of groundwater abstraction structures were collected during the aquifer mapping study by selecting key areas in the district and have been re-defined in the context of local hydrogeological set up and new findings.

(iii) **Aquifer Map Preparation:** On the basis of integration of data generated from aforesaid studies, aquifers have been delineated and characterized in terms of its potential and quality. Various maps have been prepared by bringing out Characterization of Aquifers, which can be termed as Aquifer maps providing spatial variation (lateral & vertical) in reference to aquifer extremities, quality, water level, potential and vulnerability (quality & quantity). Relationship between the groundwater management units and the mapping units has been interpreted based on the findings of aquifer parameters from the existing hydrogeological data, lithology, quantity and quality of groundwater etc.

(iv) **Aquifer Management Plan Formulation:** Based on aquifer map and analysis of present requirement and future demand, a sustainable development plan of the aquifer is formulated.

(v) The aquifer mapping requires the analysis of large amounts of exploratory data. As no sufficient exploratory data is available in Manipur, data of the existing exploratory

wells of CGWB and wells constructed by State Departments like PHED, MID etc. were also considered in order to ensure an efficient and logical approach to the study for a better correlation of aquifer parameters.

1.4 Area Details

Bishnupur district of Manipur has been undertaken as part of the National Aquifer Mapping Programme during the year 2017-18 by Central Ground Water Board, North Eastern Region, Guwahati.

Bishnupur district with its headquarter at Bishnupur (27 Km from Imphal) stretched between 93.43 º E and 93.53 º E Longitudes and 24.18 º N and 24.44 º N Latitudes with the total geographical area of 496 Sq. Km falls under the Survey of India topo sheet Nos. 83 H/13, H/14, 83L/15. It is bounded on the North by Imphal West District, on the South by Churachandpur District, on the East by Imphal and Thoubal Districts. The original name of Bishnupur was Lumlangdong (now Lamangdong). Bishnupur is popularly known as the 'land of dancing deer'.

There are sixty-four Revenue villages in the district. For a better and convenient administration, the district is divided into three Sub-Divisions, viz (i) Bishnupur Sub-Division with its HQ at Bishnupur and (ii) Moirang Sub-Division with its HQ at Moirang and (iii) Nambol Sub-Division with its HQ at Nambol. There are six Sub Divisional Circles in the district. Nambol, Oinam and Bishnupur circles are situated within Bishnupur Sub-Division. Ningthoukhong, Moirang and Kumbi circles are situated within Moirang Sub-Division. As for the convenience of developmental activities of the rural areas there are two C.D Blocks, namely (i) Bishnupur C.D. Block with its HQ at Bishnupur and (ii) Moirang C.D Block with its HQ at Moirang Khunou.

The villagers in and around the Loktak lake, the biggest fresh water lake in the North East Region of India and those of Ithing, Thanga, Karang etc. exist mainly on fishing. The lake and its surrounding wetland cover more than 50% of the total terrestrial area of the district.

As per 2011 census, the total population of Bishnupur district is 237,399, out of which 118,782 are male and 118, 618 are female population.

The district is connected with all other valley districts, hill districts and other

neighbouring States by State Highways and National Highways and also linked by Air with Silchar, Guwahati, Dimapur, Calcutta, Delhi, etc. from the nearest airport at Bir Tikendrajit International Airport, Imphal. Dimapur, the nearest rail head is at a distance of 211 km from Imphal.

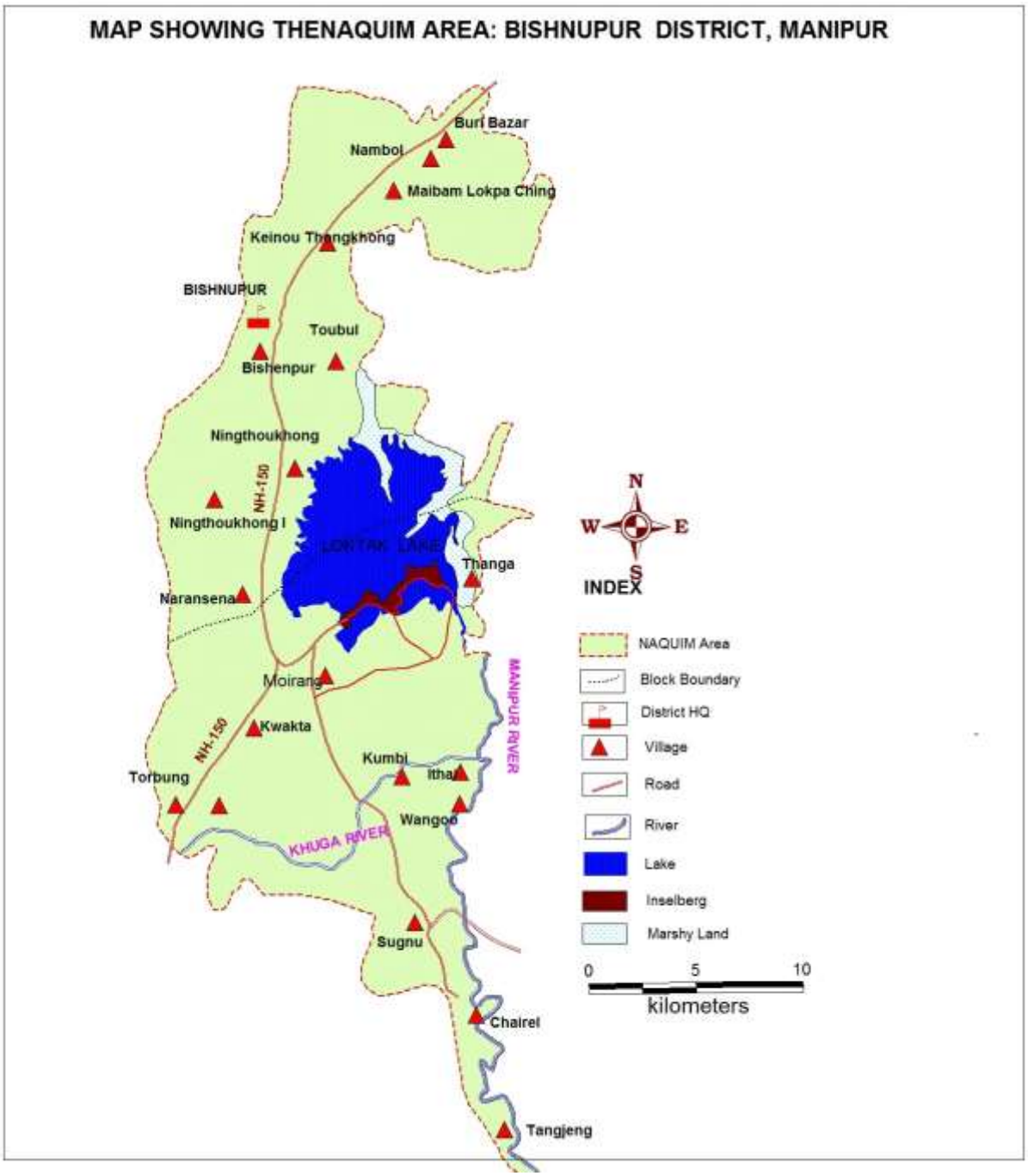


Fig.1 Map showing the study area: Bishnupur district, Manipur

The district is connected with N.H.39, N.H.53 and N.H.150. Air-ways and other road communication are also connecting other states of the country.

Table: 1. Administrative Sub-Divisions of Bishnupur district, Manipur

District	Block	**Area in sq.km.**	**Sub-Division**	**Head Quarters**	**No. Of Villages**
Bishnupur (Bishnupur is the district HQ)	Bishnupur	232.90	Bishnupur	Bishnupur	
			Nambol	Nambol	
	Moirang	476.10	Moirang	Moirang Khunou	
Total		**709**			**204**

Source: Directorate of Economics & Statistics, Govt. of Manipur

Physiographically, the district may be divided into three main parts i.e. (i). Valley or alluvial plain area, (ii) area under water or wetland / lakes and (iii) area covered under Hillocks and Forest. Alluvial plains cover majority of the district area with a flat gentle regional slope towards Loktak Lake. The district is a part of the centrally located intermontane valley, i.e., Imphal valley of Manipur. Hillocks and forests, having an area of about 34.12 acres, constitute rest of the district. Some of the worth mentioning hillocks are Lokpaching, Loukoiching, Sendra, Khongjaingambaching, Thangaching etc.

A considerable area of the district is covered by the lakes like Loktak, Ngakrapat, Awangsoi, Laisoi, Zingpat, Loukoipat, and Ikokpat etc. Loktakpat, which is the largest in Land Lake not only in Manipur but also in the North-Eastern India, covers an area of about 247 sq.km during the rainy season with an average depth of about 10-15 metres. Keibul Lamjao, the National Park is situated on the southeastern side of the Loktak Lake and it has an area of 40 sq.km. The sonapat, Utrapat, Samusang, Kharungpat and Ikokpat are also woth-mentioning lakes in Bishnupur district.

1.5 Data availability, data adequacy, data gap analysis and data generation

The preliminary works consisted of collection and review of all existing hydrogeological and exploration data of Central Ground Water Board, Geological Survey of India, Indian Meteorological department, State Water Resource Department, Minor Irrigation Department, PHED, MASTEC, etc. All data were plotted in base map on GIS Platform (MapInfo-6.5 using Projection category longitude/latitude (Indian for Pakistan, India, Bangladesh, Nepal projection).

GSI has carried out geological studies in Manipur valley to delineate the lithological units, their structures and stratigraphic disposition. Public Health Engineering Department, Govt. of Manipur has also constructed 20 nos. of tube wells for domestic purposes. In addition to these data of 2 nos. of exploratory wells constructed by CGWB, NER, Guwahati during the study on hydrogeology and ground water conditions of Imphal valley in the year 1975, which falls in the NAQUIM area has also been incorporated for better comparison with the present exploratory data.

1.6 Rainfall-spatial, temporal and secular distribution:

The district enjoys sub-tropical humid climate. Average annual rainfall in the area is 1455.542 mm. About 60 to 65 % of the annual precipitation is received during south-west monsoon from June to October. Annual average temperature of the study area is recorded to be 20.4^0C and the temperature ranges from 0^0C to 36^0C. The relative humidity is high.

The district experiences fair cold climate during winter and hot in summers. The maximum temperature is 33oC during May to September and the minimum is dips down to 4 ^{o}C in the month of January. However, the temperature of the district as a whole is moderate and there is no extreme climate in the district. Irregular rain starts in the month of April with occasional and irregular light showers and continues up to the end of May. This rain occurs due to the influence of north-eastern wind. Normal monsoon rain begins from the early part of June and heavy rains occur in the district till the month of September-October. About 80% rainfall is from south west monsoon.

The beginning of winter is marked by a steep fall in temperature during December. January is the coldest month. In February the temperature starts rising gradually. The winter winds are generally weak and variable. The average annual temperature ranges from 18°C-20°C to 23°C-25°C respectively in the higher and lower elevation. The monsoon lasts for five months from May to September with June, July and August being the wettest months. The average annual rainfall for last 5 years in Bishnupur district is 1455.542 mm (as per IMD, data) and annual monsoon rainfall is 970.738 mm and non-monsoon is 484.804 mm.

Table.2 Monthly Rainfall data in mm for the last 5 years in Bishnupur district

(Rainfall in mm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2014	0	18.87	35.46	36.41	233.35	298.03	81.13	231.54	109.19	31.42	0	0	**1075.4**

2015	40.35	5.42	17.72	207.6	49.1	227.03	331.47	252.99	154.5	111.24	9.64	0	**1407.06**
2016	6.78	26.25	51.92	217.5	316.73	185.78	310.07	99.04	177.99	125.12	58.88	2.1	**1578.16**
2017	6.9	19.6	209.41	212.97	152.71	281.14	349.32	141.89	306.14	239.85	3.51	101.84	**2025.28**
2018	0.28	7.4	52.36	114.97	195	324.15	220.5	193.15	22.91	48.1	0.2	12.79	**1191.81**
Average Annual Rainfall for the last 5 years (as Per IMD)													**1455.542**

Table 3. Monsoon and Non-monsoon rainfall data for the years 2014-2018

Year	**Total**	**Monsoon** (in mm)	**Non-monsoon** (in mm)
2014	1075.4	751.31	324.09
2015	1407.06	1077.23	329.83
2016	1578.16	898	680.16
2017	2025.28	1318.34	706.94
2018	1191.81	808.81	383
	1455.542	**970.738**	**484.804**

1.7 Physiographic set up

Physiographically the district may be divided into three main parts i.e. (i). Valley or alluvial plain area, (ii) area under water or wetland / lakes and (iii) area covered under Hillocks and Forest. Alluvial plains cover majority of the district area with a flat gentle regional slope towards Loktak Lake.

A considerable area of the district is covered by the lakes like Loktak, Ngakrapat, Awangsoi, Laisoi, Zingpat, Loukoipat, and Ikokpat etc. Loktakpat, which is the largest in Land Lake not only in Manipur but also in the North-eastern India, covers an area of about 287 sq.km during the rainy season with an average depth of about 10-15 metres. Keibul Lamjao, the National Park is situated on the south-eastern side of the Loktak Lake and it has an area of 40 sq.kms. The sonapat, Utrapat, Samusang, Kharungpat and Ikokpat are also worth-mentioning lakes in Bishnupur district.

Hillocks and forests, having an area of about 34.12 acres, constitute rest of the district. Some of the worth mentioning hillocks are Lotpaching, Loukoiching, Sendra, Khongjaingambaching, Thangaching etc.

Locally originated small tributaries control the drainage of the district. There is no large-scale river in the district. Some of the small rivers, which are flowing in the district, are Thongjaorock, Sunusiphai, Nambol, Yangoimacha, Yangoiachouba, Khuga, and Iram etc.

1.8 Geomorphology

Flat elongated and south tapering valley with isolated hills are the main geomorphologic features around the study area. The study area is part of an intermountain valley surrounded by hillocks. The western part is flanked by abruptly rising hills while by low-lying rolling hills bound the eastern side. The average trend of slope is down from north to south from an altitude of 880 to 770 meters above MSL, which is common in Imphal valley.

Geomorphologically, the study area is classified into the following geomorphic units

Table.4. Geomorphic units in the study area (after Singh, 1993 &1996)

Geomorphic Unit of Imphal Valley (After Singh, 1993)	Geomorphic Unit of Imphal Valley (After Singh, 1996)
Alluvial Plain	Intermontane Valley (Alluvial Plain)
Flood Plain	Piedmont
Abandoned Channel	Structuro-Denudational hill
Meander Scar	Denudational hill
Natural Leeves	Denudo-structural hill
Point bars	
Structural Hills	
Piedmonts	
Valley fills	

i. Structural Hills

The flat land of Bishnupur district is interrupted by occasional hills, raising above the general surface, such as Maibamlokpa Ching (892m), Ishok Ching (947 m), Thanga Ching (903 m), Karang Ching (811 m), Ething Ching (882) and Tanjeng Ching. These hills are confined in different parts of the district which further extends into the valley. They consist of shales and intercalations of sandstone belonging to the Disang Group. The drainage patterns are of sub-dendritic to sub-trellis. The structural hills are further sub classified into the following:

a. **Denudo-Structural Hill:** In the study area, it occupies the northern and central parts (Eastern area of Loktak Lake) with the highest relief of about 1866 m above men sea level. It consists of splintery shale, sandstones and siltstones of Disang Group of Upper Cretaceous to Eocene age. These hills have dendritic to sub dendritic drainage pattern. The drainage density is moderate to high as studied qualitatively.

b. **Residual Hill (Denudational Hill):** Residual hills are demarcated in the central part of the study area, with relief ranging from 900 to 1100 m above mean sea level. These are flanked on all sides by alluvial plain deposits. These hillocks lithologically consist of splintery shale, with sandstone and siltstone belonging to Disang Group of Eocene to Upper Cretaceous age. Sub-dendritic and radial drainage pattern are observed with moderate to fine drainage texture.

c. **Structuro-Denudational Hill:** These hills occupy the western part of Manipur valley with highest relief of about 2331 m above mean sea level and consist lithologically of sandstone, shale, siltstone,

d. **Piedmont:** It is well demarcated in the western margin of the alluvial valley surrounding the foot hill. It consists of colluvial and alluvial deposits comprising gravel, pebble, boulder, sand with silt/clay intercalations, formed by deposition of materials brought down by streams draining from the surrounding hills. This piedmont zone in the study area shows sensorial, coarse, braided and fanning stream patterns. Alluvial fans are prominently seen in this zone, which consists of sand, silt and clay.

ii. Alluvial plain (Intermontane valley)

It occupies the central narrow plain of lacustrine origin in between foot hills of western hill and marshy area with lake in the study area. The elongated intermontane valley consists of thick sequence of fluviolacustrine deposits. The average relief is about 780 m above mean sea level. The alluvial plain is made of rhythmic layering of sand, silt and clay. This zone shows coarse meandering to dendritic drainage pattern. This unit, as a whole, was reported to have been a lake and filled in with the sediments brought down by streams draining from the surrounding hills. The southern part of the plain is covered by water bodies and marshes which are flooded during rainy season.

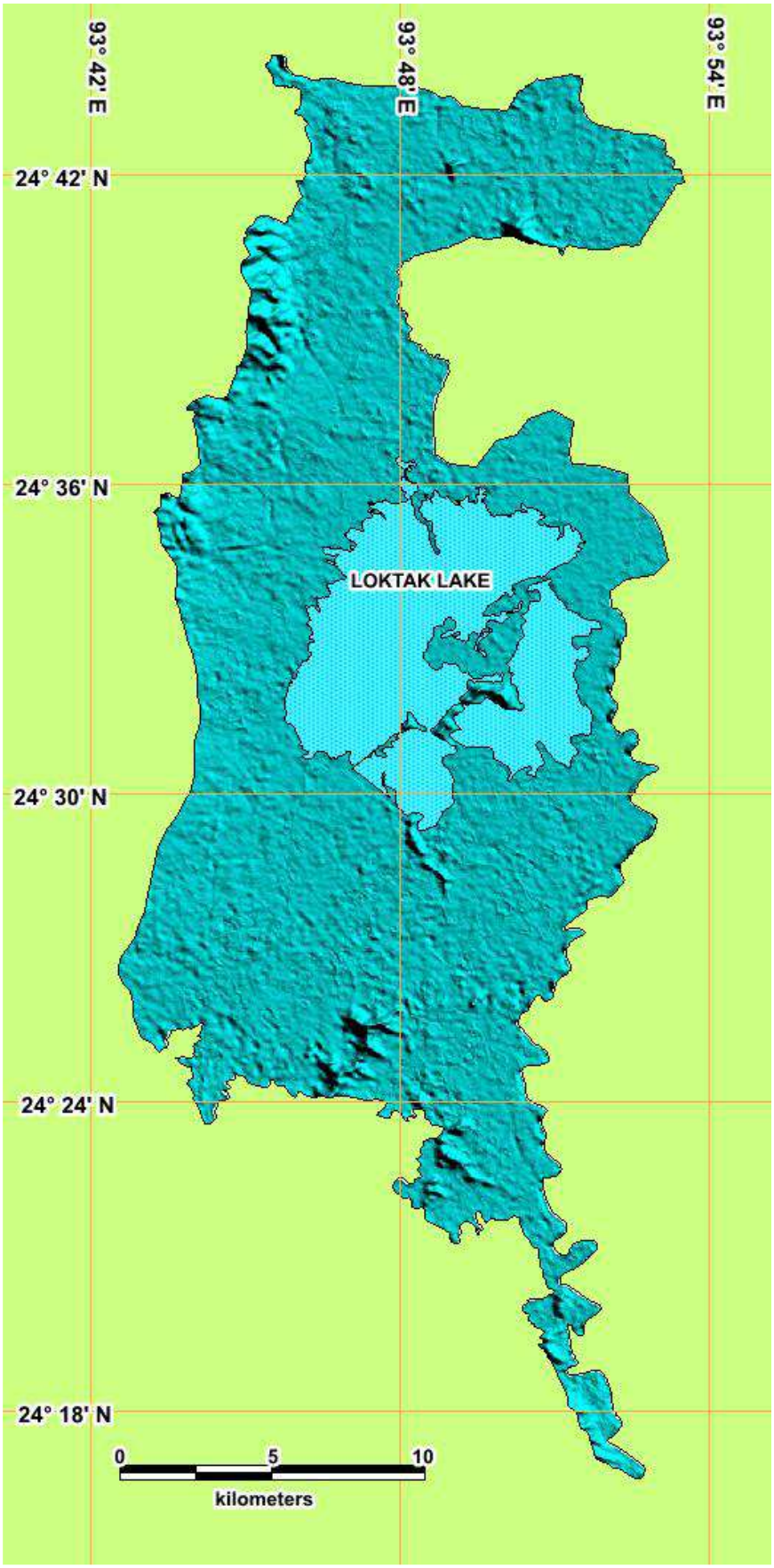


Fig.2: Digital Elevation Model (DEM) of the study area (SRTM).

ii. Flood Plain

Flood Plain is the essential product of stream erosion. In the study area the flood plains are present along the peripheral of Loktak lake. The common associated fluvial landforms such as meander scars meander loop, ox-bow lakes, natural leaves and river bars were identified by Singh (1993). Lithologically, it consists of sandy clay, gravel mixed with sand etc.

iii. Valley Fills

Valley fills in the study area consist of unconsolidated and imperfect unsorted materials comprising of clay matrix embedded with pebbles and boulders.

1.9 Land use Pattern: Land use pattern of the district is given in the following table (Table: 1.4)

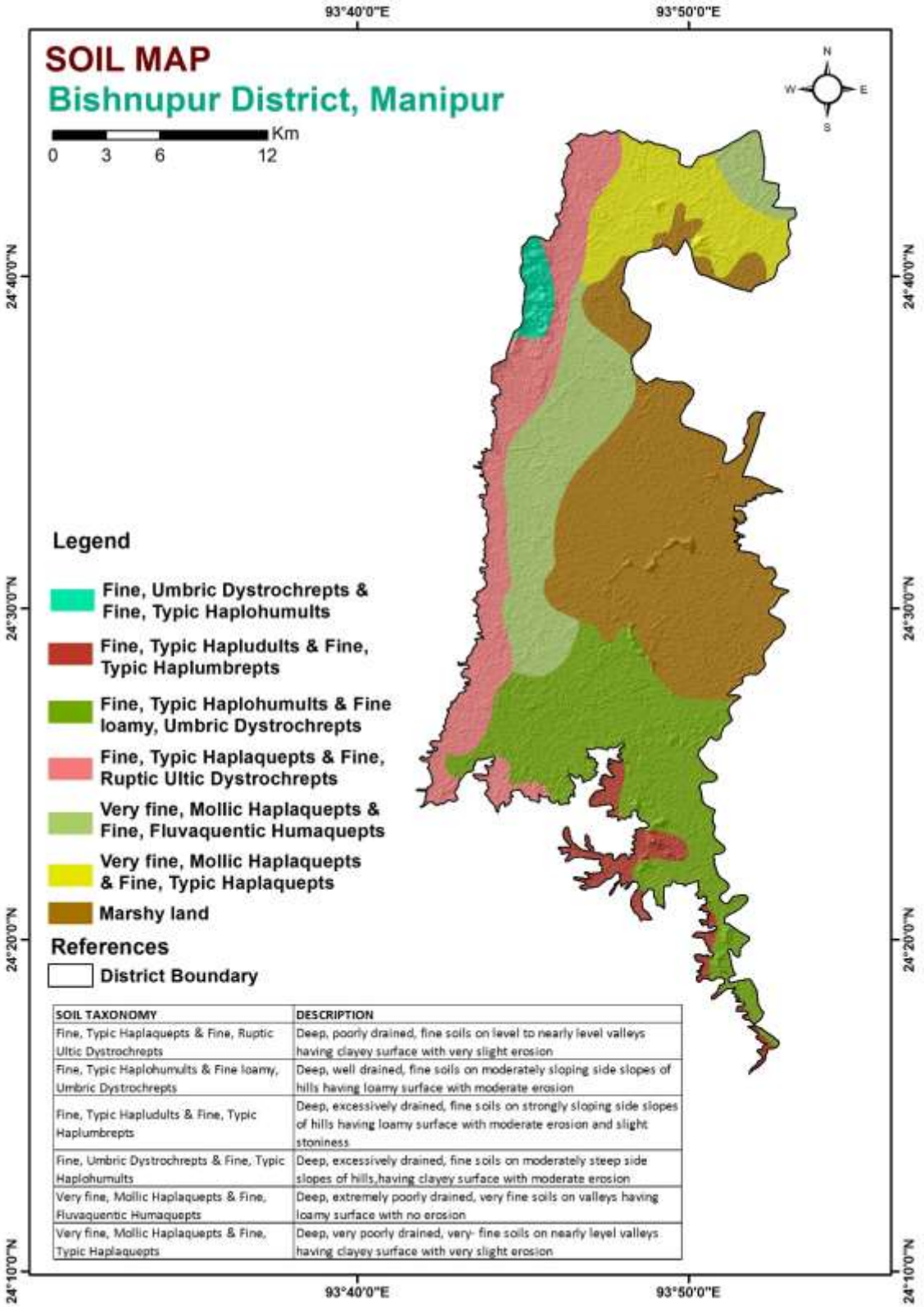
Table 5 : Land use pattern of the study area (in hectare)

Sl.No.	Land Use Pattern	Moirang CD Block	Bishnupur CD Block	In Total NAQUIM Area
1	Geographical area	21600	28000	49600
2	Net sown area	9896	8782.42	18678.42
3	Net Cultivated area	9934	8789.94	18723.94
4	Net Irrigated Area	4929	3060.64	7989.64
5	Irrigated area by canals	3375	2125.34	5500.34
6	Irrigated area by other sources	1555	3060.64	4615.64
7	Irrigated area for All Crops	4947	3067.22	8014.22
8	Unirrigated area for all crops	7600	8394.2	15994.2
9	Gross Cropped Area	12547	11461.42	24008.42

(Source: Statistical Hand book of Manipur 2017)

1.10 Soil characteristic

The nature of the soil in the district is transported type of soils. The transported soils are of two types i.e., alluvial soils (Entisols) and organic (Histosols). The area covered by plains and hillocks are mainly characterized by alluvial soils. These soils have general clayey warm texture and grey to pale brown colour. They contain a good proportion of potash and phosphate, a fair quantity of nitrogen and organic matter and are less acidic. The organic soils



SOIL TAXONOMY	DESCRIPTION
Fine, Typic Haplaquepts & Fine, Ruptic Ultic Dystrochrepts	Deep, poorly drained, fine soils on level to nearly level valleys having clayey surface with very slight erosion
Fine, Typic Haplohumults & Fine loamy, Umbric Dystrochrepts	Deep, well drained, fine soils on moderately sloping side slopes of hills having loamy surface with moderate erosion
Fine, Typic Hapludults & Fine, Typic Haplumbrepts	Deep, excessively drained, fine soils on strongly sloping side slopes of hills having loamy surface with moderate erosion and slight stoniness
Fine, Umbric Dystrochrepts & Fine, Typic Haplohumults	Deep, excessively drained, fine soils on moderately steep side slopes of hills,having clayey surface with moderate erosion
Very fine, Mollic Haplaquepts & Fine, Fluvaquentic Humaquepts	Deep, extremely poorly drained, very fine soils on valleys having loamy surface with no erosion
Very fine, Mollic Haplaquepts & Fine, Typic Haplaquepts	Deep, very poorly drained, very- fine soils on nearly level valleys having clayey surface with very slight erosion

Fig. 3: Soil Map of the study area: Bishnupur district, Manipur

covered the low-lying areas surrounding the lakes. With dark grey colour and clayed loam texture, these peaty soils have high acidity, abundance of organic matter, a good amount of nitrogen and phosphorous but are poor in potash. The hill soils are more or less rich in

organic carbon (1 to 3%) in the topsoil, but poor in available phosphorous and potash. They are acidic in nature.

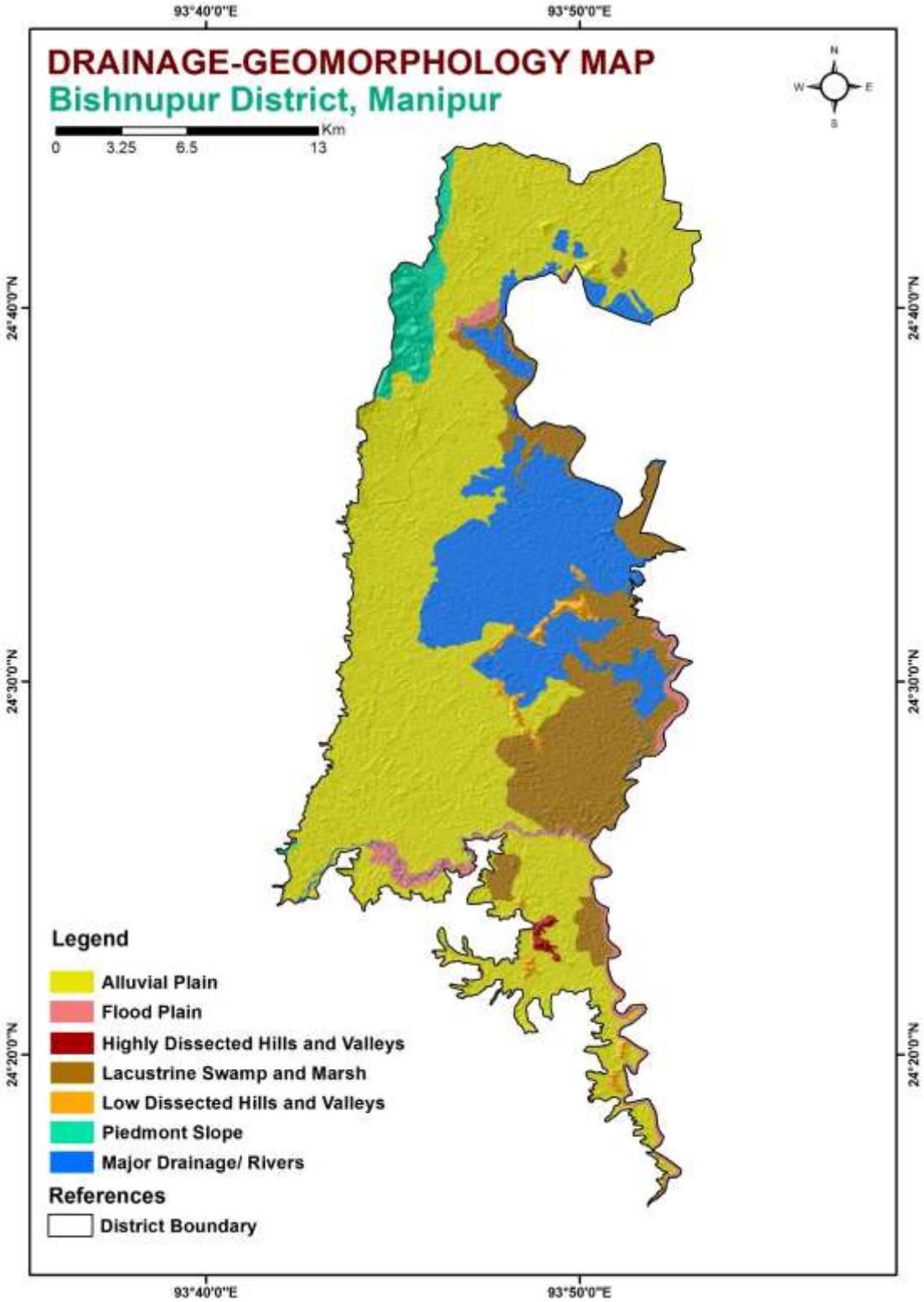


Fig.4 Drainage-geomorphology map of Bishnupur district

Alluvial sediments belonging to Quaternary ages occupy the plain areas. Based on sedimentation, soil characteristics and geomorphic features, the sediments can be divided into

two subdivisions, viz. older and younger alluvium. The older alluvium by virtue of its relative maturity is composed of somewhat oxidized sediments comprising yellow and the reddish-brown colour sand, silt and clay in contrast to the light colour, less compact younger alluvium sediment. The older alluvium always occupies the higher grounds than the adjacent younger alluvium but takes the proper stratigraphy position underlying the younger alluvium sediments in the plain areas

Main Soil classification of the study area –

(i) Younger alluvial soil
(ii) Older alluvial soil
(iii) Red gravelly sandy and loamy soil.
(iv) Piety and saline soil

1.11 Drainage

The Imphal River and the Barak River are the two main rivers draining in Manipur. The Imphal River and its tributaries drained all the Eastern half of the state including the central plain and the western half of the state is drained by Barak River and its tributaries.

The present study area falls under the Imphal River basin. This drainage map is created from the toposheets of SOI on 1:50,000 scales (Figure 4). All the rivers of the study area are originated from their surrounding hills and most of the rivers of Bishnupur district are dumped into the Loktak lake (Figure 4).

In which Thongjaorok river is the largest which dump in this lake. On its way to the Loktak Lake, Thongjaorok river and its tributaries merge together to form a characteristic network or design, refer as the drainage pattern. The Nambul a major river passes through the heart of the Imphal city and follows a course west of the Imphal river till it falls in to the Loktak lake. It originates from the Kangchup hills that lie to the western part of the Imphal valley.

The drainage of the district is controlled by locally originated small tributaries. There is no large-scale river in the district. Some of the small rivers, which are flowing in the district, are Thongjaorock, Sunusiphai, Nambol, Yangoimacha, Yangoiachouba, Khuga, and Iram etc. Except Khuga River all other river starts from the hill located at the west of the Tiddim Road and flows towards east falling into Loktak Lake. Discharging maximum quantity of water during the monsoon months (June- October), these tributaries frequently

inundate the land along their banks by experiencing havocs of flood in every year. The Khuga river passes through the Kumbi village and meets Imphal river or Manipur River passing Ithai khunou.

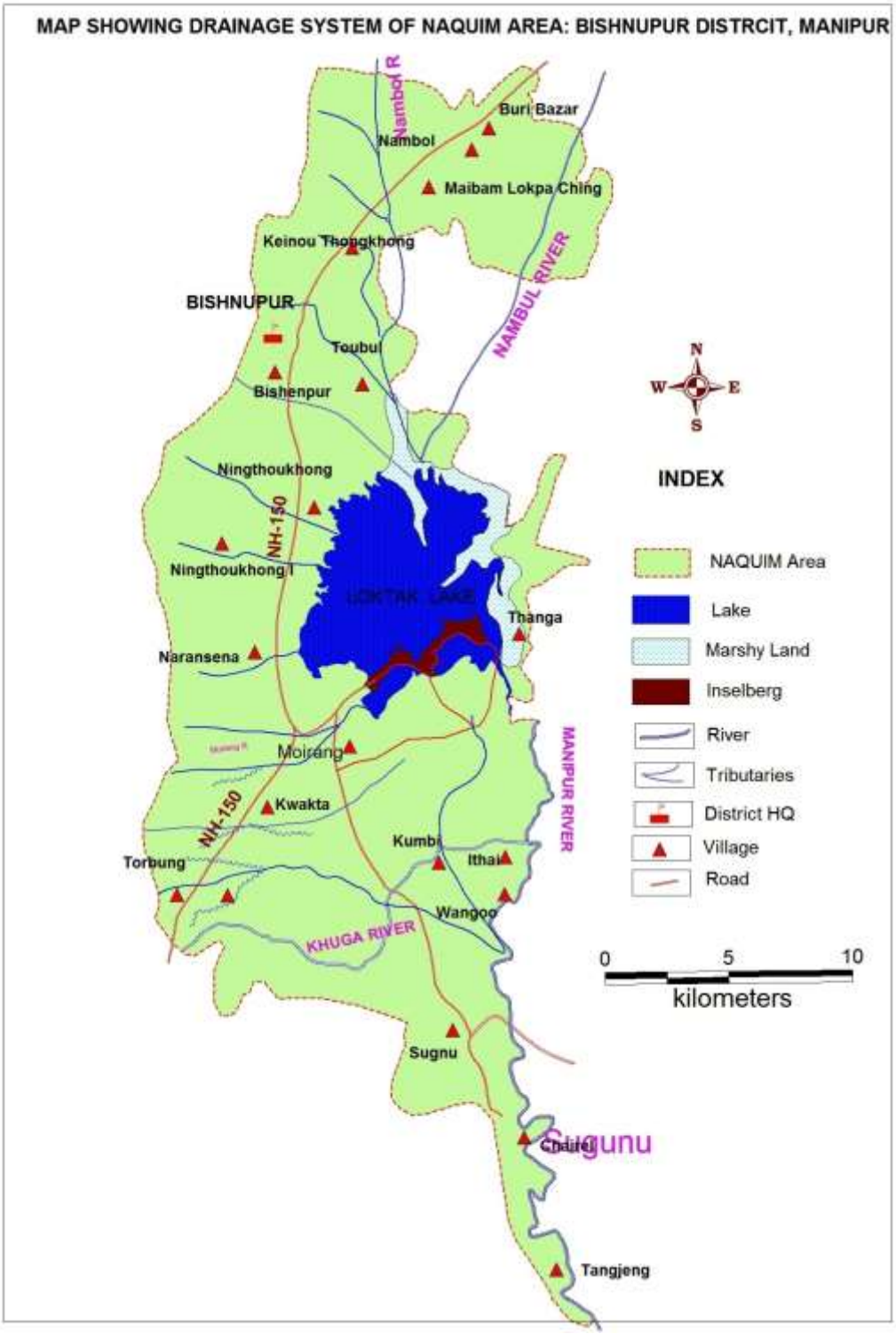


Fig. 5: Drainage System showing rivers and lakes in the study area

The lakes like Loktak, Ngakrapat, Awangsoi, Laisoi, Zingpat, Loukoipat, and Ikokpat etc cover a considerable area of the district. Loktakpat, which is the largest in Land Lake not

only in Manipur but also in the North-eastern India, covers an area of about 247 sq.km during the rainy season with an average depth of about 10-15 metres. Keibul Lamjao, the National Park is situated on the southeastern side of the Loktak Lake and it has an area of 40 sq.km. The sonapat, Utrapat, Samusang, Kharungpat and Ikokpat are also worth-mentioning lakes in Bishnupur district.

1.12 Regional Geology

The Hills of Manipur lie between the Naga–Patkai Hills on the north and northeast, and the Chin-hills on the south forming an integral part of the Indo-Myanmar (Burma) Ranges (IMR). The structural and tectonic pattern is transitional between the NE–SW trending pattern of Naga–Patkai Hills and N–S trend of Mizoram and Chin Hills (Brunnschweiler 1974). It comprises geologically young rock formations that were uplifted by the Tertiary orogeny of the Himalayas from the shallow bed of the Tethys Sea. The rocks are dominantly Tertiary and Cretaceous sediments with minor igneous and metamorphic rocks. Flysch sediments of Tertiary age underlie nearly 70% of the state (Soibam 1998).

Disang and Barail flysch sediments underlie much of Manipur central valley. The oldest formation, the Disang Series (Eocene) comprises splintery shale with minor mudstone, siltstone, sandstone and limestone. The Disang is overlain by the Oligocene Barail Formation contained abundant carbonaceous matter. The Barail is succeeded by the predominantly argillaceous Surma and the Tipam formations. The sediments of the Surma basin are molasse (Nandy 1980). Ultrabasic igneous rocks, of the Ophiolite Zone, are intruded into the Disang Group in east of Manipur. The general tectonic trend of rock formations in the state is NNE-SSW, but varies between N–S and NE–SW, and locally NNW–SSE. Almost all the major structural elements such as folds reverse and thrust faults follow this regional strike/trend.

Topographically, Manipur comprises a ridge and furrow terrain where sediments derived from surrounding ridges are deposited in the furrows (Soibam 1998). In the Manipur Valley, lenses of argillaceous sediments were deposited in the Assam–Arakan trough. Manipur is divisible into a central valley and the surrounding mountains. About 25% of the valley is occupied by lakes, wetlands, barren uplands and hillocks. The NNW–SSE oriented valley is oval shaped, and slopes gently to the south. The Imphal or Manipur River meanders through the Manipur Valley in a NW–SE direction and passes through a gorge to flow out of the state to join the Chindwin River in Myanmar. The formation of the Manipur River and its

tributaries that drain the area was closely connected with the upliftment of the South Manipur Hills and subsequent erosion of the weak crest of the anticlinorium. There were multiple episodes of low energy, fluvio-lacustrine deposition during the Quaternary, and these sediments are encountered to depths of 150 m. Disconnected lenticular water bodies dominate the valley.

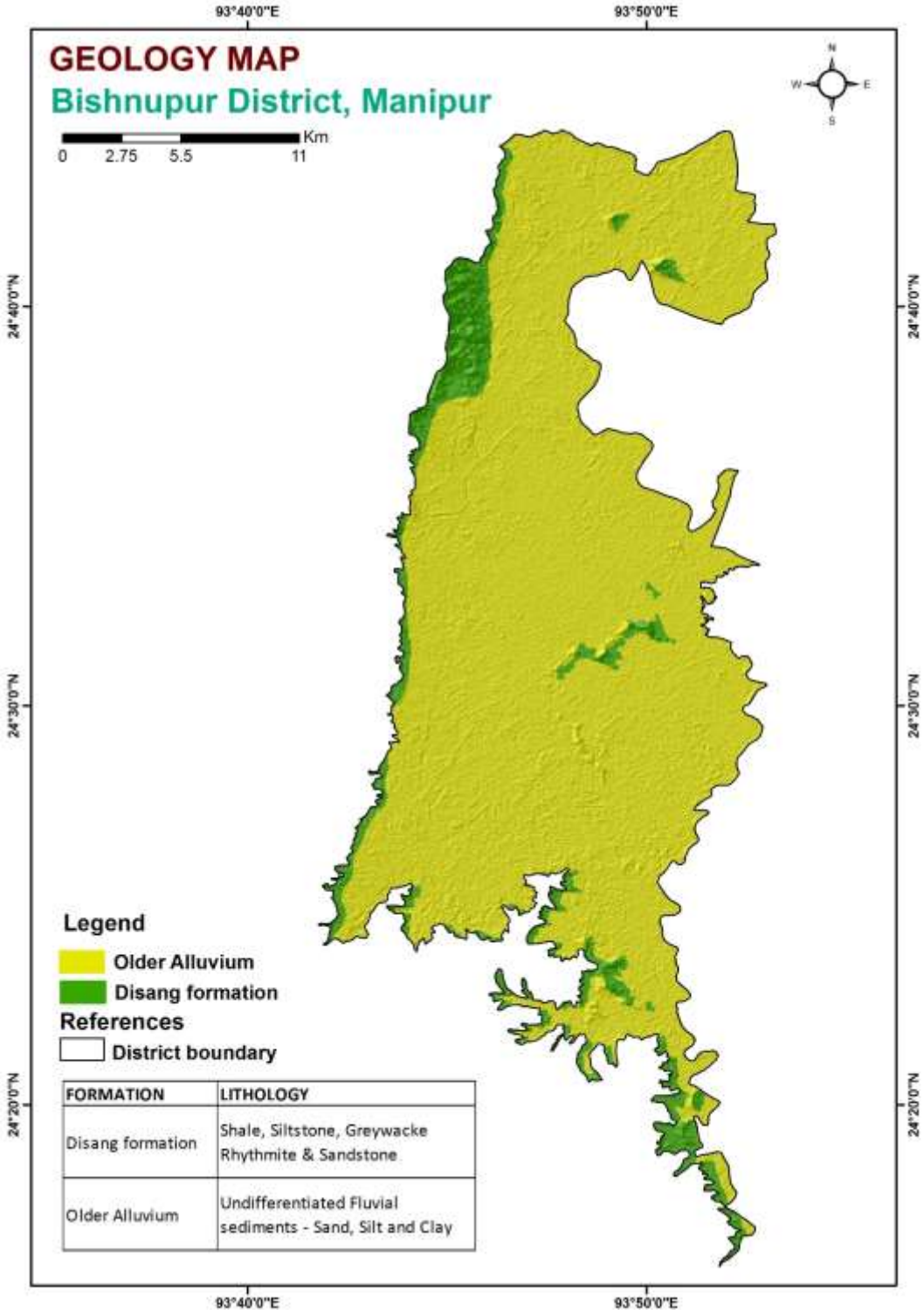


Fig.6 Map showing Geology of the study area

The Manipur Valley has been infilled by thick alluvium which is subdivided into the Older (Pleistocene) and Newer Alluvium. The Older Alluvium is made up of clay, silt, coarse sand, gravel, pebble and boulders, deposited adjacent to the foothills and forming older river terraces in the lower part of Manipur Valley. The Newer Alluvium is composed of clay, sand, silt and dark clay with carbonaceous matter, deposited mainly in the central and upper part of the Manipur Valley.

1.12.1 Geology of the Study Area

The rocks of the study area are predominantly made up of the Quaternary sediment with minor tertiary sediment. The geological time period of the study area is Oligocene (Tertiary sediments), Pleistocene and Holocene (Quaternary sediments). Quaternary sediments occupy 80% of the study area.

Geological formation occurring in the study area belongs to the Disangs and the Barails which represents shale, siltstones, sandstones and recent alluvium. These rock formations are tectonically deformed and highly weathered. Major part of the area is occupied by the recent Alluvium. CMT (Churachandpur Mao Thrust) and some major and minor lineament are passing through the western part of the study area (Figure 3.4). A simplified stratigraphic succession of the area is given in the table 3.1 (ONGC, 1987).

The district, being part of the Manipur valley, is covered with alluvial deposits brought by the streams and rivers washing the eastern slopes of the Manipur western hills and flowing into Loktak lake. The alluvium, which covers the area, have a thickness of 200-300 metres and overlies the Disang shales and contain clay, sand, sandy clay, silt and shingle. On the basis of the surface configuration, the alluvium may be divided into the higher and lower flood plain. The higher parts, formed of older alluviums, cover major part of the district, while the lower part, formed of newer and recent alluviums, comprise the area closer to the lake. It is frequently flooded and has been witnessing new deposits of sediments year after year. Light colour clays, found in Moirang area, and grey colour clays, found at Nambol area, are of commercial importance and may be used for making paints and fire bricks.

Basically, the area is made up of alluvium of fluvio-lacustrine origin. They are usually dark grey to black in colour. The principal constituents are clay, silt and sand whereas sand, gravel, pebbles and boulders are found in the foothill regions. The hillocks in the study area

are basically composed of Disang shales but some have sandstone capping. Alluvium covers the widest aerial extent in the area. They are mainly dark grey to black carbonaceous clay, silt and sand of which clay forms the main sediments while silt and sand are subordinate. Major parts of the area belong to Alluvial formation which is further divided into older and younger alluviums due to change in lithology.

Table.6 Stratigraphic Succession in the study area

Stratigraphic Units and Age	Formations	Description of rocks	Occurrence
Alluvium (Holocene to Pleistocene (?))	Newer Alluvium	Dark grey to black clay, silt and sand deposits of fluvio-lacustrine origin. Flood plain deposits of the rivers/streams	It occurs on the hill slopes as well as on the valley areas
	Older Alluvium	Clay, sand, gravel and boulder deposits of the foothills. Possibly lower deposits of the valley.	
Stratigraphic Break			
Barail Group (Oligocene to Upper Eocene)		Light to brownish grey, bedded, sandstone alternating with shales. Sometimes considerably thick sand and shale beds are occasionally present. Flysch sediments show turbidite character	It extends in the north western part and throughout the hilly region
Disang Group (Eocene to Upper Cretaceous)		Dark grey to black, laminated splintery shales. Intercalations of shales, siltstones and sandstones show occasionally rhythmite nature. Flysch sediments sometimes exhibit turbidite character.	It extends a small portion of northern, north western and southern part of the study area
Unconformity			
Basement rocks		Unseen	
Unconformity			
Basement rocks		Unseen	

1.13 Agriculture

Agriculture, fisheries and handlooms dominate the economic landscape of the district. About two-thirds of the working population is engaged in primary activities –agriculture and fisheries, and the rest in secondary and tertiary activities. Agriculture is the mainstay of the people in the district. The total cultivable area in the district is about 22000 ha lying in the

Loktak basin and along the Manipur, Khuga and Nambol rivers. The land is fertile and prospect of double and multiple-cropping have enhanced in the area after completion of the Loktak Lift Irrigation Project. The productivity is quite high although the peripheral areas remain flood-prone. Paddy, maize, pulses, sugarcane, cotton, potato, chillies and oilseeds are important crops. Over three-fourths of the cultivated land is under paddy cultivation.

A huge number of people in the area are engaged in freshwater fisheries occupying about 12,250 hectares of water area in the Loktak basin. Minnows, major and minor carps, small cat fishes, fresh water shark, climbing perch and magur are important varieties of fih caught in the area.

CHAPTER 2.0
DATA COLLECTION AND GENERATION

2.1 Data collection

The preliminary works consisted of collection and review of all existing hydrogeological and exploration data of CGWB, Minor Irrigation Department (Manipur), Water Resources Department, IPD wing PHED (Manipur), Geological Wing-Directorate of Industries & Commerce (Manipur) and MASTEC. All data were plotted in base map on GIS Platform (MapInfo-6.5 using Projection category longitude/latitude (Indian for Bangladesh, India and Nepal projection).

Data collection includes collection of rainfall data from IMD and state government, litholog collection from state groundwater departments, compilation of CGWB's earlier survey data, exploration and geophysical data. Population data is collected from Statistical Handbook of Manipur, 2017 and census of India website. Agricultural data is collected from the website of Ministry of Agriculture, Govt. of India.

CGWB had carried out hydrogeological studies in Imphal valley during 2004-05. The available hydrogeological data is incorporated in the present study. GSI has carried out geological studies in Imphal valley to delineate the lithological units, their structures and stratigraphic disposition. CGWB had constructed 2 nos exploratory wells in Bishnupur district. Investigation and Planing Division (IPD) of Public Health Engineering Department, Manipur had constructed 182 nos. of tube wells for domestic -drinking water supply in the district. Litholog details of 18 nos. of tube wells have been collected from different sources like PHED, GSI, CGWB, MID etc. Details of the wells are given in Table 9. Rainfall data was collected from Indian Meteorological Department (IMD) website and statistical Hand book of Manipur 2017. Ground water monitoring stations of Bishnupur district as per the District Groundwater Development and Management studies in Manipur valley (2004-05) were incorporated in this report for better water level data analysis (Table 7 and 8).

2.2 Data Generation

2.2.1 Hydrogeological data

Exploratory data of Central Ground water Board (CGWB) and state departments like PHED, MID etc has revealed that the district has extractable groundwater resources but could

not explore up to the desirable limit due to existing hydrogeological set up. Exploratory wells constructed down to a depth of 150 mbgl shows presence of granular zones in the district. No groundwater irrigation schemes have been implemented so far in the district through construction of tube wells.

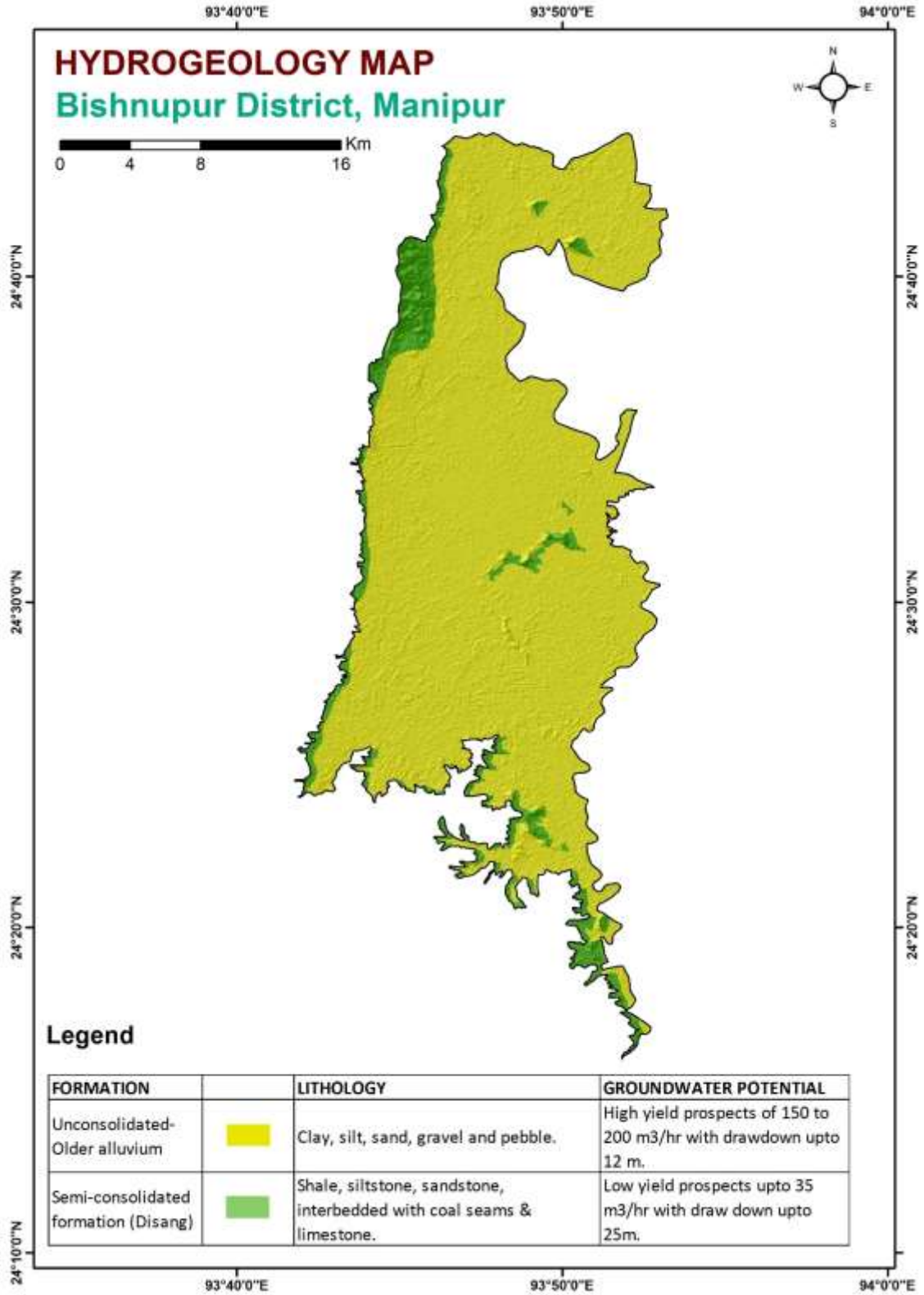


Fig.7a Hydrogeological map of the study area

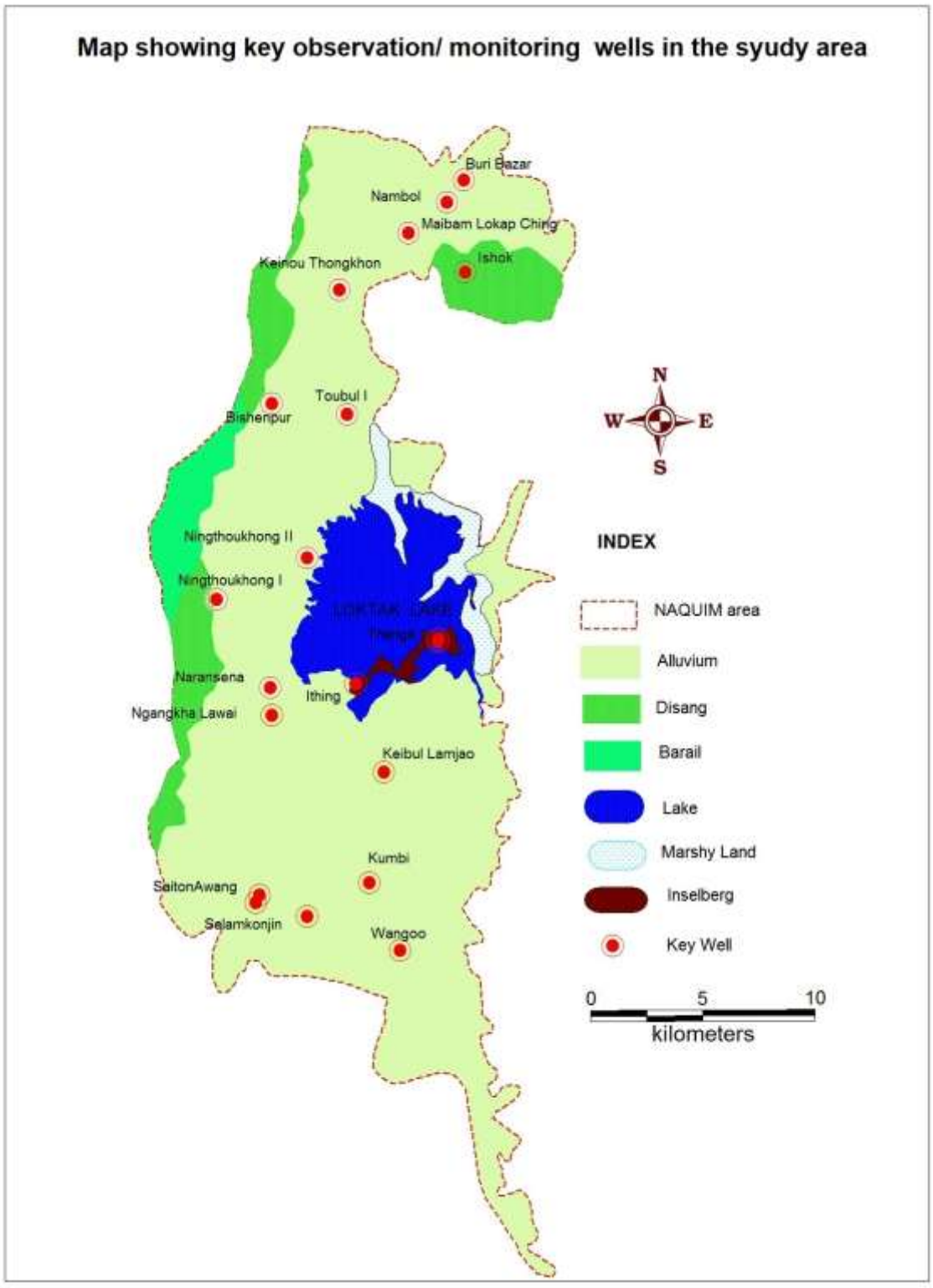


Fig.7b Map showing key observation/monitoring wells in the study area

Groundwater in the deeper aquifers occurs under sub-artesian and artesian conditions. Tube wells have been installed at various locations in the district by state government. Discharge of the tube wells ranged from 0.6 to 4 m3/hr. Considering the clayey nature of

formation in the top aquifer, groundwater development is not considered promising on a large scale either in irrigation or water supply. Hydrogeological studies revealed that the valley area is underlined by a thin veneer of alluvial deposits, which is largely clayey in nature, underlined by rocks of Tertiary age. Since the upper formations are mainly silty and clayey, dug wells/open wells have poor yield prospects. However, the deeper zone, consisting of sandstones of Tertiary age, forms good aquifers which are under semi confined conditions. Auto flow conditions are also observed in the study area with a discharge range of 0.5 to 4.0 m3/hr.

2.2.2 Water level data: A total of 20 nos. of key observation wells have been established in the district in order monitored the change in the groundwater level and 6 nos. of wells have been monitored for quality in the NAQUIM study area. Details of key observation wells established for monitoring of water level in the district are given in Table 7 & 8

Table 7: Details of Key observation wells established under NAQUIM studies in the district

Sl. No.	Well Type	Location	Latitude	Longitude	Block	RL	Drill	Well Dia.	MP	Aquifer
						(m AMSL)	Depth (m)	(m)	(m, agl)	Parameter
1	Tube well	Toubul I	93.79279	24.62341	Bishnupur	772.02	118.5	0.15	0.58	Sand, clay
2	Tube well	Bishnupur	93.75966	24.62806	Bishnupur	773.33	45.7	0.15	0.48	Sand, gravel
3	Tube well	Buri Bazar	93.84487	24.71743	Bishnupur	772.04	84.7	0.15	0.51	Sand, clay
4	Tube well	Toubul II	93.8	24.55417	Bishnupur	772	152.39	0.15	0.43	Sand, clay
5	Tube well	Ningthou khong II	93.775	24.566	Bishnupur	804	152.39	0.15	0.69	sand, clay
6	Tube well	Nambol Bazar	93.8375	24.70833	Bishnupur	772	106.67	0.15	0.45	sandy clay
7	Tube well	Keinou Thongkhong	93.79	24.67333	Bishnupur	778.34	61	0.15	0.51	sandy clay
8	Tube well	Maibam Lokpa Ching	93.82028	24.69611	Bishnupur	778.644	50.3	0.15	0.43	Sand, Shale
9	Tube well	Saiton Awang Leikai	93.752906	24.430621	Moirang	749.24	27	0.15	0.31	Clay, sand
10	Tube well	Ngangkha Lawai	93.758737	24.502749	Moirang	772.34	58	0.15	0.57	sandy clay
11	Tube well	Wangoo Terakhong	93.814824	24.408074	Moirang	767.12	40	0.15	0.54	Sandy clay
12	Tube well	Thanga Oinam	93.83227	24.532063	Moirang	777.52	46	0.15	0.26	sandy clay
13	Tube well	Kumbi	93.80127	24.435453	Moirang	766.55	51.82	0.15	0.72	Sand, gravel
14	Tube well	Ishok Sabal	93.84546	24.680098	Moirang	766.23	45.73	0.15	0.65	Sand, clay
15	Tube well	Salamkonjil	93.77397	24.42184	Moirang	780	42	0.15	0.49	Sand, clay
16	Tube well	Keibul Lamjao	93.808115	24.479807	Moirang	765.00	51.82	0.15	0.55	Sandy clay
17	Tube well	Ithing	93.795968	24.515016	Moirang	749.22	50.3	0.15	0.38	Coarse sand
18	Tube well	Saiton Bazar	93.751136	24.427656	Moirang	766.35	36	0.15	0.42	Gravel
19	Tube well	Thanga Chingjin	93.832415	24.532773	Moirang	766.23	56	0.15	0.51	Sand, clay

Table 8: Pre-monsoon and post monsoon water level data of key wells

Sl. No.	Well Type	Location	Latitude	Longitude	RL (m AMSL)	DTW (mbgl)		Fluctuation
						Pre-monsoon	Post-monsoon	
1	Tube well	Toubul I	93.79279	24.62341	772.02	4.8	4	(m)
2	Tube well	Bishenpur	93.75966	24.62806	773.33	7.2	7	0.8
3	Tube well	Buri Bazar	93.84487	24.71743	772.04	7.7	6.4	0.2
4	Tube well	Toubul II	93.8	24.55417	772	6.6	5	1.3
5	Tube well	Ningthoukhong II	93.775	24.566	804	7.4	6.9	1.6
6	Tube well	Nambol Bazar	93.8375	24.70833	772	2.3	1.8	0.5
7	Tube well	Keinou Thongkhong	93.79	24.67333	778.34	6.8	4.7	0.5
8	Tube well	Maibam Lokpa Ching	93.82028	24.69611	778.644	6.02	3.36	2.1
9	Tube well	Saiton Awang Leikai	93.752906	24.430621	749.24	2.73	1.47	2.66
10	Tube well	Ngangkha Lawai	93.758737	24.502749	772.34	5.45	4.8	1.26
11	Tube well	Wangoo Terakhong	93.814824	24.408074	767.12	3.45	2.8	0.65
12	Tube well	Thanga Oinam	93.83227	24.532063	777.52	5.54	2.9	0.65
13	Tube well	Kumbi	93.80127	24.435453	766.55	2.4	1.88	2.64
14	Tube well	Ishok Sabal	93.84546	24.680098	766.23	4.99	3	0.52
15	Tube well	Salamkonjil	93.77397	24.42184	780	1.9	1.5	1.99
16	Tube well	Keibul Lamjao	93.808115	24.479807	765.00	3.88	3	0.4
17	Tube well	Ithing	93.795968	24.515016	749.22	1.24	1.1	0.88
18	Tube well	Saiton Bazar	93.751136	24.427656	766.35	2.51	1.67	0.14
19	Tube well	Thanga Chingjin	93.832415	24.532773	766.23	5.7	5.11	0.84

2.2.3 Water Quality

To understand the chemical quality of groundwater in the district and its suitability for domestic, drinking and agricultural utilisation existing quality data of CGWB were collected. In addition to the existing quality data, groundwater samples were collected from the key observation wells of NAQUIM study for analyses of detailed, iron, heavy metals and arsenic.

2.2.4 Geophysical survey

No data of VES survey was found in Bishnupur district, Manipur. Geophycical study is recommended in the district for better ground information of the formations.

2.2.5 Exploratory Drilling

During the NAQUIM study in AAP 2017-18, exploratory drilling activity was not carried out in Bishnupur district, Manipur. Old drilling data of CGWB and Public Health Engineering Department were collected and incorporated in the report preparation after throrough study of exploratory data. Existing information of A list of wells constructed in the area was prepared incorporating location, well designs, etc.

Table 9: Details of exploratory wells in the study area

Sl.No	Well Location	Co ordinates		Type	Drilled Depth	Discharge
		Longitude	Latitude		(metre)	(LPM)
1	Toubul I	93.79279	24.62341	TW	118.5	160
2	Bishenpur	93.75966	24.62806	TW	45.7	126.62
3	Buri Bazar	93.84487	24.71743	TW	84.7	100
4	Toubul II	93.8	24.55417	TW	152.39	94
5	Ningthoukhong II	93.775	24.566	TW	152.39	
6	Nambol Bazar	93.8375	24.70833	TW	106.67	
7	Keinou Thongkhong	93.79	24.67333	TW	61	
8	Maibam Lokpa Ching	93.82028	24.69611	TW	50.3	134
9	Saiton Awang Leikai	93.752906	24.430621	TW	27	165
10	Ngangkha Lawai	93.758737	24.502749	TW	58	395
11	Wangoo Terakhong	93.814824	24.408074	TW	40	134
12	Thanga Oinam	93.83227	24.532063	TW	46	85
13	Kumbi	93.80127	24.435453	TW	51.82	232
14	Ishok Sabal	93.84546	24.680098	TW	45.73	126
15	Salamkonjil	93.77397	24.42184	TW	42	145
16	Keibul Lamjao	93.808115	24.479807	TW	51.82	86.65
17	Ithing	93.795968	24.515016	TW	50.3	88.65
18	Saiton Bazar	93.751136	24.427656	TW	36	134
19	Thanga Chingjin	93.832415	24.532773	TW	56	150

CHAPTER 3.0
ATA INTERPRETATION, INTEGRATION AND AQUIFER MAPPING

3.1 Data Interpretation: 2D disposition of aquifers

Central Ground Water Board, North Eastern Region, Guwahati has constructed two numbers of exploratory wells in the district. Public Health Engineering Department has also drilled number of wells in the area. However, only 18 nos. of well lithologs were included in data interpretation of well data after proper verification. It has been observed that down to a maximum explored depth of 152.39 m was found dominated by clay, sand, gravel with mixtures of silt. The lithologs and the lithology identified are used to understand 2D and 3D disposition of aquifer. 2D disposition of two sections are constructed to visualize the aquifer disposition in the district

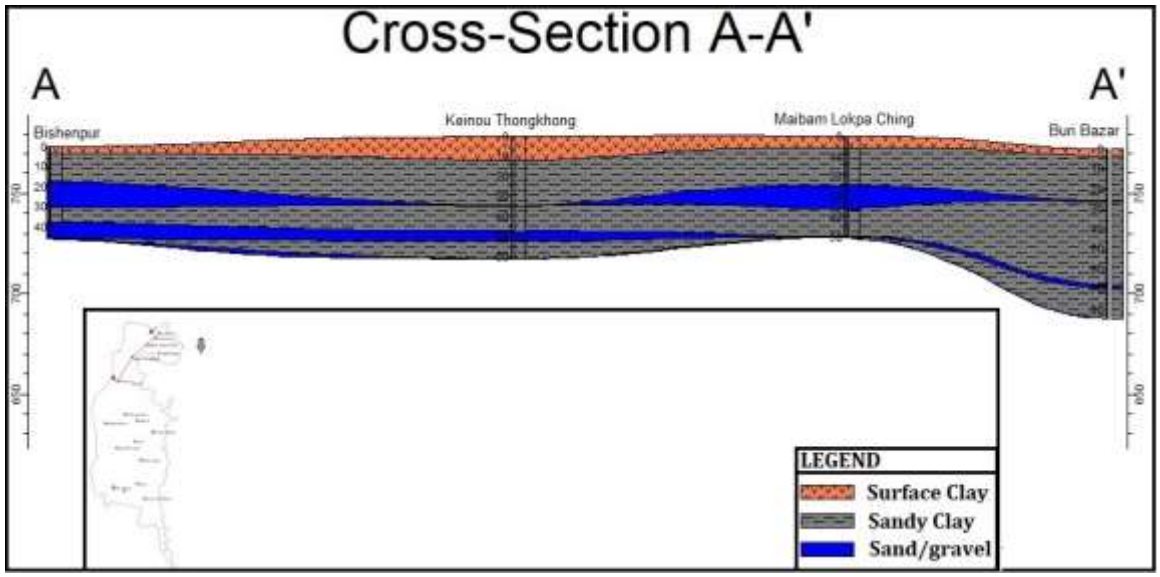


Fig.8: Cross Section: Bishenpur-Keinou Thongkhong-Maibam Lokpa Ching-Buri Bazar in Bishnupur district

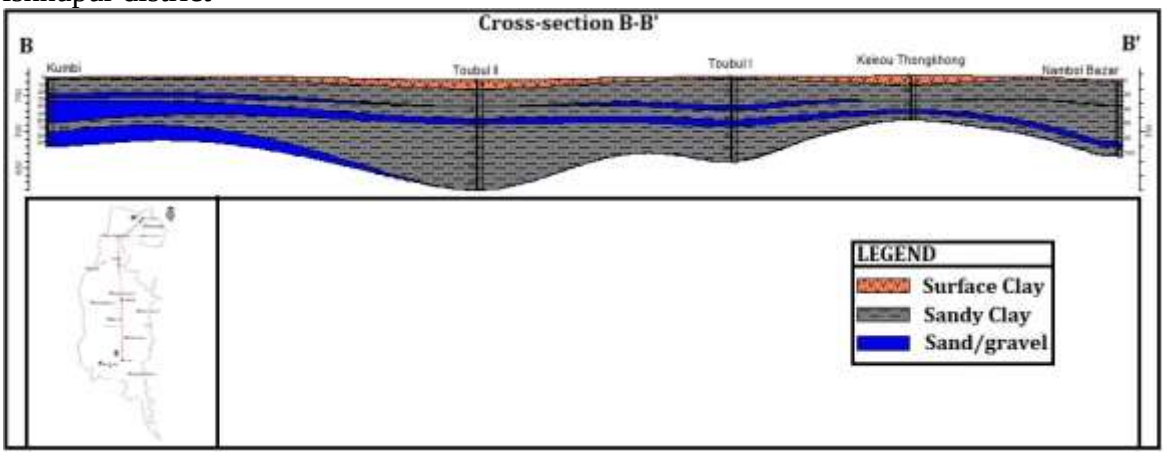


Fig.9: Cross Section: Kunbi- Toubul – Keinou Thongkhong- Nambol Bazar in Bishnupur district

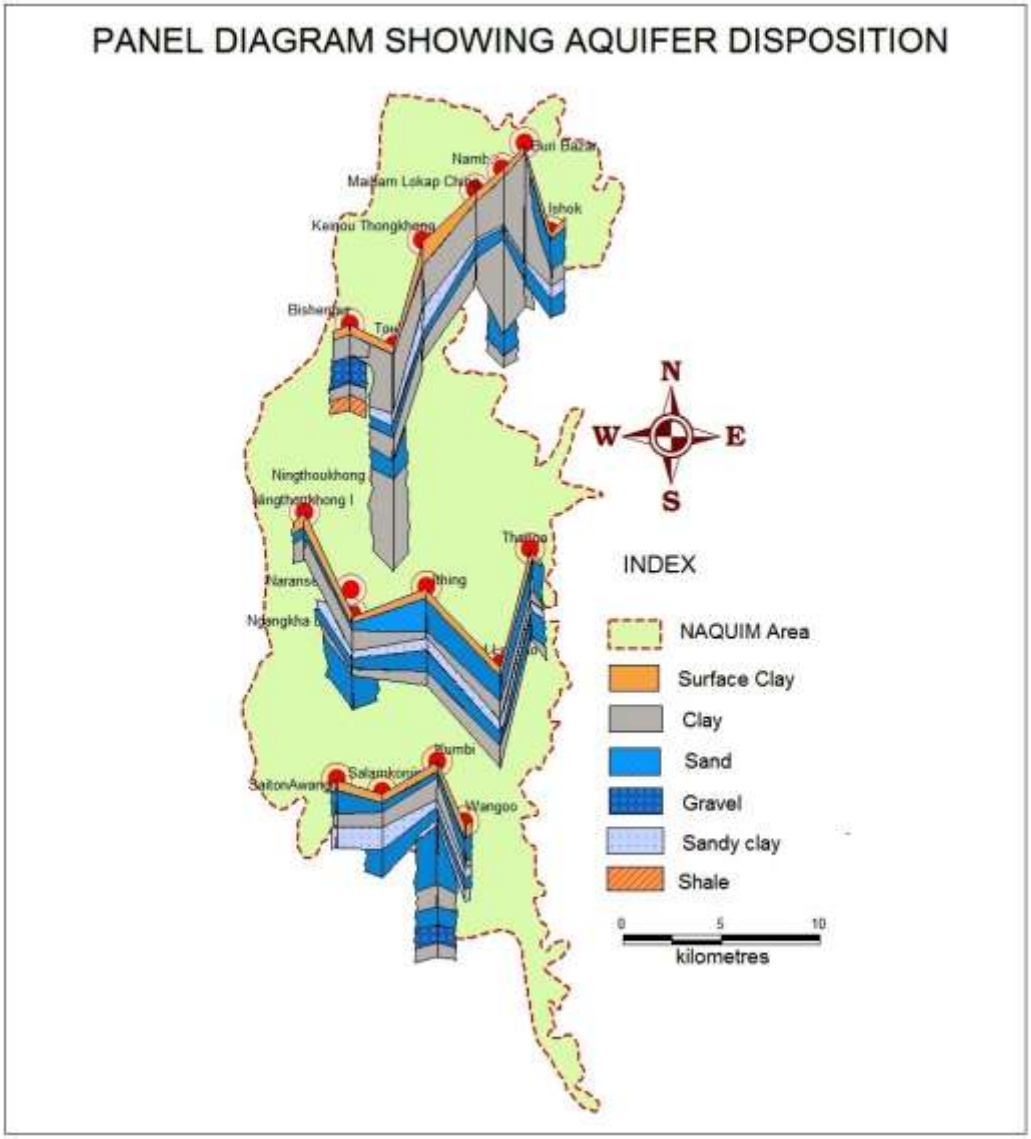


Fig.10 Aquifer Disposition in the study area

The summarized hydrogeological data of the existing exploratory wells of Central Ground Water Board is given below in table 10

Table10: Summarized hydrogeological data of exploratory well of CGWB

Sl. No	Location	Depth Drilled (m)	Depth of Construction	Tapped Aquifer thickness (m)	S.W.L (mbgl)	Discharge (lpm)	Draw Down (m)	T (m^2/day)
1	Kumbi	96.80	93.00	27.00	2.86	232.00	10.67	38.84
2	Bishnupur	45.70	44.00	12.00	3.91	100.00	18.00	4.30

(N.B. Data is well construction data of CGWB)

3.2 3D disposition of aquifer

The aquifer disposition of the area in the 3D block diagram indicates existence of two types of aquifers in the area. The confining layers are not continuous throughout the area.

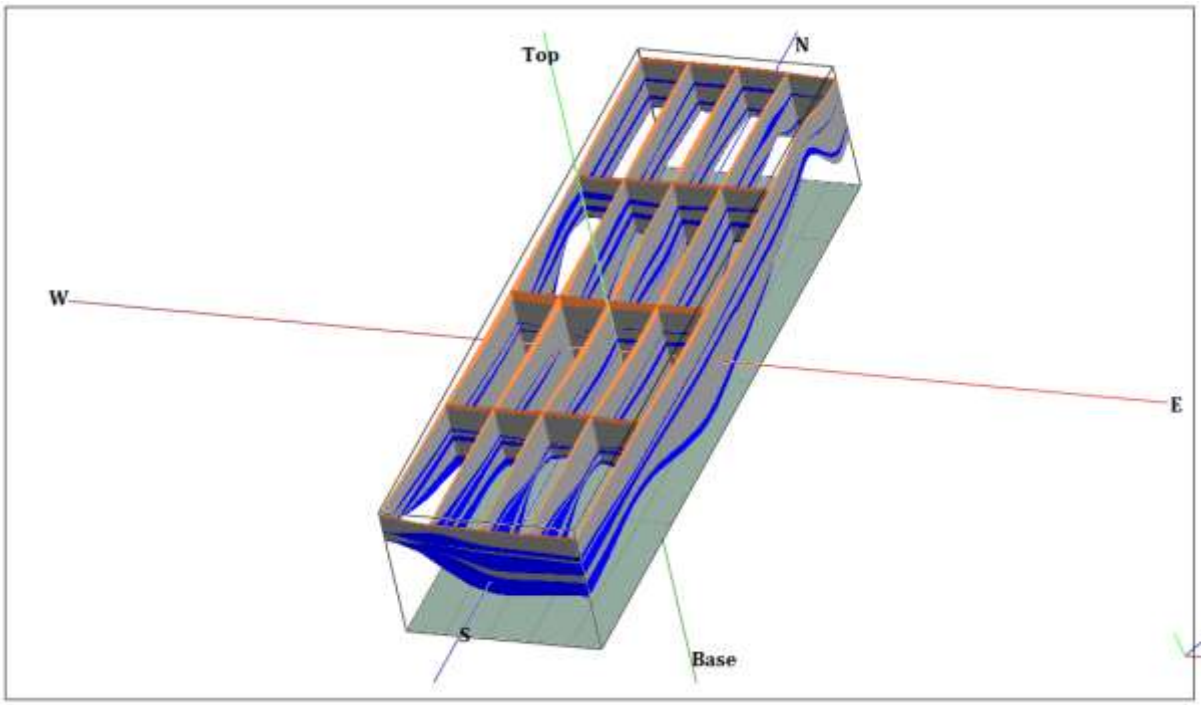


Fig.11: 3D disposition of aquifer in Bishnupur district

3.3 Ground water level

To study ground water regime of aquifers, depth to water level from the established 20 nos. of key observation wells have been monitored seasonally during pre-monsoon and post-monsoon of 2017-18. Pre-monsoon depth-to-water level of the key wells in Bishnupur block ranges from 2.3 to 7.7 mbgl and it varies from 1.24 to 5.54 mbgl in Moirang block. The post monsoon depth-to-water level in Bishnupur block varies from 1.47 to 6.9 mbgl and it varies from 1.1 to 5.11 mbgl in Moirang block. Pre-monsoon and post-monsoon depth-to-water level contour of the district is prepared (Fig. 12 and Fig. 13). Pre monsoon ad post monsoon water level fluctuation in the district ranges from 0.2 to 2.66 m.

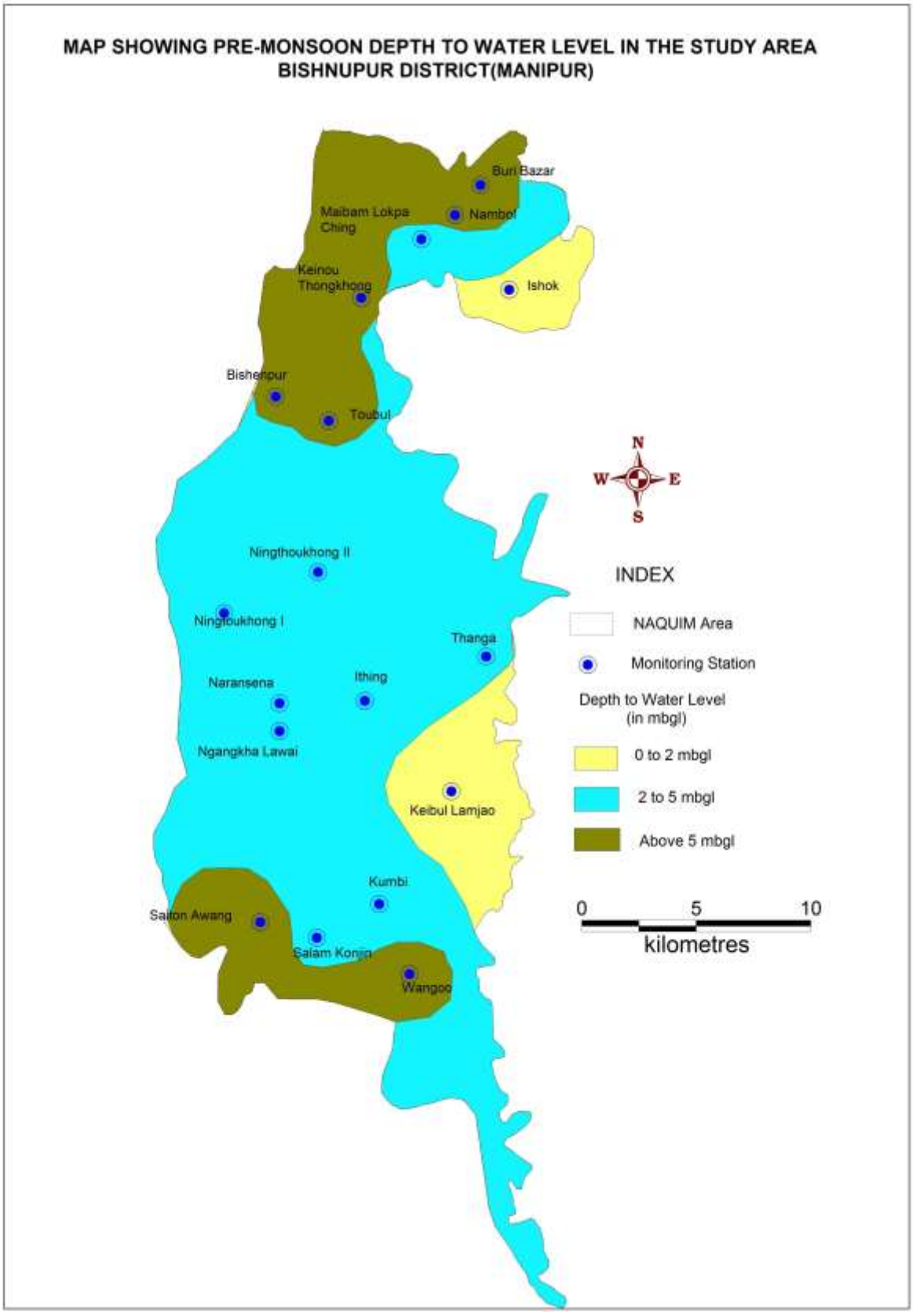


Fig. 12: Pre-monsoon DTW level contour of the study area

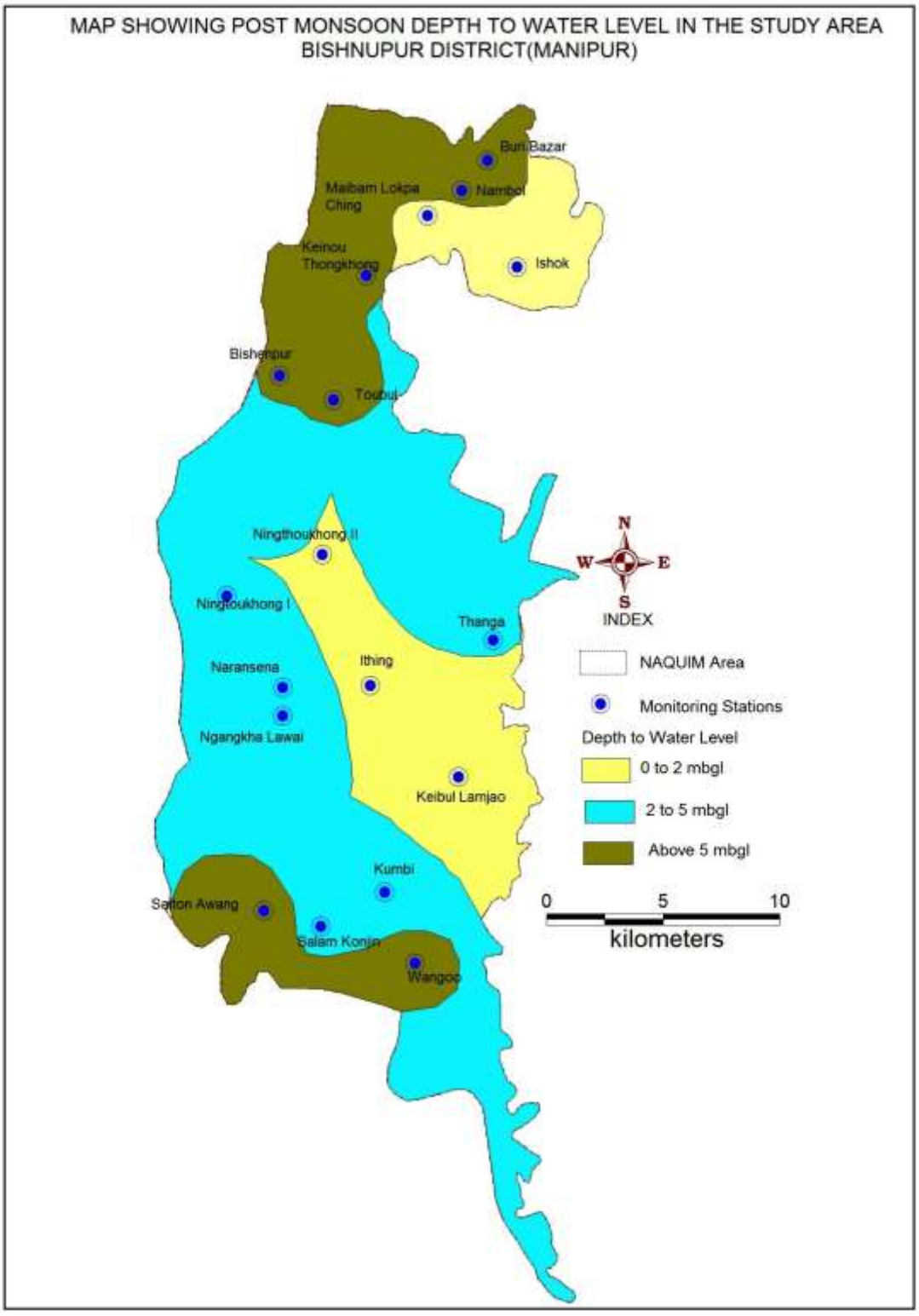


Fig. 13: Post-monsoon DTW contour of the study area

3.4 Ground Water Movement

The water table contour map has been prepared based on water level of ground water monitoring stations. The ground water flow direction is from the higher elevation in north-western towards the south eastern region of the study area.

3.5 Ground water quality

Results of chemical analysis of ground water samples carried out at the Regional Chemical Laboratory of Central Ground Water Board, North Eastern Region, Guwahati shows that the Pre-monsoon pH value ranges from 7.2 to 8.2 and in the post-monsoon pH value ranges from 7.3 to 8.0 indicating no major variation in pH. All the water samples collected during Pre-monsoon and post-monsoon are mostly alkaline in nature. Pre-monsoon pH value increases the chance of bacterial contamination. Pre-monsoon iron concentration range is BDL to 32.1 mg/l while the post monsoon Fe concentration in groundwater ranges from BDL to 24.5mg/l. Pre and post monsoon iron concentration in Bishnupur block is within permissible limit. In Moirang block its value ranges from 0.06 to 32.10 mg/l during pre-monsoon and 0.045 to 24.5 mg/l in post monsoon. It is observed that in both pre- and post-monsoon groundwater samples concentration of Ca, Mg, Cl, SO_4, TDS and hardness as $CaCO_3$ are within desirable limit. Block wise concentration range of different chemical elements in ground water during pre- and post-monsoon in the study area is given in Table 11 and 12.

Table: 11 Pre monsoon Chemical quality analysis of groundwater samples in the study area

Sl. No	Location/ Village	Well Type	PH	EC (µS/cm at 25ºC)	Turbidity	TDS mg/l	CO_3 mg/l	HCO_3 mg/l	TH as $CaCO_3$ mg/l	Cl mg/l	F mg/l	SO_4 mg/l	NO3 mg/l	Ca mg/l	Mg mg/l	Na mg/l	K mg/l	Fe mg/l
1	Buri Bazar	TW	7.7	1490	1.0	998.3	164	824	265	39	0.72	4.67	1.12	52	3.5	23.63	2.53	BDL
2	Ningthoukhong II	TW	7.7	310	0.2	207.7	32	159	70	11	0.54	4.87	2.72	12	9.7	112	1.96	17.8
3	Keinou Thongkhong	TW	8.5	636	0.3	369	45	217	100	7.1	0.56	1.385	0.34	20	7.3	8.3	3.03	1.553
4	Maibam Lokpa Ching	TW	8.0	757	0.7	369	60	187	150	60	0.39	1.994	0.59	44	8.5	91	3.55	0.386
5	Ishok Sabal	TW	8.2	940	0.32	629.8	66	427	155	24	0.78	3.02	0.3	22	24	8.99	3.9	BDL
6	Thanga Chingjin	TW	7.5	195	0.2	130.6	BDl	97	55	11	0.3	1.6	0.61	10	7.9	15.22	3.72	32.1

Table:12 Post-monsoon Chemical Quality Analysis of ground water samples in the study area

Sl.No	Location/ Village	Well Type	PH	EC (µS/cm at 25ºC)	Turbidity	TDS mg/l	CO_3 mg/l	HCO_3 mg/l	TH as $CaCO_3$ mg/l	Cl mg/l	F mg/l	SO_4 mg/l	NO3 mg/l	Ca mg/l	Mg mg/l	Na mg/l	K mg/l	Fe mg/l
1	Buri Bazar	TW	7.9	1450	1	971.5	160	844	235	48	0.65	4.12	1.03	58	5.6	21.3	2.53	BDL
2	Ningthoukhong	TW	7.4	300	BDL	201	32	179	56	9.5	0.51	4.33	2.16	18	12	108.2	1.87	14.3
3	Keinou Thongkhong	TW	7.8	740	0.34	262	46	291	95	11.9	0.61	0.53	0.29	27	16	7.9	3.00	1.695
4	Maibam Lokpa Ching	TW	7.2	920	0.61	451	57	199	175	72	0.31	0.951	0.44	47	12.6	90.2	3.21	0.943
5	Ishok Sabal	TW	7.3	1200	0.54	804	112	640	165	28	0.62	0.78	0.39	42	33	90.5	3.0	0.045
6	Thanga Chingjin		7.6	125	0.22	83.75	BDl	116	45	19	0.33	1.3	0.53	14	10	15.2	3.34	23.4

CHAPTER 4.0

GROUND WATER RESOURCES

4.1 Groundwater resources estimation

The computation of ground water resources available in the existing two blocks of Bishnupur district has been done using GEC 1997 methodology. The Dynamic Groundwater Resources Estimation presented here is taken from the Dynamic Groundwater Resources of Manipur 2017 in block level.

In the present report, the smallest administrative unit viz. Bishnupur block and Moirang block have been considered for resources assessment of the study area. Area with more than 20% slope has been excluded for the recharge assessment.

The return flow factor for surface water irrigation has been taken as 0.50 for paddy and 0.30 for non-paddy, which works out to be 0.374 for the assessment unit as a whole. Return flow factor for groundwater irrigation has been taken as 0.45 for paddy and 0.25 for non-paddy which works out to be 0.292 for the assessment unit as a whole. Recharge from tanks and ponds and Recharge from water conservation structure have been taken as Nil. In the absence of water level data, the recharge from rainfall has been calculated using Rainfall Infiltration Factor. Following the norms recommended by GEC'97, Rainfall Infiltration Factor has been taken as 0.12 for Tertiary Sedimentary Formations. The natural discharge during non-monsoon period is taken as 10% since only RIF method is considered. The population has been projected to 2025 based on decadal growth rate as given in Census of India, 2011. Categorization of assessment units are done based on stage of groundwater development only, since data on long term water level trend is absent.

Table.13. Balance of ground water availability for future use as per dynamic ground water resources (2017) in the district

Assessment Unit	Stage of Ground Water Extraction (%)	Annual Extractable Ground Water Recharge (Ham)	Ground Water Extraction for Irrigation (ham)	Ground Water Extraction for domestic use (ham)	Total Ground Water Extraction (ham)	Annual GW Allocation for Domestic Use as on 2025 (ham)	Net Ground Water Availability for future use (ham)	GW Availability for Future Irrigation@ 60% Annual extractable (ham)	No. of STW feasible as per Resource (Unit draft 3 ham)
Bishnupur	1.16	4117.64	33.11	14.97	48.08	432.08	3652.45	2,470.584	823
Moirang	1.02	3228.56	24.08	8.98	33.06	263.79	2940.69	1,937.136	645

District Total	1.09	7346.2	57.19	23.95	81.14	695.87	6593.14	4,407.72	1468

The total annual groundwater recharge of the district is 8162.45 ham (as per GWRE 2017). The Annual Extractable Ground Water Recharge worked out 7346.23 ham. The existing total groundwater extraction is 81.14 ham, of which 57.19 ham is the gross groundwater extraction for irrigation use and 23.95 ham is the gross groundwater extraction for domestic use. The stage of groundwater extraction in the district is 1.09 %. As such the district falls under Safe category. Since there is no saline/ brackish water infested area in the Aquifer Mapping area, the entire assessment area has been considered as fresh water bearing area.

4.2 Present Ground Water Development in the district

Groundwater development is very low in the district and is mainly used for drinking and irrigation purposes. As there is no major industry in this district, groundwater utilization for the same may be considered as negligible. Development of ground water in Bishnupur district is discussed below

4.2.1 Urban and Rural Water Supply Schemes

In Bishnupur district out of 496 sq.km of total geographical area, 458.98 sq.km area if rural and only 37.02 sq.km area is under urban. The present water demand for the small towns in the district is estimated to be 30.09 MLD and have been extended with water supply facility at the rural standard (i.e., at the rate of 60 litre per capita per day). Upgradation of water supply schemes of the towns at the Urban standard of supply i.e., 135 lpcd (litres per capita per day) have also been taken up by State Government.

4.2.2 Rural Water Supply

Rural Water Supply facilities are provided to the people in rural areas under centrally sponsored Minimum Need Programme (MNP) and Accelerated Rural Water Supply Programme (ARWSP). Under the National Rural Drinking Water Programme (NRDWP), a Flagship programme of the Government of India, it is expected to provide households drinking water supply to all the census habitation of state under the slogan 'HAR GHAR JAL-SDG-2030'.

Table 14: Status of Rural habitations covered under the programme in Bishnupur district

Sl.No.	Habitations	Habitations with Population Coverage				
		0-25%	25-50%	50-75%	75-100%	100%
1	90	0	36	45	0	9

Table15 : Rural Households connection with PWS in Bishnupur district

Sl.No.	No. of Rural Household	Total Household connection with PWS	100% Total Household with PWS
1	33004	11303	34.25

4.2.3 Extraction from unconfined aquifer/deeper aquifer: As mentioned earlier that groundwater in this area is utilized mainly for drinking or domestic purposes. Public Health Engineering Department water supply projects are mainly based on groundwater.

Table 16: Public water supply scenario in the study area: Bishnupur district

Total Nos. of Shallow Tube Wells (Hand Pumps) working	Total number of Public Water Supply Scheme	Source
148	58	Tube Well

PHED tube well depth is within 100 m. Besides the public water supply scheme rural population utilize dug wells for drinking and domestic water purposes. Dug well depth is generally more towards piedmont zone. Dug well depth in this area is generally within 10m. In the alluvial plain area dug well depth 3 to 7m.

4.3 Ground Water for Irrigation

The main sources of water for irrigation are rivers, ponds, lakes, tanks, wells etc. And various means of distribution are canals and pumping sets through, which water is drawn from the sources. The Loktak Lift irrigation also supplied water to a considerable area of land in the district.

Table.17 MIS schemes, Type, irrigation, potential & utilization, lifting devices and used

Structure	**Frequency**	**Irrigation (in ha)**		**Lifting devices**		
		Potential	Utilisation	Diesel	Electrical	Others

STW	3	33	29	2	-	1
Surface Lift Irrigation	4	648	388	4	0	0
Surface Flow Irrigation	12	3490	2154	0	12	0

Source: MID, Manipur

Depending upon agro climatic conditions and rainfall distribution in the district, rice is the main crop, which is cultivated during two seasons i.e., autumn paddy (March to June) and winter paddy (June to November). The distributions of minor irrigation schemes for irrigation in the district are given below.

Table.18 Distribution of Minor Irrigation Schemes in the district

Structure	**Frequency**	**Irrigation (in ha)**			**No. of Villages**
		Potential	Utilisation	Share	
MIS	19	4171	2571	14.08	16

Source: MID, Manipur

CHAPTER 5.0

GROUNDWATER RELATED ISSUES

Major groundwater related issues found in the district are low stage of ground water extraction. As per ground water resource estimation March 2017, the stage of ground water extraction is only 1.09 %. At present the irrigation by utilizing ground water (constructing tube well) is not practice in large scale by individual villagers due to small land holding, high cost for construction and running of a well compared to production outcome. Another major obstacle in accelerating groundwater irrigation is the absence of power supply in most of the cultivated/cultivable area and meagre irrigational infrastructure and in major parts of the study area.

As per groundwater quality analysis data, it was found that groundwater in the district has found higher concentration of iron, which needs to be treated before consumption.

5.1 Major Groundwater Issues in the Area

Groundwater related problems in the district that has so far been identified are emanation of gas while constructing deep tube wells and existence of clayey deposit down to a depth range of 30 to 50 mbgl which invites problem for construction of shallow tube wells. As such utmost care has to be taken during construction of deep tube wells so that any untoward incident can be averted.

Other groundwater related issues found in the study area are-

(i) Low stage of development;
(ii) Emanation of gas while construction of deep tube wells
(iii) Flood is a primary hazard in the valley during the monsoon season every year damaging crops and properties of the people;
(iv) In places, high concentration of iron in groundwater also observed;
(v) Water scarcity during lean period

5.2 Sources of water in the area

At the beginning of the twentieth century, there were approximately 500 lakes in Manipur State with innumerable small ponds, swamps and marshes along lakesides and inter-riverine tracts and many community and household ponds. Many of these water bodies no longer exist due to encroachments for paddy cultivation and human settlement. At present there are still a number of large and small lakes. Loktak in Bishnupur district is the largest and most important freshwater lake (289 km2) in the North Eastern Hill states and could be used as a potable water resource after appropriate treatment.

Before 1980, almost 100% of water used for domestic purposes was from rivers, lakes, ponds (local name Pukhris) and in hilly areas streams are used. Still now rainwater is the main source for agricultural water. With the increase in population, use of land for human settlement, agricultural activities and extensive use of fertilizers, pesticides, insecticides, herbicides have not only reduced water availability but also led to deteriorating water quality.

5.3 Future demand for agriculture

The district has rich and varied vegetation and the climatic conditions are suitable for various flora and a wide variety of medicinal plants are grown. And the Loktak lake and marshy lands around Loktak are the favourite habitat of a variety of migratory birds. The district by and large is plain in nature and rice is the principal crop grown.

The district being fertile valley region is primarily agrarian. Agricultural operations are mainly rain fed. Agriculture is, however, of subsistence type without any diversification. In some places double cropping is also carried out. The main crops grown are paddy, sugarcane, pulses and potato. Irrigated cultivable wasteland accounts for 7,101 hectares and 4,817 respectively. The Loktak lift irrigation project has a capacity to irrigate 31,000 hectares of land for double irrigation.

Agriculture and allied is the main occupation of the district and crop production is an important activity for the economy of the district which provides livelihood-cum-employment opportunities to the rural population. Mono cropping is in vogue in the area. Major crop grown in the district is paddy. Other crops include Oil Seeds, Maize, Pulses, Sugarcane, Vegetables, Potatoes, Mushroom and Fruit crops like Pineapple, Orange, Banana, Papaya, Lemon, Passion fruit etc. The most predominant crop grown in the district is Paddy. Other major crops include Mustard, Pulses, Sugarcane, Potato and Fruit crops like Pineapple,

Orange, Lemon, Passion fruit and Banana. The district receives moderate to high rainfall, the fertile, alluvial soils in the river basin. The new and emerging sectors/economic activities in the district are piggery and fishery.

5.4 Groundwater for irrigation

Few numbers of groundwater irrigation were practiced in the district under Minor Irrigation Department, Govt. of Manipur. The importance of minor irrigation is high due to the existence of numerous small valleys in Manipur valley. The main activities that carried out by M.I. department are construction of field elements, field drains, land levelling etc and conducting adaptive trials, training of farmers in irrigation, water management, enforcement warabandi for suitable distribution of irrigation water to the farmers field etc.

CHAPTER 6.0

Management Strategy

The groundwater management involves the optimum utilization of sub-surface water based on geological, hydrological, economic, ecological and legal consideration for the welfare and benefit of the society. The management of the groundwater resources has to be taken up after understanding the varied hydrogeological characteristics. In addition, the development of groundwater requires thorough understanding of the heterogeneity of the formation. The peneplain surfaces, buried pediments and valley fills are the most favourable localities for development of groundwater. Structures such as dug well and tube well are the feasible ground water structures.

The objective of management is to utilize the available groundwater resources to fulfill human needs and also to boost economy of an area without hampering the interest of future generation. That objective can be achieved by finding out demand of various sectors and adjusting the demand with available resource.

As per dynamic ground water resource of Bishnupur district, the Annual Extractable Ground Water Recharge worked out 7346.23 ham. The existing total groundwater extraction is 81.14 ham, of which 57.19 ham is the gross groundwater extraction for irrigation use and 23.95 ham is the gross groundwater extraction for domestic use. The stage of groundwater extraction in the district is 1.09 %. As such the district falls under Safe category. If an irrigation plan is made to develop 60% of the balance dynamic groundwater resources available, then 4407.72 ham of groundwater resources is available in the district for future irrigation uses. A total of 1468 tube wells can be constructed in the district for groundwater irrigation.

6.1 Construction of groundwater abstraction structures: Based on the hydrogeological conditions prospects for ground water development in the district mainly confined to the alluvial deposit plain areas surrounding the Loktak Lake. The eastern and northern region are feasible for the development of groundwater through moderately deep tube wells down to 75 m tapping about 10 to 30 m of cumulative thickness of granular horizon capable of yielding 20 to 40 m^3/hr for draw down up to 12 m.

Diameter of casing pipe, when used as housing pipe, need to be decided based on the anticipated discharge. Housing pipe should be large enough to accommodate the pump. Based on the static water level, maximum draw down and seasonal fluctuation length of housing pipe should be range from 25 to 30 mbgl. For avoiding corrosion and clogging of well screen, the entrance velocity should be less than 2 cm/sec.

The potential aquifer is found in the southern part of the valley bordering Iril River from Sugnu to Kumbhi touching some parts of Churachandpur valley. The terrace zones running from Bishnupur to Sekmai in north which are mainly comprises pebbles, boulders with clay matrix.

Major part of the district fine-grained granular horizons of cumulative thickness of 10 to 20 m are encountered up to 100 m. The area is suitable for the construction of tube wells for domestic and irrigation purposes. In the eastern and southern part of the tube wells of moderate depth are considered to be feasible with discharges of 20 to 50 m^3/hr.

6.2 Groundwater Irrigation: Groundwater irrigation system in the district is yet to be developed. As on date, neither Rabi crops nor double cropping can be practised in the district. Keeping in view these facts, District Irrigation Plan under Pradhan Mantri Krishi Sanchayii Yojna (PMKSY) has been prepared to create more irrigation potential by way of better water harvesting techniques, construction of ponds, construction of check dams, utilisation of ground water, lined channels for better distribution of irrigated water.

In addition to these, groundwater irrigation can be created through construction of tube wells in the district.

6.3 Integrated Farming system: Integrated Farming system can also be developed in the district. Since land holding in the state is very small and labour cost very high, farmers cannot get enough income from the prevailing single cropping system. To stabilize the situation and increase the income of farmers, integrated farming system such as Horticulture based farming (HBF), Livestock based farming (LBF), Fishery based farming (FBF), Dairy based farming (DBF) etc need to be

adopted. To achieve this 500 Ha each of HBF, LBF, FBF and DBF have to be earmarked.

6.4 Water Conservation and Artificial recharge: Development of rain water harvesting for the drinking water supply is also one of the appropriate measures for solving the scarcity of potable water as it involves relatively low cost, less time for implementation and provides almost entirely safe drinking water which does not require costly purification and treatment process.

Rooftop rainwater harvesting is yet to be exploited in the district. The district is facing acute drinking water shortage as the government's water supply facilities fully depends on the rivers and which are generally remain dry during the dormant season. Rooftop rainwater can be one of the best options to stored quality water for use during the dormant months.

During the water crisis period, there are many other private traders who supply the drinking at much higher price, which increases hardship to the common people. Groundwater resources are not yet exploited in Manipur, so groundwater can be one of the options for supplies of water during non-rainy months and same groundwater can be recharged during the monsoon months.

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