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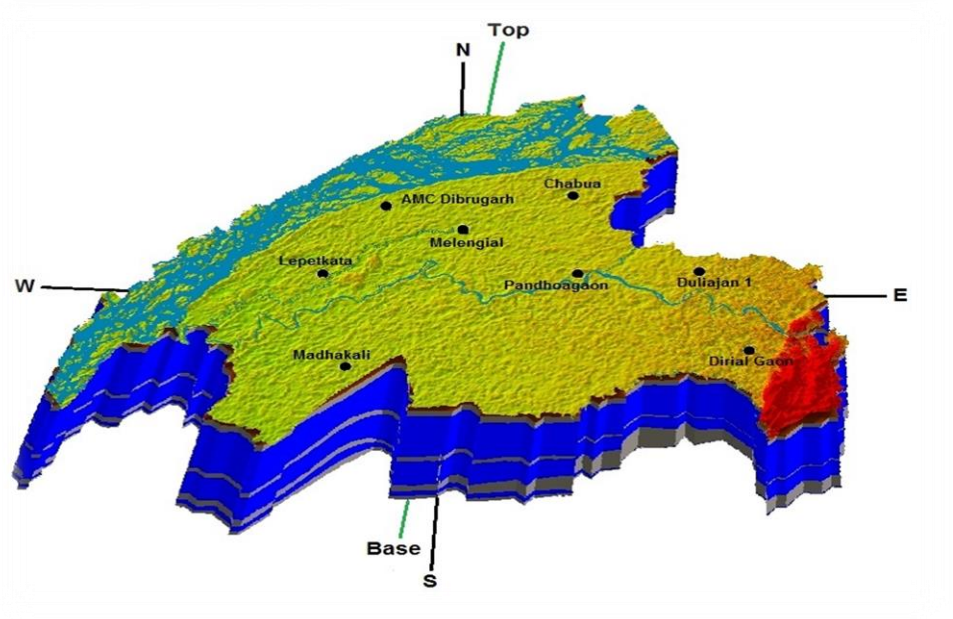

AQUIFER MAPPING REPORT AND MANAGEMENT PLAN OF DIBRUGARH DISTRICT, ASSAM

(AAP 2021-22)

NORTH EASTERN REGION
उत्तरपूर्वीक्षेत्र
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 DIBRUGARH DISTRICT, ASSAM"

(AAP 2021-22)

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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 Dibrugarh district of Assam . 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 Dibrugarhdistrict 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 ShriBiplap Ray, HOO, CGWB, NER, Guwahati for his support and guidance during the course of study.

I render my sincere thanks to my supervisor Dr. Dip JyotiKhound, Scientist-B, Nodal officer of NAQUIM, NER and, Guwahati for his support, technical input, encouragement during the year.

Sincere thanks to Dr.DhurbajyotiKhanikar (Scientist-C), Dr. S.S Singh (Scientist-C), HimangshuKachari (AHG) for the technical inputs and guidance in preparation of report.

My thanks and appreciation also go to Miss DimpiBarpatra (Young Professional) who have willingly helped me out in the preparation of GIS map layers.

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

.

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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
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

CHAPTER 1

Introduction

The vagaries of rainfall, inherent heterogenity& unsustainable nature of aquifers, over exploitation of once copious aquifers, lack of regulation mechanism etc has a detrimental effect on ground water scenario of the Country in last decade or so. Thus, prompting the paradigm shift from **"Traditional Groundwater Development concept**" to **"Modern Groundwater Management concept**". Varied and diverse hydrogeological settings demand precise and comprehensive mapping of aquifers down to the optimum possible depth at appropriate scale to arrive at the robust and implementable ground water management plans. This leads to concept of Aquifer Mapping and Ground Water Management Plan. Aquifer mapping is a process wherein a combination of geologic, geophysical, hydrologic and chemical analyses is applied to characterize the quantity, quality and sustainability of ground water in aquifers. The proposed management plans will provide the "Road Map" for ensuring sustainable management and equitable distribution of ground water resources, thereby primarily improving drinking water security and irrigation coverage. Thus the crux of NAQUIM is not merely mapping, but reaching the goal-that of ground water management through community participation.

1.1 Objective and Scope

The major objectives of aquifer mapping are

- Delineation of lateral and vertical disposition of aquifers and their characterization
- Quantification of ground water availability and assessment of its quality to formulate aquifer management plans to facilitate sustainable management of ground water resources at appropriate scales through participatory management approach with active involvement of stakeholders.

The groundwater management plan includes Ground Water recharge, conservation, harvesting, development options and other protocols of managing groundwater. These protocols will be the real derivatives of the aquifer mapping

exercise and will find a place in the output i.e, the aquifer map and management plan.

The main activities under NAQUIM are as follows:

a). Identifying the aquifer geometry

b). Aquifer characteristics and their yield potential

c). Quality of water occurring at various depths

d). Aquifer wise assessment of ground water resources

e). Preparation of aquifer maps and

f). Formulate ground water management plan.

The demarcation of aquifers and their potential will help the agencies involved in water supply in ascertaining, how much volume of water is under their control. The robust and implementable ground water management plan will provide a "Road Map" to systematically manage the ground water resources for equitable distribution across the spectrum.

1.2 Approach and Methodology

The ongoing activities of NAQUIM include hydrogeological data acquisition supported by geophysical and hydro-chemical investigations supplemented with ground water exploration .

Considering the objectives of the NAQUIM, the data on various components was segregated, collected and brought on GIS platform by geo-referencing the available information for its utilization for preparation of various thematic maps. The approach and methodology followed for Aquifer mapping is as given below:

Compilation of existing data (Central & State Govt.)

↓

Generation of different thematic layers

↓

Identification of Primary Aquifer

↓

Identification of data gaps

↓

Data generation (water level, exploration, geophysical,

hydrochemical, hydrogeological etc.)

↓

Aquifer Maps with 3D disposition

↓

Preparation of Aquifer Management Plan

1.3 Area Details

Study area is situated in eastern most part of Assam and on the southern bank of Brahmaputra.Dibrugarh district of Assam covers a geographical area of 3381 sq. km and lies between 27° 06′ 00″ and 27° 58′ 18″ N. Latitudes and 94° 39′ 00″ and 95° 30′ 00″East longitudes.The district is bounded on the West and North West by Dhemajidistrict on the East by Tinsukia district on the South by Sibsagar district and on south east by Charaideo district.The Brahmaputra River flows through the north western boundary of the district. Dibrugarh has been subdivided into seven administrative development blocks namely Khowang, Borboruah, Lahual, Tengakhat, Joypur, Tinkhong and Panitola. The study area bounded by survey of India toposheetno:83M/02,83M/03,83M/04,83M/06,83M/07,83M/08,83I/11,83I/12,83I/14,83I/15,83I/16.Administrative map of the district is given in Figure**1.**As per 2011 census report total population of Dibrugarh district is 13,27,748. Blockwise area of the district is shown in Table 1.

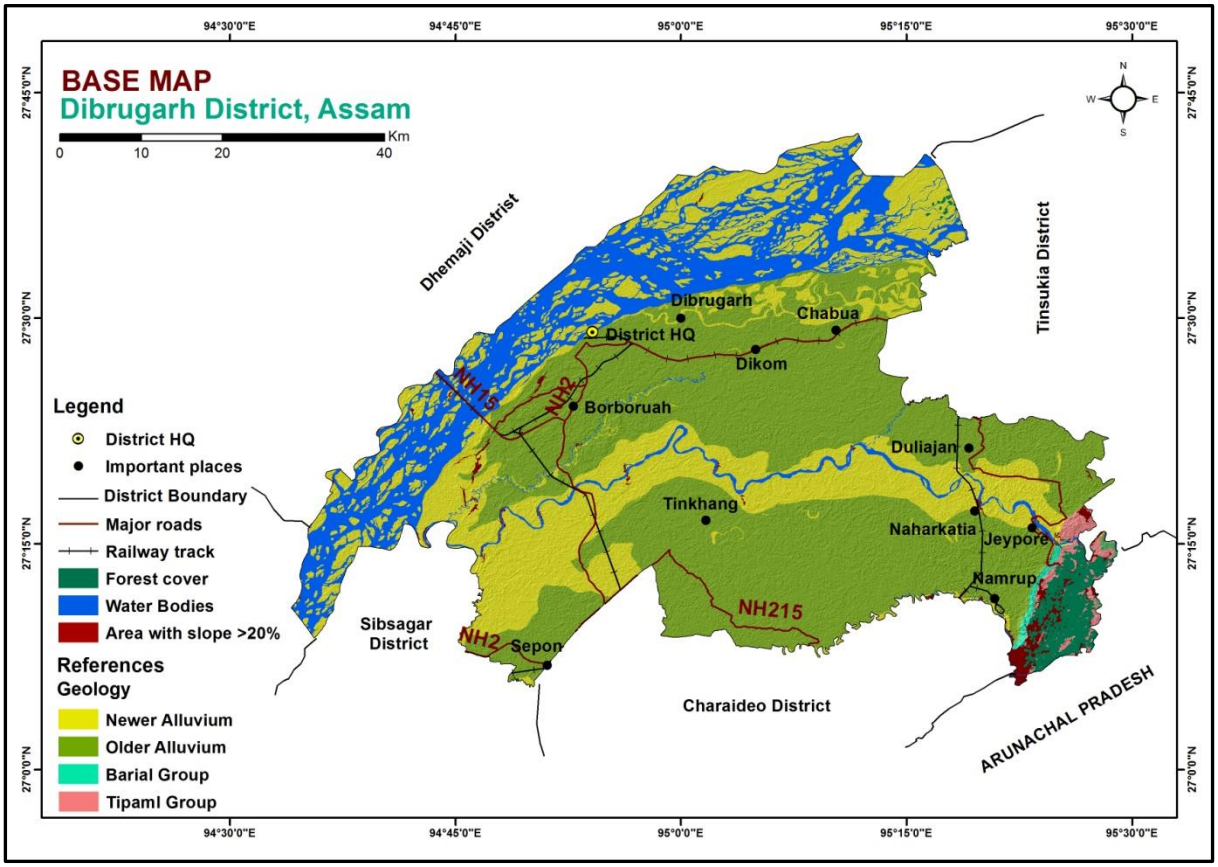

Figure 1: Base map of Dibrugarh district

Table 1: Block wise Area of Dibrugarh District, Assam

Sl. No.	Block	Area in (Hectare)
1	Barbaruah	43369
2	Lahoal	70527
3	Panitola	26950
4	Tengakhat	52912
5	Khowang	42723
6	Tingkhong	47727
7	Joypur	48828
9	Lahoal	70527
Total		333036

1.4. Data Availability Adequacy and Data Gap analysis

1.4.1 Data Availability: Central Ground Water Board has carried out exploratory drilling in the district and drilled 6 exploratory wells and 4 piezometer in alluvial formation and piedmont zone . In addition, eight numbers of permanent observation well station (NHNS) of Central Ground Water Board located in the district are being monitored for ground water regime and to assess the chemical quality of ground water.

1.4.2 Data Adequacy and Data Gap Analysis: The available data of the Exploratory wells drilled by Central Ground Water Board, North-Eastern Region, Guwahati, ground water monitoring stations and ground water quality stations monitored by Central Ground Water Board were compiled and analysed for adequacy of the same for the aquifer mapping studies.

After taking into consideration, the available data of ground water exploration, geophysical survey, ground water monitoring and ground water quality, the data adequacy has been compiled. The summarised details of required, existing and data gap of exploratory wells, ground water monitoring and ground water quality stations are given in table–2.

Table 2: Data adequacy and data gap analysis

Exploratory data			**Geophysical data**			**GW monitoring data**			**GW quality data**		
Req.	**Exist.**	**Gap**	**Req.**	**Exis.**	**Gap**	**Req.**	**Exist.**	**Gap**	**Req.**	**Exis.**	**Gap**
9	6	3	15	0	0	36	8	24	36	36	0

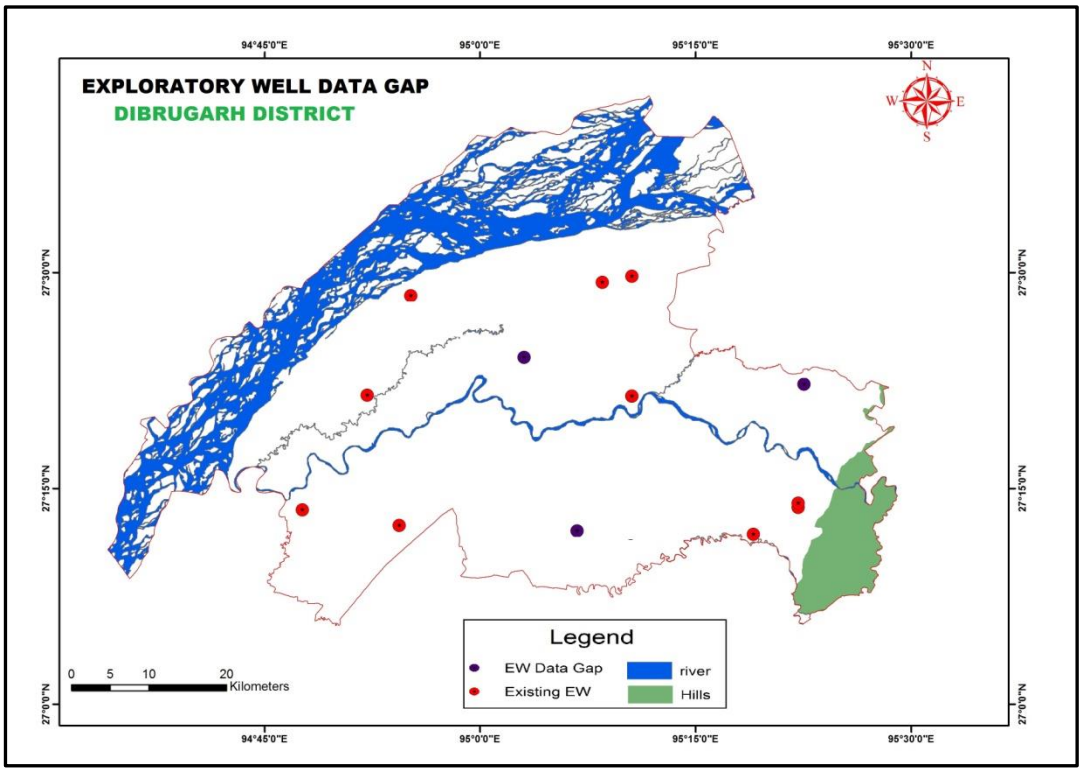

Figure 2:Exploratory well data gap map of Dibrugarh district

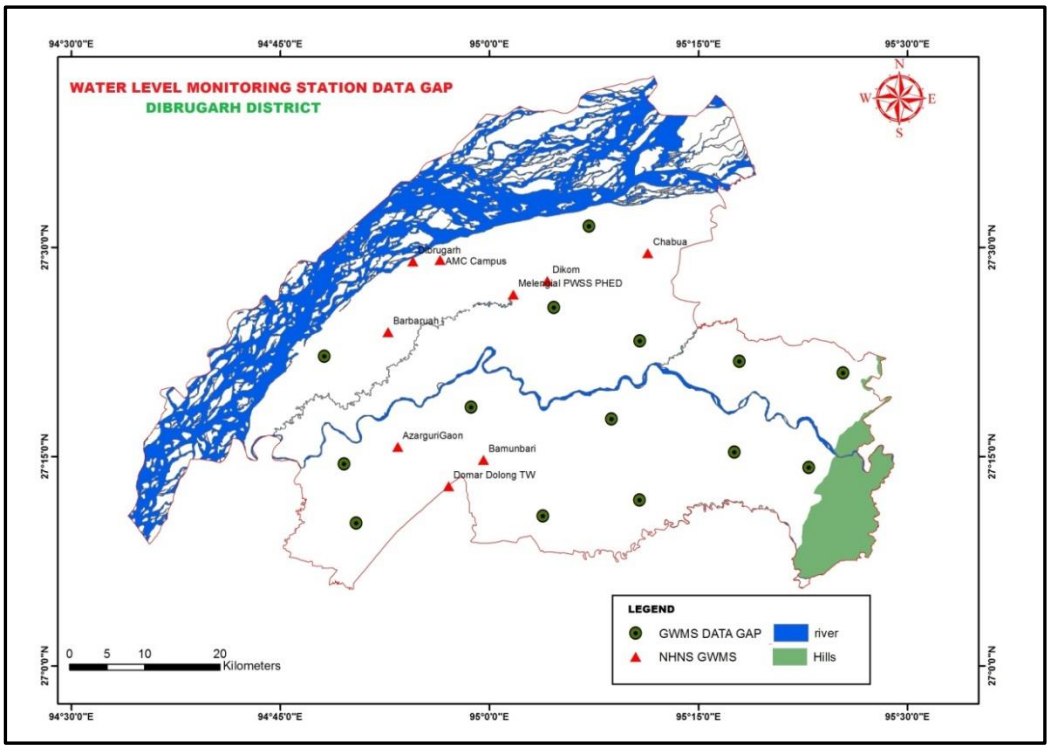

Figure 3:NAQUIM (GWMS) data gap map of Dibrugarh district

1.5 Rainfall - Climate

Climate of area is sub-tropical ,humid and typical of Brahmaputra valley. Winter usually commences in November and continues upto February, followed by brief period of spring from march to april. Pre-monsoon shower appears in first-half of April, but regular monsoon sets in may and continues upto middle of October.

Annual rainfall in Dibrugarh district for the year 2021 is 1527mm there is a deviation of 42% from normal rainfall. Rainfall analysis has been done based on gridded IMD data for the study area. Based onpercent deviation of monsoonal rainfall for a period of 10 years (2011-2021). The Rainfall Deviation (Rfdev) which is expressed in percentage terms is calculated as below:

Rfdev={(Rfi-RFn)/RFn}*100

where,

Rfi is current rainfall for a comparable period (in mm)

Rfn is the normal rainfall (at least 30 years average) for the same period (in mm).

Table 3: Classification of deviation of monsoonal rainfall from normal (2011-2021)

Deviation from Normal rainfall(%)	Category	Monsoonal rainfall year
+19 to-19	Normal	2013,2015,2017,2020
-20 to -59	Deficient	2011,2012,2014,2016,2018,2019,2021

According to IMD classification for percentage deviation of rainfall from normal rainfall during the period,it has been observed from that there has been deficit (-20% **-** -59%) monsoonal rainfall in 2021 (-42.6%). Monsoonal rainfall has been erratic in the observation period. There are few monsoon season where rainfall has been deficit. As agriculture is rainfall dependent in the study area deficit rainfall pattern creates impact on groundwater withdrawal for irrigation.

Table 4: Monthly Rainfall data of Dibrugarh district, 2021

MONTH	JAN	FEB	MAR	APRIL	MAR	JUNE	JULY	AUG	SEP	OCT	NOV	DEC
RAINFALL (mm)	15.07	2.3	38.18	74.6	304.62	271.18	239.43	388.98	119.04	55.76	5.75	12.17
NORMAL RAINFALL (mm)	36.1	56.2	103.8	222.6	313	416.6	531.6	439.8	329.5	153.7	26.7	19.8

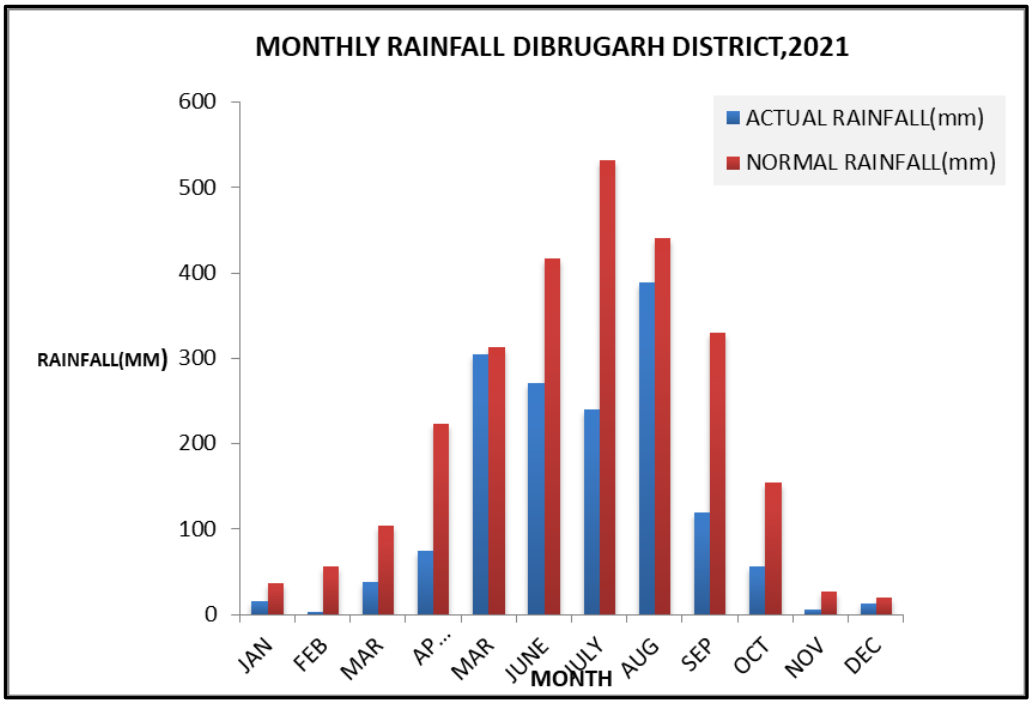

Figure 4: Graph of monthly rainfall and normal rainfall, 2021

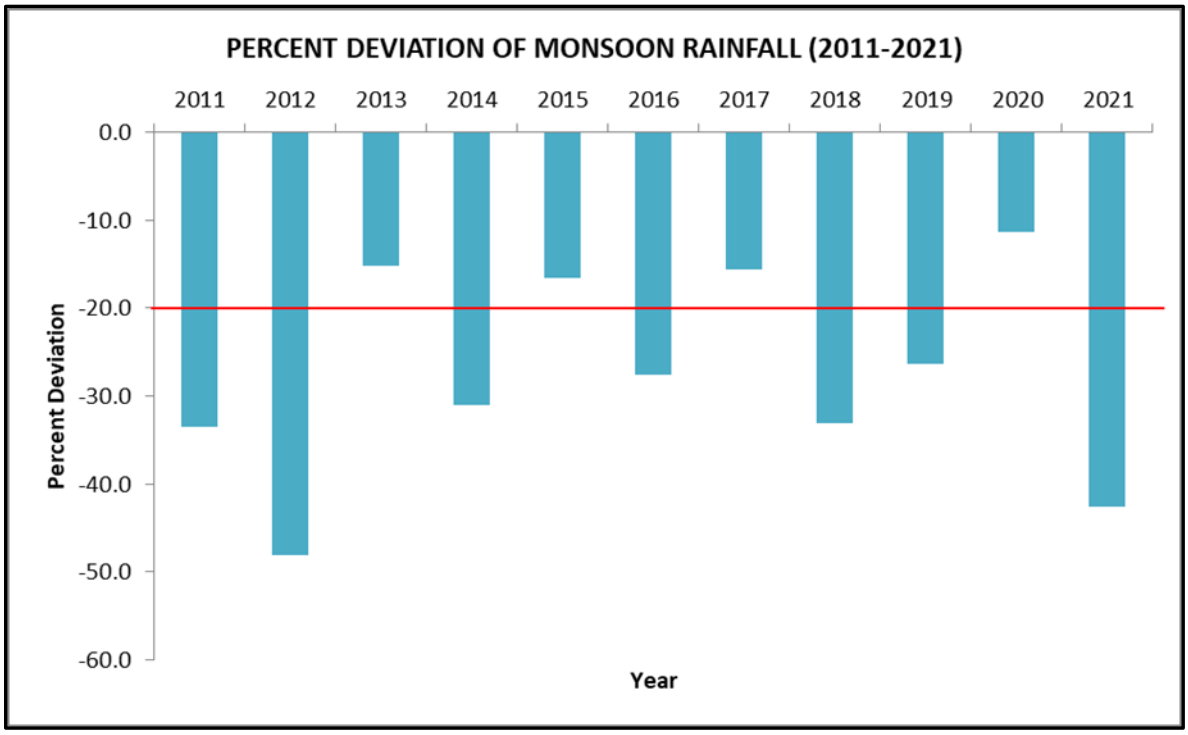

Figure 5: Graph of Percentage deviation of monsoonal rainfall from normal (2011-2021)

1.6Physiographic set up

Study area represents two distinct physiographic division viz. (a) flood plains of Brhamaputra river and (b) terrace deposits at the foothills in the southeastern part. The alluvial plain evolved during Quaternary period from the foreland depression between

Himalayan orogenicbelt and crystalline massif of shilling plateau. General elevation of alluvial plain varies from 86.88m to 152 m above m.s.l. The general slope of the area is towards west.

The area is a part of the 4th order BurhiDihing Sub-basin of the 5th order Brahmaputra Basin. The general slope of the area is towards south-west, which is the flow direction of the Brahmaputra River, BurhiDihing River & the SesaNala. The highest elevation is 108 m in the north-eastern part of the area and the lowest being 97 m above msl, towards the southern-western portion of the area. The north-western part is occupied by the south-westerly flowing Brahmaputra River with large channel bars, locally known as 'Char'. A large portion of the area is occupied by Tea Gardens, developed over the higher 'Surface'. The relatively lower Surface is mostly under cultivation.

The hills in the southern part of the district range in elevation from 115 to 350m above m.s.l and rise upto 500m above m.s.l in Tikakparbat area. The regional trend of the hill is NE-SW.

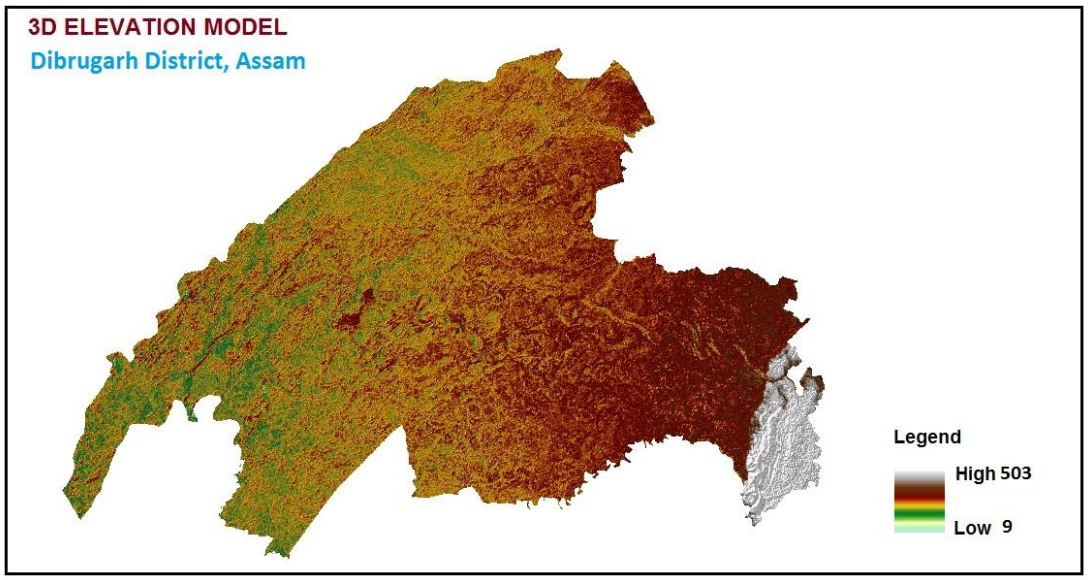

Figure 6: Digital Elevation Map of Dibrugarh.

1.7 Geomorphology

The present area of study forms part of the vast alluvial plains with gentle rolling topography of the Brahmaputra basin. It is bounded by Brahmaputra River in the north and northwest, and Tertiary hill ranges in the south and southeast. The Tertiaries are exposed in the form of highly dissected hills varying in altitudes from

140m to 240m above MSL. The alluvial sediments are extended to the foothills of Tertiary ranges from the Brahmaputra with three distinct geomorphic units. The boundary between the pediment plain and the alluvium plain is unconformably marked at places by pebble bed (Pleistocene ?). The three geomorphic units of the alluvial plain sometimes show sharp contact with prominent break in slope, distinct sediment texture and varied rate of oxidation.

Lineaments are tools to characterize special relationship of landscape features. They are significant linears of landscape, which reveal the hidden architecture of the basement. Lineaments are mapable linear features of the surface, whose parts are defined in a rectilinear or slightly curvilinear relationship, which differs distinctly from the pattern of adjacent features and presumably reflects a sub-surface phenomenon. Fracture lineaments as they control the courses of the major and some minor drainages. The first set (L1- Ll) is NNE-SSW to NE-SW trending and controls the major part of almost straight courses of the Brahmaputra River and some segments of the BurhiDihing River. The NW-SE and NNW-SSE trending second set (L2-L2) controls some segments of the BurhiDihing River, which flows over rejuvenated Deurigaon Surface. This set of lineament is also responsible for abrupt change in the courses of BurhiDihing River.

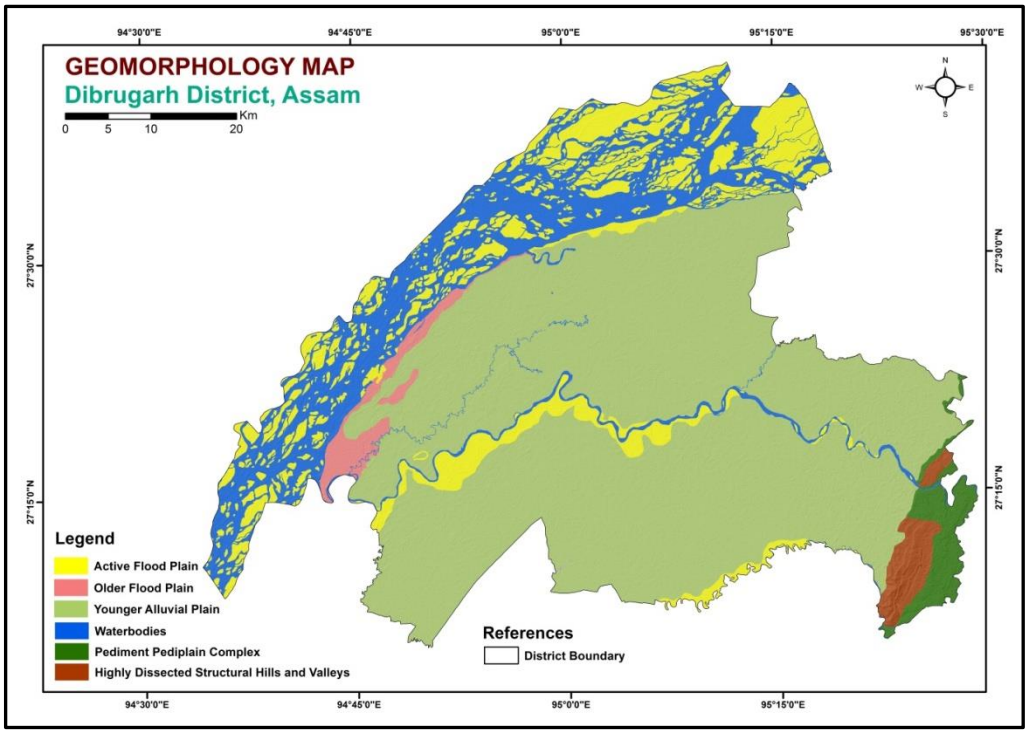

Figure 7: Geomorphology Map of Dibrugarh.

1.8 Land Use Pattern:

Land use pattern of a area has an intrinsic relationship to geology and lithology of the area. Water demand of an area depends on the utility of the land for various purposes. The total geographical area of the district is 3,33,036 Ha out of which 38.22% is cultivable, 8.5% is forest, 51.32% is under non-agricultural use and 2.12% is barren/waste land. Area under pasture is very negligible and marginally productive due to prevailing system of open grazing since long without adding any nutrient. Cropping intensity is highest in Lahoalblock (155.97%) and lowest in Barbaruahblock (136.08%).

Table 5: Land Use Pattern in Dibrugarh District (in hectares)

Name of Block	Total Geographical Area	Gross cropped Area	Net Sown Area	Area Sown more than once	Cropping Intensity	Area under Forest (Ha)	Area under Wasteland (Ha)	Area under other uses (Ha)
Barbaruah	43369	23560	17313	6247	136.08	10630	806	14620
Lahoal	70527	37674	22227	15447	169.5	980	1307	46013
Panitola	26950	13510	10140	3370	133.23	2929	1179	12702
Tengakhat	52912	33820	23413	10407	144.45	4472	928	24099
Khowang	42723	29179	19793	9386	147.42	3750	820	18360
Tingkhong	47727	21157	15326	5831	138.05	2840	946	28615
Joypur	48828	29792	19101	10691	155.97	2841	1098	25788

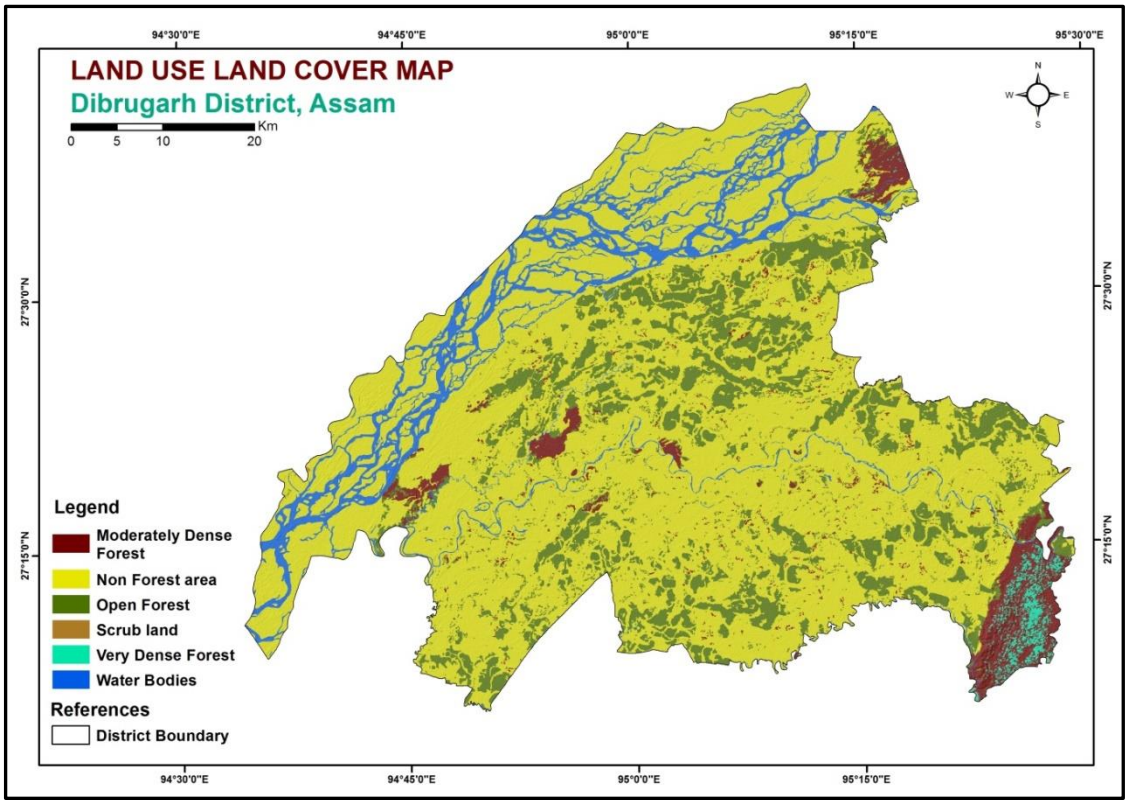

Figure 8: Land Use Land Cover Map of Dibrugarh district.

1.9Soil

Soils of the area are sandy to clayey loam type and greyish in colour. They are acidic in reaction with PH ranges from 4.6 to 5.9. Based on pedogenic and pedological characters, soils of this area may be classified into following classes a) Recent riverine alluvial soils (Antisol) b) Old riverine alluvial soils (Inceptisol) c) Old mountain valley alluvial soils (Alfisol) The predominantly soil of the district is clay loam which is covering an area of 255062 ha that is 76.59% of the total geographical area followed by clay soil with 8.78%, Sandy soil-by 7.60% and sandy loam soil-7.03%. Major areas of all AES and blocks are having clay loam soil, similarly clay, sandy and sandy loam soils are also found in all blocks. Large area under clay soil is present in two blocks namely Tengakhat and Lahowal in comparison to other five blocks.

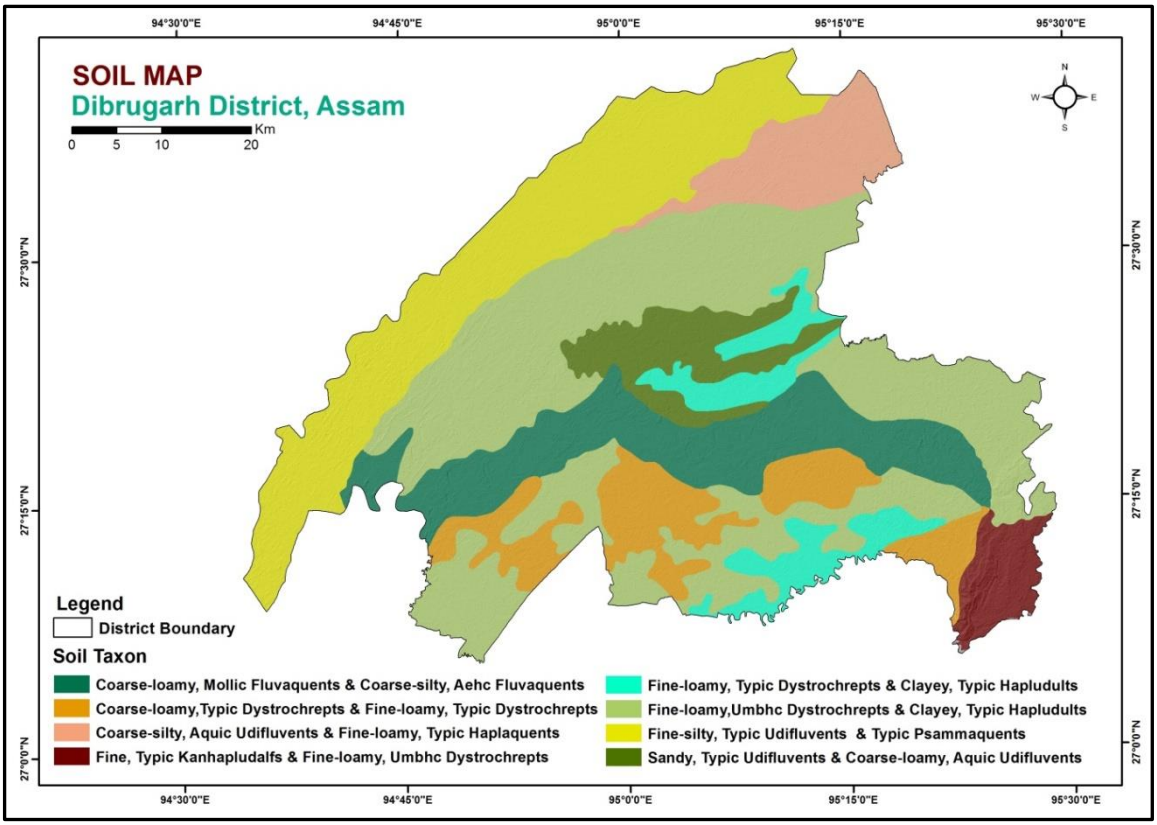

Figure 9: Soil Map OfDibrugarh district.

1.10 Hydrology and Drainage

The fifth order mighty Brahmaputra River flows from north-east to southwest direction in the north-western portion of the area . It originates at an elevation of 5000 m above m.s.l. near ManasSarovar in Tibet and flows in easterly direction as Tsangpo River. It enters India through Arunachal Himalayas and debouches onto the plains near Pasighat. Then it flows southwestward while the Dibang and Luhit rivers from further east merge into it. The Brahmaputra flows through the Assam valley as a highly braided river.

The fourth order BurhiDihing River flows in the same direction in the southern part of the area and joins the Brahmaputra River further downstream . The north-east to south-west direction of flow is also observed in SesaNala, which is a third order tributary to the BurhiDihing River. The high degree of sinuosity, compression and deep incision observed along the course of the third order SesaNala could be indicative of upliftment due to neotectonic activity. The abrupt change in the course of the BurhiDihing River from NE-SW to NW-SE for the stretch from Deurigaon to Balaigaon and tight, compressive meandering nature of NE-SW trending SesaNala for the stretch between SE of Bhogpara andLezai could be indicative of the presence of sub-surface lineaments.

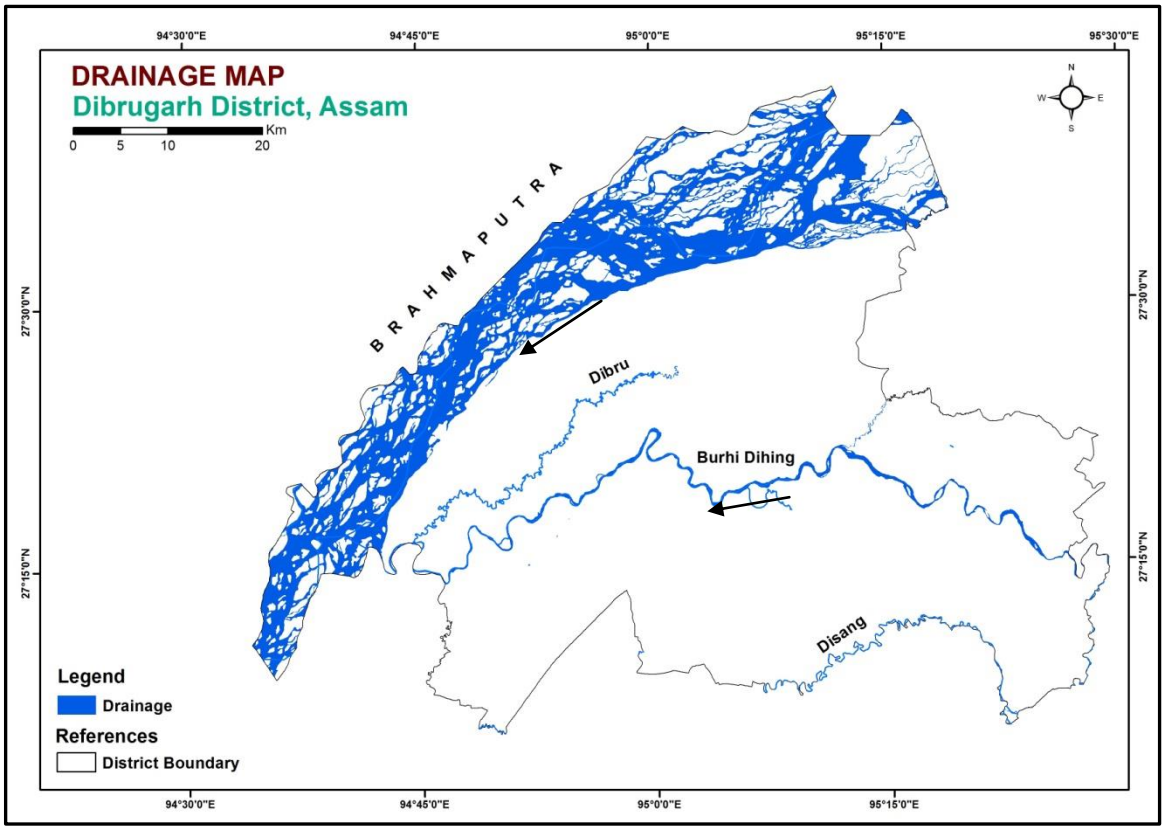

Figure 10: Drainage Map of Dibrugarh district

1.11 Agriculture

The local population of the district mostly depends on agriculture for their sustenance. The agriculture activity of the area is solely dependent upon the monsoon rainfall. Paddy is the main crop of the district. Rice and pulses are other crops grown widely in Dibrugarh and its adjoining areas. Irrigational facilities are not adequate in this district. Most agriculture is rainfed, but this is not a very dependable source of irrigation..Minor irrigation structures like surface water, tanks and ponds are the other source for irrigation. Available source wise acreage of agriculture production is given in table 5.

Table 6: Agriculture acreage and yield in Dibrugarh District (in hectares)

Rice									
Year	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16
Area (in hect.)	58846	70544	76156	77254	77409	77587	78070	74728	79342
Production (in tonnes)	93732	135347	154935	162958	105259	161327	148054	129091	153400
Average yield (in kg /	1617	1948	2065	2141	1380	2111	1925	1753	1963

hect.)									
Pulses									
Year	**2007-08**	**2008-09**	**2009-10**	**2010-11**	**2011-12**	**2012-13**	**2013-14**	**2014-15**	**2015-16**
Area (in hect.)	1055	688	1028	1099	1153	1865	1929	1779	1870
Production (in tonnes)	477	323	478	512	534	831	1105	996	1189
Average yield (in kg / hect.)	452	468	465	466	464	445	573	560	635
Rabi Pulses									
Year	**2007-08**	**2008-09**	**2009-10**	**2010-11**	**2011-12**	**2012-13**	**2013-14**	**2014-15**	**2015-16**
Area (in hect.)	1007	668	972	1034	1118	1825	1880	1730	1813
Production (in tonnes)	441	308	436	463	506	798	1063	949	1143
Average yield (in kg / hect.)	438	461	449	448	453	437	565	549	630
Oil Seeds									
Year	**2007-08**	**2008-09**	**2009-10**	**2010-11**	**2011-12**	**2012-13**	**2013-14**	**2014-15(Pr)**	**2015-16**
Area (in hect.)	858	846	1054	1198	2384	2502	2872	2794	
Production (in tonnes)	475	434	719	722	2324	2196	1799	1950	
Average yield (in kg / hect.)	552	514	682	603	975	877	626	698	

1.4.10 Irrigation

The district has net and gross cropped areas of 1,27,313 hectares and 1,88,692 hectares respectively, the net cropped area being 68 percent of the total geographical area. About 61,379 hectares out of the net cropped areas is put under multiple cropping with an average cropping intensity 148 percent as against 152.43 percent for the state. The crop wise irrigated and rainfedarea sown in different seasons likeKharif, Rabi and Summer.

The irrigation potential in the district is developed both from the surface and ground water sources. The irrigation department is responsible for creation of major, medium and minor irrigation schemes. The agriculture department has also created irrigation potential in different cultivable area by way of installation of shallow tube well schemes.

Table 7: Irrigation structures in Dibrugarh (5th MI census)

Ground water				Surface water	
Dug Well	**Shallow Tube well**	**Medium Tube Well**	**Deep Tube Well**	**Surface flow scheme**	**Surface lift irrigation**
2	**1454**	**0**	**11**	**2**	**379**

Table 8: Source wise irrigation potential created and CCA of Dibrugarh district (in hectares)

(in ha)							
In Use	Culturable Command Area	Potential Created	Potential Utilised	In Use	Culturable Command Area	Potential Created	Potential Utilised
2911	7359.5	8288.32	4627.08	95	2056.69	2714.99	431.2

1.12 Geology:

The major part of the district is underlain by unconsolidated alluvial sediments comprising of clay,silt,sand and gravel of Recent to Tertiary formation. The southeasternaprt of the distrcict is underlain by semi-consolidated formation of Tertiary age .

Tertiary group of rocks is found in southern and southeastern part of the district . They occupy 135 sq Km of area in Joypur block. Disang and Barail group of rocks are found in southern part of Joypur block. Barail group of rocks are coal bearing. Pebble and gravel beds of Dihing formation are well exposed in Naharkotiya and Joypur area.

Table 9: Geological Succession

Group	Age	Formation	Lithology
Quaternary	Recent to Pleistocene	Recent alluvium, Older alluvium.	Clay, silt, sand and gravel.
Tertiary	Pliocene	Dihing	Pebble bed,semi-consolidated sandstone
Tipam	Miocene	Girujan	Mottled clay and sandstone
		Tipam	Sandstone, sandy clay and clay
		Tikak Parbat	Sandstone, clay, carbonaceous clay
Barail	Oligocene	Borgolai	Sandstone, clay, carbonaceous clay

		Nagaon	**Sandstone, clay, carbonaceous shale, sandy shale**
Disang	**Eocene**	**Disang**	**Predominantly clay**

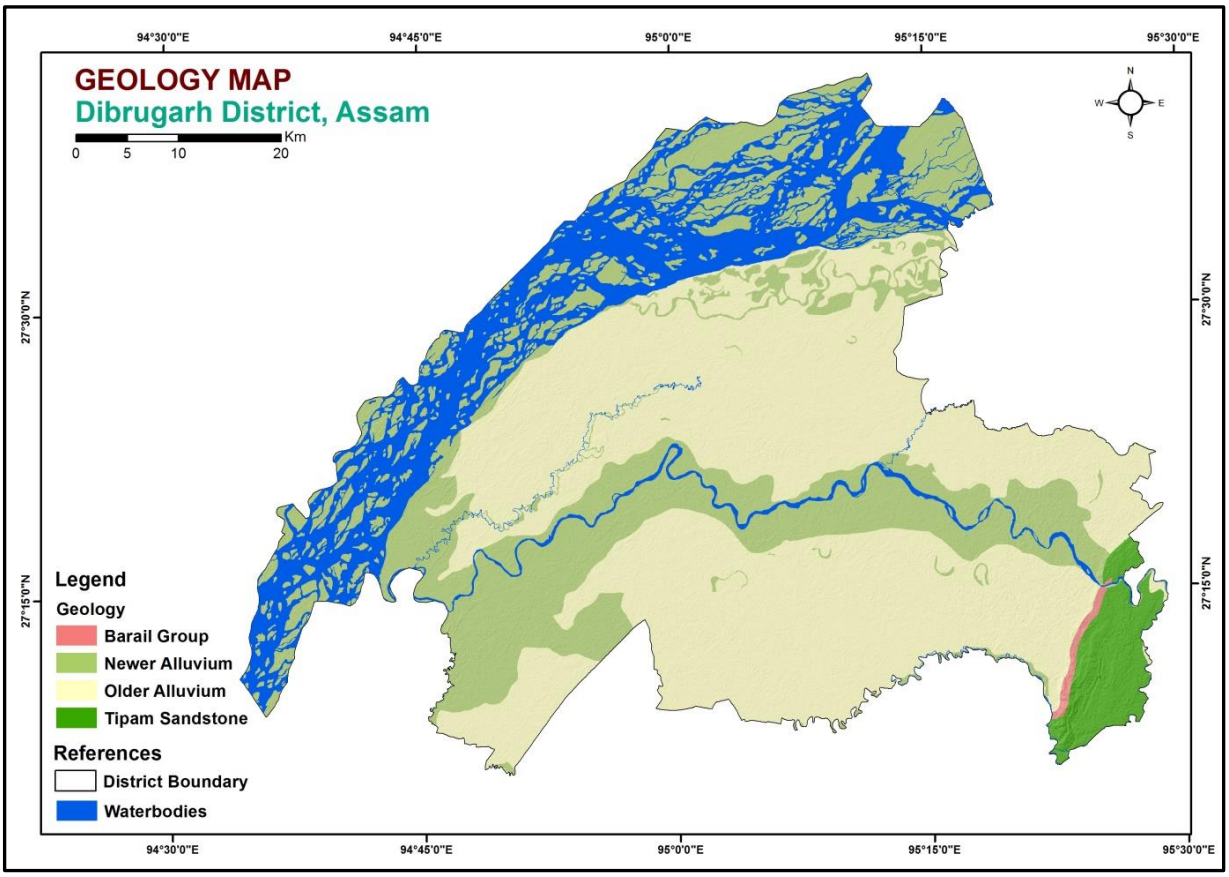

Figure 11: Geology Map of Dibrugarh district

CHAPTER 2

2. Data collection

Data collection includes collection of rainfall data from state government, tea estates, compilation of CGWB's earlier survey data, exploration, and geophysical data. Population and agricultural data are collected from Census of India website.

2.1: Hydrogeological data

The entire study area is covered by regular monitoring of existing 8 GWMS (NHNS) and another 35 Key wells have been established. All these wells are monitored after establishment. Table 2.1 and figure (10)shows the details of monitopring well (GWMS) established in Dibrugarh district in AAP 2021-2022.

2.2 Water Quality

To assess the quality of ground water for drinking and irrigation purpose water samples were collected during pre and post monsoon season from 08 no of NHNS monitoring stations and 36 other sampling locations from dug wells and tubewells.

2.3:Geophysical survey

During AAP 2021-22, no geophysical survey had been conducted in Dibrugarhdistrict.

Table 10: Details of Key wells established in Dibrugarh district.

Location	Type of well	Longitude	Latitude	Depth(mbmp)	Dia	m.p(m)	Auifer group
Digholia (PWSS)Ouphulia	TW	95.019	27.23	85.344	0.15	0.85	Unconsolidated alluvium
Ouguri	TW	95.093	27.26	91.44	0.15	0.85	Unconsolidated alluvium
Koilagarh	DW	94.994	27.25	4.5	1.2	0.3	Unconsolidated alluvium
Dhuwapathar(PWSS)	TW	95.121	27.16	100	0.15	0.79	Unconsolidated alluvium
1 no PuwaliPathar	DW	95.188	27.20	4.5	1.2	GL	Unconsolidated alluvium
Lerelapathar	DW	95.077	27.20	4.84	1.2	0.54	Unconsolidated alluvium
Simalubamgaon	DW	95.420	27.29	4.21	1.3	gl	Unconsolidated alluvium
ouguri shiv mandir	DW	95.428	27.28	13.5	0.8	0.54	Unconsolidated alluvium
TarajanBetoni(PWSS)	TW	95.445	27.29	110		0.6	Unconsolidated alluvium
Rupaibam (2 no. sopatoli)	DW	95.406	27.32	9	1.3	GL	Unconsolidated alluvium
Komargaon(Morankarichuk)	DW	95.375	27.23	12	1	GL	Unconsolidated alluvium
Chakyagaon (Namrup)	DW	95.373	27.18	9	1.2	GL	Unconsolidated alluvium
Tingraiborholla	DW	95.231	27.40	4.2	0.9	GL	Unconsolidated alluvium

Mohmari	DW	95.272	27.33	5.65	1.2	0.75	Unconsolidated alluvium
Tingraichariali	TW	95.234	27.36	55		0.5	Unconsolidated alluvium
PuroniKhongia	DW	95.150	27.38	5.7	1	0.73	Unconsolidated alluvium
Dowarichiga	DW	94.778	27.22	4.23	1.2	GL	Unconsolidated alluvium
Naharani(at the compound of agriculture office)	DW	94.850	27.24	4.9	1.2	0.8	Unconsolidated alluvium
Mazkopohuwa	DW	95.357	27.24	45		0.2	Unconsolidated alluvium
Komargaon9 in the house of mridulgogoi)	DW	95.374	27.24	9.2	1.2	0.8	Unconsolidated alluvium
Gethupathar (PWSS)	TW	95.302	27.30	91	0.15	0.85	Unconsolidated alluvium
HukaniDigholia (PWSS)	TW	95.210	27.31	100	0.15	0.7	Unconsolidated alluvium
Mathaoni(PWSS)	TW	95.160	27.31	100	0.15	0.7	Unconsolidated alluvium
Salmari (PWSS)	TW	95.130	27.28	100	0.15	0.4	Unconsolidated alluvium
Namphake village	DW	95.364	27.28	6.95	0.9	0.65	Unconsolidated alluvium
Kumarnichiga	DW	94.884	27.45	15	2	0.94	Unconsolidated alluvium
Roomarikacharigaon	DW	94.859	27.43	5.4	1.5	0.75	Unconsolidated alluvium
Gohaingaon	DW	94.859	27.38	4.5	1	GL	Unconsolidated alluvium
Hiloidari	DW	94.97	27.5	3.29	0.6	0	Unconsolidated alluvium
Hezelbank	TW	95.06	27.5	20	0.04	0.4	Unconsolidated alluvium
Tingkhong	DW	95.23	27.2	20	0.04	0.42	Unconsolidated alluvium
Jamira tea garden	DW	94.90	27.4	4.8	0.9	0.72	Unconsolidated alluvium
Rangsagiagaon	DW	95.20	27.4	4.53	0.9	0.6	Unconsolidated alluvium
Tingkhong	DW	94.86	27.5	4.6	1.1	0.6	Unconsolidated alluvium
Chabuabishmile	DW	95.200	27.50	8.45	2	0.79	Unconsolidated alluvium

2.4: Exploratory Drilling:

CGWB has drilled 08 no. of exploratory well for ground water investigation in Dibrugarh district. Under AAP 2021-22 no new exploratory well has been drilled. The details of exploratory well are given in table 2.2

Table 11: Details of exploratory well in Dibrugarh district.

District	Location	Tpye of well	Topo sheet	Depth of Drilled (mbgl)	Depth of constr. (mbgl)	Source
Dibrugarh	Chabua-EW	EW	**83 M/3**	253.06	148.00	CGWB
Dibrugarh	Lepetkata (Benaigutia)-EW	EW	**83 M/3**	251.70	151.00	CGWB
Dibrugarh	Madhakali-EW	EW	**83 M/16**	222.22	113.00	CGWB
Dibrugarh	Dirialgaon-EW	EW	**83 M/8**	129.30	127.00	CGWB
Dibrugarh	Tiloi-PZ	PZ	**83I/15**	53.51	50.51	CGWB
Dibrugarh	Hatiali-PZ	PZ	**83 M/3**	53.51	50.51	CGWB
Dibrugarh	Tengakhat (Pandhowa) -EW	EW	**83 M/3**	204.10	130.00	CGWB
Dibrugarh	Pandhowa-PZ	PZ	**83 M/3**	53.51	50.00	CGWB
Dibrugarh	Dirialgaon-PZ	PZ	**83 M/8**	48.46	43.50	CGWB
Dibrugarh	Chaykyagaon (Namrup)-EW	EW	**83 M/8**	41.95	40.00	CGWB
Dibrugarh	Medical College	EW	**83 M/3**	200.00	121.00	CGWB
Dibrugarh	Melengial-EW	EW	**83 M/3**	201.00	130.00	CGWB
Dibrugarh	Melengial (PWSS)-OW	OW	**83 M/3**	131.25	127.00	CGWB

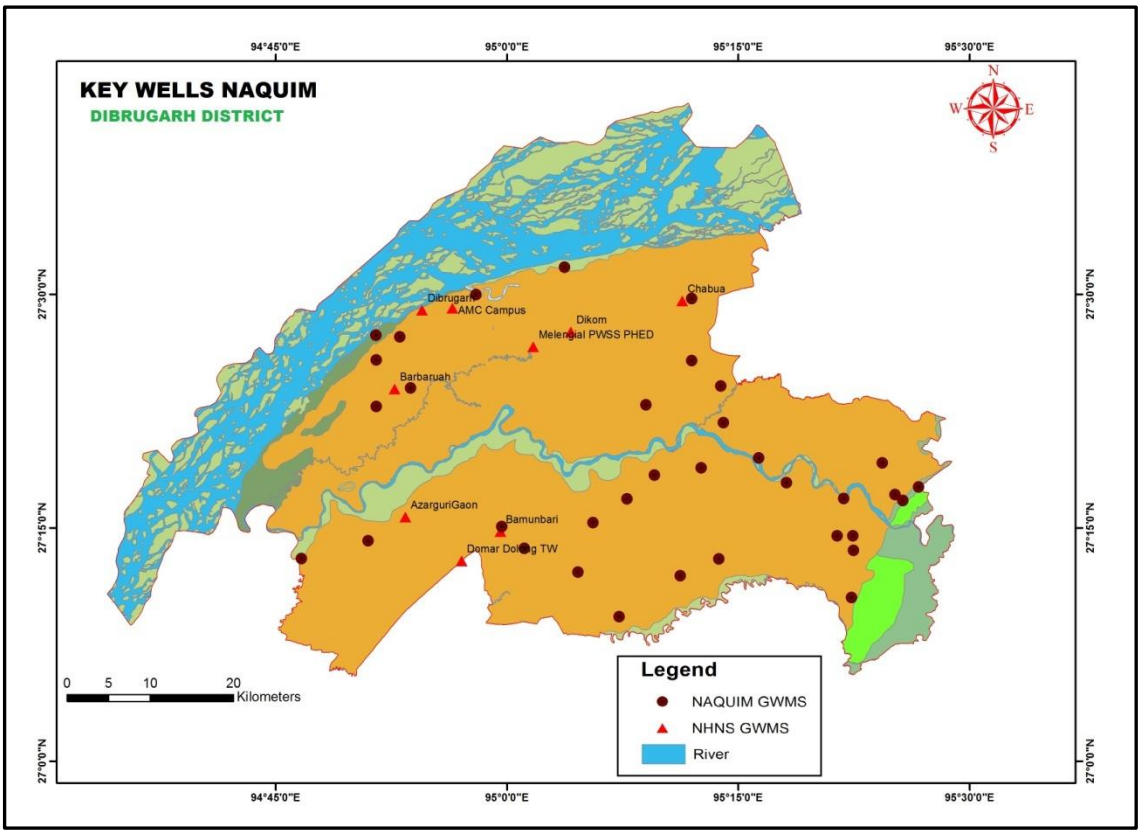

Figure 12: NAQUIM key wells (GWMS) map of Dibrugarh district

CHAPTER 3

Data Interpretation

3.1.1Geophysical Exploration and Aquifer Characterization –

Geophysical studies have not yet been conducted in Dibrugarh district. To unearth the subsurface information systematic geophysical studies such as vertical electric sounding (VES), transient electromagnetic (TEM) survey to be conducted by CGWB.

3.1.2 Aquifer disposition:

Dibrugarh district is a valley plain underlain by unconsolidated alluvial sediments deposited over a semi-consolidated tertiary group of rocks. Naga-Patkai hills which are present in the east and southeastern part of the study area act as a recharge zone for the study area.

CGWB has constructed 8 exploratory wells in Dibrugarh and major portion of wells are in younger alluvial formation. Based on the litholog major aquifers and their extent have been delineated. Clay, sand, clayey sand and gravels are the main constituents of sub-surface sediments. Mono –aquifer to semi confined system has been observed in the western part of the district in the quaternary alluvium formation.

Following sections are constructed to show the 2D disposition of the aquifer:

Northwest to southeast section: from alluvial plain on the southern bank of Brahmaputra to piedmont zone.

Mono-aquifer system is observed in northwestern part near to southern bank of Brahmaputra (AMC &Melengial exploratory well). Thickness of sand is more than 100m in the deeper aquifers. Towards the southeastern part at Pandhoagaon two aquifer systems has been observed separated by clay lens. Thickness of clay increases below the depth of 130m. Presence of boulder ranging in size from pebble to cobble has been observed at Dirialgaon near topeidmont zone at a depth of 128 m. The northwest to south east section is depicted in figure13.

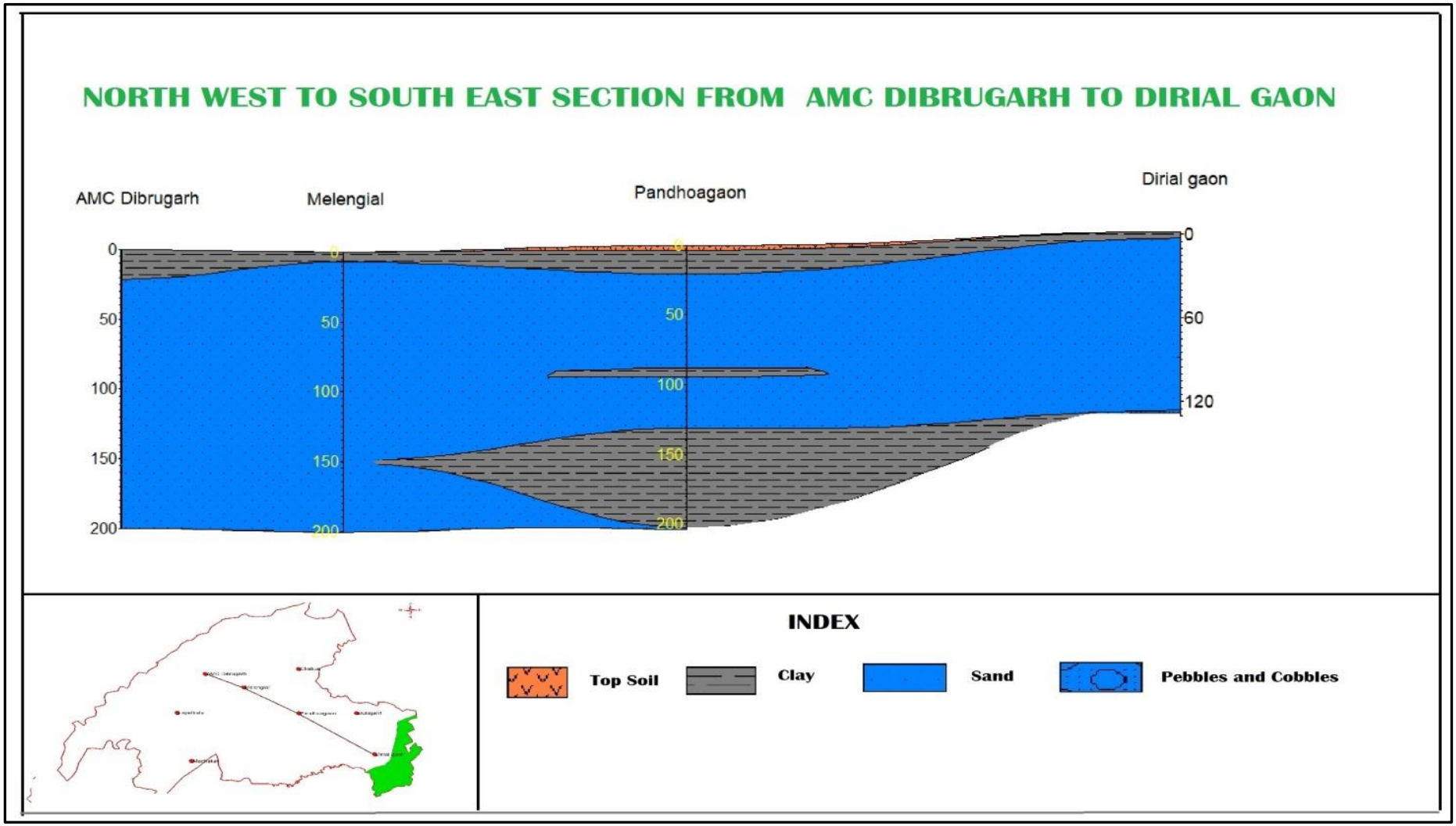

Figure 13: 2D section showing Aquifer disposition along Northwest to Southeast in Dibrugarh district.

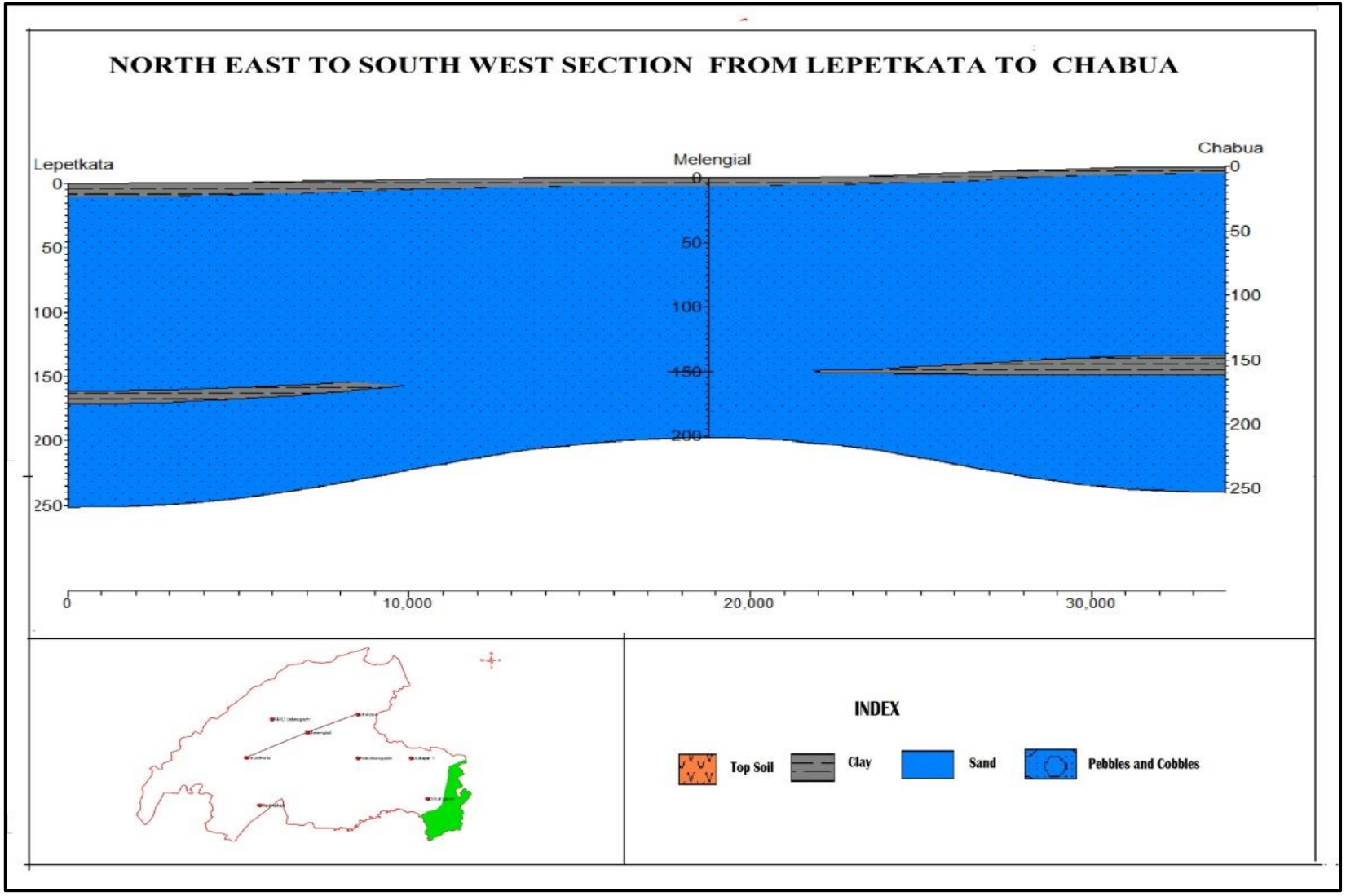

Figure 14:2D section showing Aquifer disposition along Northeast to Southwest in Dibrugarh district

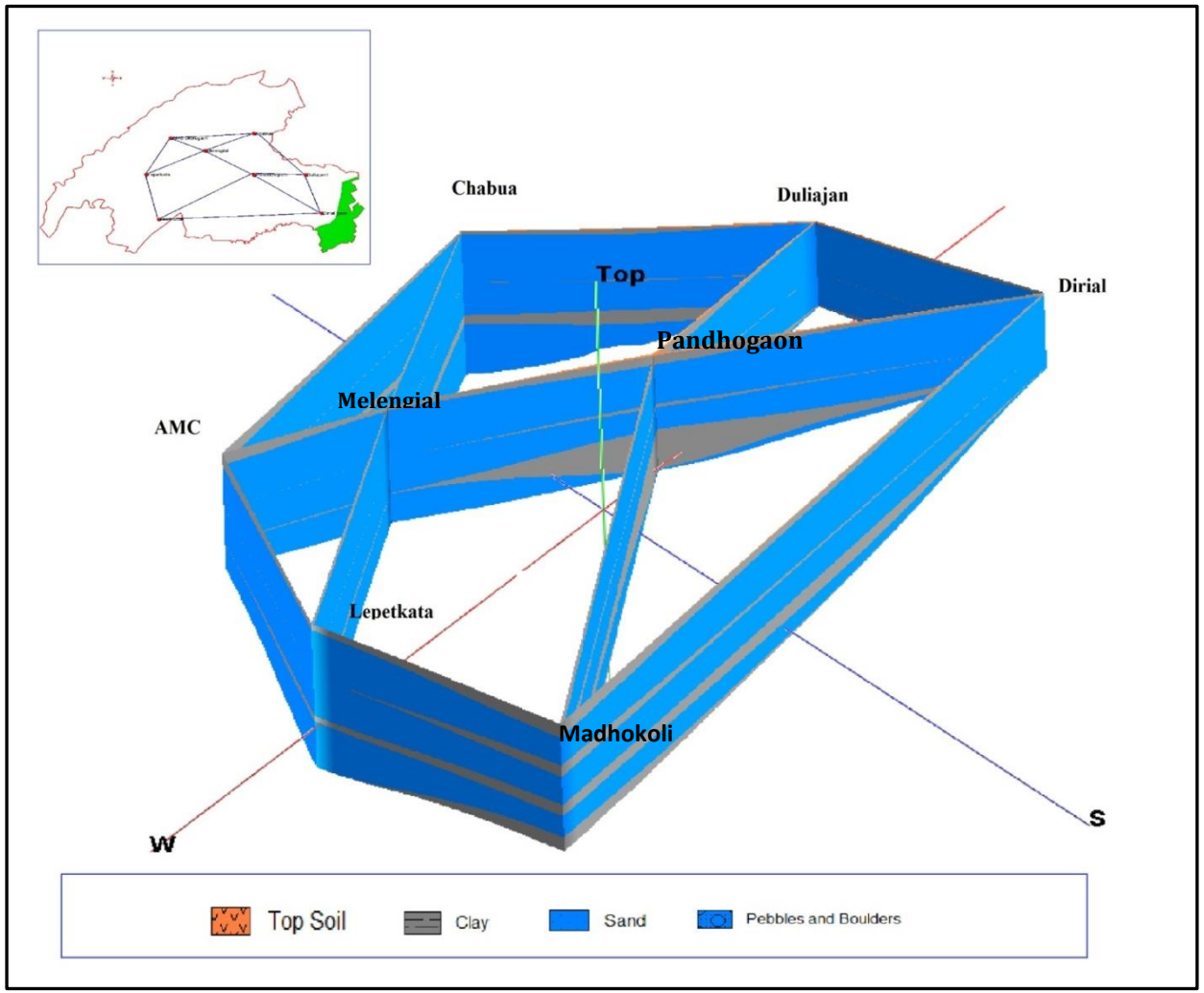

Fig 15: Fence diagram of aquifer disposition along Dibrugarh district

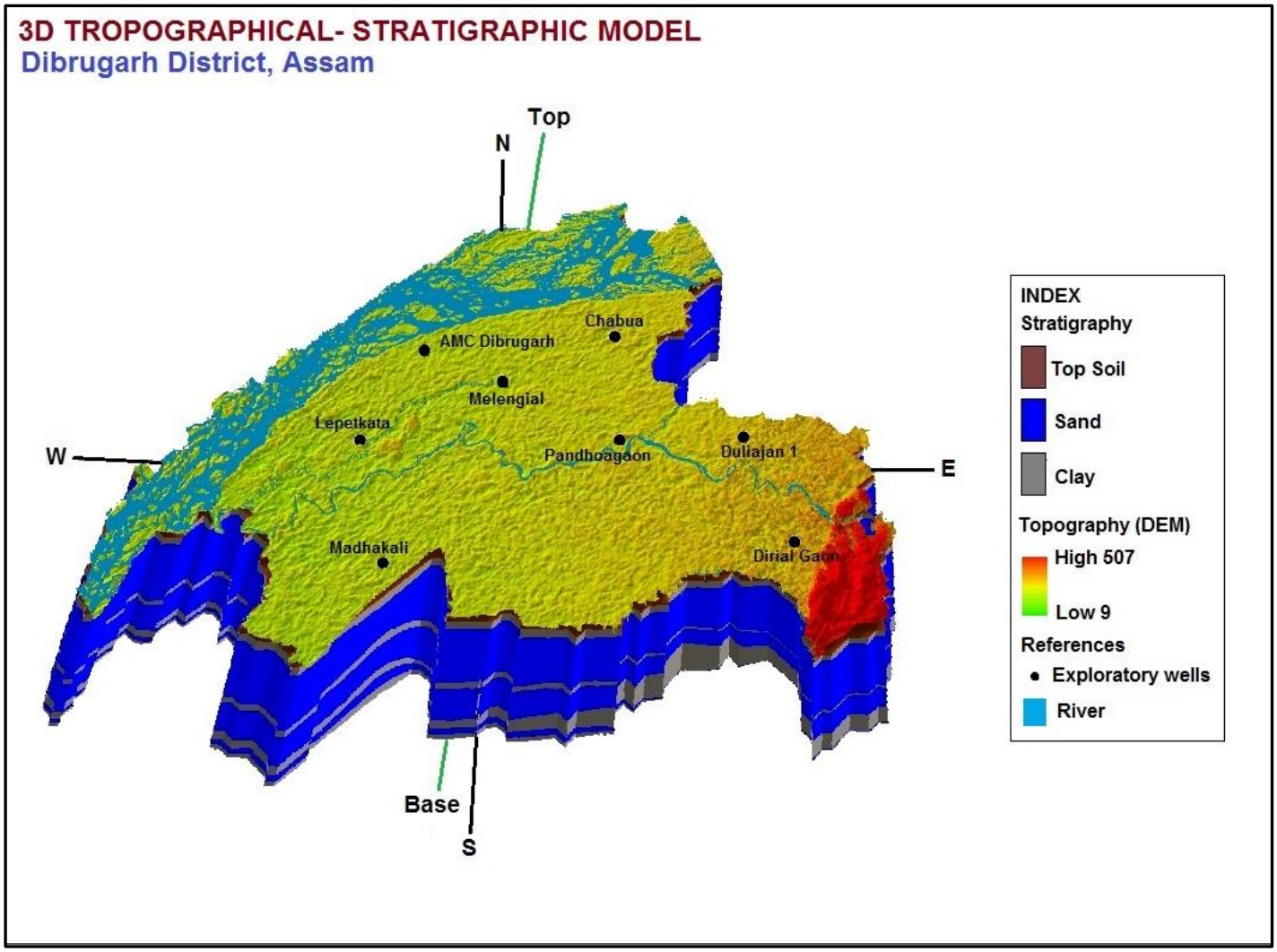

Figure 15:3D topographical-stratigaphical model of Dibrugarh district.

Northeast to Southwest section: This section is in younger alluvial formation and parallel to south bank of Brahmaputra river. The aquifer system is mainly mono-aquifer and semi - confined. Thickness of alluvium is estimated to be more than 100 m. Aquifer material is mainly sand dominated separated by clay lenses. Thickness of clay zone increases towards south (thickness of top clay layer in Madhokoli area is 25m). Multiple aquifer system is encountered in the southern part of the district separated by thick clay partings.

3.1.3 Aquifer Characteristics

Based on available hydrogeological data the granular zones in Dibrugarh district has been classified into (a) shallow aquifer zones to a depth of 50 mbgl and (b) Deeper aquifer zones between 50 to 200 mbgl.

Shallow Aquifer **:**Mono-aquifer system has been observed in most part of the district overlain by top clay layer. Thickness of aquifer is 15m to 45 m. Ground water occurs in unconfined to semi-confined condition in shallow aquifer zone. Thickness of top clay layer decreases towards west and north. In the piedmont zone the aquifer thickness is around 25 m and is confined at the top and bottom by clay layers of 5m and 25 m. Based on available information of shallow tubewells (depth 45m)under PMKSY scheme, an average discharge of 25-30 m^3/hr for a drawdown of 3m has been observed.

Deeper aquifer: Cumulative thickness of deeper aquifer is more than 200m. Based on the available litholog it has been observed that mono-aquifer system is in continuation in north and northwest along the old flood plain zone of Brahmaputra. Towards the southern part of Dibrugarh the single aquifer system is separated into multiple aquifer system by clay partings. At Dirialgaon well Tertiary semi consolidated bedrock is encountered at a depth of 128m bgl. Transmissivity values ranges from 6526m^2/day to 10350 m^2/day . The yield of well varies from 49 m^3/hr to 167 m^3/hr for drawdown of 1.6m to 3.3 m. Thickness of aquifer increases from east to west of the study area.

Table 12: Aquifer characteristics of exploratory wells and piezometer

Location	Depth of Drilled	Granular zones	Static Water level	Discharge	Draw Down	Transmissivity	Specific Capacity	Storage co-efficient (S)
	(mbgl)		(mbgl)	(m3/hr)	(m)	(m2/ day)	(lpm/m)	(lpm/m)
Tiloi-PZ	53.51	41.72-47.84	2.95	8.28	-	-	-	-
Hatiali-PZ	53.51	42.5-48.5	3.44	19.8	-	-	-	-
Pandhowa-PZ	53.51	41-47	3.1	20.0	-	-	-	-
Dirialgaon-PZ	48.46	10.00-14.00	1.82	6.00	-	-	-	-
Chaykyagaon (Namrup)-EW	41.95	26-38	9.4	378.5		-	-	-
Chabua-EW	253.06	41-53, 65-77, 97-115, 139-145	1.06	164.87	3	10350	915.94	-
Lepetkata (Benaigutia)-EW	251.70	44-50,67-79,90-102, 128-134, 142-148	3.9	162	3.39	6526.57	798.28	2.57*10-3
Madhakali-EW	222.22	35-66,101-110	4.1	164.87	3.6	7313.02	798.08	-
Dirialgaon-EW	129.30	56-68, 80-96,110-113, 122-125	3.25		-	-	-	-
Tiloi-PZ	53.51	41.72-47.84	2.95	8.28	-	-	-	-

Hatiali-PZ	53.51	42.5-48.5	3.44	19.8	-	-	-	-
Tengakhat (Pandhowa) -EW	204.10	52-64, 73-82,100-109, 118-127	3.15	81.72	-	-	-	
Pandhowa-PZ	53.51	41-47	3.1	20.0	-	-	-	-
Dirialgaon-PZ	48.46	10.00-14.00	1.82	6.00	-	-	-	
Chaykyagaon (Namrup)-EW	41.95	26-38	9.4	378.5	-	-	-	
Medical College	200.00	43 – 49 ,66 – 72,78 – 84,90 – 96 ,106 – 118	0.55	49.00	1.61	8234	-	1.162×10^{-2}
Melengial-EW	201.00	42-54,72-84,90-102, 114-126	3.84	55.18	0.71	8703.7		4.89*10-2
Melengial (PWSS)-OW	131.25	50-54, 80-84,96-100,120-124	3.48		0.61			NA

3.2 Ground water level of Shallow Aquifer zone:

CGWB has established 08 no of groundwater monitoring stations in the district but on the field year only 7 wells are in in condition to be monitored. During AAP 2021-22 as a part of NAQUIM 32 key wells were established to monitor pre and post monsoon ground water level in phreatic aquifer. Water level of NHNS wells are summarized in table 3.2. Details of key wells , pre and post monsoon data along with seasonal fluctuations is attached in Annexure (I).

Table 13: Pre & Post Monsoon DTWL and fluctuation data of NHNS monitored wells.

NHNS well	Pre monsoon DTWL(mbgl)	Post monsoon DTWL(mbgl)	Fluctuation
AMC Campus	3.06	2.4	0.7
Azargurigaon	3.84	3.1	0.8
Barbaruah	4.86	3.8	1.1
Chabua	5.42	4.2	1.2
Dikom	4.86	4.0	0.9
DomarDolong Tw	3.22	2.7	0.5
Melengial PWSS	3.34	2.9	0.5

Based on the pre & post monsoon depth to water level data collected from monitoring of the key wells, DTWL maps have been drawn and shown in Fig 3.4,3.5

In the pre monsoon season, the depth to water level in the study area ranges between 2.1 m bgl to 4.8 m bgl. Lahoal and Panitola blocks falls under Sessa basin and depth to water level in most of the area is around 4-5 mbgl. Pre-monsoon depth to water level around tengakhat block which falls under Burhidihing basin shows a depth to water level of 3-4 mbgl and in few pockets near the flood plain of Burhi –Dihing water level is 2-3 mbgl.

In south eastern part of the district the water level in the piedmont zone is between 3-4 mbgl and in areas near Disang river water level is 2-4 mbgl. In semiconsolidated formation at Dilli – Bagan water level of 9 m bgl has been observed . In north eastern

part of the district near Brahmaputra river depth to water level of 2-3 m bgl is observed in jamira ,Gohaingaon , Kunarinichiga.

In the post monsoon season, the depth to water level in the study area ranges between 0.98 m bgl to 3.9 m bgl. Area around Dibrugarh town adjacent toBrhampautra flood plain has water level below 2 mbgl. Towards the south eastern part near the piedmont zone water level is within 2-3 mbgl area around Bhadoipanchali and Duliajan near dihing river shows depth to water level of below 2 mbgl. Few sporadic areas at Dikom, chabua and Panitola shows depth to water > 3 mbgl. Post monsoon water level in major part of the distict is within 2-3 mbgl.

Seasonal water level fluctuation in major part of the district is within 0-1 m . In most parts of Borboruah,Khowang, Tingkhong block seasonal fluctuation is 0-1 m . In Joypur block area adjacent to piedmont zone shows fluctuation of 1-2 m. Areas near north eastern part of the district in Dikom, Panitola, lahoal, Chabua shows seasonal fluctuation of 1-2m.

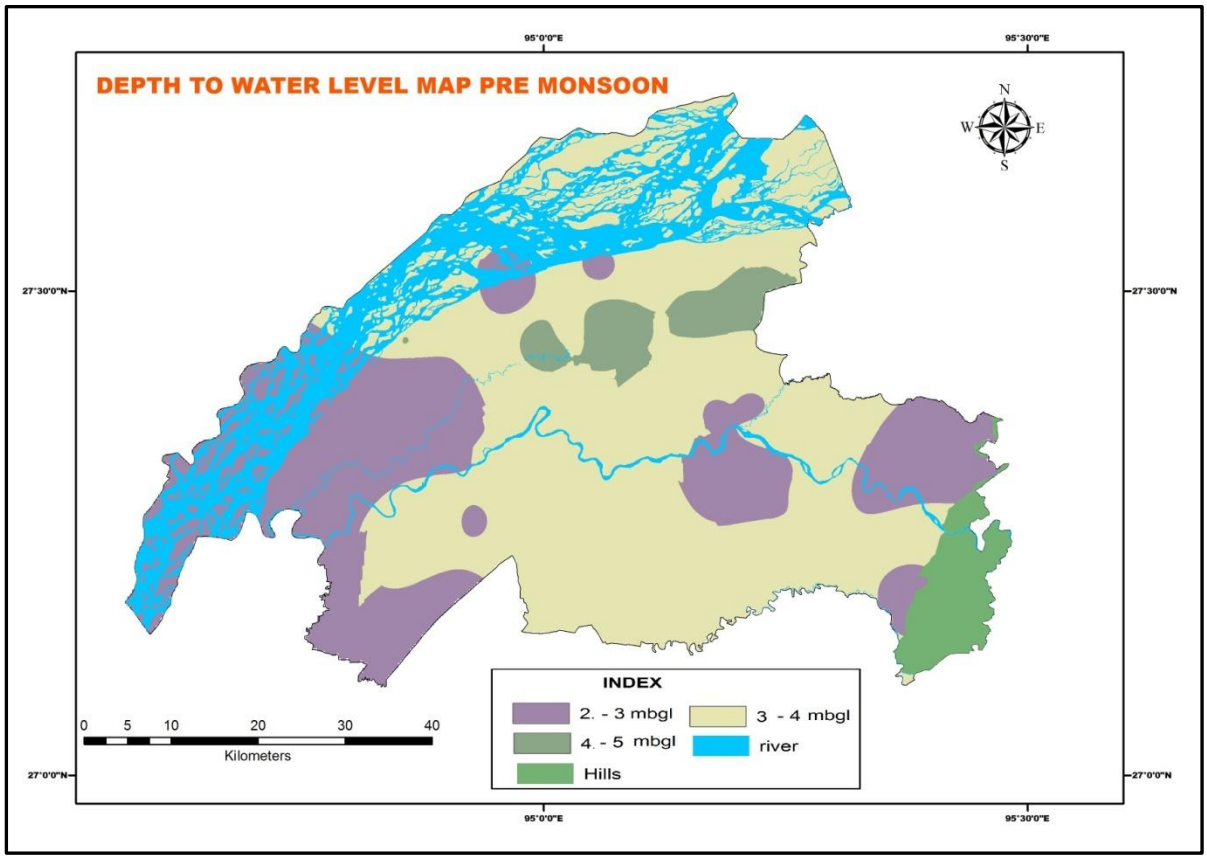

Figure 16: - Pre monsoon DTWL map of Dibrugarh district.

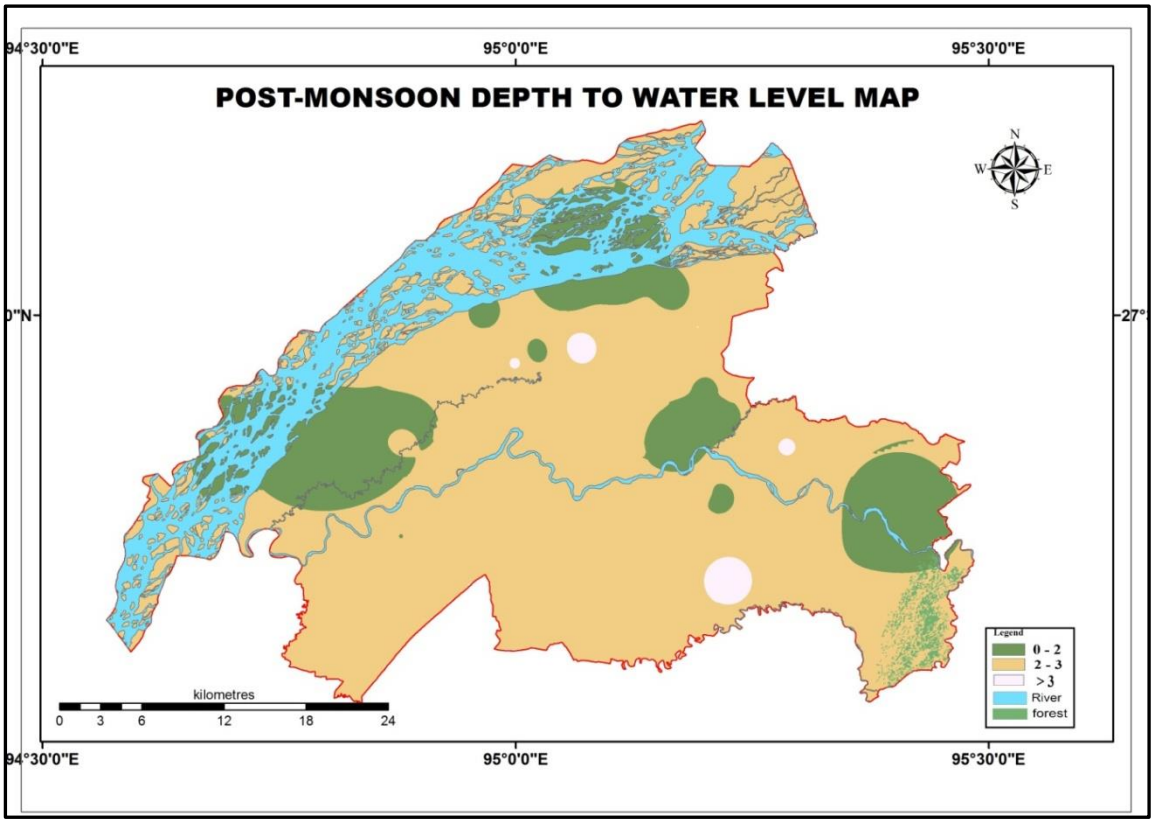

Figure 17: Post monsoon DTWL map of Dibrugarh district.

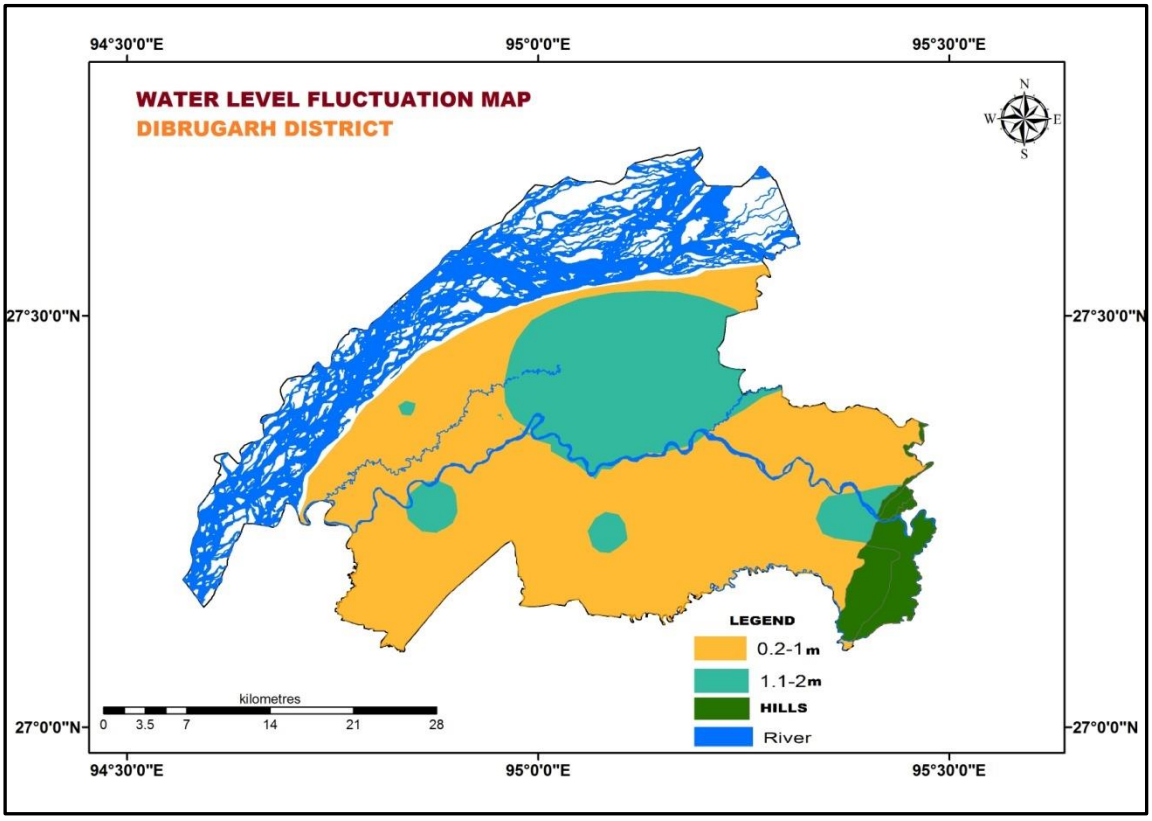

Figure 18: Water level fluctuation map of Dibrugarh district.

3.3 Ground Water Movement

The water table contour has been prepared based on the water level of ground water monitoring stations with respect to its elevation above mean sea level. Regional ground water flow conforms to the general elevation of the district gently sloping towards the west. The contour ranges in elevation from 120 m in south west to 105m towards west. In general groundwater movement is towards west i.e towards river Brahmaputra.

The hydraulic gradient is varies between 0.33 m/Km to 0.55 m/Km.

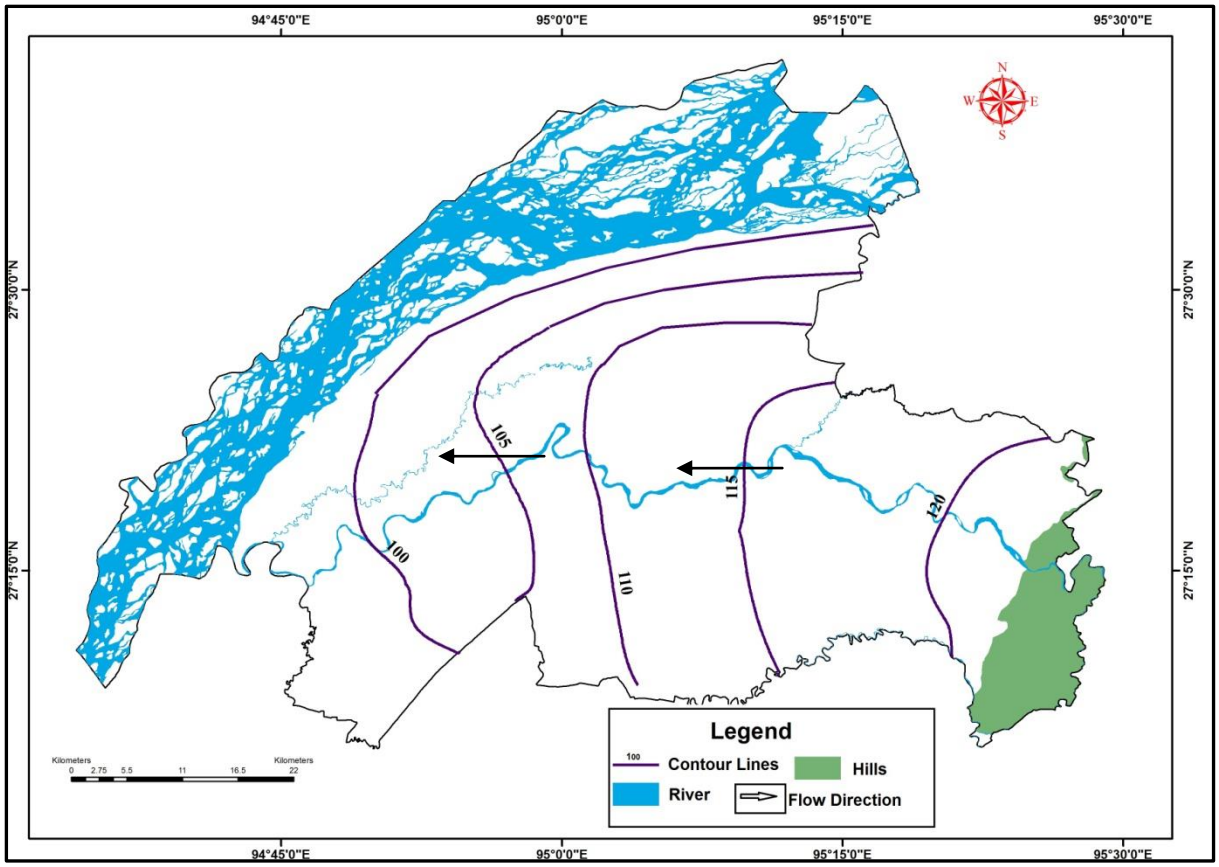

Figure 19: Water table contour map of Dibrugarh district

3.5 Ground water quality

Ground water samples were collected during pre and post monsoon field season .A total of 38 samples were collected during post monsoon period and 28 samples were collected during pre-monsoon period. Chemical analysis of ground water samples is carried out by regional chemical laboratory of Central Ground Water Board, North Eastern Region, Guwahati. Samples were analyzed for the parameters like pH, EC, Turbidity, TDS, CO3, Cl, SO4, Na, K, HCO3, NO3, F, Ca, Mg, As and Fe. Chemical analysis of groundwater samples for pre and post monsoon are summarized in Annexure III and IV.

pH:

pH is an important parameter in evaluating the acid–base balance of water. It is also the indicator of acidic or alkaline condition of water status. WHO has recommended maximum permissible limit of pH from 6.5 to 8.5. Values of pH range of water samples collected range from 6.82-8.45(pre-monsoon) and 7.2-8.5 (post-monsoon) .The overall value indicate that water from study area is within the suitable and desired range.

Electrical Conductivity(EC):

Generally, the amount of dissolved solids in water determines the electrical conductivity. Electrical conductivity (EC) actually measures the ionic process of a solution that enables it to transmit current. According to WHO standards, EC value should not exceeded 400 µS/cm. The current investigation indicated that EC value range from 60-591.10 µS/cm with an average value of 239 µS/cm. 90% of samples falls within the permissible limit. These results clearly indicate that in the study area indicate few samples were considerably ionized and higher ionic concentration activity.

Total Dissolved Solids(TDS):

According to BIS specification TDS up to 500 mg/l is the highest desirable and up to 2000 mg/l is maximum permissible. In the study area the TDS value varies between a minimum of 40.04 mg/l and a maximum of 390.13 mg/l, indicating that most of the groundwater samples lies within the maximum required acceptance limit.

Calcium and magnesium (Ca and Mg):

Calcium and magnesium are the most abundant elements in the natural surface and groundwater and exist mainly as bicarbonates and to a lesser degree in the form of sulfate and chloride. Ca^{2+} concentrations are varying from 4 to 58.05 mg/l . The desirable limit of calcium concentration for drinking water is specified as 75 mg/l (BIS,2012) which shows that all groundwater samples fall within the permissible limit.

Magnesium content is varying from 2.42 to 72.80 mg/l. The maximum permissible limit of Mg^{2+} concentration of drinking water is specified as 100 mg/l (BIS.2012) .All the samples are within the maximum permissible limit.

Iron (Fe):

Iron dissolved in groundwater is in the reduced iron,ferrous ions (Fe^{++}) form. This form is soluble and normally does not cause any problems by itself. Iron II is oxidized to iron III (ferric ion, Fe^{+++})on contact with oxygen in the air or by the action of iron related bacteria. Iron III forms insoluble hydroxides in water. The acceptable limit of iron(Fe) 0.3mg/l(BIS standard,2012).Iron content in ground water samples ranges from 0.04-17.60 mg/l in post monsoon and 0.35 to 26.504 mg/l in pre-monsoon. All the pre monsoon samples are above the acceptable limit and 85% of samples collected during post-monsoon are above acceptable limit.

3.5.1 :Hydrogeochemicalfacies:

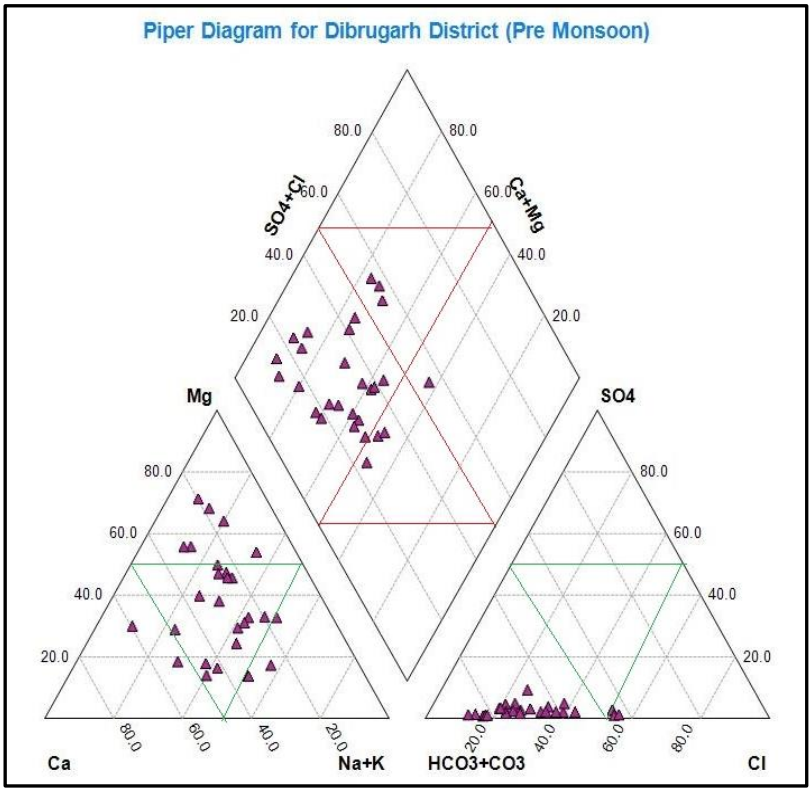

Figure 20: Piper plot of pre-monsoon groundwater samples.

A piper diagram was created for ground water samples analysed during pre and post – monsoon period. Based on plotting of data on piper plot it has been observed that during pre-monsoon period there are four water types (fig 21). Majority of the samples (72%) are plotted in Ca-HCO3 type . 14% in Ca-Mg-Cl type field and rest in Ca-Na-HCO3 type field. Alkaline earth and weak acid (CaMgHCO3) type are the domimantfacies.

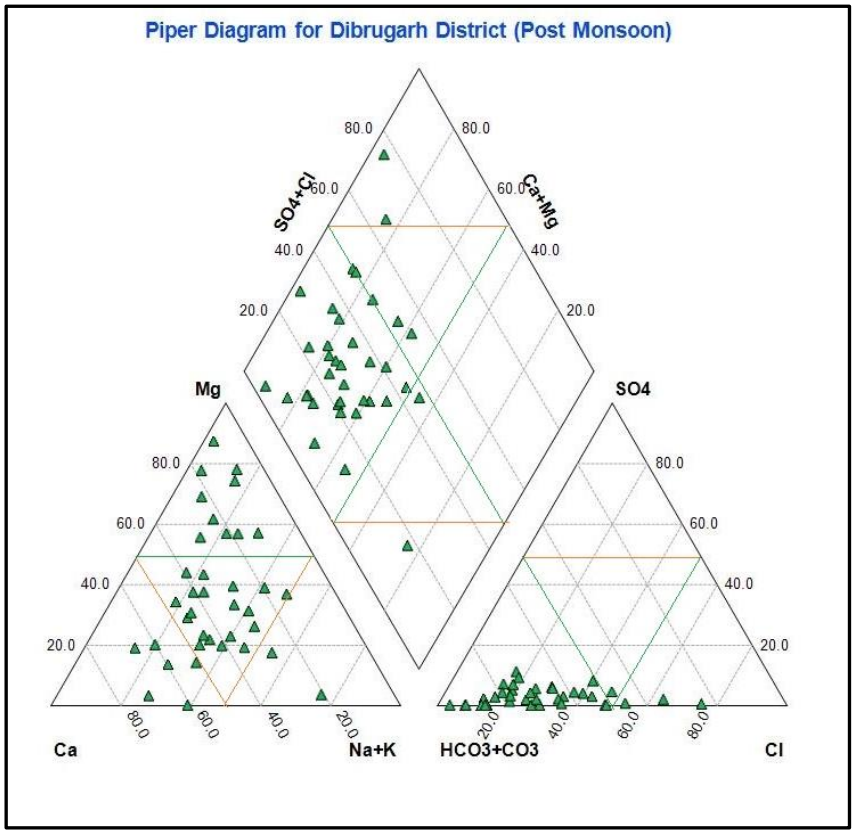

Figure 21: Piper plot of post-monsoon groundwater samples

In post monsoon sample majority of the sample belongs to Ca^{2+}- Mg^{2+}-HCO^{3-} type facies(fig:22). About 52% of sample falls in no dominant type in cation field and almost 92% of sample falls in bicarbonate type in anion triangle.

3.5.2 Irrigation water suitability Indices:

Sodium Percent (Na%)

The sodium in irrigation waters is usually denoted as percent of sodium. Na% is a common parameter to assess its suitability for irrigational purposes. The sodium percent (Na%) values was obtained by using the following equation:

Na%=Na+×100/[Ca2++Mg2++Na++K+]Na%=Na+×100/[Ca2++Mg2++Na++K+]

whereall ionic concentrations are expressed in meq/l. Based on analysis of percent and total concentration shows that 83 % of the groundwater samples fall in the field of good category and 17% of groundwater samples falls in permissible for irrigation category.

Sodium Adsorption Ratio:

Sodium adsorption ratio (SAR) is a measure of the suitability of water for use in agricultural irrigation, because sodium concentration can reduce the soil permeability and soil structure (Todd 1980). SAR is a measure of alkali/sodium hazard to crops and it was estimated by the following formula:

$$SAR=Na/\ [(Ca+Mg)/2]^{0.5}$$

The calculated values of SAR in the study area vary between 0.08 and 2.83. The SAR values of all the samples are found within the range of excellent. The water is suitable for irrigation.

Permeability index:

Based on the permeability index (PI), a water suitability classification for irrigation water was. The PI was calculated by the following equation:

$$PI= [Na+(HCO3)^{0.5}]\times100/[Na+Ca+Mg]$$

where all the ions are expressed in meq/l. The PI values in the study area vary from 33%to 145%considering both pre and post monsoon samples together. A classification based on PI was proposed by World Health Organization for assessing suitability of groundwater for irrigation purpose. According to the permeability index values, 53 % of the samples falls under suitable category (25 - 75 %) and 47 % under good category (PI >75%).

Magnesium Hazard :

Calcium and magnesium maintains equilibrium in water. High magnesium hazard (>50) leads to soil alkalinity resulting in declining crop yield.

$$\text{Magnesium ratio}= Mg^{2+}+\times100/\ (Ca^{2+}+Mg^{2+})$$

In the study area the magnesium hazard values falls in the range of 4 to 91 % (In the study area, 48 % of the samples collected showed MH ratio <50 % (suitable for irrigation) while 52 % falls in the unsuitable category with magnesium hazard >50 %.

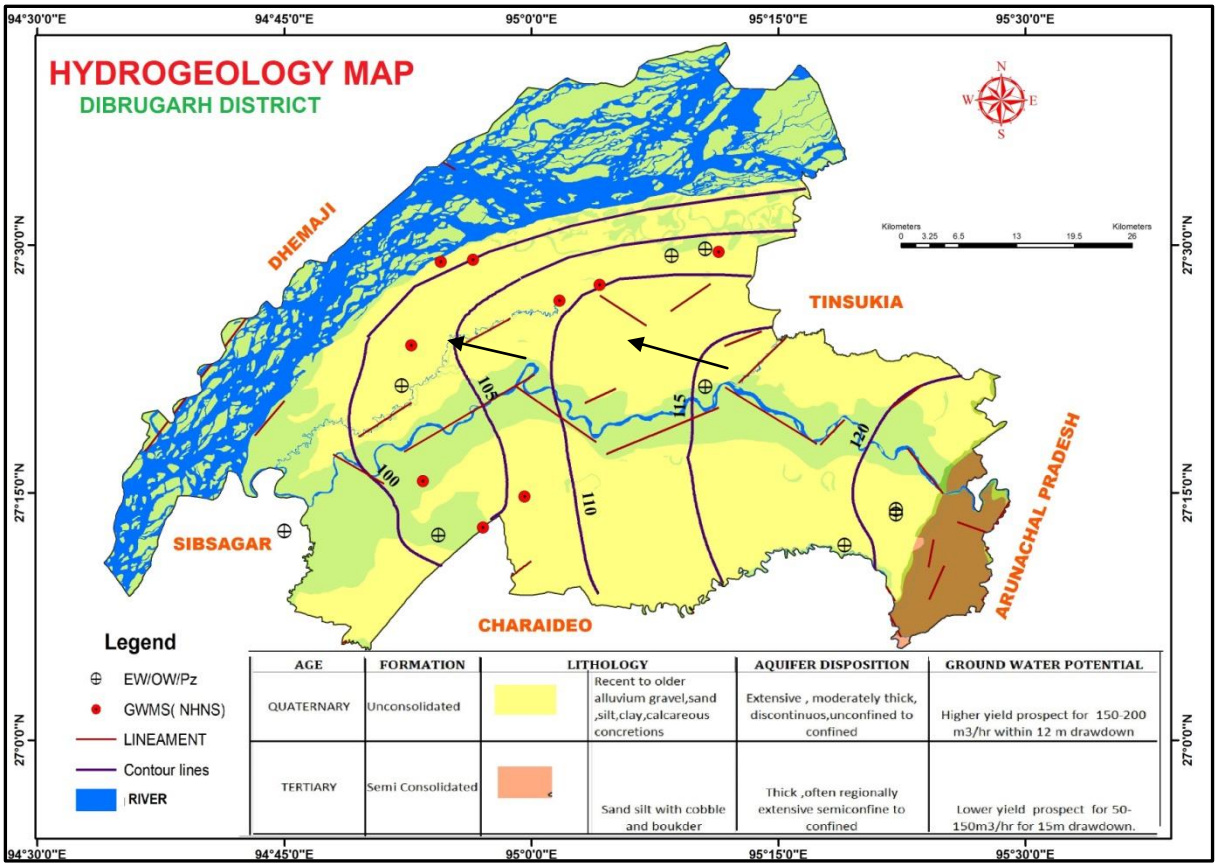

Figure 22: Hydrogeological map of Dibrugarh district.

CHAPTER-4

GROUNDWATER RESOURCE

The computation of ground water resources available in the district has been carried out using GEC 2015 methodology. The assessment unit in the present assessment is district due to paucity of block-wise data. The summarised result is presented in Table 4.1.

Data and assumptions used in the assessment: Following data and assumptions are used in the assessment:

1) Rainfall recharge has been computed by RIF method. In RIF method, rainfall infiltration factor has been taken as 0.22 for major aquifer like valley fill.

2) Last ten years rainfall data is considered for groundwater resource calculation.

3) Water level data has been considered for 2021-22. Water level fluctuation based on data of March (Pre monsoon) and November (post monsoon) has been considered since deepest water levels are recorded during the month of March.

The average pre- and post-monsoon water level of district is 3.76 mbgl and 3.44 mbgl.

4) The population figures were collected from Census, 2011and projected to 2020. The per capita domestic requirement for the rural population has been considered as 60 lpcd and for urban population, it is 135 lpcd.

5) The dependency on ground water resource for domestic and industrial water supply in rural areas is considered as 91% and for urban areas, the dependency is 79%.

6) The command area of the district is 72767 ha as per data provided by the Irrigation Department, Govt. of Assam.

7) In order to calculate the canal seepage, the data on length of the drainage channels are taken from the Irrigation Department, Govt. of Assam. The factor for return flow from surface water irrigation has been taken as 0.50 (paddy) and 0.30 (non-paddy) and for Ground water irrigation it has been taken as 0.45 (paddy) and 0.25 (non-paddy). Recharge from tanks and ponds are calculated based on the norms suggested in GEC'2015.

8) Recharge from water conservation structure has been taken as nil.

4.1 Recharge

The aquifers of the study area are recharged through a) infiltration of rainfall on the outcrop b) seepage from the tanks and ponds c) subsurface inflow across the up dip

margin. The area experiences south-east monsoon. Monsoon rainfall contributes approximately 81 percent of total rainfall (May, June, July, August, September) while share of post and pre monsoon rainfall are approximately 13 and 6 percent each.

The rainfall recharge in the command area is 117809 ham while recharge from other sources is 2114.55 ham. Total ground water recharge is 119923.5ham.

4.2 Ground Water Extraction

The ground water extraction of unconsolidated aquifer is created by natural discharge like seepages and draft created by human interference, viz., (a) withdrawals for irrigation and industry and (b) public-supply wells.

In the district natural discharge is 13241.25ham of the total groundwater recharge. Total irrigation extraction is 4890.48ham, for industry 32.028ham and extraction for domestic uses is 2863.50 ham. Total groundwater extraction for all uses is only 7786.09 ham.

4.3 Allocation of resources up to 2025

The net ground water resource allocated for domestic sector is 3088.53 ham while 96643.34 ham resource is available for future use.

4.4 Stage of Ground Water Extraction

The area has very little irrigation facilities. Similarly industrial development in the area is practically less. Groundwater is mainly utilized for domestic purposes. The stage of groundwater extraction in the district is 7.44%

There is no major or medium canal irrigation scheme and thus the whole Dibrugarh district has been considered as a non-command area.

Table 14: Net ground water availability (ham)

Monsoon recharge	Non-monsoon Recharge	Total annual ground water recharge	Environmental Flow (ham)	Annual Extractable GW Resources
83786.19	29908.06	132412.60	13241.25	104654.54

Table 15: Categorization of ground water resources (ham)

Annual Extractable GW Resources	Annual GW extraction				Allocation for Domestic use up to 2025	Annual GW Allocation for for Domestic Use as on 2025 (Ham)	Stage of ground water extraction (%)
	Irrigation	Domestic extraction	Industrial extraction	Total			
104654.42	4890.48	2863.49	32.082	4629.88	7786.05	3088.53	7.44

Groundwater Recharge

Recharge from Rainfall has been computed separately for monsoon and non-monsoon periods for the entire district. The recharge from rainfall during monsoon season has not been computed using water level fluctuation method (WLFM) as Ground Water Monitoring Wells (GWMW) in the district is very few.

Recharge from All Sources: Total recharge to groundwater has several components, rainfall being the major one. The other components include seepage from canals, return flow from surface water irrigation, return flow from groundwater irrigation, seepage from tanks/ ponds etc. Recharge from various sources has been calculated for monsoon as well as non-monsoon periods and details have been shown in table 4.3

Table 16: Recharge from various sources (ham).

District	Recharge from Rainfall during monsoon season	Recharge from rainfall during non-monsoon season	Recharge from other sources during non-monsoon Season	Total Annual Ground Water Recharge	Annual Extractable GW Resources
Dibrugarh	82471.54	47826.51	799.9	89992	132412.6

Recharge from rainfall in the district is 130298 ham. Comparison of monsoon & non-monsoon rainfall recharge shows that monsoon recharge accounts for 63 %. Recharge from other sources is 2114.55 ham. Comparison of recharge from rainfall, to recharge from sources other than rainfall shows that the later accounts for only about 0.01 % of the total recharge.

Domestic Extraction

Groundwater extraction for domestic use has been estimated on projected population for 2025, based 2011 Census data of number of households using

groundwater as “Main source of drinking water”. Groundwater extraction for irrigation is 2548 whereas for domestic and industrial supply it is 4437 ham in the district. Hence, groundwater extraction for all uses in the district is 6985 ham. Provision for domestic and industrial requirement supply to 2025 is 4611 ham.Net Ground Water Availability for future development in the district is 85488 ham.

Stage of Groundwater Development &Categorization of theBlocks

The stage of Ground Water development is defined as the ratio between the existing gross ground water drafts for all uses by net annual ground water availability multiplied by 100. The various units of assessment are categorized based on the stages of Ground Water development and long term trend of pre and post monsoon water level. The stage of ground water development forDibrugarh district is 7.44%. Based on the stages and development and long-term water level trend analysis the district can be categorized under **safe** category.

Static resource:

District administrative boundary has been considered as the assessment unit due to paucity of block-wise data. Hilly areas having slope more than 20% are deleted from the total area to get the area suitable for recharge. The average thickness of saturated unconfined aquifer below ground level as obtained from dug wells / bore wells in the district has been considered.

The Pre-monsoon (month of March) Water Level from Monitoring Wells of CGWB in Dibrugarh district has been considered as the maximum depth below ground level up to which the zone of water level fluctuation occurs. Since the north eastern states receives pre-monsoon showers, which commences from the first week of April, resulting in rise in water levels in the phreatic zones, the deepest water levels are recorded during the month of March. Specific yield value of 0.12 is considered for the district.

(e) Finally the Static Ground Water Resource is computed from the data as obtained:

$$Y = A^* (Z_1 - Z_2)^* Sy$$

Where, Y = Static ground water resources,

A = Area of ground water assessment unit

Z_1 = Thickness of saturated unconfined aquifer below ground level

Z_2 = Pre-monsoon water level

Sy = Specific yield of the unconfined aquifer

Table 17: Salient information of static resource of Dibrugarh district, Assam

Type of rock formation	Alluvium
Total Geographical Area (Ha)	338100
Assessment Area (Ha)	334688
Bottom of the unconfined aquifer (m)	50
Average Pre- monsoon Water Level (m)	3.5
Thickness of the saturated zone of the un-confined aquifer below WLF zone (m) [(5)-(6)]	46.5
Volume of Saturated zone of the unconfined aquifer below WLF zone (ham)	15562992

Static/In-storage Ground Water Resources (ham): **Volume of saturated zone X specific yield**

15562992*0.12=1867559.04 Ham.

CHAPTER 5.

Ground Water Related Issues

The main groundwater issues in the study area include areas vulnerable to water logging as well as prone to water logging conditions along with high Iron concentration in ground water above the WHO permissible limit.

5.1 Low stage of ground water development:

As per ground water resource estimation 2020, the stage of ground water extraction is just 7.44 % .Due to lack of irrigation vast tract of agriculture land remain fallow. Therefore, there is enough scope for future development of ground water in the study area to bring more area under irrigation practice. Irrigation scheme has been developed under PMKSY-HKKP scheme.

5.2 High Iron Concentration:

Quality analysis of groundwater samples collected from dug wells and tubewellsduring pre and post monsoon shows presence of high iron(Fe) concentration above permissible limit (>0.3mg/l) (fig 25) as per BIS IS 10500:2012 drinking water standard. Iron concentration is high towards southern , north western and south eastern part of the district mainly in Tengakhat and Naharkatiya block. As per analysis very high value iron concentration (26.5 mg/l) is observed in 2no.Mohmari tubewell sample.

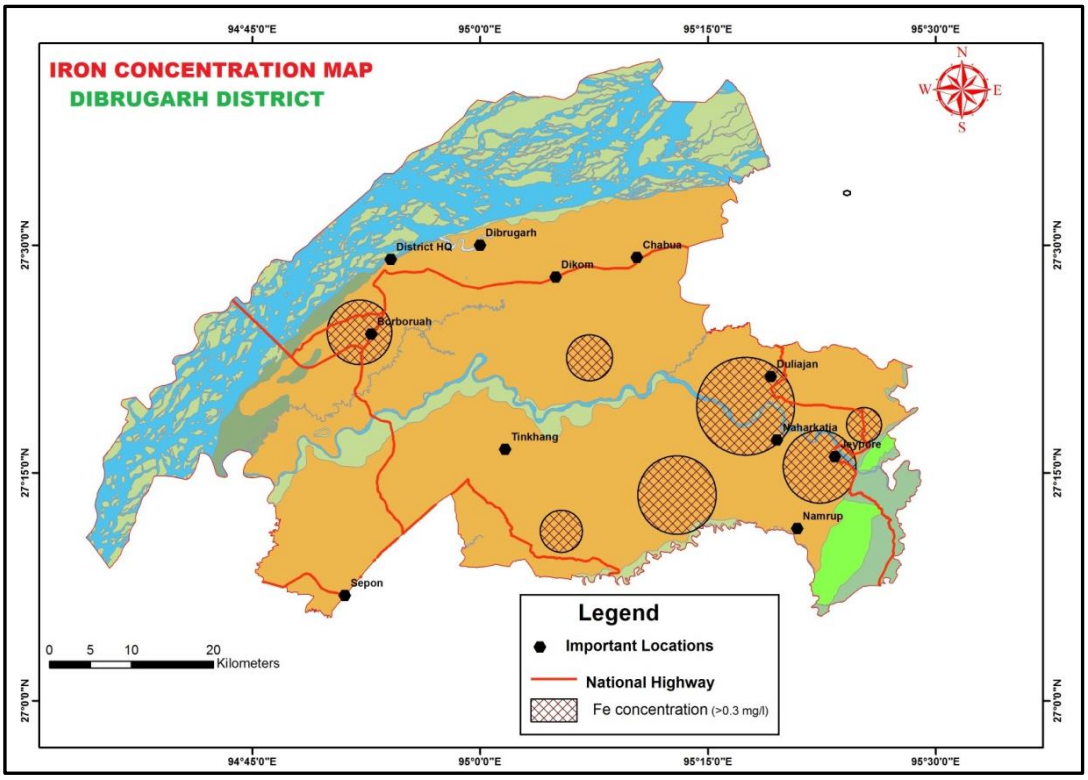

Figure 23:Iron Concentration map (>0.3 mg/l) map of Dibrugarh District.

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5.3 Water logging :

Water logged area is mainly observed in the flood plain zone of Brahmaputra,Dihing and Sessa river. Depth to ground water level in this areas is below 2 mbgl. In the south western part of the district in Tengakhat block the alluvium cover in the area is mainly clayey in nature which prevents the water to percolate downward. High rainfall and low stage of ground water development also results in water logging in the area. Such area has pre monsoon depth to water level of 2-3m.

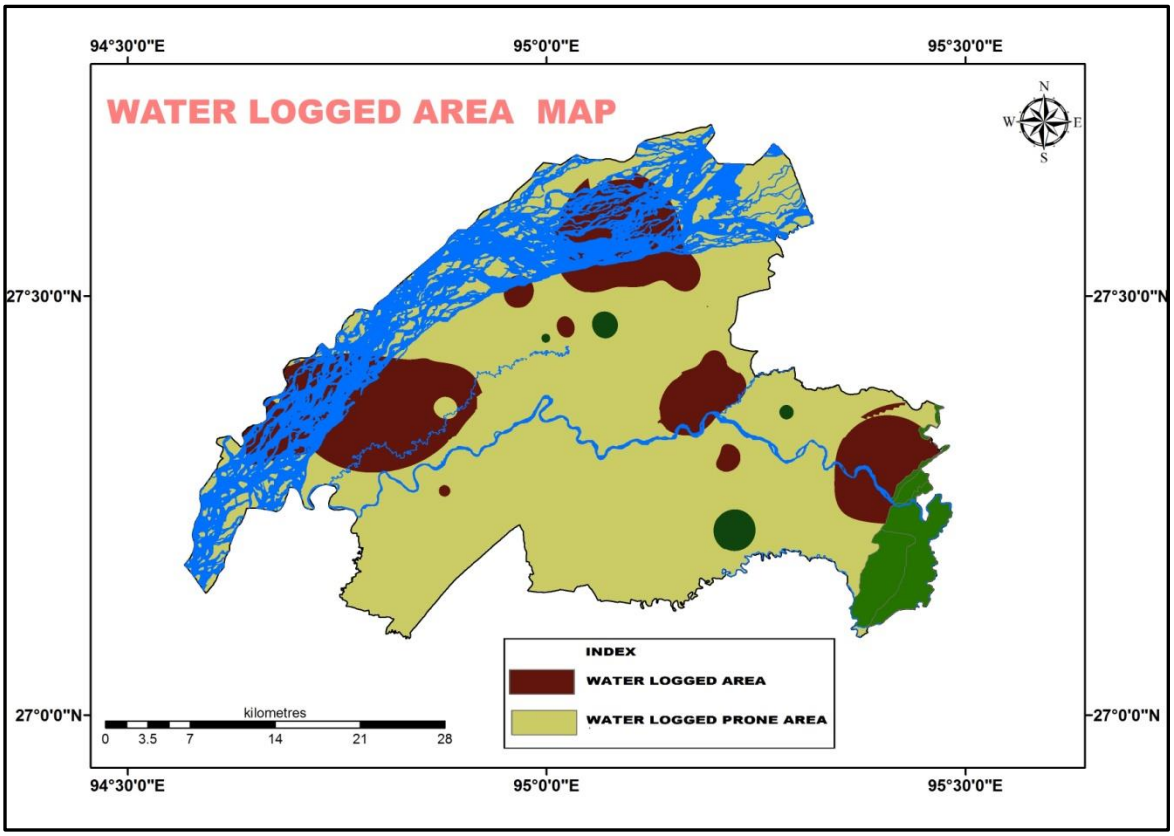

Figure 24: Water logged area prone map of Dibrugarh district

CHAPTER 6.

Management Strategies

6.1: Management strategies for agriculture

Agriculture is the mainstay of economy in Dibrugarh district. Net sown area of the district is 127313 ha and. present land under irrigation is only 7187 ha which is only 5.6% of area under cultivation. During Kharif season 74124 ha area is cultivated for paddy and another 1472 ha is under vegetables. Majorpart of the land remain fallow after kharif paddy is harvested since irrigation infrastructure is not developed to its potential. According to District Irrigation Plan prepared under PMKSY a total of 127157.5 Hectares of Irrigation potential is proposed to be created under PMKSY. Thus, 80% of cultivable area would be brought under the command of assured irrigation. Considering all these facts, a plan is formulated to bring this fallow land of about 74124 ha under assured irrigation during Rabi season and increase cropping intensity up to 200%. In rice fallow, pulses, potato, wheat, maize, mustard and rabi vegetables can be grown with the support of irrigation.

Irrigation requirement for crops is calculated based on deficit of precipitation percolating the soil and evapo-transportation. The water demand of agricultural sector to provide assured irrigation potentiality to un-irrigated areas will be calculated using CROPWAT 8.0 software of FAO. CROPWAT 8.0 is a computer program for the calculation of crop water requirements and irrigation requirements based on soil, climate and crop data. It is used to estimate crop performance under both rainfed and irrigated conditions. Based on available data on cropping pattern in Dibrugarh a plan has been formulated for irrigation requirement for un-irrigated areas(Table 6.1).

Land under winter rice (74124 ha) remains fallow after harvesting. The fallow land could be utilise for cultivation under assured irrigation. Water demand of crops depends on soil moisture, precipitation, soil type , evapotranspiration. Crop-wise and month-wise irrigation water requirement (Precipitation deficit) has been taken from CROPWAT after giving necessary meteorological, soil, crop plan inputs and the same has been shown in Table 6.2. Crop-wise and month-wise Irrigation water requirement in Ham has been further calculated in Table 6.

Table 18: Cropping pattern, proposed cropping pattern, intended cropping intensity, Dibrugarh district

Early Summer Rice-Late Winter Rice	Present Cultivated area	Area to be cultivated	Area to be cultivated (**ha**)	Irrigation requirement (**ha m**)
Summer vegetables- Late Winter Rice	(**ha**)	(**%**)		
Pulses-Late Winter Rice-Potato/Vegetables/Wheat				
Cultivated Area	74124			
	1	2 (= % of 1)	3	4
Rice (main crop)	74124			
Winter Rice	74124	50	74124	12602.9331
Potato		7.5	11119	**1294.94628**
Pulses		5	7412	**905.79528**
Mustard		12.5	18531	**2268.93564**
Winter vegetables		5	7412	**669.33972**
Summer vegetables		5	7412	**420.6537**
Wheat		**5**	7412	**738.27504**
Maize		10	14825	1250.47188
Net cultivated area	74124	100		20151.35064
Gross cultivated area (Paddy/+Maize/+Wheat+Pulses+Millet)			**148247**	
Total irrigation requirement (70% irrigation efficiency)				**28788**
Cropping intensity	**0**		**200% (Intended)**	

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Table 19: Crop-wise and month-wise precipitation deficit (IWR) from CROPWAT 8, Dibrugarh District.

Crop	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	Precipitation deficit (in mm)											
1. Rice	0	0	0	49.1	148.4	0	0	0	3.3	0	0	0
2. Rice	0	0	0	0	197.3	0	0	0	3.2	0	0	0
3. Rice	0	0	0	0	146.9	51	0	0	0	6.2	0	0
4. Rice	0	0	0	0	49	98	0	0	0	6	0	0
5. Rice	0	0	0	0	0	147	0	0	0	5.5	0	0
1. Potato	38.7	12.3	0	0	0	0	0	0	0	0	23.9	47.1
2. Potato	39.9	16.4	0	0	0	0	0	0	0	0	15.6	41.8
3. Pulses	31.8	0	0	0	0	0	0	0	0	1.2	21.2	47.1
4. Pulses	40.1	10.3	0	0	0	0	0	0	0	0	8.5	35
5. Pulses	0.6	13.5	35.1	0	0	0	0	0	0	0	0	0
6. Mustard	28	13.6	14.1	0	0	0	0	0	0	0	41.1	36.2
7. Mustard	28	13.6	14.1	0	0	1.4	0	0	0	1.2	25.3	36.2
8. Mustard	28	13.6	14.1	0	0	0	0	0	0	0	21.4	36.1
9. Small Vegetables	3.2	0	0	0	0	0	0	0	0	0	43.6	41.7
10. Small Vegetables	15.1	0	0	0	0	0	0	0	0	0	34.5	42.5
11. Small Vegetables	20.6	20.3	17.1	0	0	0	0	0	0	0	0	8.8
12. Small Vegetables	10.6	11.1	25	0	0	0	0	0	0	0	0	0
13. Winter Wheat f.f.	21.1	11.7	19.9	0	0	0	0	0	0	0	23	23.9
14. MAIZE (Grain)	10.1	0	0	0	0	0	0	0	1	0	53.9	49
15. MAIZE (Grain)	26.2	0	0	0	0	0	0	0	0	0	35.2	50.8

Table 20: Irrigation Water Requirement (in Ham), Dibrugarh District.

Crop	Net sown area(ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Cropwise Total IWR (Ham)
Winter Rice	11119	0.00	0.00	0.00	545.9233	1650	0	0	0	36.69	0	0	0	1686.69
Winter Rice	11119	0.00	0.00	0.00	0	2193.7	0	0	0	35.58	0	0	0	2229.28
Winter Rice	14825	0.00	0.00	0.00	0	2177.76	756.06	0	0	0	91.91	0	0	3025.74
Winter Rice	18531	0.00	0.00	0.00	0	908.02	1816.04	0	0	0	111.19	0	0	2835.24
Winter Rice	18531	0.00	0.00	0.00	0	0	2724.06	0	0	0	101.92	0	0	2825.98
Potato	3706.2	103.77	50.40	52.26	0	0	5.19	0	0	0	4.45	93.77	134.16	452.16
Potato	7412.4	207.55	100.81	104.51	0	0	0	0	0	0	0	158.63	267.59	842.79
Pulses	3706.2	11.86	0.00	0.00	0	0	0	0	0	0	0	161.59	154.55	375.44
Pulses	3706.2	55.96	0.00	0.00	0	0	0	0	0	0	0	127.86	157.51	348.01
Pulses	3706.2	76.35	75.24	63.38	0	0	0	0	0	0	0	0.00	32.61	182.35
Mustard	7412.4	39.29	41.14	92.66	0	0	0	0	0	0	0	0.00	0.00	985.85
Mustard	3706.2	156.40	86.73	147.51	0	0	0	0	0	0	0	170.49	177.16	444.00
Mustard	7412.4	37.43	0.00	0.00	0	0	0	0	0	0	0	199.76	181.60	839.08
Small Vegetables	3706.2	194.20	0.00	0.00	0	0	0	0	0	0	0	260.92	376.55	328.00
Small Vegetables	3706.2	0	0	0	0	0	0	0	0	0	0	0	0	341.34
Small Vegetables	3706.2	0	0	0	0	0	0	0	0	0	0	0	0	247.57
Small Vegetables	3706.2	0	0	0	0	0	0	0	0	0	0	0	0	173.08
Winter Wheat f.f.	7412.4	0	0	0	0	0	0	0	0	0	0	0	0	738.28
MAIZE (Grain)	3706.2	0	0	0	0	0	0	0	0	0	0	0	0	418.80
MAIZE (Grain)	7412.4	0	0	0	0	0	0	0	0	0	0	0	0	831.67
Total		882.82	354.31	460.31	545.92	6929.48	5301.35	0.00	0.00	72.27	309.47	1173.01	1481.74	20151.35
Total irrigation requirement (70% irrigation efficiency)		1261	506	658	780	9899	7573	0	0	103	442	1676	2117	28788

As per dynamic ground water resource estimation of Dibrugarh district for 2019-20, annual extractable ground water is 104654 Ham and stage of ground water extraction is only 7.44%. Net ground water availability for future use in the district is estimated as 96643.34 Ham. If an irrigation plan is made to develop 70% of the balance dynamic ground water resources available, then 67,650 Ham of groundwater resources is available in the district for the future irrigation uses. From this available resource (planned for future development) 28187 nos. of shallow tube wells (considering a unit draft of 2.4 Ham/year) can be constructed in the district.

Based on ground water exploration carried out by CGWB and PMKSY, GW irrigation schemes shallow tube wells can be designed within the depth of 50m. Under PMKSY, GW irrigation scheme 293 no of shallow tube wells have been constructed tapping granular zone of 10-15m with an average discharge of 24 m^3/hr. Tube wells have been constructed by using $6^{//}$ diameter housing pipe and a $4^{//}$ casing pipe down to 45 m. Shallow tube well having discharge of 24m^3/hr, if it is in operation for 8 hours a day and for 120 days, will create a draft of 2.3Ham.

Considering the area of 74124 ha, number of tubewells required for irrigation considering spacing of 200m between the tube wells is 18531. Annual draft of groundwater from 18531no of tube wells considering unit draft of 2.3 Ham/year is 42621 Ham. It is observed that annual draft from shallow tube well is 13833 Ham more than the required irrigation water requirement. There is ample scope to bring fallow land under cultivation since irrigation potential is rich in the district. Therefore, to bring this rice fallow area under double cropping conjunctive use of groundwater is required.

6.2:Demand Side Interventions

It is always essential to address the issue of constraining demand for groundwater abstraction since this will normally contribute more to achieving the groundwater balance. The concept of real water savings is critical in this regard. The main demand side interventions may be:-

- Promote improved irrigation technologies (drip or sprinkler irrigation, etc.)
- Crop choice management and diversification (promote less water intensive crops like pulses and horticulture)

- Promote treated municipal waste water for irrigation and construction use.
- Managing energy and irrigation nexus (provide quality power supply when needed through separate feeders, high voltage distribution lines, solar pumps, etc.)

6.3: Stress aspect against future demand (2022, 2031)

Demand of water is increasing day by day against the increasing population. The domestic water requirement has been worked out considering per capita water requirement of 55 lpcd for rural population and 135 lpcd for urban population (as per MOHUA). The blockwise requirementupto 2030 is tabulated in table 21.

Table 21:Blockwise population projection and water demand.

Block	Total	Rural	Urban	Decadal growth rate	Population projection 2026		Population Projection 2030		Projected water demand in2026 (ham)		Projected water demand in 2030(ham)	
					Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban
Barbaruah	166835	154988	11847.0	11.9	183706.7	11847.0	192226.1	11847.0	369	69	386	72
Lahoal	149306	146422	2884.0	11.9	173553.5	2884.0	181602.0	2884.0	348	17	365	18
Panitola	124723	124723	0.0	11.9	147833.7	0.0	154689.5	0.0	297	0	311	0
Tengakhat	220478	183100	37378.0	11.9	217027.8	37378.0	227092.4	37378.0	436	218	456	228
Khowang	169759	161325	8434.0	11.9	191218.0	8434.0	200085.6	8434.0	384	49	402	52
Tingkhong	159295	159295	0.0	11.9	188811.8	0.0	197567.9	0.0	379	0	397	0
Joypur	168471	152752	15719.0	11.9	181056.4	15719.0	189452.9	15719.0	363	92	380	96
Total	**1158867**	**1082605**	**76262.0**		**1283208.0**	**76262.0**	**1342716.3**	**76262.0**	**2576**	**445**	**2696**	**466**

Table 22: Supply and Demand gap in drinking water sector

District	Water demand for drinking purpose on 2030(Ham)	Annual GW Allocation for for Domestic Use as on 2025 (Ham)	Demand and supply gap(Ham)
Dibrugarh	**3162**	**3088.53**	**73.47**

It has been observed that annual drinking water requirement is 3162 in 2030 and there is an demand and supply deficit of 73 Ham. There is an increasing demand for groundwater for drinking purpose with the rise in population.

ANNEXURE I

Details of wells established for ground water monitoring under NAQUIM, Dibrugarh district

Sl No.	District	Location	Type of well	Longitude	Latitude	Depth (mbmp)	Dia	m.p(m)	Auifer group	w.l(mbgl) nov (2021)	w.l(mbgl) March (2022)
1	Dibrugarh	Digholia (PWSS)Ouphulia	TW	95.019	27.23	85.344	0.15	0.85	Unconsolidated alluvium	2.67	3.33
2	Dibrugarh	Ouguri	TW	95.093	27.26	91.44	0.15	0.85	Unconsolidated alluvium	2.15	3.56
3	Dibrugarh	Koilagarh	DW	94.994	27.25	4.5	1.2	0.3	Unconsolidated alluvium	1.15	2.4
4	Dibrugarh	Dhuwapathar(PWSS)	TW	95.121	27.16	100	0.15	0.79	Unconsolidated alluvium	2.81	3.85
5	Dibrugarh	1 no PuwaliPathar	DW	95.188	27.20	4.5	1.2	GL	Unconsolidated alluvium	2.87	3.67
6	Dibrugarh	Lerelapathar	DW	95.077	27.20	4.84	1.2	0.54	Unconsolidated alluvium	3.21	3.89
7	Dibrugarh	Simalubamgaon	DW	95.420	27.29	4.21	1.3	gl	Unconsolidated alluvium	2.21	3.4
8	Dibrugarh	ouguri shiv mandir	DW	95.428	27.28	13.5	0.8	0.54	Unconsolidated alluvium	3.23	4.56
9	Dibrugarh	TarajanBetoni(PWSS)	TW	95.445	27.29	110		0.6	Unconsolidated alluvium	3.9	4.8
10	Dibrugarh	Rupaibam (2 no. sopatoli)	DW	95.406	27.32	9	1.3	GL	Unconsolidated alluvium	2.2	3.56
11	Dibrugarh	Komargaon(Morankarichuk)	DW	95.375	27.23	12	1	GL	Unconsolidated alluvium	1.26	2.67
12	Dibrugarh	Chakyagaon (Namrup)	DW	95.373	27.18	9	1.2	GL	Unconsolidated alluvium	1.2	2.45
13	Dibrugarh	Tingraiborholla	DW	95.231	27.40	4.2	0.9	GL	Unconsolidated alluvium	1.89	2.67
14	Dibrugarh	Mohmari	DW	95.272	27.33	5.65	1.2	0.75	Unconsolidated alluvium	2.85	4.1

Sl No.	District	Location	Type of well	Longitude	Latitude	Depth (mbmp)	Dia	m.p(m)	Auifer group	w.l(mbgl) nov (2021)	w.l(mbgl) March (2022)
15	Dibrugarh	Tingraichariali	TW	95.234	27.36	55		0.5	Unconsolidated alluvium	2.2	3.2
16	Dibrugarh	PuroniKhongia	DW	95.150	27.38	5.7	1	0.73	Unconsolidated alluvium	2.7	3.9
17	Dibrugarh	Dowarichiga	DW	94.778	27.22	4.23	1.2	GL	Unconsolidated	1.28	2.24
18	Dibrugarh	Naharani(at the compound of agriculture office)	DW	94.850	27.24	4.9	1.2	0.8	Unconsolidated alluvium	2.25	4.2
19	Dibrugarh	Mazkopohuwa	DW	95.357	27.24	45		0.2	Unconsolidated alluvium	2.95	3.98
20	Dibrugarh	Komargaon9 in the house of mridulgogoi)	DW	95.374	27.24	9.2	1.2	0.8	Unconsolidated alluvium	2.6	3.24
21	Dibrugarh	Gethupathar (PWSS)	TW	95.302	27.30	91	0.15	0.85	Unconsolidated alluvium	2.25	3.2
22	Dibrugarh	HukaniDigholia (PWSS)	TW	95.210	27.31	100	0.15	0.7	Unconsolidated alluvium	2.3	3.3
23	Dibrugarh	Mathaoni(PWSS)	TW	95.160	27.31	100	0.15	0.7	Unconsolidated alluvium	2.85	3.25
24	Dibrugarh	Salmari (PWSS)	TW	95.130	27.28	100	0.15	0.4	Unconsolidated alluvium	3.42	4.2
25	Dibrugarh	Namphake village	DW	95.364	27.28	6.95	0.9	0.65	Unconsolidated alluvium	2.45	3.3
26	Dibrugarh	Kumarnichiga	DW	94.884	27.45	15	2	0.94	Unconsolidated alluvium	0.98	1.54
27	Dibrugarh	Roomarikacharigaon	DW	94.859	27.43	5.4	1.5	0.75	Unconsolidated alluvium	1.5	1.93
28	Dibrugarh	Gohaingaon	DW	94.859	27.38	4.5	1	GL	Unconsolidated alluvium	1.2	1.86
29	Dibrugarh	Hiloidari	DW	94.97	27.5	3.29	0.6	0	Unconsolidated alluvium	1.86	2.27
30	Dibrugarh	Hezelbank	TW	95.06	27.5	20	0.04	0.4	Unconsolidated alluvium	2.01	3.14
31	Dibrugarh	Tingkhong	DW	95.23	27.2	20	0.04	0.42	Unconsolidated alluvium	3.75	3.91
32	Dibrugarh	Jamira tea garden	DW	94.90	27.4	4.8	0.9	0.72	Unconsolidated alluvium	2.41	2.86
33	Dibrugarh	Rangsagiagaon	DW	95.20	27.4	4.53	0.9	0.6	Unconsolidated alluvium	2.52	4

Sl No.	District	Location	Type of well	Longitude	Latitude	Depth (mbmp)	Dia	m.p(m)	Auifer group	w.l(mbgl) nov (2021)	w.l(mbgl) March (2022)
34	Dibrugarh	Tingkhong	DW	94.86	27.5	4.6	1.1	0.6	Unconsolidated alluvium	3.12	4.5
35	Dibrugarh	Chabuabishmile	DW	95.200	27.50	8.45	2	0.79	Unconsolidated alluvium	2.83	4.12

ANNEXURE II

DETAILS OF GROUND WATER EXPLORATORY WELL IN DIBRUGARH DISTRICT

District	Location	Longitude	Latitude	Tpye of well	Topo sheet	Depth of Drilled (mbgl)	Depth of constr. (mbgl)	Granular Zones encountered	Static Water level (mbgl)	Discharge (m^3/hr)	Draw Down (m)	T (m2/ day	Specific Capacity(lpm/m)	Storage co-efficient (S) (lpm/m)
Dibrugarh	Chabua-EW	95.1756	27.496	EW	**83 M/3**	253.06	148.00	41-53, 65-77, 97-115,139-145	1.06	164.87	3	103.51	915.94	
Dibrugarh	Lepetkata (Benaigutia) -EW	94.8694	27.358	EW	**83 M/3**	251.70	151.00	44-50,67-79, 90-102,128-134, 142-148	3.9	162	3.39	6526.57	798.28	2.57*10-3
Dibrugarh	Madhakali-EW	94.9056	27.207	EW	**83 M/16**	222.22	113.00	35-66,101-110	4.1	164.87	3.6	7313.02	798.08	
Dibrugarh	Dirialgaon-EW	95.3675	27.228	EW	**83 M/8**	129.30	127.00	56-68, 80-96,110-113, 122-125	3.25					
Dibrugarh	Tengakhat (Pandhowa) -EW	95.1761	27.357	EW	**83 M/3**	204.10	130.00	52-64, 73-82,100-109, 118-127	3.15	81.72				
Dibrugarh	Chaykyagaon (Namrup)-EW	95.3167	27.197	EW	**83 M/8**	41.95	40.00	26-38	9.4	378.5				
Dibrugarh	Medical College	94.9400	27.480	EW	**83 M/3**	200.00	121.00	43 – 49 ,66 – 72,78 – 84,90 – 96 ,106 – 118	0.55	49.00	1.61	8234		1.162 X 10^{-2}
Dibrugarh	Melengial-EW	95.037	27.438	EW	**83 M/3**	201.00	130.00	42-54,72-84,90-102, 114-126	3.84	55.18	0.71	8703.735		4.89*10-2

ANNEXURE III

CHEMICAL ANALYSIS DATA OF PRE-MONSOON GROUND WATER SAMPLES, DIBRUGARH DISTRICT.

Location	Latitude	Longitude	Tem pºC	pH	EC (µs/cm) 25C	Turbidity (NTU)	TDS	CO3 -2	HCO3-1	TA (as CaCO3)	Cl-	SO4-2	NO3-1	F-	Ca+2	Mg+2	TH (as CaCO3)	Na	K	Fe
							(in mg/l)													
Dowariachiga	27.216	94.772	25.2	8.33	261.10	BDL	172.33	6.00	128.20	134.20	21.27	4.36	3.67	0.06	16.01	12.13	90	17.96	2.23	5.283
Ajarguri	27.2617	94.8903	25.1	6.82	119.40	BDL	78.80	BDL	67.15	67.15	21.27	3.02	6.42	0.06	10.01	6.06	50	7.81	14.50	2.011
Morankari	27.2261	95.3750	25.1	8.34	250.90	BDL	165.59	6.00	134.31	140.31	17.73	1.10	9.14	0.03	12.01	14.56	90	15.85	2.13	9.978
Morankari 1	27.2269	95.3764	25.2	8.41	216.90	BDL	143.15	6.00	128.20	134.20	17.73	1.09	4.51	0.03	12.01	14.56	90	14.22	8.64	0.325
Namphake Bodh Bihar	27.2814	95.3625	25.1	8.40	221.80	0.10	146.39	6.00	140.41	146.41	17.73	0.91	4.64	0.03	8.01	19.41	100	10.13	2.47	9.615
Namphake village	27.2814	95.3642	25.1	7.80	104.50	BDL	68.97	BDL	61.05	61.05	10.64	1.22	3.11	0.03	10.01	2.42	35	16.92	1.07	0.325
Jagun	27.3078	95.3272	25.1	7.26	60.67	BDL	40.04	BDL	30.52	30.52	21.27	1.38	5.01	0.01	10.01	3.64	40	4.90	1.33	3.618
Mohmari	27.3250	95.2722	25.2	8.45	190.70	BDL	125.86	6.00	115.99	121.99	21.27	5.92	3.32	0.01	6.00	16.99	85	17.72	5.13	0.431
2 no. Mohmari	27.3261	95.2764	25.1	7.51	98.36	BDL	64.92	BDL	54.94	54.94	21.27	1.32	6.23	0.01	4.00	4.85	30	3.98	1.25	26.504
Komargaon	27.2303	95.3742	25.3	8.37	179.90	BDL	118.73	3.00	103.78	106.78	21.27	5.65	3.37	0.02	8.01	18.20	95	6.21	1.38	3.950
Konwarbam	27.2292	95.3994	25.1	7.95	178.30	BDL	117.68	BDL	97.68	97.68	21.27	1.57	9.82	0.05	20.02	3.63	65	18.96	1.87	0.325
Chaikiyagaon	27.1756	95.3728	25.2	7.90	101.70	BDL	67.12	BDL	48.84	48.84	10.64	1.34	7.56	0.07	6.00	4.85	35	5.64	11.00	BDL

Location	Latitude	Longitude	Temp ºC	pH	EC (µs/cm) 25ºC	Turbidity (NTU)	TDS	CO3 -2	HCO3-1	TA (as CaCO3)	Cl-	SO4-2	NO3-1	F-	Ca+2	Mg+2	TH (as CaCO3)	Na	K	Fe
Disangjaan	27.1803	95.3708	25.1	7.96	157.80	BDL	104.15	BDL	109.89	109.89	21.27	2.69	3.62	0.02	12.01	8.49	65	17.95	7.25	0.452
Dangoriya baba mondir	27.2550	95.2380	25.1	7.57	97.42	0.20	64.30	BDL	61.05	61.05	17.73	1.41	6.31	0.01	10.01	2.42	35	15.91	3.20	0.346
Garibam	27.2883	95.4197	25.2	7.54	61.25	BDL	40.43	BDL	30.52	30.52	21.27	1.31	5.51	0.01	6.00	2.42	25	13.72	2.77	0.325
TarajanBetoni (PWSS)	27.2792	95.4283	25.2	7.82	186.90	BDL	123.35	BDL	91.57	91.57	14.18	2.96	5.91	BDL	24.02	7.27	90	4.07	1.47	0.410
Gethupathar (PWSS)	27.2983	95.3022	25.3	7.36	80.88	BDL	53.38	BDL	42.73	42.73	10.64	1.46	7.71	0.01	4.00	4.85	30	14.16	0.43	1.205
Merbil eco-camp	27.3142	95.2103	25.2	7.58	367.40	BDL	242.48	BDL	109.89	109.89	77.99	1.67	5.51	BDL	18.01	20.62	130	22.56	6.08	0.431
Salmari (PWSS)	27.2811	95.1300	25.1	8.39	226.40	BDL	149.42	6.00	134.31	140.31	14.18	1.54	5.23	0.02	10.01	21.84	115	4.04	2.18	3.646
PuwaliPathar	27.1986	95.1875	25.2	7.47	104.70	BDL	69.10	BDL	67.15	67.15	14.18	1.58	4.27	0.03	6.00	6.07	40	15.71	1.65	0.367
Na Bhaktiya	27.1783	95.1019	25.1	7.46	365.10	BDL	240.97	BDL	103.78	103.78	77.99	1.90	3.91	BDL	20.02	21.83	140	22.27	2.95	0.431
LerelaPathar	27.2028	95.0769	25.2	8.34	346.50	BDL	228.69	9.00	201.46	210.46	17.73	2.00	7.80	0.01	24.02	25.47	165	10.09	1.63	3.347
DoomorDolong PWSS	27.2148	94.9511	25.1	7.11	240.50	0.10	158.73	BDL	79.36	79.36	35.45	2.16	3.59	0.01	16.01	10.91	85	12.00	2.03	0.388
2 no. ChapatoliRupaibam	27.3197	95.4058	25.2	7.45	202.20	0.10	133.45	BDL	122.10	122.10	21.27	1.91	3.78	0.02	16.01	18.20	115	7.78	2.32	0.325
KumariniChiga	27.4540	94.8840	25.2	7.10	365.60	BDL	241.30	BDL	158.73	158.73	35.45	17.18	13.39	0.01	40.03	8.48	135	21.73	7.40	0.367

Location	Latitude	Longitude	Temp ºC	pH	EC (µs/cm) 25ͦC	Turbidity (NTU)	TDS	CO3 -2	HCO3-1	TA (as CaCO3)	Cl-	SO4-2	NO3-1	F-	Ca+2	Mg+2	TH (as CaCO3)	Na	K	Fe
Rohmarikacharigaon	27.4264	94.8653	25.1	8.33	466.10	BDL	307.63	6.00	158.73	164.73	60.27	4.21	5.37	0.05	36.03	8.48	125	28.38	22.91	0.410
Gohaingaon	27.3800	94.8589	25.2	7.74	552.30	BDL	364.52	BDL	183.15	183.15	70.90	11.74	8.01	0.04	32.03	14.55	140	38.50	19.47	0.734
Chabua ram jankiumadir	27.4603	95.0692	DW	25.1	7.35	184.70	BDL	121.90	BDL	91.57	91.57	28.36	2.23	9.31	0.30	20.02	4.84	70	17.78	3.33

ANNEXURE IV

CHEMICAL ANALYSIS DATA OF POST_MONSOON GROUND WATER SAMPLES

Location	long	lat	TempºC	pH	EC (µs/cm) 25C	Turbidity (NTU)	TDS	CO3-2	HCO3-1	TA (as CaCO3)	Cl-	SO4-2	NO3-1	F-	Ca+2	Mg+2	TH (as CaCO3)	Na	K	Fe
Dowariachiga	94.77	27.22	25.2	8.31	301.10	BDL	198.73	12.00	256.40	268.40	14.18	BDL	BDL	0.08	34.03	23.04	180	15.05	3.06	11.20
Ajarguri	94.89	27.26	25.1	7.20	296.90	0.40	195.95	BDL	170.94	170.94	24.82	5.40	0.50	0.93	38.03	9.69	135	23.95	10.42	0.73
Morankari	95.38	27.23	25.1	8.59	591.10	0.40	390.13	15.00	201.46	216.46	106.35	9.87	1.82	BDL	42.03	15.76	170	75.83	30.97	1.69
Morankari 1	95.38	27.23	25.2	8.09	195.20	BDL	128.83	BDL	128.20	128.20	39.00	3.22	BDL	0.56	18.01	20.62	130	7.44	5.39	15.19
Namphake Bodh Bihar	95.36	27.28	25.1	7.76	173.10	BDL	114.25	BDL	85.47	85.47	23.04	6.38	3.24	0.04	22.02	9.70	95	8.75	2.22	2.49
namphake Village	95.36	27.28	25.1	8.33	366.90	BDL	242.15	21.00	231.99	252.99	39.00	19.74	BDL	0.83	46.04	13.33	170	38.65	19.65	0.14
Jagun	95.33	27.31	25.1	8.43	359.80	0.20	237.47	18.00	286.93	304.93	7.09	0.10	0.09	BDL	24.02	44.89	245	8.94	3.15	9.93
Mohmari	95.27	27.33	25.2	8.30	439.80	BDL	290.27	12.00	238.09	250.09	31.91	10.98	BDL	BDL	58.05	9.68	185	32.81	20.62	0.83
2 no. Mohmari	95.28	27.33	25.1	7.80	133.60	BDL	88.18	BDL	128.20	128.20	17.73	15.57	4.87	BDL	30.02	6.05	100	9.27	3.60	15.12
komargaon	95.37	27.23	25.3	7.91	208.40	BDL	137.54	BDL	115.99	115.99	24.82	7.29	BDL	0.19	16.01	10.91	85	17.62	16.26	2.71
Konwarbam	95.40	27.23	25.1	8.34	284.70	BDL	187.90	12.00	225.88	237.88	60.27	BDL	6.49	BDL	12.01	65.53	300	3.23	1.79	6.57
Chaikiyagaon	95.37	27.18	25.2	8.04	210.50	0.10	138.93	BDL	152.62	152.62	17.73	10.88	1.89	BDL	42.03	7.26	135	6.14	7.70	1.03
disangjaan	95.37	27.18	25.1	7.85	280.60	BDL	185.20	BDL	140.41	140.41	21.27	14.05	BDL	BDL	32.03	12.12	130	17.14	4.11	1.22
Rongagora	95.24	27.26	25.2	8.10	286.90	BDL	189.35	BDL	115.99	115.99	53.18	14.30	1.88	BDL	30.02	18.19	150	20.40	4.54	2.20
Dangoriya baba	95.42	27.29	25.1	8.08	214.10	0.10	141.31	BDL	164.83	164.83	17.73	4.31	BDL	BDL	12.01	1.21	35	38.55	19.47	4.99

Location	long	lat	TempºC	pH	EC (µs/cm) 25C	Turbidity (NTU)	TDS	CO3-2	HCO3-1	TA (as CaCO3)	Cl-	SO4-2	NO3-1	F-	Ca+2	Mg+2	TH (as CaCO3)	Na	K	Fe
mandir																				
Garibam	95.42	27.29	25.2	7.69	216.30	0.10	142.76	BDL	85.47	85.47	92.17	3.81	BDL	1.02	8.01	35.19	165	9.07	8.45	17.60
Gariabam	95.43	27.28	25.1	7.89	161.00	BDL	106.26	BDL	115.99	115.99	24.82	BDL	11.24	BDL	12.01	19.41	110	12.26	3.25	5.57
TarajanBetoni(PWSS)	95.30	27.30	25.2	8.32	177.40	BDL	117.08	15.00	201.46	216.46	19.50	BDL	BDL	0.51	22.02	12.13	105	29.13	18.32	4.59
Gethupathar(PWSS)	95.21	27.31	25.3	8.30	206.60	BDL	136.36	15.00	152.62	167.62	17.73	0.09	0.09	1.25	24.02	18.19	135	15.00	4.52	0.80
Merbil eco-camp	95.13	27.28	25.2	7.78	120.90	BDL	79.79	BDL	109.89	109.89	21.27	2.17	BDL	0.43	6.00	16.99	85	14.78	4.54	0.07
Salmari (PWSS)	95.19	27.20	25.1	7.40	59.02	BDL	38.95	BDL	79.36	79.36	42.54	BDL	BDL	0.86	4.00	24.27	110	7.44	1.72	1.36
PuwaliPathar	95.10	27.18	25.2	7.41	61.10	BDL	40.33	BDL	54.94	54.94	17.73	2.00	11.52	0.69	12.01	3.63	45	7.19	6.36	6.55
Na Bhaktiya	95.08	27.20	25.1	8.33	216.10	0.20	142.63	9.00	195.36	204.36	17.73	4.38	BDL	0.89	14.01	26.69	145	19.69	4.76	0.79
Lerelapathar	94.95	27.21	25.2	8.47	408.40	BDL	269.54	27.00	286.93	313.93	17.73	0.21	BDL	1.41	54.04	16.96	205	29.54	25.74	4.36
Doomordolong PWSS	95.41	27.32	25.1	7.92	185.00	BDL	122.10	BDL	122.10	122.10	39.00	0.79	0.11	0.64	22.02	7.27	85	31.02	3.48	0.04
2 no. ChapatoliRupaibam	95.34	27.33	25.2	7.52	179.80	0.30	118.67	BDL	73.26	73.26	49.63	0.82	1.41	BDL	10.01	12.13	75	23.12	2.73	0.10
Jaloni PWSS	95.23	27.36	25.3	8.05	210.70	0.40	139.06	BDL	152.62	152.62	14.18	BDL	1.30	1.32	26.02	14.55	125	14.12	3.69	2.20
TingraiChariali PWSS	95.15	27.38	25.2	8.40	213.50	BDL	140.91	3.00	91.57	94.57	53.18	BDL	BDL	0.79	14.01	23.05	130	8.74	4.14	7.96
PuroniKhongia	95.10	27.37	25.2	8.37	396.70	BDL	261.82	18.00	250.30	268.30	42.54	3.75	BDL	0.33	30.02	25.47	180	28.34	19.53	3.26
Dhoriyavilage	94.90	27.43	25.1	7.80	284.70	BDL	187.90	BDL	103.78	103.78	42.54	5.69	13.93	0.32	10.01	15.77	90	35.41	7.76	0.10
Kumarinichiga	95.94	27.48	25.2	8.01	317.60	0.30	209.62	BDL	158.73	158.73	31.91	7.21	BDL	1.37	44.04	6.05	135	18.40	7.39	0.19
AMC new building	95.98	27.51	25.1	7.86	319.50	BDL	210.87	BDL	115.99	115.99	42.54	6.71	8.27	0.24	26.02	9.70	105	30.22	3.38	0.35

Location	long	lat	TempºC	pH	EC (µs/cm) 25C	Turbidity (NTU)	TDS	CO3-2	HCO3-1	TA (as CaCO3)	Cl-	SO4-2	NO3-1	F-	Ca+2	Mg+2	TH (as CaCO3)	Na	K	Fe
Maijan tea factory	94.88	27.40	25.1	7.80	268.80	0.10	177.41	BDL	170.94	170.94	24.82	8.89	4.16	2.33	32.03	13.33	135	15.37	8.85	0.11
Borboruah	94.87	27.43	25.2	7.38	428.30	BDL	282.68	BDL	103.78	103.78	60.27	7.67	28.12	0.64	26.02	16.98	135	24.57	17.26	5.11
RohmariKacharigaon	94.86	27.38	25.1	8.26	477.50	BDL	315.15	BDL	103.78	103.78	134.71	8.61	BDL	0.34	42.03	10.90	150	21.02	11.41	0.46
Gohaingaon	95.07	27.46	25.2	7.92	164.10	0.20	108.31	BDL	109.89	109.89	24.82	2.38	BDL	0.77	28.02	BDL	BDL	18.04	4.57	1.76
Chabua ram jankiumandir	95.20	27.50	25.1	7.82	181.90	BDL	120.05	BDL	103.78	103.78	187.89	1.33	0.39	0.79	28.02	72.80	370	5.69	3.48	0.10
ChabuaBishmile	95.20	27.50	25.2	7.73	208.70	BDL	137.74	BDL	103.78	103.78	28.36	7.16	10.76	1.40	44.04	1.19	115	15.85	5.38	0.10

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