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Department of Water Resources, River Development & Ganga Rejuvenation

जलसंसाधन, नदी विकास और गंगा संरक्षण विभाग

Ministry of Jal Shakti

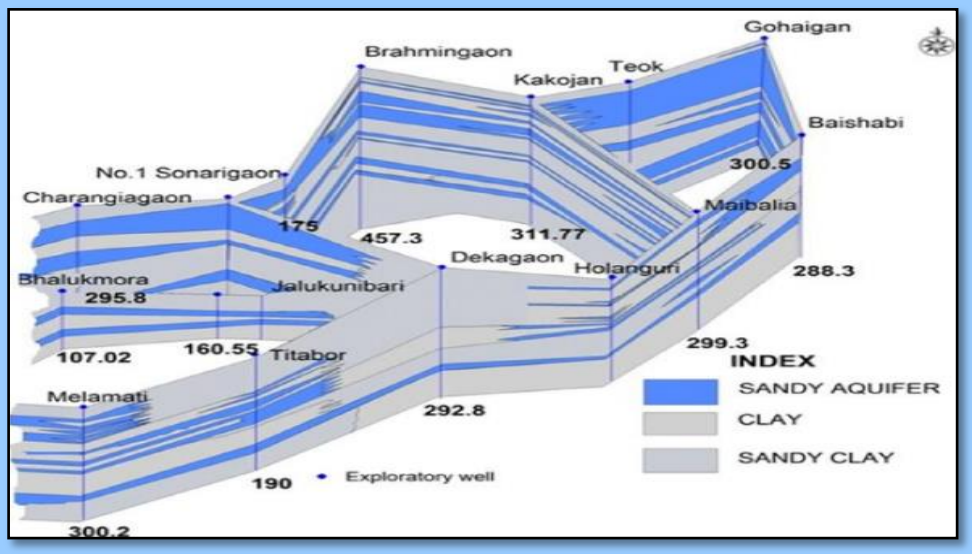
जल शक्ति मंत्रालय

GOVERNMENT OF INDIA

भारत सरकार

AQUIFER MAPPING AND MANAGEMENT PLAN OF JORHAT DISTRICT, ASSAM

AAP 2021-22



NORTH EASTERN REGION

उत्तर पूर्वी क्षेत्र

GUWAHATI

गुवाहाटी

JUNE, 2022

GOVERNMENT OF INDIA

MINISTRY OF JAL SHAKTI

DEPARTMENT OF WATER RESOURCES, RIVER DEVELOPMENT & GANGA REJUVENATION

REPORT ON

"AQUIFER MAPPING AND MANAGEMENT PLAN OF JORHAT DISTRICT, ASSAM"

(AAP 2021-22)

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Chapter 1.0

Introduction

Central Ground Water Board, North Eastern Region has carried out Aquifer mapping and management plan in Jorhat district, Assam as per the Annual Action Plan 2012-13 and 2013-14, which covered an area of 1860 sq.km and during AAP 2021-22 the area covered is 934 sq.km (Total Mapable area 2794 sq km). Under National Aquifer Mapping and Management (NAQUIM) program, combination of geologic, hydrologic and hydrochemical information is applied to characterize the quantity, quality and sustainability of ground water aquifers. Systematic aquifer mapping will improve our understanding of the geologic framework of aquifers, their hydrogeologic characteristics, quality and also quantifying the available ground water resources potential and proposing plans appropriate to the scale of demand and the institutional arrangements for management. Aquifer mapping at the appropriate scale can help to prepare, implement and monitor the efficacy of various management interventions aimed at long-term sustainability of our precious ground water resources, which, in turn, will help achieve drinking water security, improved irrigation facilities and sustainability in water resources development.

1.1 Objectives

The objectives of this project are to understand the aquifer systems, to define the aquifer geometry, type of aquifers, ground water regime behaviours, hydraulic characteristics and to establish groundwater quantity, quality, and sustainability, and to estimate the dynamic and static resources accurately through a multidisciplinary scientific approach on 1:50,000 scale and finally formulate a complete, sustainable and effective management plan for ground water development.

1.2 Scope of the study

The activities of this Aquifer Mapping and management plan can be envisaged as follows:

1.2.1 Data Compilation & Data Gap Analysis

One of the important aspect of aquifer mapping program was the synthesis of the large volume of data already collected during specific studies carried out by Central Ground Water Board and various Government organizations with a new data set generated that broadly describe an aquifer system. The data were assembled, analyzed, examined, synthesized and interpreted from available sources. These sources were predominantly non computerized data, which was converted into computer based GIS data sets. On the basis of available data, data gaps were identified.

1.2.2 Data Generation

There was also a strong need for generating additional data to fill the data gaps to achieve the task of aquifer mapping. This was achieved by multiple activities such as exploratory drilling, hydro-geochemical analysis, remote sensing, besides detailed hydrogeological surveys to delineate aquifer system; to bring out the efficacy of various geophysical techniques and a protocol for use of geophysical techniques for aquifer mapping in different hydrogeological environs.

1.2.3 Aquifer Map Preparation

On the basis of integration of data generated from various studies of hydrogeology, aquifers have been delineated and characterized in terms of quality and potential. Various maps have been prepared 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).

1.2.4 Aquifer Management Plan Formulation

Aquifer Maps and ground water regime scenario are being utilized to identify a suitable strategy for sustainable development of the aquifer in the area.

1.3 Approach and Methodology

Aquifer mapping has been carried out by adopting a multi-disciplinary approach:

(i) Geophysical Surveys through Vertical Electrical Sounding (VES)

(ii) Exploratory drilling and construction of bore wells tapping various groups of aquifers

(iii) Ground Water Regime monitoring by establishing monitoring wells tapping different aquifers at different depths for long term monitoring of water level and quality

(iv) Pumping test of bore wells, soil infiltration test for determination of ground water recharge scope, intensity and potentials and also to determine the characteristics and performances of existing aquifers at various depths.

(v) Collection of various relevant technical data from the field in aquifer mapping area and also from the concerned State Govt. Agencies and other Institutes dealing with ground water and incorporating these data along with CGWB data for final output.

(vi) Preparations of a micro level mapping of existing aquifers, their potentials depth wise and sideways in 2D and 3D forms viewed from different angles by various GIS Layers.

(vii) Formulating a complete sustainable aquifer management plan for ground water development

1.4 Area Details

Jorhat district lies between 26.20”, 27 10.30” north latitude, 93.39”, and 94 36.30" east longitudes.The district is having a mapable area of 2794 sq.km. Out of this, 934 sq.km of area was covered during AAP-2021. Remaining1860 sq km area was already covered during AAP 2012-13 and 2013-14. District area falls partly or fully in the quadrants of Survey of India Toposheets bearing nos. 83I/4 and 83I/8, 83I/12, 83J/1, 83J/2, 83J/3, 83J/5 83J/6, 83J/7, 83J/8, 83J/9, 83J/10,83F/13and is bounded by Sivsagar district in the East, Nagaland in the south, Golaghat district in the West and Lakhimpur district in North. The base map of the study area is shown in fig.1.1.

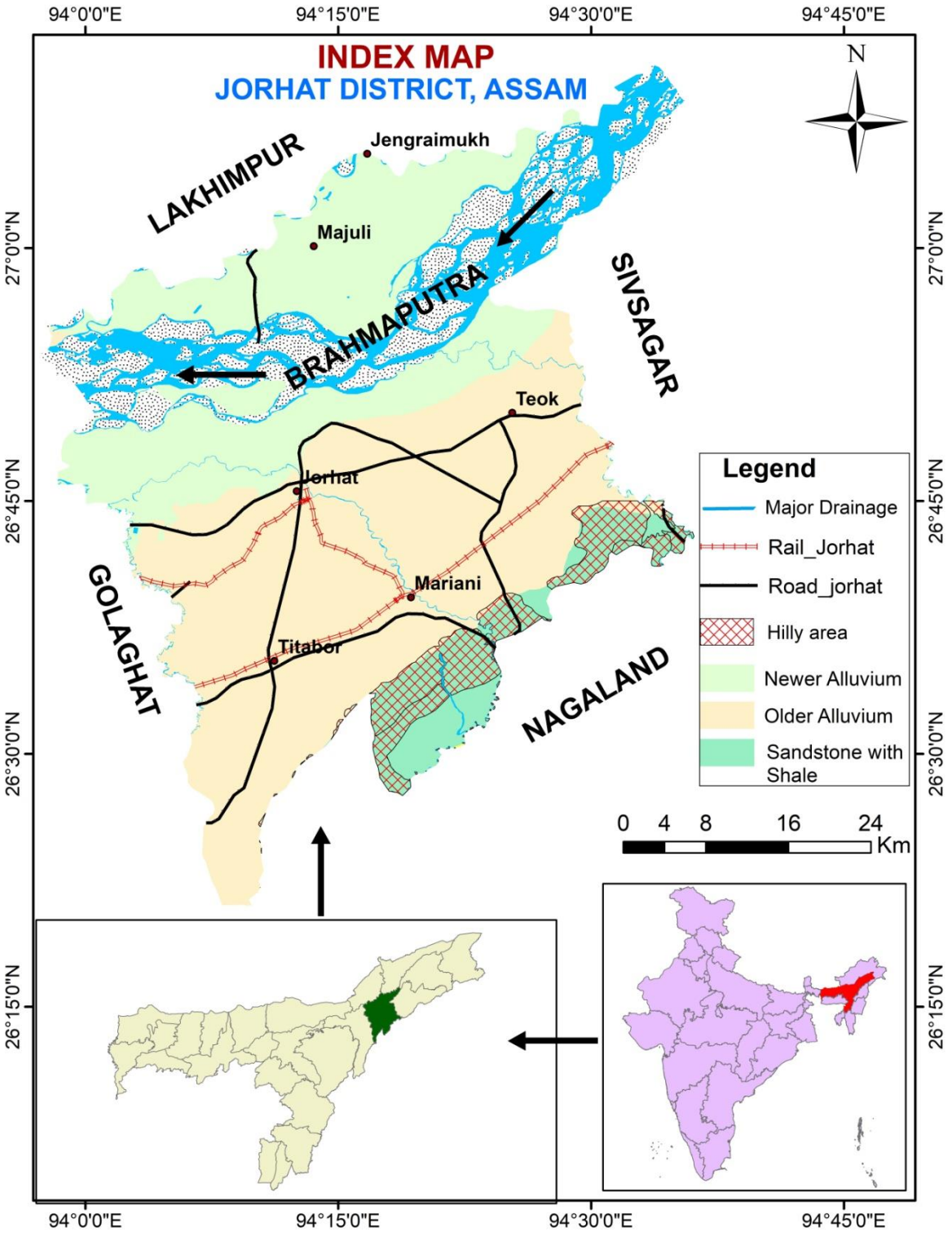


Fig 1.1: Index Map of Study area

1.5 Administrative set up of the study area

For the administrative purposes, the entire district is divided into three sub-divisions viz, Jorhat (Sadar), Majuli and Titabar. Again each sub-division is divided into revenue circles and under revenue circles there are Mauzas comprising villages of all kinds. In the district, there are 6 revenue circles and 848 villages. The names of revenue circles are Jorhat East, Jorhat West, Titabar, Teok, Mariani and Majuli. In the district there are 8 Community Development Blocks.

The names of the CD Blocks are Jorhat Dev. Block (Baghchung), North West Dev. Block (Dhekorgarah), Titabor Dev. Block (Titabor), East Jorhat Dev. Block (Selenghat), Kaliapani Dev. Block (Kaliapani), Central Jorhat Dev. Block (Chipahikhola), Majuli Dev. Block (Kamalabari) and Ujani Majuli Dev. Block (Jengraimukh). The district consists of 11 towns and which includes 4 Statutory Towns and 7 Census Towns. It has 111 Gaon Panchayats in all. Jorhat district covers an area of 2851 Sq.Km. Total population of the district 1092256 (2011 census) with population density of 349 per sq km.

Table 1.1: Administrative Divisions

No of Civil Subdivision	No. of CD Blocks	No.of Revenue Circles	No of Gram Panchayats	No of Villages (Inhabited)	No of Villages (Uninhabited)
3	8	6	110	763	85

Data Source: Statistical Handbook, 2016, Assam

Table 1.2: Revenue Circle Wise Number of villages and population of Jorhat District

District	Revenue Circles	No of Villages	Population
Jorhat	Majuli	248	167304
	Jorhat East	65	195398
	JorhatWest	130	211539
	Teok	156	184611
	Titabor	164	201791
	Mariani	85	131613

Data source: Census Handbook 2011

1.6 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 CGWB. All data were plotted in base map on GIS Platform (Arc-GIS 10.3.1 using Projection Coordinate system: UTM, Zone 46). The available data, data gap and data generation work is tabulated in Table: 1.3.

Table 1.3: Data availability, data gap and data generation in Jorhat, district, Assam

SN	Theme	Type	Data available	Data gap	Data generation	Total	Remarks
1	Borehole Lithology Data		21	3	2	23	Maximum depth of well is 457 mbgl.
2	Geophysical data		19	1	9	28	
3	Groundwater level data	Dug well/ Hand pump	11	15	22	33	
		Piezometer Aquifer-I	09 OW/ 1PZ	Nil	01 OW	11	
4	Groundwater quality data	Dug well/ Hand pump Aquifer-I	06		47	53	
5	Soil Infiltration Test		0		06	06	

1.7 Rainfall Distribution

The average annual rainfall recorded from 2015 to 2020 in Jorhat district is 1960mm. Rainfall during January to April contributes nearly 15.27% to the total rainfall whereas the rainy season which commences from May and continues up to September contributes 77.17%. October to December rainfall makes up the rest. November receives least rainfall and maximum rainfall occurs during July.The average monthly rainfall from 2015 to 2020 are tabulated in Table 1.4

Table 1.4: Rainfall variations of Jorhat District from 2015-2020

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
2015	5.7	34	35.2	248.3	289.3	277.3	281.2	308.3	223.9	92.2	15.9	46.5
2016	28.6	19.9	64	423.7	312.7	313.5	423.3	114.3	286.7	93.8	15.8	32.9
2018	3.9	29.2	98.3	112.8	157.3	374.9	313	309.7	277.8	25.5	28.5	33.8
2019	6.8	33.1	70.6	132.4	354.9	269.6	366.1	209.9	347.5	155.4	6.3	13.2
2020	40.5	19.2	18.6	80.4	320.6	504.7	448.3	264.1	202.6	146.9	34.9	1.7
Average	17.1	27.08	57.34	199.52	286.96	348	366.38	241.26	267.7	102.76	20.28	25.62

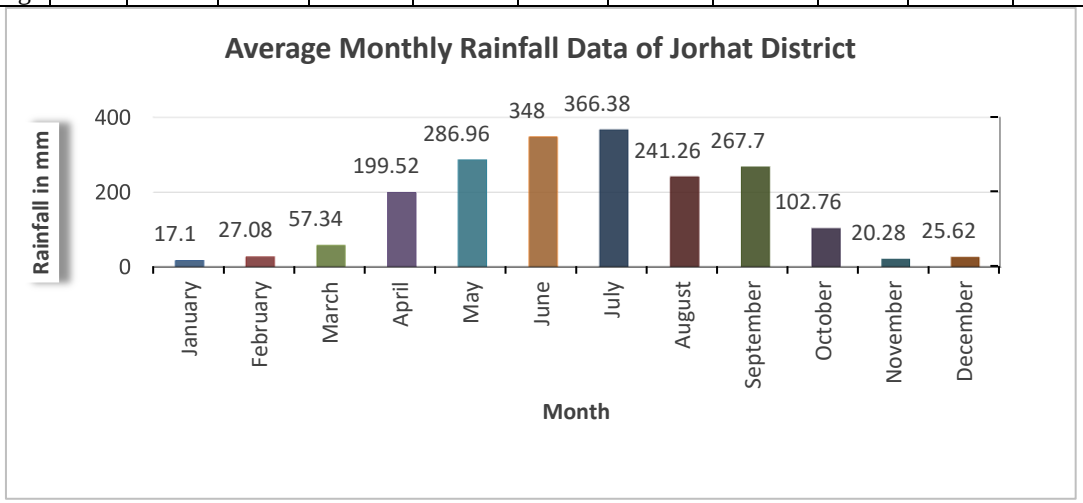


Fig 1.2 : Average monthly rainfall of Jorhat district

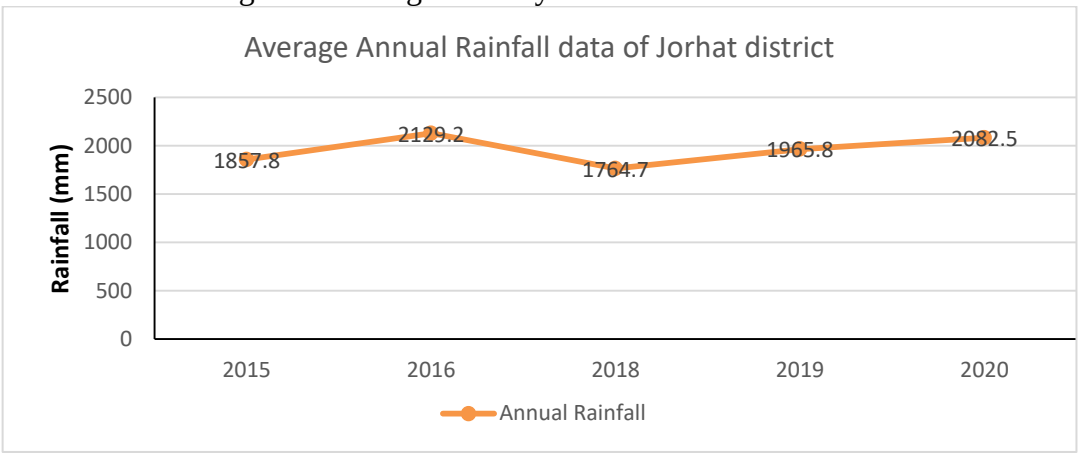


Fig 1.3: Average annual rainfall variations of Jorhat district

1.8 Temperature

The temperature in the region begins to increase from the end of February and reaches the highest point during July and August. January is the coldest month of the year. The air is highly humid throughout the year and winds are light in the district. However, some of the cyclonic

storm and depressions from the Bay of Bengal occur in the monsoon and post monsoon periods accompanied by heavy rain. Thunderstorms occur during the period from March to May. Fog occurs in the winter months.Temperature starts falling from November and rises from the month of March every year. The maximum temperature in the district is 42°C and the lowest is 8°C.

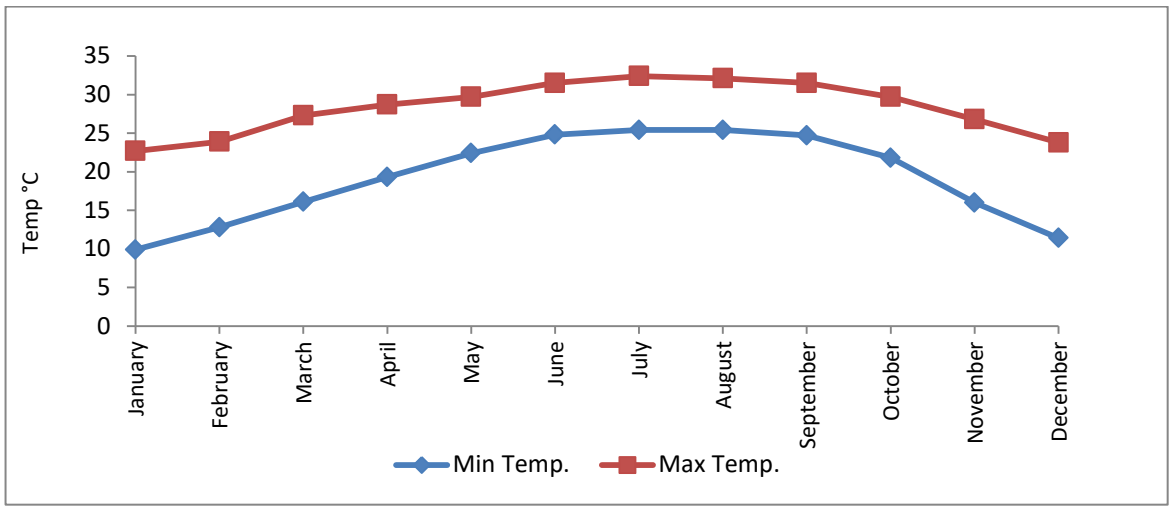


Fig 1.4:Annual variation of temperature of Jorhat district, Assam

1.9 Physiographic set up

The district can be divided into three broad natural divisions. The first one is a belt of flooded land. The expanse of flooded belt runs 4 to 12 kms in width on the southern bank of Brahmaputra. The area is covered with jungle reed interspersed, some swamps and rich variety of fodder grass. Secondly a vast plain area lies between Nagaland and the Brahmaputra. The area is thickly populated with enormous plain area for cultivation of any sort. On the high areas tea is grown exorbitantly and while the plain area is surfaced with rice cultivation and is, therefore, regarded as surplus rice grown area in the district. The third division embraces the entire Majuli subdivision. Majuli is a gift of nature. Subansiri and Kherkatia Suti have separated Majuli from Lakhimpur district. Topographically the whole of Jorhat district is a level plain. The Brahmaputra and Bhogdai is the only major river in the district. Topographically the whole of Jorhat district is a level plain which is also indicated by the profile graph A-A' moving from west to east direction of the district. Some areas at the south and southeast of the district have low hill ranges which are the continuation of the Naga hills and is also indicated by the profile graph B-B' running from North to South direction. The northern part of the valley is flat to nearly level and often subject to moderate to severe flooding whereas the other parts have very gently slopes with impeded drainage and occasionally affected by flood.

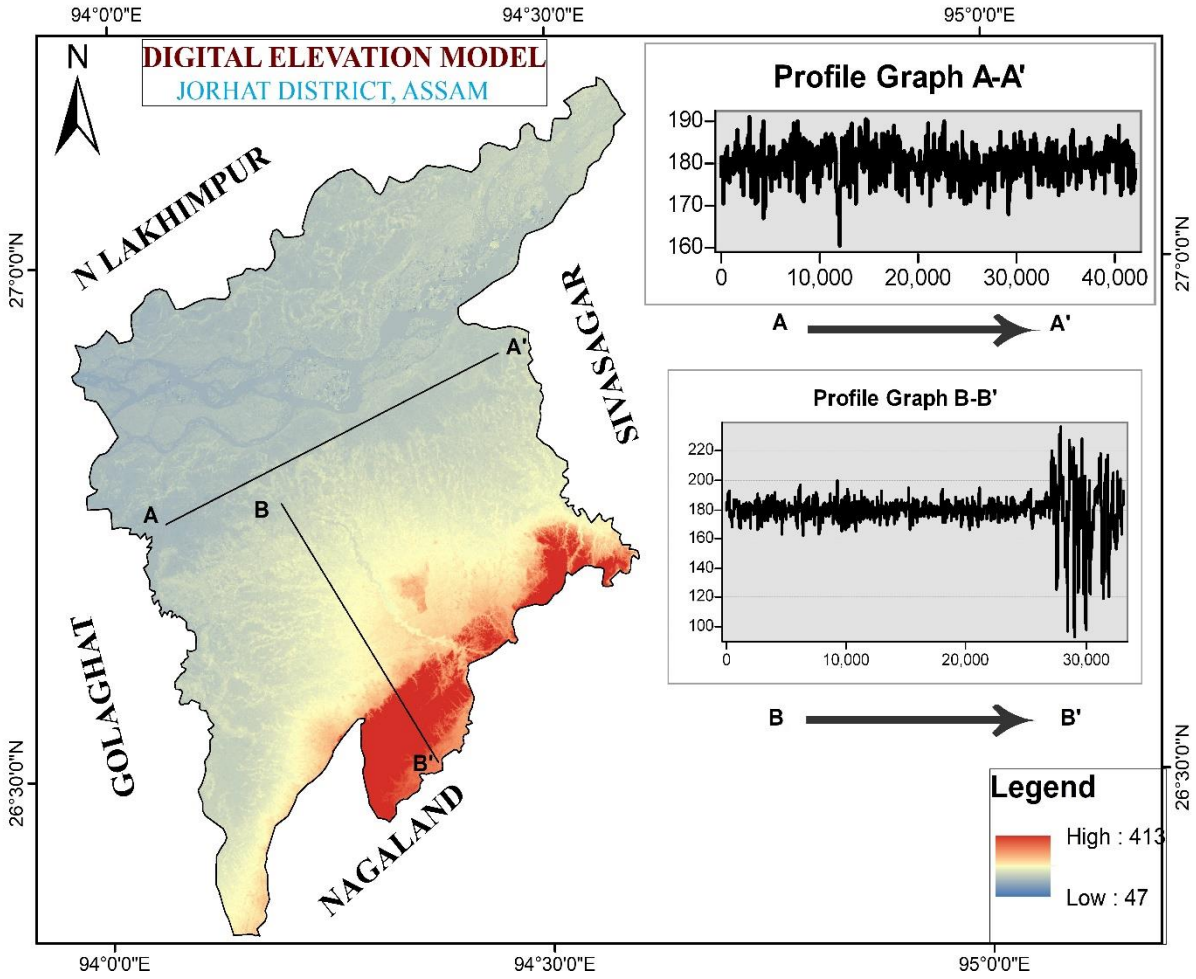


Fig 1.5:Digital Elevation Model (data source: USGS Earth Explorer, SRTM 30m resolution)

1.10 Geology

The district is covered by alluvium deposited by the river Brahmaputra and its tributaries. The older alluvium mainly of the Pleistocene period (less than 1 million years) consists of reddish to brownish sandy clay with coarser particles of sand and newer alluvium consists of sand, silt and clay along the plains of the Brahmaputra River. The rocks belonging to Tipam Group is exposed in the southern part of the district and consists mainly of course to gritty, ferruginous sandstones and shale (GSI, 1973).

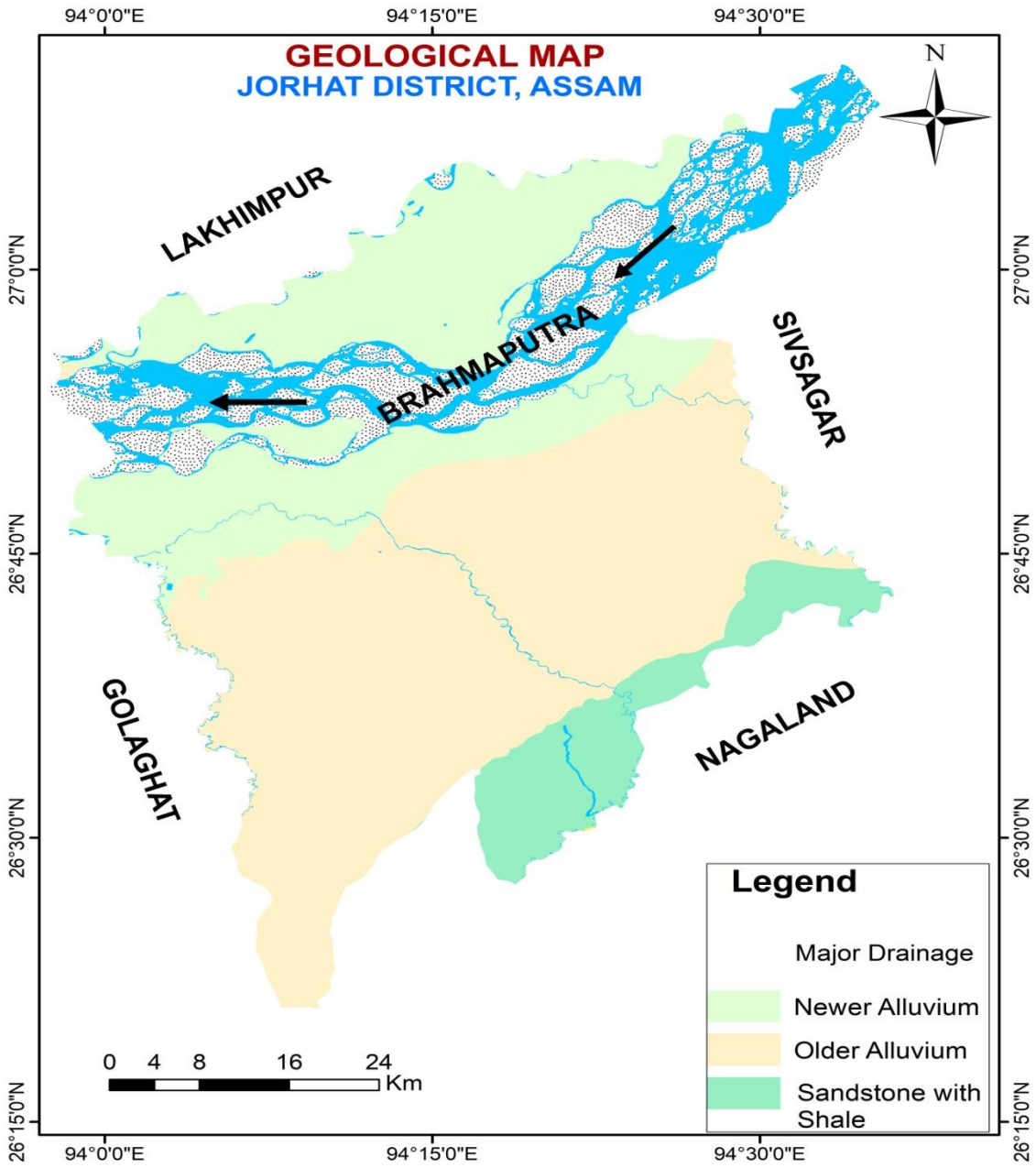


Fig 1.6: Geological Map of Jorhat District, Assam

1..11 Geomorphologic Features and Landforms

Five geomorphological units are discernible in Jorhat district,

(i) The flood plain of the Brahmaputra River in the north

(ii) The central upland area covering younger alluvial formations

(iv) The southern undulating hill area running along the Naga-Patkai range covering the piedmont plain and

(v) Structural hills.

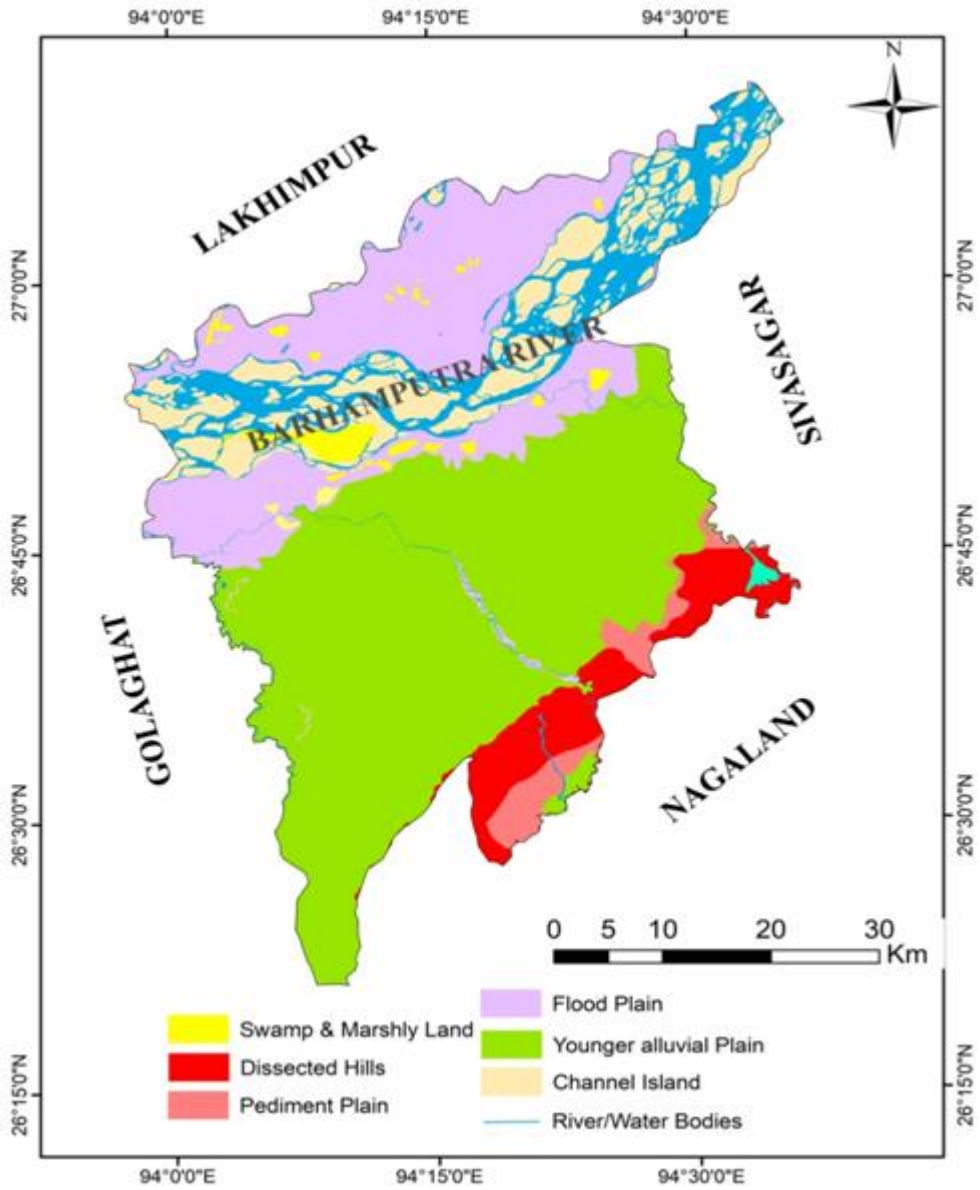


Fig 1.7: Geomorphological Map of Jorhat District, Assam (data source: Bhukosh-GSI).

The elevation of the flood plain area varies from 80 to 90 m while in the central upland area it is 95 to 110 m above Mean Sea Level. The altitude of the hills in the southern parts of the district is up to 413 m above MSL. The general trend of the hills is NE-SW and at places to N-S. The mighty River Brahmaputra and its important tributaries like south Dhansiri, Bhogdoi and Kakodonga drain the district. The tributaries originate in Naga-Patkai range and flow northward to join the Brahmaputra River almost at right angles. These tributaries retain only meager base flow during the dry winter months. The rivers and streams are highly meandering in nature and sudden changes in courses of these rivers possibly due to heavy siltation and epi-orogenic movements cause the flood havocs.

1.12 Land use Pattern

The Directorate of Economics and Statistics, the Government of Assam in its handbook, 2016, has published the land and land-use pattern of the district. These are presented below for the year 2015- 2016.

Table 1.5: Land Use Pattern in Jorhat District

Sl. No.	Land put to different uses	Area in hectares
1	Total Geographical area	285100
2	Forest area	25247
3	Land not available for cultivation	80395
a	Land put to non-agriculture uses	70000
b	Barren and un-cultural land	10395
4	Other non-cultivated land excluding fallow land	25713
a	Permanent pastures and other grazing land	4528
b	Land under misc, trees, groves etc. not included in net area	13711
c	Cultivable waste land	7474
5	Fallow land	17019
a	Fallow other than current fallow	5963
b	Current fallow	11056
Source: Statistical Handbook, Assam 2016		
6	Net area sown	136071
7	Total cropped area	148421

Source: Agricultural Census, 2015-2016

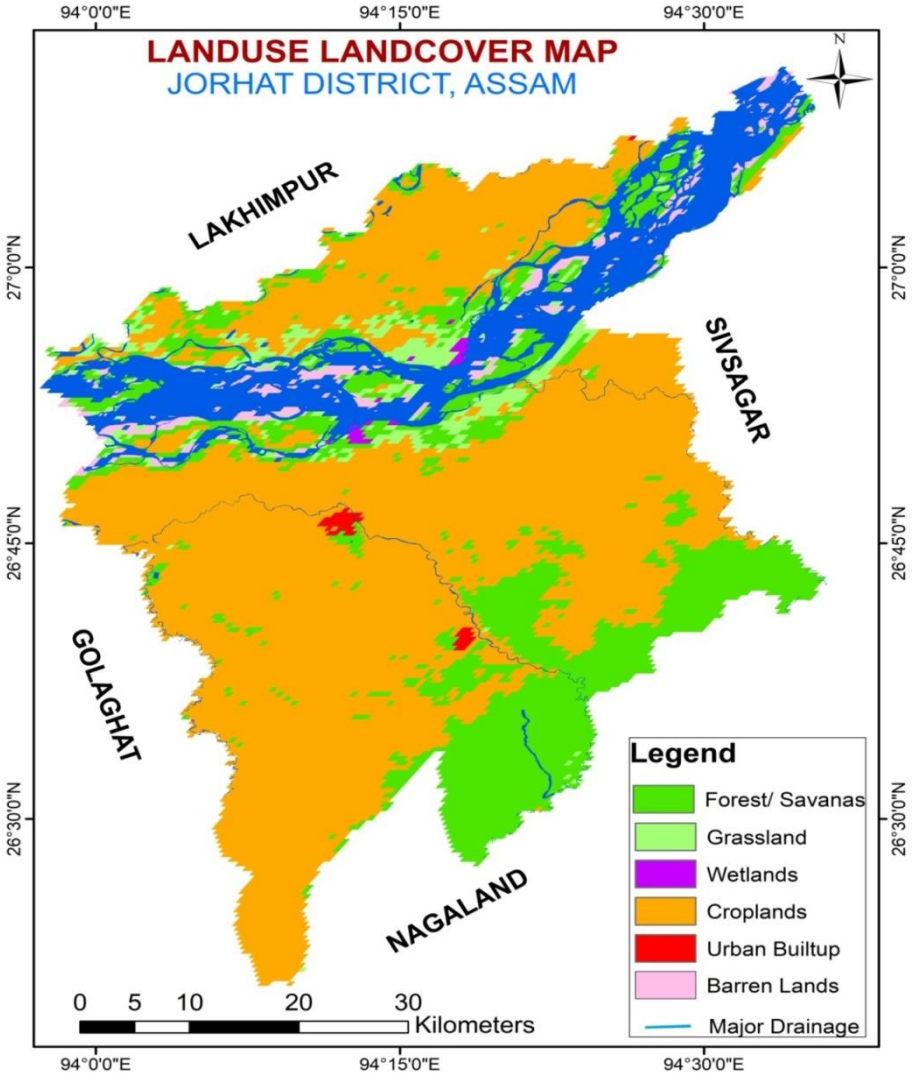


Fig 1.8: Land use Map of Jorhat District (data source: MODIS Land cover-Product MCD12Q1, land cover type 1)

1.13 Soil

The soils of the district are generally acidic in nature. The mild acidic soils of the district can be reclaimed through appropriate amendment and can be further utilized. Micronutrient

deficiency specially found in the district. Besides this, the occurrence of flood, sand deposition of soil erosion is also prevailing in the district.

The soil of Jorhat district predominantly sandy loam (58.25%) of total soils. While 15.40% silty clay loam, 9.92% sandy, 8.17% loamy and 8.26% clay soils. However, this composition varies across the blocks, sandy soil varies from zero(Baghchung block) to 43% (Jengrai), sandy loam 45% (Jengrai, Majuli), 67% (Kaliapani block), loamy soil zero (Chipahikhola block) to 12% (Baghchung block), silty clay loam 6% (Kamalabari and Jengrai block) to 21% (Chipahikhola) and clay soil from zero (Kamalabari and Jenrai block) to 12% (Titabar block). The soil of this district is very fertile for cultivation and the main crops are paddy, oilseeds, and potato. The main horticultural products are banana, jackfruit, mango, pineapple etc. In addition, the district is rich with sizeable production of vegetables.

Table 1.6: Soil Profile of the district.

Sr. No.	Major Soil Classes	Area (ha)	Percent (%) of total geographical area
1	Sandy Loam	166070.75	58.25
2	Sandy	28281.92	9.92
3	Clay	23549.26	8.26
4	SiltyClay Loam	43905.4	15.40
5	Loamy	23292.67	8.17

Source: District Irrigation Plan, Jorhat.

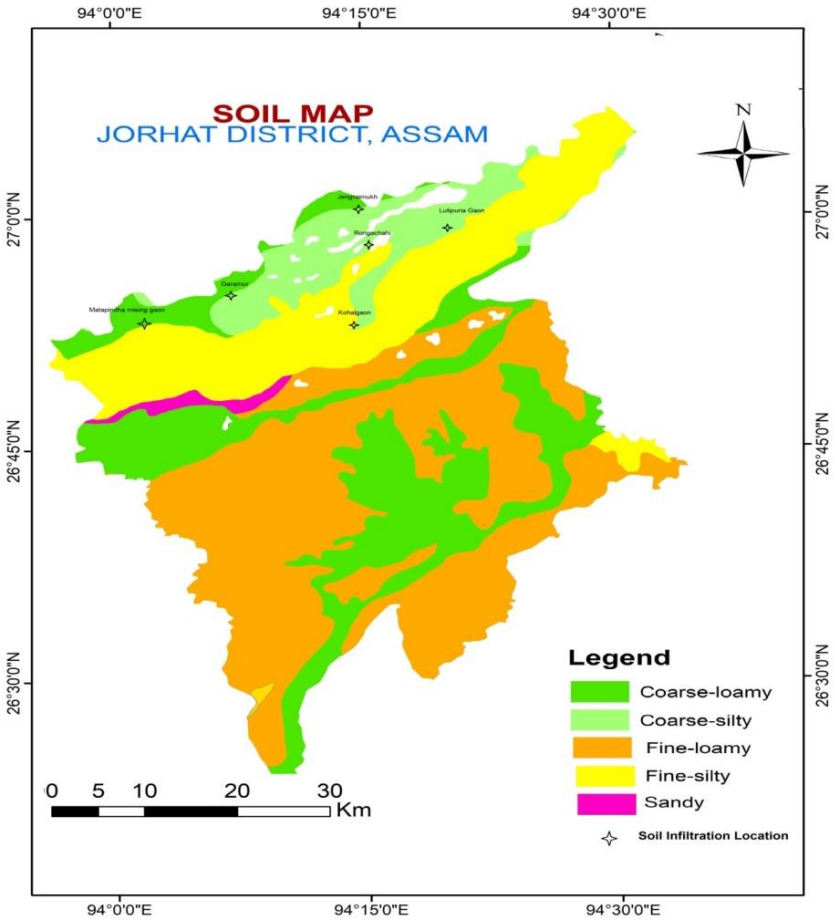


Fig 1.9:Soil Map of Jorhat District, Assam

1.14 Hydrology and Drainage

The Brahmaputra is the principal river that mainly drains the area. Its tributaries namely Jhanji, Bhogdoi and Kakodonga originating from the Naga Hills of the Purvanchal Hill ranges flow through the district. These along with a number of streams flowing from the south and southeast merge into the mighty river Brahmaputra in the north of the district. Overall the drainage network of the area shows a dendritic drainage patterns. Collectively, the rivers after coming down from hills show a marked tendency to move towards south-westerly direction.

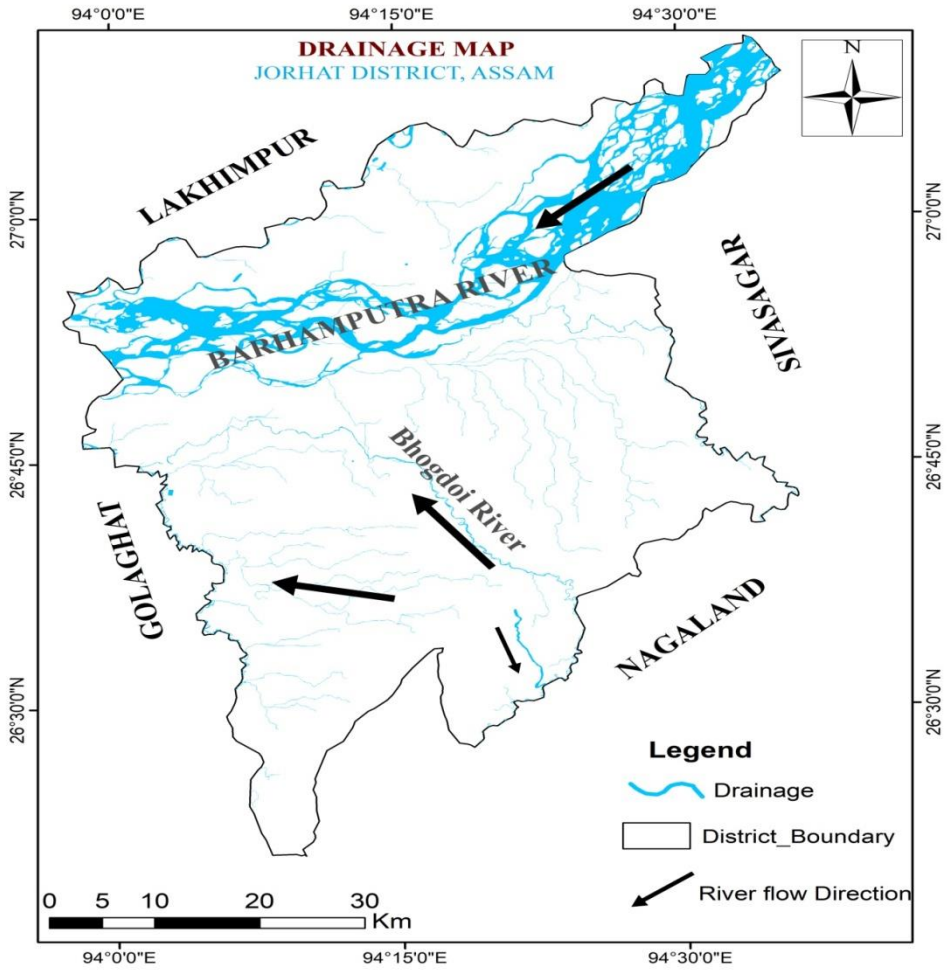


Fig 1.10:Drainage Map of Jorhat District, Assam

1.15 Agriculture and Plantation

The economy of the whole of Assam is agrarian in character and Jorhat district is no exception to this. Growing of tea, paddy, sugarcane, vegetables and fruits etc. is found extensively carried out, crops like pulses, mustard seeds are grown in plenty. Rice growing is common in all the areas of the district. The hilly areas are suitably used for tea plantation. Based on the extensive production of these items three agricultural research centres namely (1) Rice experimental station at Titabor, (2) Toklai experimental station of Jorhat and (3) Agro-economic research station at Jorhat have been established.The major crops grown are paddy, wheat; mustard, sesamum, black gram, green gram, lentil, chillies, turmeric, ginger, sugarcane and others are grown to a minor extent. Paddy is mostly grown as both Ahu (autumn) and Sali (winter) in kharif season. Ahu is grown by broadcasting in the month of March-April and harvested in June-July. Sali is cultivated by both broadcasting and transplanting in June-august

and harvested in December-January. Bao (low land/deep water) paddy is also grown to some areas in kharif season. Boro paddy (summer) is grown in Rabi season to a less extent. Irrigation facilities are very meagre and occasional floods also cause problem of crop failure. The general crop rotations followed in the district are Paddy-wheat, paddy-pulses or oilseeds, paddy-fallow-paddy, pulses-vegetables and major areas are under only one crop, mainly paddy.

CHAPTER 2.0
DATA COLLECTION AND GENERATION

2.1 Data collection

Data collection includes collection of rainfall data from state government, compilation of CGWB's earlier survey data, GWMS data, chemical data, exploration data and geophysical data. Population data is collected from district Census handbook (2011). Agriculture data are taken from Agriculture Census Department of Agriculture & Farmers Welfare. CGWB had constructed 19 nos of exploratory wells in this area earlier and during current annual action plan 2 nos exploratory well has been constructed.

2.2 Data Generation

2.2.1 Geophysical survey

In surface geophysical methods, physical properties of subsurface formations and contained fluids are measured by instruments located on the surface. All the operations are carried out on the surface only. Out of the many techniques, electrical resistivity methods are most widely used in groundwater studies. The main objectives of the geophysical surveys are to provide the information about the thickness of weathered and fractured zones, depth to bed rock, delineation of solution cavities in Karst formations, structural and stratigraphic conditions controlling ground water occurrences etc. During AAP 2021-22, there was 09nos VES conducted in the area. CGWB old record were collected and examined. Total 19nos VES survey was conducted earlier. The location details of these VES survey is shown in Table 2.1.

Table 2.1: Location details of VES data

S N	District	Block	Location	Lat	Long	Elevation	Depth of interpretation	Agency
1	Jorhat	East Jorhat	Deberapar	26.6960	94.4210	119	28	CGWB
2	Jorhat	Central Jorhat	Dangoritol	26.8050	94.2930	90	108	CGWB
3	Jorhat	Central Jorhat	Chenijan	26.8020	94.2860	93	99	CGWB
4	Jorhat	East Jorhat	Nakachari	26.6930	94.3990	117	191	CGWB
5	Jorhat	Jorhat	APDCL Nagajanka	26.6250	94.3240	119	112	CGWB
6	Jorhat	East Jorhat	Deha	26.7790	94.3580	97	54	CGWB
7	Jorhat	East Jorhat	Hemlai	26.7350	94.4580	113	56	CGWB
8	Jorhat	East Jorhat	Kaparadhara	26.7990	94.2960	91	40	CGWB
9	Jorhat	East Jorhat	Selenghat	26.6540	94.4080	131	159.2	CGWB
10	Jorhat	East Jorhat	Maibelia	26.6910	94.4330	120	185.8	CGWB
11	Jorhat	East Jorhat	Naganijan TE	26.6820	94.4500	125	146	CGWB
12	Jorhat	Jorhat	Bachagaon	26.6320	94.3570	125	156	CGWB
13	Jorhat	East Jorhat	Dihingiapar TE	26.6630	94.3730	122	93.6	CGWB
14	Jorhat	Jorhat	Kathalguri TE	26.6570	94.3500	121	264.7	CGWB
15	Jorhat	Jorhat	bahoni	26.5920	94.2860	117	112.3	CGWB
16	Jorhat	Titabar	Bandarchaliha	26.5770	94.2880	122	61.3	CGWB
17	Jorhat	Titabar	Balijan	26.5730	94.2730	118	41.3	CGWB
18	Jorhat	Jorhat	Gotonga	26.5970	94.3190	123	241	CGWB
19	Jorhat	Jorhat	Katanibari TE	26.6650	94.2920	111	130	CGWB
20	Jorhat	Majuli	Lakhomi	27.0794	94.2853	83	191	CGWB
21	Jorhat	Majuli	Kaharduvi	27.0122	94.2456	83	46	CGWB
22	Jorhat	Majuli	Naganchuk	27.0361	94.2544	84	164	CGWB
23	Jorhat	Majuli	Mohkina	26.9469	94.1572	82	125	CGWB
24	Jorhat	Majuli	Borbil	26.9383	94.2642	84	22.7	CGWB
25	Jorhat	Majuli	Pashimsyam	27.0488	94.3271	88	91.6	CGWB

S N	District	Block	Location	Lat	Long	Elevation	Depth of interpretation	Agency
26	Jorhat	Majuli	Ratanpur Shikargaon	27.0738	94.4027	87	104	CGWB
27	Jorhat	Majuli	Mohirchuk	26.9359	94.0320	79	175	CGWB
28	Jorhat	Majuli	Bokajanmiri	27.0156	94.3115	84	12.7	CGWB

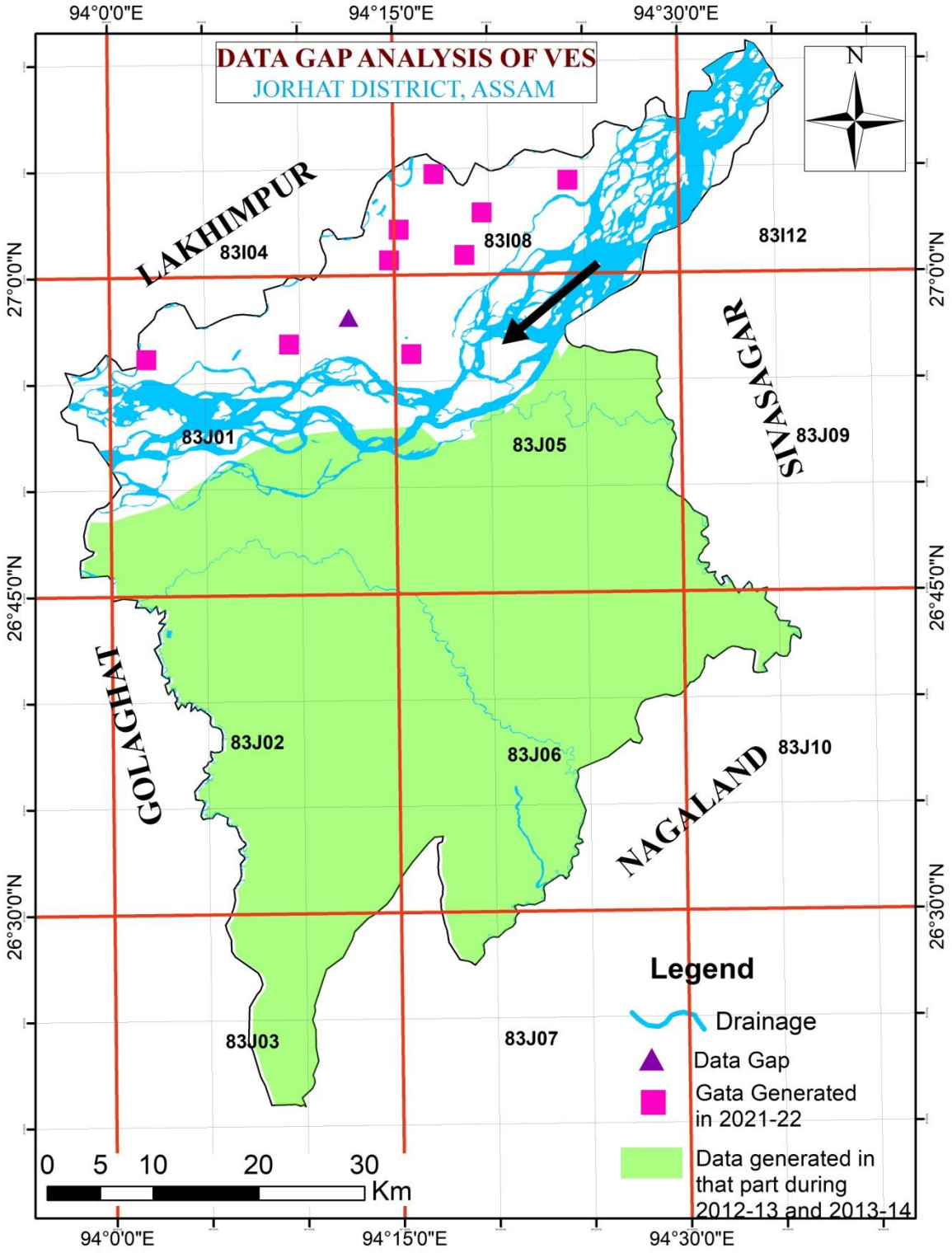


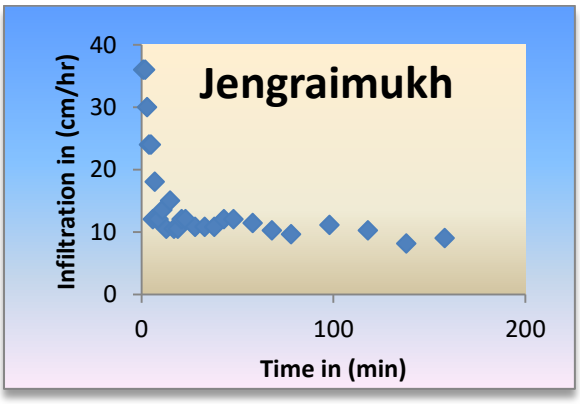
Fig 2.1:Available data and data generation map of VES

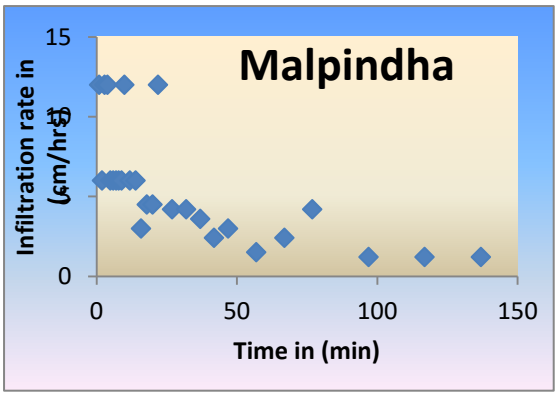
2.2.2 Soil Infiltration studies

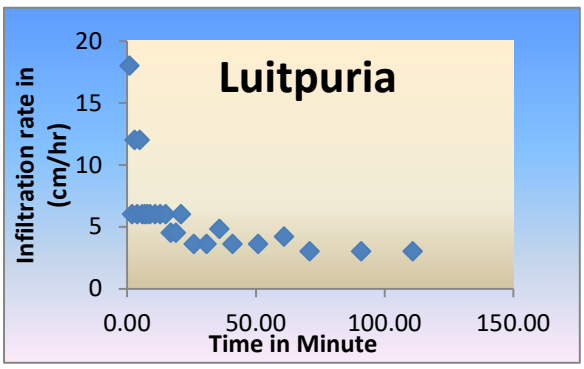
Salient features of the soil infiltration test are provided in Table 8. A perusal of the table shows that the test has been conducted only in barren land and the soil types encountered in the sites are sand/ Sandy Cay/Sandy loam admixtures. The infiltration test was conducted for 111 to 206 minutes.

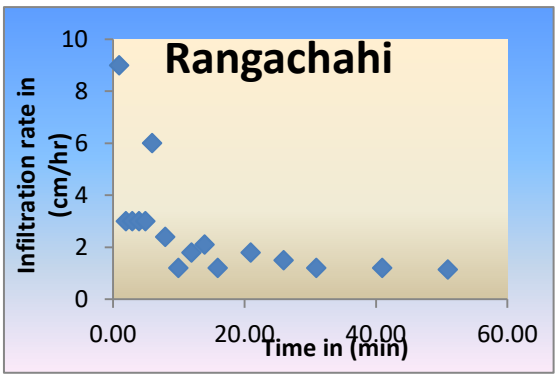
Table 2.2: Summary of Infiltration Test

S N	Site	Latitude	Longitude	RL (m)	Land use	Soil type	Infiltration rate mm/hr	Duration of test (min)	Total Quantum of water added in m	Total quantum of water recharged in m	Infiltration Factor
1	Jengraimukh	27.08	94.29	86	Barren	Sandy	147	158	0.43	0.05	10.77
2	Malapindha	26.95	94.06	82	Barren	Sandy	55.2	137	0.17	0.01	6.21
3	Luitpuria	27.05	94.35	90	Barren	Sandy	59.7	111	0.08	0.01	6.31
4	Rangachahi	27.02	94.27	83	Barren	Sandy	33.1	141	0.19	0.01	3.61
5	Kohalgaon	26.93	94.29	85	Barren	Sandy	83	112	0.25	0.02	6.38
6	Garamur	26.98	94.15	83	Barren	Sandy	17.6	206	0.19	0.00	2.52









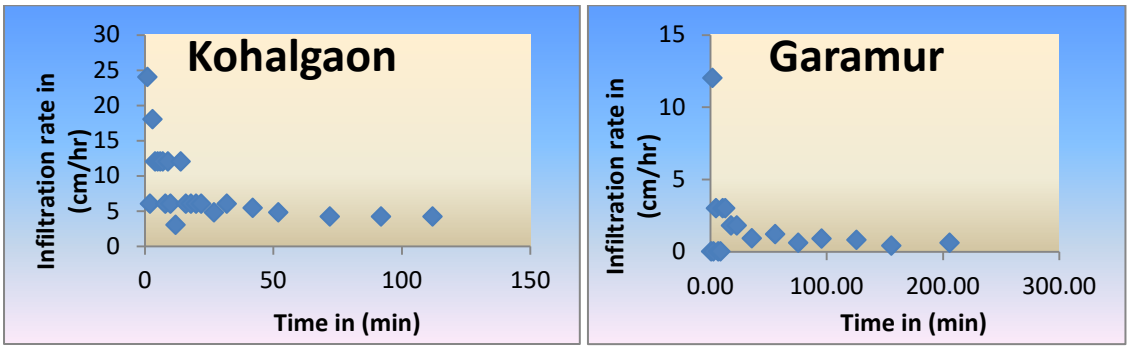


Fig 2.2: Time Vs Soil infiltration rate plot.

2.2.3. Water Quality

To understand the chemical quality of groundwater in the study area and its suitability for domestic, drinking and agricultural utilization, 46 nos. of pre-monsoon and 31 nos. of post monsoon ground water samples were collected from monitoring wells for analysis of basic elements, iron, heavy metals and arsenic. The ground water samples are submitted to Regional Chemical Laboratory CGWB NER Guwahati for chemical analysis. Chemical quality analysis data attached in annexure II, III, IV and V.

Fig 2.3: Field photograph showing water quality analysis, soil infiltration study and water level monitoring.

2.2.4 Exploratory Drilling

During AAP 2020-21, 2 nos of exploratory well drilled by CGWB in study area. 19 nos of Exploratory wells drilled by CGWB before NAQUIM, and 2 nos Exploratry well data from irrigation department, Assam and examined. Data gap analysis shown in Fig. 2.4..

Table 2.3: Details of exploratory wells in the study area

S N	Location	Block	Lat	Long	RL	Depth (m)	Discharge m^3/hr
1	Melamati	Titabor	26.5761	94.1389	92	300.2	
2	Bibijan	Titabor	26.76	94.2	82	200	85.14
3	Gohaigaon	Kaliapani	26.85	94.48	92	300.5	211.44
4	Boishabi	East Jorhat	26.78	94.5	101	288.3	NA
5	Maibalia	East Jorhat	26.7	94.44	116	299.3	7.77
6	Jagduar	Central Jorhat	26.86	94.44	90	NA	NA
7	Kakojan	Central Jorhat	26.81	94.36	92	311.77	206.16
8	Nagajanka	Jorhat	26.63	94.36	120	165.4	29.1
9	Dekagaon	Jorhat	26.67	94.3	111	292.8	NA
10	Lichubari	Jorhat	26.6833	94.228	98	230.74	22.79
11	No-1 Sonarigaon	Titabor	26.74	94.19	93	175	67.90
12	Jalukunibari	Titabor	26.6414	94.1914	83	160.55	68.04
13	Machorhat	Jorhat	26.5264	94.0764	94	171.3	NA
14	Brahmingaon	East jorhat	26.8289	94.26	90	457.3	211.42
15	Bhalukmora	Jorhat	26.6696	94.0971	90	107	NA
16	Rangajan	Jorhat	26.6394	94.2165	103	150	NA
17	Mithaamtol	Jorhat	26.8333	94.1348	85	103.65	NA
18	Khalnagon	Jorhat	26.8333	94.0083	83	106.68	NA
19	Koronga	Jorhat	26.695	94.2403	105	124	NA
20	Karkichuck Phuluni	Majuli	27.0404	94.2685	83	88.4	21.6
21	Chilakola Gaon	Majuli	26.9488	94.0969	83	86.2	18
22	Jengraimukh chapori	Majuli	27.0827	94.2891	84	73.52	94.63
23	Lakhimi Kathalguri	Majuli	27.0850	94.2907	83	73.52	94.63

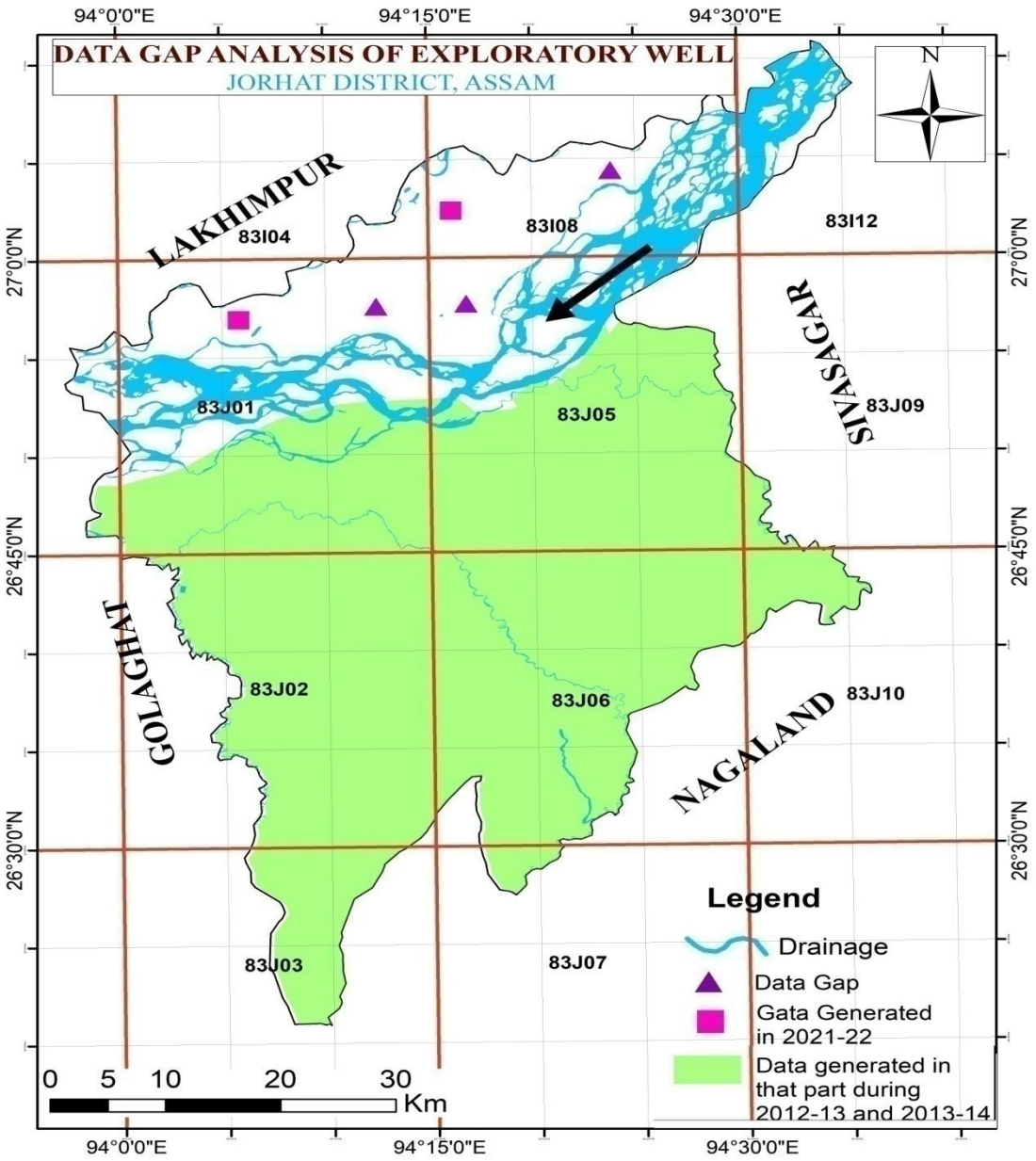


Fig 2.4:Available data and data generation map of exploration in the study area

2.2.5 Hydrogeological data

The entire study area is covered by regular monitoring of existing GWMS and another 22 key wells have been established. All these wells are under regular monitoring after establishment.

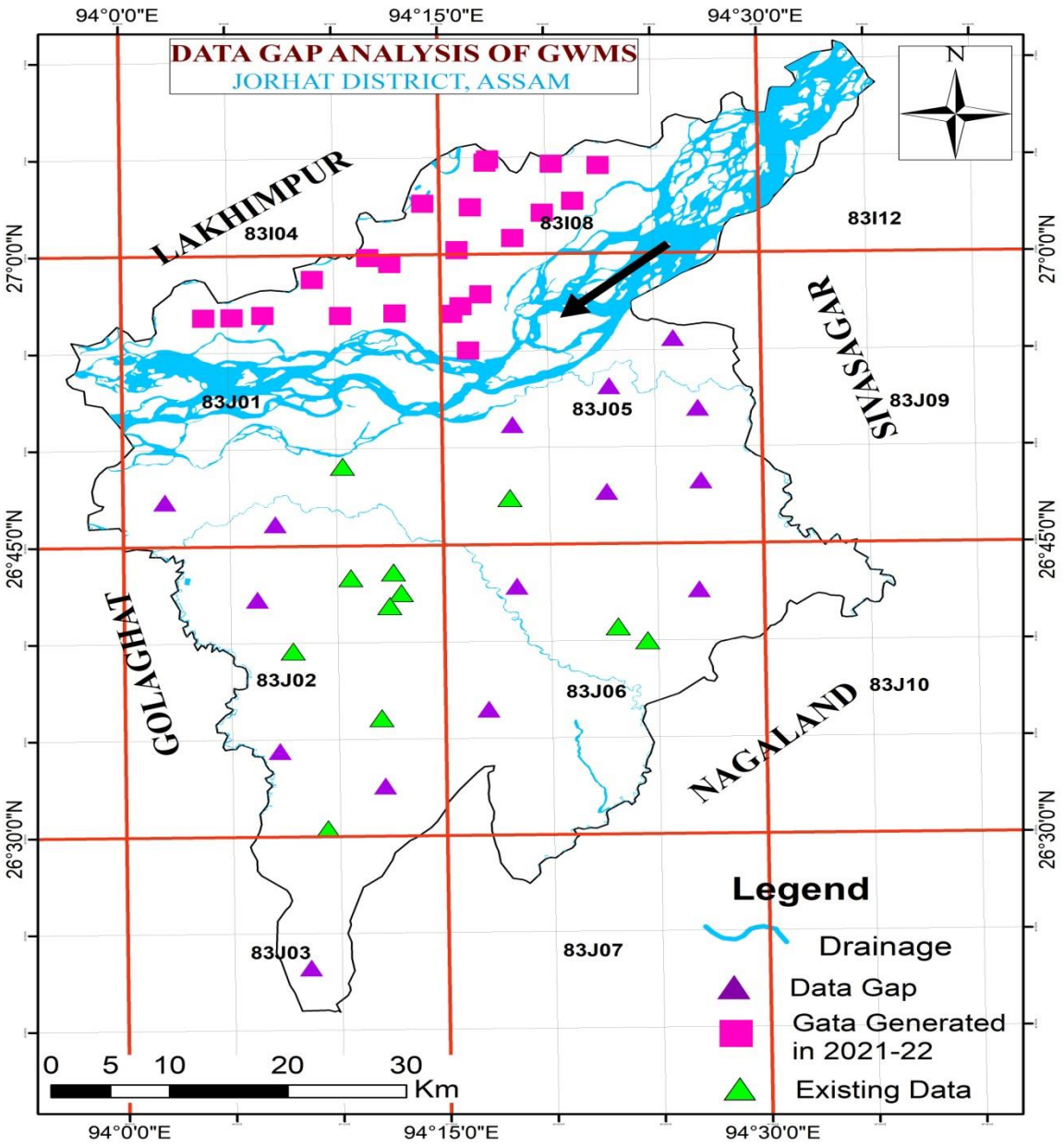


Fig 2.5:Available data and data generation map for ground water level monitoring

Table 2.4: Details of GW Monitoring Stations in the study area

S N	Location	Block	Lat	Long	RL	Type of Well	Depth (m)	Agency
1	Cinemora	Jorhat	26.7094	94.2164	82	DW	6.76	Private
2	Dabarapara	Jorhat	26.6667	94.4083	85	DW	3.78	Private
3	Kokilamukh	Jorhat	26.8186	94.1717	78	DW	6.52	Private
4	Lichubari	Jorhat	26.7272	94.2106	74	DW	2.04	Private
5	Meleng Kaparadharia	Jorhat	26.7903	94.3022	99	DW	3.6	Private
6	Sodial Kachari	Jorhat	26.5067	94.1569	83	DW	5.03	Private
7	Bijay Nagar	Jorhat	26.7225	94.1772	96	DW	3.2	Private
8	Kamarbandha TE	Jorhat	26.66	94.1314	94	DW	NA	Private
9	Kunwari Pukhuri	Jorhat	26.6983	94.2072	84	DW	NA	Private

10	Gatisunga	Jorhat	26.6789	94.3853	97	DW	7.08	Private
11	Titabor	Jorhat	26.6018	94.2	98	DW	NA	Private
12	Jengraimukh	Majuli	27.0792	94.2862	86	TW	14.18	Private
13	Mekheli gaon	Majuli	26.9557	94.2658	87	TW	29	State Govt.
14	Mudoi gaon	Majuli	26.9658	94.2814	90	TW	7	State Govt.
15	Pohumora	Majuli	27.0041	94.2634	85	TW	9	State Govt.
16	Kamalabari	Majuli	26.9483	94.1715	85	TW	28	State Govt.
17	Merua bari	Majuli	26.9979	94.1934	84	HP	7.91	Private
18	Rajguru bari	Majuli	26.95	94.2141	85	TW	47	State Govt.
19	Dakhinpat kalita gaon	Majuli	26.9176	94.2713	85	TW	19	State Govt.
20	2 no. borgayan	Majuli	26.9489	94.1108	83	TW	12	State Govt.
21	Balichapori	Majuli	26.947	94.0866	83	TW	12	State Govt.
22	Malapindha Mising Gaon	Majuli	26.947	94.0644	81	TW	15	State Govt.
23	Phuloni	Majuli	27.0408	94.2743	86	TW	11	State Govt.
24	Punctang gaon	Majuli	27.0762	94.3747	97	HP	10	Private
25	Major deuri gaon	Majuli	27.0777	94.338	86	HP	14	Private
26	Kohardubi gaon	Majuli	26.9927	94.2106	85	HP	7.2	Private
27	Garamur satra	Majuli	26.9795	94.1498	81	DW	4.75	Private
28	Narasingha satra	Majuli	27.0356	94.3305	88	TW	8.98	State Govt.
29	Sukansuti gaon	Majuli	27.0457	94.3544	90	TW	10.38	State Govt.
30	Bokajan gaon	Majuli	27.0141	94.307	89	HP	19.26	Private
31	Laon gaon	Majuli	27.0443	94.2371	85	HP	8.66	Private
32	Jengraimukh IB	Majuli	27.082	94.2884	86	TW	10.09	State Govt.
33	Rawnapar BTS	Majuli	26.9493	94.2584	84	DW	4.37	State Govt.

Chapter 3.0
DATA INTERPRETATION, INTEGRATION AND AQUIFER MAPPING

3.1 Data Interpretation

The subsurface geology of Jorhat District is interpreted based on exploration data of Central Ground Water Board (CGWB) and exploration data of State Govt. of Assam. The drilling depth of CGWB's exploratory well ranges from 86 to 457mbgl.Whereas irrigation departments exploratory well depth ranges up to 73.52mbgl.

Table 3.1: Distribution of EW based on drilled depth

Depth	< 50m	50-100m	100-150 m	150-200 m	200-300 m	>300 m
No of wells	0	5	5	5	4	4
% of wells	0	21.7	21.7	21.7	17.4	17.4

From the examination of available litholog, it is observed that down to a maximum explored depth of 457m, the subsurface lithlogy is dominated by, sand, clay, sand with gravel and clay mixed with sand. The available data indicate major aquifer of the district is younger alluvium (AL01) of quaternary age.

3.1.1 Aquifer Disposition

Following sections are constructed to show the 2D disposition of aquifers in the district.

(i) 2D disposition along Brahmaputra River: Section prepared parallel to Brahmaputra river showing 6 clay beds in the western side of district. These clay layers are absent in Khalnagaon and Mithaamtol EW. Upto 100 m thickness the aquifer material is dominated by sand. However, beyond 100m clay beds is dominated.

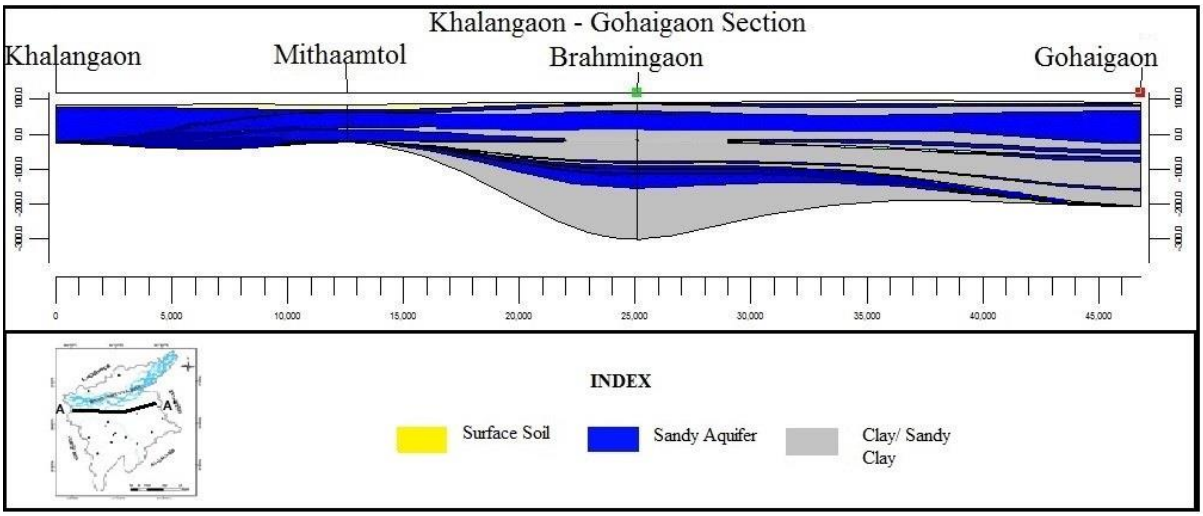


Fig 3.1: 2D disposition of aquifer along Brahmaputra River

(ii) 2D disposition along southern foothills: The thickness of the granular zone is less in this section. In Dekagaon and Maibalia EW clay is dominated down to a depth of 300m with intervening thin sand beds.

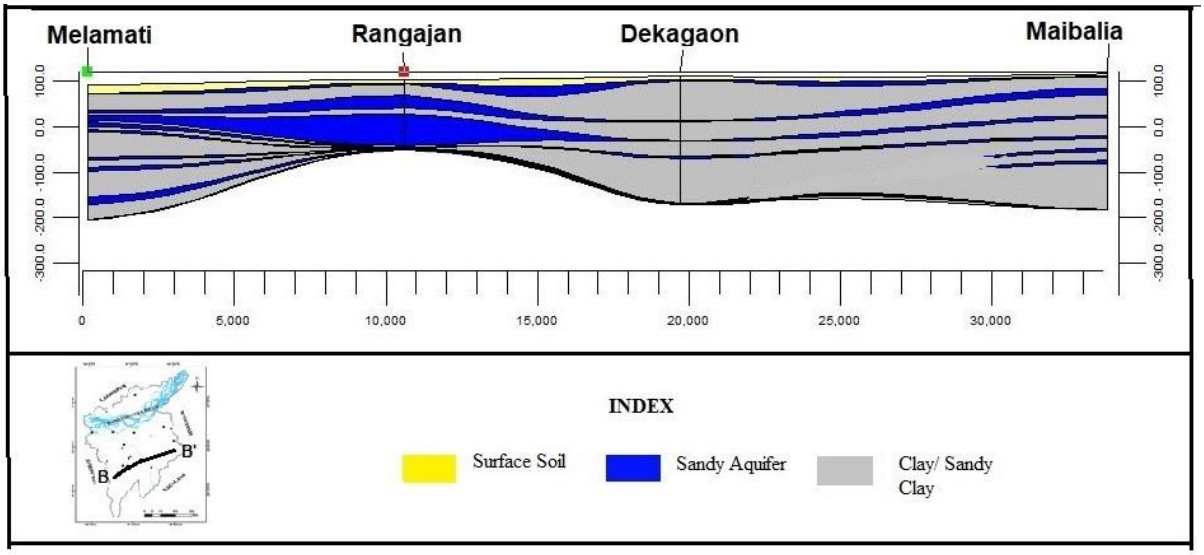


Fig 3.2:Cross section B-B' between Melamati-Maibalia.

(iii) 2D disposition of aquifer along NW-SE direction: This section indicates that the aquifer materials are dominated by sand, sand mixed with gravel and clay However sand is dominated in the northern part of the section near to Brahmaputra river and toward the south aquifer material is dominated by clay.

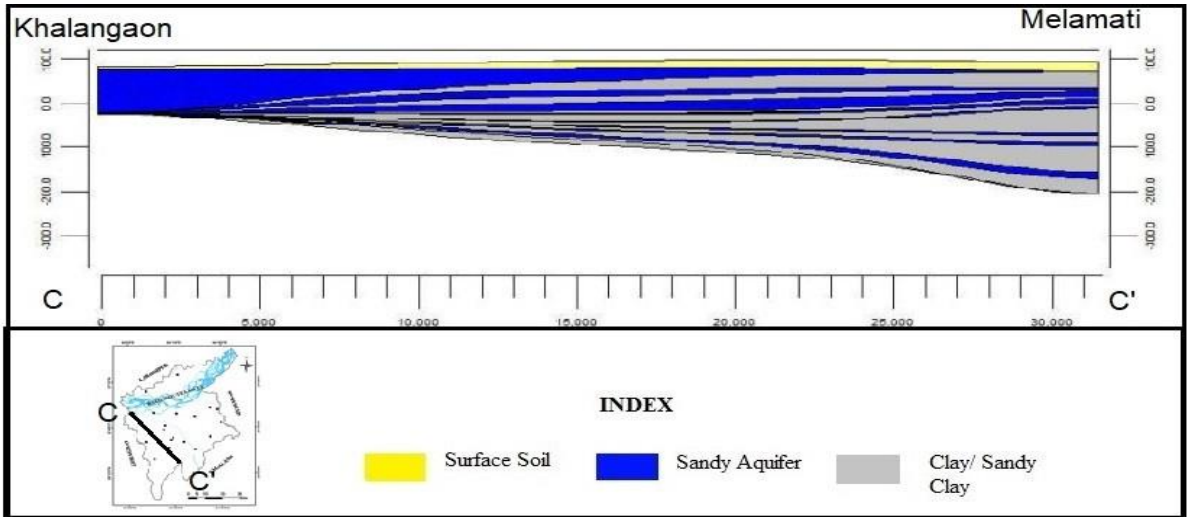


Fig 3.3: Cross section C-C' between Khalnagaon-Melamati.

3D disposition of aquifer: The fence diagram and 3D aquifer model of the district indicate that the sub-surface formation in the alluvial plain is dominated by sand, sand mixed clay, and clay. Various clay and sandy clay layers encountered south to Brahmaputra of district and thickness of this layer increasing toward south and south east. Granular zone thickness increasing toward north.

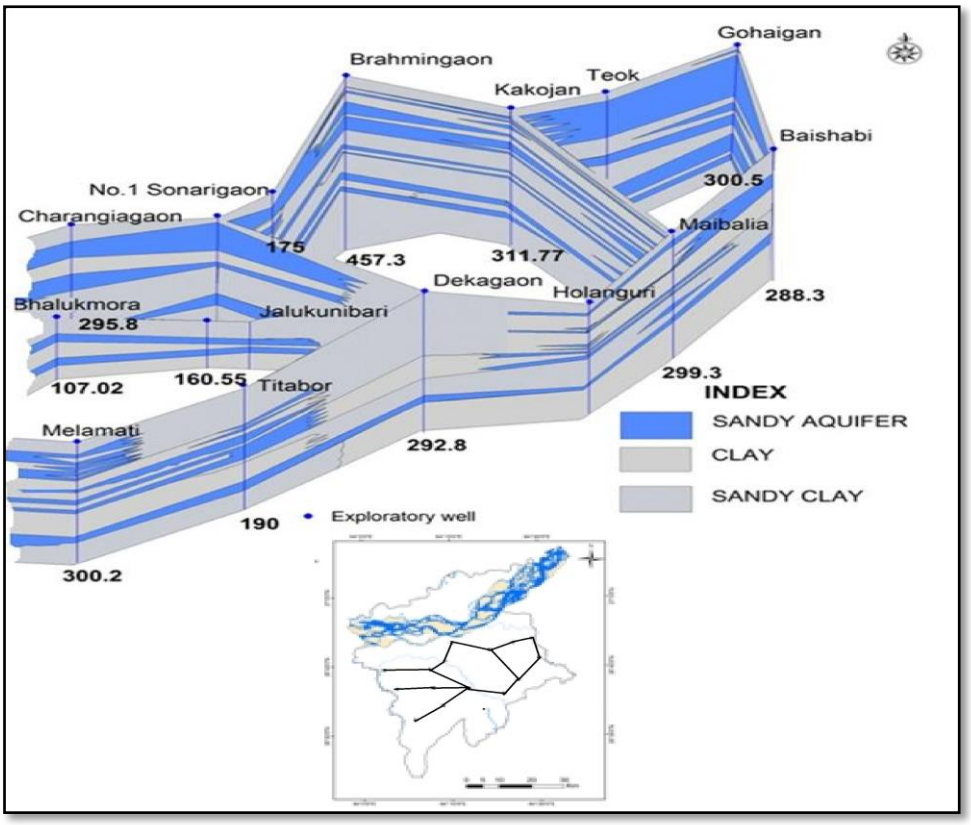


Fig 3.4:Fence diagram of showing aquifer disposition.

Aquifer Disposition in Majuli

The subsurface geology of Majuli is interpreted based on 2nos exploration data of Central Ground Water Board (CGWB) and 2 nos Exploration data of irrigation department, Assam. Following sections are prepared to shown the 2D disposition of aquifers in Majuli.

(i) Northeast- southwest section Parallel to Brahmaputra River: Based on available 4 EW data in Majuli, section prepared parallel to Brahmaputra River. Aquifer material is dominated by sand and gravelly sand up to the depth of 86 m except few meter thin clayey sand zone in the form of lenses shaped observed in the western side at 19m and 76m depth with 6.3m and 12.6 m thickness that are pinched out toward Karkichuck. (Fig.3.5)

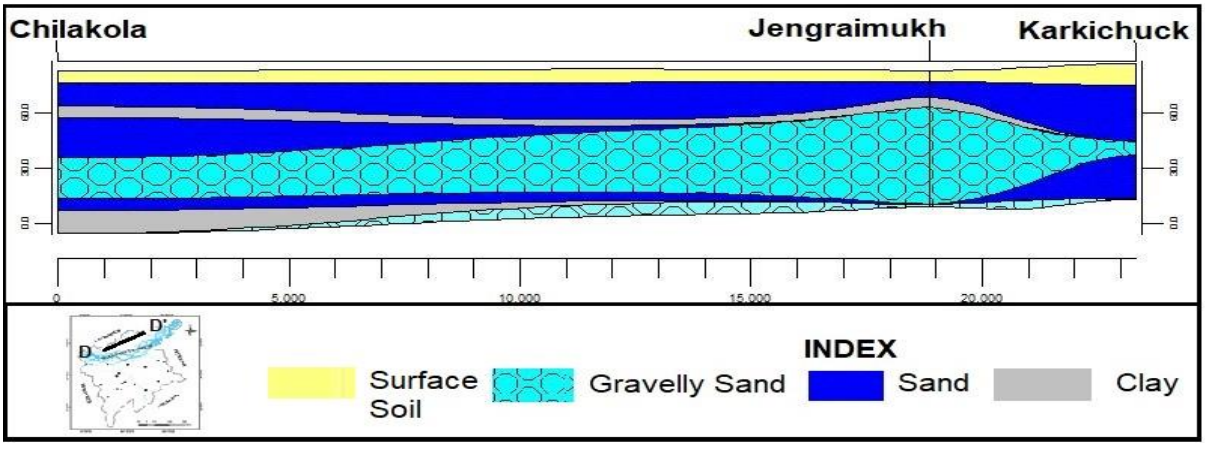


Fig 3.5:Northeast- southwest section Parallel to Brahmaputra River.

3.1.2. Aquifer Characteristics

Major aquifer of district is younger alluvium (AL01). The aquifer of the district can be broadly divided into two groups. Shallow aquifer depth limit is 50m and below which deeper aquifer exists. The cumulative thicknesses of both shallow and deeper aquifers are given in Table.

Table 3.2: Granular zones encountered in exploratory wells in Jorhat District, Assam

Village/Location	Drilled Depth (m)	Granular Zones/ Potential Zones Encountered	Cumulative thickness of granular zones (m)	
			GL to 50 m	50 to 300 m and above
Gohaingaon	300.5	25-134 232.4-278.2	25	129.8
Boishabi	288.3	67.7-76.9 86-98.2	0	21.4
Maibalia	299.3	3.5-40.1 103.6-126.6	36.6	23
Jagduar	NA	34-50	16	NA
Kakojan	311.77	45.7-50.3 66.77-89.72	4.6	22.95
Nagajanka	165.4	6.8-25.25 31.4-56, 62-68.3, 74.45-80.6, 89.9-96.05, 108-120, 135.95-165.4	37.05	65.55
Dekagaon	292.8	170-182	0	12
Melamati	300.2	57-61, 66-76, 81-91, 97-102, 159-165, 182-191, 250-266	0	60
Bibijan	200	28.2-31.2, 59-62, 74.25- 92.7, 95.85-98.85, 105-126.6	3	46.05
Lichubari	230.74	10-84.2, 122.67-125.67, 199.65-227.69	40	65
No-1 Sonarigaon	175	6.8-12.95, 71.45-99.50, 148.25-169.85	6.15	49.65
Jalukonibari	160.55	0-6.8, 142.1-154.4	6.8	12.3
Machorhat	171.3	0-53.1 59.15-83.75	50	115.25
Brahmingaon	457.3	22.6-28.6 107.1-137.16, 167.64-173.73, 181.35-189.55,	6	99.69

		190.5-202.60, 207.26-239.77, 241.4-247.40, 269.75-271.88, 317-320.6		
Bhalukmora	107.02	14.94-17.99, 19.82-50.91, 75.31-92.99,102.02-107.02	33.23	24.59
Rangajan	150	30-60 72-147	20	85
Mithaamtol	103.65	19.09-67.41 70.43-103.7	30.91	50.68
Khalnagaon	106.68	6.09-106.68	43.91	56.68
Koronga	124	42-124		
Karkichuk Phuloni	88.4	6.5-88.4	43.5	38.4
Chilakola	86.2	6.55-19.1 25.4-75.8	37.15	25.8
Jengraimukh chapori	73.52	6.09-12.19 18.28-73.15	37.82	23.15
Lakhimi Kathalguri	73.52	12.19-73.15	37.81	23.15

Shallow Aquifer zone: In shallow aquifer granular zone thickness varies from 0m to 50 m, and granular zone thickness increasing toward north of district, viz., at Kalangaon, Machorahat, Karkichuck Phuloni, Chilakola. It is observed that lowest thickness of this zone is found towards southern part of the district in Boisabi and Melamati.

The predominance of clay in the southern part of district within 50 m depth makes the shallow aquifer less productive Aquifer property storitivity, transmitivity, of shallow aquifer upto depth of 50m not known.

Deeper Aquifer Zone: The cumulative thickness of deeper aquifer beyond 200m could not be ascertained in all exploratory well, only 9 exploratory wells have drilling depth of 200 m or more, However based on the available information it can be confirmed that 12.3 to 129.8 m cumulative thickness of granular zones are available. The thickness of granular zone decreases toward south and south east. Groundwater within this depth range occurs under semi-confined to confined condition as storativity value ranges from 1.02×10^{-3} to 5.8×10^{-4}. Transmissivity value ranges from 6.65 to 5632 m2 /day. Discharge varies from 3.52 m^3/hrs to 221.4 m^3/hrs, for drawdown of 1.88m to 14.81m.

Table 3.3: Aquifer properties of deeper aquifer zones.

Depth Range (m)	SWL (mbgl)	Discharge (m3/hr)	Drawdown (m)	T (m2/day)	Permeability (m/day)	Storativity
50-457	2.05 to 19.90	3.52-211.4	1.88 – 14.81	6.65 - 5632	71.86 – 84.2	0.89^{-3} to 5.8×10^{-4}

3.2 Ground water level of shallow aquifer zone

To study ground water regime, depth to water level from 33 monitoring stations (GWMS 11, Key well 22) are measured seasonally. In pre-monsoon the depth-to-water level varies from 0.67 to 6.73 mbgl and in post monsoon depth-to-water level varies from 0.73 to 4.13 mbgl. In pre- monsoon deeper water level recorded at Kamlabari, Majuli block and shallow water level at Sodial Kacharigaon of Titabor Block. In post- monsoon deeper water level recorded in Jengraimukh of Majuli block and shallow water level at Vijay Nagar of Jorhat west Block (Fig. 3.6 and 3.7).

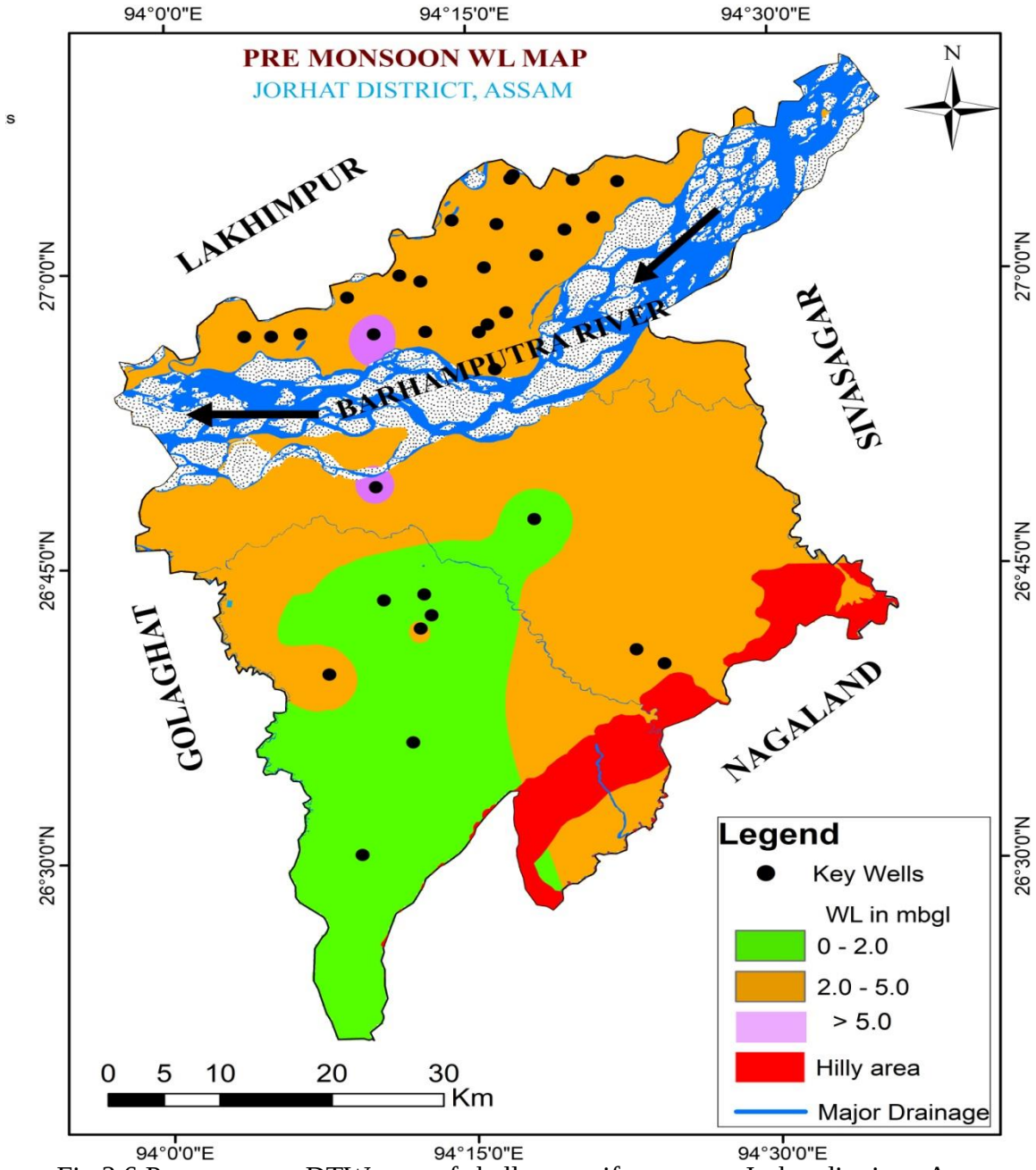


Fig 3.6:Pre-monsoon DTW map of shallow aquifer zones. , Jorhat districct, Assam

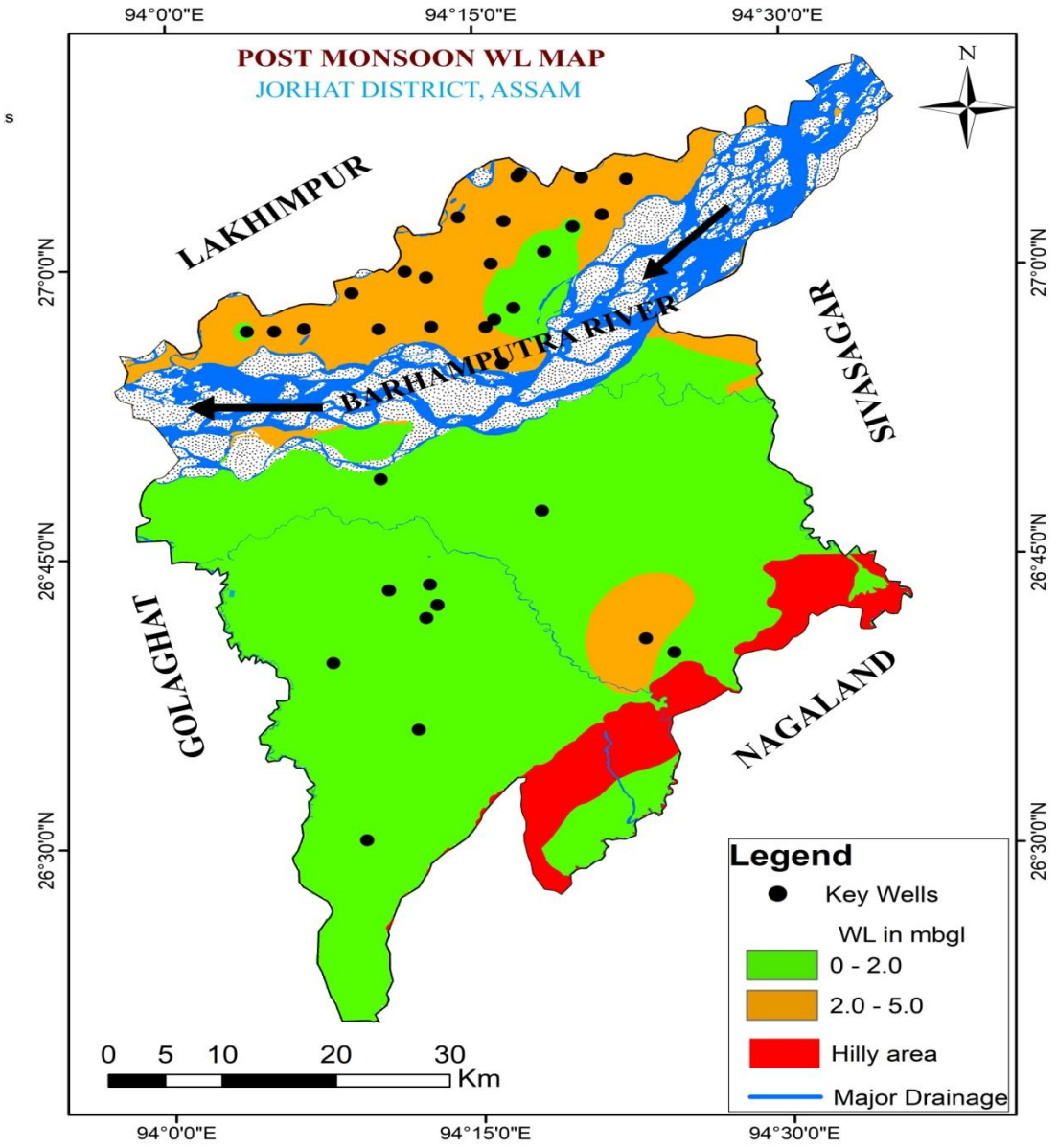


Fig 3.7:Post-monsoon DTW map of shallow aquifer zone, Jorhat districct, Assam

Seasonal fluctuation of water level ranges from0.04 m to 4.63m. Highest fluctuation observed in Kamlabari of Majuli block and Kokilamukh of Jorhat west block. Most of area showing water level fluctuation less than 2.0 m. (Fig. 3.8).

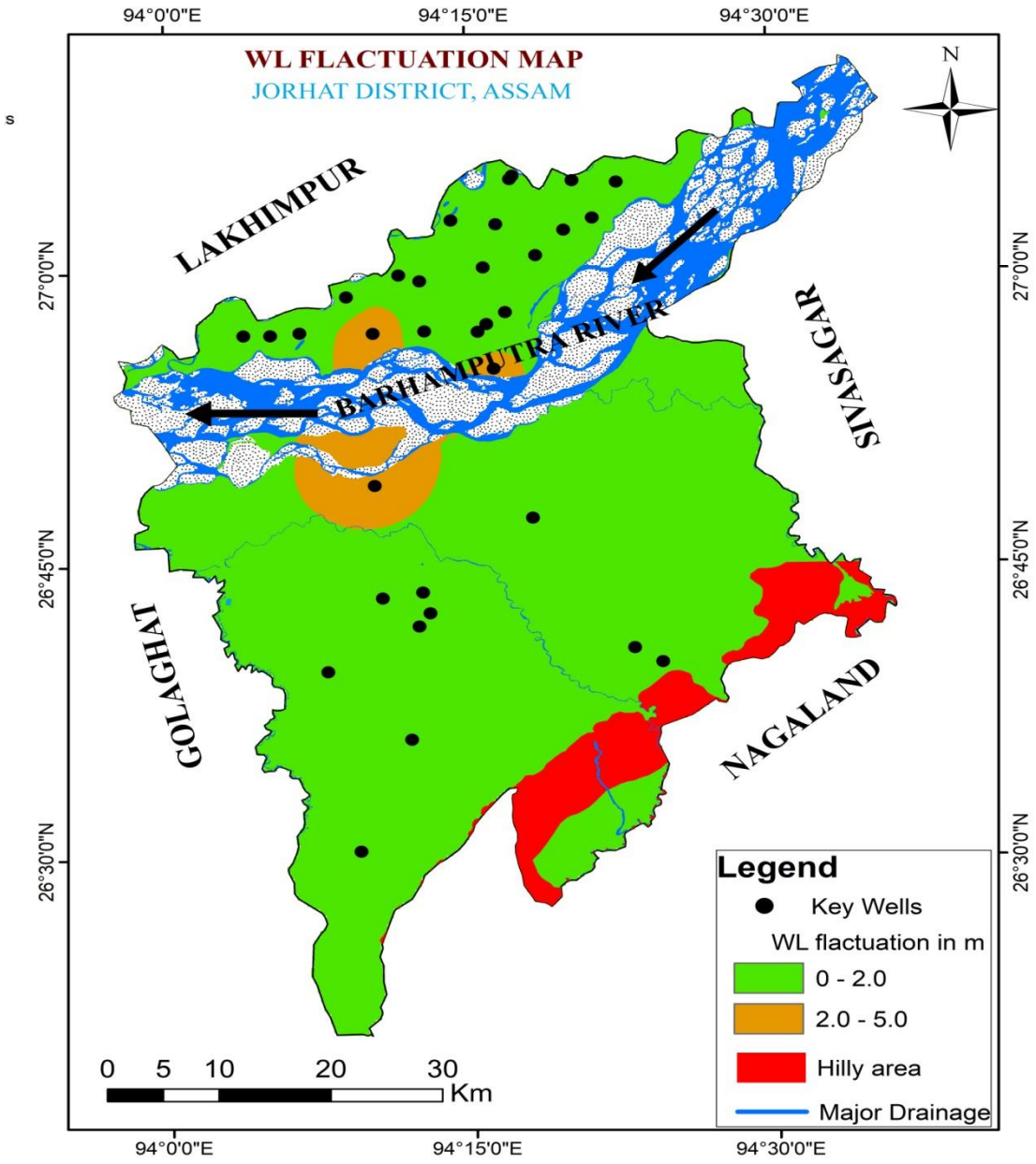


Fig 3.8:Water Level Fluctuation map , Jorhat districct, Assam

3.2.1 Ground Water Movement

The water table contour has been prepared based on water level of ground water monitoring stations which is shown in Fig.24.The ground water flow direction is toward Brahmaputra River. The highest water table is 100m and lowest water table 80 m above the mean sea level.

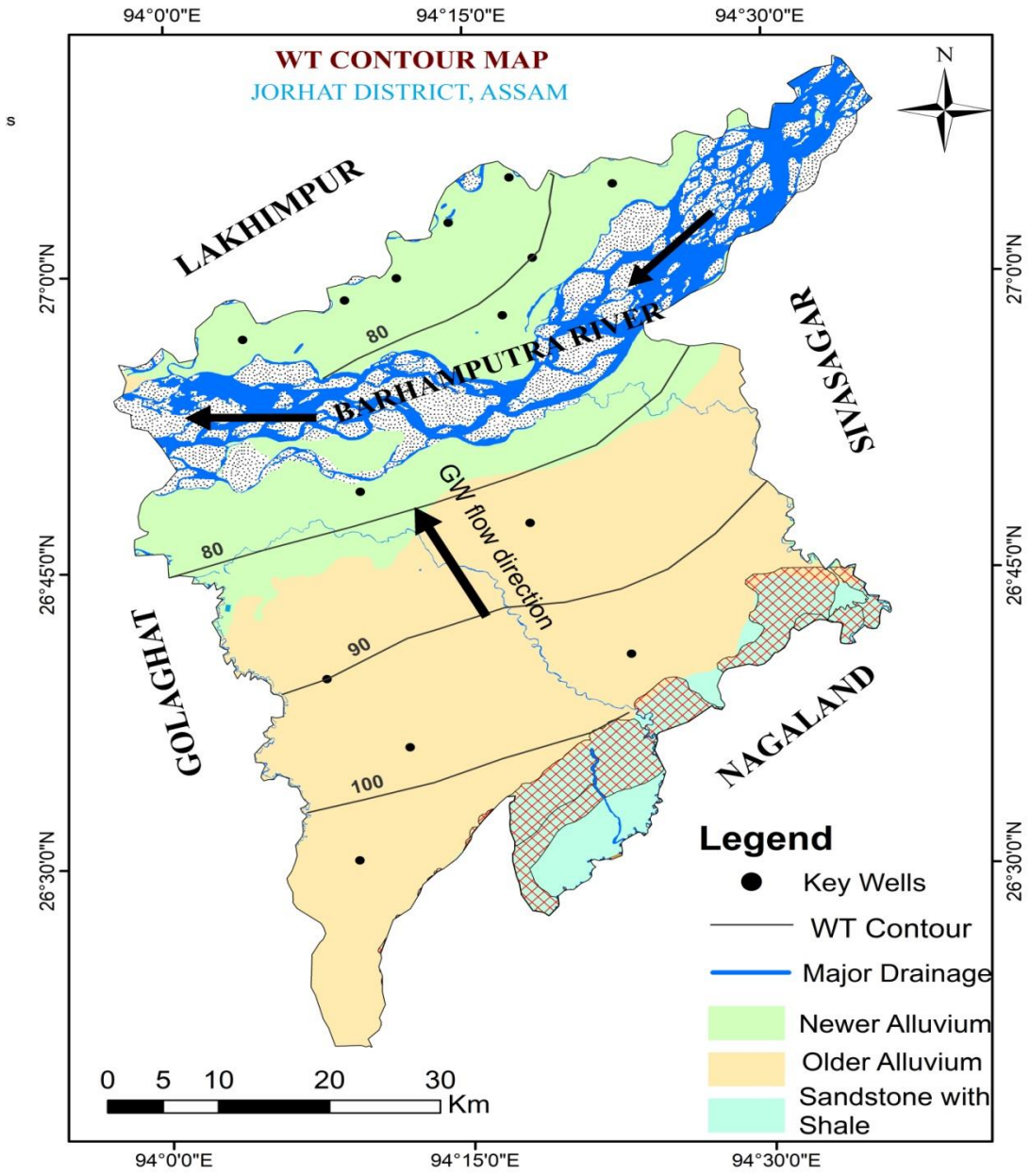


Fig 3.9:Water table contour , Jorhat district, Assam

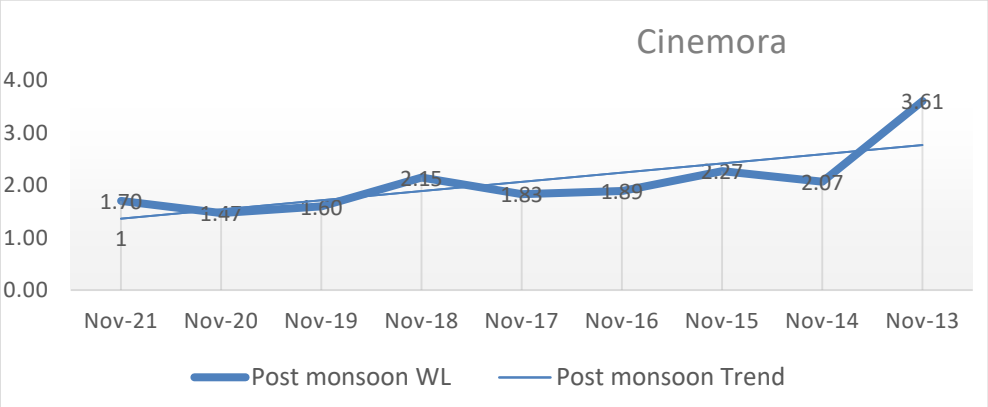
3.2.2 Water level trend analysis

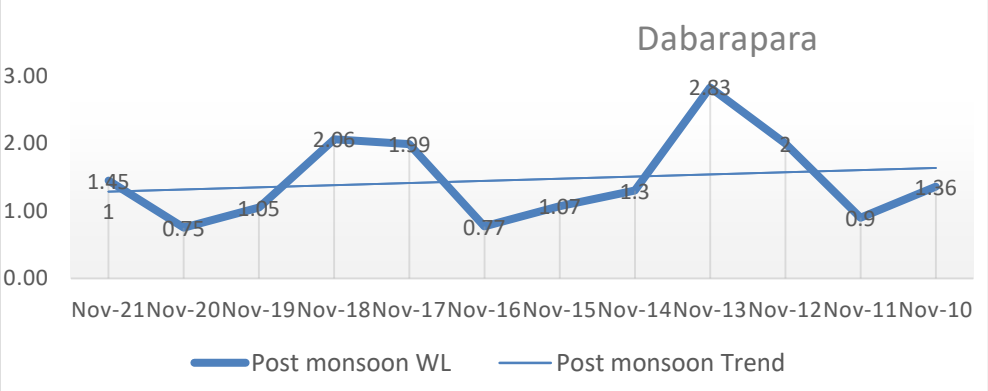
For analysis of long-term behavior of ground water level, data from Ground Water Monitoring Stations (GWMS) are utilized. Historical depth-to-water level data (in mbgl) are plotted as individual hydrographs and are given in Figure 25, 26 and Table 14 showing overall trend of water levels in GWMS wells of Jorhat district, Assam.

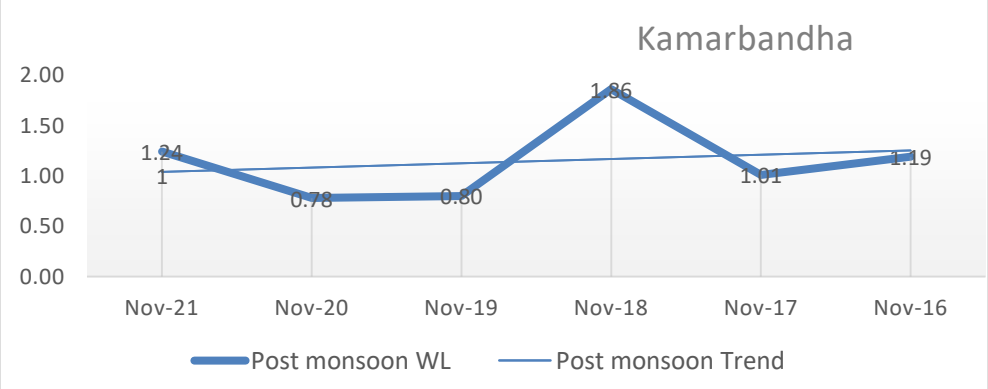
Table 3.4: Trend of Water levels in GWMS Wells

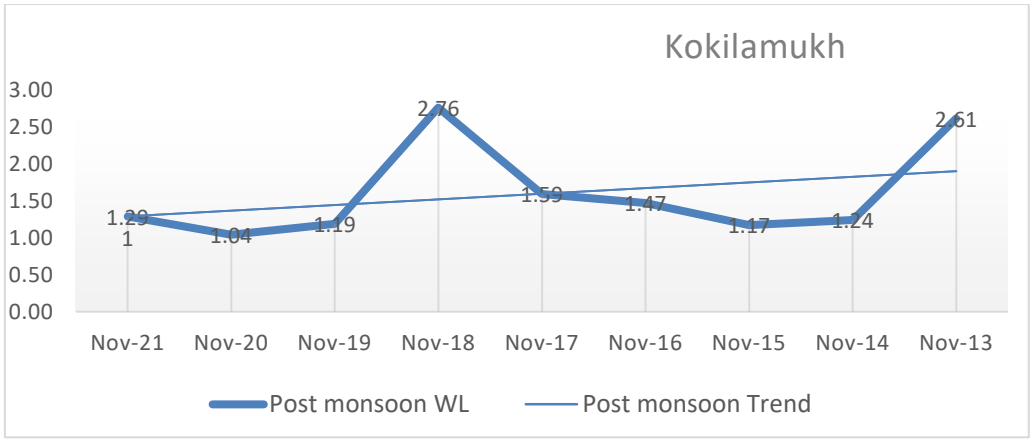
SN	Locality/Name	No. of years	Water Level Trend	
			Post-monsoon	Pre-monsoon
1	Cinemora	8	Rise	Rise
2	Debarapara	10	Rise	Rise

SN	Locality/Name	No. of years	Water Level Trend	
			Post-monsoon	Pre-monsoon
3	Kokilamukh	9	No significant change	
4	Meleng	8 and 7	Rise	Rise
5	Sodial	8	Rise	Rise
6	Titabor	10	Rise	Rise
7	Kunwari	6	No significant change	
8	Lichubari	8	Rise	
9	Kamarbandha	6	Rise	





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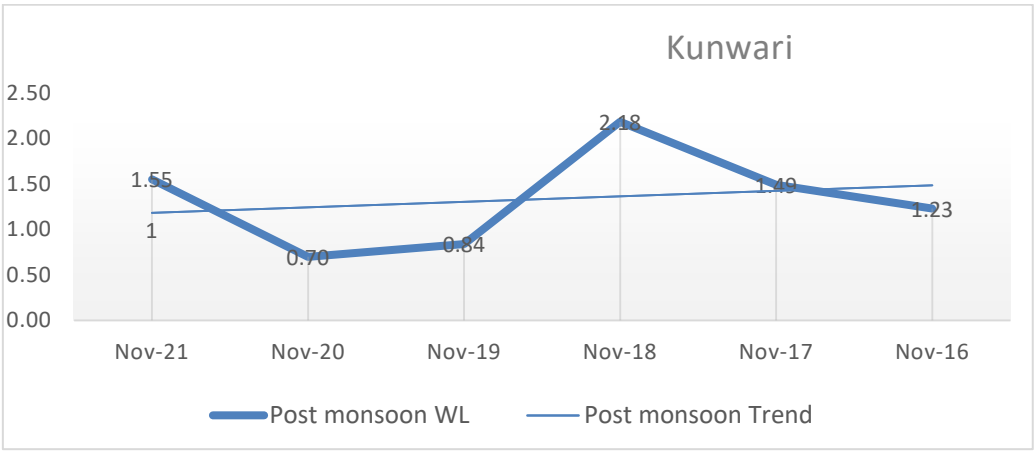
2.50
2.00
1.50
1.00
0.50
0.00
1.29
1
1.04
1.19
2.76
1.59
1.47
1.17
1.24
2.61
Nov-21
Nov-20
Nov-19
Nov-18
Nov-17
Nov-16
Nov-15
Nov-14
Nov-13
Post monsoon WL
Post monsoon Trend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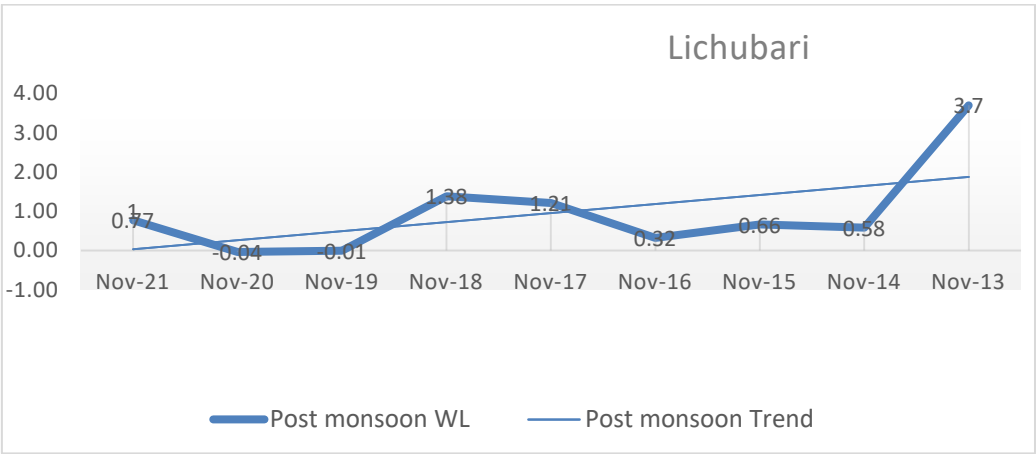
2.00
1.50
1.00
0.50
0.00
1.55
1
0.70
0.84
2.18
1.40
1.23
Nov-21
Nov-20
Nov-19
Nov-18
Nov-17
Nov-16
Post monsoon WL
Post monsoon Trend


Lichubari
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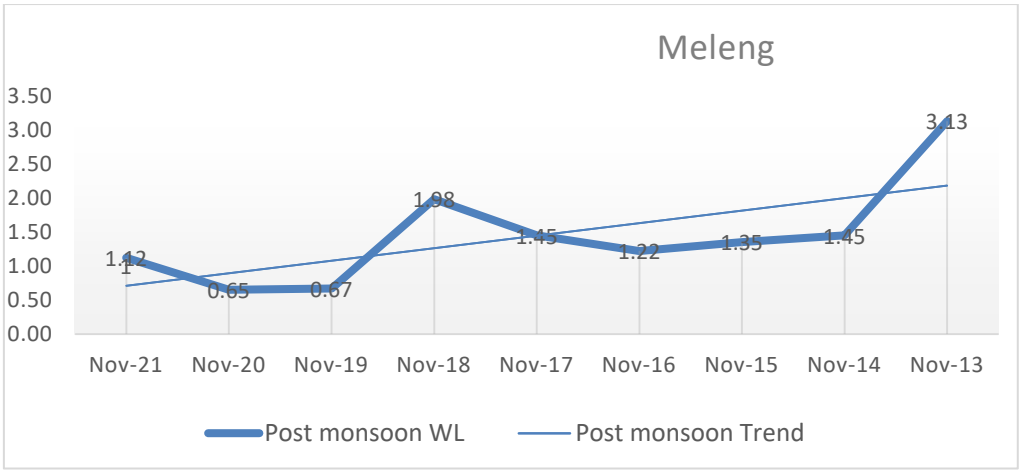
3.00
2.00
1.00
0.00
-1.00
0.77
1
-0.04
0.01
1.38
1.21
0.32
0.66
0.58
3.7
Nov-21
Nov-20
Nov-19
Nov-18
Nov-17
Nov-16
Nov-15
Nov-14
Nov-13
Post monsoon WL
Post monsoon Trend



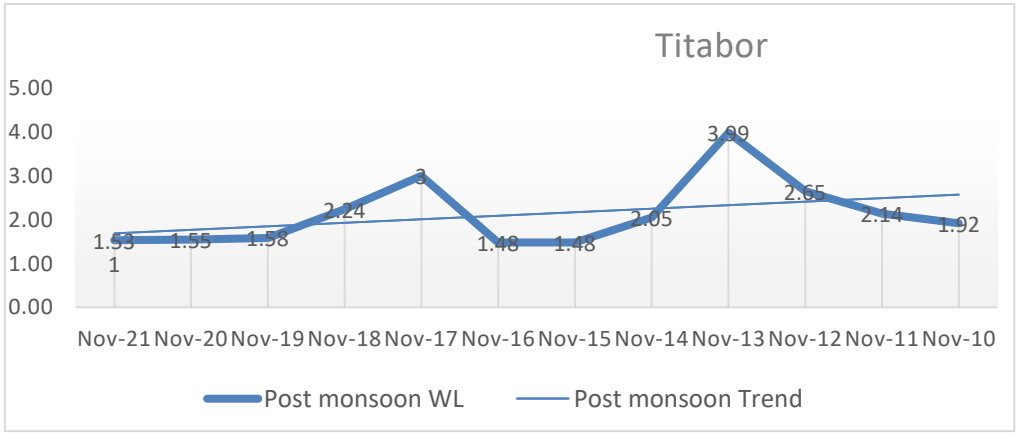
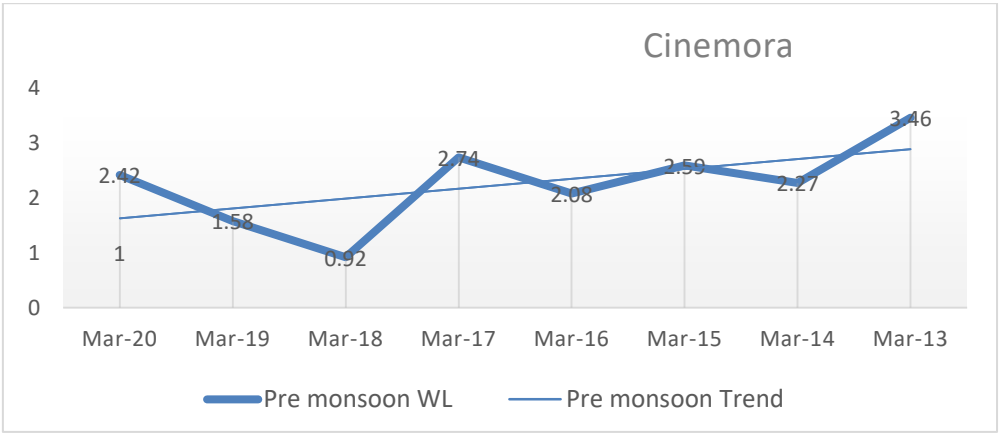
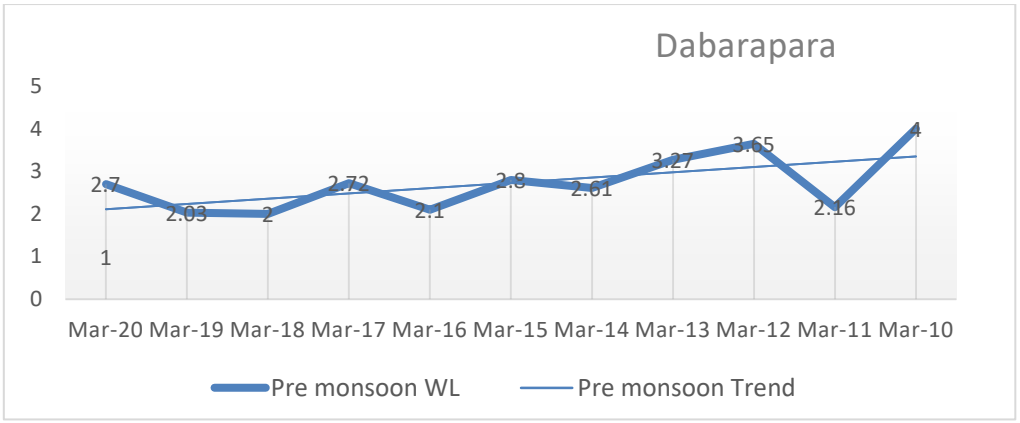
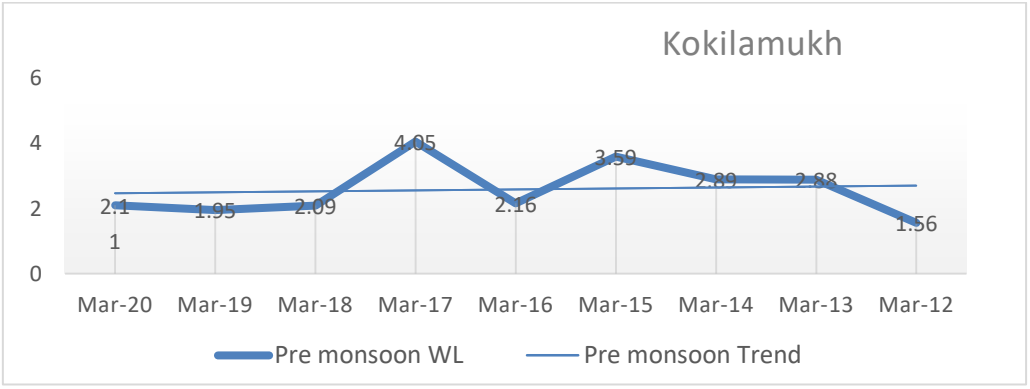
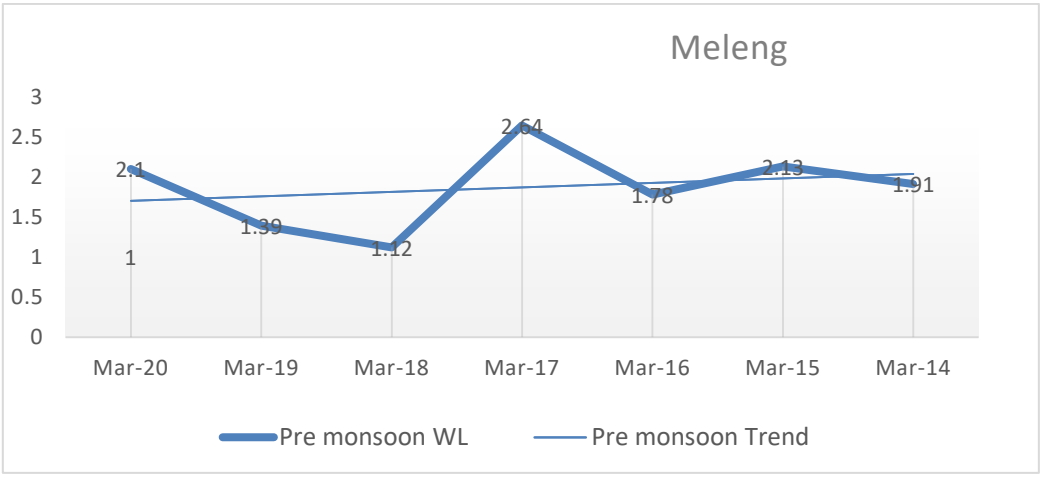


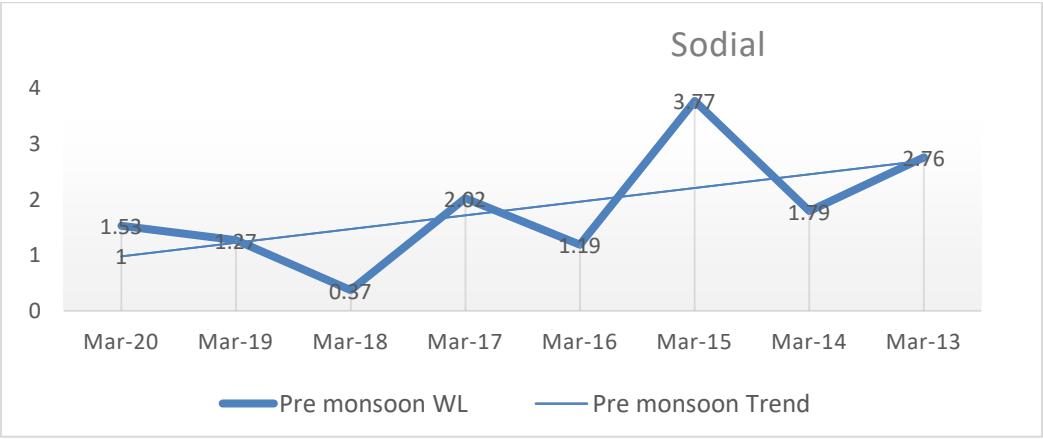
Fig 3.10:Post Monsoon Hydrograph of GWMS wells , Jorhat district, Assam




Dabarapara
5
4
3
2
1
0
2.7
2.03
2
2.72
2.1
2.8
2.61
3.27
3.65
2.16
4
1
Mar-20 Mar-19 Mar-18 Mar-17 Mar-16 Mar-15 Mar-14 Mar-13 Mar-12 Mar-11 Mar-10
Pre monsoon WL
Pre monsoon Trend


Kokilamukh
6
4
2
0
2.1
1.95
2.09
4.05
2.16
3.59
2.89
2.88
1.56
1
Mar-20 Mar-19 Mar-18 Mar-17 Mar-16 Mar-15 Mar-14 Mar-13 Mar-12
Pre monsoon WL
Pre monsoon Trend


Meleng
3
2.5
2
1.5
1
0.5
0
2.1
1.39
1.12
2.64
1.78
2.13
1.91
1
Mar-20 Mar-19 Mar-18 Mar-17 Mar-16 Mar-15 Mar-14
Pre monsoon WL
Pre monsoon Trend


Sodial
4
3
2
1
0
1.53
1.27
0.37
2.02
1.19
3.77
1.79
2.76
1
Mar-20 Mar-19 Mar-18 Mar-17 Mar-16 Mar-15 Mar-14 Mar-13
Pre monsoon WL
Pre monsoon Trend

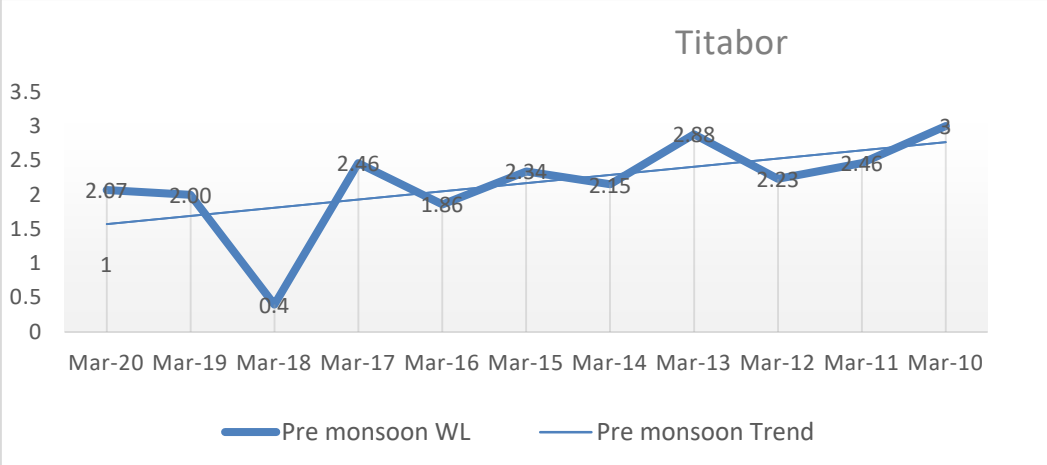


Fig 3.11:Pre Monsoon Hydrograph of GWMS wells , Jorhat districct, Assam

3.3 Ground water quality

During AAP 2021-22, 31 nos. of Shallow aquifer Groundwater samples were collected from dug well/ hand pump/tube well during post monsoon and 46 nos sample in pre-monsoon for water quality study of Jorhat district. Temperature, Ec, pH, and salinity were measured using portable digital quality kit on site. Chemical analysis of ground water samples are carried out by regional chemical laboratory of Central Ground Water Board, North Eastern Region, Guwahati. In the present study the quality of water with respect to major ion, heavy metals, iron, arsenic and uranium, TDS, TH etc. was estimated and various parameter analyzed to evaluate the suitability of ground water in the study area for human consumption and agriculture practices.

Table 3.5: Minimum, maximum and mean values of hydro chemical parameters of groundwater samples.

Parameter	Unit	Post Monsoon				Pre Monsoon			
		No of Samples	Average	Max	Min	No of Samples	Average	Max	Min
pH	No unit	31	8.1	8.8	7.50	46	8.2	8.5	7.25
EC	(µs/cm)	31	325.3	702.1	118.00	46	425.1	1000.0	162.80
Turbidity	No unit	31	0.2	0.3	0.00	46	0.2	0.4	BDL
TDS	mg/l	31	187.3	399.8	66.70	46	280.6	660.0	107.45
Carbonate	mg/l	31	2.7	12.0	0.00	46	12.5	12.6	BDL
Bicorbonate	mg/l	31	213.5	439.6	79.36	46	225.3	415.1	85.47
TA	mg/l	31	216.2	445.6	79.36	46	234.3	433.1	85.47
Chloride	mg/l	31	22.3	81.5	7.09	46	35.5	195.0	10.64
Sulphate	mg/l	31	14.7	52.0	0.00	46	7.8	34.2	0.01
Nitrate	mg/l	31	5.3	38.8	0.00	46	1.0	6.0	0.04
Flouride	mg/l	31	0.5	0.7	0.23	46	0.4	0.8	0.04
Calcium	mg/l	31	35.4	72.1	8.01	46	36.6	100.1	16.01
Magnesium	mg/l	31	24.3	50.9	6.06	46	22.4	54.6	3.63
TH	mg/l	31	188.4	345.0	70.00	46	183.0	300.0	65.00

Parameter	Unit	Post Monsoon				Pre Monsoon			
		No of Samples	Average	Max	Min	No of Samples	Average	Max	Min
Sodium	mg\	31	9.4	38.0	0.31	46	19.3	95.3	3.51
Potasium	mg/l	31	5.8	37.1	0.10	46	10.9	59.2	1.77
Iron	mg/l	31	7.0	89.6	0.63	46	3.7	29.4	0.13
Manganese	mg/l	31	0.9	2.6	0.02	46	0.9	3.3	BDL
Zinc	mg/l	31	0.7	6.6	0.05	46	—	—	—
Copper	mg/l	31	0.0	0.0	0.01	46	—	—	—
Cadmium	µg/l	31	0.3	1.6	0.14	46	0.9	9.7	0.09
Lead	µg/l	31	15.1	42.8	1.54	46	4.1	42.7	0.63
SAR	No unit	31	0.3	1.4	0.01	46	0.7	3.5	0.09
PI	%	31	57.6	95.4	32.99	46	62.8	95.1	31.80
RSC	meq/l	31	-0.3	0.9	-2.88	46	0.0	1.1	-2.78
Na%	%	31	12.8	40.2	2.77	46	23.3	67.0	6.50
KR	No unit	31	0.1	0.6	0.00	46	0.3	1.5	0.03
MH	%	31	52.6	71.4	31.21	46	49.6	81.8	15.20
PS	meq/l	31	0.8	2.4	0.2	46	1.1	5.9	0.40

Drinking Water Quality: Pre Monsoon and Post monsoon groundwater analysis data has been analyzed and were compared with the Bureau of Indian Standard for drinking water quality (BIS-2012 to evaluate the suitability of groundwater in the study area for human consumption shown in Table 3.6.

In postmonsoon67.67% of groundwater samples have iron concentration above the permissible limits in Majuli block, highest value has been observed 89mg/l in Hazarikagaon.12.9% 61.3% water sample showing lead concentration above the permissible limit and highest value 42.8 µg/l observed in Gerikigaon of Majuli block. 74.2% water sample showing manganese concentration above the permissible limit and highest value 2.56 mg/l observed in Jugikoibotro Gaon of Majuli block. (Chemical data enclosed in Annexure-II and III).

In pre monsoon water sample 56.5% of groundwater samples have iron concentration above the permissible limits, highest value has been observed 29.42 in Nambotiya mari Gaon. 4.3% of groundwater samples have lead concentration above the permissible limits; highest value has been observed 42.7 µg/l in Jengraimukh. 69.5water sample showing manganese concentration above the permissible limit and highest value 3.24 mg/l observed in Goalbari Gaon of Majuli.(Chemical data enclosed in Annexure-IV and V).

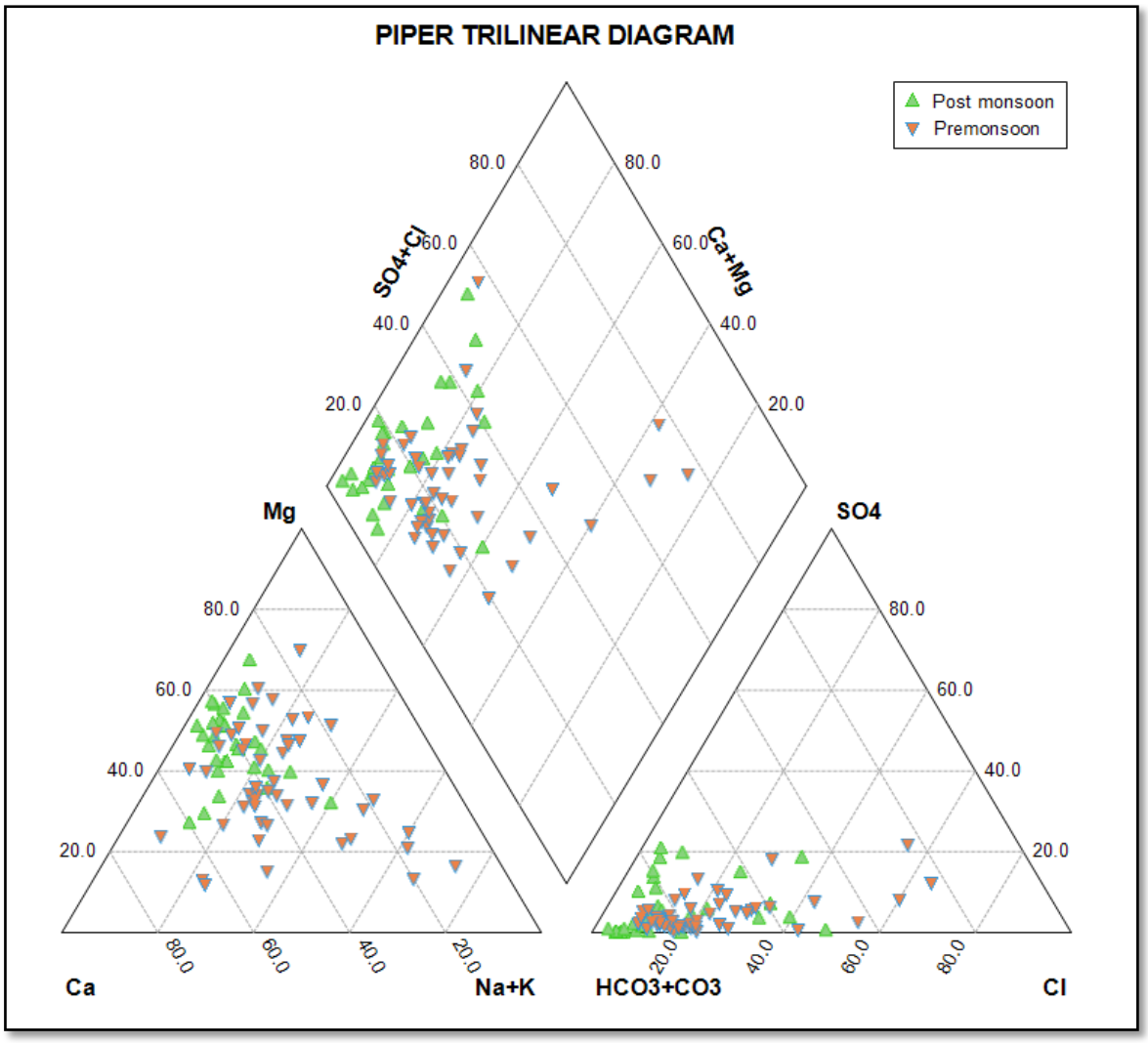


Fig 3.12:Major Hydrochemical facies of Groundwater, Jorhat district, Assam

Hydrochemical analysis data is plotted in Piper diagram (Fig 3.12). In the present study majority of samples are plotted in Calcium Bicarbonate field and few samples fall in Na-Cl field.

Table 3.6: Suitability of groundwater for drinking purposes, Jorhat district, Assam.

			Post Monsoon		**Pre Monsoon**	
Parameter	Unit	Permissible Limit BIS (2012)	% of sample under Permissible limits	% of sample exceeding Permissible limits	% of sample under Permissible limits	% of sample exceeding Permissible limits
pH	No unit	6.5- 8.5	83.88	16.12	100	0
TH (as COCO3)	mg/l	600	100	0	100	0
TDS	mg/l	2000	100	0	100	0
Turbidity	NTU	5	100	0	100	0
Calcium	mg/l	200	100	0	100	0
Magnesium	mg/l	100	100	0	100	0
Chloride	mg/l	1000	100	0	100	0

			Post Monsoon		Pre Monsoon	
Parameter	Unit	Permissible Limit BIS (2012)	% of sample under Permissible limits	% of sample exceeding Permissible limits	% of sample under Permissible limits	% of sample exceeding Permissible limits
Sulphate	mg/l	400	100	0	100	0
Flouride	mg/l	1.5	100	0	100	0
Nitrate	mg/l	45	100	0	100	0
Iron	mg/l	1	32.26	67.74	43.5	56.5
Manganese	mg/l	0.3	25.8	74.2	30.5	69.5
Zinc	mg/l	15	100	0	NA	
Copper	mg/l	1.5	100	0	NA	
Cadmium	µgl	3	100	0	91.4	8.6
Lead	µgl	10	38.7	61.3	95.7	4.3

Table 3.7: Concentration of Heavy Metal in ground water , Jorhat districct, Assam.

					Post-Monsoon					Pre-Monsoon				
Sr. No	Location	Block	Source	Depth (m)	Fe	Mn	As	Cd	Pb	Fe	Mn	As	Cd	Pb
					mg/L		µg/L			mg/L		µg/L		
1	Jengraimukh	Majuli	HP	7.8	0.8	2.1	12.	1	7	0.73	0.2		0.	42.7
2	Garamur soru	Majuli	HP	11	0.7	0.2	2.0	0	6	4.29	0.5		5.	5.40
3	Mekheli	Majuli	TW	13	3.9	0.8	1.8	0	16.7	3.33	0.2		0.	4.06
4	Pohumora	Majuli	HP	11	0.7	0.9	1.4	0	18.4	4.72	0.2		0.	4.73
5	Kamalabari,P	Majuli	TW	28	7.9	1	2.6	0	7	0.12	0.4		0.	3.05
6	Nambotiya	Majuli	HP	11	25.	1	11.	0	17.6	29.4	1.5		2.	5.06
7	Kerala gaon	Majuli	HP	11	3.9	0.2	2.2	0	20.1	0.31	BD		0.	2.03
8	Merua bari	Majuli	HP	14	1.1	0.2	1.2	0	32.1	10.4	0.3		1.	3.72
9	Borkolia	Majuli	HP	11	1.1	0.3	1.1	0	13.2	0.79	0.4		0.	2.37
10	Pakajora	Majuli	HP	11	0.9	0.1	5.4	0	15.9	0.73	0.1		0.	2.71
11	Kohardubi	Majuli	HP	7	0.8	0.4	5.2	0	17.6	0.58	0.0		0.	4.06
12	Hazarika gaon	Majuli	HP	11	89.	0.6	3.6	0	23.8	2.54	0.5		0.	13.5
13	Gereki gaon	Majuli	HP	7	8.1	0.9	1.9	0	42.8	0.16	0.0		0.	4.39
14	Bhogpur	Majuli	HP	14	14.	0.9	4.6	0	15.9	7.78	1.4		4.	5.06
15	Rajguru bari	Majuli	TW	47	6.5	1.1	8.6	0	24.2	0.16	0.0		0.	2.71
16	Komargaon	Majuli	HP	11	0.9	0.1	2.2	0	15.9	9.47	1.4		0.	2.71
17	Kalita gaon	Majuli	HP	14	0.8	1.9	1.1	0	17.6	0.46	0.2		0.	2.37
18	Jugiikoibotro	Majuli	HP	8	16.	2.6	8.4	0	15	0.29	2.1		0.	3.38
19	Goalabari-	Majuli	TW	11	0.6	1.2	1.1	0	19.3	17.6	3.2		1.	4.06
20	Kakori	Majuli	HP	8	1.7	0	1.2	0	9.7	0.24	1.9		0.	2.37
21	Malapindha	Majuli	HP	8	1.2	1.6	4.4	0	9.7	0.40	0.0		0.	6.72
22	Malapindha	Majuli	HP	8	0.9	0.2	1.3	0	7	2.75	2.9		0.	3.72
23	Boridigha	Majuli	HP	8	6.4	1	1.1	0	15	0.69	0.3		3.	2.71
24	Uluwani	Majuli	HP	11	2.1	0.4	3.6	0	29.8	2.08	1.5		0.	4.73
25	Rongachahi	Majuli	HP	8	2.1	1.3	2.1	0	11.5	1.35	0.4		0.	1.69
26	Bapuchola	Majuli	HP	14	1.7	0.4	11.	0	6	2.17	1.4		0.	3.05
27	Lahon gaon	Majuli	HP	14	4.5	1.5	11.	0	8.8	2.68	2.2		0.	2.37
28	Gosaibari	Majuli	HP	8	1.1	2.2	2.3	0	6	7.19	0.4		0.	2.37
29	Phutsang gaon	Majuli	HP	8	2	0.2	2.0	0	6	0.31	2.7		0.	2.03
30	Ratanpur miri	Majuli	HP	14	1	0.7	1.0	0	1.5	7.90	1.0		0.	1.43

Sr. No	Location	Block	Source	Depth (m)	Fe	Mn	As	Cd	Pb	Fe	Mn	Cd	Pb
					mg/L		µg/L			mg/L		µg/L	
31	Major deuri gaon	Majuli	HP	14	5.9	1.3	3.11	0.2	9.7	1.277	1.032	0.205	1.27
32	Garamura satra	Majuli	DW	4.75	In Post Monsoon sample not taken					6.148	0.468	0.205	1.11
33	Karkichuk, phuloni	Majuli	HP	8						1.256	0.651	0.167	0.95
34	Karkichuk, phuloni	Majuli	TW	88.4						0.874	0.651	0.129	0.79
35	Karkichuk, phuloni	Majuli	TW	88.4						0.756	0.586	0.393	0.63
36	Nambotiya mari	Majuli	HP	11						8.57	1.076	9.676	2.71
37	Hazarika	Majuli	HP	14						9.761	0.912	0.318	5.40
38	Bhogpur(filtered)	Majuli	HP	14						7.844	1.076	0.544	3.38
39	Kakori	Majuli	HP	14						0.639	0.255	0.959	4.06
40	Bapuchola	Majuli	HP	14						1.505	0.533	0.091	1.35
41	Lahon	Majuli	HP	14						4.859	1.902	0.431	1.69
42	Nambotiya	Majuli	HP	14						0.371	1.054	0.242	4.73
43	Kakori kota	Majuli	HP	11						1.359	0.011	0.129	2.71
44	Kakori kota	Majuli	HP	14						0.296	0.032	0.129	1.69
45	Boridigha gaon	Majuli	HP	8						2.082	1.364	0.77	2.71
46	Lahon gaon	Majuli	HP	25						0.504	BDL	0.129	1.35

HP:Hand pump TW: Tube well DW: Dug well

Irrigation Water Quality: Sodium hazards (Na%), Kelly's Index (KI), Permeability Index (PI), Magnesium Hazards (MAR), Residual Sodium Carbonate (RSC), Sodium Adsorption Ratio (SAR), Potential Salinity (PS) etc parameters has been analyzed to evaluate the suitability of ground water in the study area for irrigation. all parameters deciphered the quality of groundwater of study area are Excellent to Good for irrigation purpose and same is Summarized in table 18.

Table 3.8: Suitability of groundwater (Shallow aquifer) for irrigation in Jorhat district, Assam.

Based on EC		Post Monsoon	Pre Monsoon
EC (µs/cm)	Water Class	% of samples	
<250	Excellent	29	8.7
250-750	Good	71	86.9
750-2000	Permissible	0	4.4
2000-3000	Doubtful	0	0
>3000	Unsuitable	0	0
Based on RSC			
RSC meq/l	Water Class	% of samples	
<1.25	Good	100	100
1.25-2.5	Doubtful	0	0
>2.5	Unsuitable	0	0
Based on SAR			
SAR	Water Class	% of samples	SAR
<10	Excellent	100	100
10.0 -18.0	Good	0	0
18.0 - 26	Doubtful	0	0
> 26	Unsuitable	0	0

Based on EC		Post Monsoon	Pre Monsoon
Based on Na%			
Na%	Water Class	% of samples	
<20	Excellent	87	32.6
20-40	Good	9.67	60.8
40-60	Permissible	3.33	6.6
60-80	Doubtful	0	0
>80	Unsuitable	0	0
Based on PI			
PI in %	Water Class	% of Samples	
>75	Class-I, Suitable	9.67	15.2
25-75	Class-II, Good	90.33	84.8
<25	Class-III, unsuitable	0	0
Based on Kelly Index			
KI	Water Class	% of Samples	
<1	Recommended	100	97.8
>1	Not recommended	0	2.2
Potential Salinity			
PS in meq/l	Water Class	% of samples	
<3.0	Suitable	100	97.8
>3.0	Unsuitable	0	2.2

SAR vs EC on the US salinity diagram is shown in fig 29, most of groundwater sample fall in C1S1 and C2S1 indicating low sodium content and low to medium salinity nature of groundwater is good for irrigation purpose.

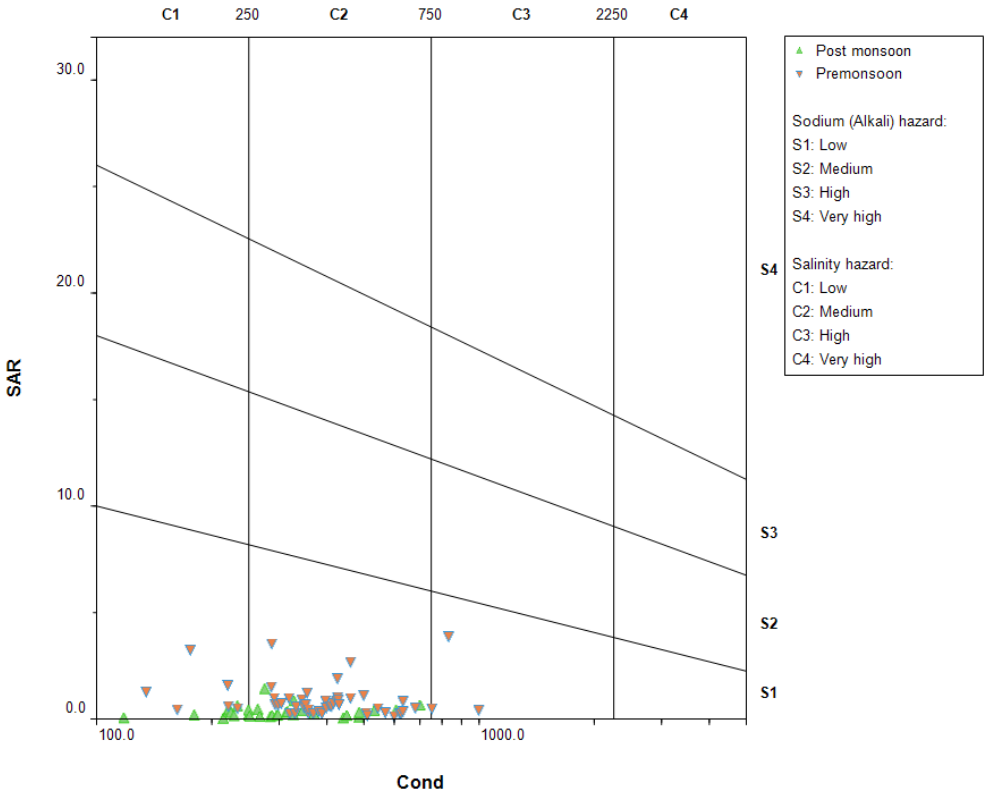


Fig 3.13: US Salinity diagram showing suitability of groundwater for irrigation based on SAR and Ec.

Chapter 4.0

Ground water Resources

The computation of ground water resources available in the district has been done using GEC 2015 methodology. The dynamic resource estimation is done district wise due to paucity of block-wise data.

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

1) Rainfall recharge has been computed by both RIF and WLF methods. To calculate rainfall recharge, both for monsoon and non-monsoon season, RIF factor is considered as 22%. Specific yield has been taken as 12 %.

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

3) Water level data has been considered for 2019-20. 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.

4) The population figures were collected from Census, 2011and projected to 2021.Therefore, domestic extraction is calculated based on per capita water requirement i.e. @60 lpcd for rural and @135 lpcd in urban areas. The dependency on ground water resource for domestic and industrial water supply in rural areas is considered as 76%.

The total replenishable ground water resources available in the study area have been computed using the average water level fluctuations in observation wells and specific yield of aquifers. These have been normalised using normal rainfall data to eliminate variations in recharge due to excess or deficit rainfall. The monsoon recharge arrived at is then compared with the recharge computed using rainfall infiltration method. In cases where the difference between the two is more than 20 percent, the recharge is computed using ad hoc method.

4.1 Recharge

Total area of assessment unit is 285100 Ha, out of which 279408 Ha considered as recharge worthy area (Slope <20%). The aquifers of the study area are recharged through a) infiltration of rainfall b) seepage from the tanks and ponds c) subsurface inflow across the up dip margin. The area experiences south-west monsoon. Monsoon rainfall contributes approximately 81 percent of total rainfall (May, June, July, August, and September). Previous records show that the rainfall occurs almost in every month of a year. The month November to December has the minimum number of rainy days in any year.

The monsoon recharge of recharge worthy area from rainfall is 53640.97ham while non-monsoon recharge is 35,381.99ham. Recharge from other sources during monsoon is 3172.98 ham and during non-monsoon is 1066.36 ham. Total ground water recharge is 93262.30ham.

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 total natural discharge is 9326.23 ham of the total groundwater recharge. Total irrigation extraction created is 4215.12 ham, for industry 3.18 ham and extraction for domestic uses is 1669.55 ham. Total groundwater extraction for all uses is only 5887.85 hams.

The water trend analysis shows that there is no significant change in the water level for both post-monsoon periods.

4.3 Allocation of resources up to 2025

The net ground water resource is allocated for domestic uses are 1756.71hams while 59463.6 ham resources are 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 8.99%.

Table 4.1: Summary results of Groundwater Resources Estimation in Jorhat District, Assam

PARAMETER	**VALUES**
Total geographical area (Ha)	285100
Recharge worthy area (Ha)	279408
Rainfall Recharge (monsoon) (Ham)	53640.97
Rainfall Recharge (non-monsoon) (Ham)	35,381.99
Annual Recharge from Other Sources (monsoon) (Ham)	3,172.98
Annual Recharge from Other Sources (non- monsoon) (Ham)	1066.36
Annual G. W. Recharge (Ham)	93262.30
Total Natural discharge (Ham)	9326.23
Annual extractable Ground Water Resource (Ham)	65454.22
Current annual gross G.W. Extraction for domestic use (Ham)	1669.55
Current annual gross G.W. Extraction for irrigation (Ham)	4215.12
Current annual gross G.W. Extraction for industrial use (Ham)	3.18
Current annual gross G.W. Extraction for All uses (Ham)	5887.85
Annual G.W. Allocation for Domestic water supply as on 2025 (Ham)	1756.71
Net Annual G.W. availability for future use (Ham)	59463.6
Stage of GW Extraction (in %)	8.99
Categorisation for Future GW extraction (Safe/Semi-Critical /Critical /Over Exploited)	Safe

Chapter 5.0

Groundwater Related Issues

The main groundwater issue in this area is vulnerable to water logging, flooding and ground water pollution.

5.1 Area vulnerable to water logging

Water logged areas are observed in the southwestern part of district, Titabor block, shown in figure 31. water level map that showing south western part of district is vulnerable to water logging and having ground water level less than 2.0 mbgl in pre-monsson.

Fig 5.1:Field photograph of study area showing rusting in iron pipe and interaction with public.

5.2 Area vulnerable to Flood

Entire Jorhat district is vulnerable to flooding. The causes of flood in Jorhat District are due to excessive rainfall in Assam, Arunachal Pradesh and Nagaland, melting of snow at Tibet etc. During flood the rivers get charged with enormous quantity of silt and in their movement the rivers alter the condition of flow and sometime change the river courses causing untold miseries to the people living in its low line basin, making the district vulnerable to annual flooding. After the great earthquake 1950 the river bed of Brahmaputra is risingcontinuously due to disposition of sand carried down from the upstream. This has also lead to the formation of saucer shaped low lying zone in the plain of the district.

5.2 Area vulnerable to Iron, Lead and other Heavy metals in groundwater

During AAP 2021-22 studies, it is confirmed to occurrence of Iron, Manganese, lead and Cadmium in Pre and Post-monsoon groundwater samples of Majuli. 67.74 % of post monsoon water sample showing iron concentration above the permissible limits in the Majuli, values having above the permissible limits observed in 21 locations, 74.21% of post monsoon water sample showing Manganese concentration above the permissible limits, concentration having above the permissible limits observed in 23 locations.61.3% of water sample showing lead concentration above the permissible limits, values having above the permissible limits observed in 19 locations (Annexure II and III).However Pre monsoon groundwater samples also having Iron, lead, manganese and other heavy metals in groundwater above the permissible limits. (Data enclosed in Annexure IV and V) Fig: 31.

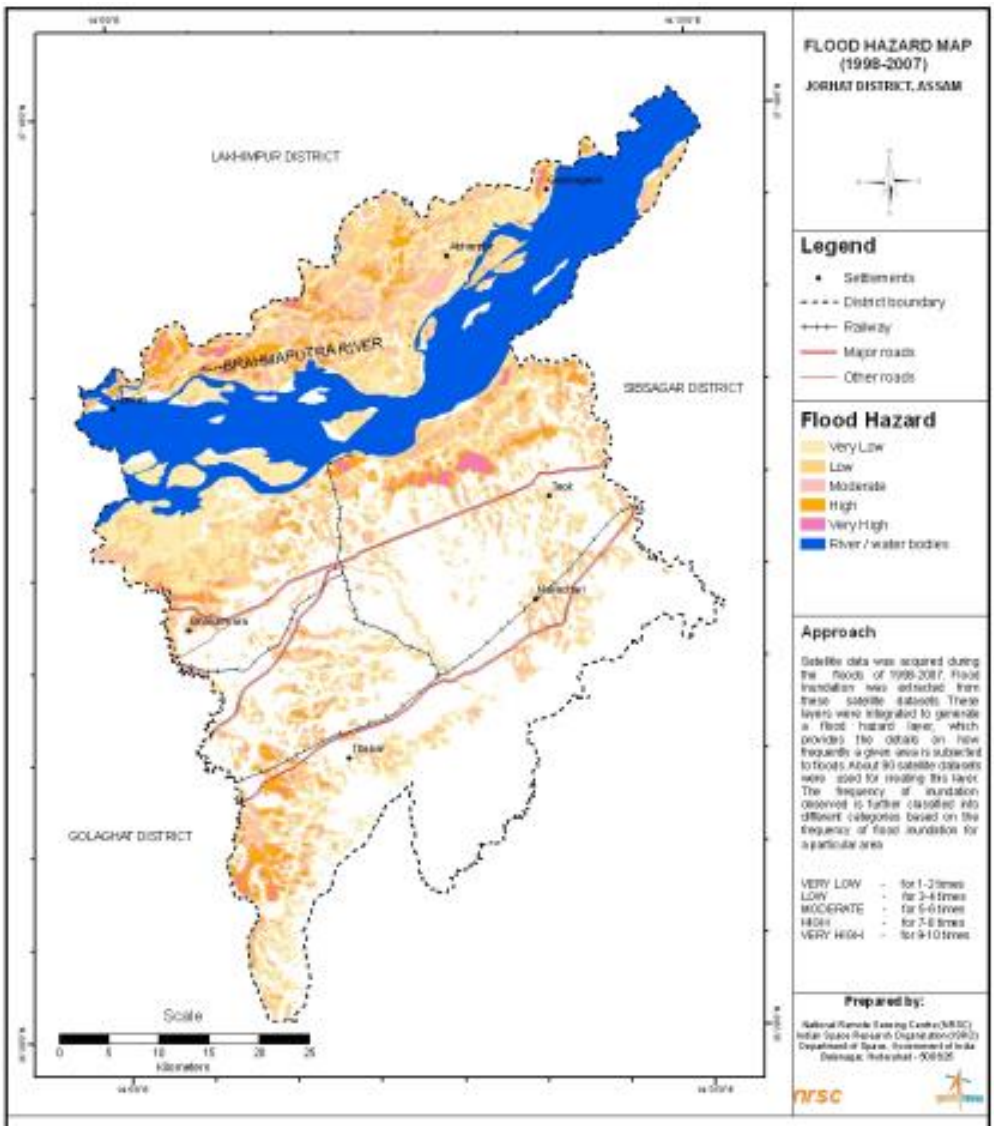


Fig 5.2:Map showing area vulnerable to Flooding.

In previous study carried out in southern part of district, during annual action plan 2012-13 and 2013-14, to know the water quality of the study area, water sampling done from both shallow and deeper aquifers. As per P.H.E.D. Govt. of Assam, concentration of arsenic and Iron in the shallow aquifer zone of Jorhat district is beyond permissible limit. (Refer to AQUIFER MAPPING REPORT Parts of Jorhat and Golaghat Districts, Assam).

The probable source of Iron, manganese and Arsenic in ground water is mostly due to leaching of geological minerals, dissolution of unstable Iron/manganese/Arsenic minerals, and chemical transformation within the formation. Alluvial environments are mostly characterized by reducing conditions (anaerobic), which cause high Arsenic concentrations in ground water. Arsenic contamination may also be caused by oxidation of pyrite, arsenopyrite that is present in aquifer sediments. Iron also plays an important role in the release of arsenic in groundwater. Another factor that can affect arsenic concentrations is the presence of anions such as bicarbonate, phosphate and sulphate. Heavy Metals like Lead, Arsenic and Cadmium that has been observed in ground water may be both Geogenic and Anthropogenic. The source of the Arsenic is mainly geogenic in nature and its occurrence in groundwater is due to

leaching of geological minerals and dissolution of unstable arsenic minerals, chemical transformation within the minerals, etc. While the occurrence of lead in groundwater may be derived from corrosion of water abstracting pipes, fixtures, etc. and also due to sewage slugs and pesticides used for agricultural purpose. Metal like Cadmium can occur due to unregulated industrial waste disposal, sewage slugs, use of fertilizer and plumbing materials.

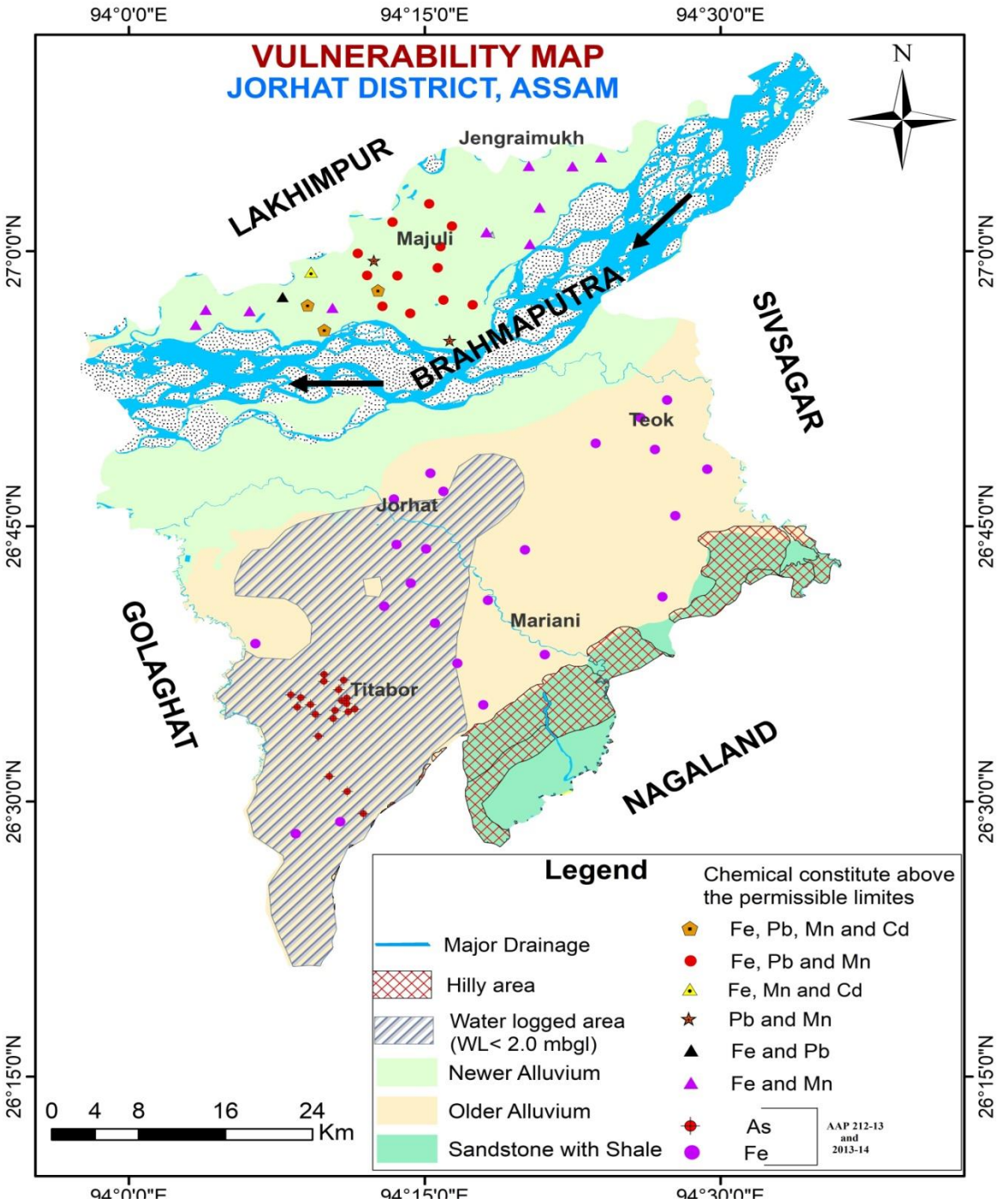


Fig 5.3:Vulnarability map of Jorhat district, Assam.

Chapter 6.0
MANAGEMENT STRATEGIES

From the panel diagram it is clear that the aquifer material is combination of sand, sand with gravel, sandy clay, clayey sand and clay. The variation of lithology and geomorphic set up of the study area has also influenced the ground water regime. From flood zonation map it becomes clear that barring the structural hills, the entire district is ravaged by flood.

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

6.1 Sustainable Management of GW resources for Irrigation

As per dynamic ground water resource estimation of Jorhat District for 2020, annual extractable ground water is 65454.22hams and stage of ground water extraction is only 8.99 %. The district is having balance net ground water availability for future development in the tune of 59463.6hams. If an irrigation plan is made to develop 60% of the balance dynamic ground water resources available, then 35687 ham of groundwater resources is available in the district for the future irrigation uses. There is ample scope for ground water development in Jorhat district for irrigation purpose which will help the district in achieving self-reliance on food grain.

In Jorhat District, net sown area is 136071 ha, and Gross cropped area is 148421 ha and cropping intensity is about 109% (agriculture census 2015-16). Cropping intensity is calculated generally from field crops, which are of short duration whereas horticulture (like citrus, banana etc) and plantation crops like spices are long duration crops. Therefore, there is enough scope for future development of ground water in the study area to bring more area under irrigation practice.

To use the groundwater for irrigation purpose a cropping plan for unirrigated kharif paddy has been designed for the district by using CROPWAT model developed by FAO (Food & Agriculture Organisation), Un irrigated Kharif paddy cultivation area of the district is 101701 ha (agriculture census 2015-16). In rice fallow land, with the support of irrigation potato, pulses, vegetables, oilseeds and wheat can be grown. The irrigation requirement of proposed cropping plan is summarised in Table 6.2 while precipitation deficiency and month-wise irrigation water requirement are shown in Table 6.3 and 6.4 respectively.

Table 6.1: Cropping sequence in unirrigated kharif paddy area of Jorhat district.

July/August –November	November/December –March
1. Rice	1. Pulses
	2. Vegetables
	3. Oil seeds
	4. Wheats
	5. Potatoes

Table 6.2: Water requirement for Kharif paddy areas of Jorhat District.

Cropping pattern (s)				
Rice based cropping pattern				
1. Rice-Pulses	Present Cultivated area	Area to be cultivated	Area to be cultivated (**ha**)	Irrigation requirement (**ham**)
2. Rice-Wheat	(**ha**)	(**%**)		
3. Rice-Vegetable				
4. Rice-Potato				
5. Rice-Oil seeds				
	1	2 (% of 1)	3	4
Rice (main crop)	101701	50	101701	17124
Pulses		10	20340	1859
Potatoes		10	20340	2498
Oil seeds		10	20340	1442
Wheat		5	10170	923
Vegetable		15	30511	2688
		100	203402	
Net cultivated area	101701		101701	
Gross cultivated area (1+pulses/+Rice/+potato/+ /+Vegetable)	101701		203402	
Total irrigation requirement				26534
Total Irrigationrequirement ((70% irrigation efficiency)				**37905**
Cropping intensity	**100 (Present)**		**200% (Intended)**	

As per information, 14392 ha cultivable area of the district is chronically flood affected and multi-cropped area is not available near flood affected area(District Disaster Management Plan, Jorhat). Therefore, the water demand of agricultural sector to provide assured irrigation potentiality to un-irrigated flood prone areas and medium/medium low land will be calculated separately using Cropwat 8.0 software of FAO. A management plan has been prepared for chronically flood affected crop land of 14392 ha.

Table 6.3: Crop-wise and month-wise precipitation deficit in winter paddy area of, Jorhat District.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Precipitation deficit												
1. Rice	0	0	0	0	0	48.7	98	0	0	12.1	23.4	0
2. Rice	0	0	0	0	0	147.3	0	0	0	0.3	0	0
3. Pulses	34.3	41.6	13.4	0	0	0	0	0	0	0	0	2.1
4. Potato	39.3	40.3	22.9	0	0	0	0	0	0	0	10	10.3
5. Oilseeds	35.2	5.3	0	0	0	0	0	0	0	0	13.9	16.5
6. Wheat	7.9	36.9	46	0	0	0	0	0	0	0	0	0
7. Vegetables	33	34.8	6.3	0	0	0	0	0	0	0	0	14

Table 6.4: Irrigation Water Requirement (in ham), in winter paddy area of Jorhat District.

Crops	Area in ha	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Precipitation deficit (ham)														
1. Rice	61024	0	0	0	0	0	2972	5980	0	0	738	1428	0	11119
2. Rice	40682	0	0	0	0	0	5992	0	0	0	12	0	0	6005
3. Pulses	20340	698	846	273	0	0	0	0	0	0	0	0	43	1859
4. Potato	20340	799	820	466	0	0	0	0	0	0	0	203	210	2498
5. Oilseeds	20340	716	108	0	0	0	0	0	0	0	0	283	336	1442
6. Wheat	10170	80	375	468	0	0	0	0	0	0	0	0	0	923
7. Vegetables	30511	1007	1062	192	0	0	0	0	0	0	0	0	427	2688

Table 6.5: Water requirement for chronically flood affected areas of Jorhat district, Assam.

Cropping pattern (s)				
Rice based cropping pattern				
1. Early summer Rice- late Winter rice	Present Cultivated area	Area to be cultivated	Area to be cultivated (**ha**)	Irrigation requirement (**ham**)
2. Pulses-Late Winter rice/Potato/Vegetables	(**ha**)	(**%**)		
3. Summer Vegetables- Late winter rice				
	1	2 (% of 1)	3	4
Rice (main crop)	14392	50	14392	3637
Pulses		15	4318	328
Potatoes		10	2878	338
Wheat		10	2878	150
Vegetable		15	4318	311
		100	28784	4764
Net cultivated area	14392		14392	
Gross cultivated area (1+pulses/+Rice/+potato/+ /+Vegetable)	14392		28784	
Total irrigation requirement				4764
Total Irrigation requirement ((70% irrigation efficiency)				**6806**
Cropping intensity	**200% (Intended)**			

Table 6.6: Crop-wise and month-wise precipitation deficit in chronically flood affected areas of, Jorhat District.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Precipitation deficit												
1. Rice	192.2	42.9	53.1	0	0	0	0	0	0	0	0	52.4
2. Rice	55.2	193.8	52.3	0	0	0	0	0	0	0	0	0
3. Rice	0	0	0	0	0	147.3	0	0	0	0.3	0	0
4. Rice	0	0	0	0	0	0	192.5	0	0	13.5	43.5	0
5. Wheat	0.6	6.4	45.1	0	0	0	0	0	0	0	0	0
6.Pulses	0	0	0	0	0	0	0	0	0	9.8	51	7.5
7. Pulses	1.2	0	0	0	0	0	0	0	0	4.6	51	23
8. Vegetable	0	0	0	0	0	0	0	0	2.1	6.2	44.9	9.4
9. Vegetable	35.6	15.7	0	0	0	0	0	0	0	0	22.7	21.4
10.Potato	40.2	32.9	3.5	0	0	0	0	0	0	2.5	14	24.3

Table 6.6: Irrigation Water Requirement (in ham), chronically flood affected areas of Jorhat District.

Crops	Area in ha	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Precipitation deficit (ham)														
1. Rice	2878	553	123	153	0	0	0	0	0	0	0	0	151	980
2. Rice	4318	238	837	226	0	0	0	0	0	0	0	0	0	1301
3. Rice	4318	0	0	0	0	0	636	0	0	0	1	0	0	637
4. Rice	2878	0	0	0	0	0	0	554	0	0	39	125	0	718
5. Wheat	2878	2	18	130	0	0	0	0	0	0	0	0	0	150
6.Pulses	1440	0	0	0	0	0	0	0	0	0	14	73	11	98
7. Pulses	2878	3	0	0	0	0	0	0	0	0	13	147	66	230
8. Vegetable	2878	0	0	0	0	0	0	0	0	0	18	129	27	174
9. Vegetable	1440	51	23	0	0	0	0	0	0	0	0	33	31	137
10.Potato	2878	116	95	10	0	0	0	0	0	0	7	40	70	338

CGWB had constructed 21 nos. of exploratory wells in this district down to a depth of 447m. The discharge of these deep exploratory wells ranges from 3.52 to 216 m^3 /hr. Discharge of the tube wells constructed by CGWB and State Govt. Irrigation department, tapping zones within depth range 30m to 88m of alluvial aquifer varies from 16.2 to 94.6 m^3 /hr. It is expected that tube wells of 50 m depth tapping 15 to 30m of granular zones of the alluvial aquifer will yield 35 m^3/hr. If such a tube well runs for 8 hrs/day for 120 days, then it will create a draft of 3.36 ham.

Total numbers of tube wells require to construct in the district to fulfil the irrigation requirement of 44711 ham, is found to be 13307 nos. Extraction of 44711 ham of groundwater will increase the stage of groundwater extraction to 77%. For sustainable groundwater development, it is necessary to keep the stage of groundwater extraction within the safe limit of 70%. Therefore, it is proposed to develop only 60% of balanced dynamic groundwater resources of the district i.e., 36213ham or 36300 ham (rounded off). To extract 36300 ham groundwater 10810 (rounded off) nos. of tube wells need to be constructed. The balanced requirement of nearly 8400 ham needs to be supplied through surface water irrigation. Towards the southern part of the district under Titabor block, thick clay layers are found at shallow depth. Such areas are suitable for construction of tanks and ponds which can be utilised for irrigation purpose. Moreover, potential resource in water logged and shallow water table area of district is 110684 ham and this resource may also be utilized for irrigation purpose.

Under PMSKY HKKP (GW), 263 nos. of shallow tube wells have been constructed in Jorhat district. Out of 263 nos. of tube wells 155 nos. are energised with electrical pumps and 108 nos. of the tube wells are energised with solar pumps. These tube wells have created an irrigated area of 1052 ha. While in Majuli district 141 nos. of tube wells are constructed and electrical pumps are installed in 75 nos. of tube wells and rest 66 nos. are energised with solar pumps. Construction of these tube wells under PMSKY HKKP (GW)in Majuli district have created irrigated area of 564 ha.

As 404 nos. of tube well has already been constructed in Jorhat (undivided) district under PMKSY HKKP (GW), total number of tube well that need to be constructed as per the NAQUIM management plan is 10406 [i.e., 10810 (as per NAQUIM management plan)-404 (under PMKSY HKKP)].

6.2 Management of groundwater for drinking and domestic uses

Iron and arsenic and other heavy metals pollution: The chemical quality of ground water indicates that groundwater in the area have high iron concentration in some pockets which are beyond the permissible limit, Removal of the iron is best effected by aeration process followed by sedimentation and filtration. Potassium permanganate or chlorine/chloride may be employed to oxidize the iron, which is then filtered from the waters. The process is applicable very much when bacteria is present in the water. Iron can also be removed by addition of a mixture of sodium carbonate and sodium phosphate to precipitate iron as insoluble, followed by settling and filtration.

During previous study in southern part of Brahmaputra River of district, it is found arsenic only in shallow aquifer. From the 2D and 3D disposition of aquifer diagram it is observed that clay or sandy clay layers are in southern part of district. These confining layers can be utilizing to separate the arsenic occurrence zone by adopting proper well construction technique in southern part of district. Deep tube well in arsenic affected areas may be constructed by proper cement sealing and clay filling as shown in fig 32.

Several methods have been used to remove heavy metals from contaminated water. They include chemical precipitation, ion exchange, adsorption, membrane filtration, reverse osmosis, solvent extraction, and electrochemical treatment. Many of these methods suffer from high capital and operational costs. Adsorption seems to be one of the best-suited methods, due to its high efficiency, low-cost, and ease of operation. Various adsorbents, such as carbon foam, activated carbon, zeolite, clay minerals, organic polymers, and biochar, reused sandhave been used for the removal of heavy metals by adsorption. The most effective heavy metal adsorbents, especially for arsenic, are adsorbents based on metal oxides (Fe, Al, Mn oxides), such as WTRs, bog iron ores, ferrihydrite, goethite, layered double hydroxide, Sn/Ti-Mn binary metal oxides, Al/Fe oxide-oxyhydroxide composite powders, and red mud.

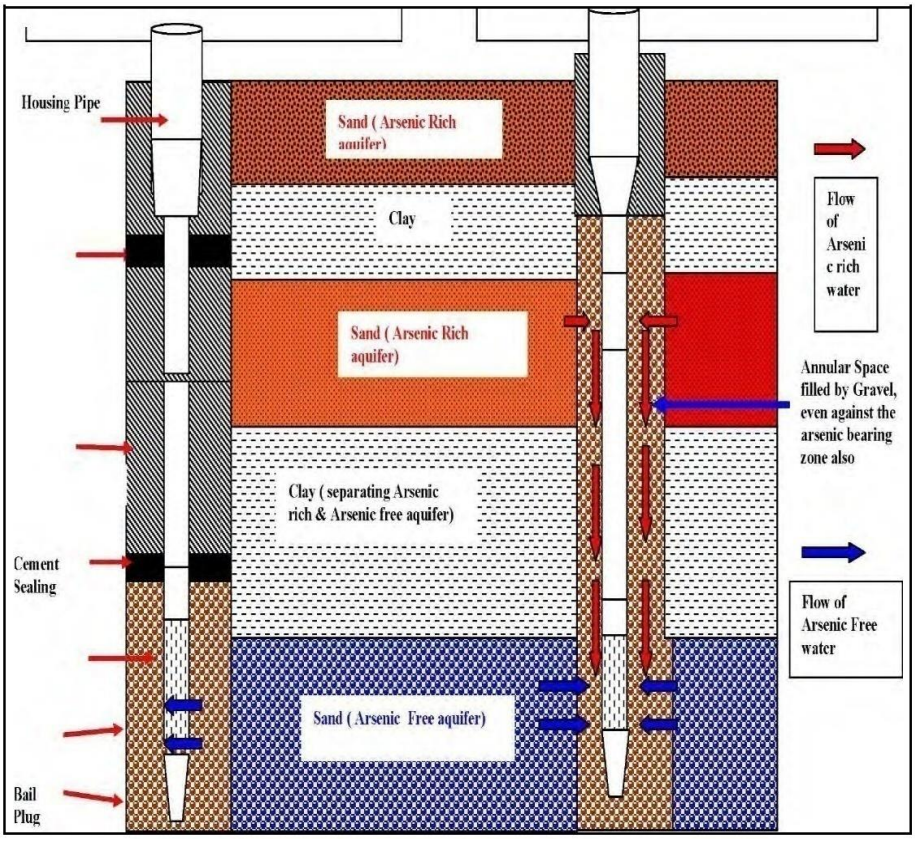


Fig 6.1: Tube-well design of a deep tube well tapping safe deeper aquifer of district where confining layer present.

(Source: Concept note on geo-genic contamination of groundwater in India)

Annexure-I: Water level data

Sl. No.	Location	Well Type	Depth(m)	Dia	MP (magl)	Nov-21 DTW (mbgl)	Mar-22 DTW (mbgl)
1	Jengraimukh	Hand Pump	14.18	0.05	1.6	3.56	4.67
2	Mekheli gaon	Tubewell	13	0.1	0.9	1.94	3.3
3	Mudoi gaon	Tubewell	7	0.1	0.17	1.65	3.16
4	Pohumora	Tubewell	9	0.1	0.9	2	3.9
5	Kamalabari	Tubewell	28	0.1	0.33	2.1	6.73
6	Merua bari	Hand Pump	7.91	0.05	0.8	2.94	4.03
7	Rajguru bari	Tubewell	27	0.15	0.83	2.7	3.88
8	Dakhinpat kalita gaon	Tubewell	78	0.1	0.74	2.21	5.13
9	2 no. borgayan	Tubewell	12	0.1	0.27	2.32	3.58
10	Balichapori	Tubewell	37	0.1	0.87	3.13	4.54
11	Malapindha mising gaon	Tubewell	15	0.1	0.71	1.85	3.08
12	Phuloni	Tubewell	11	0.1	0	2.52	2.9
13	Punctang gaon	Hand Pump	10	0.05	0.44	2.59	4.66
14	Major deuri gaon	Hand Pump	9	0.05	3.2	2.16	3.64
15	Kohardubi gaon	Hand Pump	7.2	0.05	0.45	1.95	2.33
16	Garamur satra	Dug well	4.75	0.8	0.92	2.56	3.22
17	Narasingha satra	Tubewell	8.98	0.1	0.49	1.89	2.41
18	Sukansuti gaon	Borewell	10.38	0.1	0.7	2.42	2.75
19	Bokajan gaon	Hand Pump	19.26	0.05	0.65	1.38	1.97
20	Laon gaon	Hand Pump	8.66	0.05	0.75	2.28	3.05
21	Jengraimukh IB	Tubewell	10.09	0.05	0.46	4.31	4.68
22	Rawnapar BTS	Dug well	4.37	0.93	0.42	2.09	2.8
23	Cinemora	Dug well	6.76		0.53	1.7	1.44
24	Dabarapara Charali	Dug well	3.78		0.85	1.45	2.13
25	Kokilamukh	Dug well	6.52		0.51	1.29	5.42
26	Lichubari	Dug well	2.04		0.92	0.77	0.75
27	Meleng Kaparadharia	Dug well	3.6		0.75	1.12	1.58
28	Sodial Kachari Gaon	Dug well	5.03		1.08	0.83	0.67
29	Bijay Nagar	Dug well	3.2		0.41	0.73	0.69
30	Kamarbandha TE	Dug well			1.25	1.24	2.19
31	Kunwari Pukhuri	Dug well			0.55	1.55	2.3
32	Gatisunga	Dug well	7.08		1.35	2.95	4.3
33	Titabor	Dug well			0.35	1.53	1.73

Annexure-II: Chemical data of post-monsoon water sample (Basic)

Location	Block	Tempº C	pH	EC (µs/cm) 25ºC	Turbidity **(in NTU)**	TDS	CO_3^{-2}	HCO_3^{-1}	TA (as CaCO3)	Cl-	SO_4^{-2}	NO_3^{-1}	F-	Ca^{+2}	Mg^{+2}	TH (as CaCO3)	Na	K
						in mg/L												
Jengraimukh	Majuli	27.3	7.6	214.7	0	122	0	170.9	170.9	7.1	0	11.7	0.5	24	20.6	145	0.3	3.8
Garamur soru satra	Majuli	25.7	8.3	370.9	0	210.6	0	146.5	146.5	24.8	9.1	34	0.3	30	23	170	6.3	20.4
Mekheli gaon,PHED	Majuli	26	8.1	249.8	0.2	141.3	0	183.1	183.1	10.6	0.6	0	0.4	20	23	145	4.3	2.7
Pohumora	Majuli	26.6	7.5	702.1	0.3	399.8	0	201.5	201.5	81.5	10.3	38.8	0.3	56	35.2	285	24.8	12.9
Kamalabari,PHED	Majuli	26.7	7.7	288	0	163.4	0	189.3	189.3	14.2	6.5	0	0.4	28	21.8	160	4.1	3.8
Nambotiya mari	Majuli	26.5	7.8	267.4	0	153	0	207.6	207.6	24.8	2.5	0	0.5	34	21.8	175	3.2	2.1
Kerala gaon	Majuli	25.8	7.9	229.1	0	130	0	164.8	164.8	10.6	2.3	0	0.4	24	18.2	135	3.6	3.3
Merua bari	Majuli	26.2	8.1	118	0	66.7	0	79.4	79.4	10.6	0	0	0.3	8	12.1	70	0.7	2.1
Borkolia chariali	Majuli	26	8	285.2	0	163.7	0	232	232	7.1	0	0	0.5	32	27.9	195	3	4.8
Pakajora	Majuli	26.5	7.9	314	0	178.2	0	225.9	225.9	14.2	7.5	7	0.5	38	19.4	175	8.9	4.8
Kohardubi gaon	Majuli	26.4	8.6	224.8	0	127.6	6	189.3	195.3	7.1	0	0	0.5	26	18.2	140	7.9	3.4
Hazarika gaon	Majuli	25.5	8.5	180.3	0	102.8	3	140.4	143.4	78	1.2	0	0.4	22	6.1	80	3.4	3.6
Gereki gaon	Majuli	27.7	8.8	296.5	0	169.6	12	225.9	237.9	17.7	0.5	0	0.4	38	23	190	4.9	4
Bhogpur uriampora	Majuli	25.7	8.8	327.8	0	186.2	12	262.5	274.5	10.6	1.8	4.2	0.5	38	25.5	200	5.9	3
Rajguru bari	Majuli	25.6	8.4	442.5	0	257	12	378.5	390.5	7.1	2.6	0	0.3	56	37.6	295	1.3	4.3
Komargaon	Majuli	25.9	8.5	608.3	0.2	354.8	6	244.2	250.2	74.4	10.7	36.1	0.3	72.1	40	345	17.1	4.4
Kalita gaon	Majuli	25.6	8.4	264.4	0	152.7	6	213.7	219.7	10.6	4	0	0.6	32	21.8	170	12.9	0.1
Jugiikoibotro gaon	Majuli	25.3	7.9	486.2	0	283	0	372.4	372.4	21.3	39.5	4.4	0.4	56	48.5	340	2.9	2.9
Goalabari-jadavpur	Majuli	25.6	8	220.6	0	127.7	0	158.7	158.7	7.1	21.2	0	0.6	34	10.9	130	8.9	2.9
Kakori kota,chilakola GP	Majuli	25.4	7.6	233.8	0	137.1	0	85.5	85.5	28.4	8	17.1	0.4	22	12.1	105	13.9	3.8
Malapindha mising gaon	Majuli	28.5	7.9	346.3	0	201.5	0	238.1	238.1	17.7	52	0	0.4	44	25.5	215	12.8	4.1
Malapindha koibotro gaon	Majuli	26.6	8	316.2	0	183.5	0	158.7	158.7	35.5	30.4	7	0.5	36	20.6	175	9.9	3.5
Boridigha gaon	Majuli	26.2	8.4	222	0	129	6	183.1	189.1	7.1	34.8	0	0.6	26	20.6	150	12.4	2.6
Uluwani karkichuk gaon	Majuli	25.8	8.1	250	0	145.3	0	225.9	225.9	7.1	0.4	0	0.5	36	14.5	150	11.3	3.2
Rongachahi mising gaon	Majuli	26	8.4	275.6	0	159.8	6	225.9	231.9	7.1	49.5	0	0.7	26	18.2	140	38	8.7
Bapuchola gaon	Majuli	26	8.6	328.6	0	191	9	274.7	283.7	10.6	41.1	0	0.6	36	26.7	200	27.3	14.1
Lahon gaon	Majuli	26.8	8.4	533.1	0	308.5	6	439.6	445.6	14.2	41	0	0.6	54	50.9	345	16.1	5.3
Gosaibari gaon	Majuli	25.7	7.9	486.6	0	281.7	0	293	293	24.8	14.9	4.2	0.6	44	29.1	230	9.9	37.1
Phutsang gaon	Majuli	25.3	8.1	298.4	0	171.7	0	177	177	24.8	8.3	0.5	0.7	30	23	170	5.3	3.3
Ratanpur miri gaon	Majuli	26.2	8	451.9	0	262	0	140.4	140.4	60.3	43.8	0	0.2	46	34	255	5.6	2.6
Major deuri gaon	Majuli	26.5	8.2	251.6	0.1	145.3	0	189.3	189.3	14.2	11.4	0	0.3	28	21.8	160	3.4	3.3

Annexure-III: Chemical data of post-monsoon water sample (Heavy Metals)

Location	Block	Structure	Iron	Manganese	Zinc	Copper	Cadmium	Lead
			mg/L				µg/L	
Permissible Limit →			**1**	**0.3**	**15**	**1.5**	**3**	**10**
Jengraimukh	Majuli	Hand pump	0.776	2.061	0.372	BDL	1.619	6.951
Garamur soru satra	Majuli	Hand pump	0.704	0.213	0.14	BDL	0.346	6.03
Mekheli gaon,PHED	Majuli	Tube well	3.878	0.803	0.806	BDL	0.381	16.727
Pohumora	Majuli	Hand pump	0.704	0.878	0.815	0.021	0.311	18.434
Kamalabari,PHED	Majuli	Tube well	7.938	1.048	0.322	0.021	0.241	6.951
Nambotiya mari	Majuli	Hand pump	25.234	0.972	0.164	BDL	0.207	17.584
Kerala gaon	Majuli	Hand pump	3.878	0.231	0.437	0.007	0.207	20.12
Merua bari	Majuli	Hand pump	1.07	0.213	0.204	0.007	0.137	32.067
Borkolia chariali	Majuli	Hand pump	1.14	0.304	0.281	0.007	0.241	13.248
Pakajora	Majuli	Hand pump	0.92	0.086	0.194	BDL	0.241	15.866
Kohardubi gaon	Majuli	Hand pump	0.85	0.413	0.051	0.007	0.207	17.584
Hazarika gaon	Majuli	Hand pump	89.6	0.616	6.554	0.036	0.311	23.848
Gereki gaon	Majuli	Hand pump	8.13	0.897	BDL	0.007	0.311	42.793
Bhogpur uriampora	Majuli	Hand pump	14.68	0.878	5.141	0.007	0.311	15.866
Rajguru bari	Majuli	Tube well	6.47	1.124	0.231	0.007	0.346	24.238
Komargaon	Majuli	Hand pump	0.92	0.122	0.21	0.007	0.311	15.866
Kalita gaon	Majuli	Hand pump	0.78	1.862	0.184	0.007	0.276	17.584
Jugiikoibotro gaon	Majuli	Hand pump	16.71	2.566	0.304	0.007	0.311	14.999
Goalabari-jadavpur	Majuli	Tube well	0.63	1.162	0.174	0.007	0.311	19.28
Kakori kota,chilakola GP	Majuli	Hand pump	1.67	0.015	0.328	0.021	0.241	9.682
Malapindha mising gaon	Majuli	Hand pump	1.216	1.645	0.417	0.007	0.276	9.682
Malapindha koibotro gaon	Majuli	Hand pump	0.922	0.213	0.298	0.007	0.207	6.951
Boridigha gaon	Majuli	Hand pump	6.376	0.953	BDL	0.007	0.241	14.999
Uluwani karkichuk gaon	Majuli	Hand pump	2.123	0.377	0.109	0.021	0.276	29.775
Rongachahi mising gaon	Majuli	Hand pump	2.123	1.258	0.083	0.021	0.207	11.476
Bapuchola gaon	Majuli	Hand pump	1.665	0.395	0.215	0.021	0.241	6.03
Lahon gaon	Majuli	Hand pump	4.546	1.509	0.275	0.021	0.311	8.777
Gosaibari gaon	Majuli	Hand pump	1.069	2.161	0.31	0.021	0.557	6.03
Phutsang gaon	Majuli	Hand pump	1.969	0.213	0.199	0.021	0.241	6.03
Ratanpur miri gaon	Majuli	Hand pump	0.995	0.728	0.275	0.021	0.381	1.536
Major deuri gaon	Majuli	Hand pump	5.931	1.277	0.199	0.021	0.207	9.682

Annexure-IV: Chemical data of pre-monsoon water sample (Basic)

S N	Location	Block	Structure	Depth	pH	EC µS/cm at 25°C	Turbidity (NTU)	TDS	TA as $CaCO_3$	Cl	Ca	Mg	TH	Na	K	CO_3	HCO_3	SO_4	NO_3	F^-
									mg/L											
1	Jengraimukh	Majuli	Hand pump	7.82	8.34	431.10	BDL	284.53	179.94	56.72	42.03	16.97	175.00	19.70	6.27	9.00	170.94	13.61	0.04	0.41
2	Garamur soru satra	Majuli	Hand pump	11	7.28	221.40	BDL	146.12	158.73	28.36	20.02	16.98	120.00	14.35	5.21	BDL	158.73	7.65	0.29	0.35
3	Mekheli gaon,PHED	Majuli	Tube well	29	7.25	369.50	BDL	243.87	177.04	21.27	28.02	16.98	140.00	6.05	27.66	BDL	177.04	0.01	0.19	0.38
4	Pohumora	Majuli	Hand pump	11	7.35	330.70	0.10	218.26	189.25	28.36	28.02	20.62	155.00	6.51	4.03	BDL	189.25	1.60	0.36	0.32
5	Kamalabari,PHED	Majuli	Tube well	28	8.32	682.50	BDL	450.45	274.51	60.27	34.03	42.46	260.00	18.21	25.99	12.00	262.51	2.26	1.84	0.39
6	Nambotiya mari	Majuli	Hand pump	11	8.31	333.00	BDL	219.78	231.78	17.73	30.02	20.62	160.00	15.75	4.84	12.00	219.78	7.33	0.52	0.49
7	Nambotiya mari	Majuli	Hand pump	11	8.45	511.20	0.20	337.39	329.45	35.45	40.03	37.60	255.00	4.83	6.30	12.00	317.45	2.66	1.01	0.28
8	Nambotiya mari (Filtered)	Majuli	Hand pump	14	8.41	506.90	0.10	334.55	326.35	17.73	50.04	31.53	255.00	9.22	6.26	15.00	311.35	5.48	0.11	0.32
9	Kerala gaon(Mokhina LP school)	Majuli	Hand pump	11	8.35	287.50	BDL	189.75	183.04	194.98	34.03	13.33	140.00	95.34	59.20	6.00	177.04	34.24	0.26	0.42
10	Merua bari	Majuli	Hand pump	14	8.41	293.40	BDL	193.64	183.04	31.91	32.03	14.55	140.00	17.76	4.60	6.00	177.04	20.55	1.46	0.33
11	Borkolia chariali	Majuli	Hand pump	11	7.82	162.80	BDL	107.45	91.57	17.73	18.01	8.49	80.00	8.58	3.30	BDL	91.57	7.08	0.91	0.50
12	Pakajora	Majuli	Hand pump	11	8.36	352.40	0.30	232.58	225.67	21.27	26.02	25.47	170.00	19.26	7.73	12.00	213.67	16.89	0.14	0.49
13	Kohardubi gaon	Majuli	Hand pump	7	8.40	397.40	BDL	262.28	262.20	21.27	26.02	27.90	180.00	25.65	6.01	18.00	244.20	7.20	0.82	0.46
14	Hazarika gaon namghar	Majuli	Hand pump	14	8.41	304.70	0.40	201.10	204.36	21.27	34.03	14.55	145.00	19.27	4.59	9.00	195.36	5.14	0.93	0.45
15	Hazarika gaon (filtered)	Majuli	Hand pump	14	8.44	344.60	BDL	227.44	231.78	24.82	34.03	18.19	160.00	25.86	4.77	12.00	219.78	21.43	0.43	0.31
16	Gereki gaon	Majuli	Hand pump	7	7.99	462.10	BDL	304.99	225.88	46.09	38.03	19.40	175.00	29.01	13.16	BDL	225.88	23.95	5.14	0.52

S N	Location	Block	Structure	Depth	pH	EC µS/cm at 25°C	Turbidity (NTU)	TDS	TA as $CaCO_3$	Cl	Ca	Mg	TH	Na	K	CO_3	HCO_3	SO_4	NO_3	F^-
									mg/L											
17	Bhogpur (non-filtered)	Majuli	Hand pump	14	8.39	399.10	0.10	263.41	259.20	35.45	32.03	29.11	200.00	15.78	5.31	15.00	244.20	4.77	0.40	0.49
18	Bhogpur (filtered)	Majuli	Hand pump	14	8.36	424.00	BDL	279.84	295.82	24.82	32.03	30.32	205.00	27.66	4.35	15.00	280.82	6.15	0.30	0.35
19	Rajguru bari	Majuli	Tubewell	47	8.42	429.00	BDL	283.14	304.93	21.27	24.02	35.18	205.00	28.54	4.62	18.00	286.93	1.74	1.36	0.51
20	Komargaon	Majuli	Hand pump	11	8.39	545.00	BDL	359.70	378.29	21.27	34.03	43.67	265.00	17.86	6.95	12.00	366.29	7.65	0.25	0.36
21	Kalita gaon	Majuli	Tara pump	32	7.89	754.20	BDL	497.77	201.46	88.63	20.02	54.60	275.00	17.53	7.97	BDL	201.46	0.88	0.93	0.59
22	Jugiikoibotro gaon	Majuli	Hand pump	8	7.91	358.90	BDL	236.87	195.36	31.91	30.02	20.62	160.00	12.24	1.77	BDL	195.36	0.01	0.23	0.27
23	Goalabari-jadavpur	Majuli	Tube well	27	8.39	621.30	BDL	410.06	390.40	31.91	56.04	38.81	300.00	9.29	3.70	18.00	372.40	9.58	0.75	0.68
24	Kakori kota	Majuli	Hand pump	8	8.01	381.60	BDL	251.86	164.83	24.82	28.02	20.62	155.00	9.38	5.81	BDL	164.83	2.69	0.25	0.47
25	Kakori kota	Majuli	Hand pump	11	7.93	234.10	0.10	154.51	85.47	17.73	20.02	3.63	65.00	8.68	13.13	BDL	85.47	1.60	0.08	0.26
26	Kakori kota (Filtered)	Majuli	Hand pump	14	8.36	1000.00	BDL	660.00	250.09	63.81	60.05	21.82	240.00	13.78	55.92	12.00	238.09	13.14	1.05	0.27
27	Kakori kota (Non-Filtered)	Majuli	Hand pump	14	8.32	407.50	BDL	268.95	140.31	31.91	30.02	13.33	130.00	15.31	5.58	6.00	134.31	7.87	0.10	0.04
28	Malapindha mising gaon	Majuli	Hand pump	8	8.34	298.80	BDL	197.21	143.31	39.00	30.02	14.55	135.00	16.72	4.61	9.00	134.31	9.92	0.43	0.52
29	Malapindha koibotro gaon	Majuli	Hand pump	8	8.31	500.00	BDL	330.00	292.82	28.36	20.02	33.97	190.00	34.23	7.48	12.00	280.82	10.91	1.39	0.47
30	Boridigha gaon	Majuli	Hand pump	8	8.34	358.20	0.20	236.41	195.15	24.82	26.02	27.90	180.00	7.79	5.30	12.00	183.15	10.72	0.84	0.62
31	Boridigha gaon	Majuli	Hand pump	8	8.31	320.60	0.20	211.60	207.36	10.64	22.02	27.90	170.00	6.66	4.88	12.00	195.36	9.17	0.50	0.55
32	Uluwani karkichuk gaon	Majuli	Hand pump	11	8.39	220.60	BDL	145.60	164.62	42.54	22.02	10.91	100.00	35.60	14.10	12.00	152.62	10.06	0.70	0.68
33	Rongachahi mising gaon	Majuli	Hand pump	8	8.34	318.90	BDL	210.47	237.88	14.18	42.03	12.12	155.00	27.18	5.28	12.00	225.88	11.05	0.14	0.59

S N	Location	Block	Structure	Depth	pH	EC µS/cm at 25°C	Turbidity (NTU)	TDS	TA as $CaCO_3$	Cl	Ca	Mg	TH	Na	K	CO_3	HCO_3	SO_4	NO_3	F^-
									mg/L											
34	Bapuchola gaon(non-filtered)	Majuli	Hand pump	14	8.31	355.80	BDL	234.83	243.99	21.27	24.02	19.41	140.00	32.54	6.97	12.00	231.99	3.85	0.07	0.44
35	Bapuchola gaon(filtered)	Majuli	Hand pump	14	8.41	427.30	0.30	282.02	298.82	28.36	50.04	18.18	200.00	32.18	6.52	18.00	280.82	3.48	0.41	0.32
36	Lahon gaon(non-filtered)	Majuli	Hand pump	14	8.34	286.80	BDL	189.29	189.15	24.82	16.01	13.34	95.00	33.16	11.70	6.00	183.15	2.10	0.98	0.57
37	Lahon gaon(filtered)	Majuli	Hand pump	14	7.81	626.60	BDL	413.56	372.40	21.27	86.07	18.16	290.00	8.75	7.41	BDL	372.40	11.50	5.39	0.51
38	Lahon gaon	Majuli	Hand pump	25	8.41	633.70	BDL	418.24	433.13	31.91	100.08	10.87	295.00	31.68	19.56	18.00	415.13	9.07	0.52	0.18
39	Gosaibari gaon	Majuli	Hand pump	8	8.46	569.60	BDL	375.94	329.35	28.36	58.05	27.88	260.00	9.95	6.63	18.00	311.35	5.83	1.15	0.55
40	Phutsang gaon	Majuli	Hand pump	8	7.69	633.40	0.30	418.04	268.61	42.54	50.04	26.67	235.00	11.27	44.54	BDL	268.61	3.40	1.32	0.81
41	Ratanpur miri gaon	Majuli	Hand pump	14	7.79	601.10	BDL	396.73	140.41	102.81	58.05	26.67	255.00	3.51	7.89	BDL	140.41	6.04	1.59	0.33
42	Major deuri gaon	Majuli	Hand pump	14	8.31	389.00	BDL	256.74	213.46	17.73	30.02	24.26	175.00	6.90	6.51	12.00	201.46	3.03	2.78	0.43
43	Garamura satra	Majuli	Dug well	4.75	8.39	349.60	BDL	230.74	207.36	24.82	50.04	6.04	150.00	14.32	10.61	12.00	195.36	1.62	6.00	0.42
44	Karkichuk, phuloni	Majuli	Hand pump	8	7.92	411.90	0.10	271.85	225.88	35.45	48.04	14.54	180.00	17.55	6.39	BDL	225.88	6.23	0.68	0.32
45	Karkichuk, phuloni	Majuli	Tube well	88.4	8.43	416.90	BDL	275.15	268.40	28.36	42.03	21.82	195.00	22.63	6.26	12.00	256.40	6.32	0.80	0.33
46	Karkichuk, phuloni	Majuli	Tube well	88.4	8.38	291.70	BDL	192.52	207.25	24.82	26.02	15.76	130.00	25.06	15.35	18.00	189.25	2.57	1.49	0.21

Annexure-V: Chemical data of pre-monsoon water sample (Heavy Metals)

S N	Location	Block	Structure	Depth	Fe	Mn	Zn	Cu	Cd	Pb
					mg/L				µg/L	
1	Jengraimukh	Majuli	Hand pump	7.82	0.736	0.286	—	—	0.695	42.715
2	Garamur soru satra	Majuli	Hand pump	11	4.295	0.5	—	—	5.109	5.396
3	Mekheli gaon,PHED	Majuli	Tube well	29	3.339	0.286	—	—	0.695	4.056
4	Pohumora	Majuli	Hand pump	11	4.729	0.286	—	—	0.355	4.727
5	Kamalabari,PHED	Majuli	Tube well	28	0.128	0.479	—	—	0.544	3.045
6	Nambotiya mari	Majuli	Hand pump	11	8.57	1.076	—	—	9.676	2.706
7	Nambotiya mari	Majuli	Hand pump	11	29.423	1.576	—	—	2.43	5.062
8	Nambotiya mari (Filtered)	Majuli	Hand pump	14	0.371	1.054	—	—	0.242	4.727
9	Kerala gaon(Mokhina LP school)	Majuli	Hand pump	11	0.314	BDL	—	—	0.28	2.027
10	Merua bari	Majuli	Hand pump	14	10.441	0.382	—	—	1.864	3.72
11	Borkolia chariali	Majuli	Hand pump	11	0.795	0.404	—	—	0.167	2.367
12	Pakajora	Majuli	Hand pump	11	0.736	0.127	—	—	0.091	2.706
13	Kohardubi gaon	Majuli	Hand pump	7	0.581	0.053	—	—	0.393	4.056
14	Hazarika gaon namghar	Majuli	Hand pump	14	2.549	0.597	—	—	0.469	13.519
15	Hazarika gaon (filtered)	Majuli	Hand pump	14	9.761	0.912	—	—	0.318	5.396
16	Gereki gaon	Majuli	Hand pump	7	0.165	0.074	—	—	0.318	4.392
17	Bhogpur (non-filtered)	Majuli	Hand pump	14	7.785	1.408	—	—	4.656	5.062
18	Bhogpur(filtered)	Majuli	Hand pump	14	7.844	1.076	—	—	0.544	3.383
19	Rajguru bari	Majuli	Tubewell	47	0.165	0.022	—	—	0.242	2.706
20	Komargaon	Majuli	Hand pump	11	9.474	1.475	—	—	0.242	2.706
21	Kalita gaon	Majuli	Tara pump	32	0.466	0.201	—	—	0.393	2.367
22	Jugiikoibotro gaon	Majuli	Hand pump	8	0.296	2.153	—	—	0.205	3.383
23	Goalabari-jadavpur	Majuli	Tubewell	27	17.625	3.249	—	—	1.789	4.056
24	Kakori kota	Majuli	Hand pump	8	0.24	1.982	—	—	0.28	2.367
25	Kakori kota	Majuli	Hand pump	11	1.359	0.011	—	—	0.129	2.706
26	Kakori kota(Filtered)	Majuli	Hand pump	14	0.639	0.255	—	—	0.959	4.056
27	Kakori kota(Non-Filtered)	Majuli	Hand pump	14	0.296	0.032	—	—	0.129	1.686
28	Malapindha mising gaon	Majuli	Hand pump	8	0.409	0.064	—	—	0.205	6.724
29	Malapindha koibotro gaon	Majuli	Hand pump	8	2.754	2.977	—	—	0.242	3.72

S N	Location	Block	Structure	Depth	Fe	Mn	Zn	Cu	Cd	Pb
					mg/L				µg/L	
30	Boridigha gaon	Majuli	Hand pump	8	0.697	0.329	—	—	3.524	2.706
31	Boridigha gaon	Majuli	Hand pump	8	2.082	1.364	—	—	0.77	2.706
32	Uluwani karkichuk gaon	Majuli	Hand pump	11	2.082	1.564	—	—	0.205	4.727
33	Rongachahi mising gaon	Majuli	Hand pump	8	1.359	0.447	—	—	0.205	1.686
34	Bapuchola gaon(non-filtered)	Majuli	Hand pump	14	2.17	1.497	—	—	0.544	3.045
35	Bapuchola gaon(filtered)	Majuli	Hand pump	14	1.505	0.533	—	—	0.091	1.345
36	Lahon gaon(non-filtered)	Majuli	Hand pump	14	2.686	2.279	—	—	0.167	2.367
37	Lahon gaon(filtered)	Majuli	Hand pump	14	4.859	1.902	—	—	0.431	1.686
38	Lahon gaon	Majuli	Hand pump	25	0.504	BDL	—	—	0.129	1.345
39	Gosaibari gaon	Majuli	Hand pump	8	7.197	0.447	—	—	0.393	2.367
40	Phutsang gaon	Majuli	Hand pump	8	0.314	2.754	—	—	0.431	2.027
41	Ratanpur miri gaon	Majuli	Hand pump	14	7.904	1.043	—	—	0.242	1.4303636
42	Major deuri gaon	Majuli	Hand pump	14	1.277	1.032	—	—	0.205	1.2693042
43	Garamura satra	Majuli	Dug well	4.75	6.148	0.468	—	—	0.205	1.1082448
44	Karkichuk, phuloni	Majuli	Hand pump	8	1.256	0.651	—	—	0.167	0.9471853
45	Karkichuk, phuloni	Majuli	Tube well	88.4	0.874	0.651	—	—	0.129	0.7861259
46	Karkichuk, phuloni	Majuli	Tube well	88.4	0.756	0.586	—	—	0.393	0.6250664