केंद्रीय भूमि जल बोर्ड

जल संसाधन, नदी विकास और गंगा संरक्षण

विभाग, जल शक्ति मंत्रालय

भारत सरकार

Central Ground Water Board

Department of Water Resources, River Development and Ganga Rejuvenation,

Ministry of Jal Shakti

Government of India

AQUIFER MAPPING AND MANAGEMENT OF GROUND WATER RESOURCES

CHIRANG DISTRICT, ASSAM

उत्तर पूर्वी क्षेत्र, गुवाहाटी

North Eastern Region, Guwahati

GOVERNMENT OF INDIA
भारतसरकार
MINISTRY OF JAL SHAKTI
जल शक्ति मंत्रालय
Department of Water Resources, River Development and Ganga Rejuvenation
जल संसाधन, नदी विकास और गंगा संरक्षण विभाग
CENTRAL GROUND WATER BOARD
केंद्रीय भूमि जल बोर्ड

Report on
Aquifer Mapping and Management Plan of Chirang district, Assam
Annual Action Plan 2022-23

By

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गुवाहाटी
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CHAPTER 1

INTRODUCTION

1.1 Objectives

The objectives of the present study are to prepare aquifer map of Chirang district at 1:50,000 scale, assess groundwater resources, identify groundwater issues and prepare a groundwater management plan.

1.2 Scope of study

Chirang district is one of the Bodoland Territorial Council districts of Assam. It has vast groundwater and surface water resources. The water resources of the district can be judiciously used for sustainable economic growth. In this context, proper hydrogeologic knowledge of the area is critical in preparing a sustainable management plan for groundwater utilization.

1.3. Approach and methodology

The approach involves identifying the principal aquifers and conceptualizing the aquifer system. This will help in formulating an aquifer management plan. Finally, the scientific knowledge will be disseminated to farmers, state government and stake holders. The methodology can be illustrated as follows:

Data compilation and data gap analysis: The preliminary works consisted of collection and review of all existing hydrogeological and exploration data of CGWB and State Groundwater Departments. All data were plotted in base map on GIS Platform (ArcGIS 10.8). On the basis of available data, Data Gaps were identified.

Data Generation: Efforts were made to fill the data gaps by multiple activities such as geophysical surveys, hydro-geochemical analysis, besides detailed hydrogeological surveys.

Aquifer Map Preparation: A combination of geologic, geophysical, hydrologic and chemical techniques has been deployed to characterize the quantity, quality and sustainability of ground water in aquifers. On the basis of integration of data generated from various studies of hydrogeology, hydrochemistry and geophysics, aquifers have been delineated and characterized in terms of quality and ground water potential. Various maps have been prepared to delineate the lateral and vertical disposition of aquifers and their characterization on 1: 50,000 scale.

Aquifer Management Plan Formulation: Based on the aquifer map and conceptual model, a sustainable development plan of the aquifer is formulated with the help of FAO's CROPWAT software.

1.4 Area Details

The district is located in north-western part of Assam surrounded by Bhutan in the north, Bongaigaon district and a little portion of Kokrajhar district in the south, Kokrajhar district in the west and Baksa district in the east (Fig. 1.1). Chirang district is covered by Survey of India Toposheet No. 78J/5, 78J/6, 78J/7, 78J/9, 78J/10, 78J/11, 78J/13,78J/14, 78J/15 and bounded by 26˚ 23´35" and 26˚ 49' 11" North Latitudes and 90˚21'30" and 90˚58´13" East longitudes (Fig.1.2). The district has a geographical area of 1918 sq. km.

Total population of the district is 4,82,162 with 2,37,302 being males and 73,215 being females respectively (Census 2011).

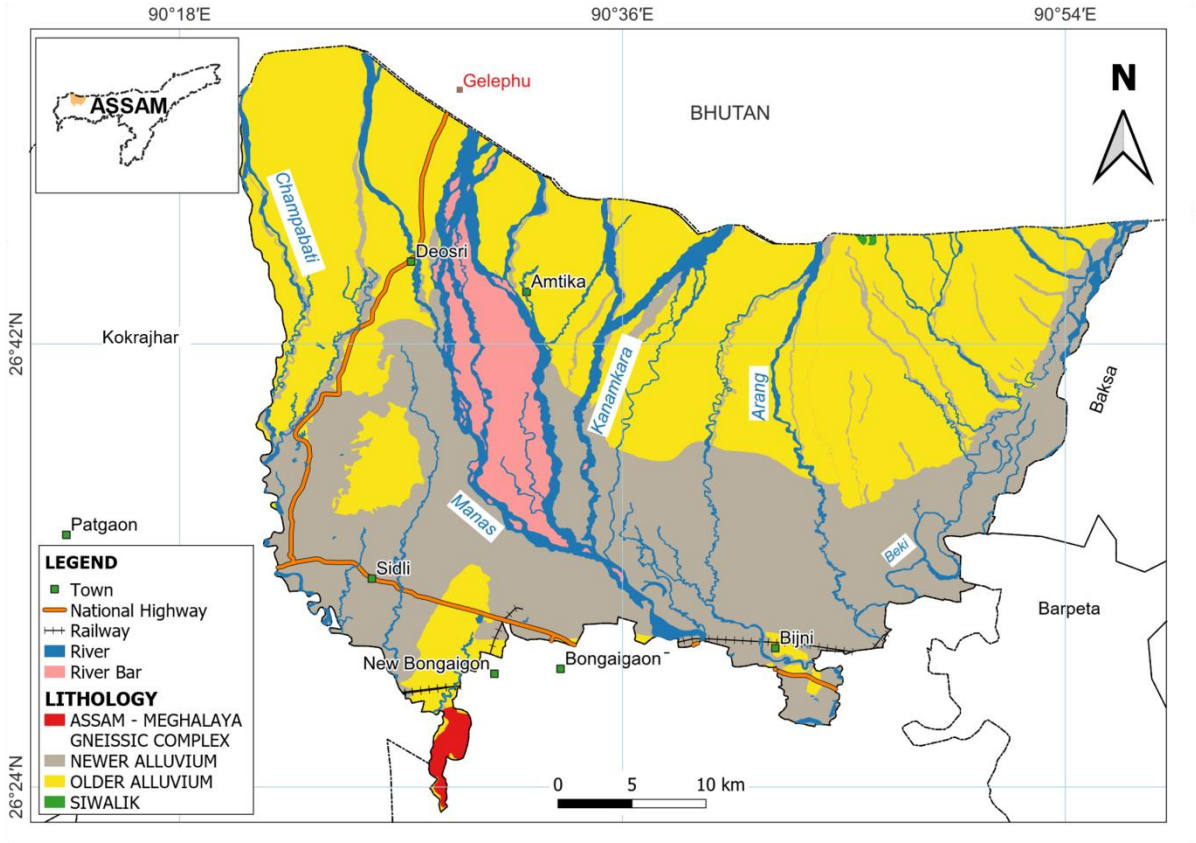

Fig 1.1. Location map of Chirang district

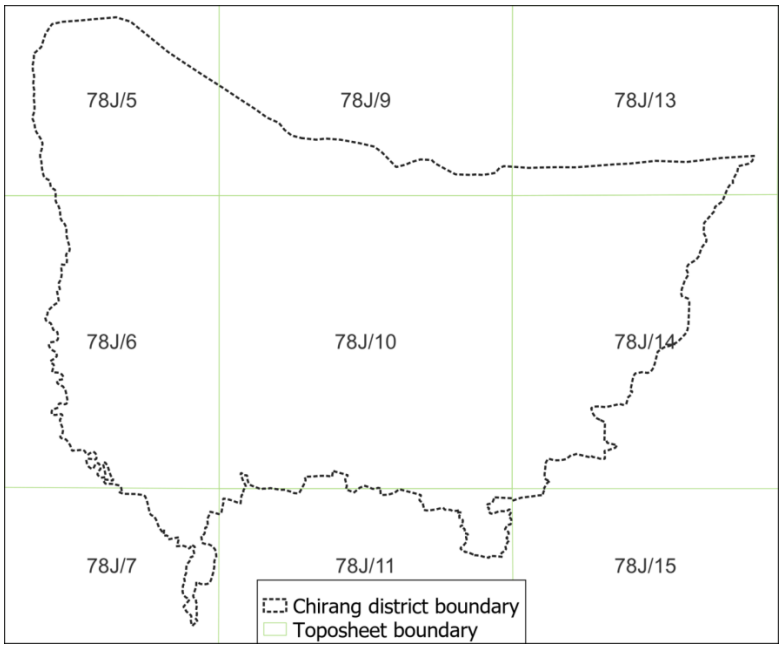

Fig 1.2. Toposheets that cover Chirang district

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

Plotting and perusal of available data indicated the data gap in the district. The available data, data gap and data generation work are tabulated in Table 1.1.

Table 1.1. Data availability, data gap and data generation in Chirang district, Assam

SN	Theme	Type	Data available	Data gap	Data generation	Total	Remarks
1	Borehole Lithology Data		NIL	5	NIL	NIL	5 EW + 5 OW are proposed to be constructed through outsourcing
2	Geophysical data		NIL	6	NIL		8 Nos of VES were carried out against AAP target of 6 nos.
3	Groundwater level data	Dug well	5	25	42	47	
4	Groundwater quality data	Dug well	5	26	26	32	
		Tubewell			1		
6	Soil Infiltration Test		NIL	3	NIL		3 Nos of Soil Infiltration were carried out

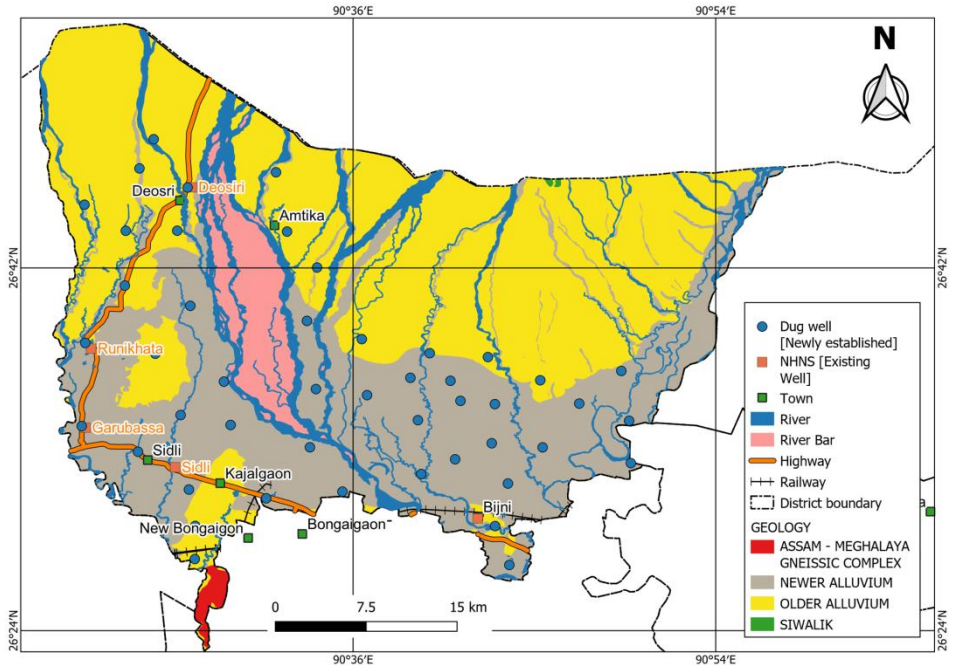

Fig 1.3. Existing NHNS wells and newly established wells

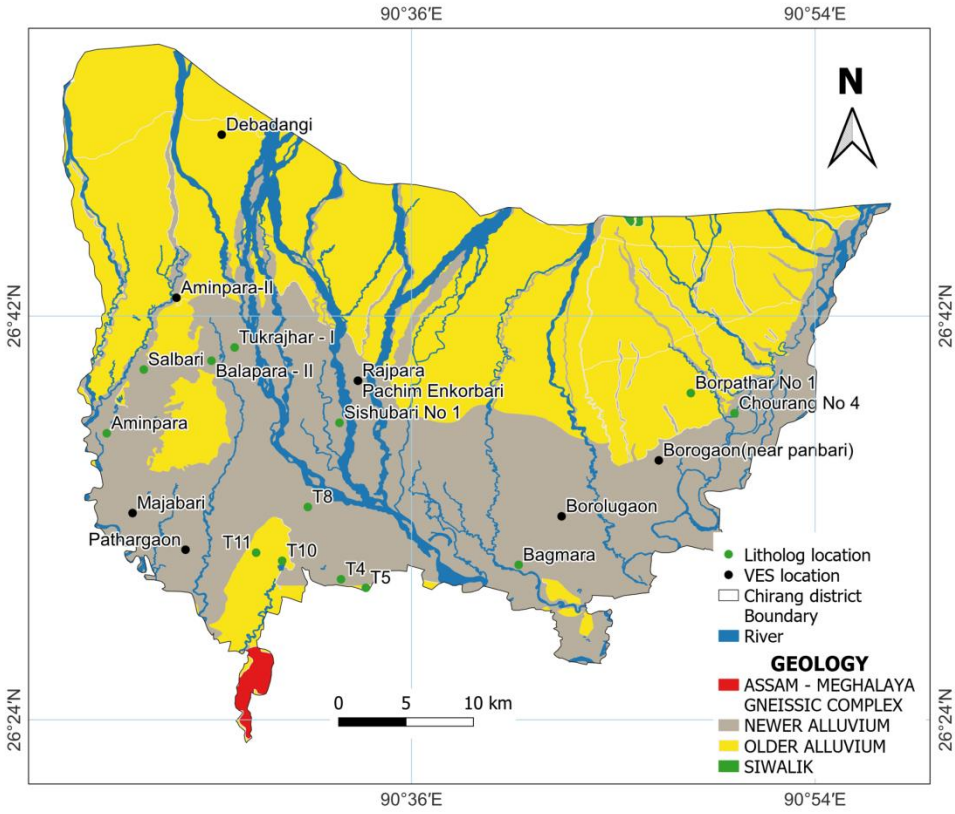

Fig 1.4 Locations of available litholog and VES data generated used for making subsurface model of aquifer in Chirang district

1.6 Rainfall distribution

The climate of the district is sub-tropical in nature with warm and humid summer followed by dry and cool winter. June, July and August are the hottest months. January is the coldest month. The winter temperature drops to 10° C and summer temperature goes up to 35° C. South West monsoon activates from June and continues up to September-October.

Rainfall during monsoon months [June to October] makes up about 80% of the total rainfall in a year whereas the rainfall during non-monsoon months [January to May and November and December] between January to April contributes only about 20% to the total rainfall in a year. December receives least rainfall and maximum rainfall occurs during July (Table 1.2).

The average monthly rainfall from 2012 to 2021 and also yearly rainfall distribution of Chirang district are given in Table 1.2. The average monthly rainfall and yearly rainfall variations are graphically illustrated in Fig. 1.5 and Fig. 1.6. Based on Indian Meteorological Department (IMD) data set from 2017 to 2021 the average annual rainfall of the district found out to be 4173 mm.

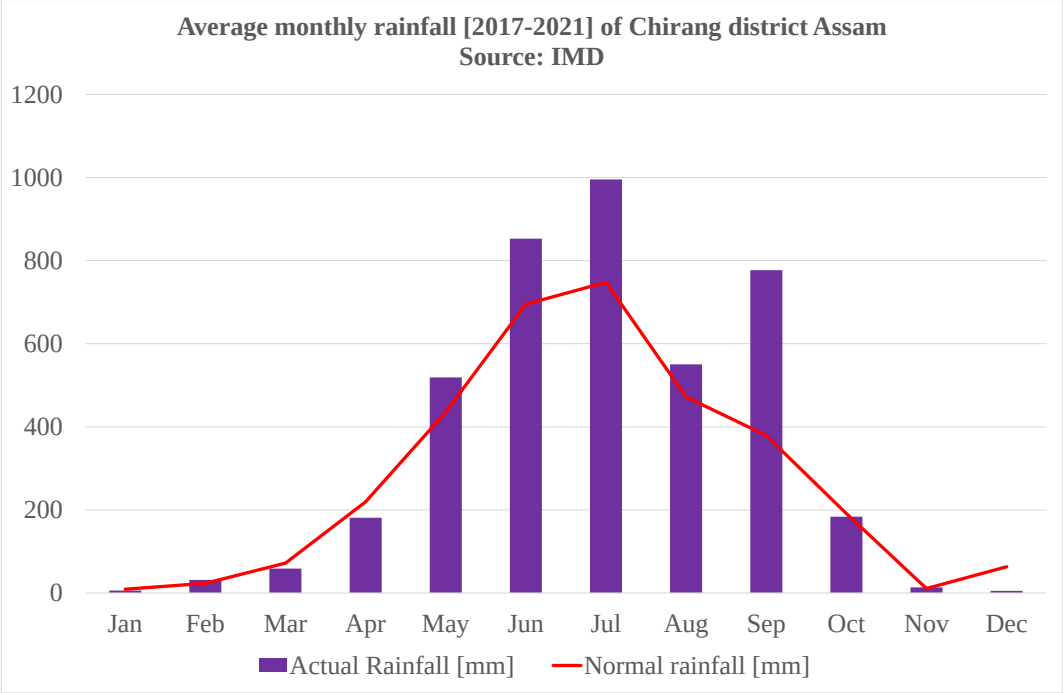

Fig 1.5. Average Monthly rainfall in Chirang district(2017-2021)

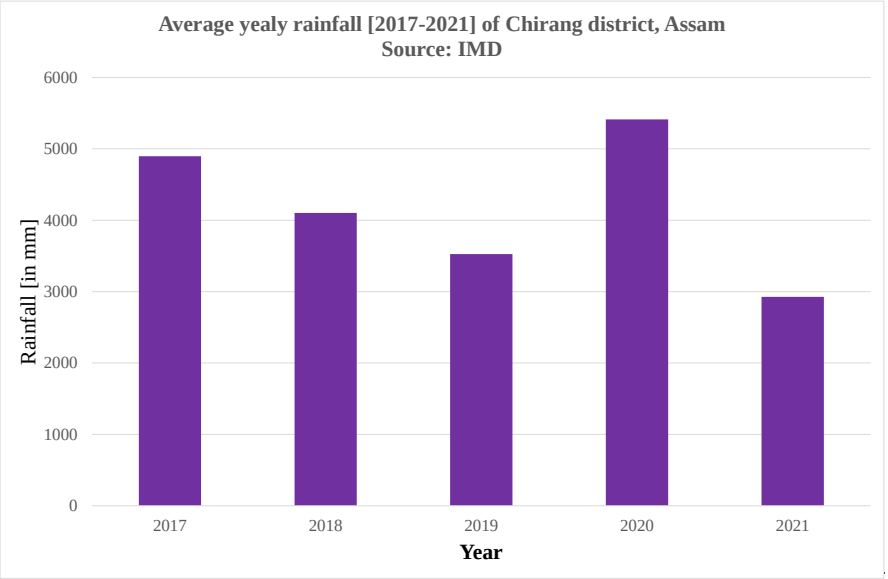

Fig 1.6. Average yearly rainfall of Chirang district (2017-2021)

1.7 Physiography

The district forms a part of the vast alluvial plains of Brahmaputra River system and sub-basin of River Manas. Physiographically, it is characterised by the different land forms, viz., a) gently sloping piedmont zone b) alluvial plains and c) inselberg. The district shares international boundary with Bhutan in the north with a mixed topography of plains and foot hills. The flat plain dominates the landscape of the district.

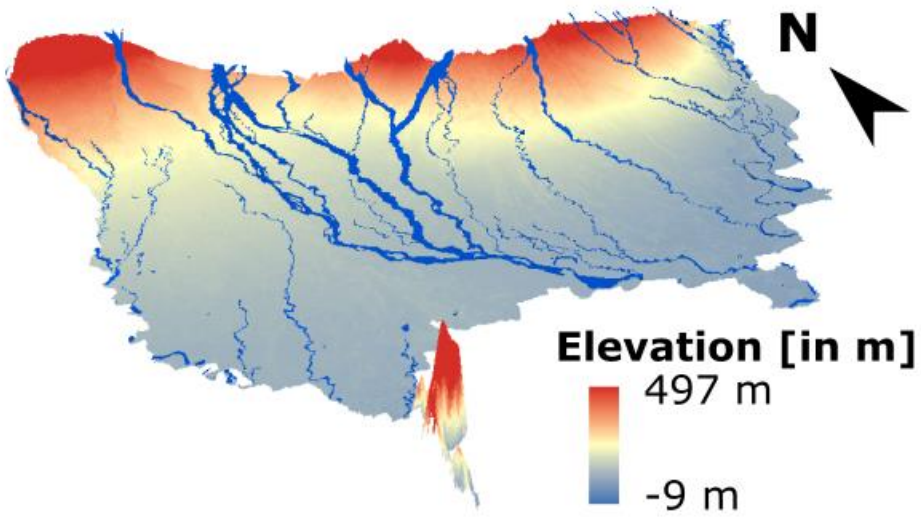

Fig. 1.7. 3D rendering of SRTM DEM of Chirang district

Table 1.2. Rainfall data of Chirang district (in mm). (Source: https://hydro.imd.gov.in/hydrometweb/(S(zmsurc45zyn1u355lwgdht2b))/landing.aspx)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	ANNUAL TOTAL
2017	0.4	27	63.8	458	425	837.9	686	1199	858	316	25.4	0	4895.8
2018	4	39	114	126	648	934.2	721	312.1	1064	91.8	28	21	4102.3
2019	0.6	73	45.2	158	429	538.6	1401	254.5	488.4	127	10.4	0	3526.1
2020	6.8	15	36.6	58.8	842	1114	1552	422.9	1237	121	2	4	5413.3
2021	16	2.8	32.6	104	251	840	617.4	563.2	237	261	1.4	0	2926.4
Monthly average	5.56	31.4	58.46	181.1	518.9	852.98	995.56	550.3	776.88	183.4	13.4	4.92	4172.78

1.8 Geomorphology

Geomorphologically, it is characterized by different land forms, viz., a) inselbergs and b) alluvial plain. The inselbergs are Archaean inliers occurring in the form of disconnected hillocks in the alluvial plains. They are found occurring in the south-eastern part of the district. The hillocks are covered by a thick lateritic mantle and are occupied by evergreen mixed forests. The alluvial plains are comprised of Older and Newer alluvium. The Older alluvium occupies the piedmont zone towards the north of the district bordering Bhutan. The high narrow zone at the Himalayan foothill is known as the Bhabar zone and supports dense forests. To the south of the Bhabar zone and parallel to it, there lies the flat Terai zone. The formation is comprised of sand, clay with mixtures of pebble, cobble and boulders. The Newer alluvium includes sand, gravel, pebble with silt and clay.

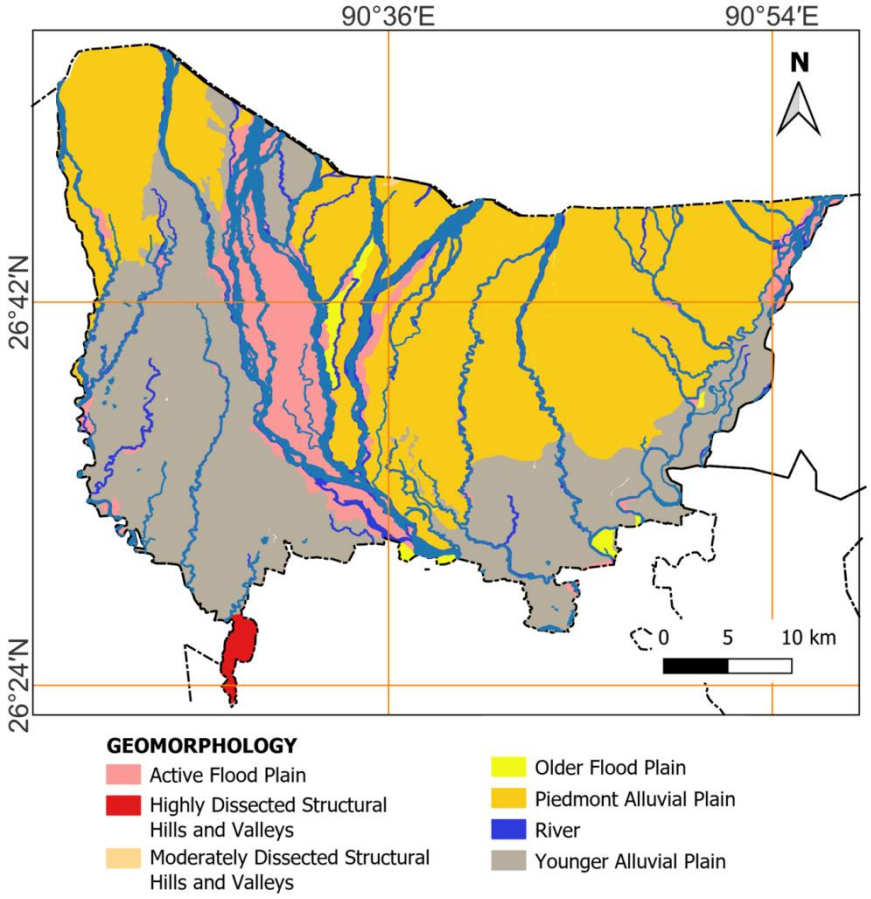

Fig 1.8. Geomorphological Map of Chirang district

Slope: Slope map was prepared using 30m resolution SRTM DEM. 98% percent of the area falls in the area with slope less than 20%. Slope greater than 20% that comprises only about 2% of the district area, is found in patches in the northern piedmont zone and in inselberg in the southern part of the district (Fig. 1.9). The actual areas of different slope classes are given in Table 1.3.

Table 1.3. Area of different slope classes

Slope Class	Area in sq. km
>20%	29
< 20%	1818

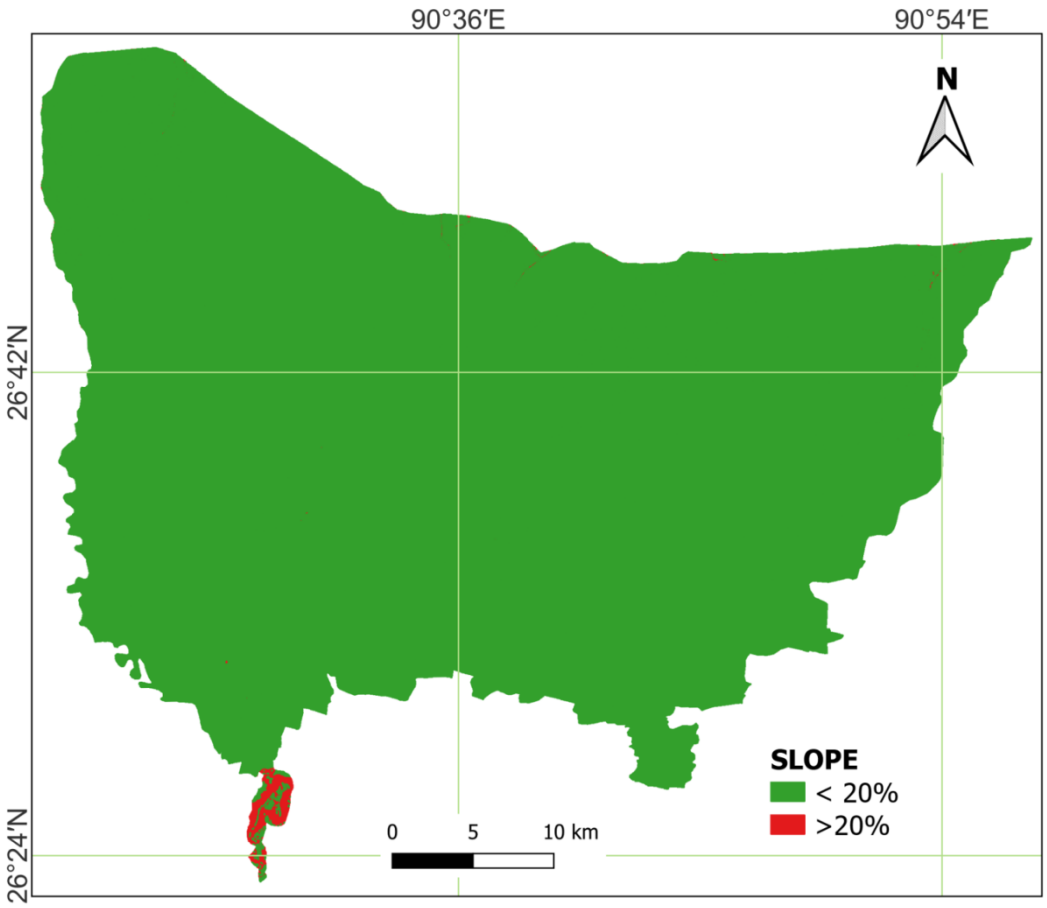

Fig. 1.9. Slope map of the district derived from 30m spatial resolution SRTM DEM

1.9 Land Use Land Classification (LULC)

As per 2021 LULC (Fig. 1.10), forest and tree cover comprises the largest LULC category followed by cropped area and built area. The breakup of different land uses is shown in Table 1.4.

Table 1.4. Area of different LULC classes

LULC Class	Area in sq km
Trees	730
Crop	636
Built area	283
Bare ground	79
Water	21

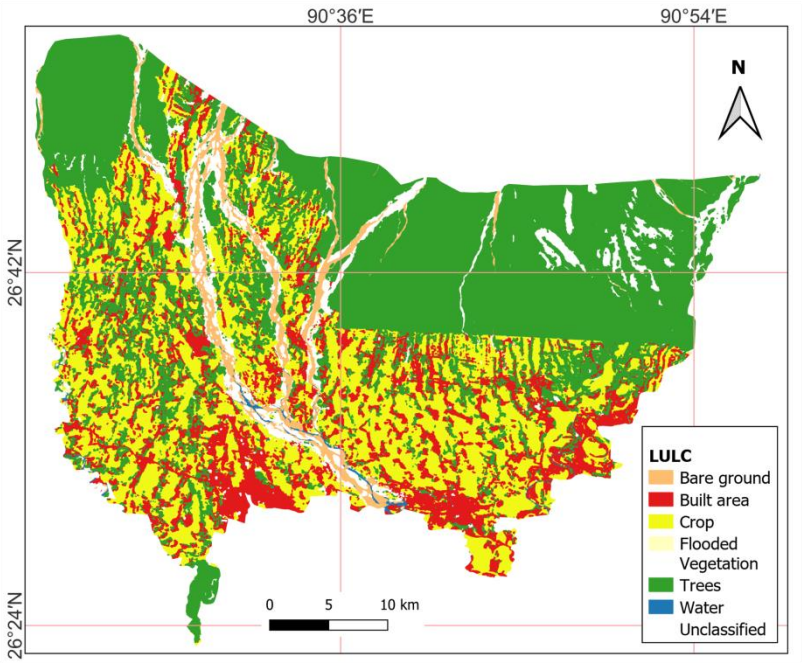

Fig. 1.10. Land Use Land Cover map of Chirang district for 2022 derived from Sentinel 2 imageries (10m spatial resolution) (Source: ESRI)

1.10 Soil

The major soil classes in the district are entisols, inceptisols, alfisols and ultisols.

Table 1.5. Soil types by slope categories in Chirang district

	Soil Type		**Land Slope**			
Block	**Major Soil Classes**	**Area (Ha)**	**0-3% (Ha)**	**3-8% (ha)**	**8-25% (ha)**	**>25% (ha)**
Borobazar	Entisols (recent alluvium)	13140	13140	0	0	0
	Inceptisols (old alluvium)	9855.3	9855.3	0	0	0
	Alfisols (Mountain valley)	6570.2	6570.2	0	0	0
	Utisols (Laterised red)	3285.1	3285.1	0	0	0
Sidli	Entisols (recent alluvium)	21528	21528	0	0	0
	Inceptisols (old alluvium)	16146	16146	0	0	0
	Alfisols (Mountain valley)	10764	10764	0	0	0
	Utisols (Laterised red)	5381.9	5381.9	0	0	0
Dangtol	Entisols (recent alluvium)	1457.6	1457.6	0	0	0
	Inceptisols (old alluvium)	1093.2	1093.2	0	0	0
	Alfisols (Mountain valley)	728.8	728.8	0	0	0
	Utisols (Laterised red)	364.4	364.4	0	0	0

Soil in greater parts of the district is sandy and silty loam, or clayey loam. The soils of the alluvium are partly new or recent and partly old. The variation in composition is mainly a result of the varying composition of the river borne materials deposited at different times and under different conditions. The younger alluvial soil has a high phosphorous content whereas in Older Alluvial soils, the content is very low. In general, the soil is acidic to slightly alkaline in nature and is moderately permeable and characterized by the presence of low organic carbon and low soluble salts. Soils restricted to inselberg areas are more clayey, lateritic and less permeable and are highly acidic in nature. From agricultural point of view, soils in major part of the district are suitable for all sorts of crops.

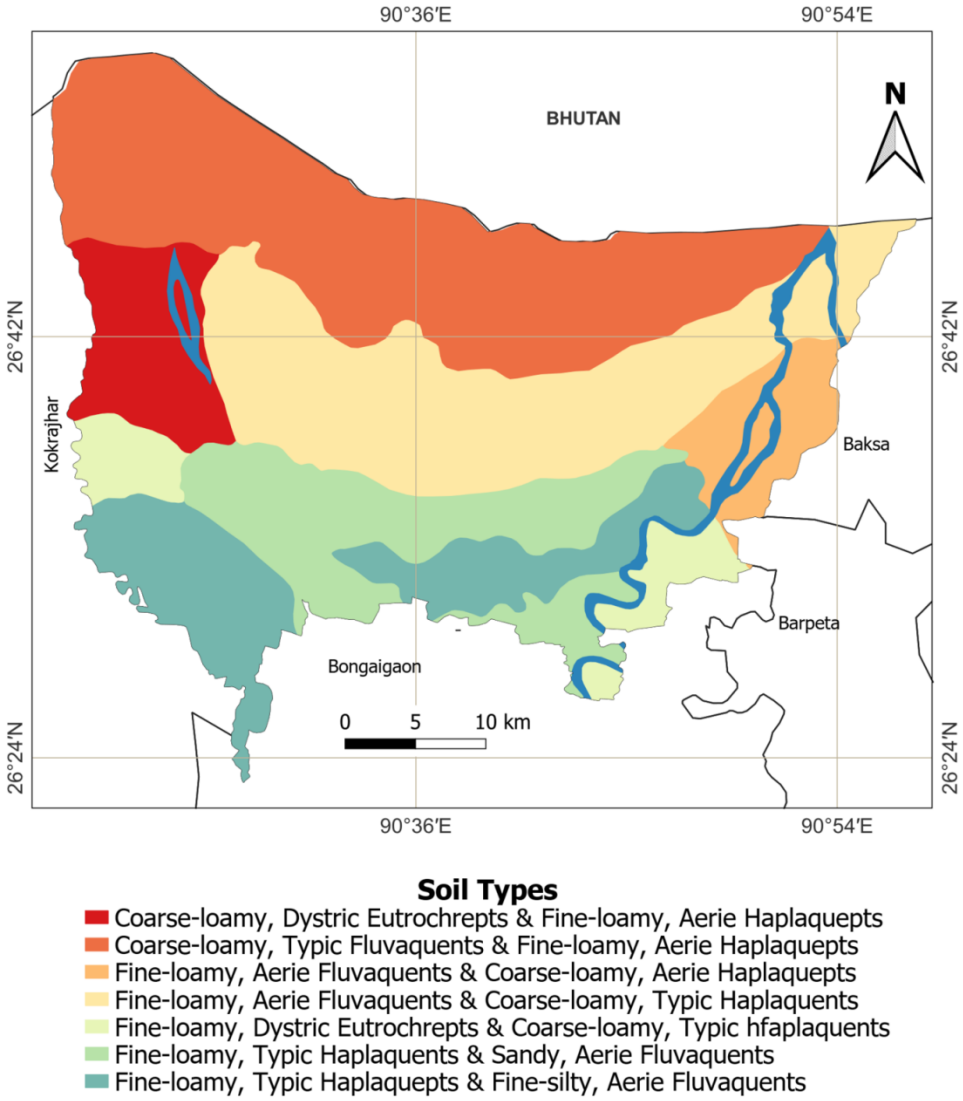

Fig 1.11. Soil map of Chirang district

1.11 Hydrology and surface water

The district is drained by transboundary, snow and glacier melt fed rivers like Manas, Beki and Champabati rivers that originate in the Bhutan Himalaya. These rivers drain the entire north-south extent of the district. Bhabar zone at the Indo-Bhutan border is characterised by dried up streams that have disappeared into the coarse fan deposit at the base of Bhutan Himalaya but reappear further down south. One such river is Hole stream near Indo-Bhutan border near Gelephu (**Field photo 1.1**).

The largest river draining the district, viz., Manas originates in Bhutan and assumes an anastomosing and braiding nature as it enters the piedmont zone adjacent to the Bhutan Himalaya. It is the largest north bank tributary of the Brahmaputra with a recorded maximum discharge of 7641 cubic metres and contributes about 5.48% of the total average volume of the Brahmaputra (Wikepedia). Other rivers are notable for their meandering characteristics in the flat topography south of the piedmont zone.

Field photo 1.1: Field photograph of dried up stream near Indo-Bhutan border taken in the month of August 2022. This stream is ephemeral in nature and flows only during the monsoon.

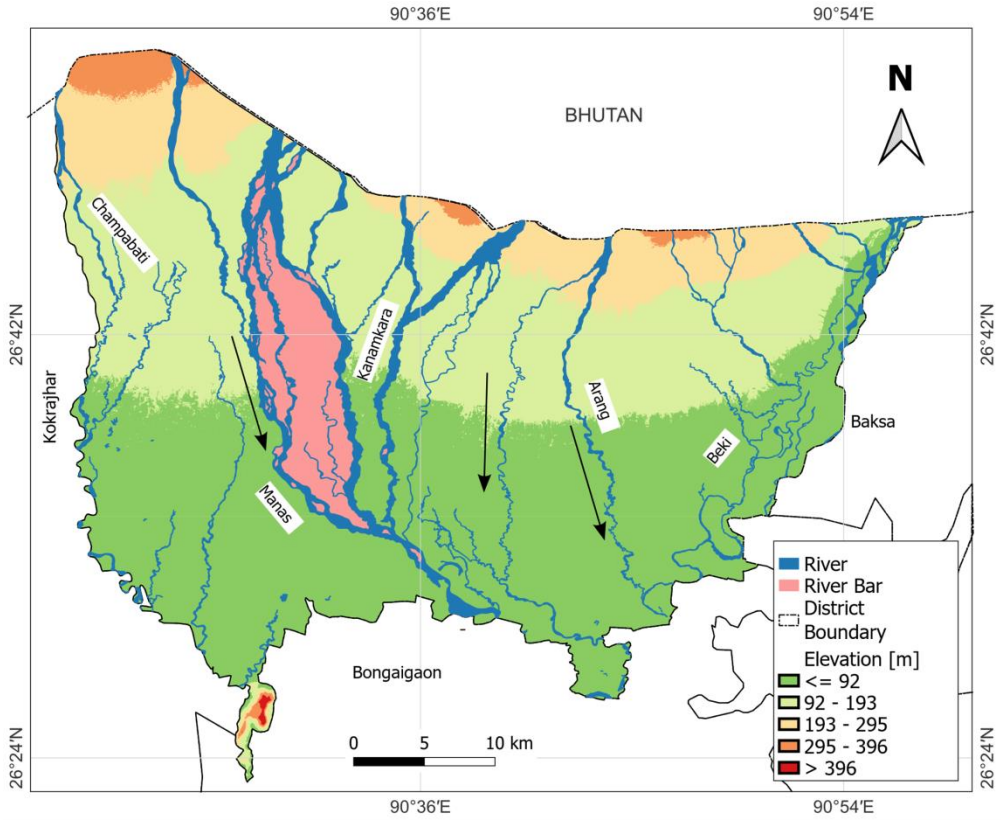

Fig 1.12. Drainage system of Chirang district

1.12 Agriculture

The major crops grown in Chirang district are rice, wheat, maize, jute, sugarcane, lentil, pea, mustard, potato and vegetables. Major plantation crop in the district is betelnut. As opposed to other neighbouring districts, tea plantation is not widely practiced in the district. The main horticultural crops include watermelon, bananas, pineapple and oranges. Horticultural crops are grown in the piedmont zone close to Bhutan. The major portion of cultivable land in the district is used for cultivation of cereals. Three types of rice are grown in the district, viz., autumn rice or *ahu*, winter rice or *Sali* and summer rice or *boro*. *Sali* or winter rice is the more widely grown rice variety in the district. In the rabi season, oilseed crops mainly mustard and rapeseed are extensively grown in the district (District Irrigation Plan, 2016-2020).

Net irrigated area of the district is 10280 ha whereas non-irrigated area amounts to 41220 ha. The gross cropped area comprises of 93361 ha whereas the net cultivable area covers 51400 ha, yielding cropping intensity of 181.63%. The net irrigated area computes to 11% of the gross cropped area.

Table 1.6. Summary of agricultural land usage (Source: District Irrigation Department)

1	Total Geographical area	99705.6	Hectares
2	Net Cultivable area	51400	Hectares
3	Gross cropped area	93361	Hectares
4	Cropping intensity at present (=Gross area/Net cultivable area X 100)	181.63%	
5	Irrigated area	10280	Hectares
6	Non irrigated area	41220	Hectares
7	Relay cropping area	5840	Hectares
8	Inter cropping area	4106	Hectares
9	Single crop area	23073	Hectares
10	Double cropped area	40465.5	Hectares
11	Multiple cropped area	11195	Hectares
12	Flood prone area	5929	Hectares
13	Nos of revenue village	479	
14	Forest village	35	514

Table 1.7. Acreage of different types of crops in Chirang district (Source: District Irrigation Department)

Achieved area of different crops (Area in Hectare) in Chirang district					
Sl No	Name of crop	2019-20	2020-21	2021-2022	2022-2023
1	Sali Paddy	42013	35650	35120	
2	Summer Paddy	2660	755	973	1230
3	Mustard	7001	5803	5809 (9240)	
4	Pea	654	616	695	
5	Lentil	1660	2013	2447	
6	Dhemchi(Buck Wheat)	271	275	295	

7	Potato	3495	3490	3324	
8	Linseed	349	349	354	
9	Black Gram	1700	1166	1397	716 (Summer)
10	Maize	1296	1100	1427	667 (Summer)
11	Water Melon	12	58	52	55
12	Strawberry	5	8	10	15
13	Dragon Fruits	4	6	7	10
14	Apple Ber	16	18	20	continuing
15	Assam Lemon	650	738	753	continuing
16	Banana	720	735	685	continuing

1.13 Industries

Following are some of the industries found in the district.

Table 1.8. Existing industries as per CGWA database

Location	**Industry Name**	**Type of industry**	**Extraction [m3/day]**
Palashbari, Sidli-Chirang	New Age Petcoke Pvt Ltd	Petroleum products	24
Chapaguri Part II, Borobazar	RT Industries	Beverages	40
Basugaon, Sidli-Chirang	Bodoland Pariwar	Packaged Drinking water	80
Kharija Dhaligaon Part 2, Borobazar	Maa Bageswari Beverages	Packaged Drinking Water	9
Kukurmari, Sidli-Chirang	Carbon Resources Pvt Ltf Unit III	Petroleum Products	50

Table 1.9. Status of Command Area Development (Source: District Irrigation Plan, 2016-2020)

Status of Command Area Development									
Sl No	Name of the Block	Information of canal command			Information on the other services command			Total Area	
		Total Area	Developed Area	Undeveloped Area	Total Area	Developed Area	Undeveloped Area	Developed Command	Undeveloped Command
1	Sidli- Chirang Development Block	16,921.44	9,937.81	6,983.63				9,937.81	6,983.63
2	Borobazar Development Block	4852	4852					4852	
3	Dangtol Development Block	2,074.48	1,184.00	890.48				1,184.00	890.48

Table 1.10. Existing Types of Irrigation (Source: District Irrigation Plan, 2016-2020)

Source of Irrigation	Surface Irrigation (1)					Ground Water (2)						Other Sources including Traditional WHS (3)	Treated Effluent discharged from STP	Water extraction devices/ Lift			Total	
	Canal Based		Tanks/Ponds/ Reservoirs			Tube Wells		Open Wells		Bore Well								
	Govt. Canal	Community/ Pvt. Canal	Community Ponds Including Small	Individual /Pvt. Ponds	Govt. Reservoirs/ Dams	Govt.	Pvt.	Community/ Govt.	Pvt.	Govt.	Pvt.			Electricity pump (4)	Diesel pump (5)	Others (6)	Irrigation Sources (1 + 2 + 3)	Water Extracting units (4 + 5 + 6)
No	89	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Command Area (ha)	16,170.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

CHAPTER 2
DATA COLLECTION AND GENERATION

2.1 Data collection

2.1.1 Hydrogeological data

47 nos. of GWMS including 5 NHNS wells cover the study area. Monitoring of water level was done in the month of August 2022, November 2022 (post monsoon) and February 2023(pre-monsoon).

2.1.2 Litholog data

Litholog data have been collected from different state organisations. A summary of the litholog data is given in Table 2.1 and Table 2.2.

Table 2.1: Location, Depth, Reduced Level and Source of data currently available

Locations	Latitude	Longitude	Depth	RL	Source
Borpathar No 1	26.642777	90.807647	27	77	PMKSY
Sishubari No 1	26.620674	90.546471	27	72	PMKSY
Bagmara	26.515136	90.679677	30	49	PMKSY
Chourang No 4	26.627809	90.840116	27	55	PMKSY
Salbari	26.660262	90.400970	54.5	92	PHED
Aminpara	26.612926	90.373485	93	75	PHED
Tukrajhar - I	26.676692	90.468497	93	99	PHED
Balapara	26.666825	90.451274	93	94	PHED
T8	26.558120	90.522949	119	68	CGWB report*
T10	26.518128	90.503836	81	60	CGWB report*
T11	26.524186	90.484487	119	61	CGWB report*
T4	26.504425	90.547591	136	62	CGWB report*
T5	26.498074	90.566058	138	59	CGWB report*
* CGWB-NER 2000 Ground Water Pollution Studies in Dhaligaon-Bongaigaon Area, Bongaigaon District, Assam					

Table 2.2: Summary of the data available

Sources	Available sections	Used for subsurface modelling
JJM [PHED]	5	4
Bongaigaon Refinery [CGWB Pollution Study Report]	11	5
PMKSY	8	4

2.1.3 Population and agriculture data

Population and groundwater dependency were collected from Census 2011, Assam Statistical Handbook, Agriculture Contingency Plan and District Agriculture Office. All the data pertaining to agriculture were collected from District Irrigation Plan of Chirang District for 2016-20 prepared by NABARD.

2.2. Data Generation

2.2.1 Key wells

42 nos. of key wells have been established to fill up the data gap (Fig. 2.1 and Table 2.3). There are 5 NHNS wells in the district. These wells were periodically monitored for the present study.

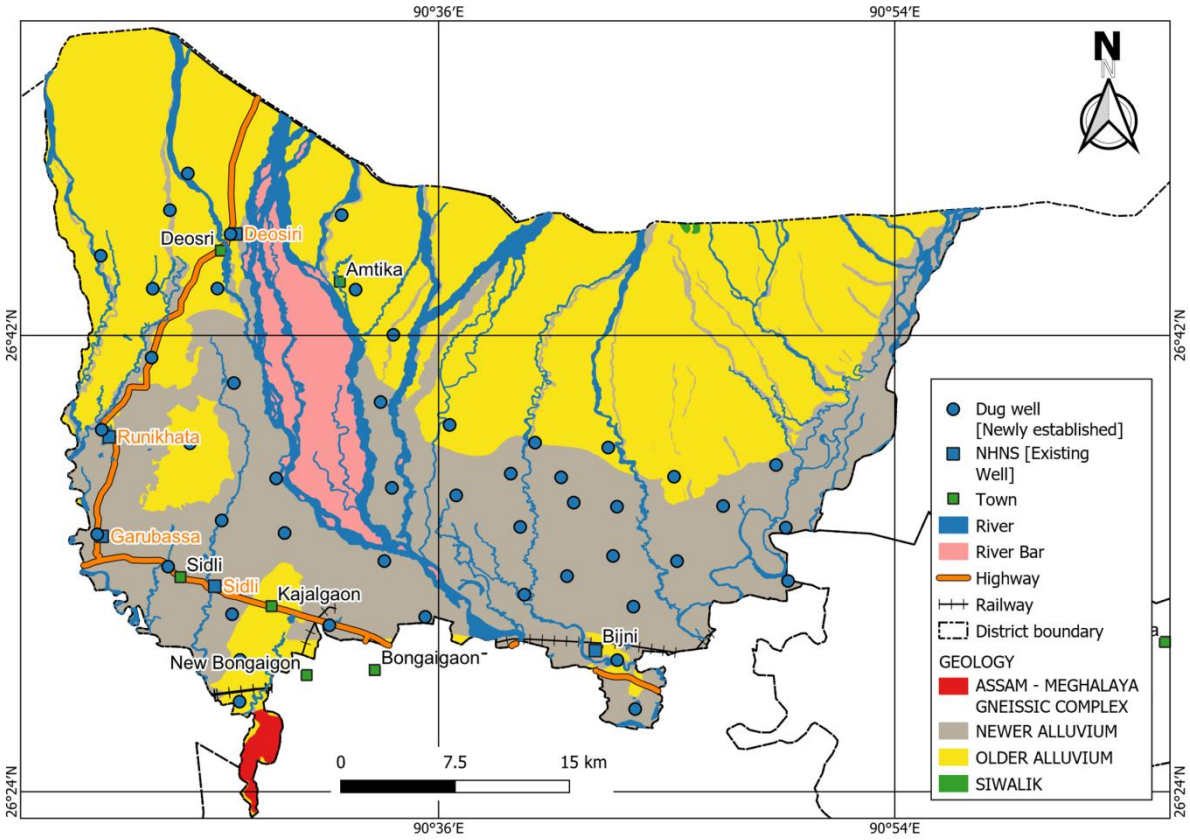

Fig 2.1. Dug wells established to monitor GW regime of Chirang district, Assam

Table 2.3. GWMS established during August Field Tour

Sl No	Name of the Village/site	Latitude	Longitude	Establishment Type	RL (masl)	Total depth	Type of well	Aquifer	Measuring Point (magl)	Agency/Ownership
1	Pub Bairajora	26.578342	90.457359	Key well	72	5.33	DW	Alluvium	0.83	Private
2	Kadamtala	26.570132	90.498717	Key well	73	6.1	DW	Alluvium	0.86	Govt
3	Pub Domgaon	26.605999	90.493179	Key well	78	5.97	DW	Alluvium	0.72	Private
4	AojharTinali ME School	26.629080	90.436439	Key well	86	6.26	DW	Alluvium	0.76	Private
5	Tukhrajhar	26.668700	90.465400	Key well	99	5.67	DW	Alluvium	0.8	Private
6	Nizlaguri	26.730820	90.454550	Key well	124	6.45	DW	Alluvium	0.87	Private
7	Deosiri temple NHNS	26.766583	90.463139	NHNS	146	9.35	DW	Alluvium	1.65	Private
8	Koraibarigaon	26.806505	90.435091	Key well	173	11.7	DW	Alluvium	1.3	Private
9	Kaola Bazaar	26.782342	90.423308	Key well	152	3.92	DW	Alluvium	0.52	Private
10	Dhaligaon High School	26.509478	90.528183	Key well	64	5.3	DW	Alluvium	0.88	Govt
11	Delasi Bazaar Samthebari Village	26.730750	90.412004	Key well	124	5.3	DW	Alluvium	0.7	Private
12	Silikaguri Village market	26.752354	90.377832	Key well	141	5.8	DW	Alluvium	0.74	Private
13	Gorubasa NHNS	26.569201	90.375520	NHNS	68	5.23	DW	Alluvium	0.7	Private
14	Runikhata NHNS	26.637984	90.378469	NHNS	88	6.1	DW	Alluvium	0.75	Govt
15	BhurbalaparaRanipur	26.685461	90.411241	Key well	105	6	DW	Alluvium	0.86	Private
16	Gendergaon	26.548000	90.422100	Key well	64	6.76	DW	Alluvium	0.93	Private
17	Sidli NHNS	26.516720	90.464207	NHNS	62	6.88	DW	Alluvium	0.92	Private
18	Kashdoha	26.454359	90.729296	Key well	46	5.6	DW	Alluvium	0.84	Private
19	Shyamthaibari	26.486646	90.469454	Key well	62	4.3	DW	Alluvium	0.9	Private
20	Dimakumari	26.459248	90.469125	Key well	56	6.35	DW	Alluvium	0.93	Private
21	Simlaguri	26.551664	90.564331	Key well	63	4.8	DW	Alluvium	0.83	Private
22	Bijni NHNS	26.486523	90.717535	NHNS	50	6.64	DW	Alluvium	0.9	Govt
23	Bhalatal No 2	26.529550	90.656421	Key well	56	7.77	DW	Alluvium	0.92	Private

24	Dhaukanaghar No 1	26.514992	90.591206	Key well	58	4.94	DW	Alluvium	0.79	Private
25	Bhabhanipur Village	26.599799	90.569272	Key well	72	5.5	DW	Alluvium	0.95	Private
26	Rajpara	26.656207	90.561859	Key well	86	4.38	DW	Alluvium	0.9	Private
27	Amlaguri	26.730100	90.545400	Key well	122	9.95	DW	Alluvium	0.41	Govt
28	Jomunaguri No 2	26.779129	90.536284	Key well	147	14.4	DW	Alluvium	1	Private
29	Sabkhata	26.700371	90.570248	Key well	104	6.57	DW	Alluvium	0.95	Private
30	Subhaijhar	26.594816	90.611579	Key well	70	5.5	DW	Alluvium	0.91	Private
31	Betnapara	26.574100	90.653660	Key well	64	4.1	DW	Alluvium	0.7	Private
32	Khamargura	26.541743	90.684459	Key well	56	5.89	DW	Alluvium	0.95	Private
33	Kaliagaon	26.555018	90.714714	Key well	55	4.7	DW	Alluvium	0.84	Private
34	Mukhnaguri	26.590083	90.688862	Key well	70	4.67	DW	Alluvium	0.62	Private
35	Bhauraguri	26.606683	90.680592	Key well	77	7.2	DW	Alluvium	0.7	Private
36	Ballamguri bazaar	26.609133	90.647453	Key well	77	6.8	DW	Alluvium	0.78	Private
37	Paschim Bhowraguri	26.641151	90.607256	Key well	85	6.3	DW	Alluvium	0.84	Private
38	Dhangsiapara	26.629524	90.663441	Key well	88	9	DW	Alluvium	0.7	Private
39	MakraPatkiguri	26.587400	90.717315	Key well	64	2.9	DW	Alluvium	1	Private
40	Dharanga No 1	26.626304	90.711560	Key well	84	13.95	DW	Alluvium	0.5	Private
41	Bispani	26.607117	90.754837	Key well	72	8.6	DW	Alluvium	0.77	Private
42	Borgaon Shiv Mandir	26.587840	90.787100	Key well	54	4.4	DW	Alluvium	1.04	Private
43	Barshijhar	26.614835	90.821922	Key well	57	3.8	DW	Alluvium	0.64	Private
44	Amon Bazaar	26.573622	90.828359	Key well	53	4.9	DW	Alluvium	0.9	Private
45	Monakosha	26.538568	90.829810	Key well	56	5.35	DW	Alluvium	0.6	Private
46	Pub Kharmapara	26.551600	90.756800	Key well	49	6.25	DW	Alluvium	1.23	Private
47	Motiapara	26.521700	90.728100	Key well	50	4.83	DW	Alluvium	0.95	Private

2.2.2 Soil Infiltration test

Soil Infiltration test is carried out to determine the infiltration rate in different types of soil. Infiltration rate is the velocity or speed at which water enters into the soil. In dry soil, water infiltrates rapidly. This is called the initial infiltration rate. As more water replaces the air in the pores, the water from the soil surface infiltrates more slowly and eventually reaches a steady rate. This is called the basic infiltration rate. The infiltration rate depends on soil texture (the size of the soil particles), soil structure (the arrangement of the soil particles), preexisting moisture condition and atmospheric condition (https://www.fao.org/3/s8684e/s8684e0a.htm). Knowing the infiltration rate can help in determining the recharge potential of different soil types and is also a useful way of categorizing soils from irrigation point of view.

The Infiltration test was carried out using the double ring infiltrometer of diameters 30 cm and 60 cm. The rings are driven into the soil with the least disturbance to the soil structure as far as possible. The outer annular space in between the rings are filled first. The inner ring is then filled with water. The initial water level in the inner ring and the subsequent levels with subsequent infiltration are measured at determined interval in the inner ring using a graduated scale. The filling of water in the annular space ensures that lateral/outward spread is minimized thereby ensuring that the infiltration rate thus obtained is of vertical infiltration rate.

3 soil infiltration were conducted in the district as per the AAP 2020-2023 in the last week of November and First week of December 2022. Table 2.5 summarises the test conducted in the district. The locations of the test sites are shown in Fig. 2.2.

Table 2.4. Location and soil types details of Soil infiltration Test

S. No	Site	Location	Land Use	Soil Type	Latitude	Longitude
1	Bhirangaon	Next to Bhirangaon High School	Open field	Fine Loam	26.548483	90.532663
2	Ballamguri	Next to a farm	Open field	Fine Loam	26.604214	90.647343
3	Nakedara	Next to a farm	In a forest	Coarse Loam	26.765100	90.439833

Table 2.5. Result of Summary of Soil infiltration Test

Site	RL(m)	Infiltration rate(mm/hr)	Duration of test(min)
Bhirangaon	66	1	96
Ballamguri	74	1	69
Nakedara	141	2	60

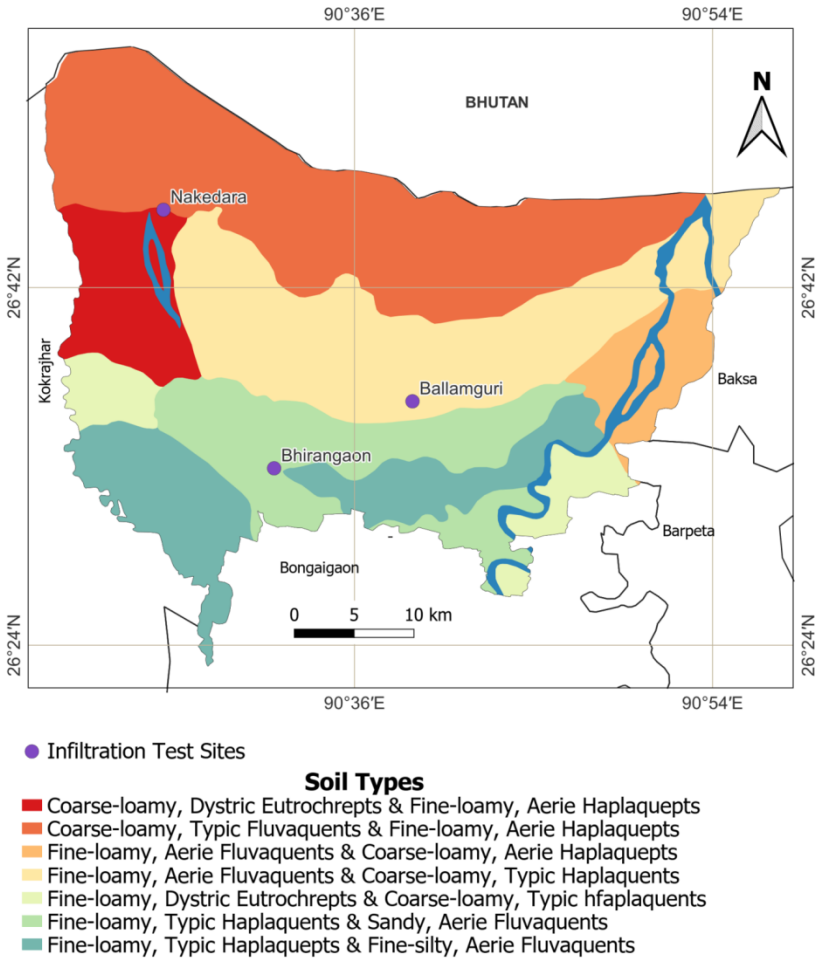

Fig. 2.2. Locations of Soil Infiltration Test

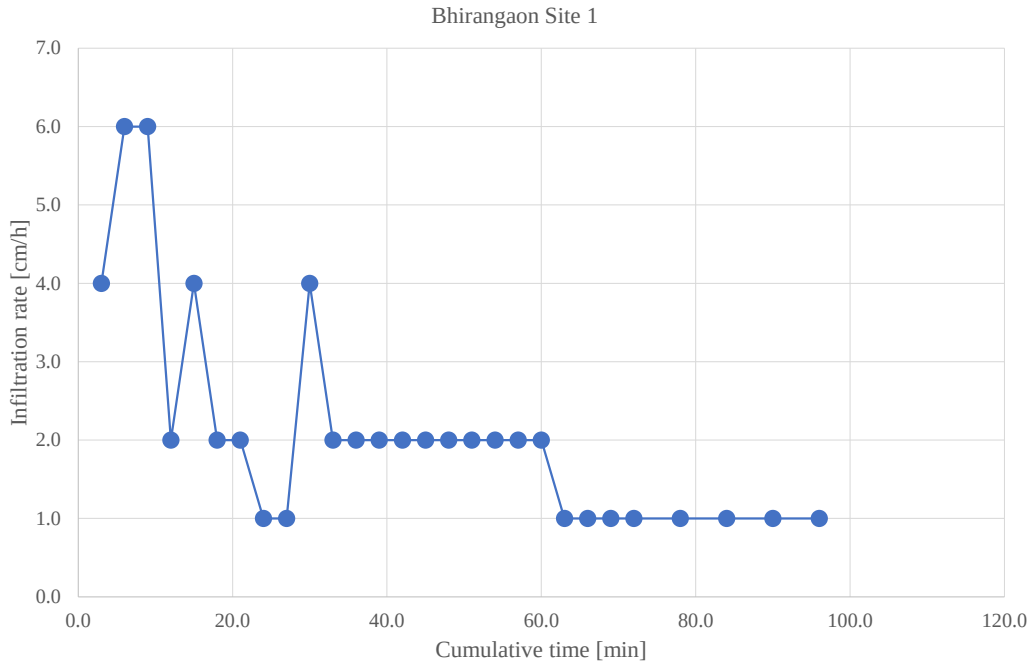

Fig. 2.3. Cumulative time versus Infiltration rate plot of Soil Infiltration Test at Bhirangaon near a playfield in fine loamy soil

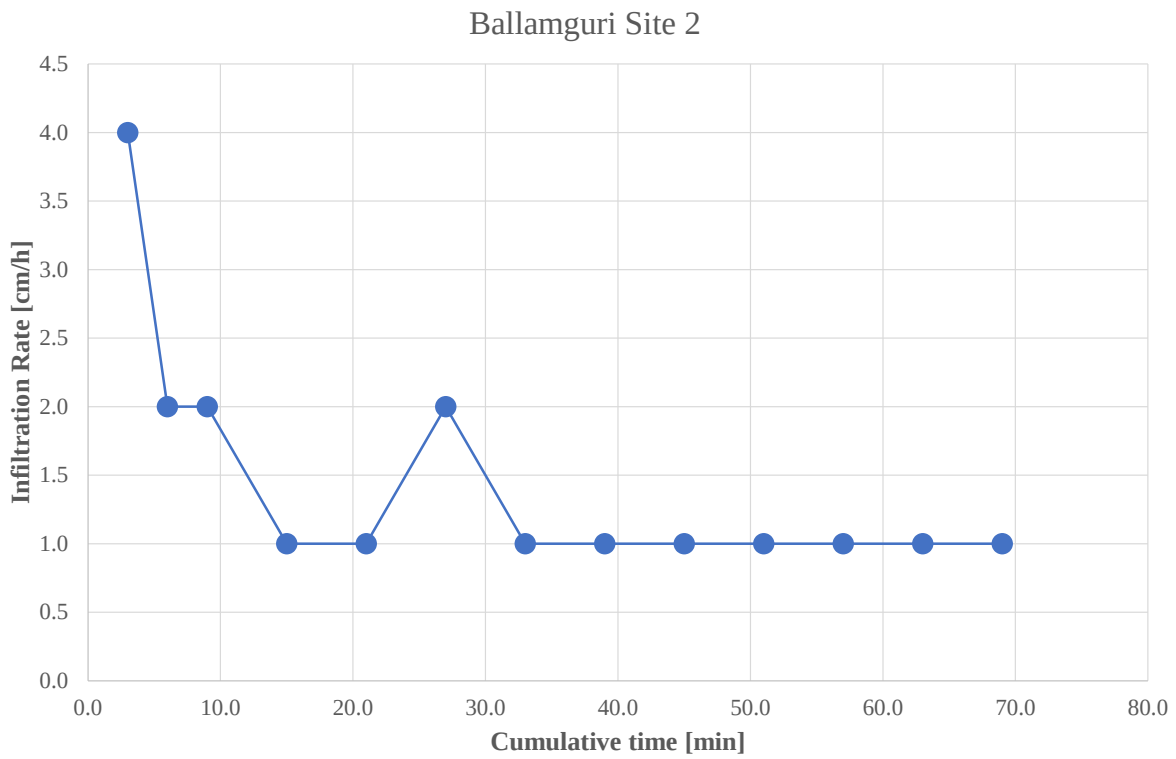

Fig. 2.4. Cumulative time versus Infiltration rate plot of Soil Infiltration Test in fine loamy soil at Ballamguri in an open field near a farm

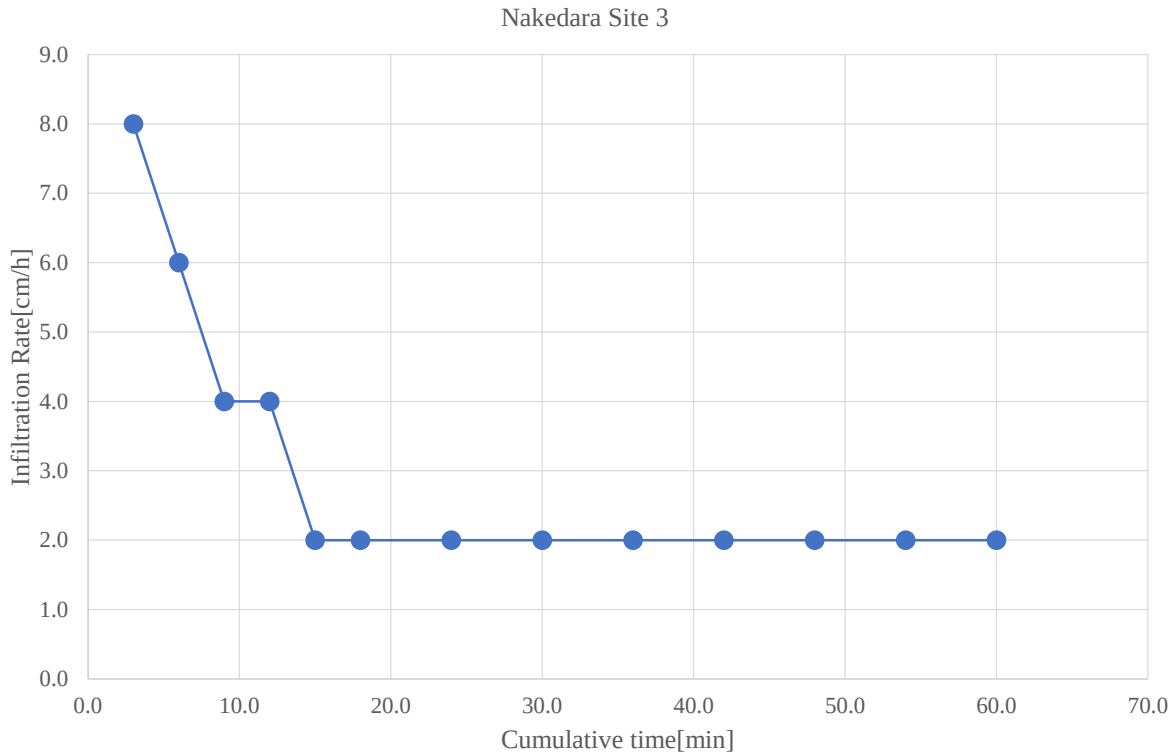

Fig 2.5. Cumulative time versus Infiltration rate plot of Soil Infiltration Test in fine loamy soil at Nakadera

Field Photo 2.1 Soil Infiltration Test in progress

The infiltration rate at Nakedara in the northern part of the district is expectedly higher at 2cm/hr as compared to the rate of 1cm/hr at Ballamguri and Bhirangaon in the central and southern part of the district.

2.2.3 Hydrogeochemical analysis (post monsoon)

During November 2022 field tour (post monsoon) and February 2023 field tour (pre-monsoon), 32 water samples (31 water samples from monitoring wells and 1 sample from a borewell) were collected and analysed for various water quality parameters including iron, heavy metals and arsenic to understand the chemical quality of groundwater in the study area and its suitability for domestic, drinking and agricultural utilisation.

2.2.4 Geophysical survey

Against the target 6 nos. of VES will be carried out in the month of December under AAP 2022-23, 8 nos. of VES was carried out in the month of November 2022 in Chirang (Fig. 2.6).

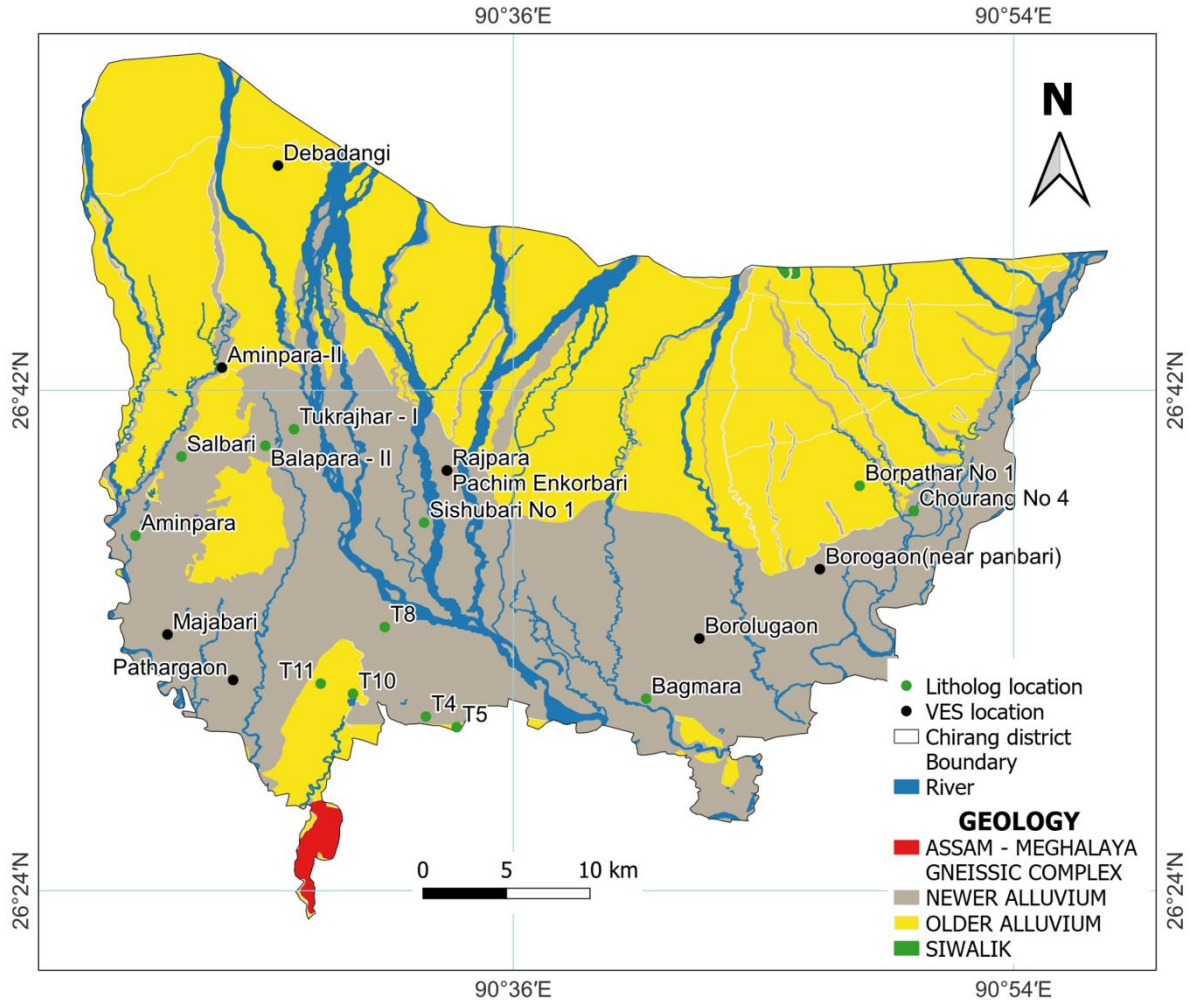

Fig 2.6. Locations of VES survey and available litholog used for making subsurface model of aquifer in Chirang district

Large number of buildings and constructions in the study area of Chirang posed constraints resulting in limited spaces for resistivity surveys. Current electrodes spread available was in the range of 300 m and 700 m. QHK, AKQ, AAK, KQ, HKH, QQH, HAKH and HKQ type VES curves were obtained. The following table describes the interpreted results of VES and inferences with respect to possible sub-surface geology.

Table 2.6: VES-1: Majabari
District: Chirang, Block: Sidli, Village: Majabari, Assam
(Latitude: 26.5536279 N, Longitude: 90.3926418 E)
Elevation: 47 mtr
AB/2: 200 M

Depth range (m)	Thickness	Interpreted layer resistivity (ohm m)	Inferences
G.L.-2	2	2693	Topsoil with pebbles and boulders

2-9	7	1045	Sand with pebbles
9-46	37	520	Sand with gravel and clay
46-100	54	792	Sand with gravel
>100		345	Sand formation

Table 2.7: VES-2: Pathargaon
District: Chirang, Block: Sidli, Village: Pathargaon, Assam
(Latitude: 26.526388 N, Longitude: 90.432000 E)
Elevation: 59 mtr
AB/2: 200 M

Depth range(m)	**Thickness**	**Interpreted layer resistivity (ohm.m)**	**Inferences**
G.L.-1	1	234	Topsoil
1-8	7	523	Sand with pebbles
8-18	10	1735	Sand with pebbles and boulders
18-112	94	624	Sand and Gravel and pebbles
>112		111	Sand with silt

Table 2.8: VES-3: Aminpara -II
District: Chirang, Block: Bengtol, Village: Aminpara -II, Assam
Latitude: 26.713617 N, Longitude: 90.425288 E
Elevation: 116 mtr
AB/2: 150 M

Depth range(m)	**Thickness**	**Interpreted layer resistivity (ohm.m)**	**Inferences**
G.L.-1	1	269	Topsoil
1-4	3	354	Sand
4-20	16	771	Sand with pebbles
20-100	80	979	Sand with pebbles and Gravel
>100		225	Sand

Table 2.9: VES-4: Debadangi
District: Chirang, Block: Bengtol, Village: Debadangi, Assam
Latitude: 26.8347801 N, Longitude: 90.4588841 E
Elevation: 196 mtr
AB/2: 300 M

Depth range(m)	Thickness	Interpreted layer resistivity (ohm.m)	Inferences
G.L.-1	1	4033	Topsoil with pebbles
1-16	15	21255	Sand with pebbles and boulders
16-162	146	4400	Sand with pebbles
>162		35	Sand with silt

Table 2.10: VES-5: Borolugaon
District: Chirang, Block: Borobazar, Village: Borolugaon, Assam
Latitude: 26.5511999 N, Longitude: 90.7115863 E
Elevation: 55 mtr
AB/2: 350 M

Depth range(m)	Thickness	Interpreted layer resistivity (ohm.m)	Inferences
G.L.-2	2	71	Topsoil with clay
2-9	7	49	Sandy clay
9-38	29	180	Sand
38-170	92	92	Silty sand
>170		211	Sand

Table 2.11: VES-6: Borogaon
District: Chirang, Block: Bijni, Village: Borogaon(near panbari) , Assam
Latitude: 26.5927850 N, Longitude: 90.7838280 E
Elevation: 55 mtr
AB/2: 250 M

Depth range(m)	Thickness	Interpreted layer resistivity (ohm.m)	Inferences
G.L.-1	1	1375	Topsoil with boulders
1-4	3	191	Sand with gravel

4-32	28	164	Sand with clay
32-66	34	97	Silty sand
>66		248	Sand

Table 2.12: VES-7: Rajpara
District: Chirang, Block: Borobazar, Village: Rajpara, Assam
Latitude: 26.6519752 N, Longitude: 90.5601993 E
Elevation: 82mtr
AB/2: 300 M

Depth range(m)	**Thickness**	**Interpreted layer resistivity (ohm.m)**	**Inferences**
G.L.-1	1	91	Topsoil with clay
1-3	2	40	Sandy clay
3-15	12	157	Sand with clay
15-36	21	362	Sand with gravel
36-180	144	168	Sand
>180		3539	Consolidated formation

Table 2.13: VES-8: Pachim Enkorbari
District: Chirang, Block: Sidli, Village: Pachim Enkorbari, Assam
Latitude: 26.6519752 N, Longitude: 90.5601993 E
Elevation: 82mtr
AB/2: 250 M

Depth range(m)	**Thickness**	**Interpreted layer resistivity (ohm.m)**	**Inferences**
G.L.-2	2	3572	Topsoil with pebbles and boulders
2-4	2	863	Sand with pebbles
4-9	5	3099	Sand with pebbles and boulders
9-44	35	1488	Sand with pebbles gravel
>44		459	Sand with gravel

2.2.6 Exploratory Drilling:

Currently there are no EW of CGWB in the district. Under AAP 2022-2023, 5 EWs and 5 OWs have been proposed to be constructed through outsourcing. The proposed sites are tabulated below.

Table 2.14. Proposed Exploratory Wells and Observatory Wells

Sl. No	Name if the Site	Type of well	Latitude	Longitude
1	No 284 Boulajhar L P School Panbari	EW	26.600172	90.831689
2	Dakhin Padampur L P School	EW	26.541525	90.481679
3	427 No Nagdarbari L P School	EW	26.587516	90.374998
4	Vivekananda Vidyapith M E School	EW	26.466399	90.415322
5	966 No Malavita Bidyakunja L P School	EW	26.818688	90.525577
6	No 2 Aie Powali L P School	EW	26.796644	90.467727
7	222 No Batabari Prathmik Vidyalaya	EW	26.628148	90.627624
8	Patalmari L P School	EW	26.66262	90.582467
9	Chirang Polytechnic 1 no Gargaon, Bijni	OW	26.532623	90.671769
10	IOCL, Bongaigaon Refinery Township	OW	26.505877	90.516745

CHAPTER 3
DATA INTERPRETATION, INTEGRATION AND AQUIFER MAPPING

3.1 Data Interpretation

The subsurface geology has been interpreted based on available litholog data of tube wells [provided by PHED Chirang [4 Nos.], data from PMKSY [4 Nos.], previous CGWB report [5 Nos.], VES surveys [8 Nos.] and shallow dug wells established and monitored in present study [47 Nos]. The depth of tube wells included in the present study ranges from 62 mbgl to 119.12 mbgl whereas the depth of the dug wells ranges from 3.16 mbgl to 13.45 mbgl.

3.1.1 Interpretation of geophysical surveys

Interpretation of geophysical surveys shows dominance of sandy, pebbly and gravelly formation with minor clay content in the district. The exception is at Borolugaon and Borogaon which indicate little to no detection of pebbly, gravelly, boulder formation (Table 2.10, Table 2.11; Fig. 3.5).

VES at Rajpara is indicative of presence of consolidated formation below the depth of 180m (Fig. 3.3). Of note is also the presence of granitic basement in litholog T11(see Fig 3.2 and Fig. 2.6) at a depth of 69mbgl. This shows the presence of basement rock at varying depth in the district. Thus, non-detection of consolidated basement rocks in other survey sites could be due to sloping/undulating nature of basement rock and or insufficient depth of survey due to non-availability of open space. From hydrogeological point of view, the inference of dominant sandy and gravelly layers up to a depth of 100m below ground level is significant.

3.1.2 Interpretation from available lithological data

Available lithologs provided by District PHED and District Agriculture Office, Kajalgaon, Chirang have also aided in the interpretation of subsurface geology. 13 lithologs were used for subsurface modelling of geology. The total depth of the lithologs ranges from 27m to 138m. Lithology includes sand, clay, pebble and/or mixture of these.

Table 3.1. Sources of the lithologs used in the present study

Sources	**Available sections**	**Used for subsurface modelling**
JJM [PHED]	5	4
Bongaigaon Refinery [CGWB Pollution Study Report]	11	5
PMKSY	8	4

Table 3.2. Depth summary of existing lithologs

Depth in m	0-50	50-100	100-150	Total
Number of lithologs	4	5	4	13
Percentage	30.77	38.46	30.77	

3.2 Data integration

Available data indicate presence of one principal aquifer in the district, viz., Sandy Gravel and Sand belonging to Older Alluvium. The geology of the district mainly comprises of Quaternary Deposits, which include Older and Newer Alluvium. The Older Alluvium are of Middle to Upper Pleistocene Age whereas the Newer Alluvium are of Holocene Age (GSI, 2009). Older Alluvium is characterized by coarser sand, clay, pebble, gravel and boulder whereas the Newer Alluvium is characterised by sand, silt and clay. The latter are darker in colour compared to the former. Siwalik Group and Precambrian Inselbergs are other minor geological units in the district. Slope < 20% comprises about 98% of the district and hence the relatively flat alluvial deposit is a potential recharge zone. Ground water bearing potential of consolidated Precambrian basement rocks are yet to be explored although these rocks were encountered at T11 and VES survey at Rajpara.

3.3 Aquifer disposition

Lithologic units of the district are grouped according to size of alluvial materials. Fine sand with pebbles, Fine sand mixed with gravel, Coarse sand mixed with pea gravel, Coarse sand with pea gravel have been labelled as Sandy Gravel. Fine, medium and Coarse sand have been clubbed as Sand. Top clay and clay deposit have been relabelled as Clay and Fine sand with clay as Sandy Clay.

Following sections have been prepared from the available litholog data to show the 2D disposition of aquifer in the study area.

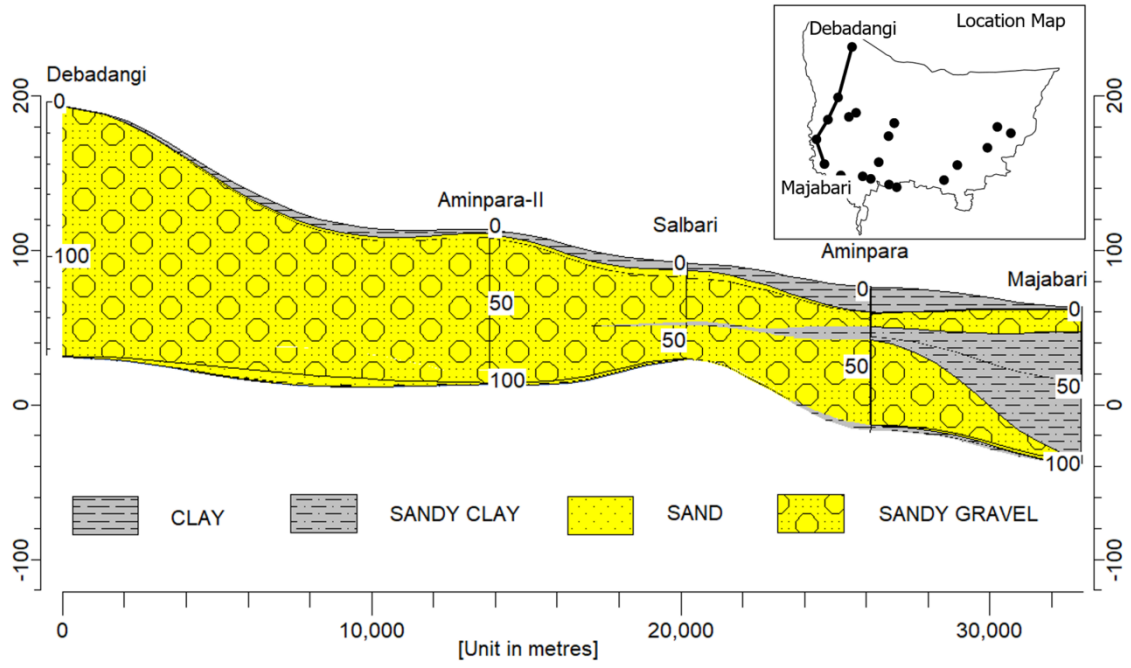

Fig 3.1. North-South 2D Section in the western part of the district [Section 1]

North-South Section [Section 1]: The section is characterised by the presence of clay on top. The presence of Sandy Gravel up to a depth of 164 m is prominent in the northern part. But there is a clear transition to finer grained sediments like clay and sandy clay in the southern part. At Majabari, the finer layer of sandy clay reaches to a thickness of 91 m. Minor lenses of sand also occur in conjunction with Sandy gravel. The sandy gravel and sand layers, ranging in thickness from 150m to 10m from North to South of the section constitute the main aquifer (Fig 3.1.).

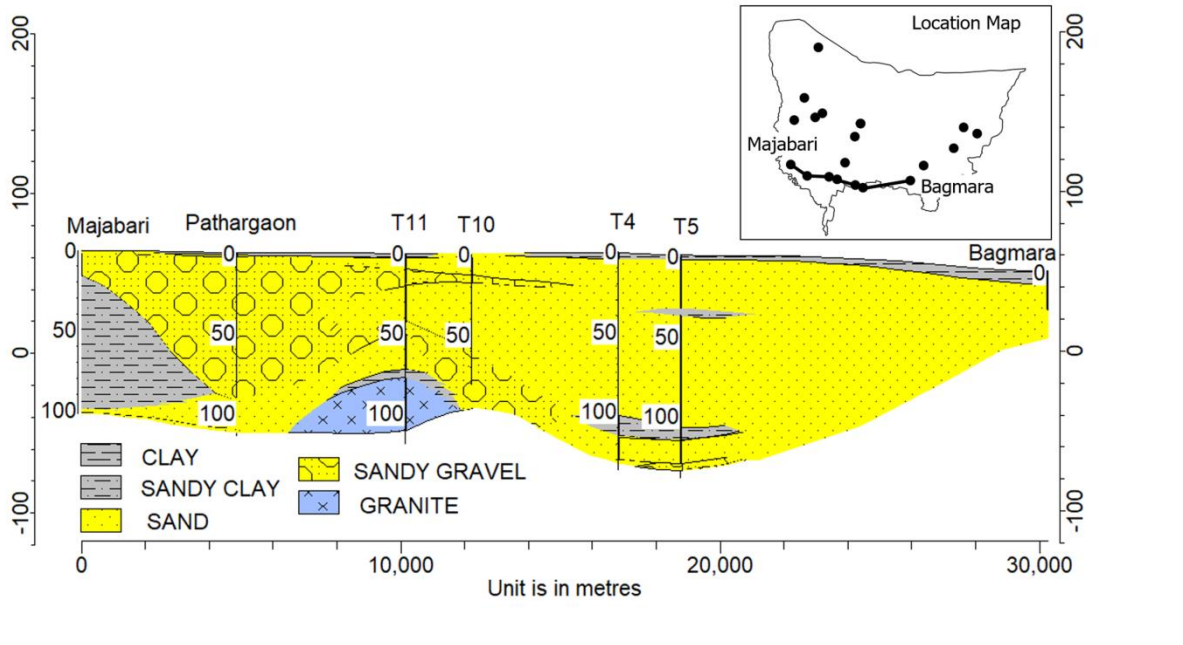

Fig 3.2. West-East 2D Section in the southern part of the district [Section 2]

West-East 2D Section [Section 2]: Thin layer of clay covers the transect at the top. The transect is characterised by the presence of sandy gravel in the western part that gradually gives way to sandy layer in the middle and eastern part. The thickness of sand layer in the middle reaches up to 120m. A thick lens of sandy clay with thickness of about 80 m is present in the western section. Minor lenses of clay and sandy clay intersperse the thick layer of sand in the middle. The dominant aquifer along this transect is sandy gravel and sandy layers. Notably basement granitic rock is encountered at a depth of 69 m below ground level at the location of T11. The occurrence of basement rock is however localised in nature (Fig 3.2.).

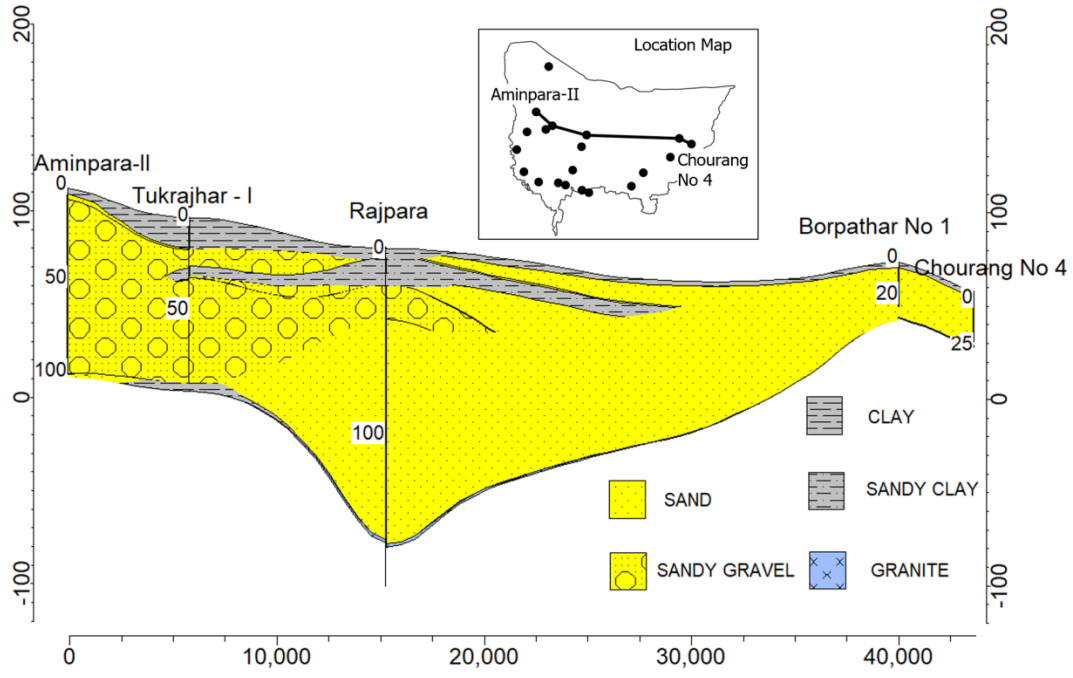

Fig 3.3. West-East 2D Section in the northern part of the district [Section 3]

West-East 2D Section [Section 3]: Thin layer of clay overlay the transect. There is gradual fining trend from sandy gravel in the western part of the district to sand in the eastern part along this transect. The main aquifer along this transect is the sandy gravel and sand layer. VES survey has revealed presence of consolidated basement rock at Rajpara. The sand and sandy gravel layer at Rajpara reaches up to a thickness of 165m. Gravelly and sandy sediments constitute the main aquifer along this transect (Fig 3.3.).

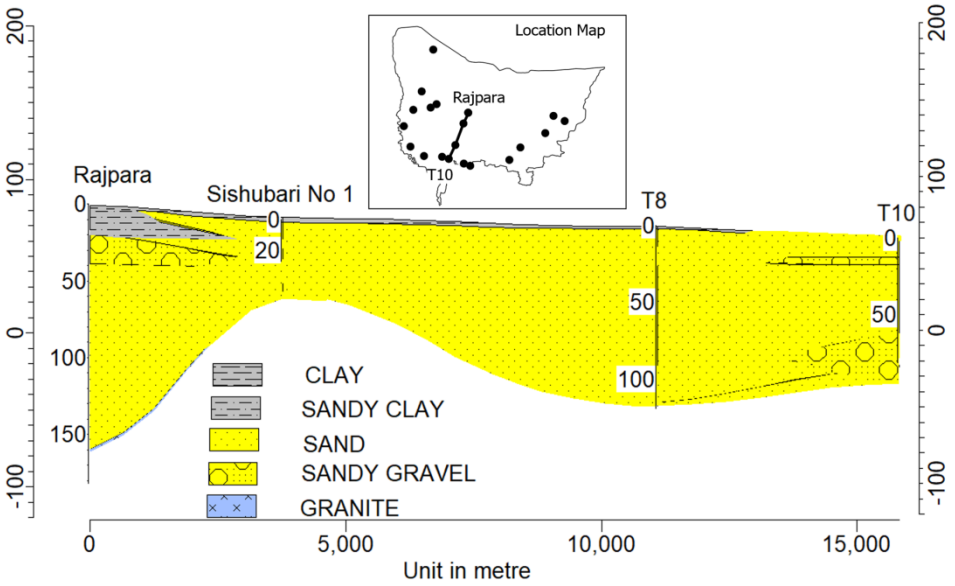

Fig 3.4. North East-South West 2D Section in the central part of the district [Section 4]

North East- South West 2D Section [Section 4]: The sequence is capped by a clay layer.at the top. Dominant **s**and layer with minor lenses of sandy gravel is the major aquifer along the transect. Lobes of sandy gravel are present in the northern and southern ends. Thickness of sandy layer reaches up to 110 m at Rajpara and 120 m at T8 (Fig 3.4.).

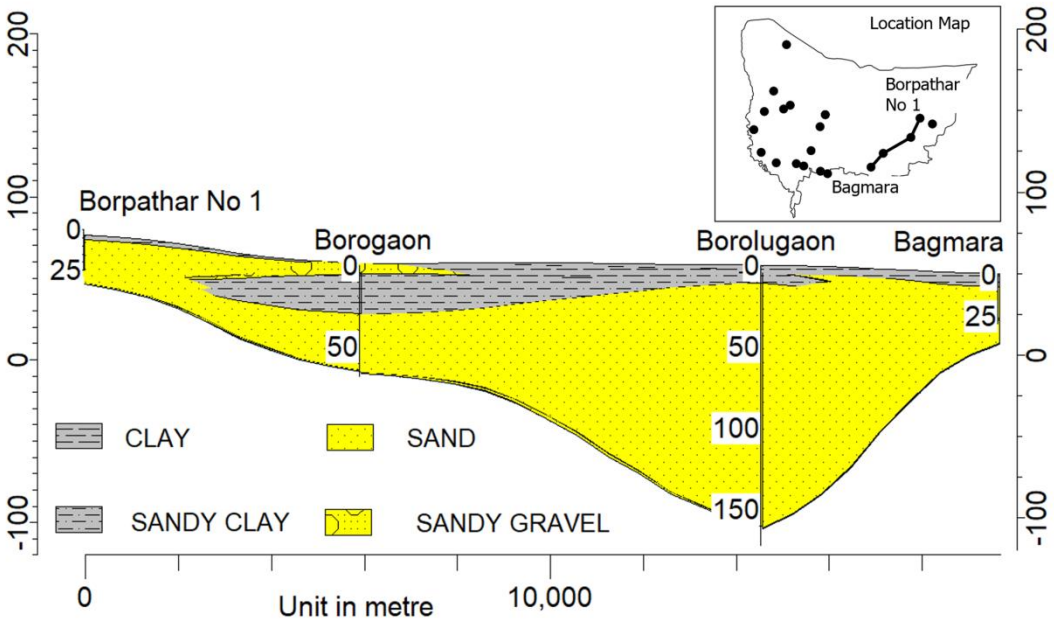

Fig 3.5. North East- South West 2D Section in the eastern part of the district [Section 5]

North East- South West 2D Section [Section 5]: The section is characterised by the presence of clay and sandy clay at the top with minor lens of sandy gravel. These layers are underlain by sand layer with thickness ranging from 20m to 150m (Fig 3.5.).

Fence/Panel diagram

The fence diagram (Fig. 3.6) and the 3-D model of the subsurface (Fig. 3.7) give a fuller representation of the aquifer disposition in the study area. Coarser grained deposit is more dominant in the northern part of the district and gradually reduces in thickness towards the south. This is in line with the depositional environment of the area in which sediments originate in the Himalaya in the North. The largest particles are deposited nearest to the source in the north and there is gradual decrease in the sediment size towards the south. Another notable trend is the pinching out of sandy gravel towards the east. This may be explained by the presence of larger river fed by numerous tributaries in the western part of the district as a result of favourable tectonic and topographical evolution as compared to the eastern part of the district.

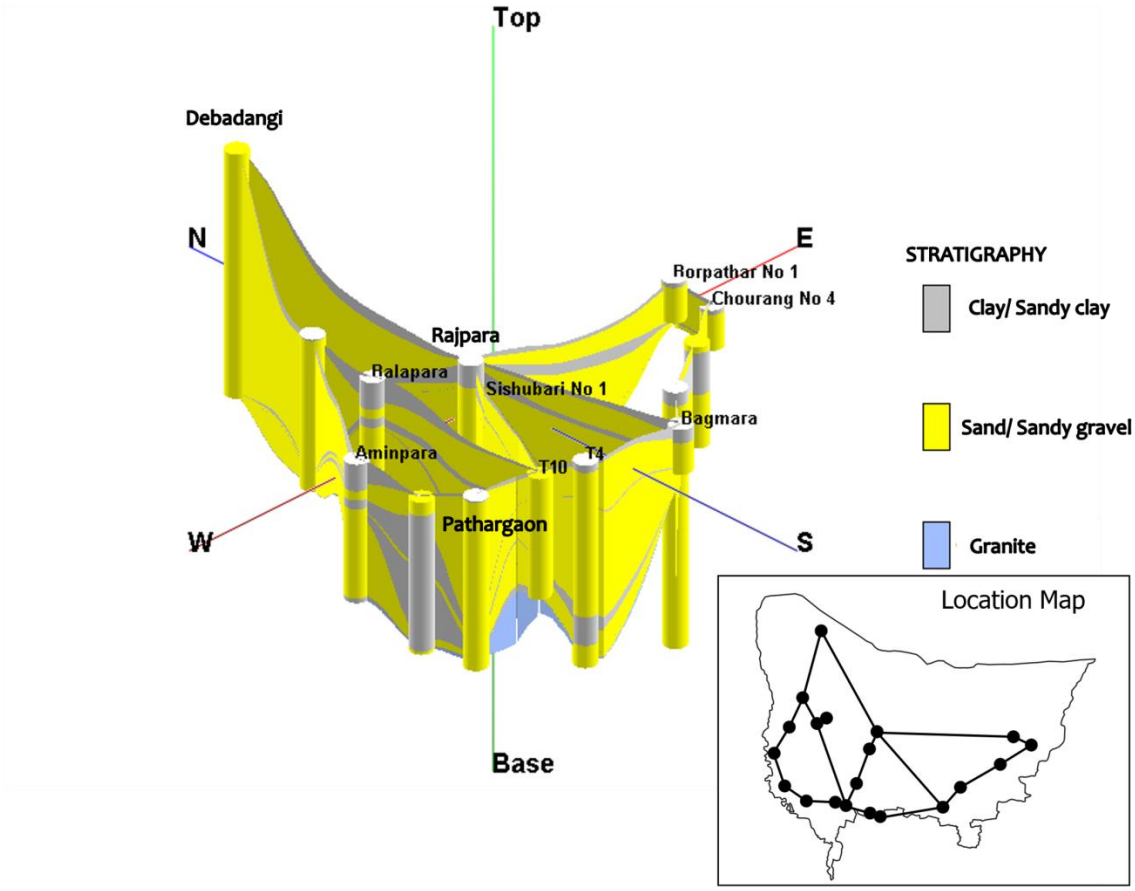

Fig 3.6. Fence diagram of the sub-surface formation of Chirang district, Assam

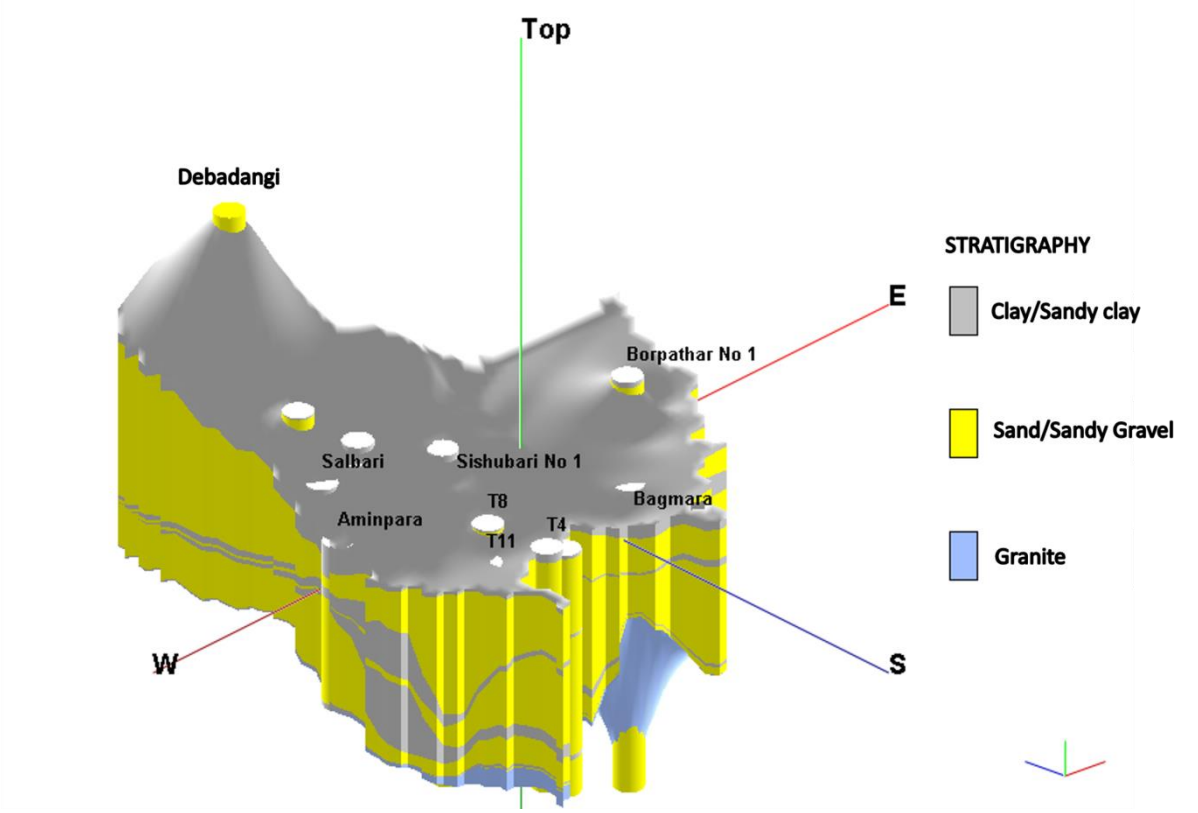

Fig 3.7. 3D view of the aquifer disposition

3.4 Aquifer Characteristics and parameters

Present study suggests that both dug wells and tube wells included in the study tap the one prominent aquifer in the study area, viz., Sandy Gravel and Sand belonging to the Older Alluvium.

3.4.1 Tube wells

Some aquifer parameters are available for T4, T5, T8, T10 and T11 (see Fig. 1.3 for locations of these tube wells) from previous report of the Board (CGWB-NER 2000).

Table 3.3: Aquifer zones tapped and aquifer parameters of the deeper aquifer, i.e., tube wells (Source: CGWB-NER 2000)

	Aquifer zones tapped [mbgl]	**Aquifer**	**Discharge [m^3/hr]**	**SWL [mbgl]**	**KD [m^3/day]**	**K [m/day]**	**S**
T4	48.53-60.85; 76.80-98.62	Sand	200	3.1	2552	60	1.23 x 10^{-3}
T5	69.57-113.19	Sand	150	3.8	2100	53	
T8	36.96-48.49; 61.44-72.27; 89.64-101.34; 105.63-110.9	Sand	266		2610	66	
T10	34.60-72.10	Sand	200	2.35			
T11	31.10-60.10	Sand	190	3.54			

3.4.2 Dug wells

CGWB, NER has 5 nos. of groundwater monitoring stations (GWMS) in the district. During NAQUIM study 42 nos. of key wells were established covering the non-forested parts of the district. During AAP 2022-23, water level of the GWMS was measured four times in a groundwater year. The key wells were established in June and August 2022 and the water levels of the key wells were monitored during November 2022 and March 2023. Water level data of the district are summarized in Table 3.6.

Depth of dug wells included in the study, that tap the shallower, phreatic aquifer, range from 3.8 mbgl to a maximum depth of 14.4 mbgl (Fig 3.8). These dug wells mostly tap the sandy gravel and sand aquifer of the Older Alluvium. Available litholog data and VES survey suggest that the veneer of finer, younger alluvium towards the southern part of the district is also underlain by coarser pebbly and sandy layers belonging to the Older Alluvium. The deeper dug wells are found in the piedmont zone closer to the mountain front. Further, dug wells become rarer as we move towards the mountain front especially towards Indo-Bhutan border.

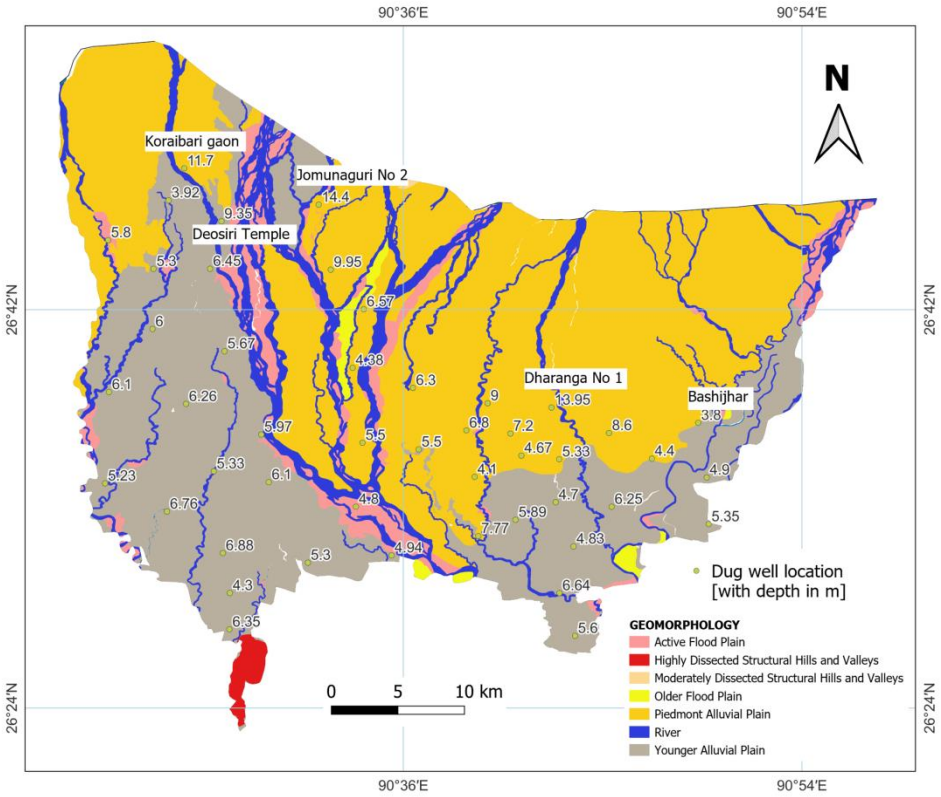

Fig 3.8. Depth of dug wells included in the present study

Depth to water table in shallow aquifer zone

Post-monsoon (November 2022): The depth to water table of phreatic aquifer belonging to the during post monsoon ranged from 0.82 to 6.12 mbgl (Fig 3.9 and Table 3.4). Generally, the deeper water levels are observed in the dug wells located in the Piedmont Alluvial Plain in the northern part of the district. The water table deepens towards northern part of the district.

Pre-monsoon (February (2023): The depth to water table of phreatic aquifer during pre-monsoon ranged from 1.11 to 9.19 mbgl (Fig 3.10 and Table 3.4). Deepening of water level over a wider area is observed for water level of 5-10 mbgl (Fig 3.10 and Table 3.4).

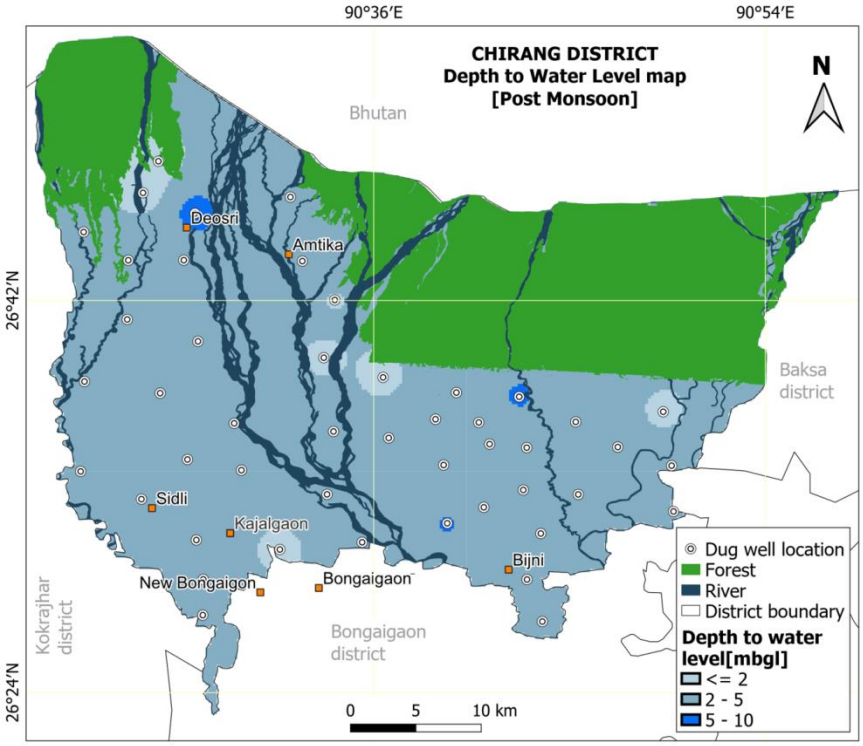

Fig 3.9. Depth to water level map during post monsoon

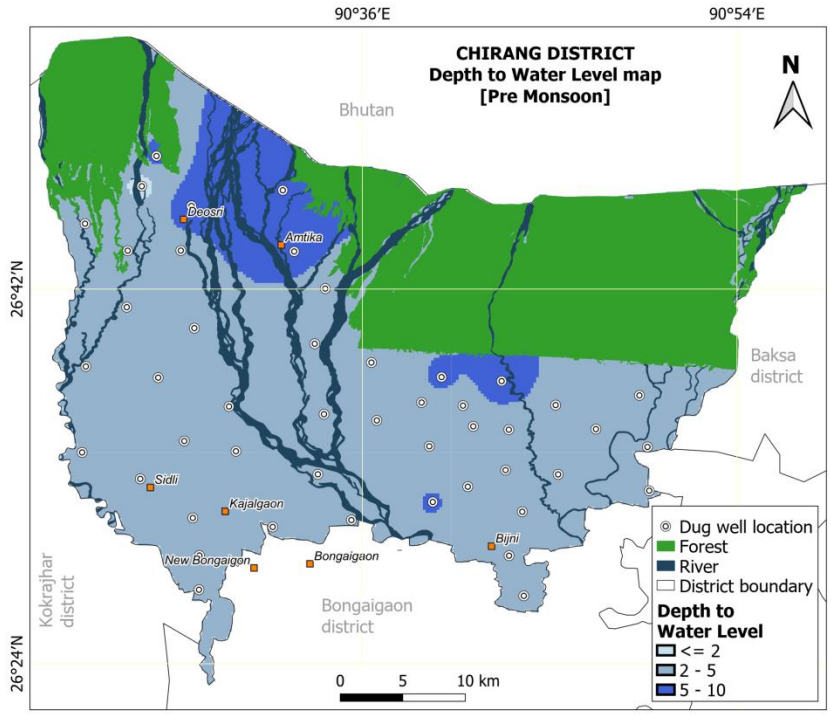

Fig 3.10. Depth to water level map of the phreatic aquifer of Chirang district during pre-monsoon

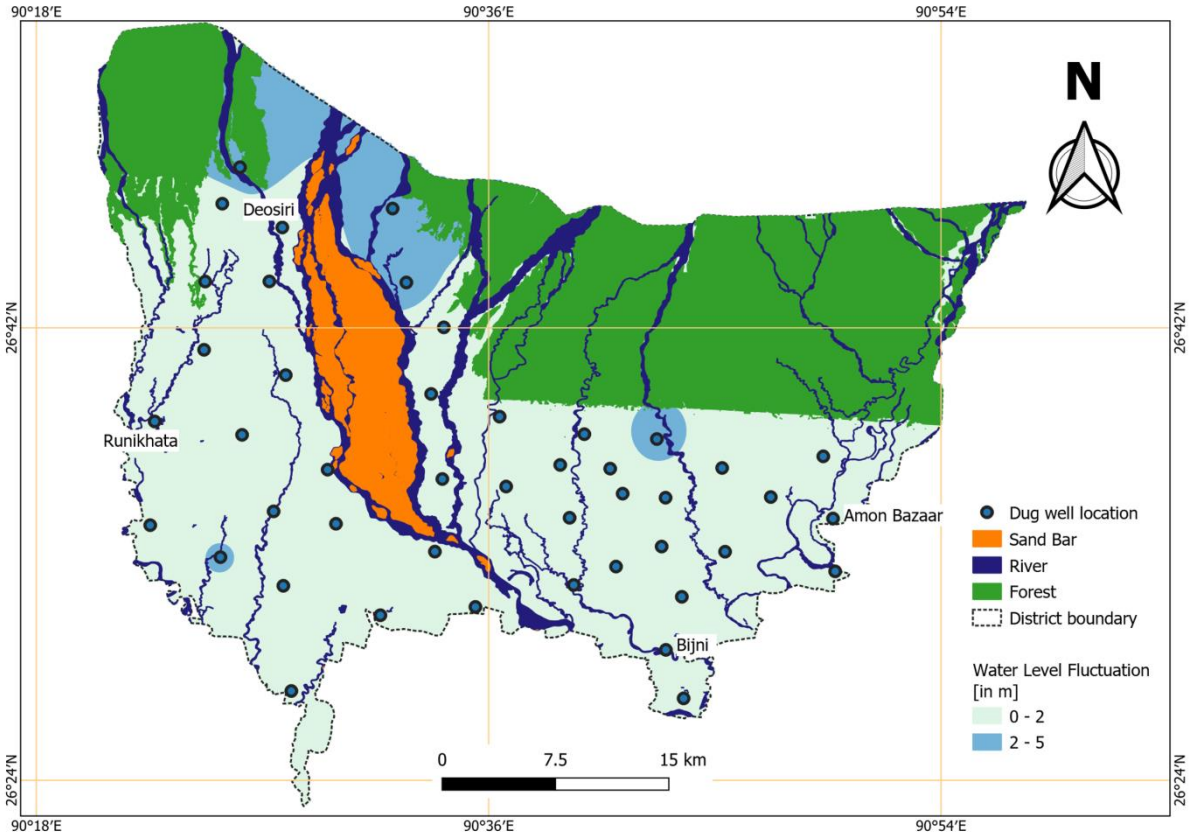

Fig 3.11. Water level fluctuation map of phreatic aquifer in Chirang district

3.5 Seasonal water level fluctuation

The pre-monsoon and post-monsoon water level fluctuation ranges between 0.13mbgl to 4.46mbgl (Fig 3.11 and Table 3.4). The more pronounced fluctuation is observed in the dug wells located in the piedmont zone whereas the fluctuation in dug wells further away from the mountain fronts is more subdued.

3.6 Ground Water Movement

The water table contour of phreatic aquifer has been prepared based on water level data with respect to elevation of ground water monitoring stations from mean sea level (Fig. 3.12). Water table contour of Chirang district varies from 160m to 50 m above mean sea level. In general groundwater movement is towards south and south east and conforms to the general topography of the district. Manas river and its tributaries are effluent in nature, i.e., they receive ground water in the northern part of the district but tend to become influent in the southern part of the district. Water table contours are more closely spaced in the northern part of the district, indicating steeper hydraulic gradient in the northern part compared to the southern part. The hydraulic gradient ranged from 7m/km in the north-west part of the district to 1.6m/km in the south eastern part of the district.

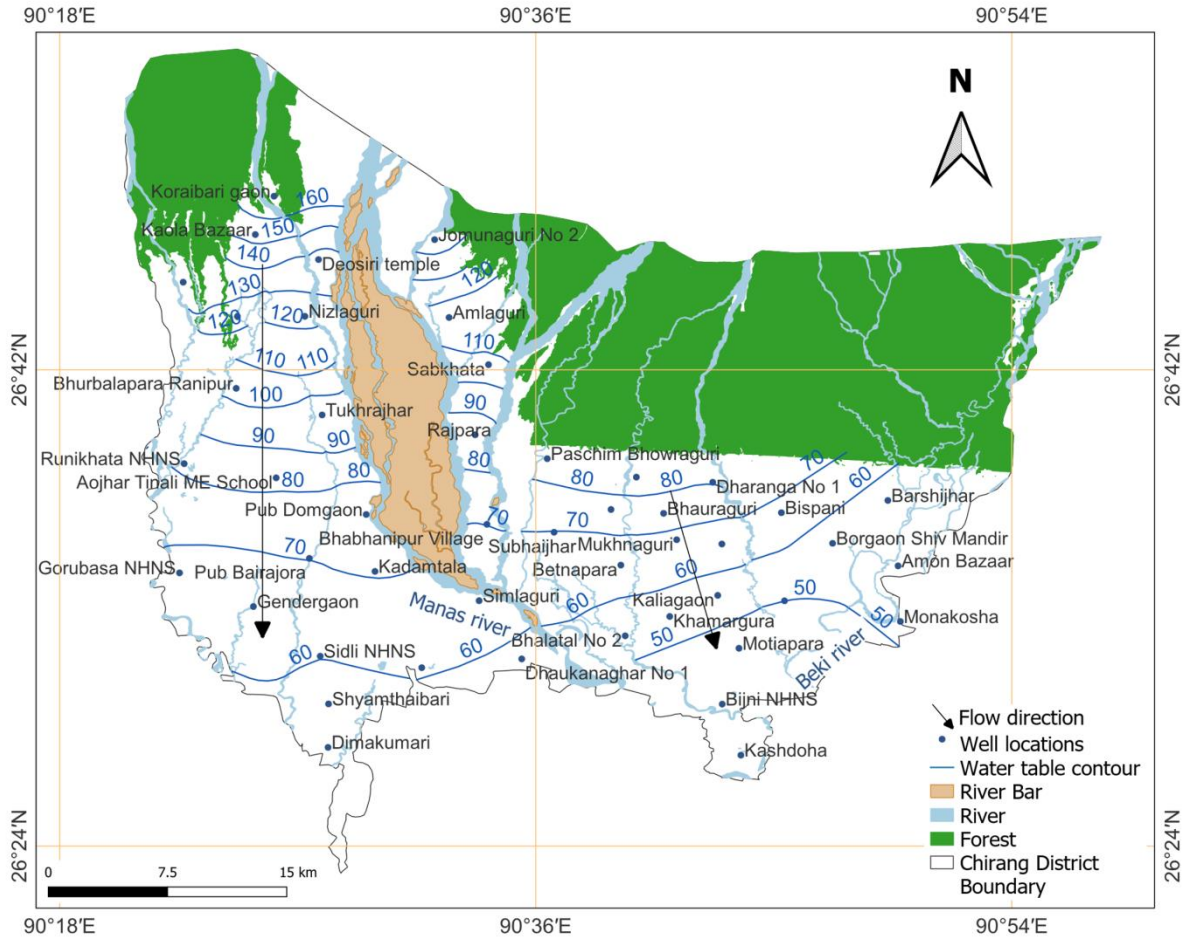

Fig 3.12. Water Table Contour map showing groundwater flow direction prepared from August 2022 water level data

Table 3.4: Depth to water level and seasonal fluctuation of water level data of key wells

S. No.	Location	Well Type	MP(m)	DIA(m)	Depth(m)	RL(m)	WL Nov 2022 (mbgl)	WL Feb 2023 (mbgl)	WL fluctuation (m)
1	Pub Bairajora	Dug Well	0.83	0.72	5.33	72	3.59	4.21	0.62
2	Kadamtala	Dug Well	0.86	0.78	6.1	73	2.19	4.11	1.92
3	Pub Domgaon	Dug Well	0.72	0.78	5.97	78	3.13	3.38	0.25
4	Aojhar Tinali ME School	Dug Well	0.76	0.77	6.26	86	2.9	3.94	1.04
5	Tukhrajhar	Dug Well	0.8	0.92	5.67	99	3.82	4.68	0.86
6	Nizlaguri	Dug Well	0.87	0.78	6.45	124	3.31	4.51	1.2
7	Deosiri temple	Dug Well	1.65	0.7	9.35	146	6.12	6.38	0.26
8	Koraibari gaon	Dug Well	1.3	0.7	11.7	173	0.98	5.44	4.46
9	Kaola Bazaar	Dug Well	0.52	0.76	3.92	152	0.82	1.11	0.29
10	Dhaligaon High School	Dug Well	0.88	0.65	5.3	64	1.54	2.54	1
11	Delasi Bazaar Samthebari Village	Dug Well	0.7	0.76	5.3	124	3.67	3.85	0.18
12	Silikaguri Village market	Dug Well	0.74	0.92	5.8	141	Demolished		
13	Gorubasa NHNS	Dug Well	0.7	0.8	5.23	68	3.54	3.91	0.37
14	Runikhata NHNS	Dug Well	0.75	0.72	6.1	88	2.77	3.14	0.37
15	Bhurbalapara Ranipur	Dug Well	0.86	0.77	6	105	4.14	4.34	0.2
16	Gendergaon	Dug Well	0.93	0.78	6.76	64	1.97	4.21	2.24
17	Sidli NHNS	Dug Well	0.92	0.68	6.88	62	2.88	3.56	0.68
18	Kashdoha	Dug Well	0.84	1.1	5.6	46	2.46	2.74	0.28
19	Dimakumari	Dug Well	0.93	0.77	6.35	56	3.47	4.78	1.31
20	Simlaguri	Dug Well	0.83	0.7	4.8	63	2.39		-2.39
21	Bijni NHNS	Dug Well	0.9	0.9	6.64	50	3.07	3.4	0.33
22	Bhalatal No 2	Dug Well	0.92	0.96	7.77	56	5.25	5.38	0.13
23	Dhaukanaghar No 1	Dug Well	0.79	0.73	4.94	58	2.86	3.01	0.15
24	Bhabhanipur Village	Dug Well	0.95	0.67	5.5	72	3.23	3.36	0.13

25	Rajpara	Dug Well	0.9	1.1	4.38	86	1.68	1.97	0.29
26	Amlaguri	Dug Well	0.41	1	9.95	122	4.39	7.39	3
27	Jomunaguri No 2	Dug Well	1	0.76	14.4	147	4.77	8.65	3.88
28	Sabkhata	Dug Well	0.95	0.7	6.57	104	1.9	2.2	0.3
29	Subhaijhar	Dug Well	0.91	1	5.5	70	3.39	3.64	0.25
30	Betnapara	Dug Well	0.7	0.63	4.1	64	2.4	2.79	0.39
31	Khamargura	Dug Well	0.95	1.8	5.89	56	2.97	3.63	0.66
32	Kaliagaon	Dug Well	0.84	1.1	4.7	55	2.36	2.61	0.25
33	Mukhnaguri	Dug Well	0.62	0.65	4.67	70	2.5	2.86	0.36
34	Bhauraguri	Dug Well	0.7	0.67	7.2	77	2.36	3.16	0.8
35	Ballamguri bazaar	Dug Well	0.78	0.7	6.8	77	3.72	4.19	0.47
36	Paschim Bhowraguri	Dug Well	0.84	0.67	6.3	85	1.23	2.13	0.9
37	Dhangsiapara	Dug Well	0.7	0.98	9	88	4.2	5.85	1.65
38	Makra Patkiguri	Dug Well	0.67	1.1	5.33	64	2.21	2.51	0.3
39	Dharanga No 1	Dug Well	0.5	0.94	13.95	84	5.54	9.19	3.65
40	Bispani	Dug Well	0.77	0.63	8.6	72	3.46	4.23	0.77
41	Borgaon Shiv Mandir	Dug Well	1.04	1	4.4	54	2.12	2.42	0.3
42	Barshijhar	Dug Well	0.64	0.62	3.8	57	1.68	2.74	1.06
43	Amon Bazaar	Dug Well	0.9	0.65	4.9	53	3.07	3.46	0.39
44	Monakosha	Dug Well	0.6	0.63	5.35	56	3.08	3.99	0.91
45	Pub Kharmapara	Dug Well	1.23	0.33	6.25	49	2.27	2.49	0.22
46	Motiapara	Dug Well	0.95	0.6	4.83	50	2.26	2.73	0.47

3.7 Water Quality analysis

To study the groundwater chemistry of aquifer in the district, a total no. of 31 groundwater samples were collected from dug wells during post monsoon (November 2022) and pre-monsoon (February 2023) field tour for analysis of major parameters. In addition 1 tube well sample was also collected. Water samples were collected in 1l, 500ml and two 250ml clean plastic bottles. Before collection of samples, bottles were properly rinsed with the water to be sampled. The tube wells were pumped for sufficient duration before collecting ground water sample so that the stagnant water, if any, is completely removed from storage within the well assembly. Samples were analysed for basic parameters including basic parameters (Total Dissolved Solids, Chloride, Fluoride, Sodium and Potassium), iron, arsenic, uranium and other parameters like alkalinity, nitrate, sulphate and turbidity. These water samples were analysed at Regional Chemical Laboratory, CGWB-NER, Guwahati. The analysis results are tabulated in Table 3.7 to Table 3.10.

Post-monsoon pH value ranges from 6.13 to 8.31. Most samples fall within the acceptable limit of 6.5 to 8.5. The analysis shows that post-monsoon groundwater samples concentration of Ca, Mg, Cl, SO_4, TDS and hardness as $CaCO_3$ are within either desirable or permissible limit.

Pre-monsoon pH value ranges from 5.86 to 8.04. Most samples fall within the acceptable limit of 6.5 to 8.5. More samples are acidic in pre-monsoon compared to post monsoon. The analysis shows that post-monsoon groundwater samples concentration of Ca, Mg, Cl, SO_4, TDS and hardness as $CaCO_3$ are within permissible limit.

Iron, Arsenic, fluoride and Uranium in shallow aquifer zone

Post-monsoon: Samples of Silikaguri Village market, Dhaukanaghar No 1 and Kaliagaon has Iron concentration higher than permissible limit of 1 mg/l. Arsenic concentration is either below detectable limit (BDL) or below acceptable limit of 0.01mg/l or 10ppb. Fluoride level is also within the acceptable limit of 1 mg/l. Further, Uranium concentration is either below detectable level (BDL) or lower than the maximum permissible limit of 30µg/l.

Post-monsoon: In the pre-monsoon samples, Fluoride level is within the acceptable limit of 1 mg/l. Further, Uranium concentration is either below detectable level (BDL) or lower than the maximum permissible limit of 30µg/l.

Table 3.5: Iron, Arsenic, Fluoride and Uranium concentration in the post monsoon and pre-monsoon ground water samples of Chirang district

		Post monsoon	Post monsoon	Post monsoon	Pre monsoon	Post monsoon	Pre monsoon
Location	**Type of sample (EW or DW)**	**Fe (Permissible limit 1mg/l)**	**As (in ppb from AAS) (Acceptable limit 10ppb)**	**F^-(Acceptable limit 1.5mg/l)**	**F^-(Acceptable limit 1.5mg/L)**	**U from Fluorimeter) (Maximum permissible limit 30 µg/l)**	**U from Fluorimeter) (Maximum permissible limit 30 µg/l)**
Pub Bairajora	Dug Well	0.174	BDL	0.17	0.04	BDL	BDL
Kadamtala	Dug Well	0.988	BDL	0.06	0.02	BDL	BDL
Aojhar Tinali ME School	Dug Well	0.11	BDL	0.04	0.02	BDL	BDL
Tukhrajhar	Dug Well	0.068	BDL	0.1	0.01	BDL	BDL
Deosiri temple	Dug Well	0.942	0.308	0.13	0.01	BDL	BDL
Koraibari gaon	Dug Well	0.174	BDL	0.35	0.07	BDL	BDL
Dhaligaon High School	Dug Well	0.988	BDL	0.26	0.03	0.087	BDL
Silikaguri Village market	Dug Well	1.429	0.82	0.27	0.03	BDL	BDL
Gorubasa NHNS	Dug Well	0.195	4.566	0.24	0.02	BDL	BDL
Runikhata NHNS	Dug Well	0.988	6.726	0.09	0.01	BDL	BDL
Bhurbalapara Ranipur	Dug Well	0.224	7.785	0.19	0.03	BDL	BDL
Sidli NHNS	Dug Well	0.123	BDL	0.25	0.04	BDL	0.2356
Kashdoha	Dug Well	0.003	BDL	0.11	0.02	0.3612	BDL
Dimakumari	Dug Well	0.163	0.477	0.08	0.01	0.0424	BDL
Bijni NHNS	Dug Well	0.063	0.084	0.24	0.01	0.1506	BDL
Bhalatal No 2	Dug Well	0.143	0.648	0.44	0.05	1.1739	0.2706
Dhaukanaghar No 1	Dug Well	5.376	7.429	0.83	0.06	0.0334	BDL

Bhabhanipur Village	Dug Well	0.837	1.518	0.74	0.09	0.4876	0.255
Simlaguri	Dug Well	0.556	0.534	0.38	0.04	0.0967	0.013
Jomunaguri No 2	Dug Well	0.123	0.252	0.34	0.13	BDL	BDL
Sabkhata	Dug Well	0.063	0.534	0.45	0.17	0.3611	0.2579
Subhaijhar	Dug Well	0.083	0.534	0.36	0.11	0.3829	BDL
Betnapara	Dug Well	0.143	0.762	0.41	0.17	0.2247	BDL
Kaliagaon	Dug Well	2.325	2.054	0.98	0.1	0.7851	0.215
Mukhnaguri	Dug Well	0.063	BDL	0.53	0.07	0.849	0.3742
Dhangsiapara	Dug Well	0.123	BDL	0.34	0.04	0.478	0.428
Dharanga No 1	Dug Well	0.083	BDL	0.53	0.05	0.5661	0.3719
Borgaon Shiv Mandir	Dug Well	0.043	BDL	0.52	0.06	1.0136	0.862
Barshijhar	Dug Well	0.083	BDL	0.38	0.06	0.2188	0.063
Monakosha	Dug Well	0.083	BDL	0.54	0.08	0.2821	0.028
Pub Kharmapara	Dug Well	0.183	BDL	0.38	0.04	0.5438	BDL
Bongaigaon	Tube Well	0.103	BDL	0.08	0.03	0.0458	BDL
	Pre-monsoon samples analysis for Fe and As still in process at the time of submission of this report						

Table 3.6. Water level data of key wells of June 2022, August 2022, November 2022 and February 2023

S. No.	Location	Well Type	MP(m)	DIA(m)	Depth(m)	RL(m)	Latitude	Longitude	WL June 2022 (mbmp)	WL Aug 2022 (mbmp)	WL Nov 2022 (mbmp)	WL Feb 2023 (mbmp)
1	Pub Bairajora	Dug Well	0.83	0.72	5.33	72	26.578342	90.457359		2.92	4.42	5.04
2	Kadamtala	Dug Well	0.86	0.78	6.1	73	26.570132	90.498717	1.37	1.8	3.05	4.97
3	Pub Domgaon	Dug Well	0.72	0.78	5.97	78	26.605999	90.493179	2.87	3.32	3.85	4.1
4	Aojhar Tinali ME School	Dug Well	0.76	0.77	6.26	86	26.62908	90.436439		2.54	3.66	4.7
5	Tukhrajhar	Dug Well	0.8	0.92	5.67	99	26.6687	90.4654	2.28	3.66	4.62	5.48
6	Nizlaguri	Dug Well	0.87	0.78	6.45	124	26.73082	90.45455	2.64	2.42	4.18	5.38
7	Deosiri temple	Dug Well	1.65	0.7	9.35	146	26.766583	90.463139		7.18	7.77	8.03
8	Koraibari gaon	Dug Well	1.3	0.7	11.7	173	26.806505	90.435091		3	2.28	6.74
9	Kaola Bazaar	Dug Well	0.52	0.76	3.92	152	26.782342	90.423308		1.34	1.34	1.63
10	Dhaligaon High School	Dug Well	0.88	0.65	5.3	64	26.509478	90.528183		0	2.42	3.42
11	Delasi Bazaar Samthebari Village	Dug Well	0.7	0.76	5.3	124	26.73075	90.412004		3.72	4.37	4.55
12	Silikaguri Village market	Dug Well	0.74	0.92	5.8	141	26.752354	90.377832		4.9	Dry	Demolished
13	Gorubasa NHNS	Dug Well	0.7	0.8	5.23	68	26.569201	90.37552		3.42	4.24	4.61
14	Runikhata NHNS	Dug Well	0.75	0.72	6.1	88	26.637984	90.378469		2.56	3.52	3.89
15	Bhurbalapara Ranipur	Dug Well	0.86	0.77	6	105	26.685461	90.411241		4.64	5	5.2
16	Gendergaon	Dug Well	0.93	0.78	6.76	64	26.548	90.4221	1.45	2	2.9	5.14
17	Sidli NHNS	Dug Well	0.92	0.68	6.88	62	26.528999	90.463803	2.3	2.75	3.8	4.48
18	Kashdoha	Dug Well	0.84	1.1	5.6	46	26.454359	90.729296		2.5	3.3	3.58

19	Dimakumari	Dug Well	0.93	0.77	6.35	56	26.459248	90.469125		2	4.4	5.71
20	Simlaguri	Dug Well	0.83	0.7	4.8	63	26.551664	90.564331		2.6	3.22	3.52
21	Bijni NHNS	Dug Well	0.9	0.9	6.64	50	26.486523	90.717535	1.18	2.9	3.97	4.3
22	Bhalatal No 2	Dug Well	0.92	0.96	7.77	56	26.52955	90.656421		5.75	6.17	6.3
23	Dhaukanaghar No 1	Dug Well	0.79	0.73	4.94	58	26.514992	90.591206		2.9	3.65	3.8
24	Bhabhanipur Village	Dug Well	0.95	0.67	5.5	72	26.599799	90.569272	2.46	2.8	4.18	4.31
25	Rajpara	Dug Well	0.9	1.1	4.38	86	26.656207	90.561859		2.51	2.58	2.87
26	Amlaguri	Dug Well	0.41	1	9.95	122	26.7301	90.5454	5.6	3.86	4.8	7.8
27	Jomunaguri No 2	Dug Well	1	0.76	14.4	147	26.779129	90.536284		3.35	5.77	9.65
28	Sabkhata	Dug Well	0.95	0.7	6.57	104	26.700371	90.570248		2.8	2.85	3.15
29	Subhaijhar	Dug Well	0.91	1	5.5	70	26.594816	90.611579	2.9	3.6	4.3	4.55
30	Betnapara	Dug Well	0.7	0.63	4.1	64	26.5741	90.65366	1.41	2.33	3.1	3.49
31	Khamargura	Dug Well	0.95	1.8	5.89	56	26.541743	90.684459	1.74	2.95	3.92	4.58
32	Kaliagaon	Dug Well	0.84	1.1	4.7	55	26.555018	90.714714		2	3.2	3.45
33	Mukhnaguri	Dug Well	0.62	0.65	4.67	70	26.590083	90.688862		2.63	3.12	3.48
34	Bhauraguri	Dug Well	0.7	0.67	7.2	77	26.606683	90.680592		2.53	3.06	3.86
35	Ballamguri bazaar	Dug Well	0.78	0.7	6.8	77	26.609133	90.647453	3.2	3.76	4.5	4.97
36	Paschim Bhowraguri	Dug Well	0.84	0.67	6.3	85	26.641151	90.607256		1.86	2.07	2.97
37	Dhangsiapara	Dug Well	0.7	0.98	9	88	26.629524	90.663441		4.1	4.9	6.55
38	Makra Patkiguri	Dug Well	0.67	1.1	5.33	64	26.5874	90.717315	1.9	2.4	2.88	3.18
39	Dharanga No 1	Dug Well	0.5	0.94	13.95	84	26.626304	90.71156		4.7	6.04	9.69
40	Bispani	Dug Well	0.77	0.63	8.6	72	26.607117	90.754837		3.97	4.23	5
41	Borgaon Shiv Mandir	Dug Well	1.04	1	4.4	54	26.58784	90.7871	1.16	2.09	3.16	3.46
42	Barshijhar	Dug Well	0.64	0.62	3.8	57	26.614835	90.821922		2.9	2.32	3.38

43	Amon Bazaar	Dug Well	0.9	0.65	4.9	53	26.573622	90.828359	0.7	2.78	3.97	4.36
44	Monakosha	Dug Well	0.6	0.63	5.35	56	26.538568	90.82981		2.53	3.68	4.59
45	Pub Kharmapara	Dug Well	1.23	0.33	6.25	49	26.5516	90.7568	1.44	-1.23	3.5	3.72
46	Motiapara	Dug Well	0.95	0.6	4.83	50	26.5217	90.7281	1.37	2.16	3.21	3.68

Table 3.7: Summary of post monsoon water quality parameters analysed in the study (Part 1)

S. No	Location	Type of sample	Salinity (ppt)	ORP (mV)	pH	EC (µs/cm) 25°C	Turbidity (NTU)	TDS (mg/l)	CO_3^{-2} (mg/l)	HCO_3^{-1} (mg/l)	TA (as $CaCO_3$) (mg/l)	Cl^- (mg/l)
1	Pub Bairajora	Dug Well	80.4	205	6.66	113.5	BDL	74.91	BDL	6.10488	6.10488	14.18
2	Kadamtala	Dug Well	70.6	76	6.42	72.8	BDL	48.048	BDL	24.41952	24.41952	10.64
3	Aojhar Tinali ME School	Dug Well	50	185	6.5	47.7	BDL	31.482	BDL	30.5244	30.5244	7.09
4	Tukhrajhar	Dug Well	52.6	228	6.13	66.69	BDL	44.015	BDL	36.62928	36.62928	14.18
5	Deosiri temple	Dug Well	45.6	147	6.24	57.73	BDL	38.102	BDL	24.41952	24.41952	10.64
6	Koraibari gaon	Dug Well	97.1	203	6.81	129.9	BDL	85.734	BDL	73.25856	73.25856	3.545
7	Dhaligaon High School	Dug Well	0.212	225	6.88	314.5	BDL	207.57	BDL	140.4122	140.41224	28.36
8	Silikaguri Village market	Dug Well	82.9	64	6.98	99.68	0.01	65.789	BDL	67.15368	67.15368	7.09
9	Gorubasa NHNS	Dug Well	70.6	163	6.58	85.26	BDL	56.272	BDL	48.83904	48.83904	10.64
10	Runikhata NHNS	Dug Well	107	127	6.28	134.8	BDL	88.968	BDL	48.83904	48.83904	21.27
11	Bhurbalapara Ranipur	Dug Well	63.4	196	6.82	76.59	BDL	50.549	BDL	54.94392	54.94392	7.09
12	Sidli NHNS	Dug Well	120.9	171	7.33	180.6	BDL	119.2	BDL	103.783	103.78296	7.09
13	Kashdoha	Dug Well	137.4	176	6.92	193.8	BDL	127.91	BDL	103.783	103.78296	10.64
14	Dimakumari	Dug Well	106.2	164	6.86	132.3	BDL	87.318	BDL	67.15368	67.15368	10.64
15	Bijni NHNS	Dug Well	155.4	216	7.45	213.5	0.04	140.91	BDL	122.0976	122.0976	14.18
16	Bhalatal No 2	Dug Well	139	64	7.88	219.6	0.02	144.94	BDL	134.3074	134.30736	7.09

17	Dhaukanaghar No 1	Dug Well	157.3	-45	6.92	208.7	0.04	137.74	BDL	115.9927	115.99272	14.18
18	Bhabhanipur Village	Dug Well	0.337	170	7.76	467.8	BDL	308.75	BDL	347.9782	347.97816	10.64
19	Simlaguri	Dug Well	79.7	99	6.51	97.37	0.02	64.264	BDL	61.0488	61.0488	10.64
20	Jomunaguri No 2	Dug Well	84.7	191	7.18	98.08	BDL	64.733	BDL	67.15368	67.15368	10.64
21	Sabkhata	Dug Well	0.261	202	7.54	377.8	BDL	249.35	BDL	244.1952	244.1952	10.64
22	Subhaijhar	Dug Well	0.291	174	8.04	428.7	BDL	282.94	BDL	329.4	317.244	10.64
23	Betnapara	Dug Well	0.385	137	7.9	598.8	0.11	395.21	BDL	420.9	411.92208	14.18
24	Kaliagaon	Dug Well	0.394	-53	7.77	567.4	0.01	374.48	BDL	439.2	424.02696	14.18
25	Mukhnaguri	Dug Well	0.366	132	8.03	564.8	0.07	372.77	BDL	433.1	414.8172	7.09
26	Dhangsiapara	Dug Well	0.39	10	7.68	604.5	BDL	398.97	BDL	402.6	445.3416	14.18
27	Dharanga No 1	Dug Well	0.325	61	7.74	514.8	BDL	339.77	BDL	353.8	387.39768	10.64
28	Borgaon Shiv Mandir	Dug Well	0.318	42	8.16	448.9	0.02	296.27	BDL	378.2	335.45376	10.64
29	Barshijhar	Dug Well	0.315	54	7.86	512.8	BDL	338.45	BDL	353.8	366.08304	10.64
30	Monakosha	Dug Well	0.306	168	7.95	475.3	0.05	313.7	BDL	396.5	341.66352	7.09
31	Pub Kharmapara	Dug Well	0.356	-41	8.31	509.8	BDL	336.47	15	366.2928	381.2928	10.64
32	Bongaigaon	Tube Well	85.2	102	7.07	89.5	0.02	59.07	BDL	61.0488	61.0488	10.64

Table 3.8: Summary of post monsoon water quality parameters analysed in the study (Part 2)

S. No	Location	Type of sample	SO_4^{-2} (mg/l)	NO3-1 (mg/l)	F- (mg/l)	Ca+2 (mg/l)	Mg+2 (mg/l)	TH (as CaCO3) (mg/l)	Na (mg/l)	K (mg/l)	Fe (mg/l)	As (ppb)	U (from Fluorimeter) in ppb
1	Pub Bairajora	Dug Well	17.9552	24.797	0.17	6.0048	9.705825	55	3.12	6.07	0.174	BDL	BDL
2	Kadamtala	Dug Well	4.6992	11.7039	0.06	2.0016	7.280583	35	4.71	2.23	0.988	BDL	BDL
3	Aojhar Tinali ME School	Dug Well	3.1223	3.8744	0.04	4.0032	3.638835	25	5.59	3.07	0.11	BDL	BDL
4	Tukhrajhar	Dug Well	5.1832	4.5148	0.1	2.0016	7.280583	35	8.42	2.71	0.068	BDL	BDL
5	Deosiri temple	Dug Well	4.3025	8.813	0.13	10.008	-0.00485	25	5.77	4.79	0.942	0.308	BDL
6	Koraibari gaon	Dug Well	15.8999	2.4238	0.35	14.0112	4.847573	55	8.55	2.19	0.174	BDL	BDL

7	Dhaligaon High School	Dug Well	27.7973	0	0.26	38.0304	6.049515	120	16.22	9.26	0.988	BDL	0.087
8	Silikaguri Village market	Dug Well	5.8055	2.9093	0.27	6.0048	8.492233	50	6.72	2.86	1.429	0.82	BDL
9	Gorubasa NHNS	Dug Well	2.5753	3.3483	0.24	8.0064	2.423301	30	9.6	3.9	0.195	4.566	BDL
10	Runikhata NHNS	Dug Well	7.8465	17.8257	0.09	8.0064	6.064078	45	16.43	3.76	0.988	6.726	BDL
11	Bhurbalapara Ranipur	Dug Well	1.6357	3.5172	0.19	14.0112	1.206796	40	6.41	3.4	0.224	7.785	BDL
12	Sidli NHNS	Dug Well	10.7069	2.8801	0.25	34.0272	1.197087	90	4.2	3.77	0.123	BDL	BDL
13	Kashdoha	Dug Well	19.5107	2.7434	0.11	22.0176	9.698058	95	6.98	6.1	0.003	BDL	0.3612
14	Dimakumari	Dug Well	5.4448	1.4919	0.08	12.0096	4.848544	50	7.59	7.32	0.163	0.477	0.0424
15	Bijni NHNS	Dug Well	9.8411	1.3299	0.24	20.016	6.058252	75	16.09	8.99	0.063	0.084	0.1506
16	Bhalatal No 2	Dug Well	14.3124	2.6564	0.44	34.0272	6.051456	110	3.33	6.51	0.143	0.648	1.1739
17	Dhaukanaghar No 1	Dug Well	12.2135	1.2924	0.83	28.0224	9.695146	110	5.49	5.84	5.376	7.429	0.0334
18	Bhabhanipur Village	Dug Well	7.788	0.2919	0.74	64.0512	30.30874	285	3.54	2.2	0.837	1.518	0.4876
19	Simlaguri	Dug Well	8.3447	0.9174	0.38	12.0096	3.634951	45	7.71	4.49	0.556	0.534	0.0967
20	Jomunaguri No 2	Dug Well	5.5562	0.8468	0.34	12.0096	3.634951	45	8.87	4.96	0.123	0.252	BDL
21	Sabkhata	Dug Well	14.7353	1.6421	0.45	30.024	33.96602	215	3.47	2.85	0.063	0.534	0.3611
22	Subhaijhar	Dug Well	9.6484	0.1495	0.36	28.0224	44.88932	255	8.97	2.89	0.083	0.534	0.3829
23	Betnapara	Dug Well	5.1745	0.0637	0.41	28.0224	60.66602	320	9.33	9.48	0.143	0.762	0.2247
24	Kaliagaon	Dug Well	5.5866	0.1086	0.98	62.0496	38.80485	315	14.96	4.29	2.325	2.054	0.7851
25	Mukhnaguri	Dug Well	7.6511	0	0.53	40.032	49.73786	305	11.22	7.73	0.063	BDL	0.849
26	Dhangsiapara	Dug Well	6.5531	0.2526	0.34	56.0448	46.08932	330	13.41	7.99	0.123	BDL	0.478
27	Dharanga No 1	Dug Well	7.2828	1.2794	0.53	18.0144	63.09806	305	6.16	3.63	0.083	BDL	0.5661
28	Borgaon Shiv Mandir	Dug Well	12.9425	0	0.52	18.0144	47.32136	240	24.63	11.76	0.043	BDL	1.0136
29	Barshijhar	Dug Well	4.9075	0	0.38	20.016	57.02913	285	5.89	1.84	0.083	BDL	0.2188
30	Monakosha	Dug Well	8.3915	0	0.54	18.0144	50.96214	255	21.48	10.52	0.083	BDL	0.2821
31	Pub Kharmapara	Dug Well	10.9125	0	0.38	20.016	57.02913	285	15.81	5.66	0.183	BDL	0.5438
32	Bongaigaon	Tube Well	4.0486	0.6392	0.08	6.0048	6.065049	40	8.26	4.88	0.103	BDL	0.0458

Table 3.9: Summary of pre-monsoon water quality parameters analysed in the study (Part 1)

S. No	Location	Type of sample	pH	EC (µs/cm) 25C	Turbidity (NTU)	TDS	$CO_3^{-}_2$	HCO_3^{-1}	TA (as $CaCO_3$)	Cl^-
1	Pub Bairajora	Dug Well	6.06	58.55	0.09	38.64	BDL	36.62928	36.62928	21.27
2	Kadamtala	Dug Well	5.86	35.45	0.06	23.40	BDL	30.5244	30.5244	14.18
3	Aojhar Tinali ME School	Dug Well	6.14	24.97	0.04	16.48	BDL	24.41952	24.41952	10.635
4	Tukhrajhar	Dug Well	5.92	30.31	0.02	20.00	BDL	30.5244	30.5244	10.635
5	Deosiri temple	Dug Well	5.95	26.85	0.25	17.72	BDL	24.41952	24.41952	10.635
6	Koraibari gaon	Dug Well	6.6	84.58	0.07	55.82	BDL	79.36344	79.36344	7.09
7	Dhaligaon High School	Dug Well	6.53	157.2	0.03	103.75	BDL	140.4122	140.41224	24.815
8	Silikaguri Village market	Dug Well	6.68	58.52	BDL	38.62	BDL	67.15368	67.15368	7.09
9	Gorubasa NHNS	Dug Well	6.18	61.38	0.06	40.51	BDL	54.94392	54.94392	14.18
10	Runikhata NHNS	Dug Well	6.05	72.93	0.07	48.13	BDL	42.73416	42.73416	21.27
11	Bhurbalapara Ranipur	Dug Well	6.5	36.24	0.1	23.92	BDL	42.73416	42.73416	10.635
12	Sidli NHNS	Dug Well	6.795	105.5	0.59	69.63	BDL	115.9927	115.99272	10.635
13	Kashdoha	Dug Well	6.501	125.6	0.21	82.90	BDL	140.4122	140.41224	21.27
14	Dimakumari	Dug Well	6.272	57.85	0.35	38.18	BDL	48.83904	48.83904	21.27
15	Bijni NHNS	Dug Well	5.93	67.55	0.42	44.58	BDL	54.94392	54.94392	14.18
16	Bhalatal No 2	Dug Well	7.545	126.5	0.12	83.49	6	164.8318	170.83176	10.635
17	Dhaukanaghar No 1	Dug Well	6.425	99.87	0.37	65.91	BDL	91.5732	91.5732	24.815
18	Bhabhanipur Village	Dug Well	7.407	24.26	0.11	16.01	9	299.1391	308.13912	14.18
19	Simlaguri	Dug Well	6.169	56.77	0.15	37.47	BDL	67.15368	67.15368	17.725
20	Jomunaguri No 2	Dug Well	7.348	92.01	0.09	60.73	0	91.5732	91.5732	10.635
21	Sabkhata	Dug Well	7.764	204.3	0	134.84	0	256.405	256.40496	10.635
22	Subhaijhar	Dug Well	8.037	226.1	0.02	149.23	15	274.7196	289.7196	10.635
23	Betnapara	Dug Well	8.007	312.4	0.01	206.18	9	317.4538	326.45376	10.635

24	Kaliagaon	Dug Well	7.842	284.9	0.03	188.03	BDL	402.9221	402.92208	21.27
25	Mukhnaguri	Dug Well	7.968	304.2	BDL	200.77	BDL	378.5026	378.50256	21.27
26	Dhangsiapara	Dug Well	7.581	282.2	0.22	186.25	BDL	384.6074	384.60744	14.18
27	Dharanga No 1	Dug Well	7.888	273.7	BDL	180.64	BDL	384.6074	384.60744	14.18
28	Borgaon Shiv Mandir	Dug Well	7.955	273	0.01	180.18	12	366.2928	378.2928	7.09
29	Barshijhar	Dug Well	7.918	277.8	BDL	183.35	BDL	341.8733	341.87328	17.725
30	Monakosha	Dug Well	7.844	236.3	0.04	155.96	BDL	299.1391	299.13912	14.18
31	Pub Kharmapara	Dug Well	7.803	266.2	0.07	175.69	BDL	323.5586	323.55864	10.635
32	Bongaigaon	Tube Well	7.01	42.09	0.18	27.78	BDL	79.36344	79.36344	10.635

Table 3.10: Summary of pre-monsoon water quality parameters analysed in the study (Part 2)

S. No.	Location	Type of sample	SO_4^{-2}	NO_3^{-1}	F^-	Ca^{+2}	Mg^{+2}	TH (as CaCO3)	Na	K	U from Fluorimeter)
1	Pub Bairajora	Dug Well	BDL	0.0099	0.04	16.0128	1.205825243	45	4.06	5.7	BDL
2	Kadamtala	Dug Well	4.1564	0.0364	0.02	8.0064	3.636893204	35	6.18	3.05	BDL
3	Aojhar Tinali ME School	Dug Well	BDL	0.0393	0.02	4.0032	1.211650485	15	7.3	2.3	BDL
4	Tukhrajhar	Dug Well	5.3547	0.0314	0.01	8.0064	4.850485437	40	3.3	1.85	BDL
5	Deosiri temple	Dug Well	BDL	0.022	0.01	6.0048	2.424271845	25	2.43	6.56	BDL
6	Koraibari gaon	Dug Well	23	0.026	0.07	34.0272	1.197087379	90	2.81	1.84	BDL
7	Dhaligaon High School	Dug Well	BDL	0.0292	0.03	44.0352	7.260194175	140	8.62	3.85	BDL
8	Silikaguri Village market	Dug Well	17.55	0.0231	0.03	14.0112	9.701941748	75	5.12	4.7	BDL
9	Gorubasa NHNS	Dug Well	BDL	0.0199	0.02	14.0112	3.633980583	50	5.65	6.77	BDL
10	Runikhata NHNS	Dug Well	BDL	0.0182	0.01	16.0128	3.633009709	55	4.25	3.61	BDL
11	Bhurbalapara Ranipur	Dug Well	BDL	0.0166	0.03	10.008	2.422330097	35	5.38	2.59	BDL
12	Sidli NHNS	Dug Well	9.2536	0.7423	0.04	32.0256	2.411650485	90	8.85	4.24	0.2356
13	Kashdoha	Dug Well	4.3115	2.183	0.02	26.0208	10.90970874	110	9.43	8.26	BDL
14	Dimakumari	Dug Well	6.5184	4.6788	0.01	14.0112	4.847572816	55	7.03	5.23	BDL

15	Bijni NHNS	Dug Well	1.9313	2.8039	0.01	8.0064	1.209708738	25	13.51	7.42	BDL
16	Bhalatal No 2	Dug Well	8.9584	3.0589	0.05	34.0272	13.33300971	140	6.45	5.8	0.2706
17	Dhaukanaghar No 1	Dug Well	12.3831	0.0809	0.06	18.0144	10.91359223	90	8.93	5.63	BDL
18	Bhabhanipur Village	Dug Well	8.1677	0.6017	0.09	52.0416	32.74174757	265	2.14	2.14	0.255
19	Simlaguri	Dug Well	6.4521	4.3357	0.04	8.0064	7.277669903	50	14.06	4.42	0.013
20	Jomunaguri No 2	Dug Well	9.0254	2.1616	0.13	22.0176	4.84368932	75	5.94	6.11	BDL
21	Sabkhata	Dug Well	18.0604	1.4458	0.17	50.04	24.24757282	225	6.08	5.93	0.2579
22	Subhaijhar	Dug Well	8.6033	1.88	0.11	38.0304	33.96213592	235	6	5.87	BDL
23	Betnapara	Dug Well	15.222	2.8973	0.17	62.0496	43.6592233	335	2.11	1.21	BDL
24	Kaliagaon	Dug Well	0.8507	1.456	0.1	60.048	31.52427184	280	27.05	5.8	0.215
25	Mukhnaguri	Dug Well	4.5438	3.5204	0.07	72.0576	37.58640777	335	5.55	5.63	0.3742
26	Dhangsiapara	Dug Well	4.5515	1.0951	0.04	68.0544	33.94757282	310	5.76	6.12	0.428
27	Dharanga No 1	Dug Well	6.8937	0.9604	0.05	62.0496	37.59126214	310	5.9	6.18	0.3719
28	Borgaon Shiv Mandir	Dug Well	7.1916	1.0698	0.06	58.0464	38.80679612	305	5.61	6.08	0.862
29	Barshijhar	Dug Well	3.1173	1.2046	0.06	54.0432	35.16796117	280	5.74	6.16	0.063
30	Monakosha	Dug Well	1.7604	4.5141	0.08	26.0208	43.67669903	245	5.67	5.8	0.028
31	Pub Kharmapara	Dug Well	9.5968	0.0998	0.04	60.048	27.88349515	265	5.44	6.16	BDL
32	Bongaigaon	Tube Well	4.801	BDL	0.03	12.0096	10.91650485	75	6.33	2.17	BDL

CHAPTER 4

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. In RIF method, rainfall infiltration factor has been taken as 0.22 for major aquifer like valley fill. In WLF method, specific yield has been taken as 0.16.

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

3) Water level data has been considered for 2018-21. Water level fluctuation based on data of March (Pre-monsoon) and November (post monsoon) has been considered since deepest water levels are recorded during the month of March. The average pre- and post-monsoon water level of Chirang district is 3.45 mbgl and 1.79 mbgl.

4) The population figures were collected from Census, 2011 and projected to 2022. The per capita domestic requirement for the rural population has been taken as 55 lpcd.

5) Population and groundwater dependency on ground water resource for domestic water supply in rural areas were extracted from Census 2011 is considered as 89%.

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

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

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 Ground Water Resources of Chirang District

Chirang has a total geographic area of 1923 sq.km. of which hilly area having slope more than 20% is 5 sq.km. Hence, area taken up for Aquifer Mapping was 1918 sq.km which is the total rechargeable area.

4.2 Recharge

The aquifers of the study area are recharged through a) infiltration of rainfall on the outcrop, b) seepage from the tanks and ponds and d) recharge from surface water irrigation and ground water irrigation. The area experiences south-west monsoon. Monsoon rainfall contributes approximately 80

percent of total rainfall (June to October) while share of post and pre-monsoon rainfall (January to May and November to December) are approximately 20 percent.

4.2.1 Recharge from Rainfall

Seasonal i.e., Monsoon and Non-Monsoon, ground water recharge is estimated both by rainfall infiltration and water table fluctuation or water balance method for Monsoon season and by rainfall infiltration method for non-monsoon season as per guidelines. The monsoon recharge computed by WLF method is normalized for the current year rainfall.

Table 4.1. Rainfall Recharge in Command and Non-Command Area in Chirang district

Sl. No.	**District**	**Rainfall Recharge (Ham)**			
		Command	**Non Command**	**Poor Quality**	**Total**
1	Chirang	8,040.78	85,181.41	0.00	93,222.19

4.2.2 Recharge from Other sources

Recharge from other sources means recharge through return flow from tanks and ponds, canals, water conservation structures, surface and ground water irrigation.

Table 4.2. Recharge from Other sources

District		**Non-Command (ham)**	**Command (ham)**	**Total(ham)**
Chirang	**Canal**	-	3503.18	3503.18
Chirang	**Tanks & Ponds**	183.24	-	183.24
Chirang	**Surface Water Irrigation**	83.65	3888	3971.65
Chirang	**Ground water irrigation**	285.70	-	285.70

The total ground water recharge from all sources, i.e., recharge from rainfall and recharge from other sources, is 101165.96 ham.

4.3 Ground Water Extraction

The ground water extraction of unconsolidated aquifer is created by a) domestic extraction (b) withdrawals for irrigation and (c) industry.

Total irrigation extraction created is 1523.76 ham, for industry 3.55 ham and extraction for domestic uses is 969.95 ham. Total groundwater extraction for all uses is only 2497.26 ham.

Table 4.3. Extraction of groundwater by different sectors

District	**Domestic**	**Industrial**	**Irrigation**	**Extraction from all source**
Chirang	969.95 ham	3.55 ham	1523.76 ham	2497.26 ham

4.4 Annual ground water recharge

Annual ground water recharge is the sum-total of monsoon and non-monsoon recharge. An allowance is kept for Environmental Flow (un-accounted natural discharge as per GEC'97) in the non-monsoon season by deducting 5% of total annual ground water recharge, where WLF method is employed to compute rainfall recharge during monsoon season and 10% of total annual ground water recharges where RIF method is employed before getting the annual extractable ground water resource.

Table 4.4. Annual Groundwater Recharge, Environmental Flows and Annual Extractable Groundwater resource

	Non-Command (ham)	**Command (ham)**	**Total (ham)**
Annual Ground water Recharge (ham)	85,439.89	15,431.96	1,00,871.85
Environmental Flows (ham)	8,573.40	1,543.20	10,116.60
Annual Extractable Ground water Resource (ham)	76,866.49	13,888.76	90,755.25

4.5 Allocation of resources up to 2025

2,541.77 ham of resource is allocated for domestic use in future. Net G.W. Availability for future Use is 88,213.48 ham.

4.6 Stage of Ground Water Extraction

The area has very little irrigation facilities. Similarly, industrial development in the area is also very less. Groundwater is mainly utilized for domestic purposes. The stage of groundwater extraction in the district stands at 2.75 %.

CHAPTER 5

GROUNDWATER RELATED ISSUES

The main groundwater issues identified in the area include

a) Low stage of groundwater extraction

As per ground water resource estimation of 2022, the stage of ground water development is only 2.75 % .

b) Water logging

The depth to water level is less (<2mbgl) in some parts of the district. These areas are vulnerable to water logging during the monsoon season (Fig. 5.1). This in turn can cause soil erosion and sand deposition.

c) Water Quality

Overall, ground water of the district is suitable and safe for drinking and other uses as per the result of the ground water samples analysed. Post monsoon ground water samples have indicated a few pockets where iron concentration is higher than the permissible limit of 1mg/l (Fig. 5.2).

d) Drilling problem

Towards the northern side, Shallow tube well is not feasible in the northern piedmont zone due to the presence of near surface boulder formation. Boulder formation makes it difficult to drill tube wells with conventional DTH and rotary drilling rigs.

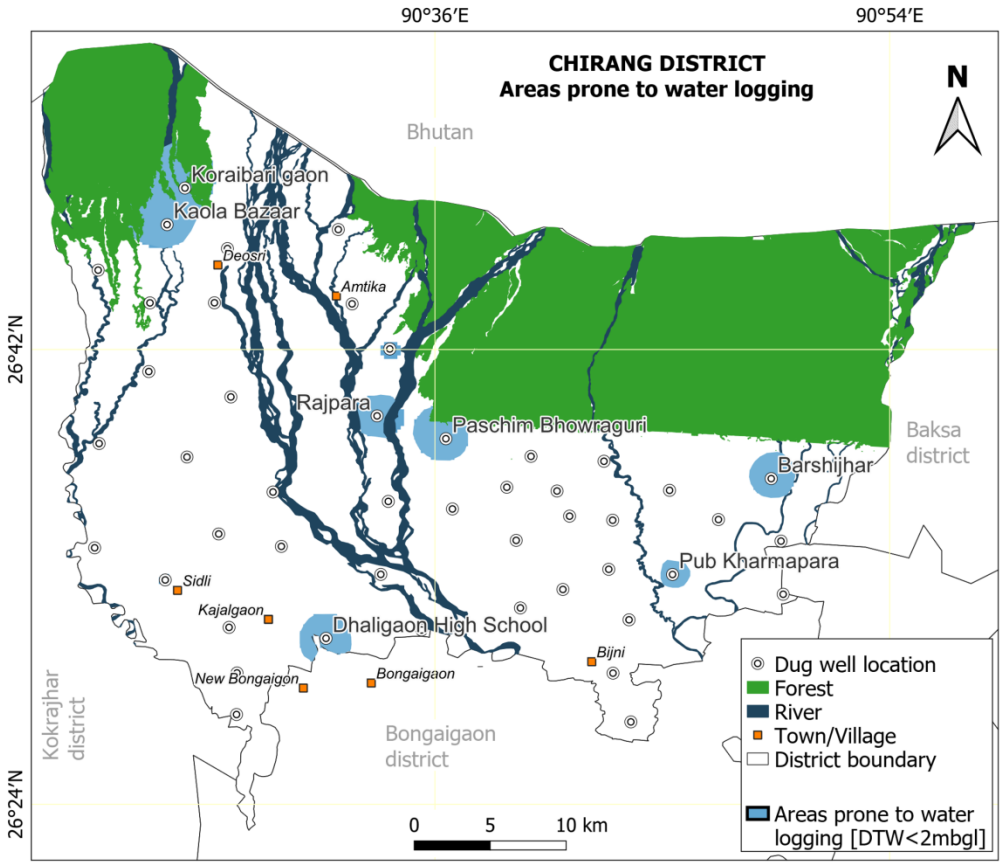

Fig 5.1. Pockets of the district prone to water logging

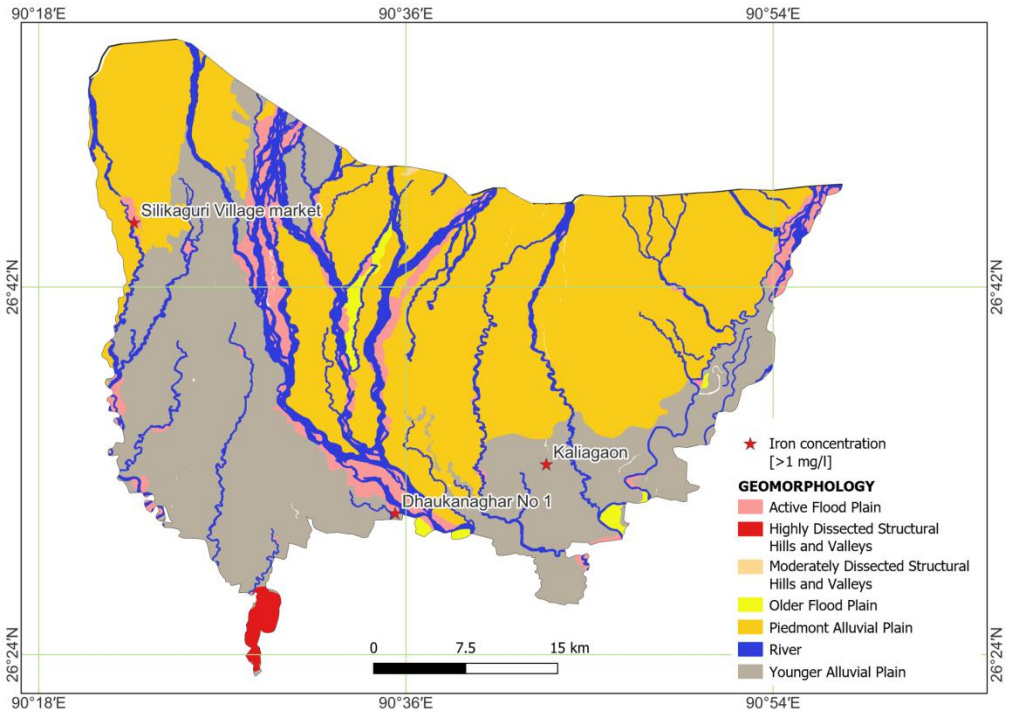

Fig 5.2. Pockets of the district having concentration of iron (post monsoon) greater than the permissible limit

CHAPTER 6

MANAGEMENT STRATEGY

In an agrarian economy like India, agriculture utilizes the major share of country's exploitable water resources. Though the sector utilizes maximum share of exploitable water resources, availability of the same to different extent at different locations makes it vital to adopt effective management strategy of water. Increasing water use efficiency is required within agriculture sectors as well as other sectors. Reallocation is also required in order to reduce waterlogging and salinization of irrigated land, to reduce negative environmental impacts and other externalities of irrigation (caused by over extraction of groundwater and depletion and pollution of surface water).

Sustainable Management Plan of Resource: As per dynamic ground water resource estimation of Chirang district for 2021-22, Annual Extractable Ground water Resource is 90,755.25 ham and stage of extraction is only 2.75 %. The district has a net balance ground water availability for future use of 88,213.48 ham. If an irrigation plan is made to develop 70% of the balance dynamic ground water resources available, then 61,749.1 ham of groundwater resources is available in the district for the future irrigation uses. It is observed that there is a huge gap between irrigation water available and irrigation demand. The gap can be minimized by suggesting suitable management plan.

6.1 Future demand for agriculture

Major crop of Chirang district includes different varieties of paddy. Winter paddy and summer paddy are the main types of paddy that are grown in the district. Winter paddy (Sali) is the most important crop in the district occupying 50% followed by summer paddy (Boro) occupying 25% of the total annual paddy area. Among cash crops, jute is grown in the district. Other cereal crops such as maize, wheat, small millets cover negligible area as compared to rice. Cereals, Coarse cereals, pulses, oil seeds, vegetables, potato and lemon are also grown in the district.

Future demand of water for agriculture is estimated in the present analysis by projecting the cropping intensity to 200%. As per data provided by Department of Agriculture, Govt. of Assam, the Gross cropped area of Chirang is 93361 ha and the net cropped area is 51400 ha. During winter season an area of 23073 ha is used for Winter Paddy production. Gap between area cultivated during kharif season and rabi season is 23073 ha. The intention of this plan is to utilize this fallow land of about 23073 ha and bring it under assured irrigation during Rabi season which will help in increasing gross cropped area by 46146 ha and increase the cropping intensity to 200%. The present season wise cropping pattern of Chirang district is shown in Table 6.1.

Table 6.1. Season wise cropping pattern of Chirang district

SN	Main Crop	Sowing season					
		Kharif		Summer		Rabi	
		Rainfed	Irrigated	Rainfed	Irrigated	Rainfed	Irrigated
1	Paddy	June to July	June to July		November to December	-	December to January
2	Rape seed Mustard				-		October to November
3	Pulse						October to November

To use groundwater for irrigation purpose, a cropping plan has been designed for the district by using CROPWAT software of FAO. CROPWAT 8.0 for Windows is a computer program for the

calculation of crop water demand/requirements and irrigation demand/requirements based on soil, climate and crop data. In addition, the program allows the development of irrigation schedules for different management conditions and the calculation of scheme water supply for varying crop patterns. FAO defined water requirements of various crops as the depth (or amount) of water needed to meet the water loss through evapotranspiration. The crop water need can be calculated using the following formula.

$$ETcrop = ETo * Kc$$

Where: ETcrop = Crop water need (mm/unit time)
ETo = Reference crop evapotranspiration (mm/unit time) [Influence of climate]
Kc = Crop factor [Influence of crop type and growth stage]

The results are tabulated in Table 6.3 and Table 6.4.

6.2 Cropping Plan

Present cropping pattern, proposed cropping pattern, intended increase in cropping intensity are shown in tabular form (Table 6.2).

Table 6.2. Cropping pattern, proposed cropping pattern, intended cropping intensity

Cropping pattern (s)				
Early Summer Rice-Late Winter Rice	Present Cultivated area	Area to be cultivated	Area to be cultivated (**ha**)	Irrigation requirement (**ham**)
Summer vegetables- Late Winter Rice	(**ha**)	(**%**)		
Pulses-Late Winter Rice-Potato/Vegetables/Wheat				
Net cultivated area	**23073**			
	1	2 (= % of 1)	3	4
Winter Rice (main crop)	23073	50	23073	3649.71
Summer Rice	0	25	11536.5	3804.38
Potato		3.75	1730.48	346.46
Pulses		3.75	1730.48	229.70
Mustard		6.25	2884.13	812.78
Winter vegetables		2.5	1153.65	149.75
Summer vegetables		2.5	1153.65	177.84
Wheat		1.25	576.825	92.69
Maize		5	2307.3	428.37
Gross cultivated area (Paddy/+Maize/+Wheat+Pulses+Vegetables)			**46146**	6041.98
Total irrigation requirement (70% irrigation efficiency)				**8631**
Cropping intensity			**200% (Intended)**	

Table 6.3. Crop-wise and month-wise precipitation deficit (IWR) from CROPWAT 8.0

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Precipitation deficit												
1. Rice	0	0	0	0	147	51.2	0	0	0	6.1	0	0
2. Rice	0	0	0	0	49	98	0	0	0	5.9	0	0
3. Rice	0	0	0	0	48.4	92	0	0	0	0	0	0
4. Rice	0	0	0	0	0.5	144.3	0	0	0	0	0	0
5. Rice	0	0	0	0	0	147.1	0	0	0	0	2.6	0
6. Rice	0	0	0	0	0	49.1	98	0	0	0	24.1	0
7. Rice	17.7	70.8	42.1	0	0	0	0	0	0	48.8	227.3	69.9
8. Rice	17.9	72.8	90.7	0	0	0	0	0	0	0.4	255.7	70.4
9. Rice	18.1	72.8	104.5	14.1	0	0	0	0	0	0	79.4	222.2
1. Potato	17.9	39.3	0	0	0	0	0	0	0	0	46.1	69.7
2. Potato	19.1	72.5	48.8	0	0	0	0	0	0	0	26	47.4
3. Pulses	10.7	3.4	0	0	0	0	0	0	0	1.3	40.6	69.8
4. Pulses	18.6	18.9	0	0	0	0	0	0	0	2.4	30.4	63.4
5. Pulses	19.4	47.7	0	0	0	0	0	0	0	0	20.8	50.8
6. Mustard	10.3	60	88.9	46.2	0	1.5	0	0	0	2.4	36.6	57.5
7. Mustard	10.3	60	88.9	46.2	0	0	0	0	0	0	29.5	55.1
8. Mustard	10.3	60	88.9	46.2	0	0	3.1	0	0	0	10.5	43.8
9. Small Vegetables	8.3	0	0	0	0	0	0	0	0	2.3	62.6	64.8
10. Small Vegetables	5.6	0	0	0	0	0	0	0	0	0	52.9	63.1
11. Small Vegetables	9.4	67.8	41.8	0	0	0	0	0	0	0	0	31.1
12. Small Vegetables	7.3	67.8	59.3	0	0	0	0	0	0	0	0	23.8
13. Spring Wheat	17.2	69	26.2	0	0	0	0	0	0	0	15.6	32.7
14. MAIZE (Grain)	14.4	77.5	55.4	0	0	0	0	0	0	0	4.3	26.4
15. MAIZE (Grain)	11.1	77.6	85.8	0	0	0	0	0	0	0	0	18.8

Table 6.4. Actual monthly water requirement for different crops in Chirang district, Assam

Actual monthly water requirement for different crops in Chirang of district, Assam														
Crop	Net sown area	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Cropwise Total IWR (Ham)
Winter Rice	3460.95	0.0	0.0	0.0	0.0	508.8	177.2	0.0	0.0	0.0	21.1	0.0	0.0	707.1
Winter Rice	3460.95	0.0	0.0	0.0	0.0	169.6	339.2	0.0	0.0	0.0	20.4	0.0	0.0	529.2
Winter Rice	5191.425	0.0	0.0	0.0	0.0	251.3	477.6	0.0	0.0	0.0	0.0	0.0	0.0	728.9
Winter Rice	5191.425	0.0	0.0	0.0	0.0	2.6	749.1	0.0	0.0	0.0	0.0	0.0	0.0	751.7
Winter Rice	3460.95	0.0	0.0	0.0	0.0	0.0	509.1	0.0	0.0	0.0	0.0	9.0	0.0	518.1
Winter Rice	2422.665	0.0	0.0	0.0	0.0	0.0	119.0	237.4	0.0	0.0	0.0	58.4	0.0	414.8
Summer Paddy	5191.425	91.9	367.6	218.6	0.0	0.0	0.0	0.0	0.0	0.0	253.3	1180.0	362.9	1796.2
Summer Paddy	5191.425	92.9	377.9	470.9	0.0	0.0	0.0	0.0	0.0	0.0	2.1	1327.4	365.5	1695.0
Summer Paddy	1038.285	18.8	75.6	108.5	14.6	0.0	0.0	0.0	0.0	0.0	0.0	82.4	230.7	313.1
Potato	576.825	10.3	22.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	26.6	40.2	99.8

Actual monthly water requirement for different crops in Chirang of district, Assam														
Crop	Net sown area	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Cropwise Total IWR (Ham)
Potato	1153.65	22.0	83.6	56.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.0	54.7	246.7
Pulses	576.825	6.2	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	23.4	40.3	72.6
Pulses	576.825	10.7	10.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	17.5	36.6	77.1
Pulses	576.825	11.2	27.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.0	29.3	80.0
Mustard	576.825	5.9	34.6	51.3	26.7	0.0	0.9	0.0	0.0	0.0	1.4	21.1	33.2	175.0
Mustard	1153.65	11.9	69.2	102.6	53.3	0.0	0.0	0.0	0.0	0.0	0.0	34.0	63.6	334.6
Mustard	1153.65	11.9	69.2	102.6	53.3	0.0	0.0	3.6	0.0	0.0	0.0	12.1	50.5	303.2
Small Vegetables	576.825	4.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	36.1	37.4	79.6
Small Vegetables	576.825	3.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.5	36.4	70.1
Small Vegetables	576.825	5.4	39.1	24.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.9	86.6
Small Vegetables	576.825	4.2	39.1	34.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.7	91.3
Spring Wheat	576.825	9.9	39.8	15.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.0	18.9	92.7
MAIZE (Grain)	1153.65	16.6	89.4	63.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	30.5	205.4
MAIZE (Grain)	1153.65	12.8	89.5	99.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.7	223.0
TOTAL	**46146**													**6041.98**

Based on available groundwater resource and subsurface condition, the approximate numbers of tube wells that can be constructed in the area is worked out.

Groundwater draft is calculated assuming a well discharge of 36 m^3/hr. If a well is allowed to run 8 hrs a day for 120 days of a year then a tube well having discharge of 36 m^3/hr will create a draft of 3.45 ham. To meet irrigation demand of 8631ham area, 2502 numbers of shallow TW will be required to cover the area. Currently, Chirang District has a total extraction of 2497.26 ham resulting in a Stage of ground water development of 2.75%. In extracting additional requirement of 8631 ham, stage of development in Chirang District will increase from 2.75% to 12.26%.

6.3 Water Quality Management

Except for iron, overall quality of ground water in Chirang district is potable for drinking and other domestic and irrigation use.

Iron:

Presence of iron in ground water is mainly geo-genic and originates from the underlying rock formation. As water infiltrates into the aquifer, it dissolves some iron and accumulates in aquifer.
Since iron occurs naturally in nature, it cannot be removed in situ. There are several methods by which iron can be removed. Iron filters/iron removal plants can be installed in order to remove iron from ground water.

1. **Iron removal by ion exchange**: Resins such as polystyrene-type gel resin in water softeners can remove iron from water by the process of ion exchange if the water is not exposed to oxygen.
2. **Iron removal by filtration**: Iron can be easily removed from water by the process of gravity and pressure filtration after oxidation with air (aeration), chlorine or potassium permanganate.

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