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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

HAILAKANDI DISTRICT, ASSAM

उत्तर पूर्वी क्षेत्र, गुवाहाटी

North Eastern Region, Guwahati

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Technical series D

No…01../2019-20

Govt. of India
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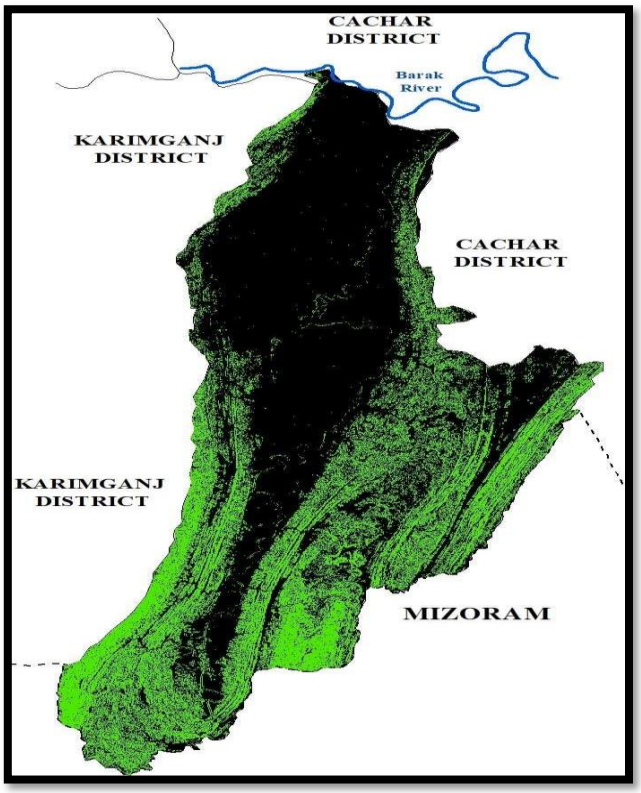
Ministry of Water Resources, River Development & Ganga Rejuvenation

AQUIFER MAPPING IN HAILAKANDI DISTRICT

ASSAM
(AAP 2019-20)



North Eastern Region
Guwahati

June 2021

CONTENT

Chapter 1 - Introduction

1.1 Objectives

The objective of the study is to prepare aquifer map of the area in 1:50,000 scale, identify the aquifer system of the study area and prepare a groundwater management plan.

1.2 Scope of the study

Hailakandi district has vast groundwater and surface water resources. However, the Agro based economy of the area has very less irrigation facility and the stage of ground water extraction is very low. Proper hydrogeological knowledge of the area can be helpful to prepare a sustainable management plan for groundwater utilization.

1.3 Approach and methodology

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

The methodology can be illustrated as follows -

1. Data compilation and data gap analysis- The preliminary works consisted of collection and review of all existing hydrogeological and exploration data of CGWB, PHED, Agriculture department, Irrigation department, Water resource department. All data were plotted in base map on GIS Platform. On the basis of available data, Data Gaps were identified.

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

3. Aquifer Map Preparation - On the basis of integration of data generated from various studies of hydrogeology & geophysics, 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 aquifer extremities, quality, water level, potential and vulnerability (quality & quantity).

4. Aquifer Management Plan Formulation - Based on aquifer map and conceptual model a sustainable development plan of the aquifer is formulated.

1.4 Area Details

The study area for aquifer mapping falls under Survey of India Toposheet No. 83D/8, 83D/9, 83D/10, 83D/11, 83D/12, 83D/14, 83D/15 bounded by 24.886˚ N and 24.130˚ N Latitudes and 92.420˚E and 92.781˚ E Longitudes covering an area of 1327 sq. km of

Hailakandi district of Assam. The demographic details have been furnished in Table 1.1 and the Base Map is attached as Figure 1.1.

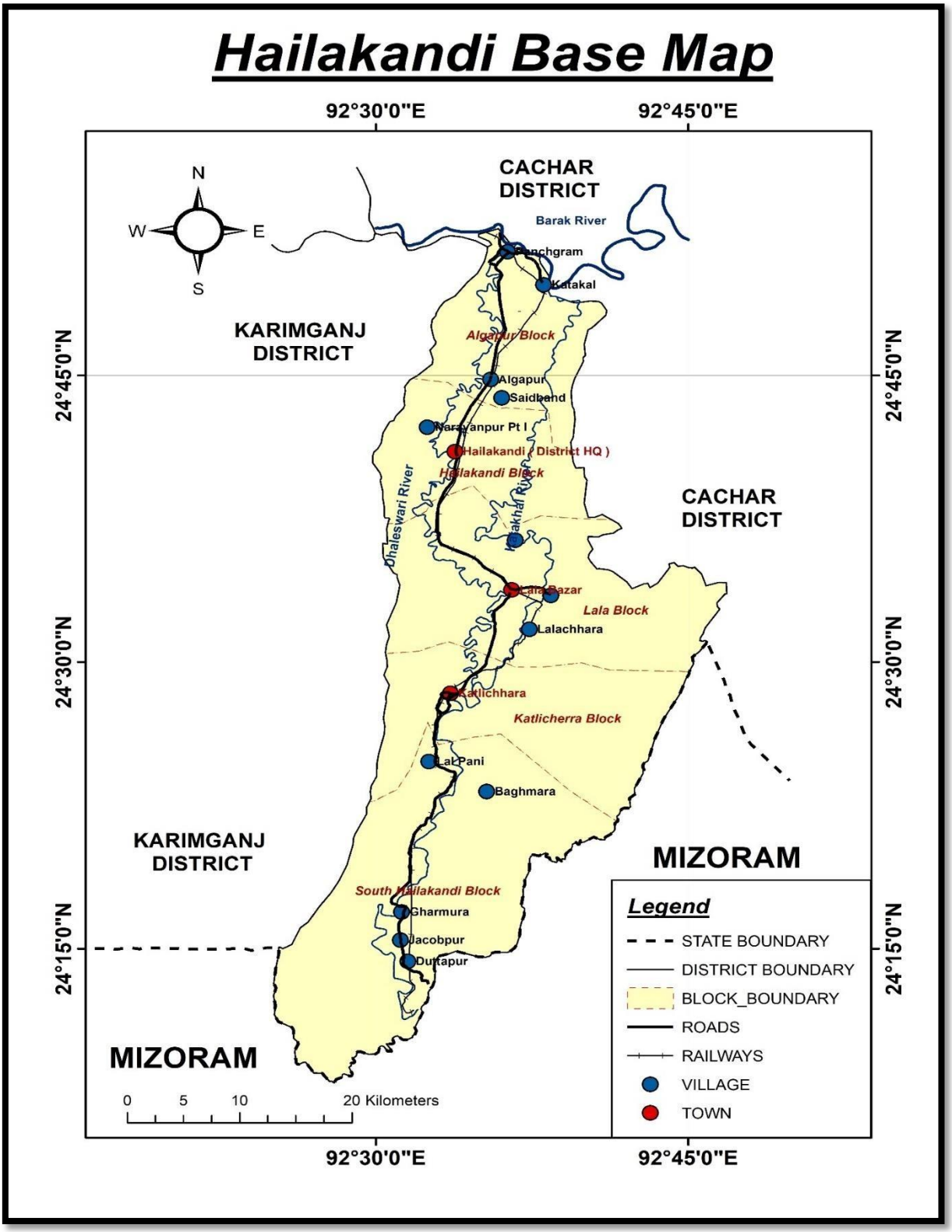


Figure 1.1 – Base Map of Hailakandi District, Assam

Table 1.1 – Block wise demographic details, Hailakandi district, Assam.

STATE	DISTRICT	BLOCK	AREA (sq.Km)	G.P	VILLAGES	HOUSEHOLD	POPULATION
ASSAM	HAILAKANDI	ALGAPUR	160.10	13	69	26783	121379
		HAILAKANDI	160.42	14	67	29922	133260
		LALA	244.69	18	81	42144	191172
		KATLICHERRA	73.52	8	90	15327	73266
		SOUTH HAILAKANDI	165.99	9	24	19648	94811

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

The preliminary works consisted of collection and review of all existing hydrogeological and exploration data of CGWB, State Groundwater Departments. All data were plotted in base map on Arc GIS Platform. The available data, data gap and data generation work are tabulated in Table: 1.2 and shown in Figure 1.2 and 1.3.

Table 1.2 – Exploration and monitoring database, Hailakandi district, Assam.

Sr No.	Theme	Type	Data available	Data gap	Data generation	Total	Remark
1	Borehole Lithology Data		5	0	5	10	
2	Geophysical Data		Nil	Nil	Nil	Nil	
3	Groundwater Level Data	Dug Well	8	7	33	41	
		Piezometer	1	0	2	3	
4	Groundwater Quality Data	Dug Well	8	7	33	41	
		Piezometer	1	0	2	3	
5	Specific Yield		Nil	Nil	Nil	Nil	
6	Soil Infiltration Test		Nil	7	3	3	

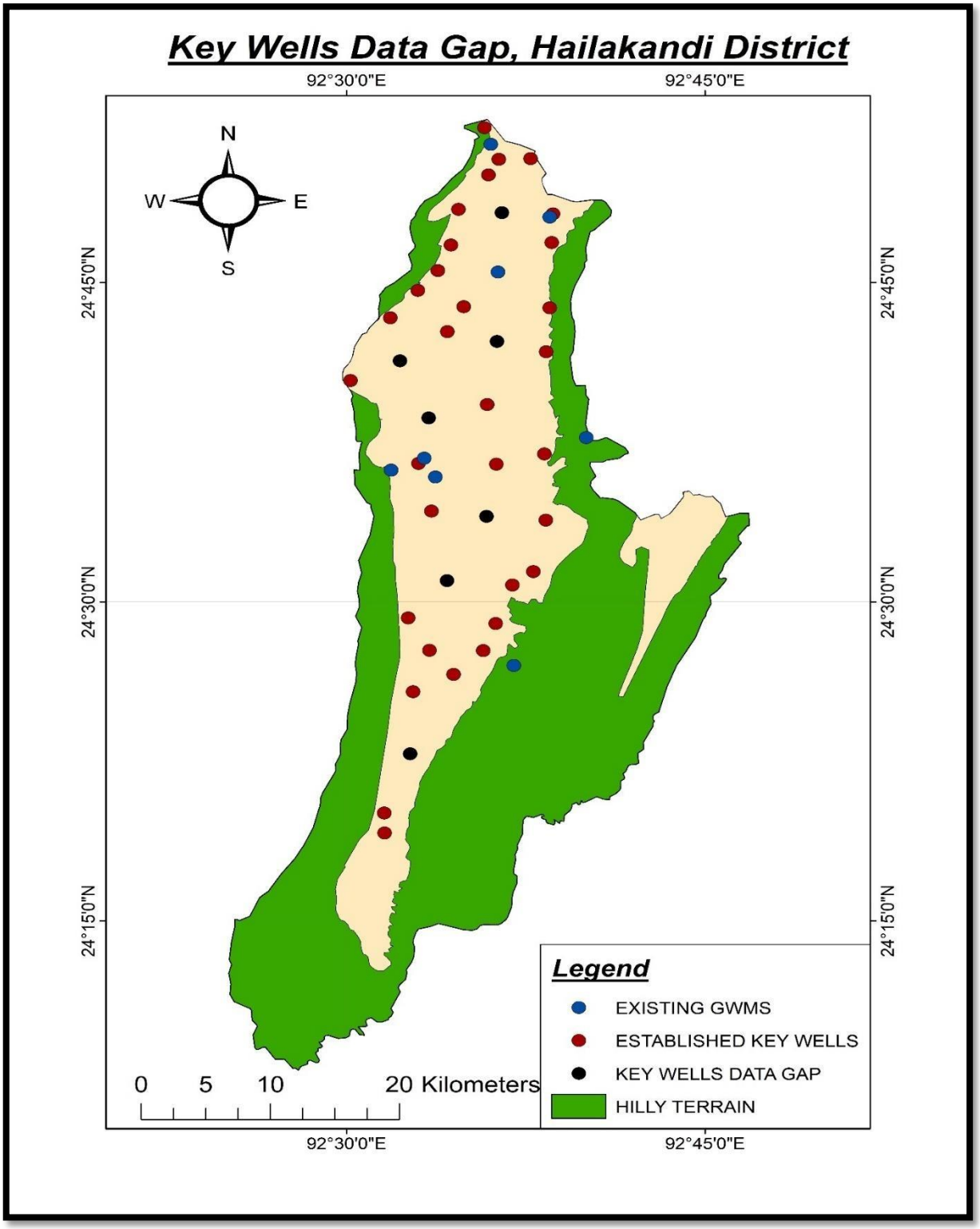


Figure 1.2 – Key Wells Data Gap, Hailakandi District, Assam

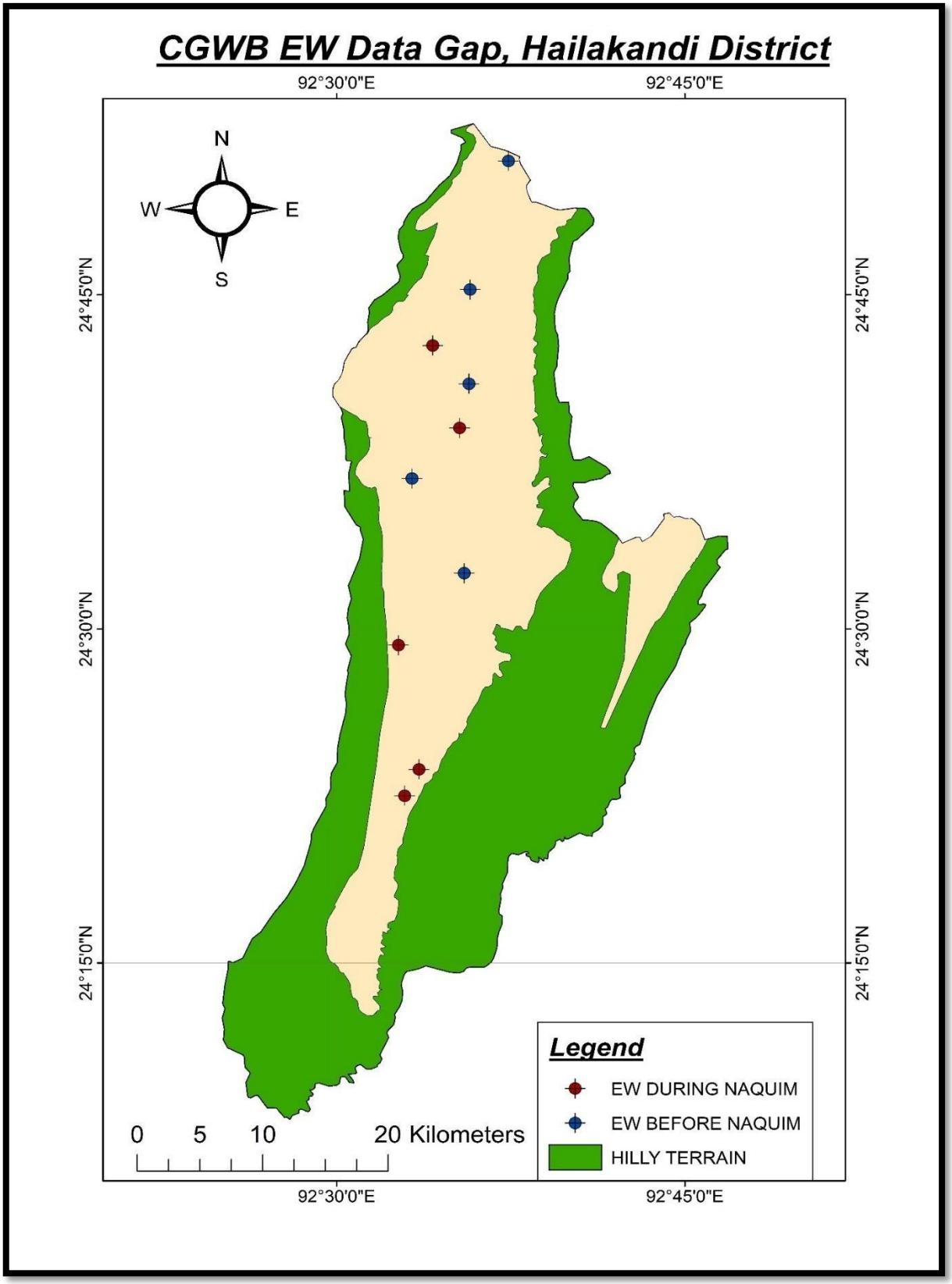


Figure 1.3 – CGWB EW Data Gap, Hailakandi District, Assam

1.6 Hydrometeorology

The area enjoys a sub-tropical warm climate with short dry season (Am type of climate). This climate is characterized by a hot humid summer and a dry cool winter with heavy rainfall during May to September. Rainfall is received from the South -West Monsoon, which normally breaks in the month of May. The hydrometeorogical details have been furnished in Table 1.3 and the graphical illustration of the rainfall data is shown in Figure 1.4 respectively.
(Source- IMD and Shirishpur Tea Estate, Hailakandi district, Assam)

Table 1.3 – Hydrometeorogical data, Hailakandi district, Assam.

Parameter	Details
Average Monsoon rainfall	1677.52 mm
Average Non-Monsoon rainfall	1161.10 mm
Average annual rainfall	2838.62 mm
Maximum rainfall	May (490.41 mm)
Minimum rainfall	January (4.91 mm)
Average annual temperature	24.9° C
Maximum temperature	September (31.8°C)
Minimum temperature	January (11.7 °C)

Figure 1.4 - Graphical illustration of Average monthly rainfall and yearly rainfall variations

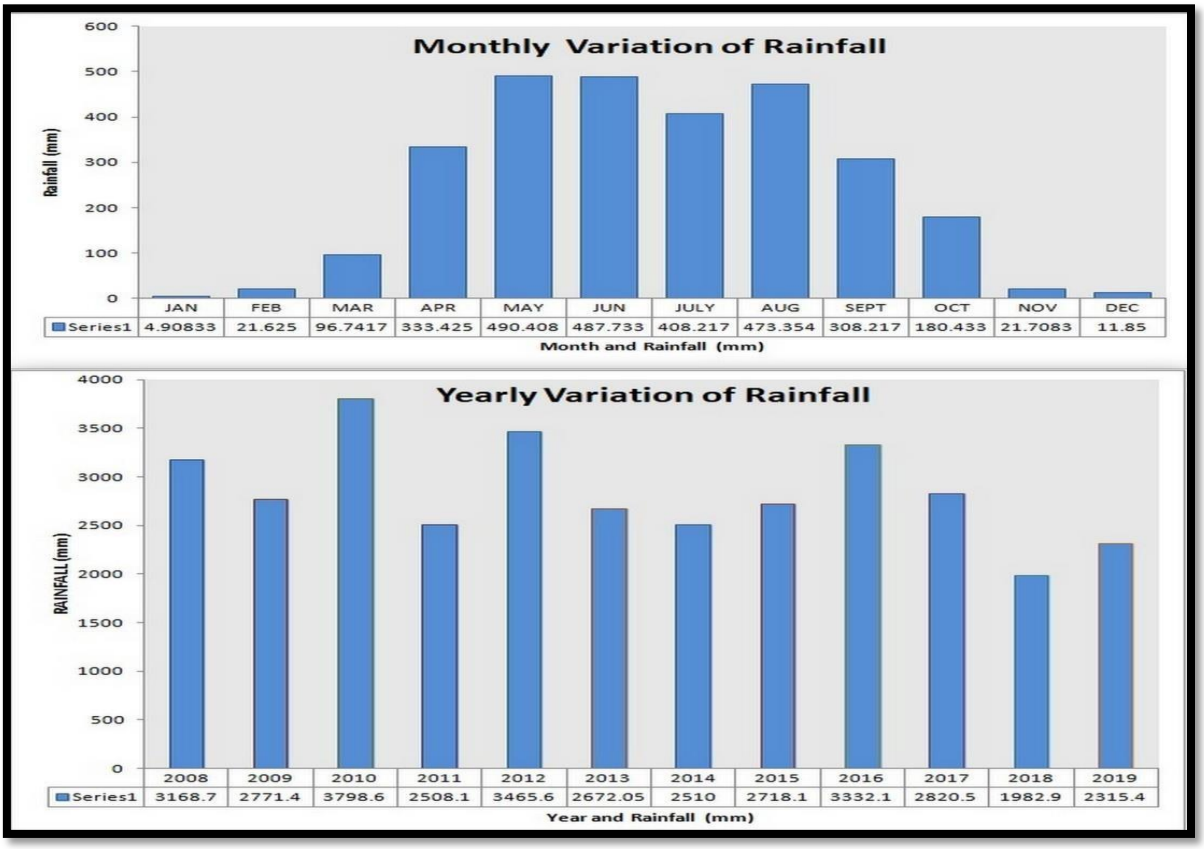


Table 1.4 – Annual variation of Temperature, Hailakandi district, Assam.

ANNUAL VARIATION IN TEMPERATURE OF HAILAKANDI DISTRICT												
MONTH	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JULY**	**AUG**	**SEPT**	**OCT**	**NOV**	**DEC**
MIN TEMP °C	11.7	13.4	17.4	20.8	22.8	24.4	24.9	25	24.4	22.2	17.3	12.9
MAX TEMP °C	25.5	27.2	30.4	31.4	31.6	31.4	31.7	31.8	31.8	31.4	29.1	26.5
AVG TEMP °C	18.6	20.3	23.9	26.1	27.2	27.9	28.3	28.4	28.1	26.8	23.2	19.7

1.7 Geomorphology

The area can be divided into three parts:

a. Highly dissected hill range - The general trend of the anticlinal hill range is NE-SW and occasionally varies to N-S. The height of the hill ranges decreases from south to north. The highest elevation is 636m above MSL at Chhatachura in the south western part, along the border with Karimganj district. The lowest part of the hills in north is known as the Badarpur hills.

b. Pediment- pediplain complex – A broad, gently sloping expanse of rock debris extending outwards from the foot of a dissected hill slope is found. This zone is found significantly in the western and eastern sides between the dissected hills and alluvial plains.

c. Alluvial Plain - The alluvial plain is found over the synclinal flat bottom valleys. This broad synclinal valley occurs in the study area is the Hailakandi valley. The average elevation of the Hailakandi valley is 25m above MSL. The valley becomes narrow and constricted towards the south and widens towards the north. The master slope of the valley is towards north. Some isolated hillocks are present in the plains of the study area. In the alluvial plains, the flood plains of river Dhaleswari, Katakhal and Barak is present. The Geomorphological Map of the district is shown in Figure 1.5.
Owing to this physiographical setting, out of 1327 km² of the district, 459 km² of the area has slope more than 20%. The slope map of the district is shown in Figure 1.6.

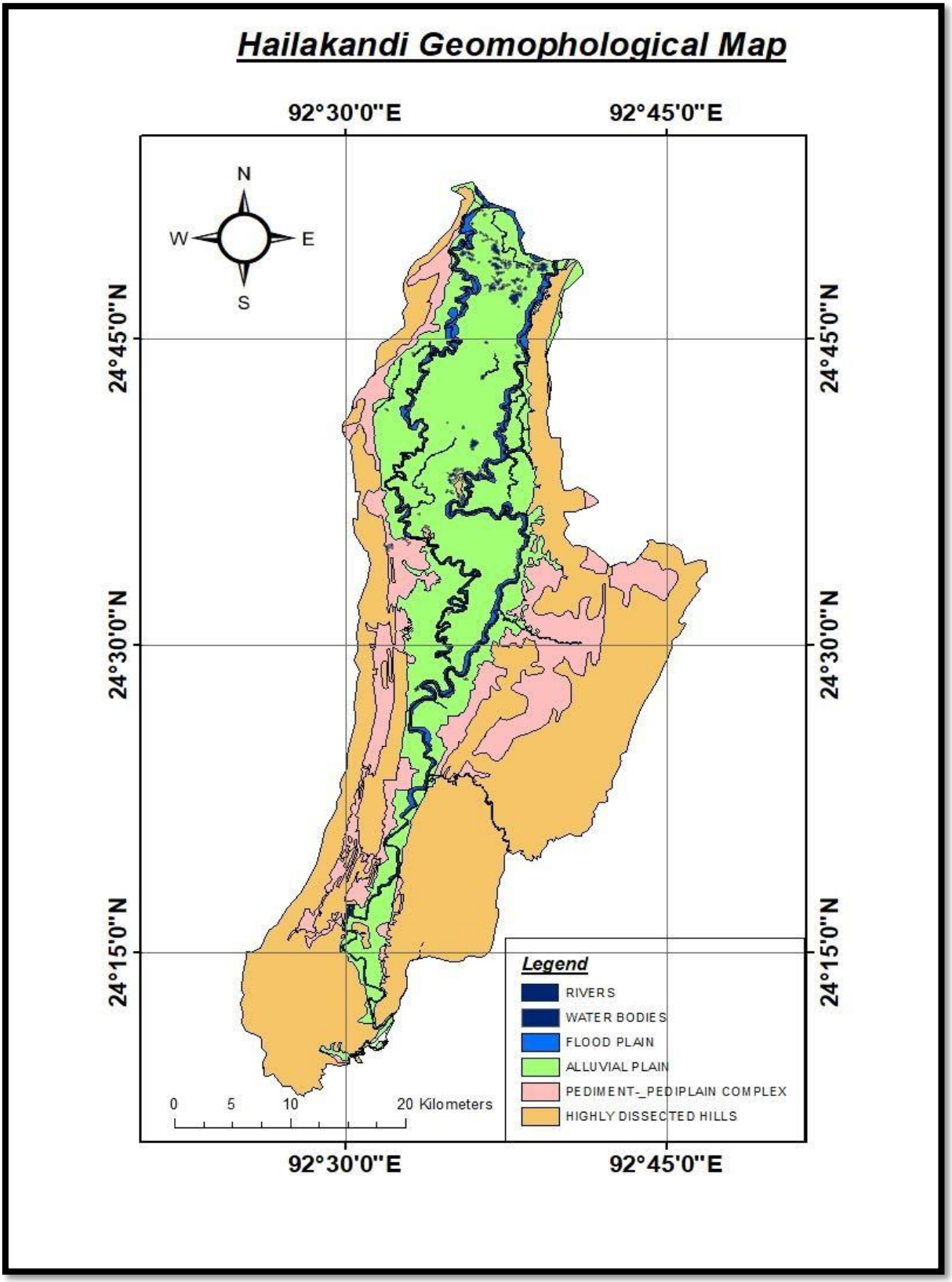


Figure 1.5 – Geomorphological Map, Hailakandi District, Assam

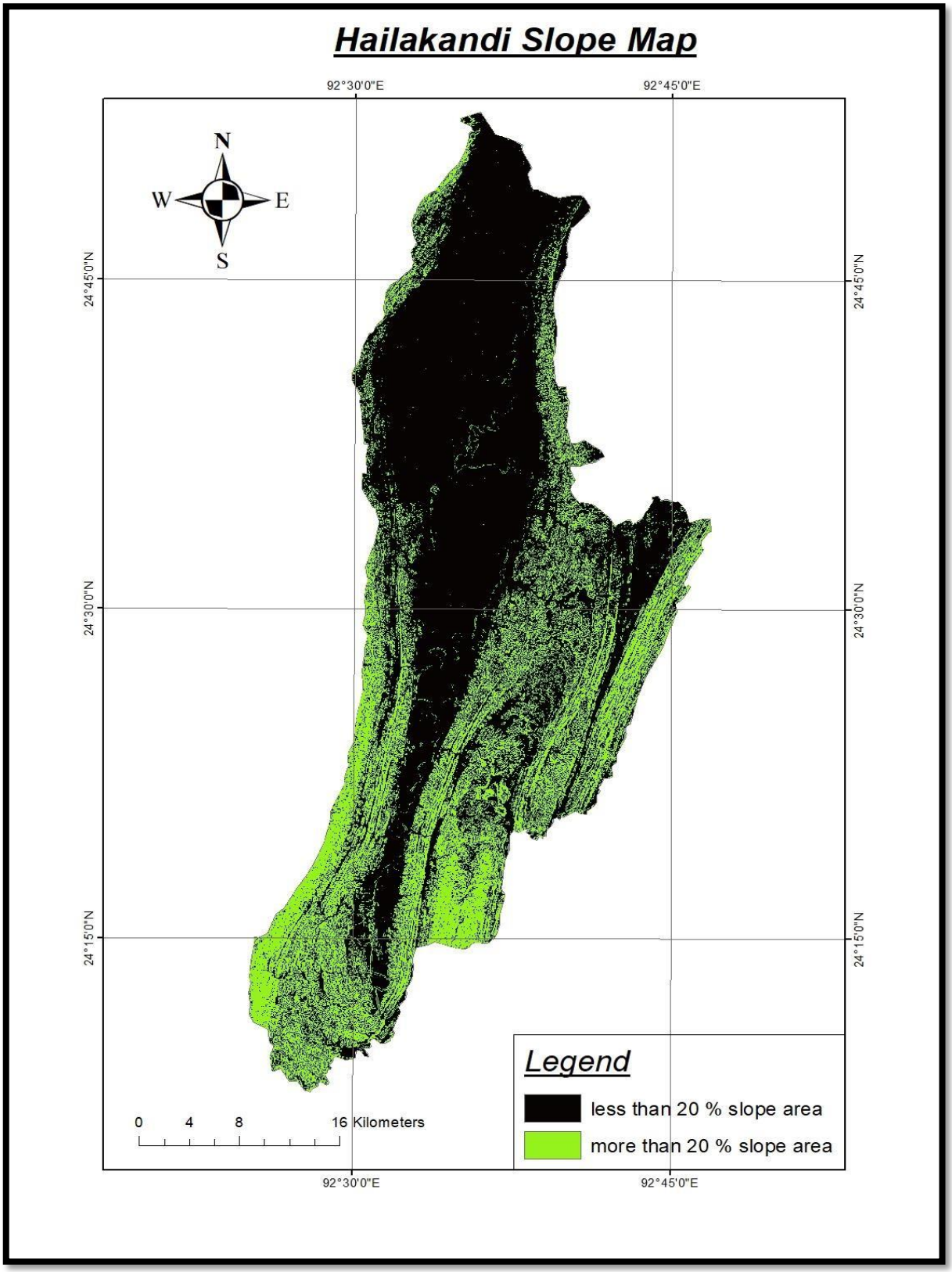


Figure 1.6 – Slope Map, Hailakandi District, Assam

1.8 Geology

The study area is situated in the Barak Valley of Assam. It is occupied by the folded sedimentary formations of Surma, Tipam, Dupitila, Alluvium groups ranging in age from Lower Miocene (Tertiary) to Holocene (Quarternary). The regional strike of the folded geosynclinal facies sequences is NNE-SSW. The geological succession of the area is shown in Table 1.5.

Table 1.5 – Geological Succession, Hailakandi district, Assam.

AGE	AGE	GROUP	FORMATION	LITHOLOGY
Quarternary	Holocene to Pleistocene	Recent	Alluvium	Alluvium, represented by unconsolidated pale to dirty grey silt, sand, clay , silty clay ,sandy clay, yellowish brown coarse river sand, gravel and concretions.
	UNCONFORMITY			
Upper Tertiary	Miocene to Pliocene	Dupitila	Dupitila	Sandstone, mottled clay, grit, conglomerate, poorly consolidated sand with layers and packets of pebbles, clayey sandstone with ferruginous material and laterites.
	UNCONFORMITY			
	Miocene	Tipam Group	Tipam	Fairly bedded fine to medium grained sub arkosic sandstone with sandy shale and siltstone
	UNCONFORMITY			
	Miocene	Surma Group	Bokabil	Shale, sandy shale, siltstone, mudstone and lenticular coarse ferruginous sandstone.
			Bhuban	Alternation of sandstone, sandy shale, thin conglomerate shaly in the middle part

The Geology map of the district is shown in Figure 1.7.

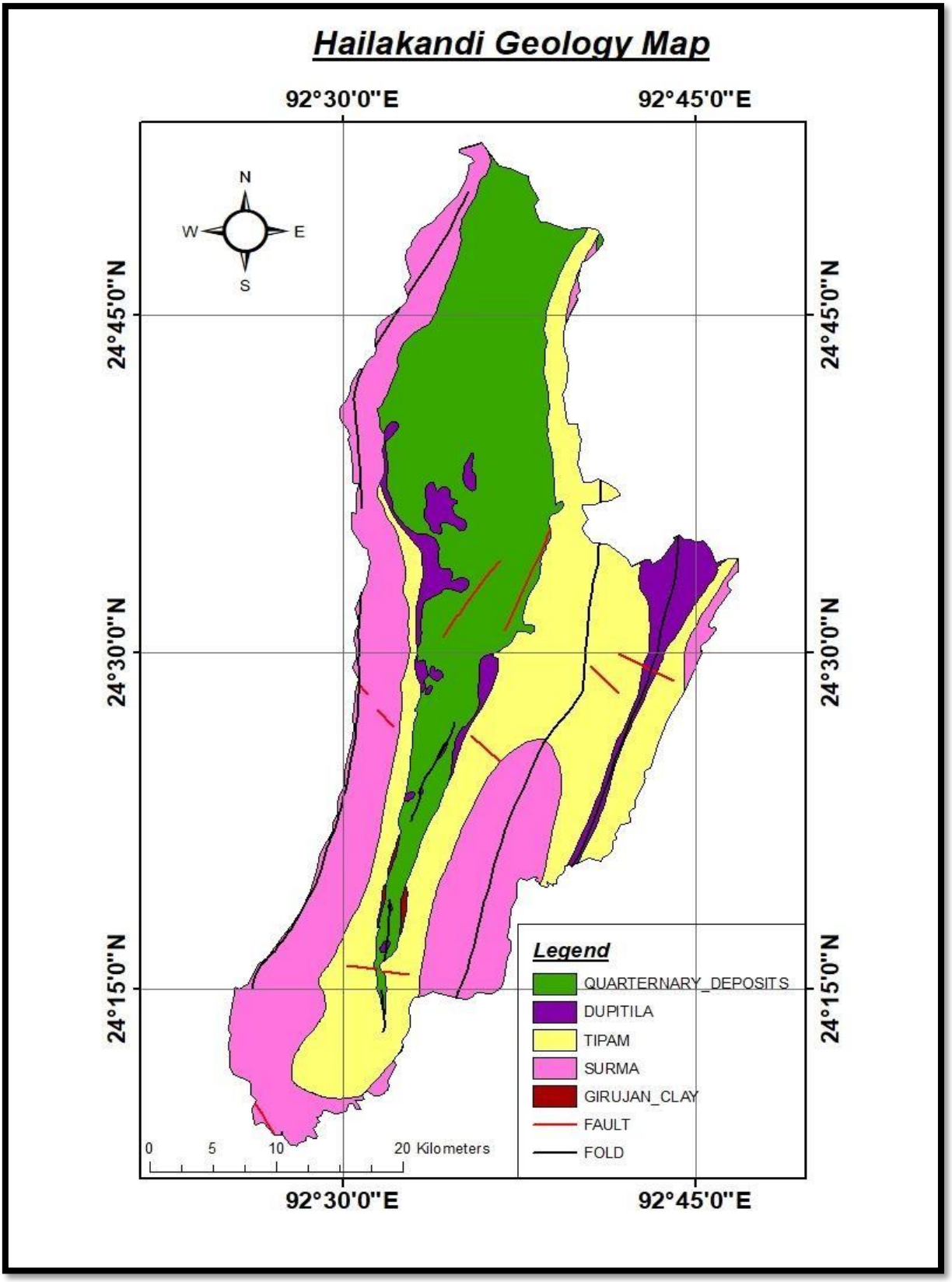


Figure 1.7 – Geological Map, Hailakandi District, Assam

1.9 River and Drainage

The anticlinal hill ranges forms the watershed from which various drainage channel emerged. The common drainage pattern is sub parallel to parallel and dendritic. Up to 4th order stream are found in the study area. In general, drainage pattern of the area is in conformity with the topography, which area structurally controlled.

The major river in the study area is Barak River and its tributaries are Dhaleswari, Katakhal. All of them are perennial rivers. The Barak River and its tributaries control the entire drainage system in the area. The river Barak originating from the southern slopes of north Manipur hill ranges and enter the study area through its north eastern corner near Badarpur Ghat and after travelling a length of 11km up to a place called Haritikar near Bhanga is bifurcated into the Kushiara and the Surma. From the point of bifurcation, the Kushiara flows westwards to Bangladesh forming the northern boundary of Karimganj district. Dhaleswari River originates from the Mizo hills where it is known as Twang. Originally it used to flow along the western side of Hailakandi district and merges with river Barak in Panchgram. There is river Katakhal which flows along the east of the valley and merges with Barak River near Katakhal railway junction. The drainage map of the district is shown in Figure 1.8.

1.10 Soil

Both residual and transported soils are found in the study area. Older alluvial soil is developed almost entirely in the area and its brown in color. This is practically unaltered alluvium representing a broad spectrum of sand, silt and humus rich bog clay depending on landform component. The alluvial soil which is light grey to brown in color is at places sandy and has localized occurrence. In the southeastern corner of Hailakandi district forest and hilly lateritic soil is present. The soils are mainly clay to clay-loam except Riverine tracts and hilly tracts. The lateritic soil is found in tillas (hilly area), younger soils are found along all major river courses and clayey soils are found in paddy fields.
The soil map of the district is shown in Figure 1.9.

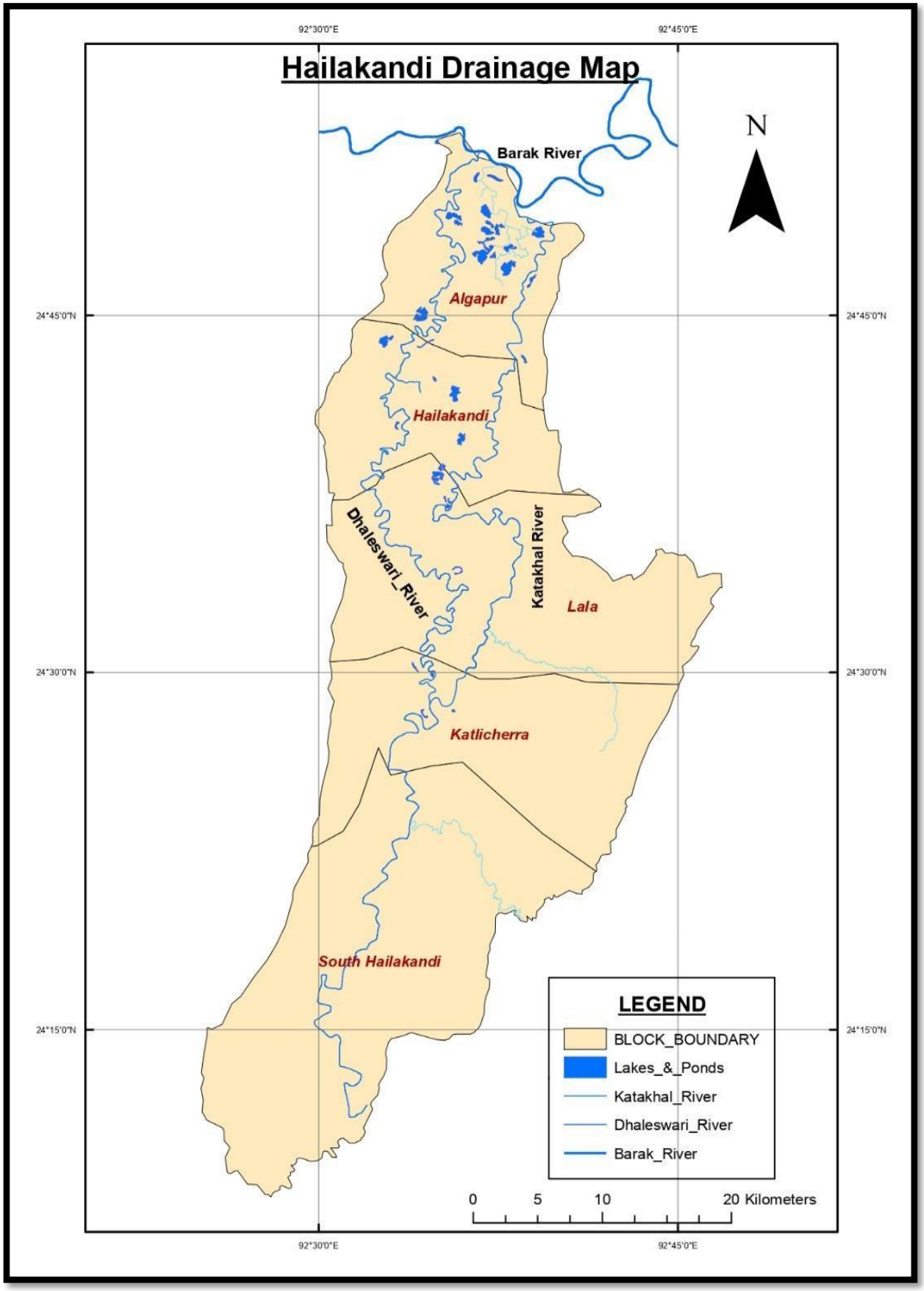


Figure 1.8 – Drainage Map, Hailakandi District, Assam

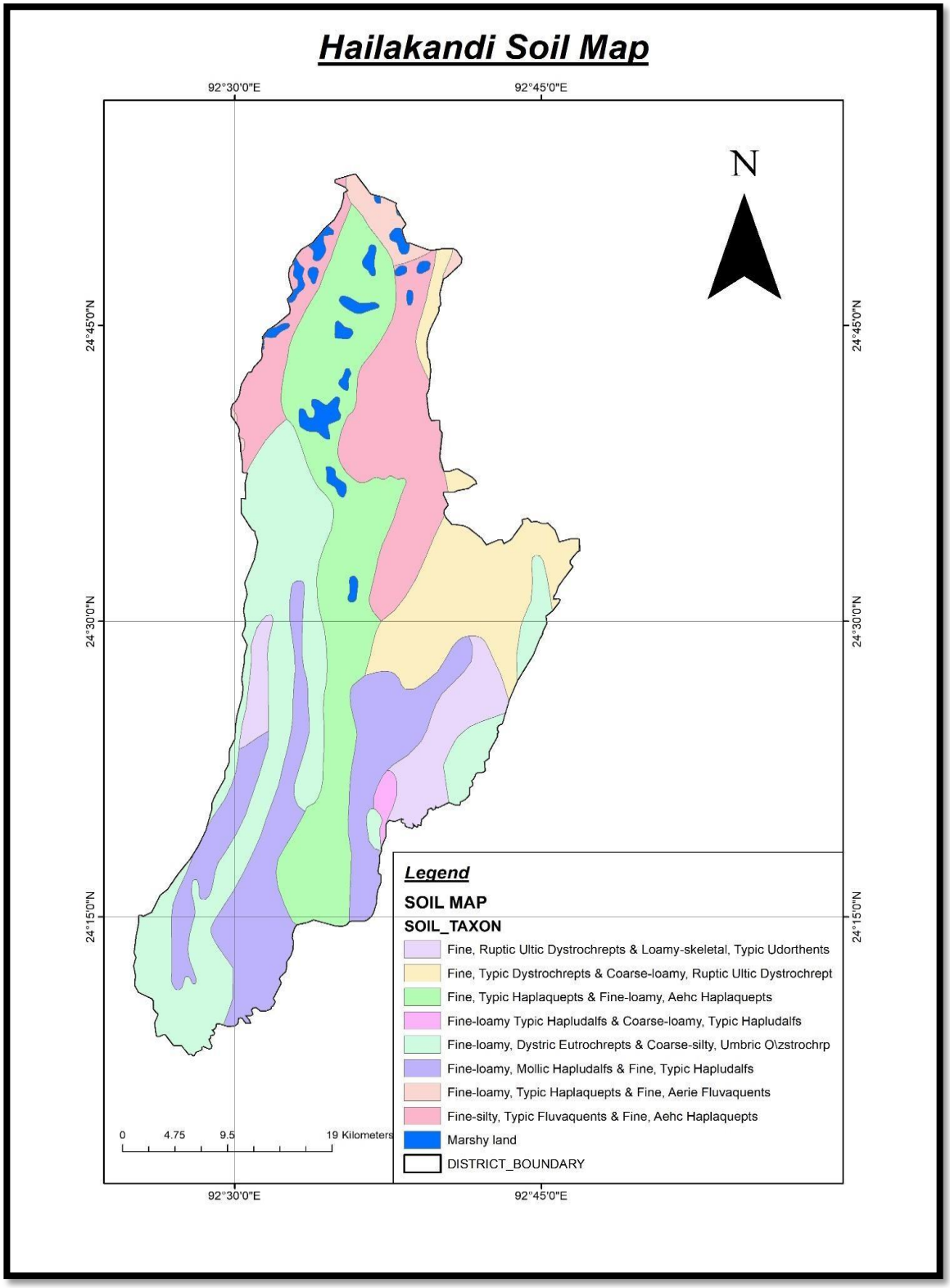


Figure 1.9 – Soil Map, Hailakandi District, Assam

1.11 Agriculture

Hailakandi district with geographical area of 1327 sq. Km occupies 19.26% area of the Barak Valley Agro Climatic zone of Assam. Majority of the population depend on cultivation. In the study area, agriculture is rain fed and paddy is the principal crop. The pre monsoon rain (February-April) helps for growing Autumn Paddy and Kharif vegetable, normal monsoon (May – September) helps for growing winter paddy and in case of excess rainfall it causes damage to crops and livestock. The post monsoon (October – November) shower helps in panicle initiation stage of paddy crop. If sufficient shower is not received then it causes little dry spell condition in October on the other hand excess shower sometimes delays the cultivation of Rabi crops. Winter months (December – January) remains generally dry with scanty rainfall. Double cropping pattern is not observed in all the parts mainly due to lack of irrigation facility. There are 19 tea gardens in the district. Some of the important crops are Paddy, Black Gram, Green Gram, Pea, French, Bean, Arhar, Rape & Mustard, Linseed Sesamum, Kharif Vegetable, Rabi Vegetable, Sweet Potato, Potato, Chilli, Turmeric, Zinger, Black Pepper, Areca nut, Coconut, Pineapple, Litchi, Banana, Mango, Guava, Jack fruit, Assam Lemon, Orange, Papaya, Cashew nut, Other Indigenous fruit crops. Cropped area details are as follows:

Gross cropped area	Net cropped area	Area under Mono crop	Area under Double crop	Triple cropped area	Cropping Intensity
59450 Ha	44147 Ha	25182 Ha	11410 Ha.	2150 Ha	135%

1.12 Land use pattern

The block wise land use pattern of the district is given in Table No 1.6. (Area in Hectare)

Table 1.6 – Block wise land use pattern, Hailakandi district, Assam.

Name of Block	Algapur	Hailakandi	Lala	Katlicherra	South Hailakandi	Total
Geographical area	13208	15465	44225	8438	51364	132700
Cultivable area	10772	12605	18569	6195	7892	56033
Cultivated area	8074	10310	14851	5182	6740	45157
Cultivable waste	1264	936	2004	242	322	4768
Current fallow	674	779	764	373	452	3042
Forest	580	851	20296	315	34475	56517
Pasture	171	92	298	187	181	929
Land in non Agril. use	1426	1648	2156	1168	1399	8187
Misc. Plantation	78	120	376	48	1130	1752
Barren (Waste Land)	63	170	392	25	836	1486

1.13 Hydrology

The major rivers in the district are Barak River, Dhaleswari River, and Katakhal River. All the rivers are rain fed and drain the major valley in the area. There is no major or medium irrigation project present in the district. A few minor irrigation projects are available such as river lift irrigation system. There are many small ponds available in the district area. These ponds are mainly used for fish cultivation and also for domestic purpose. These ponds are rarely used for irrigation purpose as they don't have sufficient water during dry period.

Total natural area in the form of beels, hawars, and rivers is 4545.88 Ha.
Artificial area in the form of ponds, tanks, lakes is 1412 Ha.
Total water spread area in Hailakandi district is 5957.88 Ha

There are natural depressions and water-logged area scattered in the district. These are confined to flat/plain/low lying areas in the central part of the valley and found near the river. At places these are formed due to abandoned channel of the rivers.

Chapter 2 - Data collection

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

2.1 Hydrogeological data

The entire study area is covered by regular monitoring of existing 07 GWMS (NHNS) and another 33 Key wells have been established. All these wells are monitored after establishment. Table 2.1 shows the existing ground water monitoring stations (GWMS) under NHNS and Table 2.2 shows the details of the Key wells established in Hailakandi district in AAP 2019-2020.

2.2 Water Quality

To understand the chemical quality of groundwater in the study area and its suitability for domestic, drinking and agricultural utilization, pre monsoon and post monsoon water samples were collected from the existing 07 GWMS under NHNS and newly established 22 Key wells under NAQUIM. The samples collected were for analyzed for base, iron, heavy metals and arsenic.

2.3 Geophysical survey

During AAP 2019-20, no geophysical survey had been conducted in Hailakandi district.

Table 2.1 - Details of GW monitoring stations under NHNS in Hailakandi District, Assam

Village	Long	Lat	Well Type	Depth of well	Dia (m)	MP (m)	RL (m)
Burakhai	92.67472	24.62917	Dug Well	4.16	1.26	0.80	12.00
Katlicherra N	92.61944	24.45139	Dug Well	6.49	1.36	0.20	35.00
Lakhinagar	92.53111	24.60306	Dug Well	6.03	2.42	0.85	18.00
Lala	92.56194	24.59778	Dug Well	4.63	1.03	0.62	37.00
Monacherra OW	92.55417	24.61250	Tube Well	3.89	1.23	0.89	25.00
Panchgram New	92.60056	24.85833	Dug Well	10.10	1.45	0.90	4.00
Syedband Part II	94.58333	24.72750	Dug Well	6.30	1.80	0.90	21.00

Table 2.2 - Details of Key Wells established in Hailakandi District, Assam

LOCATION	LONGITUDE	LATITUDE	TYPE	RL	DIA	DEPTH	MP	AQUIFER GROUP
Uttar Khairabari	92.606111	24.846667	DUG WELL	20.0	1.11	6.6	0.9	Unconsolidated
Panchgram New	92.596111	24.871389	DUG WELL	34.0	0.90	5.2	0.9	Unconsolidated
Raman Chandra School	92.598950	24.834360	DUG WELL	23.0	1.00	6.1	0.9	Unconsolidated
Kalinagar	92.628333	24.847222	DUG WELL	24.0	1.00	11.0	0.9	Unconsolidated
Kalinagar Part VI	92.643889	24.803889	DUG WELL	25.0	1.45	2.6	0.6	Unconsolidated
North Narayanpur	92.643056	24.781389	DUG WELL	21.0	1.50	15.0	1.3	Unconsolidated
Mohanpur Grant	92.641667	24.730278	DUG WELL	27.0	1.50	4.5	0.7	Unconsolidated
Hitarmukh Chandipur Part II	92.578056	24.807500	DUG WELL	24.0	1.00	5.6	0.8	Unconsolidated
Chandipur Part III	92.572778	24.779444	DUG WELL	24.0	1.00	5.4	0.8	Unconsolidated
Banasbari Part II	92.563611	24.759444	DUG WELL	33.0	0.94	7.1	0.9	Unconsolidated
Banasbari Part I	92.549722	24.743889	DUG WELL	30.0	1.00	5.1	0.7	Unconsolidated
Syedbond Part II	92.581667	24.731111	DUG WELL	25.0	1.00	5.4	0.8	Unconsolidated
Bhajantipur Part I Bono Bazar	92.639167	24.695833	DUG WELL	30.0	1.00	3.4	0.4	Unconsolidated
Hajirkuna	92.598056	24.654444	DUG WELL	29.0	0.94	5.7	1.0	Unconsolidated
Sibuttar	92.530556	24.722500	DUG WELL	29.0	1.00	4.2	1.0	Unconsolidated
Kayakhal	92.502778	24.673333	DUG WELL	28.0	1.10	3.9	0.7	Unconsolidated
Lakhirbond Part I	92.570278	24.711667	DUG WELL	22.0	1.00	6.3	0.8	Unconsolidated
Kattlicherra Battalion	92.542960	24.487250	DUG WELL	35.0	1.00	4.0	0.8	Unconsolidated
Katlicherra PS	92.557778	24.461944	DUG WELL	34.0	1.20	6.7	0.8	Unconsolidated
Sonacherra	92.595278	24.461667	DUG WELL	31.0	1.02	5.0	0.9	Unconsolidated
Kabuli tila Dholai	92.574570	24.443100	DUG WELL	32.0	0.90	5.5	0.8	Unconsolidated
Rupcherra LP School	92.603980	24.482960	DUG WELL	32.0	1.00	5.4	0.8	Unconsolidated
Moonacherra railway station	92.550100	24.608400	DUG WELL	31.0	1.00	5.1	0.5	Unconsolidated
Lakhinagar	92.531111	24.603056	DUG WELL	33.0	2.20	6.5	1.0	Unconsolidated
Singala	92.559120	24.570970	DUG WELL	35.0	0.90	5.0	0.9	Unconsolidated
Rajyeswarpur Part V	92.604444	24.607778	DUG WELL	30.0	0.90	5.0	0.9	Unconsolidated
Lalamukh	92.638889	24.563889	DUG WELL	30.0	0.94	6.0	0.7	Unconsolidated
Lalacherra	92.630278	24.523611	DUG WELL	37.0	0.95	6.7	0.8	Unconsolidated
Vernerpur	92.615556	24.513056	DUG WELL	30.0	1.50	3.7	0.8	Unconsolidated
Sudarshanpur	92.637820	24.615790	DUG WELL	30.0	0.90	4.0	0.8	Unconsolidated
Shibbari Mahadevbari	92.546420	24.429440	DUG WELL	30.0	1.00	4.5	0.7	Unconsolidated
Jamira State Dispensary	92.526500	24.318800	DUG WELL	39.0	1.00	4.1	0.6	Unconsolidated
Sultanicherra	92.526300	24.334450	DUG WELL	41.0	0.90	4.5	1.0	Unconsolidated

2.4 Exploratory Drilling

During AAP 2019-20, CGWB took up GW exploration in the study area by both inhouse and outsource drilling. Details of the exploration activity in Hailakandi district is given in Table 2.3.

Table 2.3: Details of exploration wells constructed by CGWB in Hailakandi District, Assam

Location	Block	Longitude	Latitude	Topo sheet	Year of const.	Depth of Drilled (mbgl)	Depth of constr. (mbgl)	Source
Kalinagar EW	Algapur	92.62333	24.85000	83D/9	Jan-79	299.80	178.00	CGWB
Kalinagar OW	Algapur	92.62333	24.85000	83D/9	Jan-79	299.00	178.00	CGWB
Hailakandi EW	Hailakandi	92.59500	24.68333	83D/10	Jan-79	299.70	151.00	CGWB
Hailakandi OW	Hailakandi	92.59222	24.68333	83D/10	Jan-79	157.18	150.00	CGWB
Nyamatpur EW	Lala	92.59167	24.54167	83D/10	Dec-79	279.20	188.70	CGWB
Monacherra-EW	Lala	92.55417	24.61250	83D/10	Nov-91	50.00	50.00	CGWB
N. Narayanpur EW	Algapur	92.59583	24.75389	83D/9	Dec-92	50.00	50.00	CGWB
Alaicherra EW	South Hailakandi	92.55014	24.38178	83D/11	Nov-19	116.00	110.00	CGWB
Alaicherra OW	South Hailakandi	92.55014	24.38178	83D/11	Feb-20	110.60	96.00	CGWB
Katlicherra EW	Katlicherra	92.54440	24.48781	83D/11	Mar-20	139.70	134.00	CGWB
Katlicherra OW	Katlicherra	92.54440	24.48781	83D/11	Jun-20	136.50	134.00	CGWB
Kuchila Farm EW	Hailakandi	92.58826	24.65024	83D/10	Apr-20	305.50	220.00	WAPCOS
Kuchila Farm OW	Hailakandi	92.58826	24.65024	83D/10	May-20	230.75	219.00	WAPCOS
Manipur Farm EW	South Hailakandi	92.55797	24.39123	83D/11	Jan-21	305.50	251.00	WAPCOS
Manipur Farm OW	South Hailakandi	92.55797	24.39123	83D/11	Jan-21	256.75	250.00	WAPCOS
Boalipar EW	Hailakandi	92.56986	24.71182	83D/10	Feb-21	305.50	271.00	WAPCOS
Boalipar OW	Hailakandi	92.71178	24.71178	83D/10	Feb-21	273.00	270.00	WAPCOS

Chapter 3 - Data Interpretation, Integration and Aquifer Mapping

3.1 Data Interpretation

1. Geophysics and Aquifer Characterization –

Geophysical logging was conducted at the exploratory drilling sites of Kuchila, Manipur and Boalipar. The results from geophysical logging at Kuchila seed farm site, Manipur seed farm site and Boalipar site are shown in Table 3.1,3.3,3.5 respectively. They are attached as Annexure 3.1, 3.2, and 3.3.

Kuchila seed farm -

The interpreted results of geophysical logging report have shown that top soil has resistivity value within 225 Ohm m being approximately 7m thick and comprises of dominantly clay. At Kuchila seed farm, below the top soil in first 100m bgl, zones between (40-53) m & (79-92) m have resistivity values of (250 – 312) ohm m & (117-127) ohm m. This indicates medium to fine grained sand and fine-grained sand respectively. In the following 100m, there are five zones between (102-119) m, (127-131) m, (134-140) m, (165-171) m, (183- 192) m. The resistivity values of these zones are up to 169-ohm m, which indicates that the zones are composed of fine sand. There is a zone between (158-165) m which has resistivity value between (10- 22) ohm m, which indicates a prominent clay zone. In the next 100m, a zone between (212-218) m shows resistivity value between (116-123) ohm m, which indicates a fine sand zone. Below this zone, the resistivity values suggest presence of clayey sand and sandy clay zones till a depth of 300 m. The result of VES survey has shown that the subsurface formation is sand (fine-grained) dominated but clay occur with sand in different proportions to form sandy clay or clayey sand formations. Moreover, saturated formation is extended below 300m.

Manipur seed farm -

The interpreted results of geophysical logging report have shown that top soil has resistivity value within 225 Ohm m being approximately 9m thick and comprises of dominantly clay. At Manipur seed farm, below the top soil in first 100m bgl, zones between (90-95) m has a resistivity values of (48-140) ohm m. This indicates presence of fine-grained sand. There is a zone between (71-90) m which has resistivity value between (25-32) ohm m, which indicates a prominent clay zone.In the following 100m, there are two zones between (101-143) m, (170-185) m. The resistivity values of these zones are between (180 – 264) ohm m, which indicates that the zones are composed of medium grained sand. In the next 100m, two zones between (227-233) m and (235-244) m shows resistivity value between (88-259) ohm m, which indicates a fine sand zone. Below this zone, the resistivity values suggest presence of clayey sand and sandy clay zones till a depth of 300 m. The result of VES survey has shown that the subsurface formation is sand (fine-grained) dominated but clay occur with sand in different proportions to form sandy clay or clayey sand formations. Moreover, saturated formation is extended below 300m.

Boalipar SIPRD -

The interpreted results of geophysical logging report have shown that top soil has resistivity value within 225ohm m being approximately 7m thick and comprises of dominantly clay. At Boalipar, below the top soil in first 100m bgl, no zones have been found. This indicates presence of clay.

In the following 100m, there are two zones between (105-120) m, (143-150) m. The resistivity values of these zones are between 106–159-ohm m, which indicates that the zones are composed of fine sand. In the next 100m, two zones between (211-221) m and (232-264) m shows resistivity value between (111-178) ohm m, which indicates a fine sand zone. Below this zone, the resistivity values suggest presence of clayey sand and sandy clay zones till a depth of 300 m. There is a zone between (278-308) m which has resistivity value

between (37-47) ohm m, which indicates a prominent clay zone. The result of VES survey has shown that the subsurface formation is sand (fine-grained) dominated but clay occur with sand in different proportions to form sandy clay or clayey sand formations. Moreover, saturated formation is extended below 300m.

2. Aquifer disposition

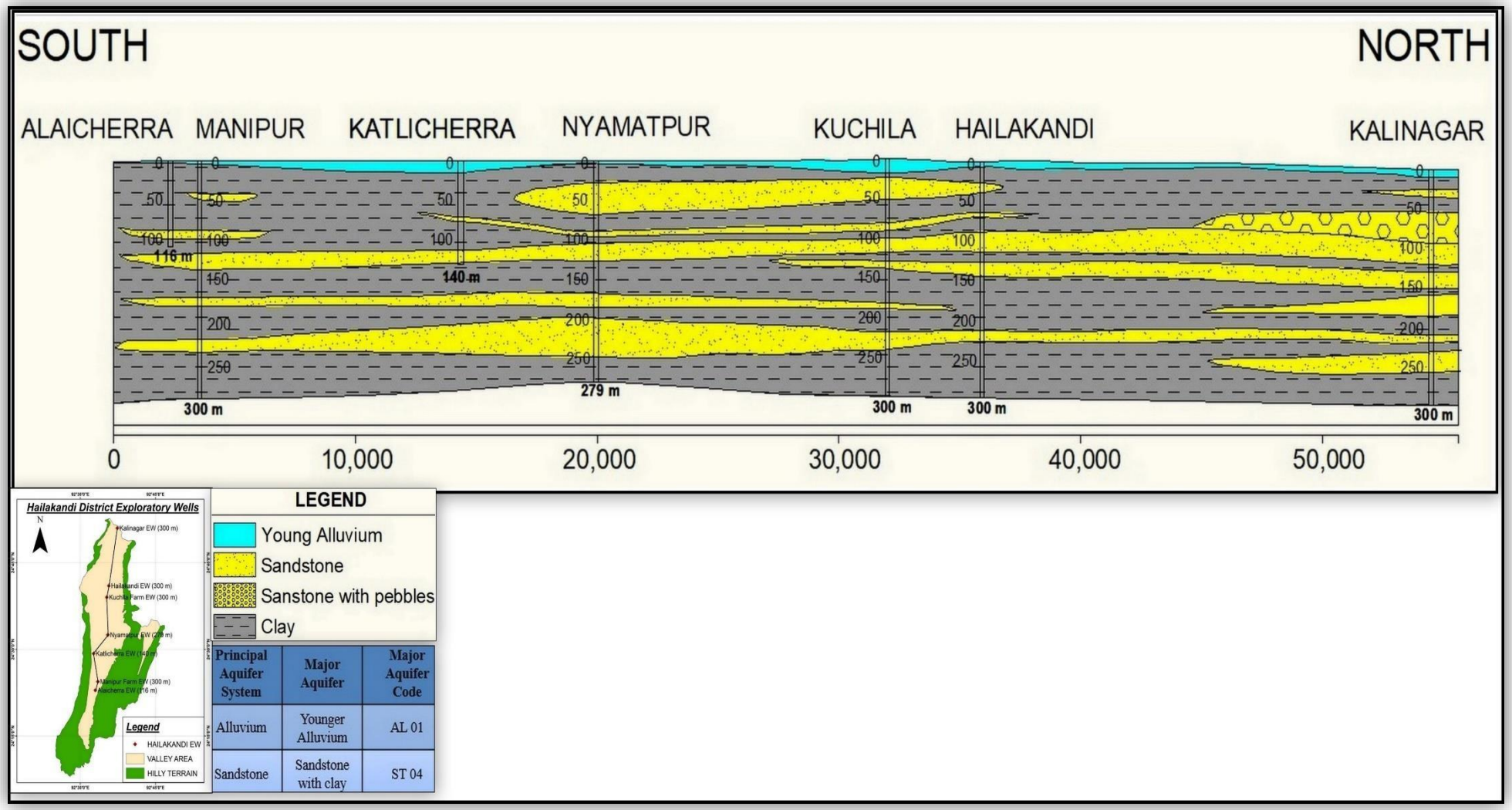
The Hailakandi district is surrounded by dissected hills on the western and eastern sides and it tappers down towards the south, giving rise to a valley which is narrow in the south and gradually opens up towards the Barak river in the northern side. The general slope is from South to North direction. CGWB has constructed ten exploratory wells across the Hailakandi district with depth ranging from 50.0 m to 300.0 m. The major aquifers of the district have been delineated based on the litholog of these exploratory wells. In the district, two principal aquifers have been delineated-

- **Alluvial aquifer of Quaternary age** - The alluvial aquifer consists of clay, sand and clayey sand. The clay is yellowish brown in color.
- **Sandstone aquifer of Tertiary age** - The sandstone aquifer is composed of friable sandstone with clay. Sandstone occurs as lenses and the color of clay is grey.

Based on the litholog of the exploratory wells, a section has been prepared to show the 2D disposition of the aquifers along the North-South direction (Figure 3.1). From the section, it is observed that the clay is more dominant in the southern part of the district and sandstone is dominant in the northern part near the Barak river. A thin layer of alluvial cover of average thickness of 9m spreads across the valley area of the district surrounded by the dissected hills. The alluvium thickness encountered in the EW range between 3m to 18m. Underneath the alluvial aquifer, five granular zones have been encountered.

- The first granular zone encountered within 50m depth is in between Nyamatpur to Hailakandi. The thickness of the granular zone ranges between 41.27m to 6.0 m. The zone pinches out towards the north of Hailakandi and south of Nyamatpur. Within 50m depth, this granular zone was also encountered at Kalinagar in the north and Manipur in the south.
- The second granular zone is encountered between Katlicherra to Hailakandi. The thickness of this granular zone is varies from 4.57 to 12m. The zone pinches out towards north of Hailakandi and south of Katlicherra.
- The third granular zone is extensive throughout the district and it struck at an average depth of 100m. Its thickness in the northern part is 59 m, in the central part ranges between 35.05m to 23.47m, in the southern part ranges between 9.75m to 12.3m. This granular bed thins out towards the south of Alaicherra in the southern part. In the northern part, this zone's upper part consists of sandstone with pebbles and lower part is sandy.
- The fourth granular zone is encountered between Kuchila and Manipur. The thickness of this zone ranges between 18.29m to 8m. It pinches out towards north of Kuchila. The granular zone is found in the northern part at Kalinagar where its thickness is 50 m.
- The fifth granular zone occurs extensive throughout the district between Manipur to Kalinagar. The thickness of this zone in the central region is 54.5m and its thickness gradually decreases towards the northern part towards the Barak river where its thickness is 20.9 m.

The Aquifer property delineated from CGWB's EW in Hailakandi district have been furnished in Table 3.7 attached as Annexure 3.



Principal Aquifer System	Major Aquifer	Major Aquifer Code
Alluvium	Younger Alluvium	AL 01
Sandstone	Sandstone with clay	ST 04

Fig 3.1- 2D section showing Aquifer disposition along North- South direction of Hailakandi district

3.2 Ground water level

To study ground water regime, depth to water level from 07 monitoring stations under NHNS are measured seasonally. The pre monsoon and post monsoon depth to water level as well as the fluctuation are shown in Table 3.8.

Table 3.8 - Pre & Post Monsoon DTWL and fluctuation data of NHNS monitored wells

NHNS WELL	PRE-MONSOON DTWL (mbgl)	POST-MONSOON DTWL (mbgl)	FLUCTUATION (m)
Burakhai	1.13	0.30	0.83
Katlicherra N	1.70	0.97	0.73
Lakhinagar	2.78	1.78	1.00
Lala	3.48	2.89	0.59
Monacherra OW	2.19	0.98	1.21
Panchgram New	5.93	1.60	4.33
Syedband Part II	1.52	0.61	0.91

Apart from these 07 NHNS wells, 33 key wells have been established all over the district to monitor the depth to water level and its seasonal fluctuation whose details are given in Table 3.9 attached as Annexure 3.5.

Based on the pre & post monsoon depth to water level data collected from monitoring of the key wells, DTWL maps have been drawn and shown in Fig 3.2,3.3.

In the pre monsoon season, the depth to water level in the study area ranges between 0.69m bgl to 6.97m bgl. The area close to the hills in the southern parts of the valley has very shallow water level up to 2m bgl while in the northern parts close to the Barak river, the depth to water level is up to 7m bgl.

In the post monsoon season, the depth to water level in the study area ranges between 0.45m bgl to 4.24m bgl. The area close to the hills in the southern parts of the valley has water level below 1 m bgl, while in the central part and northern part of the valley close to the Barak river, the depth to water level is between range of 1.0 to 2.0 m bgl.

The pre monsoon and post monsoon DTWL fluctuation map shows that the major portion of the valley undergoes DTWL fluctuation up to 1m, while areas close to the hills in the southern part and northern parts show fluctuation up to 2m.

3.3 Ground Water Movement

The water table contour has been prepared based on the water level of ground water monitoring stations. Regionally the ground water flow direction is from the higher elevation on eastern, western and southern sides towards the central valley portion which ultimately flows north towards the Barak river. Overall ground water flow direction is from South to North. The pre & post monsoon water table contour map are shown in Fig 3.5,3.6.

The pre and post monsoon water table maps show that the WT in the southern side is at 35m and it gradually decreases to 20m in the northern part. The WT contours forms a V shape as the study area is a synclinal valley which tappers towards the southern side and widens up in the northern side. The flow direction in both pre and post monsoon season is from south to north. The hydraulic gradient is varies between 0.25 m/Km to 0.33 m/Km.

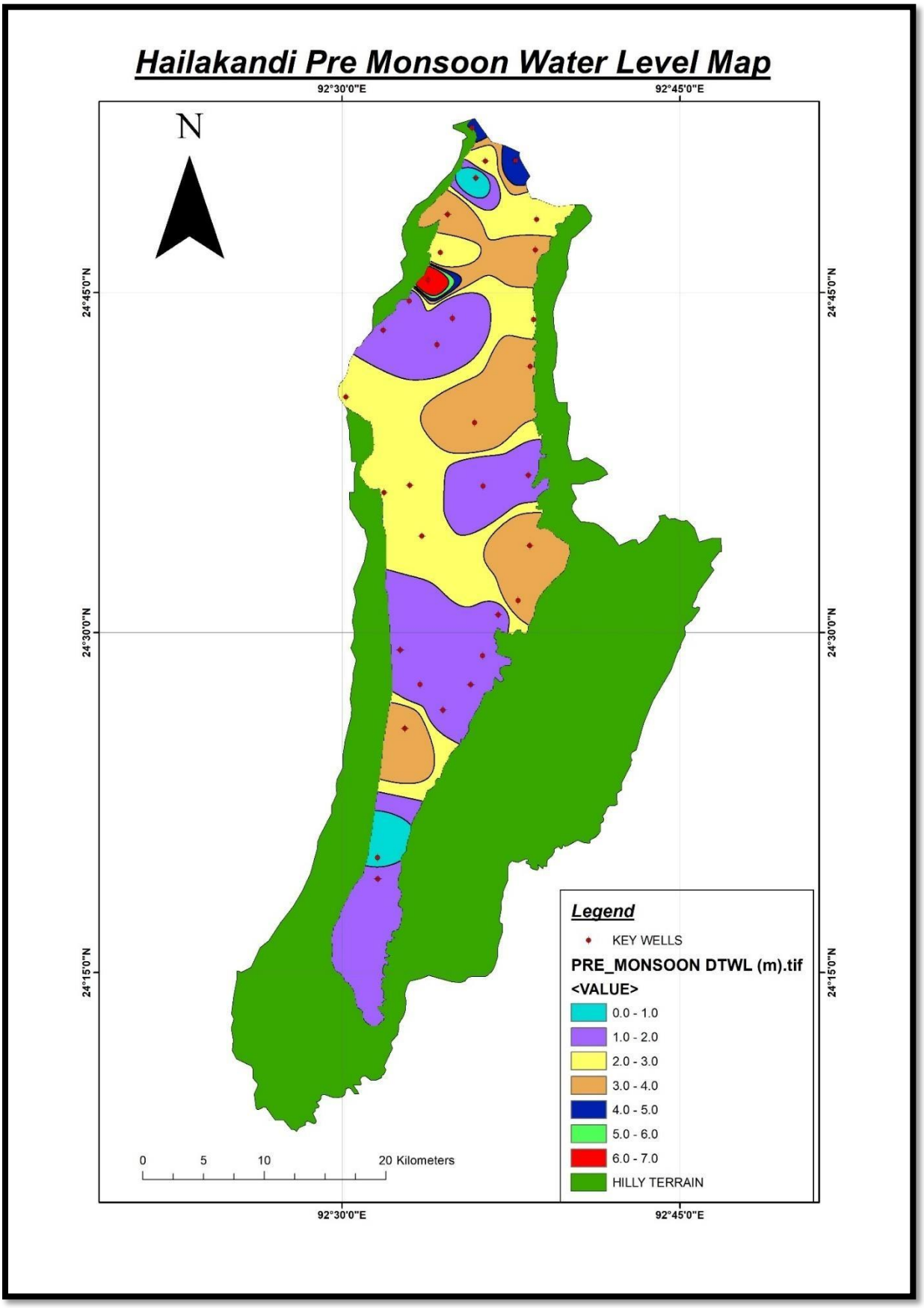


Fig 3.2 - Pre monsoon DTWL map of Hailakandi district

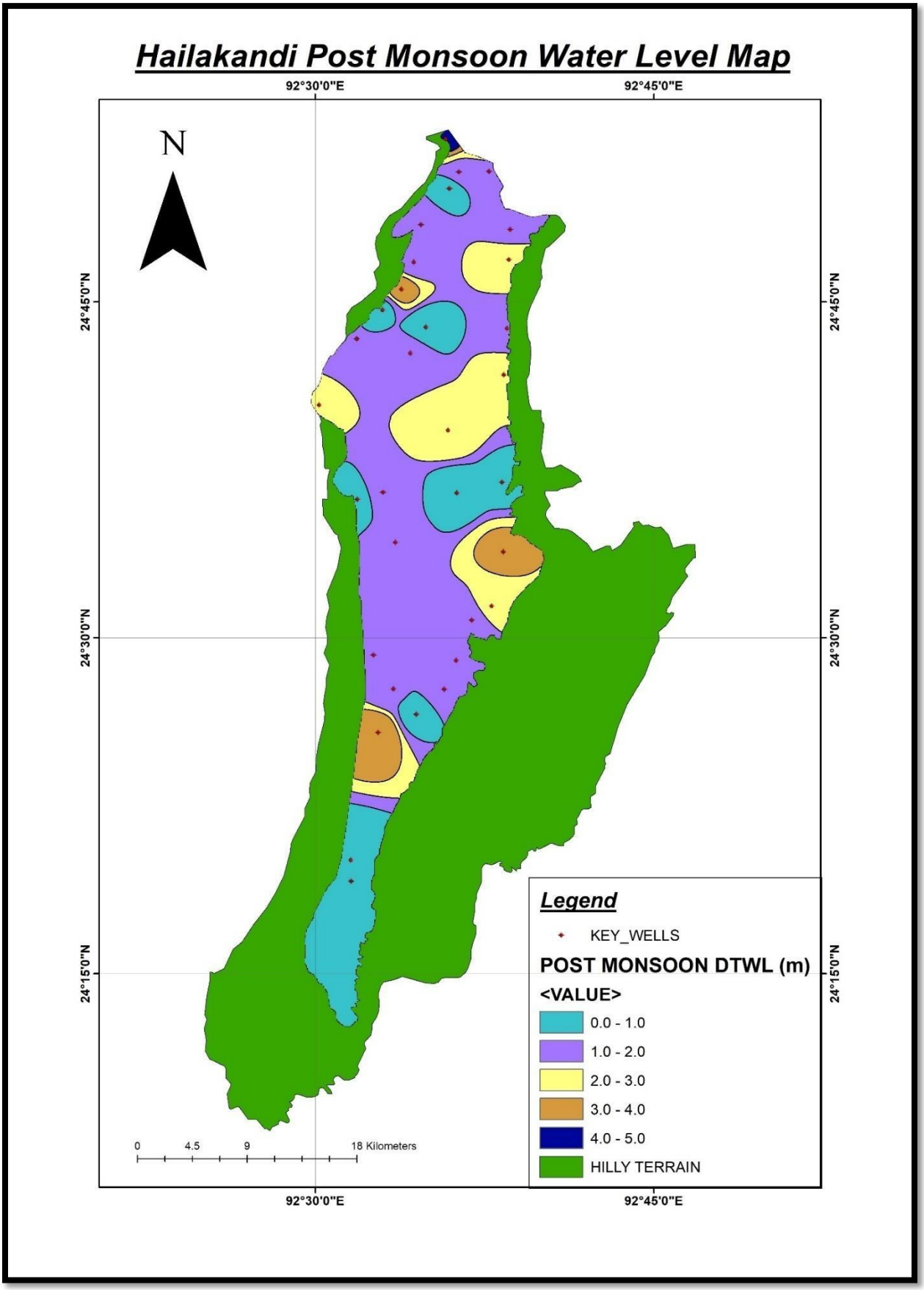


Fig 3.3 - Post monsoon DTWL map of Hailakandi district

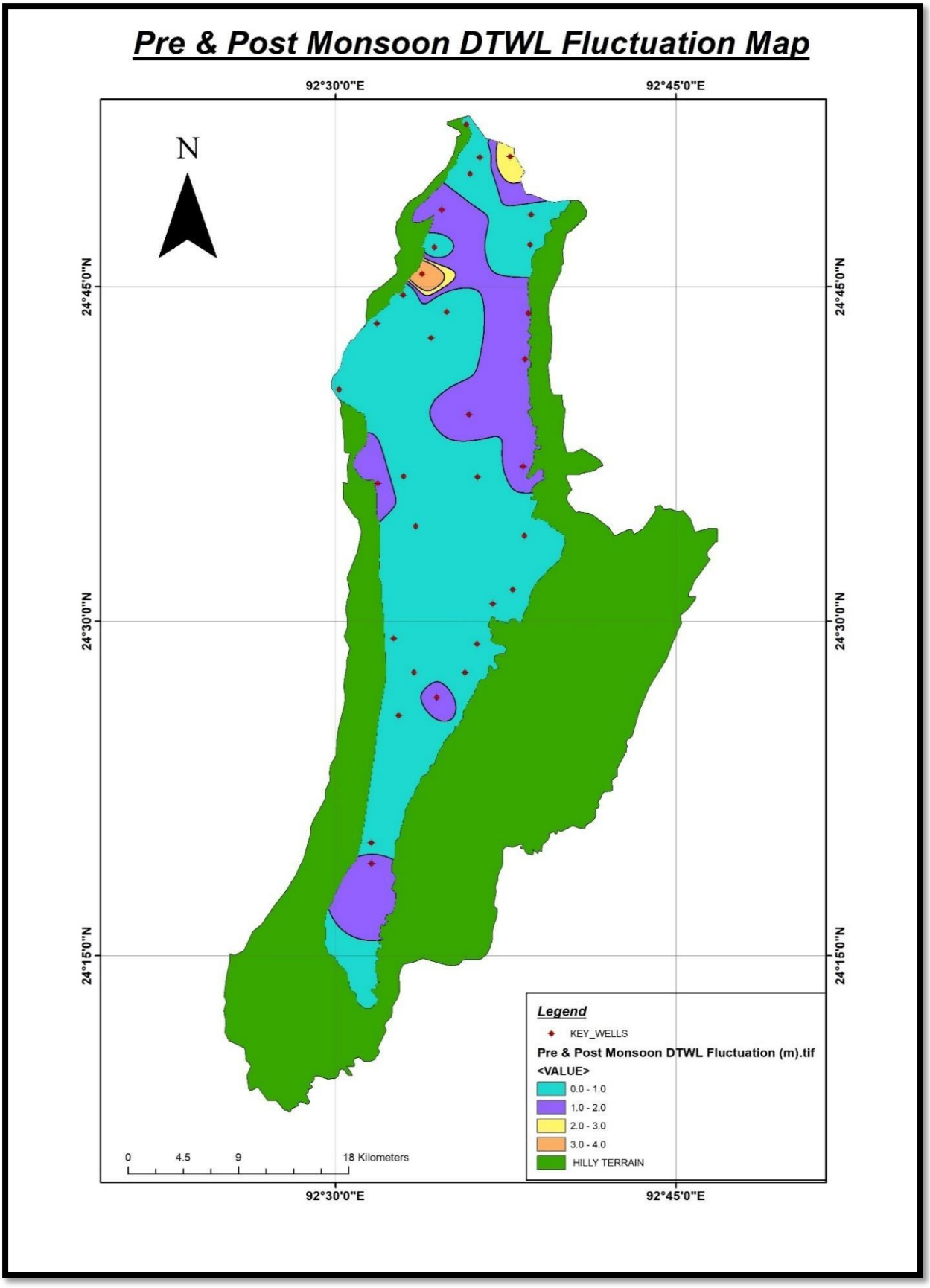


Fig 3.4 – Pre & Post monsoon DTWL fluctuation map of Hailakandi district

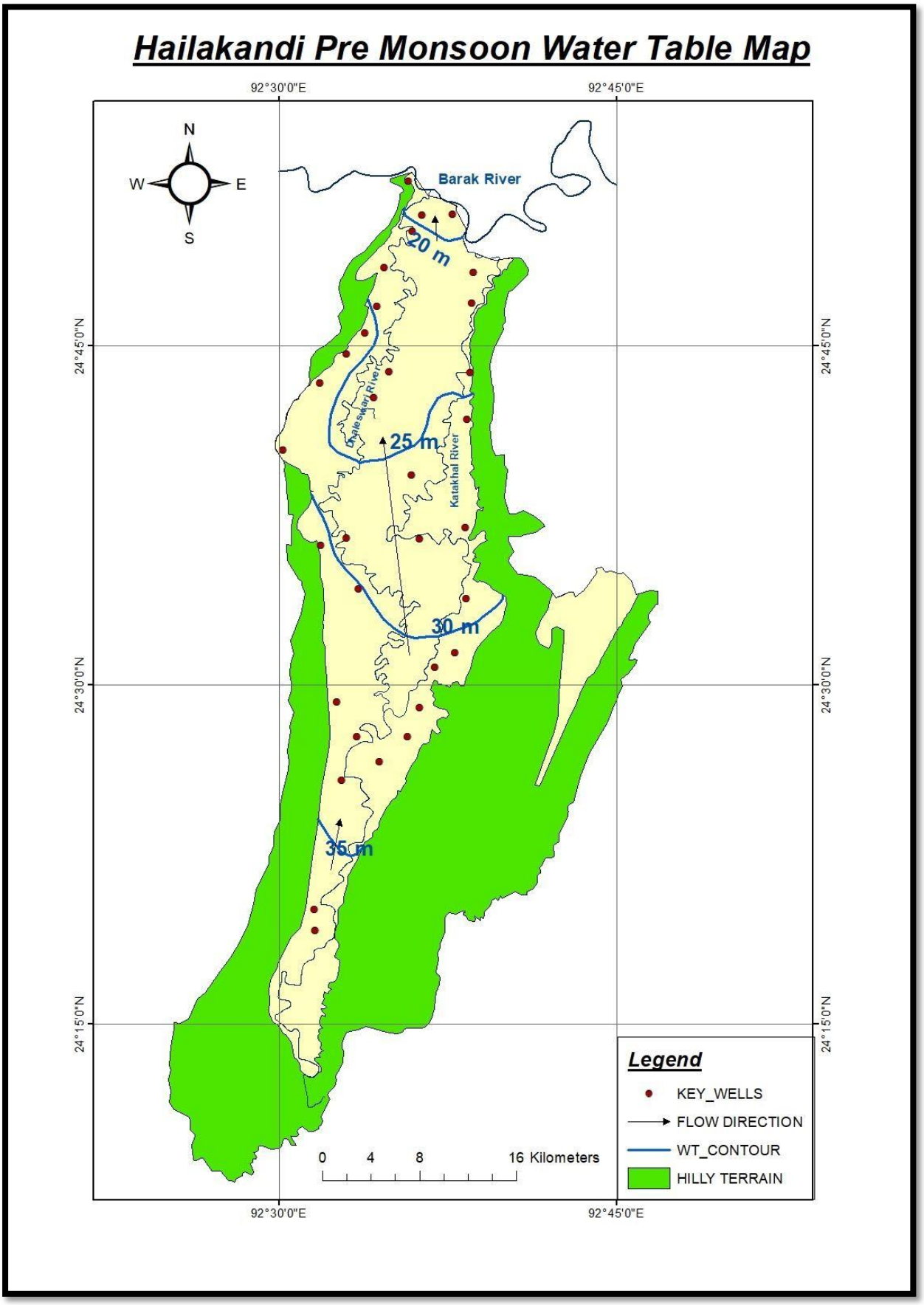


Fig 3.5 – Pre monsoon water table map of Hailakandi district

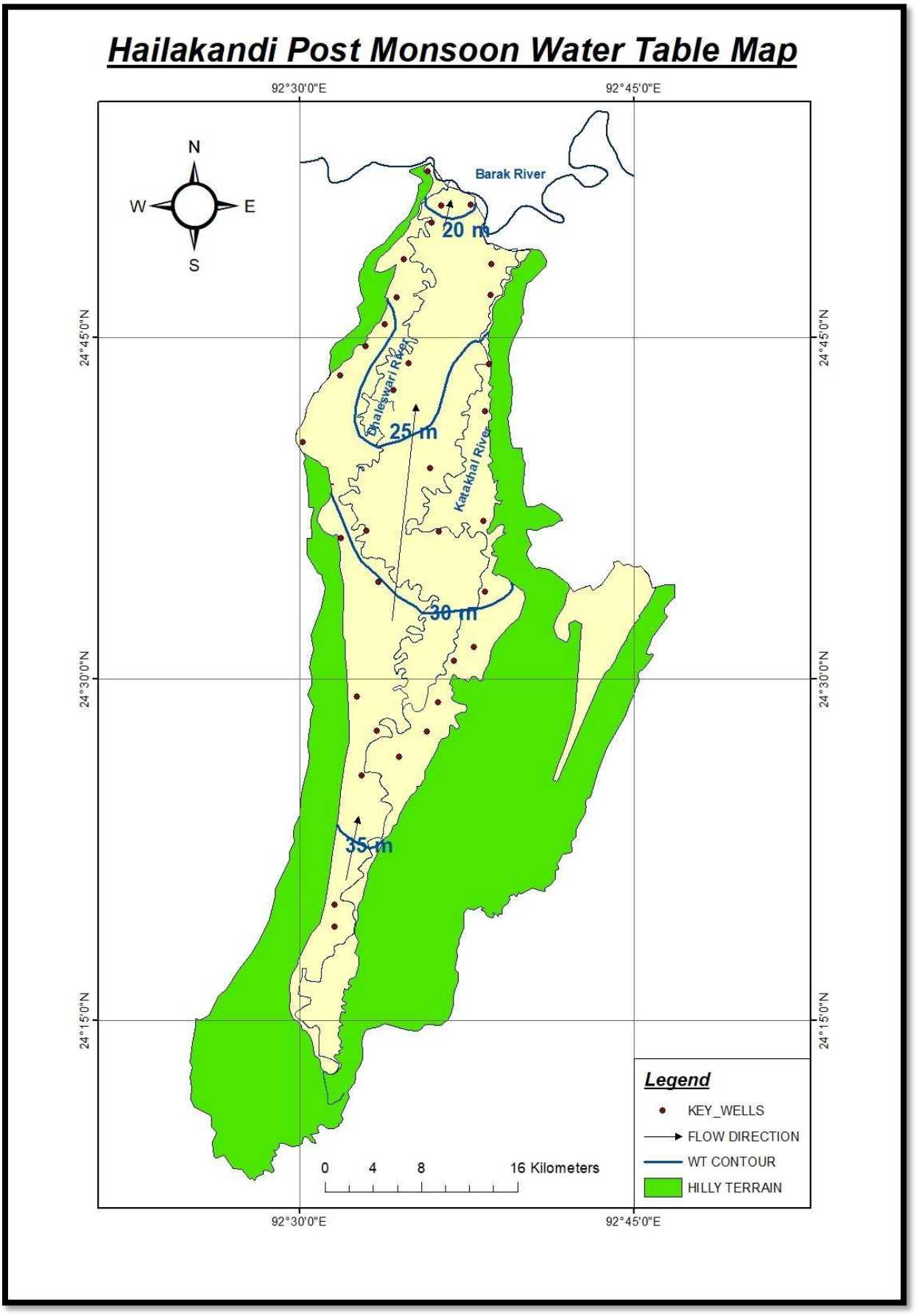


Fig 3.6 – Post monsoon water table map of Hailakandi district

3.4 Ground water quality

Chemical analysis of ground water samples is carried out by regional chemical laboratory of Central Ground Water Board, North Eastern Region, Guwahati. Groundwater data from CGWB's earlier study is also utilized in this work. In the present study, groundwater samples were collected for Basic, Iron, Arsenic and other Heavy Metal analyses. The result of the chemical analyzes of samples collected from GWMS of Hailakandi district in pre monsoon season and post monsoon season have been furnished in Table 3.10 and 3.11 respectively attached as Annexure 3.6.

The value of pH in the pre monsoon season varies between 7.39 to 8.62 while in the post-monsoon pH values range from 6.34 to 8.88. In post monsoon water samples, It is observed that in both pre and post monsoon period concentration of Ca, Mg, Cl, SO4, NO_3-, F-, TDS and hardness as CaCO3 in groundwater samples are within desirable limit.

Iron concentration in groundwater

The Iron concentration in water samples from 11 GWMS have been found above 1.0 mg / ltr. These stations are at Panchgram, Uttar Khairabari, Hatirmukh, Kalinagar, Kayakhal, Hajirkuna, Natunpur, Lakhinagar, Singala, Katlicherra PS, Sutanicherra. Apart from these, water samples from the exploratory wells at Alaicherra and Katlicherra also have Iron concentration more than 1.0 mg/ ltr. The stations with Fe concentration more than permissible limit of BIS have been shown in the Fig 3.7.

Electrical conductivity in groundwater

The electrical conductivity (EC) in the water samples are found between 45 to 660 µS/cm and is safe for irrigation purpose. The EC contour map with two classes of 0-250 µS/cm and 250-750 µS/cm have been shown in Fig 3.8.

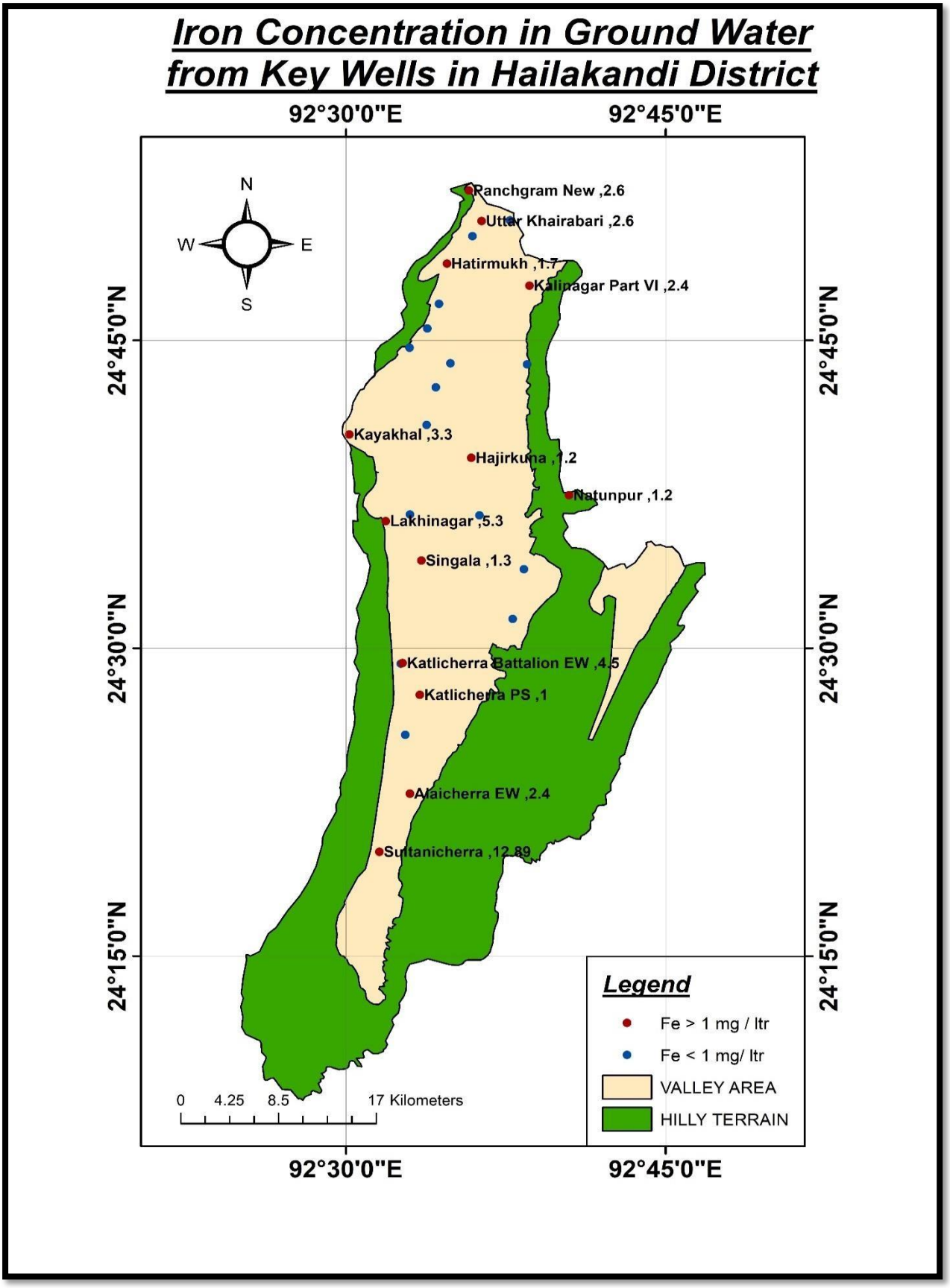


Fig 3.7 – GWMS with Iron concentration more than 1.0 mg/ltr

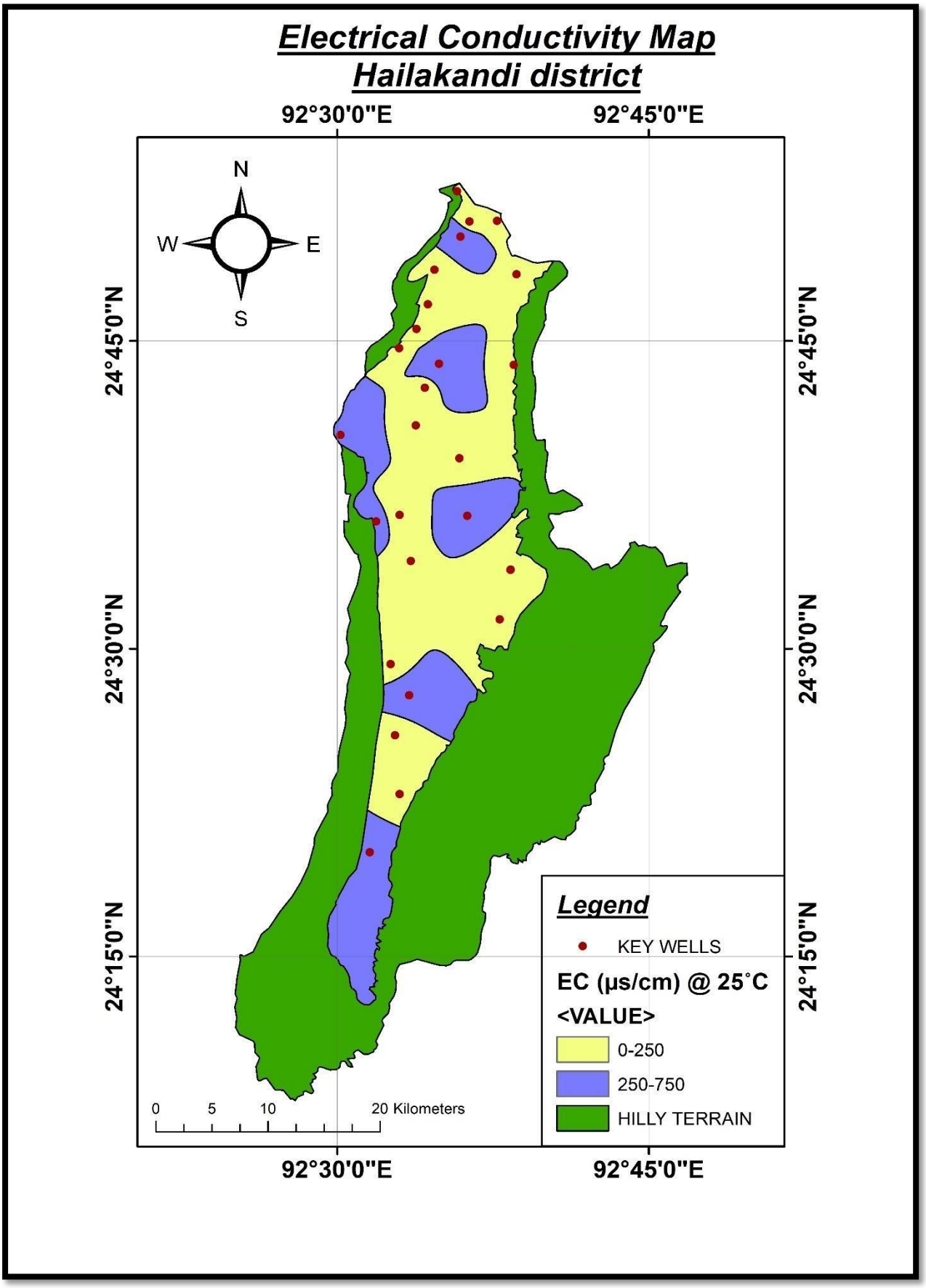


Fig 3.8 – EC contour map for Hailakandi district

Arsenic in groundwater

During 2017-18 and 2018-19, NHNS monitoring of GWMS in Hailakandi district were carried out along with water sampling. The study focused on the occurrence of Arsenic in Hailakandi district. In that survey, ground water samples were collected from seven key wells that include tube well and dug-well. The results of the study are shown in Table 3.12.

Table 3.12 – Arsenic concentration in NHNS GWMS in Hailakandi district

Location	Latitude	Longitude	Type of sample (EW/DW)	2017-18 Conc. Of Arsenic (in ppb)	2018-19 Conc. Of Arsenic (in ppb)
Burakhai	92.67472	24.62917	Dug Well	3.5	3.545
Katlicherra New	92.61944	24.45139	Dug Well	5.5	3.545
Monachera	92.55417	24.61250	Tube Well	7.5	5.364
Panchgram New	92.60056	24.85833	Dug Well	8.5	6.273
Syedbond Part II	94.58333	24.72750	Dug Well	BDL	6.273
Lakhinagar	92.53111	24.60306	Dug Well	8.5	7.182
Lala	92.56194	24.59778	Dug Well	BDL	8.091

The permissible limit of Arsenic concentration in drinking water by WHO has been prescribed as 10 ppb. All the GWMS are within the permissible limit of As concentration. 22 water samples were collected from the NAQUIM GWMS established in the district during 2019-20. The value of Arsenic concentration ranges between 0.033 to 5.705 ppb during post monsoon season and 0.563 to 4.041 ppb during pre-monsoon season. The permissible limit of Arsenic concentration in drinking water by WHO has been prescribed as 10 ppb. Hence all the stations are within the permissible limit of As concentration. The results of the study are shown in Table 3.13.

Table 3.13 – Arsenic concentration in NAQUIM GWMS in Hailakandi district

Location	Block	Latitude	Longitude	75As (ppb) Post-Monsoon	75As (ppb) Pre-Monsoon
Uttar Khairabari	Algapur	24.84667	92.60611	1.344	1.346
Raman Chandra School	Algapur	24.83436	92.59895	0.623	2.510
Kalinagar	Algapur	24.84722	92.62833	0.174	2.123
Kalinagar Part IV	Algapur	24.80389	92.64389	0.559	2.510
Mohanpur Grant	Algapur	24.73028	92.64167	1.648	1.735
Hatirmukh	Algapur	24.80750	92.57806	1.023	4.041
Chandipur Part III	Algapur	24.77944	92.57278	0.157	3.661
Banasbari Part I	Algapur	24.74389	92.54972	0.190	3.278
Kayakhal	Hailakandi	24.67333	92.50278	0.390	3.278
Natunpur	Hailakandi	24.62917	92.67472	0.281	0.563
Lakhinagar	Lala	24.60325	92.53139	0.176	4.041
Moonacherra RS	Lala	24.60840	92.55010	0.196	0.955
Ishancherra	Lala	24.59639	92.50806	0.141	2.510
Singala	Lala	24.57097	92.55912	1.012	2.510
Rajyeswarpur Part V	Lala	24.60778	92.60444	5.705	1.346
Lalamukh	Lala	24.56389	92.63889	0.033	0.563
Lalacherra	Lala	24.52361	92.63028	0.203	1.346
Khasia Ring (DBGP)	Lala	24.50417	92.66639	0.306	0.563
Katlicherra Battalion	Katlicherra	24.48725	92.54296	1.073	2.510
Katlicherra PS	Katlicherra	24.46194	92.55778	0.706	0.563
Shibbari Mahadevbari	S.Hailakandi	24.42944	92.54642	0.712	0.955
Sultanicherra	S.Hailakandi	24.33445	92.52630	0.269	0.955

Chemical Analysis of water samples from wells constructed by CGWB – NER in 2019-20 AAP

The chemical analysis of the water samples collected from the exploratory and observation wells constructed by CGWB in Hailakandi district in 2019-20 was also done. The chemical data for Alaicherra PWSS and Katlicherra Battalion sites have been furnished in Table 3.14.

Table 3.14 – Chemical data of EW & OW at Alaicherra PWSS and Katlicherra Battalion

Location	Allaicherra PWSS		Katlicherra Battalion		Unit
District	Hailakandi		Hailakandi		
Block	S. Hailakandi		Katlicherra		
Type of Well	EW	OW	EW	OW	
pH	8.17	8.02	8.11	7.704	
EC	193.60	211.50	248.80	248.40	µs/cm at 25ºC
TDS	97.52	105.50	124.80	130.80	mg/L
CO3-2	BDL	BDL	BDL	0.00	mg/L
HCO3-1	109.89	115.99	73.26	42.73	mg/L
TA (as CaCO3)	109.89	115.99	73.26	42.73	mg/L
Cl-	10.64	14.18	35.45	53.18	mg/L
SO4-2	47.26	63.90	55.74	81.95	mg/L
NO3-1	0.00	10.00	0.00	2.25	mg/L
F-	0.30	0.33	0.31	0.34	mg/L
Ca+2	39.98	54.99	19.83	6.00	mg/L
Mg+2	9.70	13.35	4.81	3.64	mg/L
TH (as CaCO3)	65.00	70.00	235.00	30.00	mg/L
Na	8.65	5.05	33.39	58.31	mg/L
K	4.54	3.67	2.37	15.01	mg/L
Fe	2.39	1.22	4.53	3.2269	mg/L
As	0.563	0.955	0.563	1.346	ppb

From the data, we can see that the Arsenic concentration in exploratory well as well as observation well of both the sites to be below 10 ppb. Hence it is under permissible limit of As concentration in water. The Iron concentration for all four wells is above 1.0 mg/ltr. They are above the permissible limit of Fe concentration in water.

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 presented here has been calculated on the basis of data of 2019.

The aquifers of the study area are recharged through:
a) infiltration of rainfall on the outcrop.
b) seepage from the tanks and ponds.
c) irrigation through ground water schemes and surface water schemes.

The area experiences south-east monsoon. Monsoon rainfall contributes approximately 54 percent of total rainfall (June, July, August, September) while non-monsoonal rainfall contributes to remaining 46 percent of the total rainfall. The month December to January has the minimum number of rainy days in any year and the period May to September has maximum number of rainy days.

4.1 Data and assumptions 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 0.12 for Barak valley where clayey contents are more. In WLF method, specific yield has been taken as 0.10 for fine grained sandy alluvium. Rainfall data is taken from IMD. The rainfall of Hailakandi district is 2315.40 mm.

2) Water level data has been considered for 2019 from the key wells established. 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 Hailakandi district is 2.53 mbgl and 1.65 mbgl.

3) The population figures were collected from Census, 2011 and projected to 2019. The per capita domestic requirement for the population has been considered as 70 lpcd.

4) Rural dependency on ground water as per 2011 Census is 60% while the Urban dependency on ground water as per 2011 Census 31%. Average dependency on ground water is 46%.

5) Recharge from other sources is calculated for surface water irrigation, groundwater irrigation, tanks and ponds based on the norms suggested in GEC'15. In order to calculate the recharge from other sources, 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 is 1.4 mm/day. Recharge from water conservation structure has been taken as nil.

6) 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. Difference between two methods is compared. If the difference is less than 20%, then the monsoon recharge is calculated by multiplying the RIF by 1.2. This value is considered as monsoon recharge.

4.2 Recharge

The monsoon recharge of the 86808.2239 Ha of recharge worthy area is 15479.25 Ham while non-monsoon recharge is 8875.27 Ham. Recharge from other sources during monsoon is 854.29 Ham and during non-monsoon is 1414.32 Ham. The total annual ground water recharge is 22325.30 Ham.

4.3 Extraction

The Extraction from the unconsolidated aquifer is created by natural discharge like seepages and extraction created by human interference, viz., (a) withdrawals for irrigation and industry and (b) public-supply wells.
In the district natural discharge is considered to be 5% of the total groundwater recharge, i.e., 1116.2651 Ham.
Total irrigation Extraction created is 26.88 Ham.
Total industrial Extraction created in the area 151.80 Ham.
Extraction for domestic uses is 901.67 Ham.
Total groundwater Extraction for all uses is 1080.35 Ham.
The water trend analysis shows that the water level for post-monsoon periods is falling.

4.4 Allocation of resources up to 2025

The rechargeable area is 868.0822 sq.km. The projected population in 2025 with decadal growth rate of 21.45% is 871843.
The net ground water resource is allocated for domestic, industrial and irrigation sector.
Annual Allocation of ground water for Domestic water supply up to 2025 is 1019.71 Ham.
Current annual gross ground water extraction for irrigation is 26.88 Ham.
Current annual gross ground water extraction for industrial is 151.80 Ham.
Net Annual G.W. availability for future use is 20010.65 Ham.

4.5 Stage of groundwater extraction

The area has very little irrigation facilities. Similarly, industrial development in the area is practically nil. Groundwater is mainly utilized for domestic purposes. However, Public Health Engineering & Water Supply Department has supplied water mainly through surface water sources. The stage of groundwater extraction in the district is 5.09%.

4.6 Block wise dynamic ground water resource

As mentioned earlier, due to paucity of block level irrigation data, ground water uses for domestic purpose and rainfall data, the resource estimation is carried out district wise.

A brief summary of the Ground water resources is as following -

PARAMETER	VALUES
State	ASSAM
District	HAILAKANDI
Total geographical area (Ha)	132700
Recharge worthy area (Ha)	86808.2239
Rainfall Recharge (Ham) (monsoon)	15479.25
Rainfall Recharge (Ham) (non-monsoon)	8875.27
Annual Recharge from Other Sources (Ham) (monsoon)	854.29
Annual Recharge from Other Sources (Ham) (non- monsoon)	1414.32
Resultant Flows (ET Loss) (Ham) (monsoon)	1795.05
Resultant Flows (ET Loss) (Ham) (non-monsoon)	2502.79
Annual G. W. Recharge (Ham)	22325.30
Ecological Flow (Ham)	1116.27
Total Natural discharge (Ham)	1116.27
Annual extractable Ground Water Resource (Ham)	21209.04
Current annual gross G.W. Extraction for domestic use (Ham)	901.67
Current annual gross G.W. Extraction for irrigation (Ham)	26.88
Current annual gross G.W. Extraction for industrial use (Ham)	151.8
Current annual gross G.W. Extraction for All uses (Ham)	1080.35
Annual G.W. Allocation for Domestic water supply as on 2025 (Ham)	1019.71
Net Annual G.W. availability for future use (Ham)	20010.65
Stage of GW Extraction (in %)	5.09
Quantity Categorisation for Future GW extraction (Safe/Semi-Critical/Critical/Over Exploited)	Safe

4.7 Static resource:

The static groundwater resource of the district has been calculated for the base year 2017. Here also the administrative district has been considered as the assessment unit due to paucity of block-wise data. Hilly areas having slope more than 20% are deleted from the total area to get the area suitable for recharge). The average thickness of saturated unconfined aquifer below ground level as obtained from dug wells / bore wells in the district has been considered.

The Pre-monsoon (month of March) Water Level from Monitoring Wells of CGWB in Hailakandi district has been considered as the maximum depth below ground level up to which the zone of water level fluctuation occurs. Since the north eastern states receives pre-monsoon showers, which commences from the first week of April, resulting in rise in water levels in the phreatic zones, the deepest water levels are recorded during the month of March. Specific yield value of 0.10 is considered for the district.

Finally, the Static Ground Water Resource is computed from the data as obtained:

Y = A* (Z1- Z2) * Sy:

where, Y = Static ground water resources,

A = Area of ground water assessment unit

Z1 = Thickness of saturated unconfined aquifer below ground level

Z2 = Pre-monsoon water level;

Sy = Specific yield of the unconfined aquifer.

Name of the assessment unit	Type of rock formation	Total Geographical Area (Ha)	Assessment Area (Ha)	Bottom of the unconfined aquifer (m)	Average Pre-monsoon Water Level (m)	Thickness of the saturated zone of the unconfined aquifer below WLF zone (m) [(5)-(6)]	Volume of Saturated zone of the unconfined aquifer below WLF zone (Ham)
1	2	3	4	5	6	7	8
Hailakandi district	Alluvium	132700	86808.2239	30.0	2.53	27.47	2384622

Static/In-storage Ground Water Resources (Ham)= Volume of saturated zone X specific yield

= 2384622 X 0.1

= 238462.20 Ham

Chapter 5 - Groundwater Related Issues

The main groundwater issues in this area are its vulnerability issue. These include areas vulnerable to water logging as well as prone to water logging conditions along with Iron concentration in ground water above the WHO permissible limit. The vulnerability map of Hailakandi district has been shown in Figure 5.1.

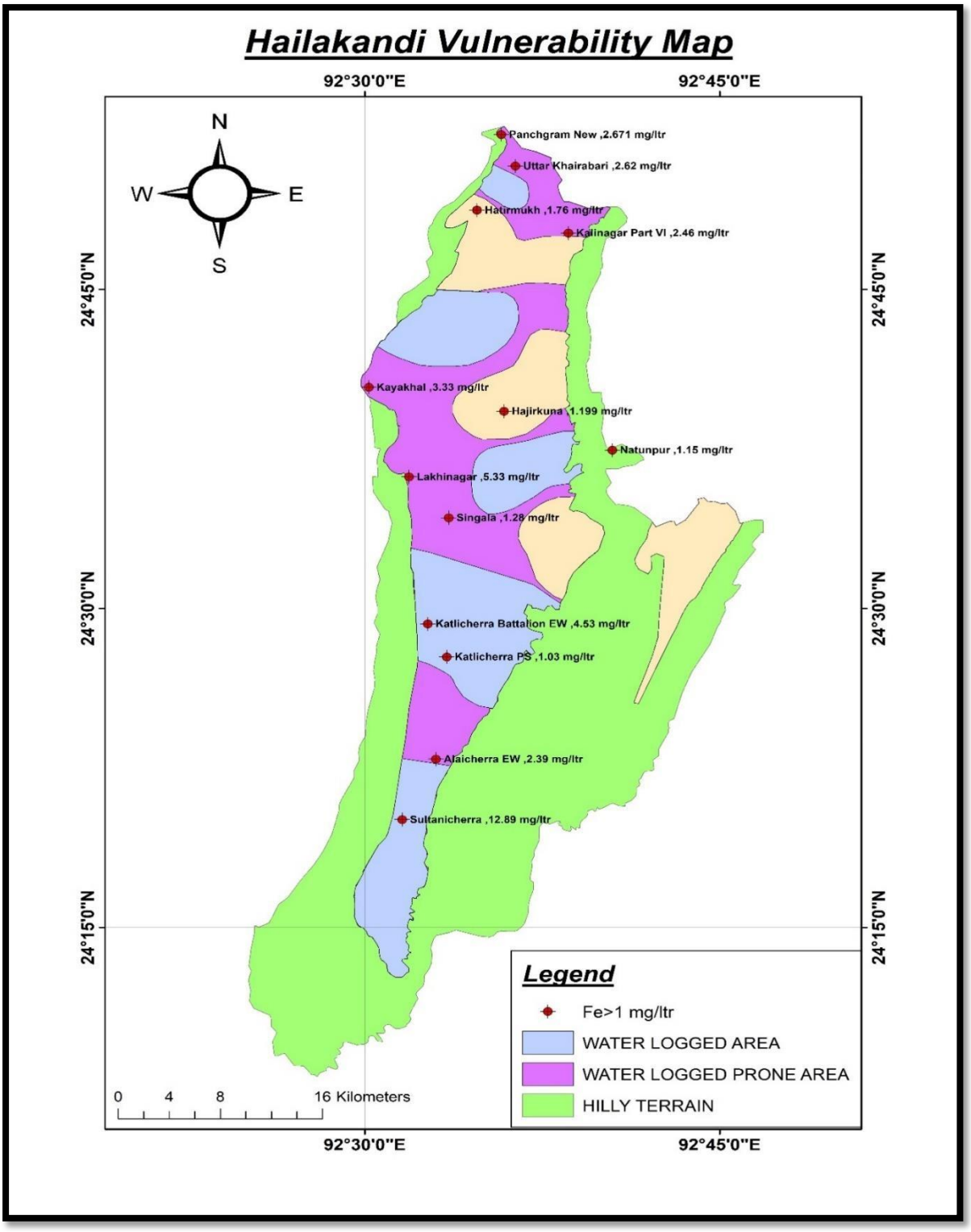


Fig 5.1: Vulnerability Map of Hailakandi District, Assam

5.1 Area vulnerable to water logging condition

It has been seen from the pre monsoon water level data that major part of the study area is perennially in water logged or prone to water logged condition. In the Figure 5.1, it can be seen that this vulnerable area is spread over major part of the central alluvial plain on the synclinal valley. 238 Km² area is water logged and 216 sq. Km² is prone to water logging. The post monsoon depth-to-water level varies from 0.45 to 4.24 mbgl. Even in pre-monsoon season the depth-to-water level varies from 0.69 to 6.97 mbgl.

The alluvium cover in the water-logged area is clayey in nature. The groundwater flow gradient from south to north is very sluggish. With high rainfall and low stage of ground water development along with poor drainage facility in the area causes water logging condition. Surface irrigation to such water-logged areas may add to the problem and further reduce the yield of crops. Proper use of surficial water and ground water along with adequate drainage will help towards solving the water logging problem.

5.2 High Iron concentration

In the water-logged areas high Iron concentration has been observed. In the Figure 5.1, the red points show the GWMS where Fe concentration in ground water have been found above the permissible limit of 1.0 mg/ltr set by WHO.

5.3 Low stage of ground water development

Physiographically, the area is divided into hills and valleys. The major groundwater development is taking place in the valley portion. The depth to water level map of the area shows that water level is within 5.0 m bgl in major part of the valley portion for both pre & post monsoon period. In addition to it, the groundwater development in the area is also very little. Therefore, artificial recharge for groundwater in the area is not required.

5.4 Water borne disease area

In the previous reports of CGWB's Ground Water Management Studies in Hailakandi district during AAP 2007-08, it has been reported that people living in the hilly terrain of the study area are used to take water for drinking purpose from the springs. In those areas and even in the rural areas, water borne diseases like Diarrhea, Dysentery and Gastro-enteritis is prevalent. These areas include hilly tracts along the Mizoram border. State government needs to take measures to construct safe drinking water sources.

Chapter 6 - Management Strategy

a. Future demand:

Future demand of ground water is analyzed for domestic, drinking and irrigation purposes. Domestic and drinking purpose: The drinking and domestic requirement is worked out for projected district population and requirement is considered as 70 litre per person per day. The district requirement up to 2025 is worked out and tabulated as below:

Table 6.1 – Hailakandi population and GW demand projected to 2025

District	Decadal Growth rate 2011-2021	Population as per 2011 Census	Population (Projected)		Annual Requirement (in Ham) @70 lpcd	Dependency on Ground Water	Projected Ground Water Demand considering per person water need of 70 litre per day (Ham)	
		2011	2019	2025			2019	2025
Hailakandi	21.45	659296	772431	871843	1973.56	46 %	901.67	1019.71

Irrigation purposes:

As per dynamic ground water resource estimation of Hailakandi district for 2019-20, net ground water availability for future use is 20010.65 Ham and stage of development is only 5.09 %. The current annual gross GW extraction for irrigation is 26.88 Ham. If an irrigation plan is made to develop 25% of the net ground water available for future use, then 5000 Ham of groundwater resources is available in the district for the future irrigation uses. Considering a unit draft of 0.42 Ham/year, from this available resource (planned for future development) 11037 nos. of tube wells (depth up to 50 m) can be constructed. Therefore, there is enough scope for future development of ground water in the study area to bring more area under irrigation practice. Present land under irrigation during kharif season is 2842 Ha, during rabi season it is 1765 Ha. Present minor irrigation schemes are using surface water sources only. Present irrigation from ground water sources is almost nil. (Source – District Irrigation Plan, Hailakandi district) Hence, there is ample scope for ground water development for irrigation purpose which will bring prosperity to the society and help the district in achieving self-reliance on food grain.

During 2019-20, net sown area in the district is 44147 Ha, gross cultivated area is 59450 Ha and cropping intensity is 135%. The net cultivated area included field crops as well as horticulture. Cropping intensity is calculated generally from field crops, which are of short duration. During kharif season, paddy is cultivated in 37086 Ha. After Kharif crops are over major portion of this area remains fallow during Rabi season. The land use pattern of Hailakandi district has been shown in Table 6.2.

Table 6.2 – Land use pattern details of Hailakandi district

Parameter	Area (Ha)
Total geographical area	132700
Net sown area	44147
Irrigated area	2801
Double cropping area	11410
Cropping intensity	135 %
Gross cropped area	59450
Forest area	57600
Wasteland area	7254
Other use area	23699
Total rain fed area	41346

***Source- District Irrigation Plan, Hailakandi District.**

To use the groundwater for irrigation purpose a cropping plan has been designed for the district by using CROPWAT 8 model developed by FAO. With the help of this plan, the fallow land can be utilized by bringing it under assured irrigation during Rabi season which will help to increase the cropping intensity up to 200%. In this rice fallow, potato, mustard, pulses, winter and summer vegetables can be grown with the support of irrigation. Cropping pattern data for the district is presented in Table 6.3.

Table 6.3 – Cropping pattern data of Hailakandi district

Crop Name	Planting date	Harvest date	Area (%)
Rice	01-Jun	28-Sep	12.5
Rice	08-Jun	05-Oct	12.5
Rice	15-Jun	12-Oct	12.5
Rice	22-Jun	19-Oct	12.5
Mustard	30-Nov	13-Apr	10
Pulses	30-Oct	16-Feb	5
Pulses	10-Dec	29-Mar	5
Potato	15-Oct	21-Feb	5
Potato	15-Nov	24-Mar	5
Winter Vegetables	10-Oct	12-Jan	5
Winter Vegetables	20-Oct	22-Jan	5
Summer Vegetables	25-Dec	29-Mar	5
Summer Vegetables	15-Jan	19-Apr	5

***Source - CROPWAT**

Present cropping pattern, proposed cropping pattern, targeted increase in cropping intensity were shown in Table 6.4

Table 6.4 – Cropping pattern, proposed cropping pattern of Hailakandi district

Cropping pattern (s)				
Winter Paddy - Winter vegetables - Potato - Pulses - Potato - Mustard - Pulses - Summer vegetables	Present Cultivated area	Area to be cultivated	Area to be cultivated	Irrigation requirement
	(Ha)	**(%)**	**(Ha)**	**(Ham)**
Cultivated Area	**37086**			
	1	2 (= % of 1)	3	4
Rice (main crop)	37086	100	37086	5773
Mustard	462.5	20	7417.2	722
Pulses	0	20	7417.2	875
Potato	0	20	7417.2	1151
Winter Vegetable	0	20	7417.2	928
Summer Vegetable	0	20	7417.2	396
Total	**37548.5**		**74172**	**9845**
Net cultivated area	**37086**		**37086**	
Gross cultivated area (Rice+Pulses+Mustard+Potato+Winter Veg+Summer Veg)	**37548.5**		**74172**	
Total irrigation requirement (70% irrigation efficiency)				**14065**
Cropping intensity	**101**		**200% (Intended)**	

The total area of rice cultivation comprises of 50% (37086 Ha) of the targeted gross cultivated area of (74172 Ha). Since this huge area cannot be cultivated in a single day (one planting date), so it is considered/ planned to cultivate the crops in stages. During kharif season, rice is cultivated from first week of June to first week of July in four phases of 25% of the 37086 Ha. During Rabi season, on the Kharif paddy fallow land of 37086 Ha, Pulses are cultivated in two phases, first 10% in October and next 10% in December. Oil Seed is cultivated from November over 20% of the target area. Potato cultivation is done in the two phases, first 10% in October and next 10% in November. The winter vegetables are cultivated over 10% area in second and fourth week of October each. Summer vegetables are cultivated over 10% area in December and 10% in January. The assured irrigation is aimed to be provided to the Kharif paddy fallow land during Rabi season only.

Depending on the cropping pattern and area sown, a crop-wise and month-wise irrigation water requirement (Precipitation deficit) for the entire year has been estimated from CROPWAT 8 software after giving necessary meteorological, soil, crop plan inputs and the same has been shown in Table 6.5.

Table 6.5-Crop-wise and month-wise precipitation deficit (mm) using CROPWAT 8 for Hailakandi dist.

Precipitation Deficit (mm)													
Sr. No	**Crop**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
1	Rice	0	0	0	0	151	0	0	0	0	0	0	0
2	Rice	0	0	0	0	92	51	0	0	0	0	0	0
3	Rice	0	0	0	0	91	90	0	0	0	7	0	0
4	Rice	0	0	0	0	0	142	0	0	0	0	0	0
5	Mustard	44	24	0	0	0	0	0	0	0	0	1	29
6	Pulses	58	9	0	0	0	0	0	0	0	3	8	61
7	Pulses	39	39	3	0	0	0	0	0	0	0	0	16
8	Potato	57	22	0	0	0	0	0	0	0	0	22	68
9	Potato	57	38	0	0	0	0	0	0	0	0	8	38
10	Winter Vegetables	21	0	0	0	0	0	0	0	0	2	35	63
11	Winter Vegetables	38	0	0	0	0	0	0	0	0	2	27	63
12	Summer Vegetables	34	30	0	0	0	0	0	0	0	0	0	10
13	Summer Vegetables	16	17	0	0	0	0	0	0	0	0	0	0

Crop-wise and month-wise Irrigation water requirement in Ham has been further calculated in Table 6.6

Table 6.6- Irrigation water requirement (Ham) of Hailakandi district

Irrigation water requirement (in Ham) for different crops in Hailakandi district, Assam																	
Sr. No.	**CROP**	**Area (%)**	**Gross cultivated area (Ha)**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**TOTAL IWR**	**Ham/ crop**
1	Rice	12.5	9271.5	0	0	0	0	1398	0	0	0	0	0	0	0	1398	5773
2	Rice	12.5	9271.5	0	0	0	0	850	472	0	0	0	0	0	0	1322	
3	Rice	12.5	9271.5	0	0	0	0	845	831	0	0	0	63	0	0	1738	
4	Rice	12.5	9271.5	0	0	0	0	0	1315	0	0	0	0	0	0	1315	
5	Mustard	10	7417.2	323	177	0	0	0	0	0	0	0	0	7	214	722	722
6	Pulses	5	3708.6	216	34	0	0	0	0	0	0	0	10	29	228	516	875
7	Pulses	5	3708.6	145	145	10	0	0	0	0	0	0	0	0	59	359	
8	Potato	5	3708.6	212	82	0	0	0	0	0	0	0	0	81	253	627	1151
9	Potato	5	3708.6	213	140	0	0	0	0	0	0	0	0	30	141	523	
10	Winter Vegetables	5	3708.6	76	0	0	0	0	0	0	0	0	9	129	234	448	928
11	Winter Vegetables	5	3708.6	139	0	0	0	0	0	0	0	0	9	99	232	480	
12	Summer Vegetables	5	3708.6	127	111	0	0	0	0	0	0	0	0	0	35	273	396
13	Summer Vegetables	5	3708.6	59	65	0	0	0	0	0	0	0	0	0	0	123	
		100	74172	1510	754	10	0	3093	2617	0	0	0	90	376	1396	9845	9845
Gross irr. Requirement with 70% irr. Efficiency (Ham)				2157	1077	14	0	4419	3739	0	0	0	129	537	1994		14065

The peak water requirement for irrigation for Pulses is in the month of January, Mustard in the January, for Potato it is in the month of January, for Winter vegetables it is in the month of December, for Summer vegetables it is in the month of January. With respect to the cropping pattern, annual irrigation required to achieve 200% cropping intensity is 9845 Ham. With 70 irrigation efficiency, the annual gross irrigation requirement is 14065 Ham/yr. But due to abundant rainfall in the region during the kharif season, the assured irrigation shall be provided during dry season spanning from October to March. The irrigation requirement during dry season is 4136 Ham. With 70 irrigation efficiency, the required irrigation is 5907 Ham.

Under ground water exploration programme, CGWB has constructed 10 bore wells in the district and has established that the shallow aquifer (up to 50 m) in most part of the district is having very low potentiality, having an average discharge of about 3.5 m^3/hr, while deeper aquifer at depth of 150m has a discharge of 10 m^3/hr. The shallow aquifer can be sustainably developed and use for irrigation purpose. A bore well in the area is expected to yield 3.5 m^3/hr. If such a bore well runs for 10 hrs/day for 120 days, then it will create a draft of 0.42 Ham. To extract the 5907 Ham groundwater for irrigation purpose, 14065 bore wells of depth 50 m and 8" diameter casing pipe can be constructed.

In considered net sown area of 44147 Ha, 11037 nos. of shallow bore wells can be constructed (considering 200m distance between any two shallow bore well). 11037 nos. of bore wells can extract 4636 ham of water annually. Rest of the 1272 Ham of water required for irrigation has to be covered from the surficial water like streams, nalas. Figure 6.1 shows the Aquifer Isopach Map (up to 50m depth) for Hailakandi district. From the Figure no. 6.1 showing the Aquifer Isopach Map, it can be said that the shallow aquifer present within 50 m depth has maximum thickness of 30-45 m in the central part of the valley area. The area north and south of it has aquifer thickness of 15-30 m within the 50m zone and towards the southern part of the valley, the thickness of aquifer is between 0-5m. This granular zone of 5.0 m consists of very fine sand which can't be tapped. Hence, it can be said, that the shallow aquifer zone is least in the southern part of the valley. Bore wells in this part of the area will not fetch enough water.

The surface water can be used where sufficient ground water is not available for irrigation purpose. Hence, for all the district, a conjunctive use of groundwater and surficial water is recommended for irrigation purpose. Shallow borewells for groundwater irrigation for all the district and in the South Hailakandi block along areas with thin shallow aquifer can opt for deep borewell and surface water like streams, nalas for irrigation purpose.

Groundwater in the area is infested with iron, therefore before consumption aeration/ filtering/ installation of Iron Removal Plant is necessary.

The aquifer system in the study area is a multi-aquifer type. From the 2D section it is clear that there is variation of lithology as clay, sand and clayey sand in the study area. In the alluvium plains and flood plains, the depth to water level in both the season remains within 5.0m bgl. The water going into the aquifer does not recharge it as the aquifer remains fully saturated, causing major parts of the alluvial plain and flood plain to be in water logged condition. It is observed that the groundwater resource of this area is not sufficiently utilized for economic development of the area evident from the low stage of groundwater extraction of 5.09%. If more bore wells are made, then the stage of groundwater development will increase leading to room for recharge of the aquifer and water logging conditions can be managed.

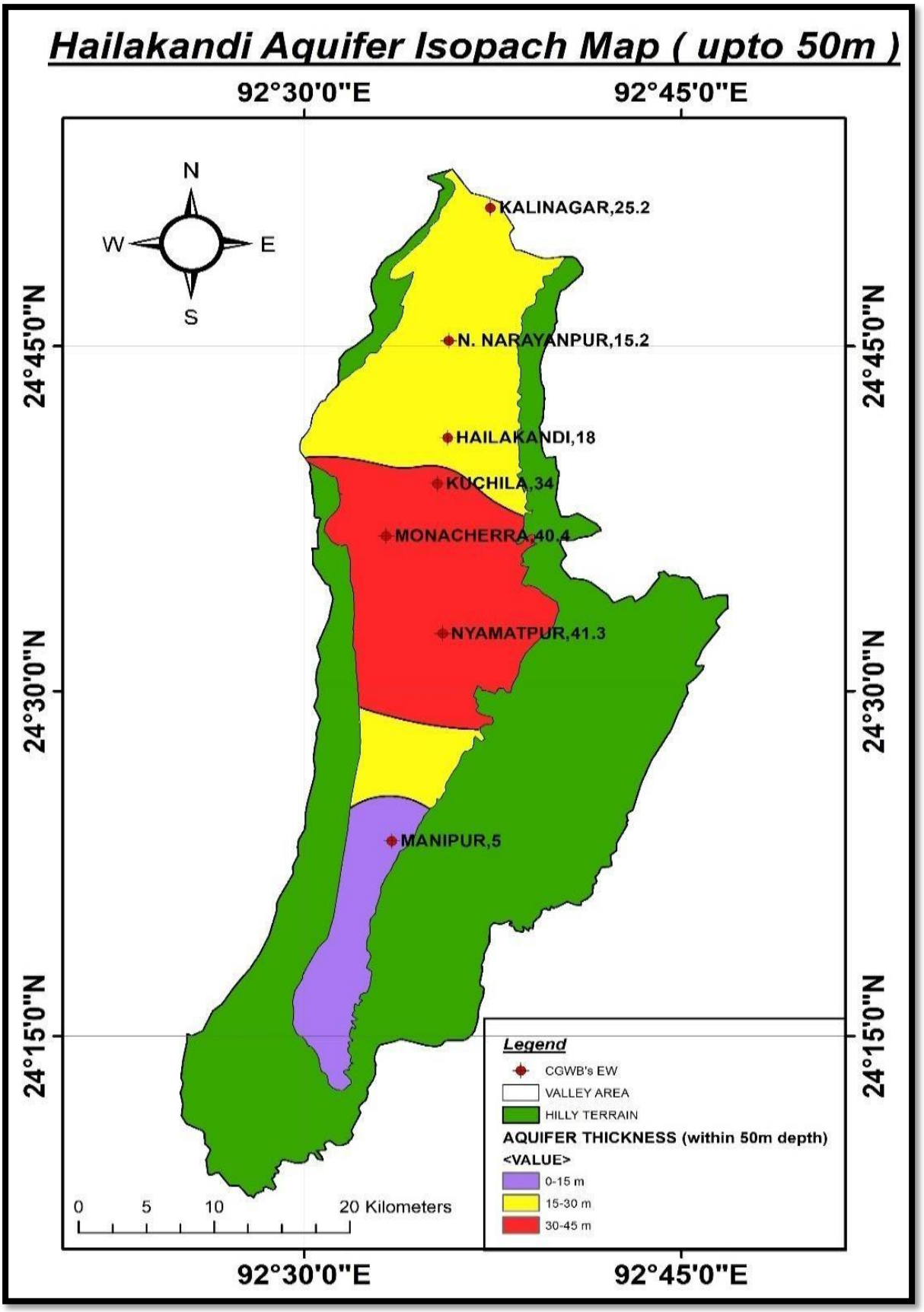


Fig 6.1- Aquifer Isopach Map (up to 50 m depth) of Hailakandi district

Table 3.1 - Geophysical logging report for Kuchila EW, Hailakandi

GEOPHYSICAL DIGITAL LOGGING REPORT AT KUCHILA SEED FARM, HAILAKANDI DISTRICT				
Sl. No.	**Depth**		**Thickness (m)**	**INFERRED LITHOLOGY**
	From (m)	**To (m)**		
1	0	7	7	TOP SOIL/CLAY
2	7	15	8	**COARSE SAND**
3	15	24	9	**FINE SAND**
4	24	35	11	**MEDIUM SAND**
5	35	40	5	FINE SAND MIX WITH CLAY
6	40	53	13	**MEDIUM TO FINE SAND**
7	53	61	8	SANDY CLAY
8	61	63	2	**FINE SAND**
9	63	79	16	SANDY CLAY
10	79	92	13	**FINE SAND**
11	92	102	10	CLAYEY SAND
12	102	119	17	**MEDIUM TO FINE SAND**
13	119	127	8	SANDY CLAY
14	127	131	4	**FINE SAND**
15	131	134	3	SANDY CLAY
16	134	140	6	**FINE SAND**
17	140	153	13	SANDY CLAY
18	153	158	5	CLAYEY SAND
19	158	165	7	CLAY
20	165	171	6	**FINE SAND**
21	171	183	12	CLAYEY SAND
22	183	192	9	**FINE SAND**
23	192	212	20	SANDY CLAY
24	212	218	6	**MEDIUM TO FINE SAND**
25	218	240	22	SANDY CLAY
26	240	262	22	CLAYEY SAND
27	262	268	6	SANDY CLAY
28	268	300	32	CLAYEY SAND
Conductivity of mud samples of KUCHILA SEED FARM, DEPT OF AGRICULTURE, LALA, HAILAKHNDI, ASSAM			**Conductivity (µS/cm)**	**Resistivity (Ω - m)**
MUDPIT			492	20.33
SOURCE WATER			28	357.14

Table 3.2- Geophysical logging data for Kuchila EW, Hailakandi

GEOPHYSICAL DIGITAL LOGGING REPORT OF KUCHILA SEED FARM, HAILAKANDI DISTRICT								
GRANNULAR (AQUIFER) ZONES								
Sl. No.	**Depth (m)**		**Thickness (m)**	**FORMATION GEOPHYSICAL PARAMETERS**				
	From	**To**		**SP (mV)**	**RES (16") (Ωm)**	**RES (64") (Ωm)**	**N GAMMA (API)**	**Inferred Lithology**
1	40	53	**13**	95-107	110-249	59-312	45-70	**MEDIUM TO FINE SAND**
2	79	92	**13**	102-117	19-117	23-127	42-76	**FINE SAND**
3	102	119	**17**	97-116	31-155	25-169	47-73	**MEDIUM TO FINE SAND**
4	127	131	**4**	103-115	22-63	32-74	48-75	**FINE SAND**
5	134	140	**6**	101-112	39-136	43-150	46-72	**FINE SAND**
6	165	171	**6**	89-109	19-122	23-136	49-79	**FINE SAND**
7	183	192	**9**	87-98	42-137	49-156	43-71	**FINE SAND**
8	212	218	**6**	78-95	37-116	45-123	40-77	**MEDIUM TO FINE SAND**
PROMINENT CLAY ZONES								
1	158	165	**7**	105-114	10-19	17-22	88-117	**CLAY**
Conductivity of Mud and Source water samples of KUCHILA SEED FARM, DEPT OF AGRICULTURE, LALA, HAILAKHNDI, ASSAM						**Conductivity (µS/cm)**		**Resistivity (Ω - m)**
MUDPIT						492		20.33
SOURCE WATER						28		357.14

Table 3.3 - Geophysical logging report for Manipur EW, Hailakandi

GEOPHYSICAL DIGITAL LOGGING REPORT AT MANIPUR SEED FARM, HAILAKANDI DISTRICT				
Sl. No.	**Depth**		**Thickness (m)**	**INFERRED LITHOLOGY**
	From (m)	**To (m)**		
1	0	9	9	TOP SOIL/CLAY
2	9	20	11	FINE SAND MIX WITH CLAY
3	20	43	23	MEDIUM TO COARSE GRAIN SAND MIX WITH CLAY
4	43	71	28	SANDY CLAY
5	71	90	19	CLAYEY SAND
7	90	95	5	**FINE SAND**
8	95	101	6	CLAYEY SAND
9	101	143	42	**COARSE TO MEDIUM GRAIN SAND**
10	143	174	31	CLAYEY SAND
11	174	185	11	**FINE SAND**
12	185	195	10	SANDY CLAY
13	195	224	29	CLAYEY SAND
14	224	227	3	CLAY
15	227	233	6	**FINE SAND**
16	233	235	2	SANDY CLAY
17	235	244	9	**FINE SAND**
18	244	255	11	SANDY CLAY
19	255	267	12	CLAY
20	267	300	33	CLAYEY SAND
Conductivity of mud samples of Manipur Seed farm, Hailakandi district			**Conductivity (µS/cm)**	**Resistivity (Ω - m)**
MUDPIT			92	108.70
SOURCE WATER			48	208.33

Table 3.4 - Geophysical logging data for Manipur EW, Hailakandi

GEOPHYSICAL DIGITAL LOGGING REPORT OF MANIPUR SEED FARM, HAILAKANDI DISTRICT								
GRANNULAR (AQUIFER) ZONES								
Sl. No.	**Depth (m)**		**Thickness (m)**	**FORMATION GEOPHYSICAL PARAMETERS**				**Inferred Lithology**
	From	**To**		**SP (mV)**	**RES (16") (Ωm)**	**RES (64") (Ωm)**	**N GAMMA (API)**	
1	90	95	**5**	104-123	25-140	29-48	40-81	**FINE SAND**
2	101	143	**42**	71-122	45-264	50-280	33-78	**COARSE TO MEDIUM GRAIN SAND**
3	170	185	**15**	92-132	35-180	41-190	39-79	**FINE SAND**
4	227	233	**6**	70-116	30-147	43-88	41-79	**FINE SAND**
5	235	244	**9**	48-105	46-259	51-190	27-81	**FINE SAND**
PROMINENT CLAY ZONES								
1	71	90	**19**	111-127	18-25	22-32	59-110	**CLAYEY SAND**
Conductivity of Mud and Source water samples of Manipur Seed farm, Hailakandi district						**Conductivity (µS/cm)**		**Resistivity (Ω - m)**
MUDPIT						92		108.70
SOURCE WATER						48		208.33

Table 3.5 – Geophysical logging report at Boalipar SIPRD EW, Hailakandi

GEOPHYSICAL DIGITAL LOGGING REPORT AT BOALIPAR SIPRD, HAILAKANDI DISTRICT				
Sl. No.	**Depth**		**Thickness (m)**	**INFERRED LITHOLOGY**
	From (m)	**To (m)**		
1	0	7	7	TOP SOIL/CLAY
2	7	20	13	**FINE SAND**
3	20	25	5	**COARSE SAND**
4	25	34	9	**FINE SAND**
5	34	49	15	**MEDIUM SAND**
7	49	68	19	SANDY CLAY
8	68	76	8	**FINE SAND**
9	76	95	19	SANDY CLAY
10	95	105	10	**FINE SAND**
11	105	120	15	**MEDIUM TO FINE SAND**
12	120	127	7	SANDY CLAY
13	127	132	5	**FINE SAND**
14	132	143	11	SANDY CLAY
15	143	150	7	**FINE SAND**
16	150	164	14	SANDY CLAY
17	164	168	4	**FINE SAND**
18	168	196	28	SANDY CLAY
19	196	200	4	**FINE SAND**
20	200	211	11	SANDY CLAY
21	211	221	10	**FINE SAND**
22	221	232	11	SANDY CLAY
23	232	264	32	**MEDIUM TO FINE SAND**
24	264	274	10	SANDY CLAY
25	274	278	4	**FINE SAND**
26	278	305	27	SANDY CLAY
Conductivity of mud samples of BOALIPAR, HAILAKANDI, ASSAM			**Conductivity (µS/cm)**	**Resistivity (Ω - m)**
MUDPIT			576	17.36
SOURCE WATER			226	44.25

Table 3.6 – Geophysical logging data at Boalipar SIPRD EW, Hailakandi

GEOPHYSICAL DIGITAL LOGGING REPORT OF BOALIPAR SIPRD, HAILAKANDI DISTRICT								
GRANNULAR (AQUIFER) ZONES								
Sl. No.	**Depth (m)**		**Thickness (m)**	**FORMATION GEOPHYSICAL PARAMETERS**				
	From	**To**		**SP (mV)**	**RES (16") (Ωm)**	**RES (64") (Ωm)**	**N GAMMA (API)**	**Inferred Lithology**
1	105	120	**15**	76-85	18-106	31-130	48-78	**MEDIUM TO FINE SAND**
2	143	150	**7**	71-78	24-133	37-159	49-79	**FINE SAND**
3	211	221	**10**	49-58	16-111	25-131	44-80	**FINE SAND**
4	232	264	**32**	17-53	15-140	24-178	53-79	**MEDIUM TO FINE SAND**
PROMINENT CLAY ZONES								
1	278	308	**30**	76-92	10-47	18-37	54-106	**SANDY CLAY**
Conductivity of Mud and Source water samples of BOALIPAR, HAILAKANDI, ASSAM						**Conductivity (µS/cm)**		**Resistivity (Ω - m)**
MUDPIT						576		17.36
SOURCE WATER						226		44.25

Table 3.7- Aquifer property delineated from CGWB' s EW in Hailakandi

District	Block	Location	Latitude	Longitude	Depth of Drilled (m.b.g.l)	Zones / Fractured encountered upto 50 m.b.g.l	Zones / Fractured encountered upto 100 m.b.g.l	Zones / Fractured encountered upto 200 m.b.g.l. l	Zones / Fractured encountered up to 300 m.b.g.l. l	Static Water level (mbgl)	Discharge (m^3/hr)	Draw Down (m)	T (m2/ day	Storativity (S)
Hailakandi	Lala	Nyamatpur EW	24.54167	92.59167	279.20	42-57	91-97	104-110, 115.3-127, 167.7-185.7		3.89	78.47	12.57	191.59	
	Algapur	Kalinagar EW	24.85000	92.62333	299.80		55-67, 78-90	125-140,160-175		5.93	85.05	5.22	934.46	
	Hailakandi	Hailakandi EW	24.68333	92.59500	299.70	41.20-47.20	58-64,80-83,86-95,97-106,	110-112,128-137,145-148		9.17	78.47	9.17	416.52	
	Lala	Monachara EW	24.61250	92.55417	50.00	08.00-14.00					1.67	1.62	36.97	
	Algapur	N.Narayanpur EW	24.75389	92.59583	50.00						5.40	2.51	79.00	
	South Hailakandi	Alaicherra EW	24.38178	92.55014	116.00		94-100	100-104		8.00	11.87			
	Katlicherra	Katlicherra EW	24.48781	92.54440	139.70		76-82	125-131		2.65	8.11	12.85	86.84	
	Hailakandi	Kuchila Farm EW	24.65024	92.58826	305.50			104-107, 111-117, 137-140, 166-169, 188-191	213-216	4.8	83.5	10.16	238.9	4.2*10^-3
	South Hailakandi	Manipur Farm EW	24.39123	92.55797	305.50		90-95	101-143, 170-185	227-233, 235-244	12	60.4	9.43	893.7	3.4*10^-4
	Hailakandi	Boalipar SIPRD EW	24.71182	92.56986	305.50			105-120, 143-150	211-221, 232-264	4.3	83.5	10.66	219.9	1.13*10^-4

Annexure 3.5

Table 3.9 - Pre & Post Monsoon DTWL and fluctuation data of Key wells

BLOCK	LOCATION	PRE-MONSOON DTW (mbgl)	POST MONSOON DTW (mbgl)	FLUCTUATION (m)
Algapur	Uttar Khairabari	2.82	1.92	0.90
	Panchgram New	4.29	4.24	0.05
	Raman chandra school	0.69	0.53	0.16
	Kalinagar	4.54	2	2.54
	Kalinagar Part VI	2.4	1.4	1.00
	North Narayanpur	3.39	2.9	0.49
	Mohanpur Grant	2.85	1.15	1.70
	Hitarmukh Chandipur Part II	3.67	1.9	1.77
	Chandipur Part III	2.42	1.49	0.93
	Banasbari Part II	6.97	3.26	3.71
	Banasbari Part I	1.63	0.93	0.70
	Syedbond Part II	1.1	0.45	0.65
Hailakandi	Bhajantipur Part I Bono Bazar	3.7	2.44	1.26
	Hajirkuna	3.9	2.84	1.06
	Sibuttar	1.44	1.00	0.44
	Kayakhal	2.97	2.12	0.85
	Lakhirbond Part I	1.92	1.52	0.40
Katlicherra	Kattlicherra Alexanderpur	1.4	1.40	0.00
	Katlicherra PS	1.72	1.04	0.68
	Sonacherra	1.56	1.50	0.06
	Kabuli tila Dholai	1.84	0.76	1.08
	Rupcherra LP School	1.45	1.27	0.18
Lala	Moonacherra railway station	2.37	1.92	0.45
	Lakhinagar	2.08	0.53	1.55
	Singala	2.02	1.30	0.72
	Rajyeswarpur Part V	1.2	0.50	0.70
	Lalamukh	3.69	3.15	0.54
	Lalacherra	3.46	2.46	1.00
	Vernerpur	1.92	1.17	0.75
	Sudarshanpur	1.86	0.80	1.06
South Hailakandi	Shibbari mahadevbari	3.71	3.62	0.09
	Jamira state dispensary	1.84	0.61	1.23
	Sultanicherra	0.73	0.47	0.26

Table 3.11 – Chemical data of GWMS of Hailakandi district (Post-monsoon)

Location	Block	Latitude	Longitude	Type of Well	Temp °C	pH	EC (µs/cm) 25°C	Turbidity (NTU)	TDS	CO3-2	HCO3-1	TA (as CaCO3)	Cl-	SO4-2	NO3-1	F-	Ca+2	Mg+2	TH (as CaCO3)	Na	K	Fe
Uttar Khairabari	Algapur	24.84667	92.60611	DW	24.72	7.14	191.50	0.10	114.300	0.000	90.072	90.072	24.815	20.582	0.000	0.070	22.018	7.271	85.000	17.400	2.270	1.436
Panchgram New	Algapur	24.87139	92.59611	DW	24.44	6.34	127.80	0.00	73.440	0.000	15.012	15.012	21.270	68.623	0.000	0.100	4.003	9.707	50.000	19.500	4.940	2.671
Raman Chandra School	Algapur	24.83436	92.59895	DW	24.56	7.78	406.10	0.00	233.300	0.000	240.192	240.192	17.725	35.272	0.000	0.230	42.034	21.824	195.000	17.470	8.240	0.488
Kalinagar	Algapur	24.84722	92.62833	DW	24.78	7.09	221.30	0.00	127.300	0.000	95.076	95.076	28.360	38.511	0.000	0.130	24.019	13.338	115.000	16.390	3.650	0.318
Kalinagar Part IV	Algapur	24.80389	92.64389	DW	23.89	7.27	242.40	0.00	139.200	0.000	85.068	85.068	42.540	39.526	0.077	0.170	24.019	10.911	105.000	21.180	11.570	0.558
Mohanpur Grant	Algapur	24.73028	92.64167	DW	24.56	6.96	187.20	0.00	107.900	0.000	75.060	75.060	42.540	18.713	0.000	0.060	10.008	6.063	50.000	34.580	11.580	0.949
Hatirmukh	Algapur	24.80750	92.57806	DW	26.11	6.86	156.00	0.00	90.080	0.000	55.044	55.044	38.995	11.887	0.000	0.080	8.006	7.278	50.000	30.840	2.190	1.527
Chandipur Part III	Algapur	24.77944	92.57278	DW	25.56	7.09	79.14	0.00	45.390	0.000	45.036	45.036	14.180	8.454	0.000	0.040	8.006	7.278	50.000	5.620	1.160	0.057
Banasbari Part II	Algapur	24.75944	92.56361	DW	24.22	6.95	167.40	0.00	95.800	0.000	80.064	80.064	28.360	9.624	0.000	0.120	14.011	10.916	80.000	19.480	3.190	0.401
Banasbari Part I	Algapur	24.74389	92.54972	DW	24.94	7.59	198.80	0.00	114.100	0.000	100.080	100.080	24.815	14.068	0.000	0.150	30.024	7.267	105.000	10.520	2.960	0.181
Syedbond Part II	Algapur	24.73111	92.58167	DW	25.90	6.73	615.80	0.00	324.900	0.000	90.072	90.072	106.350	30.927	11.601	0.280	34.027	19.401	165.000	31.570	5.880	0.043
Hailakandi	Hailakandi	24.68111	92.56306	DW	25.8	8.88	200.80	0.10	128.512	0.000	55.044	55.044	17.725	44.929	1.079	0.120	12.010	10.917	75.000	12.510	3.460	0.216
Hajirkuna	Hailakandi	24.65444	92.59806	DW	22.78	7.10	151.60	0.00	87.714	0.000	60.048	60.048	24.815	23.681	0.000	0.110	20.016	3.631	65.000	17.270	4.890	1.199
Kayakhal	Hailakandi	24.67333	92.50278	DW	26.11	7.21	475.20	0.10	270.900	0.000	85.068	85.068	173.705	47.116	0.000	0.080	24.019	18.192	135.000	84.060	10.290	0.394
Natunpur	Hailakandi	24.62917	92.67472	DW	26.83	7.14	97.08	0.00	54.960	0.000	45.036	45.036	24.815	5.452	9.980	0.000	22.018	4.844	75.000	7.030	2.160	0.258
Lakhirbond Part I	Hailakandi	24.71167	92.57028	DW	23.28	7.69	214.60	0.00	121.400	0.000	110.088	110.088	21.270	23.596	0.000	0.120	14.011	24.265	135.000	5.520	4.370	0.009
Burakhai	Hailakandi	24.62925	92.69139	DW	25.80	7.15	1554.00	0.00	831.800	0.000	325.260	325.260	414.765	35.590	3.394	0.630	60.048	43.660	330.000	98.960	16.600	0.274
Lalamukh 1	Lala	24.56400	92.63917	DW	25.3	8.22	50.93	0.00	32.595	0.000	30.024	30.024	10.635	4.061	0.000	0.000	6.005	2.424	25.000	3.840	4.570	0.968
Lakhinagar	Lala	24.60325	92.53139	DW	24.5	8.44	309.20	0.00	197.888	20.000	125.116	145.116	17.725	6.784	0.000	0.170	34.027	8.479	120.000	23.180	2.820	0.237
Moonacherra RS	Lala	24.60840	92.55010	DW	26.67	7.26	129.80	0.30	74.310	0.000	70.056	70.056	14.180	10.966	0.000	0.050	16.013	8.487	75.000	7.080	4.130	0.449
Lakhinagar	Lala	24.60306	92.53111	DW	24.17	7.06	270.40	0.00	154.800	0.000	100.080	100.080	38.995	26.135	0.000	0.130	22.018	10.912	100.000	20.450	19.410	5.689
Ishancherra	Lala	24.59639	92.50806	DW	25.06	7.66	294.70	0.00	168.800	0.000	155.124	155.124	28.360	11.240	0.000	0.250	28.022	25.472	175.000	9.320	1.810	0.081
Singala	Lala	24.57097	92.55912	DW	25.00	7.04	231.50	0.00	132.900	0.000	85.068	85.068	49.630	7.342	0.000	0.080	14.011	6.061	60.000	42.880	3.950	1.970
Rajyeswarpur Part V	Lala	24.60778	92.60444	DW	26.67	7.97	435.10	0.00	247.700	0.000	200.160	200.160	21.270	70.734	0.000	0.190	54.043	23.032	230.000	14.050	12.180	0.015
Lalamukh 2	Lala	24.56389	92.63889	DW	27.22	7.28	82.16	0.00	46.680	0.000	45.036	45.036	10.635	5.539	0.000	0.040	10.008	6.063	50.000	3.530	1.910	0.106
Lalacherra	Lala	24.52361	92.63028	DW	26.67	6.54	44.33	0.00	25.380	0.000	30.024	30.024	21.270	27.771	8.697	0.000	10.008	14.558	85.000	5.000	3.050	0.131
Khasia Ring (DBGP)	Lala	24.50417	92.66639	DW	24.44	7.93	318.90	0.00	181.600	0.000	195.156	195.156	14.180	13.452	0.000	0.100	4.003	30.338	135.000	34.700	3.060	0.042
Katlicherra Battalion	Katlicherra	24.48725	92.54296	DW	24.17	7.60	161.40	0.00	92.630	0.000	80.064	80.064	10.635	25.503	0.000	0.280	22.018	7.271	85.000	8.510	6.380	0.713
Katlicherra PS	Katlicherra	24.46194	92.55778	DW	26.72	7.50	487.40	0.00	276.200	0.000	170.136	170.136	74.445	55.039	0.000	0.240	32.026	26.683	190.000	58.930	5.690	0.295
Shibbari Mahadevbari	S.Hailakandi	24.42944	92.54642	DW	22.22	7.37	130.10	0.00	74.890	0.000	75.060	75.060	10.635	19.388	0.000	0.160	24.019	4.843	80.000	2.370	3.730	0.622
Sultanicherra	S.Hailakandi	24.33445	92.52630	DW	25.61	8.01	372.00	0.00	214.400	0.000	180.144	180.144	24.815	53.941	0.000	0.210	52.042	15.751	195.000	14.520	7.460	0.295

Table 3.10 – Chemical data of GWMS of Hailakandi district (Pre- monsoon)

Location	Block	Latitude	Longitude	Well	Temp (ºC)	pH	EC (µs/cm) @25ºC	Turbidity (NTU)	TDS	CO3-2	HCO3-1	TA (as CaCO3)	Cl-	SO4-2	NO3-1	F-	Ca+2	Mg+2	TH (as CaCO3)	Na	K	Fe
Uttar Khairabari	Algapur	24.846667	92.606111	DW	23.3	8.128	155.50	0.30	79.41	0.00	103.78	103.78	24.82	8.07	0.00	0.21	4.96	1.20	50.00	37.19	11.83	2.62
Kalinagar	Algapur	24.847222	92.628333	DW	24.6	7.860	303.9	0.10	156.3	0.00	103.78	103.78	42.54	92.93	19.69	0.28	79.97	19.41	115.00	1.27	1.28	0.19
Kalinagar Part VI	Algapur	24.803889	92.643889	DW	20.9	7.877	293.20	0.00	150.20	0.00	103.78	103.78	60.27	53.67	0.75	0.29	49.97	12.13	90.00	19.93	9.96	2.46
Mohanpur Grant	Algapur	24.730278	92.641667	DW	22.0	8.087	176.00	0.10	90.66	0.00	67.15	67.15	49.63	24.71	0.00	0.16	19.99	4.85	30.00	26.25	10.30	0.94
Raman Chandra School	Algapur	24.834360	92.598950	DW	24.2	8.561	447.60	0.00	233.70	12.00	311.35	323.35	21.27	43.72	15.15	0.21	109.92	26.68	205.00	5.50	3.87	0.14
Hatirmukh	Algapur	24.807500	92.578056	DW	23.7	7.841	223.60	0.50	117.30	0.00	103.78	103.78	49.63	19.93	0.00	0.13	34.98	8.49	65.00	30.23	1.22	1.76
Chandipur Part III	Algapur	24.779444	92.572778	DW	25.3	8.138	86.14	0.20	45.22	0.00	54.94	54.94	24.82	10.55	0.00	0.12	14.98	3.64	35.00	14.78	0.87	0.30
Banasbari Part I	Algapur	24.759444	92.563611	DW	25.6	8.493	290.70	0.00	151.20	12.00	195.36	207.36	31.91	59.57	7.97	0.16	89.96	21.83	140.00	2.07	3.60	0.58
Natunpur	Hailakandi	24.629167	92.674722	DW	22.6	8.099	188.30	0.00	96.86	0.00	97.68	97.68	42.54	8.96	0.00	0.11	24.97	6.06	65.00	25.85	4.20	1.15
Kayakhal	Hailakandi	24.673333	92.502778	DW	22.6	8.497	658.10	0.30	342.40	0.00	134.31	134.31	255.24	31.16	0.00	0.13	84.96	20.62	135.00	92.40	2.25	3.33
Moonacherra RS	Lala	24.608400	92.550100	DW	23.7	8.070	174.30	0.00	89.06	0.00	109.89	109.89	10.64	29.13	0.00	0.20	19.96	4.84	75.00	23.17	3.53	0.75
Lalacherra	Lala	24.523611	92.630278	DW	24.2	7.393	45.08	0.00	23.37	0.00	30.52	30.52	21.27	3.02	0.00	0.09	4.99	1.21	20.00	15.60	2.98	0.26
Khasia Ring (DBGP)	Lala	24.504167	92.666389	DW	24.2	8.609	361.40	0.40	187.60	12.00	274.72	286.72	10.64	27.53	7.97	0.15	89.97	21.84	125.00	3.60	2.61	0.11
Lalamukh	Lala	24.56400	92.63917	DW	24.0	8.039	57.13	0.10	29.53	0.00	48.84	48.84	21.27	4.43	0.00	0.07	19.98	4.85	40.00	1.68	1.25	0.22
Rajyeswarpur Part V	Lala	24.607778	92.604444	DW	22.6	8.495	519.90	0.20	270.80	12.00	274.72	286.72	35.45	80.25	0.00	0.16	164.95	40.04	225.00	13.11	11.91	0.05
Ishancherra	Lala	24.596389	92.508056	DW	24.2	8.620	331.30	0.10	173.20	15.00	225.88	240.88	35.45	90.70	18.97	0.22	114.96	27.90	165.00	2.09	1.30	0.15
Lakhinagar	Lala	24.603056	92.531111	DW	23.1	8.386	338.90	0.00	177.40	0.00	152.62	152.62	46.09	70.77	7.41	0.19	74.97	18.20	110.00	7.93	6.56	5.33
Singala	Lala	24.570970	92.559120	DW	22.6	8.089	252.80	0.10	133.30	0.00	97.68	97.68	67.35	14.51	0.00	0.12	14.97	3.63	55.00	43.17	19.79	1.28
Katlicherra PS	Katlicherra	24.461944	92.557778	DW	23.7	8.540	578.30	0.20	297.40	9.00	140.41	149.41	102.81	55.75	0.00	0.27	134.96	32.76	185.00	56.61	3.90	1.03
Kattlicherra Battalion	Katlicherra	24.487250	92.542960	DW	23.7	8.598	280.60	0.00	148.30	12.00	189.25	201.25	17.73	26.76	0.00	0.32	64.95	15.76	130.00	8.23	5.94	0.11
Sultanicherra	S.Hailakandi	24.334450	92.526300	DW	23.7	7.952	87.50	0.00	45.41	0.00	67.15	67.15	17.73	17.68	0.00	0.06	14.98	3.64	40.00	6.05	4.46	12.89
Shibbari Mahadevbari	S.Hailakandi	24.429440	92.546420	DW	22.0	8.427	248.10	0.00	129.50	15.00	231.99	246.99	24.82	51.58	0.00	0.15	149.99	36.40	165.00	11.74	9.56	0.28