केन्द्रीय 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

CACHAR DISTRICT
ASSAM

उत्तर पूर्वी क्षेत्र, गुवाहाटी
North Eastern Region, Guwahati

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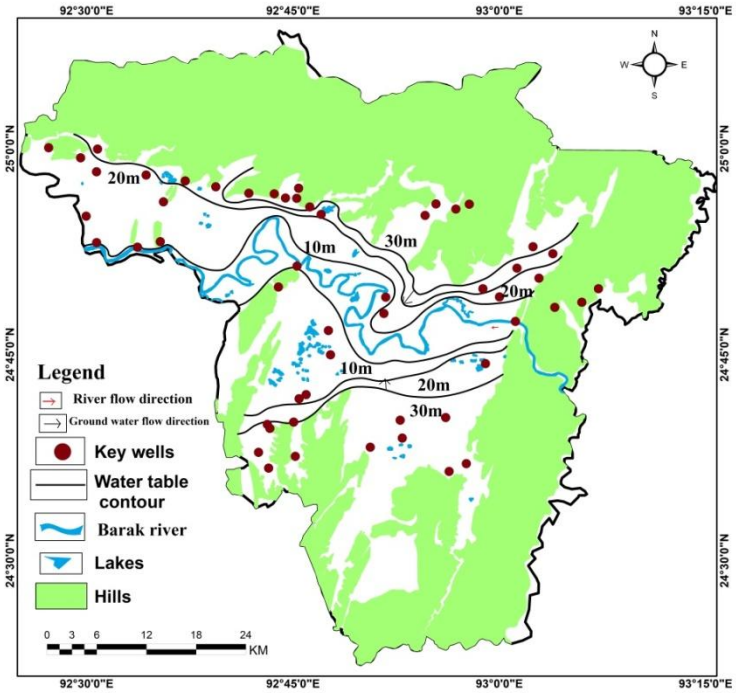
Central Ground Water Board
केंद्रीयभूजलबोर्ड
MINISTRY OF JAL SHAKTI
जलशक्तिमंत्रालय
Department of Water Resources, River Development and Ganga Rejuvenation
जलसंसाधन, नदीविकासऔरगंगासंरक्षणविभाग
GOVERNMENT OF INDIA
भारतसरकार

REPORT ON AQUIFER MAPPING AND MANAGEMENT PLAN OF CACHAR DISTRICT, ASSAM

कछारजिला, असमकीजलभुतमानचित्रणऔरप्रबंधनयोजनापरप्रतिवेदन
(AAP2021-2022)



NORTH EASTERN REGION
उत्तरपूर्वीक्षेत्र
GUWAHATI
गुवाहाटी
JUNE,2022

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

REPORT
ON

"REPORT ON AQUIFER MAPPING AND MANAGEMENT PLAN OF CACHAR DISTRICT, ASSAM"
(AAP 2021-22)

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EXECUTIVE SUMMARY

Aquifer Mapping Studies and Management Plan has been carried out in Cachar district, Assam under National Aquifer Mapping and Management Plan (NAQUIM) program with an objective to know the different aquifer system prevailing in the study area, to decipher the vertical and lateral extend of the aquifer down to the depth of 200 m, its characteristic, quantity as well as quality so as to bring a complete sustainable and effective aquifer management plan for ground water resources development in the study area. These studies have been done through multi-disciplinary approach so as to achieve the said objectives.

The total coverage area of aquifer mapping and management plan is 2734sq.km out of 3786 sq.km of the district and is underlain by alluvium and semi-consolidated rock of Sandstone.

Ground water occurs in the study area mainly in alluvium aquifer and sandstone. The different hydrogeological data are generated through intensive field data collection and testing. The aquifers present in the district can be divided into a two aquifer system viz., first aquifer (shallow) and second aquifer (deeper). Shallow or first aquifer consists of alluvium where ground water occurs under unconfined to semi confined condition and is mainly developed by construction of dug wells, shallow bore wells or hand pump. The second aquifer is the deeper aquifer constitute of sandstone. Based on the study of litholog and analysis of depth of construction of dug wells and shallow bore wells, it is found that the first aquifer occur within 5 to 50 m bgl. Ground water in the second aquifer occurs under semi-confined to confined conditionupto the maximum depth of 200 m bgl.

Study of water level trend and its behavior in phreatic aquifer were carried out in the aquifer mapping area.

In order to study the chemical quality of ground water in the district, water samples from aquifer (dug wells and tube wells) were collected during the course of field work. The samples were analyzed and found that there is a moderately high concentration of iron and arsenic in some of the dug well and tube well. Based on the analysisusing various method and chemical index such as sodium absorption ratio (SAR), sodium percentage(SP), residual sodium carbonate (RSC), Kelly's ratio Permeability index and magnesium ratio, it is found that the ground water in the district is suitable for irrigation purpose.

Dynamic Groundwater Resources of the study area has been estimated based on the methodology recommended by Groundwater Estimation Committee (GEC'2015). The net

ground water availability was 40443 ham and the stage of ground water extraction was 9.97% which comes under safe category.

Finally, the aquifer map of the study area is generated based on the inputs from geological, hydrogeological and hydrochemical studies and a management plan was made with an emphasis in providing irrigation facilities through ground water development as agriculture is the main means of livelihood of the people living in the district.

Acknowledgement

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

I would like to extend our heartfelt gratitude to Shri. Biplap Ray, HOO, CGWB, NER, Guwahati for his constant support and guidance during the course of this study.

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I would like to thank Dr. KeishamRadhapyari, Scientist-B (Chemist) and her team for analysing the ground water samples and providing the data.

I sincerely thank Geological Survey of India, North East Space Application Centre, Survey of India and Indian Meteorological Department for providing the valuable data and maps.

I would also like to thank Assam State Government officials of Irrigation Department, Public Health Engineering Department, Statistical Department and Agricultural Department for providing all the necessary information of the study area.

I thank all the officials and staff of CGWB, SUO, Shillong for their help and support during the course of this work.

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ABBREVIATION

AAP	Annual Action Plan
CGWB	Central Ground Water Board
NER	North Eastern Region
NAQUIM	National Aquifer Mapping and Management Plan
GL	Ground Level
GSI	Geological Survey of India
IMD	Indian Meteorological Department
LPM	Litres per minute
LPS	Litres per second
m	metre
mbgl	meters below ground level
MCM	Million Cubic Meter
Mm	Milli meter
mg/l	milligram/litre
mamsl	Metre above mean sea level
Sq.Km	Square Kilometre
µS/cm	Microsimens/centimetre
AMP	Aquifer Management Plan
AQM	Aquifer Mapping
BIS	Bureau of Indian Standards
BDL	Below detectable level
BCM	Billion Cubic Metres
DGM	Directorate of Geology and Mining
DTW	Depth to water table
DW	Dug Well
BW	Bore well
EC	Electrical Conductivity
EW	Exploratory Well
GEC	Ground water Estimation Committee
Ha	Hectare
Ham	Hectare meter
Km	Kilometer
MP	Measuring Point
OW	Observation Well
°C	Degree Celsius
Ppm	Parts per million equivalents to mg/l
Pz	Piezometer
SWL	Static water level
TDS	Total dissolved solid

Chapter 1.0

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

Cachar 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, 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. 83C/12, 83C/16, 83D/13, 83D/14, 83D/15, 83G/4, 83H/1, 83H/2, 83H/5 bounded by 25°5’0”N, 92°50’0”E in northern side and 24°25’0”N, 92°50’0”E in southern side while 24°45’0”N, 92°25’0”E in western side and 24°45’0”N, 93°15’0”E in eastern side covering an area of 3786 sq. km of Cachar district of Assam. The administrative details of the district have been furnished in Table 1.1 and the Base Map is attached as Figure 1.1.

Fig. 1.1: Base Map of Cachar District, Assam.

1.5 Administrative division

Administratively the district is now divided into two subdivisions viz. Silchar (Sadar) and Lakhipur. There are five revenue circles and fifteen community development blocks (CD) in the district.

Table1.1- District Statistics

No. Of Subdivision	No. Of Revenue circle	No. of development block	No. of villages	Total population (2011 census)
2	5	15	895	1736617

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

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

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

Sr No.	Theme	Type	Data availability	Data gap	Data generation	Total
1	Borehole Lithology Data		11		2	13
2	Geophysical Data		5		Nil	5
3	Groundwater Level Data	Dug Well	17		43	60
4	Groundwater Quality Data	Dug Well(DW) Exploratory well(EW)	17(DW) 11(EW)		57	85
5	Specific Yield		Nil	Nil	Nil	Nil
6	Soil Infiltration Test		10		3	13

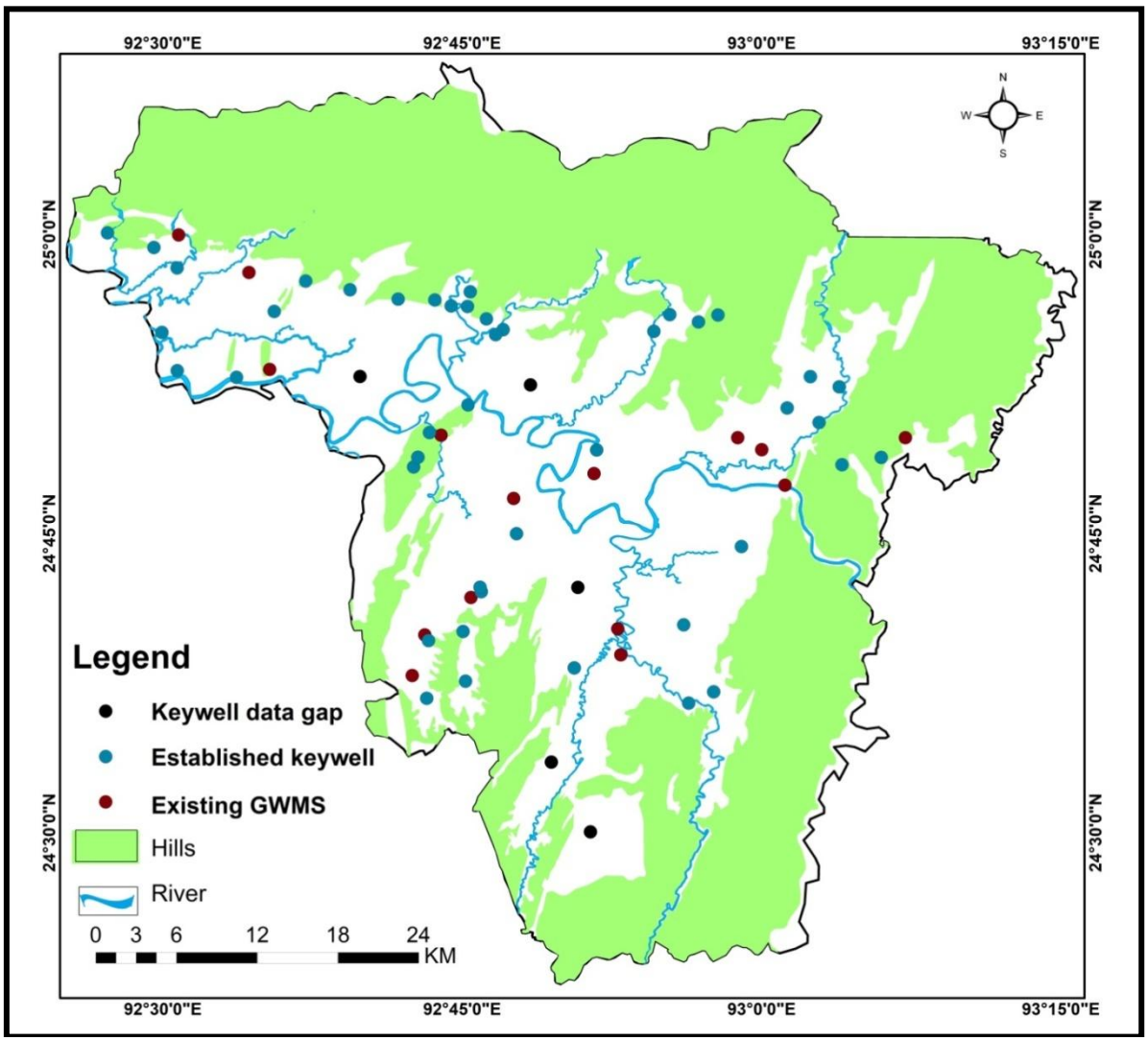


Fig. 1.2 : Data gap analysis of GW level monitoring station, Cachar, District, Assam.

In Cachar district key well data gap has been addressed in 48locations. However during AAP 2021-22, 43 key wells were established and 5 data gaps were not covered as no wells were found in those location during field work.

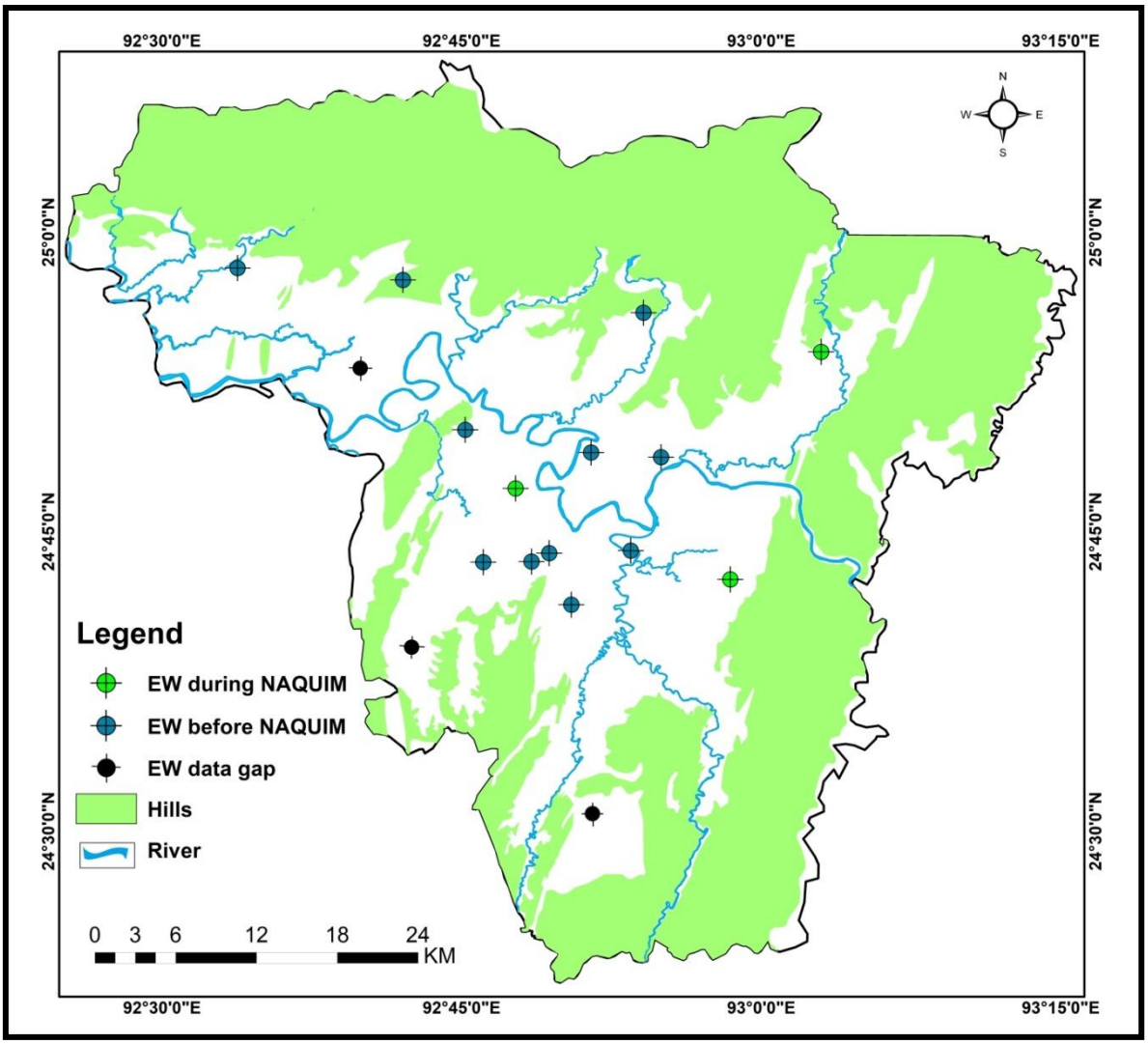


Fig. 1.3: Data gap analysis of exploration, Cachar, District, Assam.

In Cachar district exploratory well data gap has been addressed in 5location. During AAP 2021-22 two EW data gap was covered while remaining 3 data gap can be covered during future operation in the district. The proposal for drilling in those locations has already been sent to regional office.

1.5 Rainfall and climate

The district enjoys tropical climate with temperature varying from 35^{o}C in summer to 15^{o}C in winter. The humidity varies from 32% to maximum of 80% during July and October. The average annual rainfall is 3000mm, 80% of which is precipitated during the period from April to October. The period from December to March is practically dry. The hydrometeorogical details have been furnished in Table 1.3and the graphical illustration of the rainfall data is shown in Figure 1.4 respectively.

There are 3 rainfall stations in the district at Silchar, Kumbhirgram and Silkuri. The coefficient of variation and standard deviation of those rainfall station located in the district are 16.1%, 12.6%, 14.8% and 524mm, 428mm, 454mm respectively.

Table 1.3 – Hydrometeorogical data, Cachar district, Assam (Source- IMD)

Parameter	Details
Average annual rainfall	3291 mm
Maximum rainfall	March(1202 mm)
Minimum rainfall	December (0mm)
Average annual temperature	26 ° C
Maximum temperature	October(33.4 °C)
Minimum temperature	January (13.2°C)

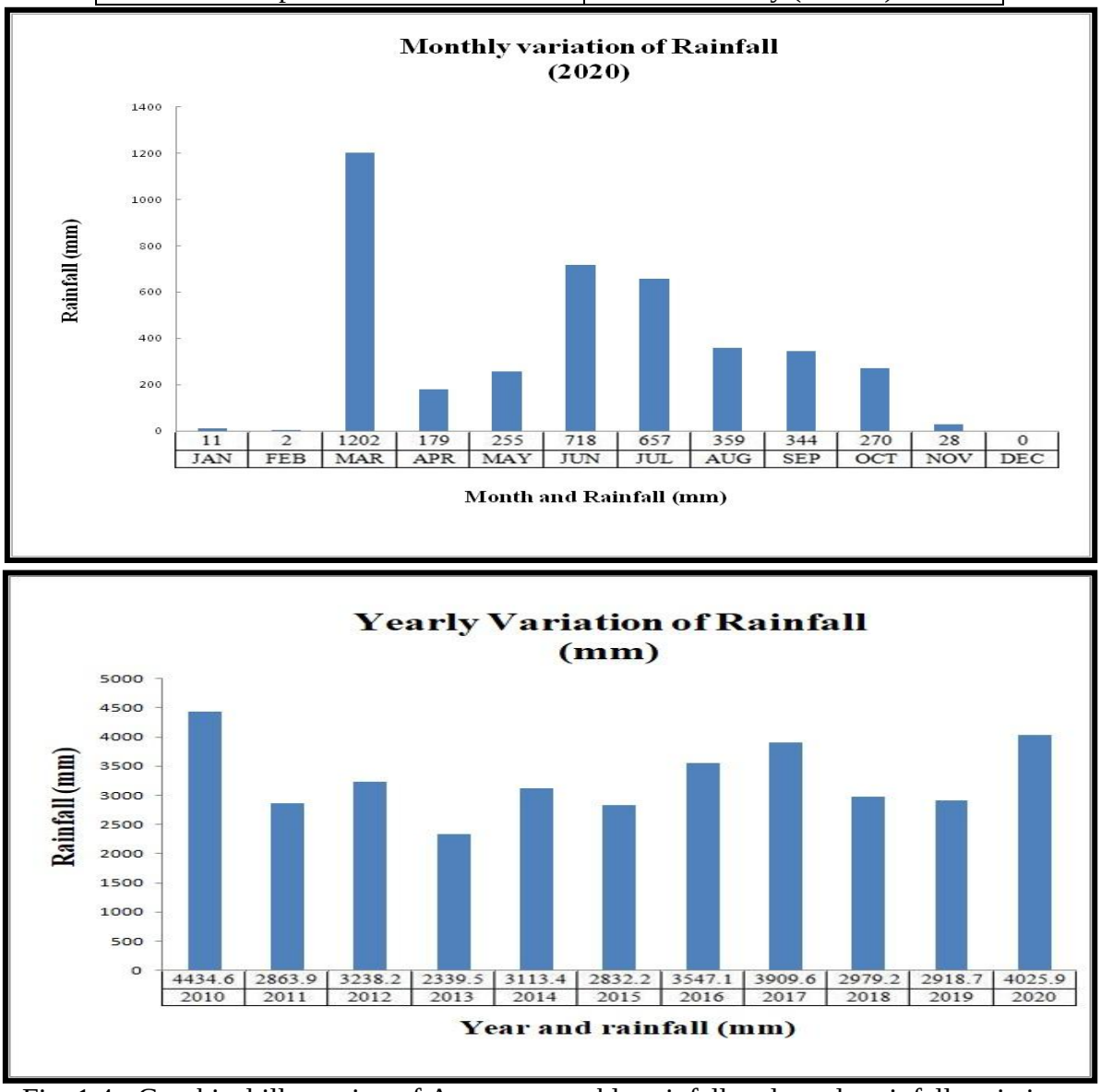


Fig. 1.4 - Graphical illustration of Average monthly rainfall and yearly rainfall variations

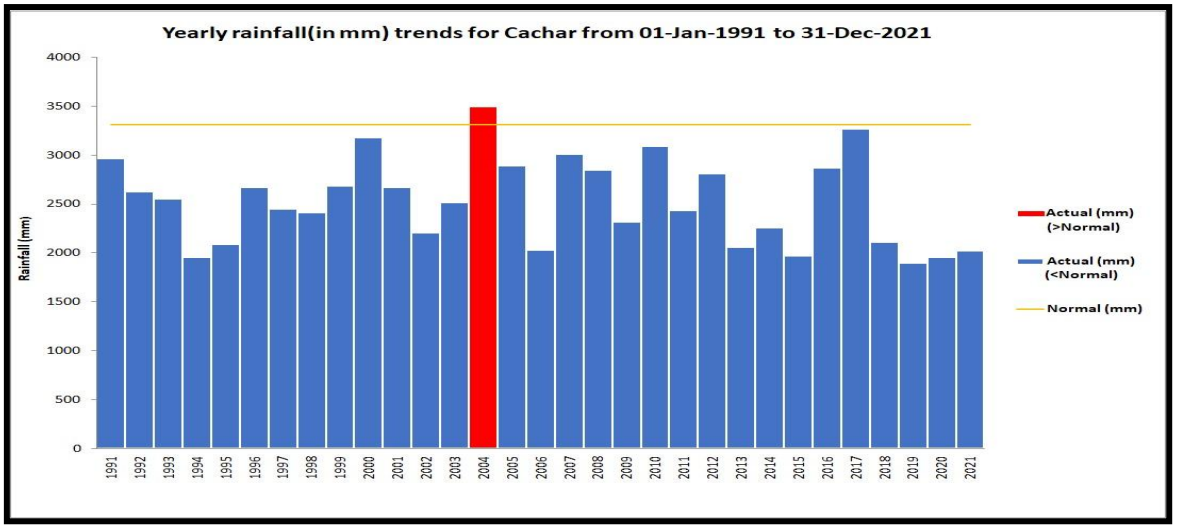


Fig1.4(a): Graph showing yearly average rainfall in Cachar district from 1991-2021

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

MONTH	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEPT	OCT	NOV	DEC
MIN TEMP °C	13.2	14.1	25.2	20.1	23.6	25.8	26	26.4	26	25.6	18.1	14.1
MAX TEMP °C	24.1	27	32.4	33.2	32.1	31.9	32.4	30.2	33.1	33.4	29.8	26
AVG TEMP °C	18.65	20.55	28.8	26.65	27.85	28.85	29.2	28.3	29.55	29.5	23.95	20.05

1.6 Geomorphology

The major geomorphic features observed in the area are both structural and topographic 'highs' and 'flats' and are in accordance with the normal first order structural elements suggesting comparatively recent orogenic movement in the area and immature topography.

The 'highs' comprise areas of Barak, Sonai and Katakhal reserve forests. The total area occupied by the hills is 750 sq km and the maximum height attained by the anticlinal hills is 512 meters above mean sea level in the Barak reserve forest. It is observed that the central part of these hill ranges which have a north-south trend show the highest elevation.

The 'flats' essentially form the central portion of the area and can be called Silchar- Dhalai and Hailakandi- Lala synclinal valleys. The total area occupied by these flat valleys is 900 sq km. The average elevation of the plains is 30m above mean sea level. The valleys are broad and flat with low to moderate Bed Relef index (Mathur and Evans,1964).

The southern foot of E-W running Barail ranges forms the low lying hilly terrain to the northof Barak river. It is intervened by broad valleys like Dalu and Madhura.

One salt spring at Noonkhuli near Lalmati area, Srikona is reported from the area. Gas seepages are associated with the spring and are found within the Bhuban Formation of Surma Group and along the fault line.

According to the slope map prepared using DEM data, around 3012Km^2 area of the district has less than 20% slope while around 896 Km^2 area of the district has more than 20%

slope. Those area having less than 20% slope are considered ground water recharge worthy area as per GEC 2015 norms.

The geomorphology map and slope map of the district are shown in fig 1.5 and fig 1.6 respectively.

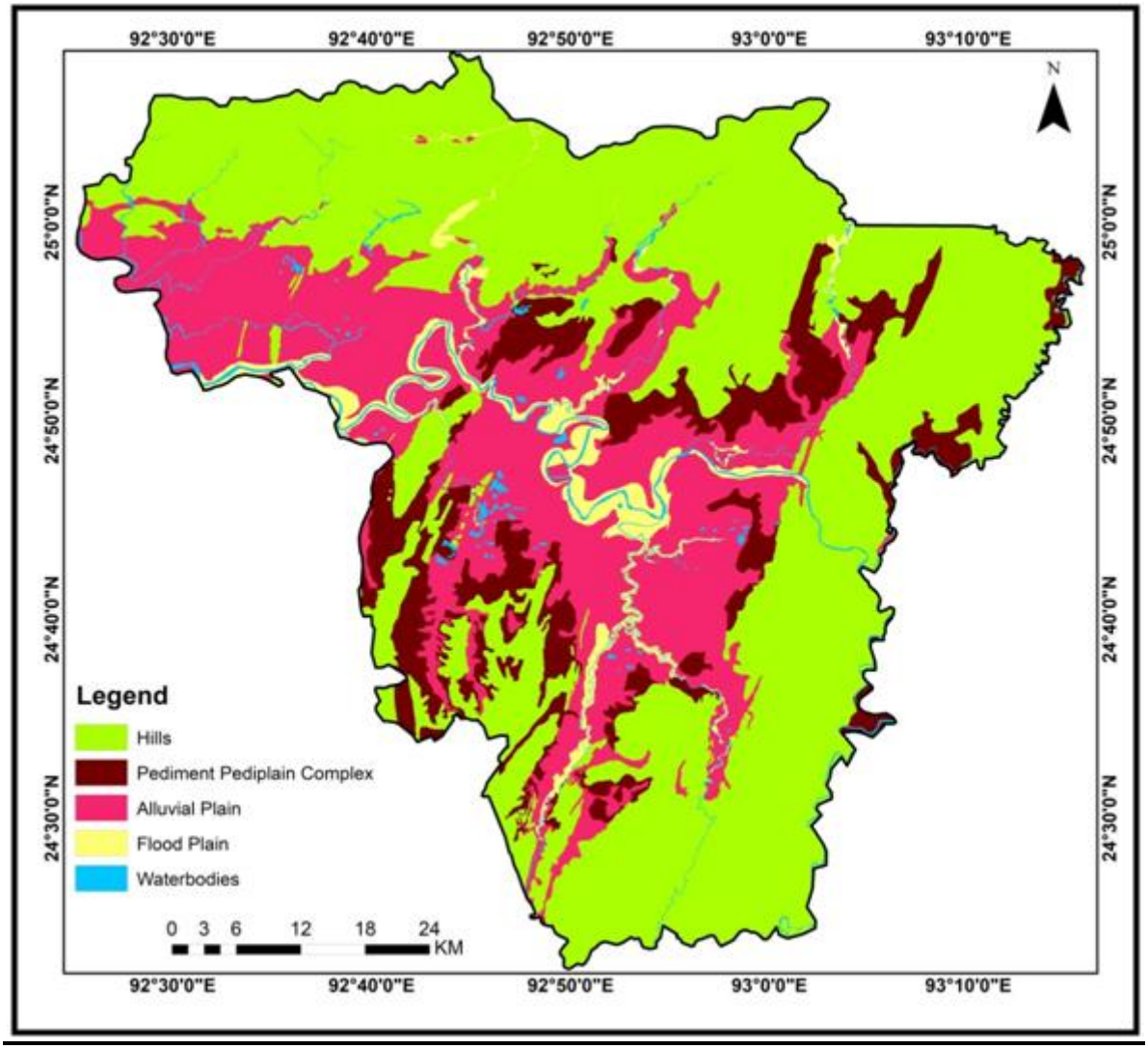


Fig. 1.5: Geomorphological Map, Cachar District, Assam.

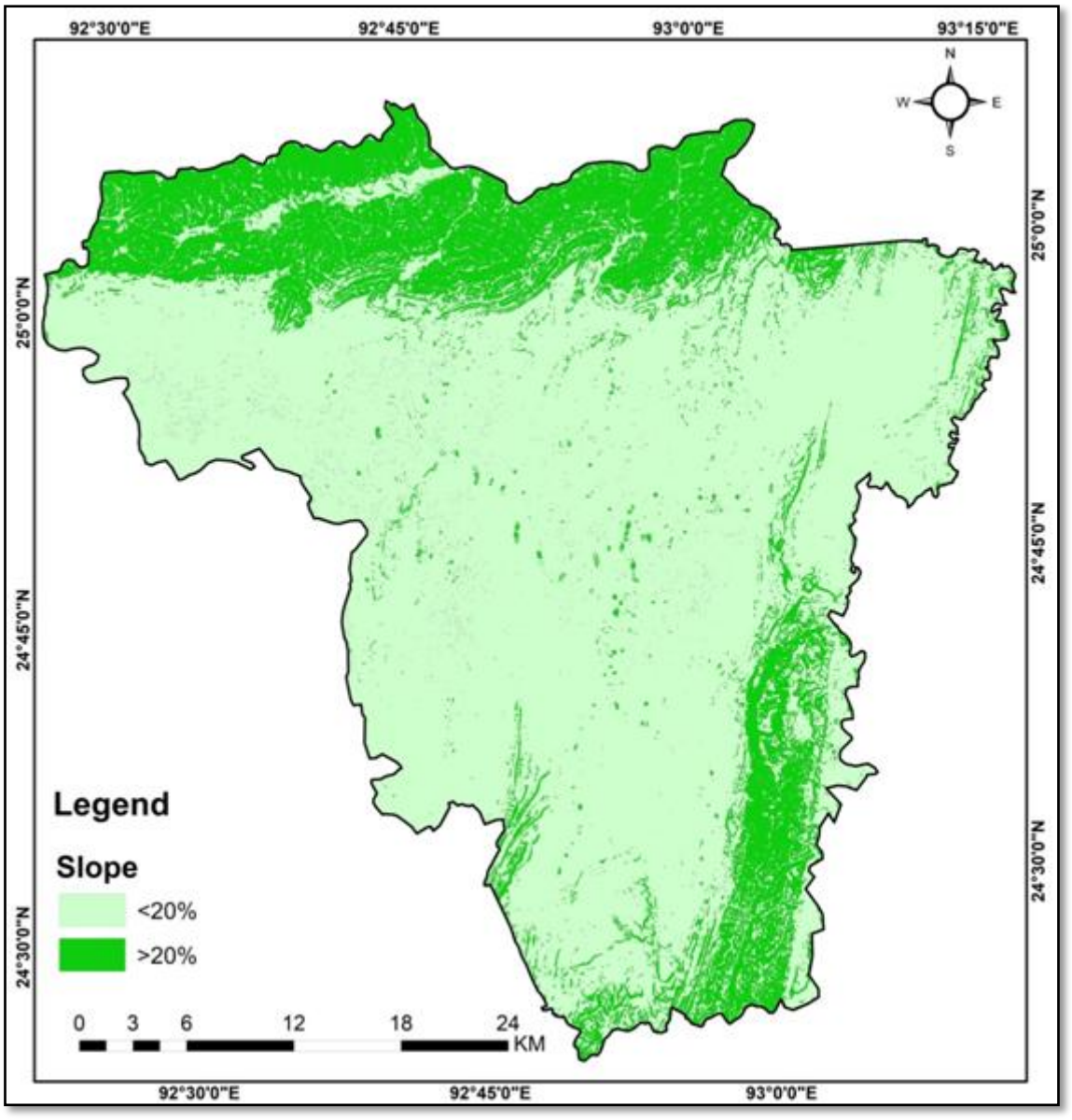


Fig. 1.6: Slope Map, Cachar, District, Assam.

1.7 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 (Quaternary). The regional strike of the folded geosynclinals facies sequences is NNE-SSW. The geological succession of the area is shown in Table 1.5.

Table 1.5 – Geological Succession, Cachar district, Assam.

SYSTEM	SERIES	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
	UNCONFORMITY			
	Oligocene	Barail Group	Renji Formation	Massive bedded sandstone
			Jenam Formation	Shale, Sandy shale and carbonaceous shale with interbedded hard sandstone.
			Laisong Formation	Well bedded compact flaggy sandstone and subordinate shale.

The Geology map of the district is shown in Figure 1.7

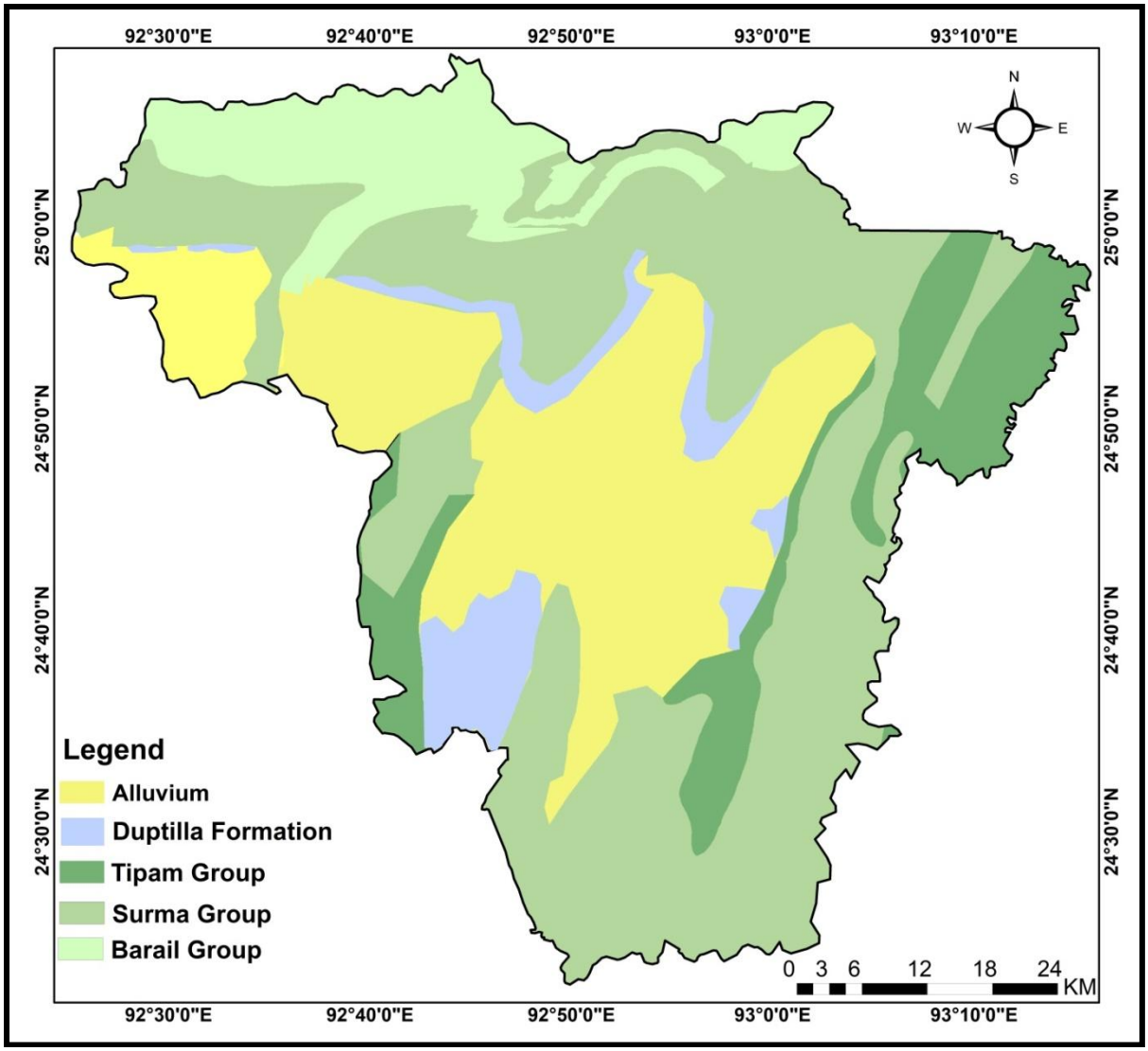


Fig. 1.7 – Geology Map, Cachar ,District, Assam.

1.8 River and Drainage

Barak river and its tributaries control the entire drainage system in the area and inundate large area annually. The Barak river originates in the southern slopes of the mountain ranges north of Manipur and after flowing to north again touching the northern top of Mizoram and then it flows westward through Cachar district and joins the Kushiara river, ultimately meeting the Surma and forms the Meghna in Bangladesh. The upper reaches of Barak are marked by steep banks and several falls and the river is highly meandering with many oxbow lakes. The total length of the river upto its out fall in Meghna is 900kmof which 560 km is within the Indian Territory. The catchment area of Barak river uptoBadarpur is 25900 sq km.

The anticlinal hill ranges form the watershed from which various drainage channel emerged. The common drainage pattern is sub parallel to parallel and dendritic. In general, drainage pattern of the area is in conformity with the topography, which area structurally controlled.

The drainage map of the district is shown in Fig.1.8.

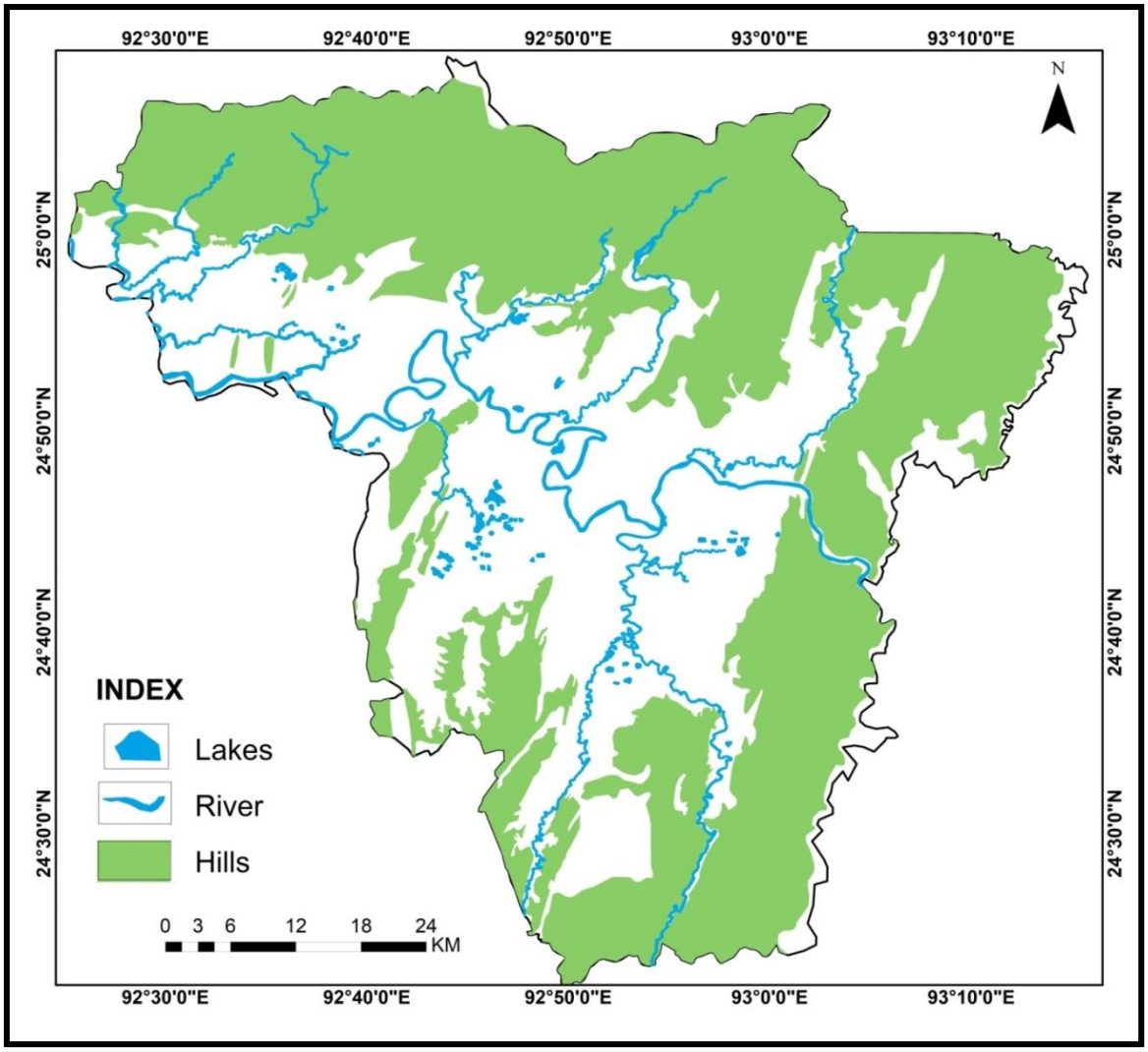


Fig. 1.8 – Drainage Map, Cachar District, Assam

1.9 Hydrology

The major river in the district is Barak along with its tributaries Jiri, Chiri, Madhura, Jatinga, Sonai, Kathakal and others flows through the centre of the plain valley of the district. 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. There are many small ponds available in the district area. These ponds are mainly used for fish cultivation and also for domestic purpose. These water bodies cover an area of about 2611 Ha. These ponds are rarely used for irrigation purpose as they don't have sufficient water during dry period.

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.

1.10 Soil

Both residual and transported soils are found in the study area. The residual soils on the hills are loamy sands and support dense vegetation with bamboos, bananas and grass vegetation. Tea is exclusively grown on the hill slopes.

The transported soils mostly comprise clay, silts and sands are found in plains. Due to predominance of clay, the soil in the area has low water absorption capacity and as such pools of water are seen accumulated in low lying areas. Due to enormous amount of surface run off during the rainy season the flood plains are enriched every year with the suspended silt and clay brought by the rivers, thus contributing towards annual replenishment of the fertility of the soils where rice, jute and sugarcane are extensively grown. Due to clayey nature of the soil moisture retention capacity is high.

The soil map of the district is shown in Figure 1.9.

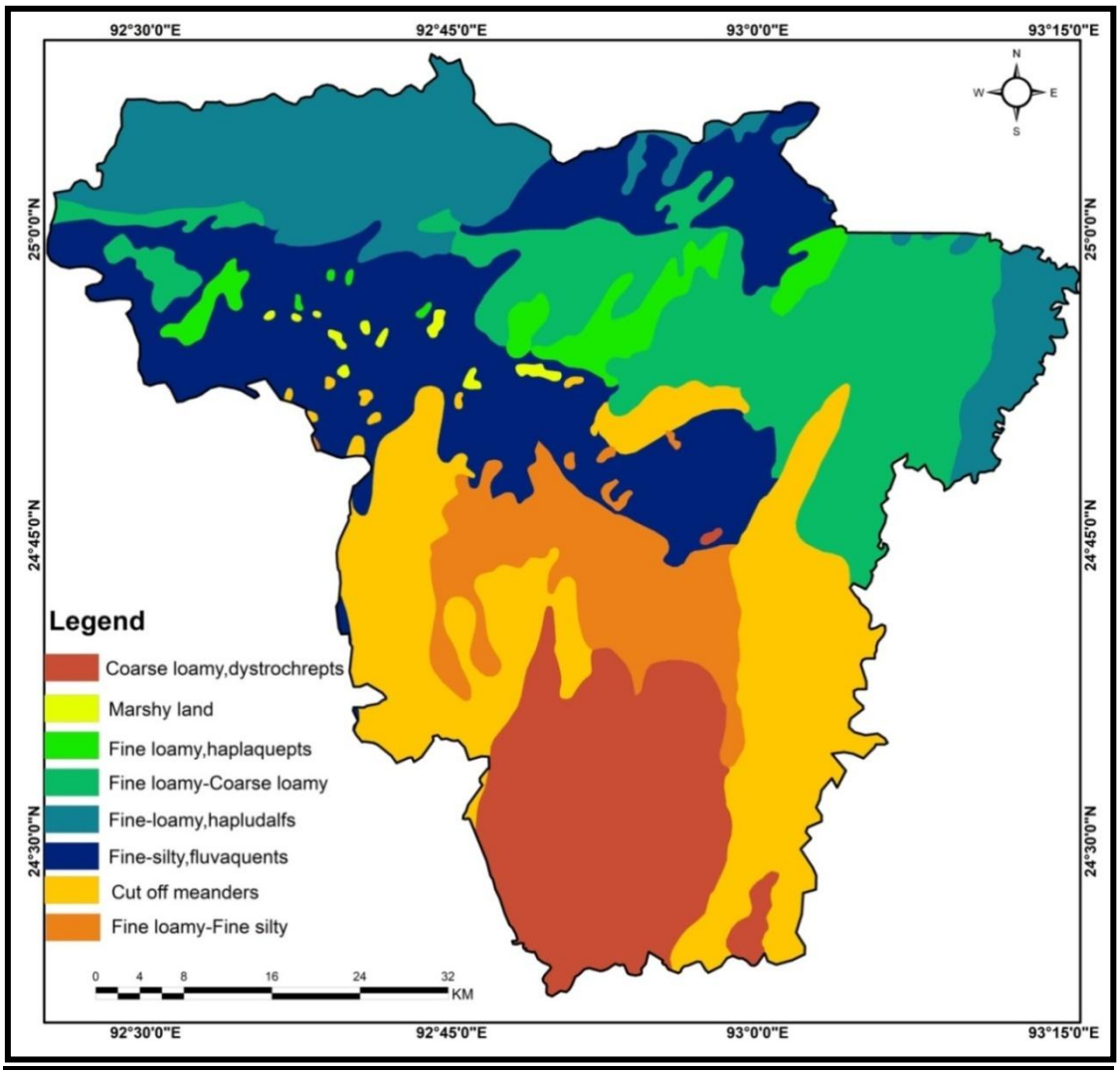


Fig. 1.9 : Soil Map, Cachar District, Assam.

1.11 Agriculture

Among the 15 agro-climatic regions of the country, categorized/identified on the basis of homogeneity in agro characteristics, Cachar falls in the Barak Valley zone. The agro climatic conditions of the district are conducive for various agricultural activities like development of the plantation crops viz., tea, rubber, cashew, coffee, areca nut, coconut and also aromatic plant like Patchouli. The types of land available in the district are classified as: medium land 69048 Ha, high land 11642 hectares, low land 19512 hectares, very low land 10792 hectares and beel area 4735 hectares.

Crops cannot be grown in more than 20 percent of geographical areas of the district during April to September due to water stagnation. On the other hand due to lack of rain from November to April, most of the cultivable land remains fallow during the period. The district falls under Barak river basin. The district has a total forest cover of 2225 sq.km area which is 58.77 percent of its total geographical area as per the estimates of Forest Survey of India. The dense forest cover in the district is 45 percent while 55 percent of the forest cover is under open forest. The District is a heterogeneous plain composed of both low lands and high hills and level plains. Actually the whole of the District lies at the foot hills of the nearby sates of Manipur and Mizoram and that of the DimaHasao district 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. 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:

Total geographical area(Ha)	Cultivable Area(Ha)	Net cropped area(Ha)	Gross cropped Area(Ha)	Cropping intensity	Autumn Paddy (Ha)	Winter paddy (Ha)	Summer Paddy (Ha)
378600	146219	125000	188765	150.94%	8346	93845	8865

Source: Agricultural department website

1.12 Land use pattern

Agriculture is the principal occupation of the people of Cachar district. Table No 1.6.(Area in Hectare)

Table 1.6 –Land use pattern, Cachar district, Assam.

SI. No	Land put to different uses	Area in Ha
1	Total geographical area	377610
2	Forest area	138409
3	Land not available for cultivation	89148
a	Land put to nonagricultural uses	61447
b	Barren and un- cultural land	27701
4	Other non cultivated land excluding fallow land	21745
a	Permanent pastures and other grazing land	2600
b	Land under misc trees, groves etc not included in net area	17108

c	Cultivable waste land	2037
5	Fallow land	12922
a	Fallow other than current fallow	6071
b	Current fallow	6851
6	Net area sown	115386
7	Total cropped area	160728
8	Area sown more than once	45342

Source: Statistical handbook, 2012

The Land use land cover map of the district is shown in Figure 1.10.

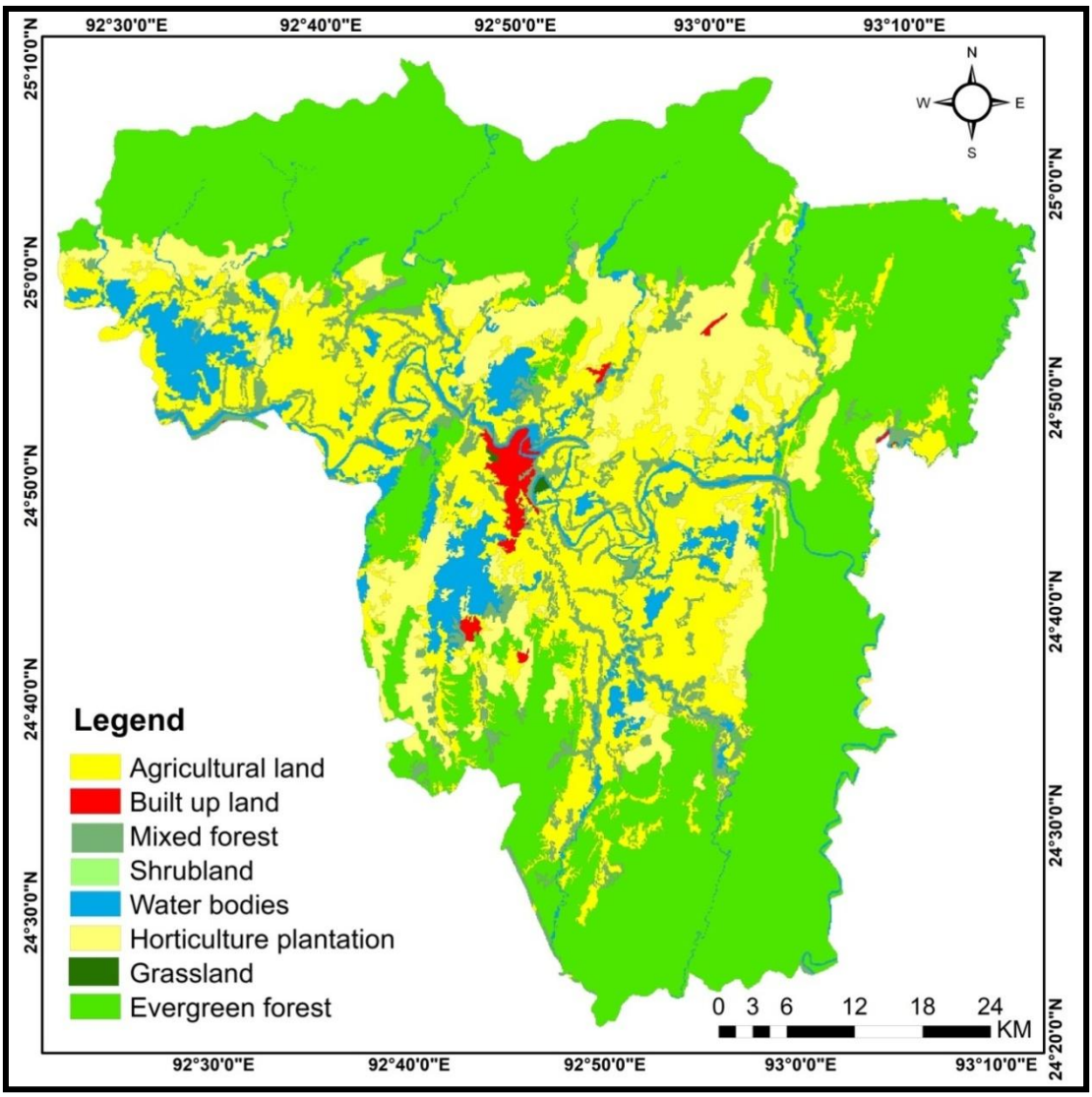


Fig. 1.10 –Land use land cover map, Cachar District, Assam.

Chapter 2.0

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 17GWMS (NHNS) and another 44Key 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 Cachar district in AAP 2021-2022.

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 18 GWMS under NHNS, newly established 39 Key wells under NAQUIM and additional 30 wells under special studies for Arsenic concentration in ground water. The samples collected were for analyzed for base, iron, heavy metals, arsenic and uranium.

2.3 Geophysical survey

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

Table 2.1 - Details of GW monitoring stations under NHNS inCachar district, Assam

Area	Lat	Lon	Parapet(m)	Depth	Type	Aquifer Group
Badribasti	24.8	92.86	0.92	6.48	Dugwell	Uncosolidated
Tarapur	24.83	92.98	1.19	4.3	Dugwell	Uncosolidated
Shivtila	24.82	93	0.65	8.35	Dugwell	Uncosolidated
Poilapool	24.83	93.12	0.85	3.36	Dugwell	Uncosolidated
Razabazar	24.87	93.06	0.89	10.57	Dugwell	Uncosolidated
Fulertal	24.79	93.02	0.63	6.69	Dugwell	Uncosolidated
Atalbasti	24.78	92.79	0.82	7.41	Dugwell	Uncosolidated
Dargakona	24.70	92.76	0.8	3.8	Dugwell	Uncosolidated
Borjalenga	24.67	92.72	1.4	8.57	Dugwell	Uncosolidated
Dwarbond	24.63	92.71	0.7	8.49	Dugwell	Uncosolidated
Katigora	24.89	92.59	0.75	4.9	Dugwell	Uncosolidated
Digarkhal	25.00	92.51	0.5	9.5	Dugwell	Uncosolidated
Kalain	24.97	92.57	0.8	5.3	Dugwell	Uncosolidated
Nagdirgram	24.67	92.88	0.66	3.85	Dugwell	Uncosolidated
Palanghat	24.65	92.88	1	4.5	Dugwell	Uncosolidated
Borkhola	24.95	92.73	0.5	3.32	Dugwell	Uncosolidated
Srikona/Masimpur	24.83	92.73	0.49	4.13	Dugwell	Uncosolidated
Chaltabasti/Kathaltila	24.70	92.77	0.64	5.12	Dugwell	Uncosolidated

Table 2.2 - Details of Key Wells established in Cachar district, Assam

Area	Lat	Lon	Parapet (m)	Depth	Type	Aquifer Group
Dewanbagan	24.85	93.02	0.8	4	Dug well	Uncosolidated
Barthal	24.88	93.04	0.4	5.3	Dug well	Uncosolidated
Kamranga	24.84	93.04	0.9	6.9	Dug well	Uncosolidated
Chalitatal	24.80	93.06	0.77	5.2	Dug well	Uncosolidated
Jirighat	24.81	93.10	0.88	5.1	Dug well	Uncosolidated
Kashipur	24.81	92.86	0.8	6.8	Dug well	Uncosolidated
Sadhutila	24.74	92.79	0.75	7.2	Dug well	Uncosolidated
Dwarbond PHC	24.61	92.72	0.75	4	Dug well	Uncosolidated
Nayabil 1	24.62	92.75	0.9	5.4	Dug well	Uncosolidated
Nayabil 2	24.67	92.75	0.8	4.5	Dug well	Uncosolidated
Kachudaram	24.67	92.93	0.77	5	Dug well	Uncosolidated
Ganganagar	24.62	92.96	0.8	5	Dug well	Uncosolidated
Sachinpur	24.61	92.94	0.7	6	Dug well	Uncosolidated
Panibhora	24.64	92.84	0.6	5	Dug well	Uncosolidated
Sarbantila	24.66	92.72	0.8	5	Dug well	Uncosolidated
Tikal TE	24.93	92.96	0.7	3.65	Dug well	Uncosolidated
Shiverband	24.93	92.95	0.7	8.4	Dug well	Uncosolidated
Thaligram	24.93	92.92	0.6	6	Dug well	Uncosolidated
Ghungorbond	24.92	92.91	0.9	5.4	Dug well	Uncosolidated
Khalkuri	24.74	92.98	0.8	6.3	Dug well	Uncosolidated
Dolu	24.92	92.78	0.88	3	Dug well	Uncosolidated
Boromampur	24.93	92.77	0.9	4.5	Dug well	Uncosolidated
Balachara	24.95	92.76	0.7	4.8	Dug well	Uncosolidated
Puthichara	24.94	92.75	0.85	5	Dug well	Uncosolidated
Borkhola	24.94	92.74	0.8	4	Dug well	Uncosolidated
Dolchera	24.95	92.70	0.7	3	Dug well	Uncosolidated
Behara	24.95	92.66	0.9	6.4	Dug well	Uncosolidated
Burunga	24.96	92.62	0.75	5	Dug well	Uncosolidated
Hilara	24.94	92.59	0.7	5.9	Dug well	Uncosolidated
Masimpur	24.86	92.75	0.6	1.8	Dug well	Uncosolidated
Kalyanpur	24.88	92.56	1	8.2	Dug well	Uncosolidated
Haritikar	24.89	92.51	0.88	5	Dug well	Uncosolidated
Chandinagar	24.92	92.50	1	4	Dug well	Uncosolidated
Kandigram	24.97	92.51	0.76	4.3	Dug well	Uncosolidated
Jalalpur	24.99	92.49	0.3	5	Dug well	Uncosolidated
Jalalpur TE	25.00	92.45	0.6	3	Dug well	Uncosolidated
Rampur	24.92	92.78	0.67	5	Dug well	Uncosolidated
Lalmati	24.81	92.71	0.7	5	Dug well	Uncosolidated
Mithapani	24.71	92.76	0.3	4	Dug well	Uncosolidated

2.4 Groundwater Exploration

During 1990-1993, CGWB, NER, Guwahati had carried out Hydrogeological studies in Tipaimukh project canal command area. During this study CGWB had drilled 4 shallow tube wells (TW) and 8 observation wells (OW) upto 50 m depth in Cachar district.

Table 2.3: Details of Shallow tube well drilled in Cachar district under Tipaimukh Project

Location	Depth drilled (m bgl)	Depth of construction (m bgl)	Aquifer tapped (m)
Salchapra	50		Abandoned due to lack of productive zone.
Pangram (Test well)	50	40	31-37
Pangram - OW-I	40.2	34.5	30-33
Pangram - OW-II	37.15	27.5	23-26
Silkuri (Test well)	50	22	16-20
Silkuri - OW-I	31.05	25.5	21-24
Silkuri - OW-II	33.05	30.5	26-29
Ghungoor – Pz	50	21.5	17-20
Kalain (Test well)	42.7	39	18.5-22
Kalain - OW-I	27.5	25	19-23
Kalain - OW-II	41.1	37.25	30-34
Badribasti (Test well)	50.35	33	15-18, 24-30
Badribasti - OW-I	35	31	15-18, 25-28
Badribasti - OW-II	35	31	15-18, 25-28
Palanghat -Pz	50	41	35.39
Behara – Pz	50.25	44	35-41
Rajabazar – Pz	50	12	6-9
Pailapool – Pz	50	44	35-41
Sonaimukh – Pz	50	24	19-22

N.B.: OW: Observation well Pz:Piezometer

During AAP 2021-22, CGWB took up GW exploration in the study area by in-house drillingatBinnakandi, Silchar and Joypur area. Details of the exploration activity in Cachar district is given in Table 2.3.

Table 2.4: Details of the exploration activity by CGWB in Cachar district, Assam

SI No.	Location	Lat	Lon	Depth drilled(m)	Constructed Depth (m)	Thickness of aquifer tapped	Water Level (mbgl)
1	Kalajor	24.73	92.81	278.9	163	85	2.48
2	Sildubi	24.73	92.82	297	198	42	2.72
3	Sonaimukh	24.73	92.89	300	236	51	8.51
4	Banskandi	24.81	92.92	298.45	68.5	47.2	6.88
5	Silkuri	24.72	92.77	277.78	179	59	0.52
6	Pangram	24.93	92.9	301.49	195.18	55.39	1.92
7	Kashipur	24.82	92.86	300.84	205	102	1.38
8	Narshingpur	24.69	92.84	301.22	196	50	4.67
9	Binnakandi	24.71	92.97	72	60	21	6.77
11	Silchar	24.79	92.8	122	91	18	4.9

SI No.	Location	Lat	Lon	Depth drilled (m)	Constructed Depth (m)	Thickness of aquifer tapped	Water Level (mbgl)
12	Ramnagar	24.84	92.75	182	125	36	4.35
13	Tikalpar	24.93	92.96	132.5	123	43	_
14	Joypur	24.9	93.05	20	Abandoned		

The preliminary yield test has been conducted on the exploratory well and the observatory well at Binnakandi and Silchar in AAP 2021-22. The PYT reports of the EW have been furnished in the Annexure 2.1 and 2.2 respectively.

2.5 Soil Infiltration Test

Three soil infiltration tests have been performed in the Cachar district at Silchar, Chandrapurand Badribasti. The soil infiltration reports have been furnished in Annexure 2.3, 2.4,2.5.

During hydrogeological studies in Tipaimukh project, 10 infiltration tests were done in the district. The result of different infiltration tests is given below.

Table 2.6: Result of soil infiltration tests carried out during Tipaimukh project

Location	Basic infiltration rate(cm/hr)	Category infiltration	Soil type inferred
Kalain	0.6	Low	Loamy
Borkhola	1.08	Low	Sandy,silt
Silkuri	1.68	Moderate	Sandy,silt
Pangram	1.02	Low	Sandy,silt
Ghungoor	1.8	Moderate	Sandy,silt
Badribasti	0.18	Very Low	Clayey
Rajabazar	4.02	Very high	Sand
Sonaimukh	2.64	High	Silt
Palanghat	1.38	Moderate	Silt
Pailapool	2.22	High	Silt

Chapter 3.0

Data Interpretation, Integration and Aquifer Mapping

3.1 Data Interpretation

3.1.1 Aquifer Geometry

Cachar district is surrounded by dissected hills on Northern, Eastern and Southern sides due to which valley lies only in the central portion of the district. The general slope is towards Barak river from both Northern and Southern sides. CGWB has constructed 13 exploratory wells across the Cachar district with depth ranging from 72.0 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, gravels and pebbles. The clay is grey in color.
- **Sandstone aquifer of Tertiary age**- The sandstone aquifer is composed of friable sandstone with clay and Shale. Sandstone and clay/shale occurs as alternating layers.

Based on the litholog of the exploratory wells, two panel diagram for shallow aquifer zone in the northern and the southern part of the Barak riverand three cross sections for deeper aquifer has been prepared to show the disposition of the aquifers in the district. From the section, it is observed that the aquifer in the district comprises mainly of sand, clay, sandstone and shale. The aquifer in the northern side of the Barak river is more arenaceous than the aquifer in the southern side of the Barak river. The soil thickness encountered in the EW range between 3.0 m to 10m in both side of the Barak river. Underneath the soil cover, three to seven granular zones have been encountered in northern side and two to eight granular zones have been encountered in southern side of the Barak river.

Shallow Aquifer zone in the Southern Bank of Barak River

The panel diagram is prepared using lithologs from Salchapra, Ghungoor, Sonaimukh, Binnakandi and Palanghat tube well. It is found that the shallow aquifer zone in the southern bank of the Barak river mainly comprises of younger alluvium and it is argillaceous in nature. In Salchapra area, clay occur upto a depth of 50m with no granular zone. This clay layer continues up to Palanghat with intervening granular zone occurring at different depth. A granular zone of about 6m thickness is encountered near Ghungoor area at a depth of 16-21m. This granular zone extends up to Sonaimukh. At Binnakandi granular zone extends from surface to 24m with a clay layer separating another granular zone occurring at a depth of 27-50m. The first granular zone near Binnakandi is absent in Palanghat area. The thickness of second granular zone encountered at Binnakandi decreases in Palanghat to 6m occurring at a depth of 34-40m. Aquifer performance tests at Silkuri shows that transmissivity, discharge and storativity of the aquifer is 41.25m^2/day, 2.16m^3/hr and 5.5 x 10^{-4} to 8.8 x 10^{-4}.

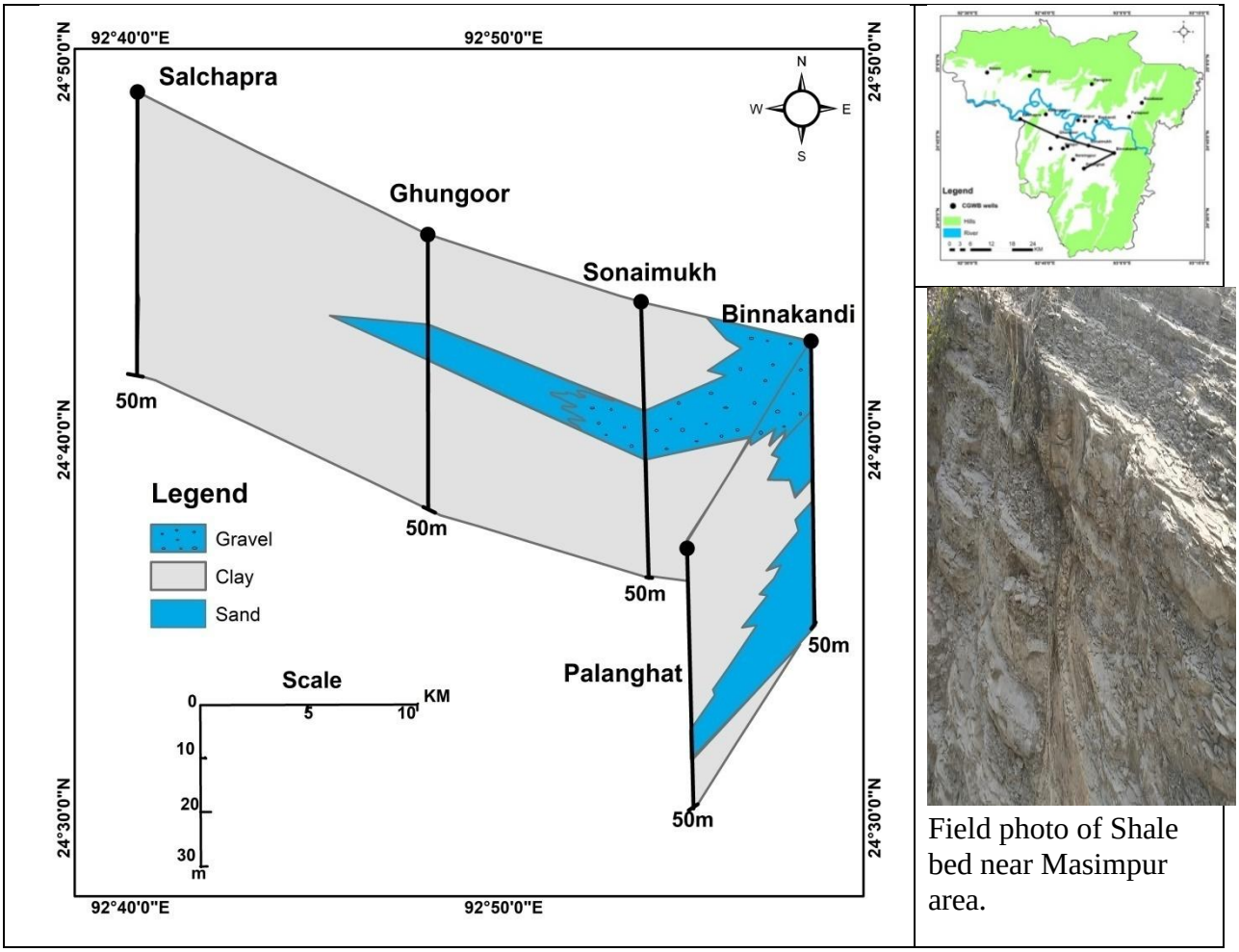


Fig3.1: Panel diagram showing shallow aquifer zone in the southern part of Cachar district.

Shallow aquifer zone in the Northern Bank of Barak River

The panel diagram is prepared using lithologs from Kalain, Dhalchara, Pangram, Rajabazar, Pailapool, Baskandi and Badribast observation well. The shallow aquifer zone in the northern part of the district mainly comprises of younger alluvium and is mostly arenaceous in nature with multiple granular zones. The northern shallow aquifer comprises of a top clay layer of varying thickness from Kalain to Badribasti via Pangram, Rajabazar, Pailapool and Baskandi. In Dhalchara area instead of the top clay layer pebble bed is encountered near the surface. In Kalain area first granular zone occurs at a depth of 19-42m with pebbles occurring at a depth of 24-27m. In Dhalchara area pebbles occurs from surface to 10m depth with three granular zones encountered at a depth of ground level (GL) to 18m, 21-42m and 43-50m respectively. In Pangram granular zone occurs at a depth of 10- 46m. In Rajabazar area granular zone occurs at a depth of 10-50m, however it is characterised by sandy clay and the thus yield may be less. The granular zone gets thinner near Pailapool area and it occurs at a depth of 35-50m. In Baskandi area the granular zone is thicker and occurs at a depth of 12-45m. The thickest granular zone occurs in Badribasti area at a depth of 5-50m. A gravel bed is encountered at different depths near Badribasti, Baskandi and pinches out near Pailapool area. Aquifer performance tests at Kalain, Pangram and Badribasti shows that transmissivity, discharge and storativity of the aquifer varies from 116-210 m^2/day, 2.8-7.2m^3/hr and 2.1x 10^{-4} to 8.8 x 10^{-4} respectively.

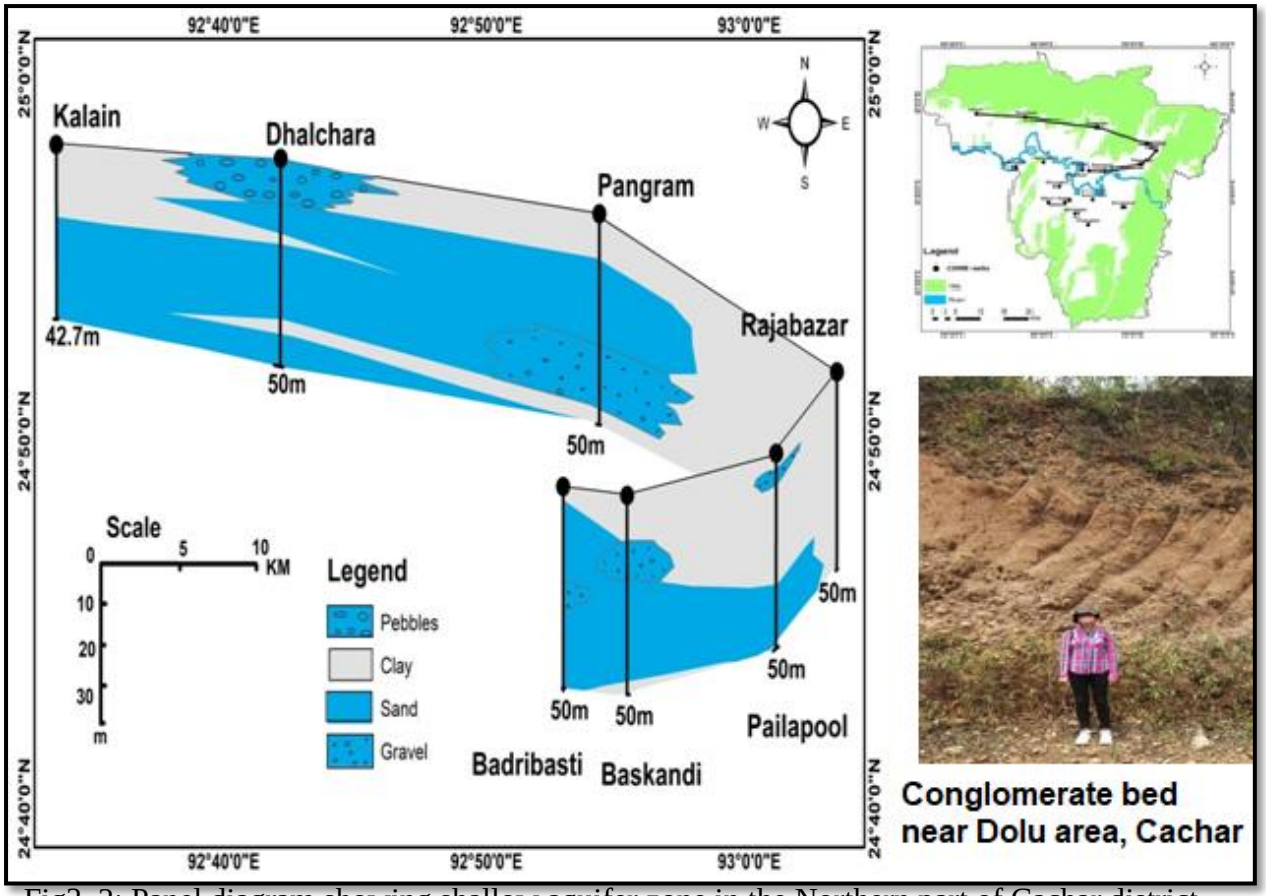


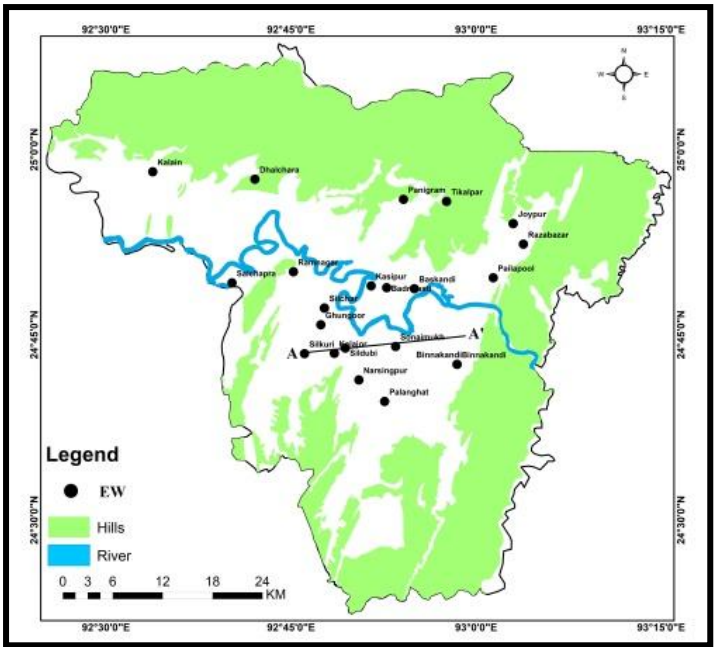
Fig3. 2: Panel diagram showing shallow aquifer zone in the Northern part of Cachar district.

Deep aquifer Zones

To study the deeper aquifer zones of the district three sections are prepared.

(i) 2D disposition of aquifer along E-W direction in the southern bank of the Barak River: This section extends from Silkuri to Binnakandi and two major aquifers are delineated in this section, viz., younger alluvium (AL01) and sandstone with shale (ST 02).

The younger alluvium is mainly confined to shallow depth whereas the sandstone aquifer is encountered 50m below. The sandstone aquifer occurring at a depth of 100-180m is extensive from Silkuri to Sonaimukh with intermediate shale layer which is absent only in Kalajor area. The aquifer beyond 180m depth from Silkuri to Sonaimukh area is dominated by shale with 6-10m thick granular zones occurring within the shale.



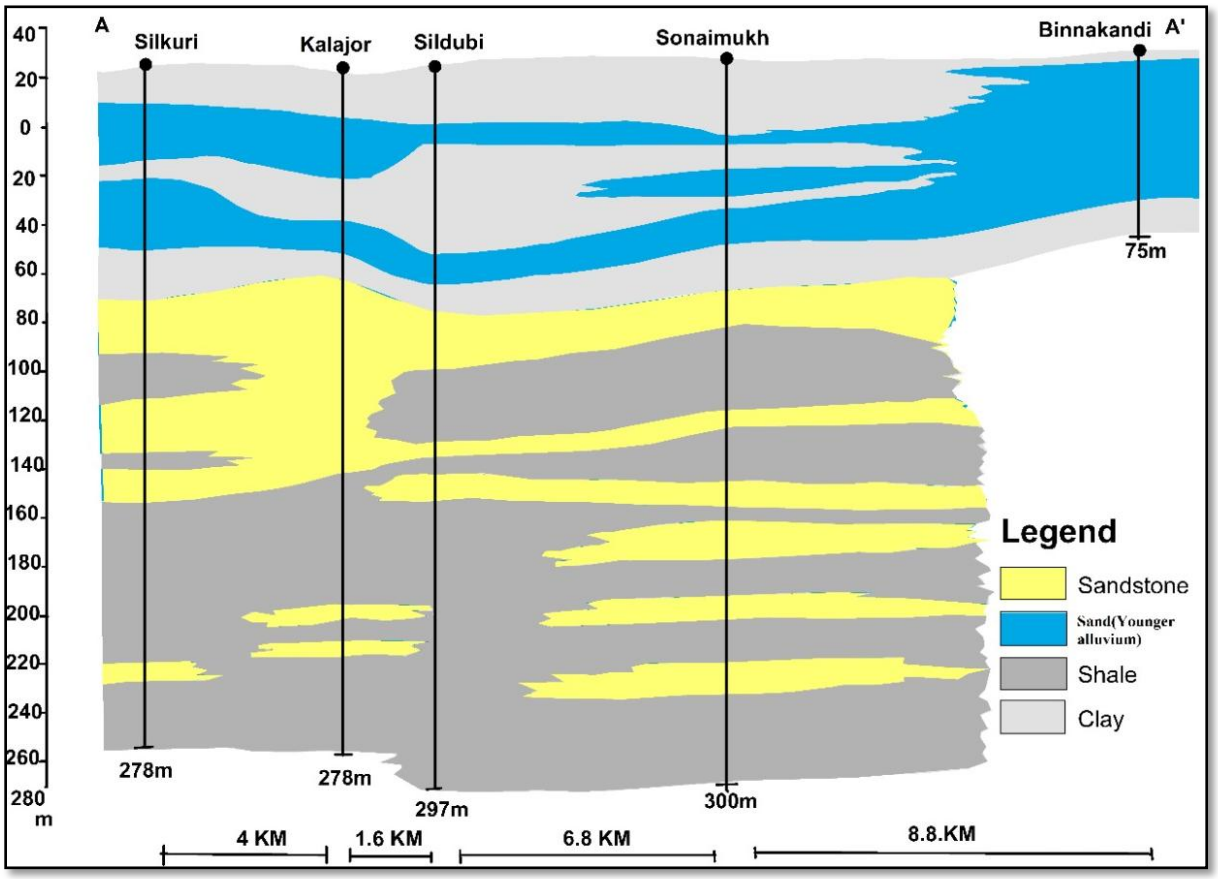
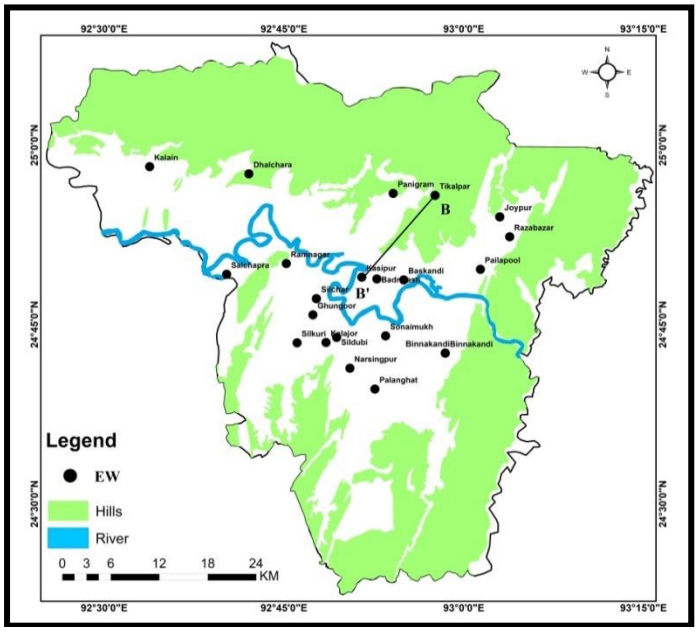


Fig3.3: 2D disposition of aquifer along East-West direction

2D disposition of aquifer along NE-SW direction in the northern bank of the Barak River: This section extends from Tikalpar to Kashipur and two major aquifers are delineated in this section, viz., younger alluvium (AL01) and sandstone with shale (ST 02) (Fig.3.4).

In the younger alluvial aquifer clay layer thickness is more towards north and its thickness decreases toward south near the Barak river. The sand layer of nearly 40m thickness at Tikalpar in the north attains a thickness of 100m at Kashipur in the south.

In Tikalpar area sandstone occurs at a depth of 126-132m. This sandstone layer extends up to Kashipurarea occurring at a depth of 156-166m. The deeper aquifer beyond 150m depth contains alternating layers of sandstone and shale. The deeper aquifer beyond 100m depth in Kashipur area is dominated by shale.



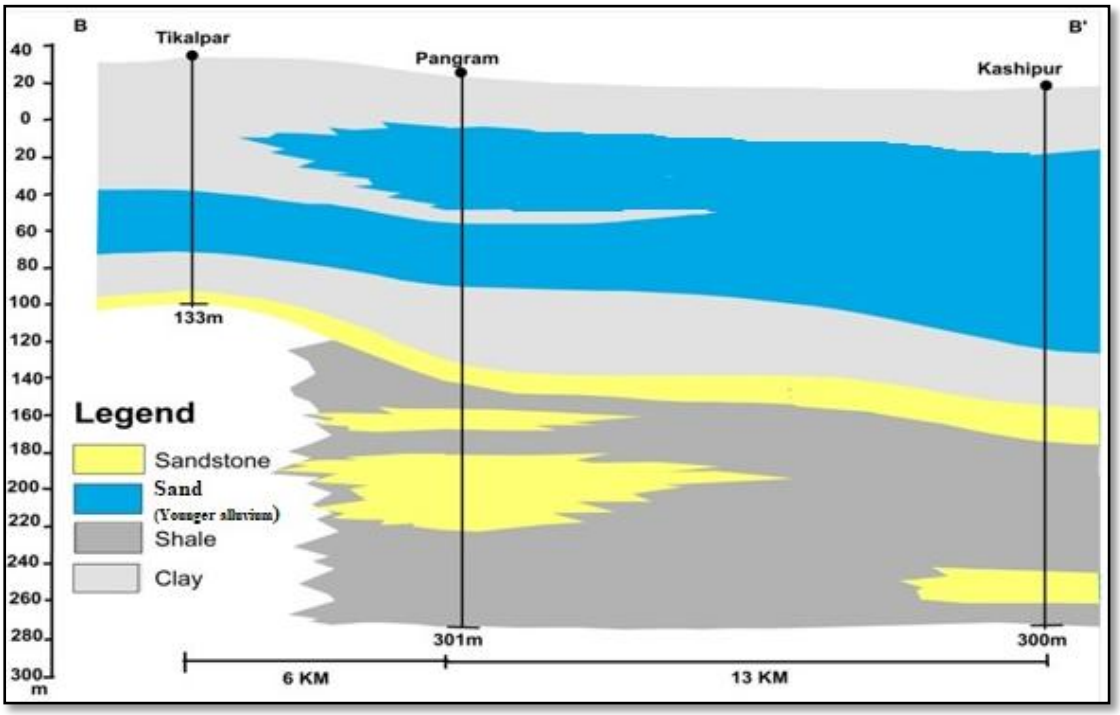


Fig3.4: 2D disposition of aquifer along NE-SW direction

2D disposition of aquifer along NW-SE direction in the southern bank of the Barak River: This section extends from Ramnagar to Silchar and two major aquifers are delineated in this section, viz., younger alluvium (AL01) and sandstone with shale (ST 02) (Fig.3.5).

The younger aluvial aquifer occurs at a depth of 8-60m. The aquifer is more arenaceous in nature and thickness of the aquifer decreases at Silchar Polytechnic. At Silchar Polytechnic sandstone occurs at shallow depth.

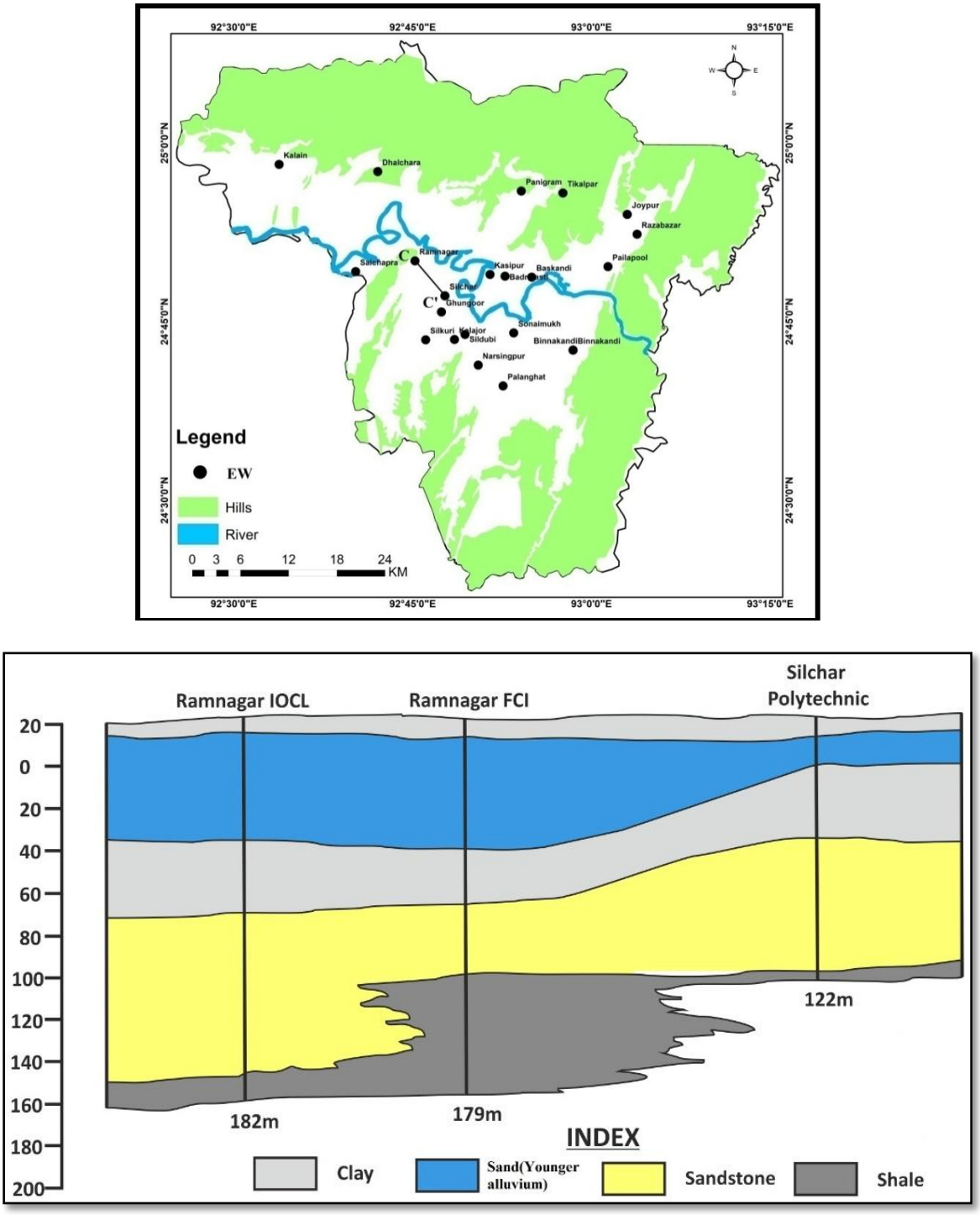


Fig3.5: 2D disposition of aquifer along NW-SE direction.

3.1.3 Aquifer Characteristics

The aquifer properties of younger alluvium down to a depth of 50m are established during the Hydrogeological studies (1990-1993) carried out in Tipaimukh project canal command area. Shallow aquifer parameters computed during the project are furnished in Table 3.2.

Table 3.2 :Shallow aquifer parameters in Cachar district

Location	Thickness of aquifer (m)	Discharge (m^3/h)	Draw down (m)	Specific capacity (Lpm/m)	Transmissivity (m2/day)	Storativity (S)	K (m/day)
Badribasti-TW	9	5.4	4.8	18.75	42.09	5.6×10^{-4} to 8.8×10^{-4}	6.1
Pangram TW	6	7.2	2.41	49.79	181.065	4.14×10^{-4}	45.21
Silkuri TW	4	2.16			40.815	5.5×10^{-4}	13.6
Kalain TW	12	7.85	4.65	28.15	91.35	2.1×10^{-4}	29.51

The study show that specific capacity in shallow aquifer varies from 18.75 to 49.79 lpm/m of drawdown, transmissivity ranges from 28.23 to 210.840m2/day and Storativity ranges from 2.1 X 10^{-4} to 8.8 X 10^{-4}. Transmissivity values show that shallow aquifers are having moderate groundwater potentiality and S values show that it is semi-confined in nature.

The Aquifer properties delineated from CGWB's deeper exploratory wells in Cachar district have been furnished in Table 3.3.

Table 3.3: Deeper Aquifer Properties of Cachar District

Location	Lat	Lon	Thickness of aquifer tapped	Water Level below GL(m)	Q (m^3/hr)	T (m^2/day)	K (m/day)	Storage coefficient
Kalajor	24.73	92.81	85	2.48	78	250.29	3.12	_
Sildubi	24.73	92.82	42	2.72	88	91.46	2.17	_
Sonaimukh	24.73	92.89	51	8.51	33	28.9	0.5	_
Banskandi	24.81	92.92	47.2	6.88	39	96.19	1.6	0.0005
Silkuri	24.72	92.77	59	0.52	48	89.29	1.5	0.0009
Pangram	24.93	92.9	55.39	1.92	24.6	46.1	0.83	_
Kashipur	24.82	92.86	102	1.38	39	80.76	0.79	_
Narshingpur	24.69	92.84	50	4.67	25.08	10.5	0.21	_
Binnakandi	24.71	92.97	21	6.77	20.88	41.68	_	_
Silchar	24.79	92.8	18	4.9	22.1	37.34	_	_
Ramnagar	24.84	92.75	36	4.35	17.71	104.5	3.48	_
Tikalpar	24.93	92.96	43	_	_	_	_	_
Joypur	24.9	93.05	20	Abandoned				

3.2 Ground Water Level

To study ground water regime, depth to water level from 18 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 3.4.

Table 3.4: Pre & Post Monsoon DTWL and fluctuation data of NHNS monitored wells

NHNS	Pre-monsoon (WL(bgl)	Post-monsoon (WL(bgl)	Fluctuation
Badribasti	3.4	1.62	1.78
Tarapur	1.06	0.21	0.85
Shivtila	2.63	2.35	0.28
Poilapool	1.35	1.05	0.3
Fulertal	3.12	2.37	0.75
NHNS	**Pre-monsoon (WL(bgl)**	**Post-monsoon (WL(bgl)**	**Fluctuation**
Atalbasti	6.26	4.68	1.58
Chaltabasti/Kathaltila	4.46	2.06	2.4
Dargakona	0.94	0.6	0.34
Borjalenga	0.24	0.1	0.14
Dwarbond	6.1	2.9	3.2
Katigora	2.25	1.55	0.7
Digarkhal	7.9	0.68	7.22
Kalain	1.65	1.35	0.3
Nagdirgram	1.54	1.14	0.4
Palanghat	2.5	0.9	1.6

Apart from the 18 NHNS wells, 39 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 3.5 attached as Annexure 3.3.

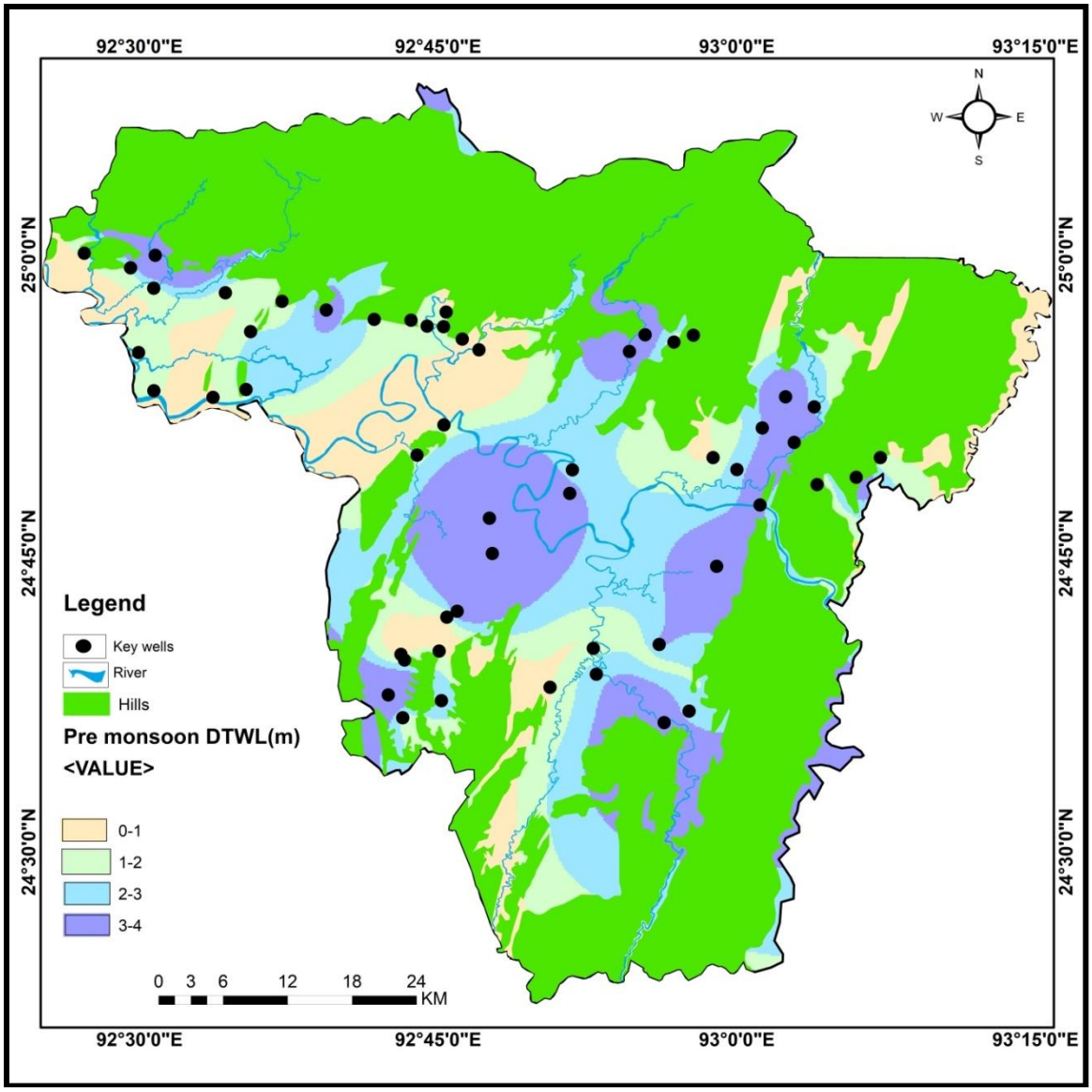


Fig 3.6: Pre monsoon DTWL map of Cachar district.

In the pre monsoon season, the depth to water level in the district ranges between 0.2 m bgl to 6.1m bgl. The deepest water level lies in the central part of the district near Silchar town (Fig.3.6).During pre-monsoon the area with DTWL ranging from 0-2mbgl(water logged condition) is around 250sqkm and DTWL ranging from 2-3mbgl(prone to water logged condition) is around 441 sqkm

In the post monsoon season, the depth to water level in the study area ranges between 0.1m bgl to 4.68m bgl. The deepest water level lies in the central part of the district near Silchar town (Fig.3.7).During post-monsoon the area with DTWL ranging from 0-2mbgl(water logged condition) is around 690sqkm and DTWL ranging from 2-3mbgl is around 480sqkm(water logged condition).

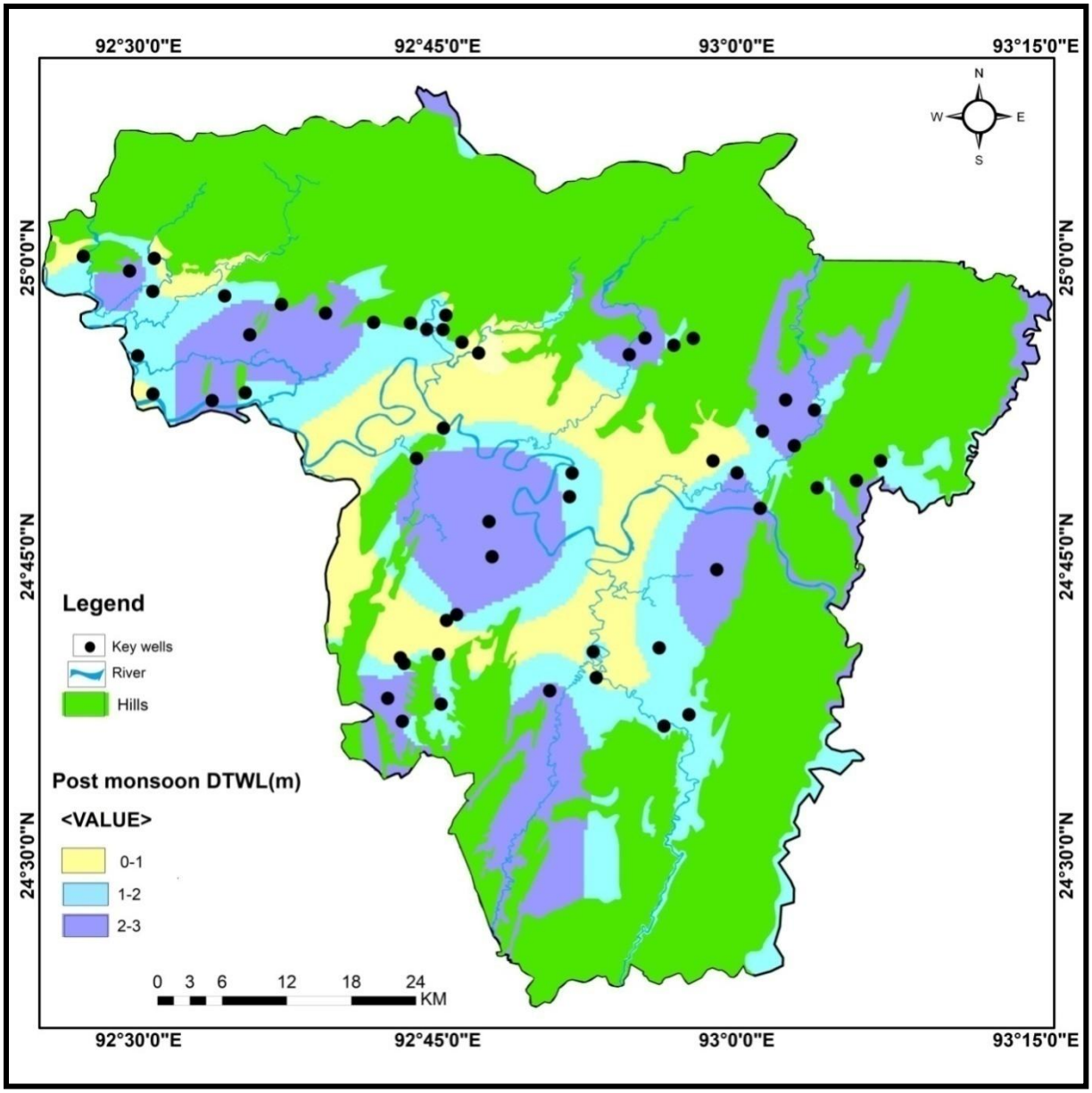


Fig 3.7: Post monsoon DTWL map of Cachar district

During course of field work artesian well having water level 0.03m above ground level during pre-monsoon and 0.18m above ground level during post monsoon was found near Dolu area.

In the district pre- and post-monsoon water level fluctuate generally within 2m interval. However, fluctuations of water level more than 4m are noticed along the foothills of south and also north of the Barak River (Fig.3.8).

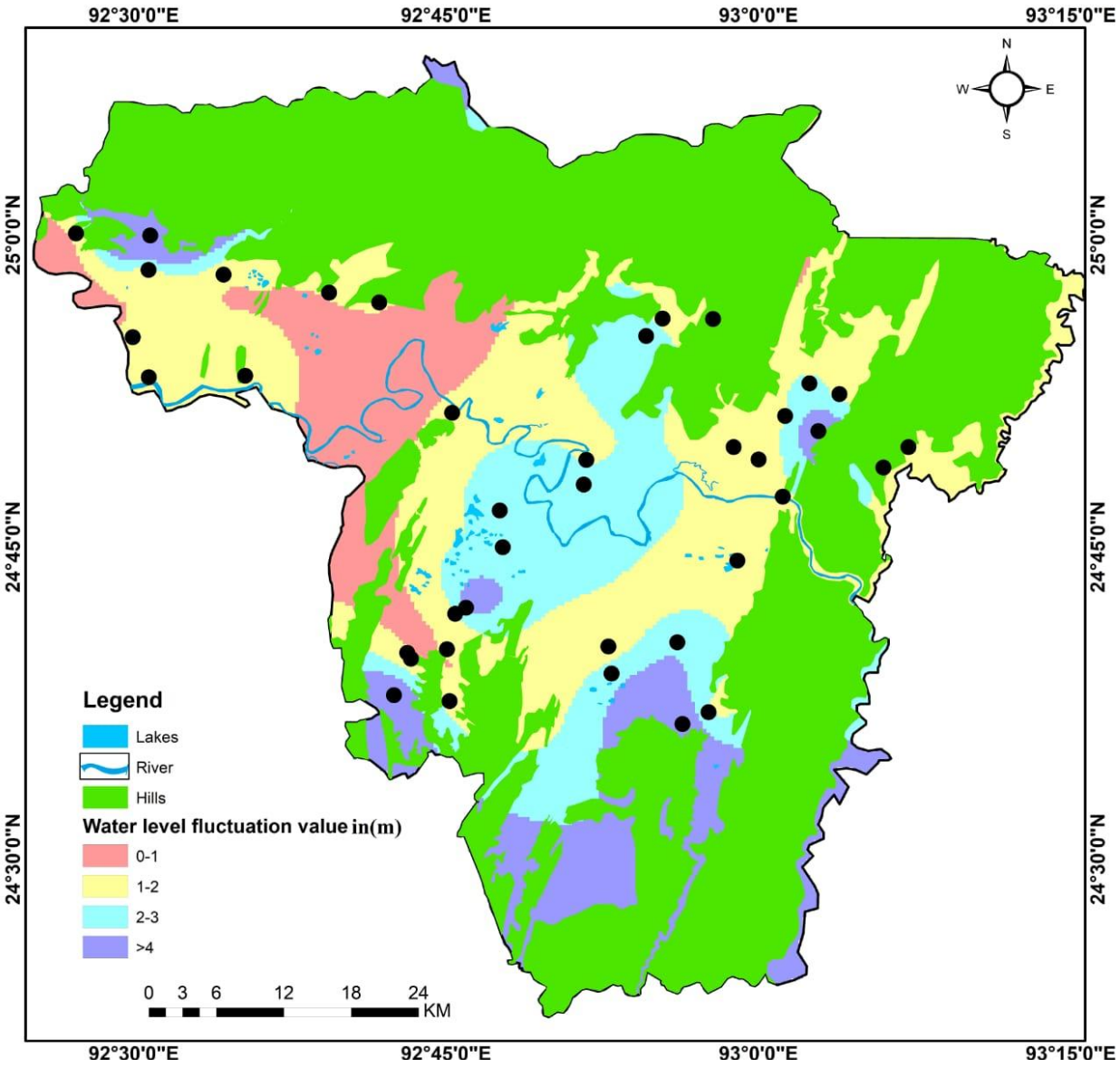


Fig 3.8: Water level fluctuation map of Cachar district

3.2.1 Ground Water Movement

The water table (WT) 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 of the Northern and the Southern side towards the valley portion which ultimately flows towards the Barak River in the central portion of the valley. The water table contour map is shown in Fig 3.9.

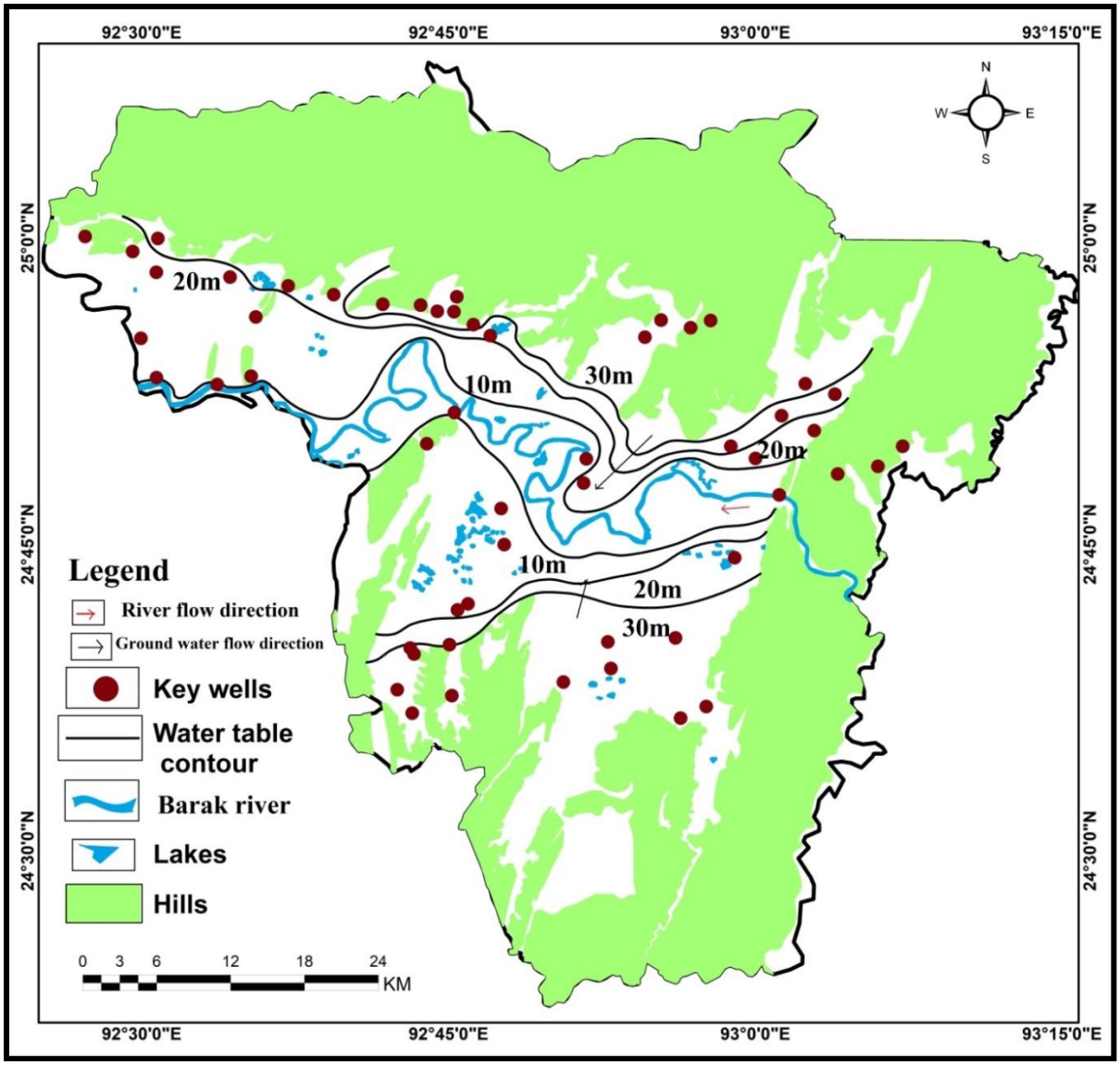


Fig 3.9: Water table (WT) contour map of Cachar district

From the water table contour map GW recharge areas can be identified in the northern and southern pediment complexes. The GW flow direction is towards the central portion of the district from both the northern and southern side. The hydraulic gradient varies between 40 m/Km in the north to 58.82 m/Km in the south. The shape of water table contour also indicates that the Barak River is an effluent river which is recharged by the aquifer.

3.3 Ground Water Quality

To study the chemical quality of the ground water in Cachar district around 57 samples (from dug well and tube well) during pre monsoon and 41samples (from dug well and tube well) during post monsoon are collected and sent to Regional Chemical Laboratory for analysis. One sample from a saline spring is also collected for analysis. Chemical analysis of ground water samples is carried out by regional chemical laboratory of Central Ground Water Board, North Eastern Region, Guwahati. Samples were analyzed for the parameters like pH, EC, Turbidity, TDS, CO_3, Cl, SO_4, Na, K, HCO_3, NO_3, F, Ca, Mg, As and Fe. The chemical analysis data of groundwater samples from Cachar district during pre-monsoon and post-monsoon season are

given in the Table 4.1 and 4.2 as Annexure 4.1 and 4.2 respectively. Table 3.5 and 3.6 (a to b) summarizes the results of chemical analysis

Table 3.5 : Chemical quality of water samples from dug well and tube well in Cachar district during pre-monsoon

SI.NO.	Chemical constituents (Concentrations in mg/l except pH, EC and As)	Maximum	Minimum
1	pH	8.33	6.06
2	EC (µs/cm) 25°C	667.8	21.54
3	Turbidity (NTU)	0.3	BDL
4	TDS	440.75	14.22
5	CO_3^{-2}	15	BDL
6	HCO_3^{-1}	305.24	12.21
7	TA (as $CaCO_3$)	314.4	12.21
8	Cl^-	113.44	7.09
9	SO_4^{-2}	65.42	BDL
10	NO_3^{-1}	32.17	BDL
11	F^-	0.28	BDL
12	Ca^{+2}	44.04	6
13	Mg^{+2}	40.04	3.62
14	TH (as $CaCO_3$)	225	40
15	Na	81.45	3.01
16	K	28.2	1.56
17	Fe	22.52	0.05
18	As (µg/L)	55.53	BDL

Table 3.6 (a)- Chemical quality of water samples from Noonkhuli Saline spring in Cachar district during pre-monsoon

SI.NO.	Chemical constituents	(Concentrations in mg/l except pH, EC)
1	pH	8.47
2	EC (µs/cm) 25°C	25670
3	Turbidity (NTU)	BDL
4	TDS	16942.2
5	CO_3^{-2}	84
6	HCO_3^{-1}	2582.36
7	TA (as $CaCO_3$)	2666.36
8	Cl^-	8508
9	SO_4^{-2}	0.83
10	NO_3^{-1}	BDL
11	F^-	BDL
12	Ca^{+2}	32.03
13	Mg^{+2}	30.32
14	TH (as $CaCO_3$)	205
15	Na	8008.5
16	K	129
17	Fe	0.15

Table 3.6 (b): Chemical quality of water samples from dug well and tube well in Cachar district during post-monsoon

SI.NO.	Chemical constituents (Concentrations in mg/l except pH, EC and As)	Dug Well		Tube Well	
		Maximum	Minimum	Maximum	Minimum
1	pH	8.5	5.9	8.4	5.4
2	EC (µs/cm) 25°C	544	45	447	22.1
3	Turbidity (NTU)	0.2	BDL	0.4	BDL
4	TDS	359	29.7	295	14.5
5	CO_3^{-2}	24	BDL	18	BDL
6	HCO_3^{-1}	250	18.31	225.8	24.42
7	TA (as $CaCO_3$)	262.3	18.31	243.8	24.42
8	Cl^-	70.9	17.73	109.9	17.73
9	SO_4^{-2}	26.13	0.37	18.18	0.37
10	NO_3^{-1}	8.56	BDL	55.5	BDL
11	F^-	2.03	BDL	1.23	BDL
12	Ca^{+2}	52.04	4	30	6
13	Mg^{+2}	24.2	1.2	25.4	6.06
14	TH (as $CaCO_3$)	230	25	155	50
15	Na	58.5	5.6	79.9	2.8
16	K	36.46	3.27	9.1	0.34
17	Fe	4.08	0.08	23.08	0.1
18	As (µg/L)	BDL	1.8	BDL	61.8

Table 3.6 (c): Chemical quality of water samples from Noonkhuli Saline spring in Cachar district during post-monsoon

SI.NO.	Chemical constituents	(Concentrations in mg/l except pH, EC)
1	pH	8.3
2	EC (µs/cm) 25°C	22370
3	Turbidity (NTU)	BDL
4	TDS	14764.2
5	CO_3^{-2}	96.0
6	HCO_3^{-1}	2197.76
7	TA (as $CaCO_3$)	2293.76
8	Cl^-	8649.8
9	SO_4^{-2}	2.27
10	NO_3^{-1}	34.69
11	F^-	1.35
12	Ca^{+2}	84.07
13	Mg^{+2}	7.24
14	TH (as $CaCO_3$)	240
15	Na	2801.75
16	K	44.25
17	Fe	8.35

Table 3.7: Concentration of Fe, As and pH value in ground water during pre-monsoon

Type of Structure	No. of Sample analysed	Conc. of Iron (mg/l)			Conc. of Arsenic (µg/L)	pH value	
		<0.3	**0.3 to 1**	**>1**	**>10**	**<6.5**	**6.5 to 8.7**
Dug well	35	8	16	11	3	0	35
Tube well	21	2	8	11	5	6	15

Table 3.8: Concentration of Fe, As and pH value in ground water during post-monsoon

Type of Structure	No. of Sample analysed	Conc. of Iron (mg/l)			Conc. of Arsenic (µg/L	pH value	
		<0.3	**0.3 to 1**	**>1**	**>10**	**<6.5**	**6.5 to 8.7**
Dug well	19	7	7	5	1	1	18
Tube well	22	9	1	12	6	2	20

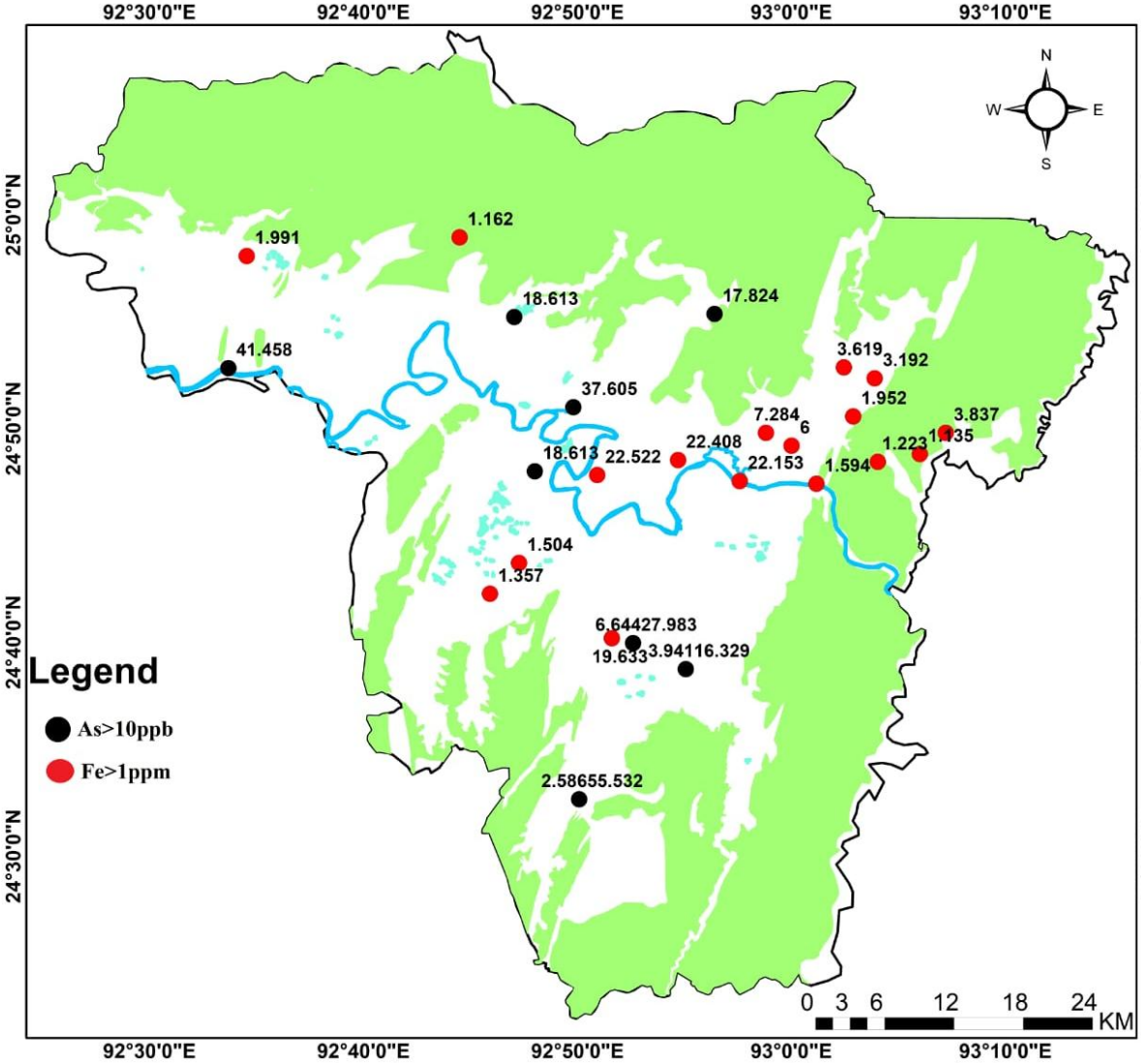


Fig 3.10: Map showing distribution of arsenic and iron during pre monsoon.

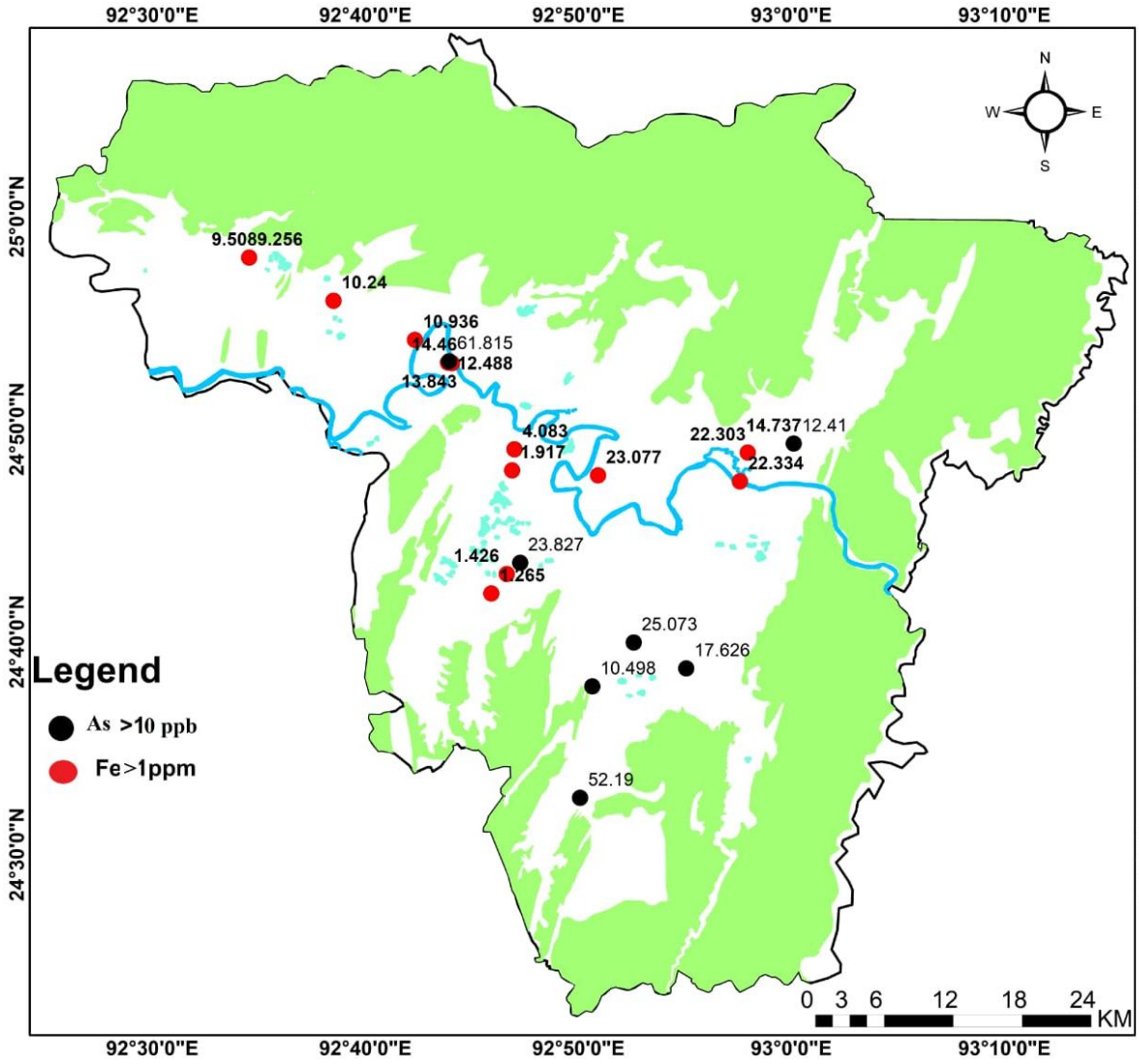


Fig 3.11: Map showing arsenic and iron distribution during post monsoon.

3.3.1 Ground Water Quality of Shallow Aquifer

A total of 35 and 19 ground water samples were collected from dug wells during pre-monsoon and post monsoon studies respectively. The range of concentrations of different chemical constituents present in the ground water samples are given in table 3.3 and 3.4.

It is deciphered from table 4.3 and 4.4 that the all the dug wells samples have pH values in the range from 5.9 to 8.7 during pre-monsoon and post monsoon season. No dug wells sample has pH value less than 5.9. So it can be inferred that the nature of ground water in the dug wells in both the seasons is neutral to slightly alkaline. The concentration of Fe in 11 dug wells during pre-monsoon and 5 dug wells during post monsoon are beyond the permissible limit of WHO i.e>1mg/L. The As concentration in water samples in 3 dug wells collected during pre-monsoon season are beyond the permissible limit of 10µg/L as given by WHO.

3.2.1 Ground water quality of Deeper Aquifer

A total of 21 and 22 ground water samples were collected from tube wells during pre-monsoon and post monsoon studies respectively. The range of concentrations of different chemical constituents present in the ground water samples are given in table 3.3 and 3.4.

It is deciphered from table 3.3 and 3.4 that the 6 tube wells from pre monsoon and 2 tube wells from post monsoon have pH less than 6.5, which indicates slightly acidic in nature. The rest of the tube wells from both pre and post monsoon have pH values in the range 6.5 to 8.7, which indicates neutral to slightly alkaline nature of the ground water. The concentration of Fe in 11 tube wells during pre-monsoon and 12 tube wells during post monsoon are beyond the permissible limit of WHO i.e>1mg/L. The As concentration in water samples in 5 tube wells collected during pre-monsoon season are beyond the permissible limit of 10μg/L as given by WHO.

The pre and post monsoon iron and arsenic conc. map are shown in Figure no. 3.10 and 3.11 respectively.

3.3.2 Assessment of ground water quality with various chemical diagram

Ground water quality has been assessed with the help of various chemical diagram such as Piper diagram, Wilcox diagram and Stiff diagram prepared with the help of Aquachem 9 software.

Piper diagram

In order to understand water composition and chemical relationship between dissolved ions, Pipers trilinear diagram for graphical analysis (Figure 4.1) is used. This diagram reveals similarities and differences among water samples. Most of the water samples analyzed fall within the no dominant type and Magnesium type in case of cations and very lessnumber of samples fall under calcium type and Na-K type. In case of anions, most of the samples are under bicarbonate type and few other samples under no dominant type and chloride type. These trends are reflected in the central diamond of the diagram where most of the samples fall under the category of alkaline dominant field in case of cations within which around 53% of the samples falls under Magnesium bicarbonate (Mg-HCO3) type ,37% of the samples falls under mixed type and 5% both under calcium chloride (CaCl) type and sodium chloride (NaCl) type. In case of anions, most of samples are within weak acids (HCO3 - CO3) dominant field with few samples under strong acids (Cl-SO4) dominant type. The results suggest that Magnesium bicarbonate and mixed type are the dominant hydro chemical facies for the studied groundwater samples.

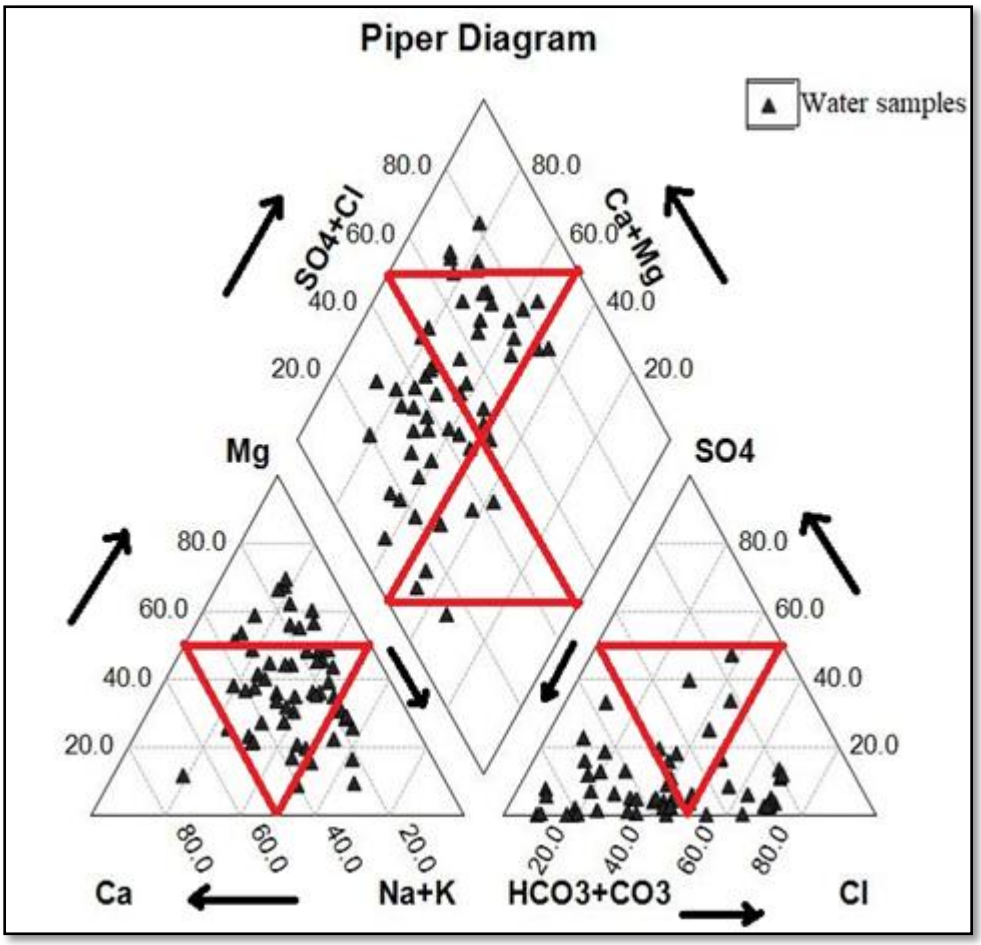


Figure 3.12: Piper diagram for representing the analysis of ground water

Wilcox diagram

According to Wilcox diagram (US Salinity Laboratory's diagram) in Figure 4.2, salinity and alkalinity hazard class of water samples were C1–S1 (60 %) and C2–S1 (40 %). The result shows that a majority of the ground water samples possess low salinity with low sodium (C1–S1). Such water can be used directly for irrigation purpose. However, water samples falling in medium salinity and low sodium class(C2-S1) should be treated before using for irrigation purposes.

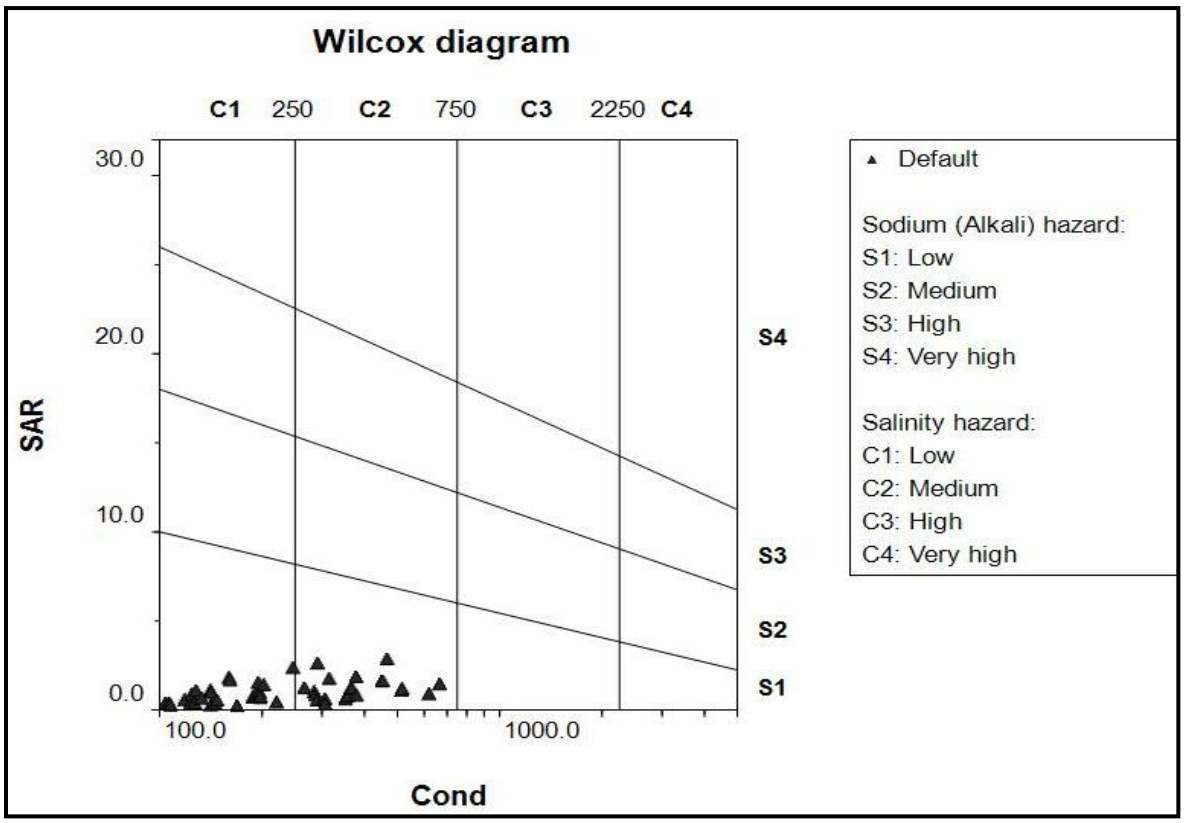


Fig.3.13: Wilcox diagram to analyze the quality of water in relationship to salinity & sodium hazard.

Stiff diagram

In the Figure 4.3 it can be seen that the ground water present in the study area shows a higher concentration of magnesium (Mg) in comparison to sodium (Na) and calcium (Ca). In terms of anions the ground water of the study area has a higher concentration of Carbonate and Bicarbonate ions (CO3+HCO3) in comparison to chloride ions (Cl) and sulphate ions (SO4).

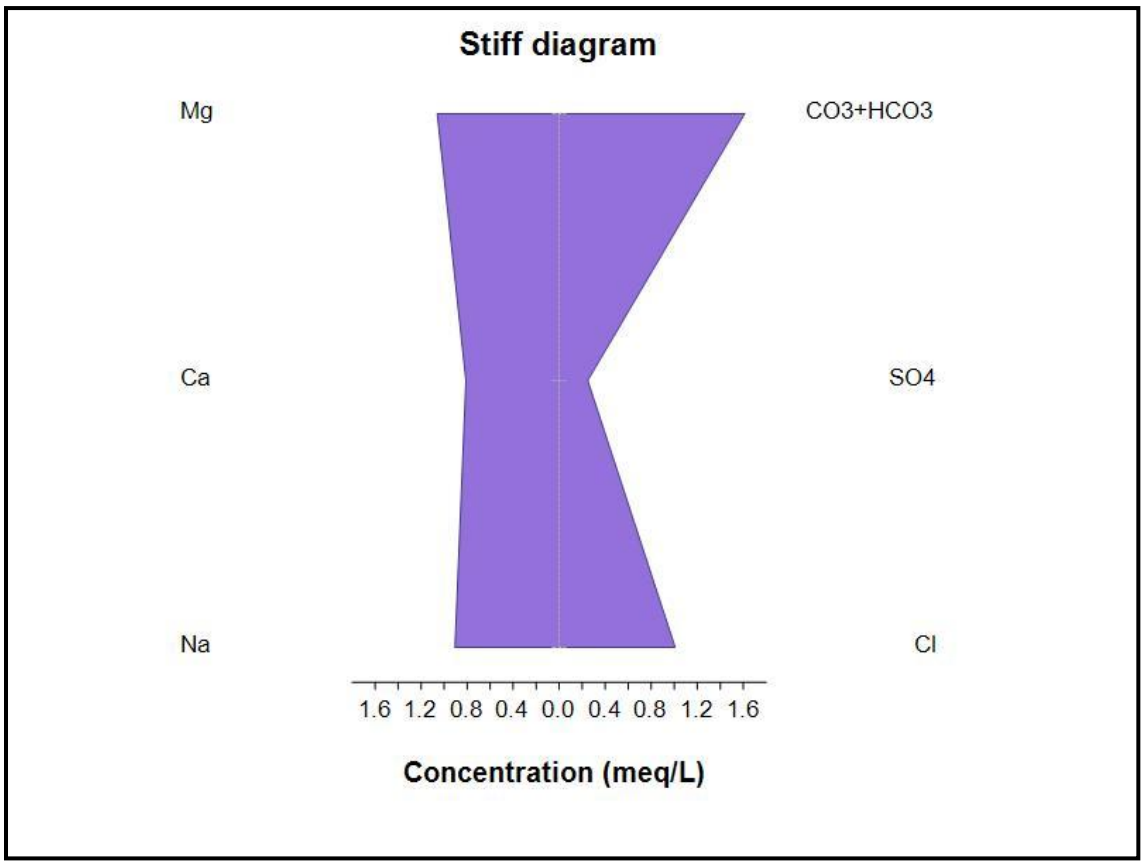


Figure 3.14: Stiff diagram to analyze the concentration of various cations and anions present in the ground water

3.3.3Water Quality Evaluation for Irrigation Purpose

To study the water quality for irrigation purpose, 56 water samples (both DW and TW) are collected during pre-monsoon and 41 water samples during post monsoon. Different chemical parameters like pH, electrical conductivity(EC), total dissolved solids (TDS), Ca2+, Mg2+, Na+, K+, Cl-, HCO3,CO3, SO4, F- and various chemical index such as sodium absorption ratio (SAR), sodium percentage(SP), residual sodium carbonate (RSC), Kelly's ratio and magnesium ratio were analyzed by adopting the standard procedures of water analysis. The feasibility check of ground water for irrigation purpose is given in Table No. 3.5.

Suitability of the groundwater for irrigation purpose was discussed by the following basic criteria.

pH

The pH of the water samples ranges from 6.06-8.33 during the pre-monsoon and from 6-8.5 during the post monsoon in the study area. All the water samples fall in the safe limit of pH standard (6–8.5) for irrigation purpose.

Salinity Hazard

Determination of salinity hazard is very important in irrigation water, as high salt content renders the soil saline. This also affects the salt intake capacity of the plants through the roots. In the present study, the salinity hazard was evaluated by EC and TDS. EC varies from

21.54 to 667.8µS/cm during pre-monsoon and 22.1-544.9 µS/cm during post monsoon. TDS varies from 14.22- 440.75mg/L during pe monsoon and 14.59- 359.63 mg/L during post monsoon. Based on the classification of TDS as suggested by USSL, all the water samples both from pre and post monsoon are classified as non-saline. According to the EC grading standards as suggested by Wilcox, 60% samples are classified as excellent category and 40% samples should be treated before use in irrigation.

Alkalinity Hazard (SAR)

Irrigation water is classified on the basis of SAR. Hence, the assessment of sodium hazard is necessary while considering the suitability for irrigation. The SAR values of the groundwater samples from pre monsoon and post monsoon varies from 0.2-1.5 and 0.2-2.2 respectively. The SAR values of the water samples of the study area less than 10 and are classified as excellent for irrigation. To determine the hazardous effect of sodium on water quality for irrigation, Percent Sodium (%Na) and Kelly's Index are calculated. The percent sodium (%Na) of pre monsoon samples varies from 17- 69% and the post monsoon samples varies from 28-48%. Around 87.5% of the pre monsoon samples are categorized as excellent-permissible while 12.5% of the samples as doubtful and all the post monsoon samples are categorized as excellent- permissible for irrigation purpose. Around 76.7% of the pre monsoon samples and 100% of the post monsoon samples has Kellys Index less than 1 and is classified as suitable for irrigation.

Magnesium Ratio

In the study area, nearly 23.2% of the pre monsoon water samples and 46.3% of the post monsoon samples has Mg ratio less than 50 % which is suitable for irrigation, as magnesium ratio of more than 50% indicate that the soil is more alkaline which adversely effects the crop yield.

Residual Sodium Carbonate (RSC)

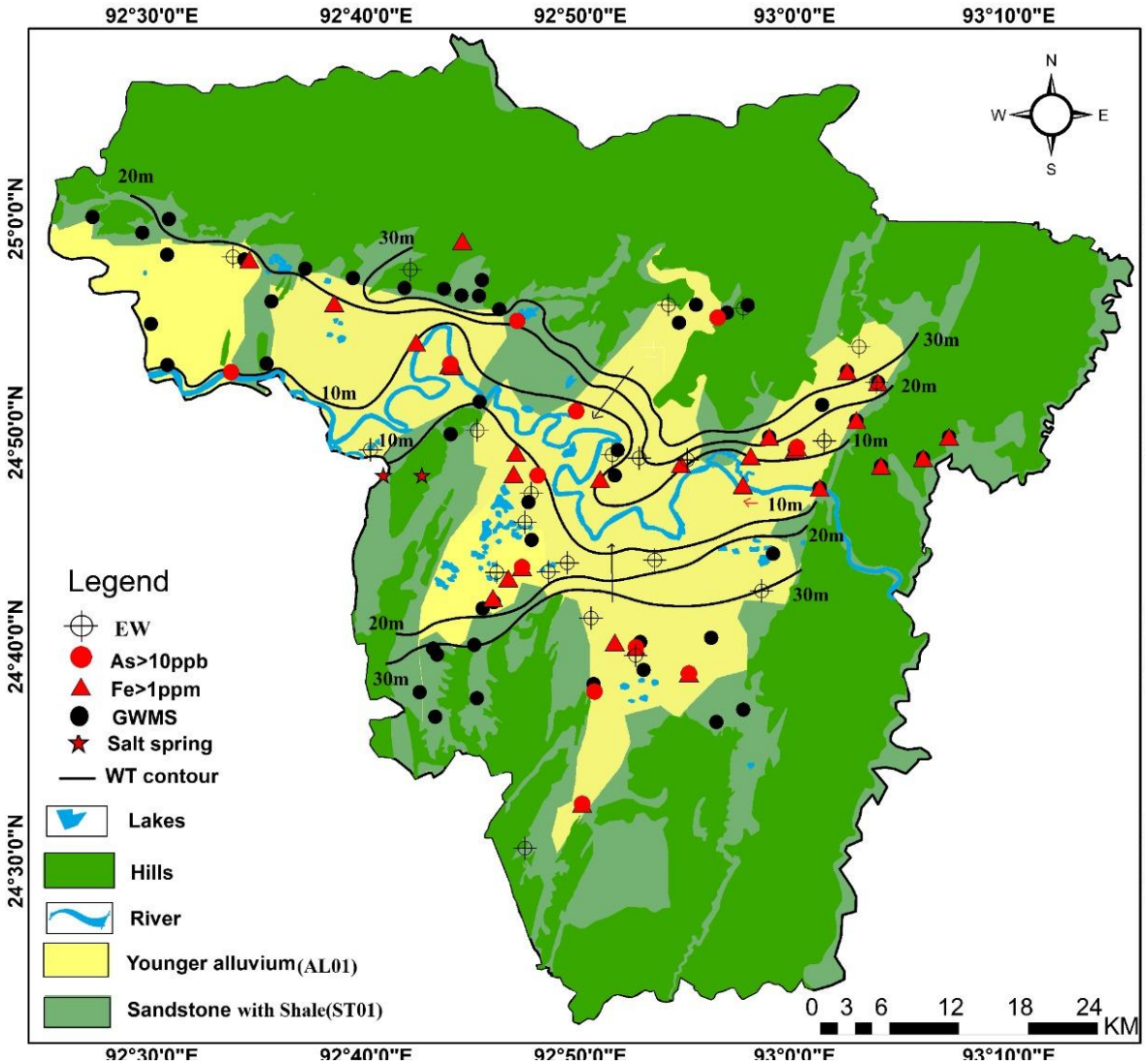
The RSC values varies from -0.4 to 3.3 ppm and -0.8 to 0.5ppm for pre monsoon and post monsoon water samples respectively.90% of the pre monsoon water samples are suitable for irrigation, 5% are marginally suitable and 5% are unsuitable for irrigation. All the post monsoon water samples are suitable for irrigation. The water with high RSC has high pH and land irrigated by such water becomes infertile owing to deposition of sodium carbonate as indicated by the black colour of the soil.

Table 3.5 - Feasibility check of ground water for irrigation purpose

Parameters	Range	Classification	Pre monsoon (No. samples)	Post monsoon (No. samples)
Total Dissolved Solid(TDS) (mg/L)	<1000	Non-saline	56	41
	1000-3000	Slightly saline	0	0
	3000-10000	Moderately saline	0	0
	>10000	Very saline	0	0
Salinity Hazard(EC) (µS/cm)	<250	Excellent	35	30
	250-750	Good	21	11
	750-2000	Permissible	0	0
	2000-3000	Doubtful	0	0
	>3000	Unsuitable	0	0
Alkalinity Hazard (SAR)	<10	Excellent	56	41
	10-18	Good	0	0
	18-26	Doubtful	0	0
	>26	Unsuitable	0	0
Percent Sodium (%Na)	<20	Excellent	2	0
	20-40	Good	24	39
	40-60	Permissible	23	2
	60-80	Doubtful	7	0
	>80	Unsuitable	0	0
Kelly's Index (KI)	<1	Suitable	43	41
	>1	Unsuitable	13	0
Magnesium Ratio (MR)	>50%	Unsuitable	43	22
	<50%	Suitable	13	19
Residual Sodium Carbonate (RSC)	<1.25	Suitable	50	41
	1.25-2.5	Marginally suitable	3	0
	>2.5	Unsuitable	3	0

3.4 Aquifer Map

Aquifer map of Cachar district is prepared using the available and generated data. Two major aquifers are delineated in the district, viz., younger alluvium (AL 01) and sandstone and shale (ST 02). The GW in the district is infested with iron and arsenic in shallow zones of younger alluvial aquifer. The aquifer map is shown in Fig.3.15.



Aquifer	Thickness of Zone (m)	Discharge (m^3/h)	Draw down (m)	Permeability (m/day)	Transmissivity (m2/day)	Storativity (S)
Younger Alluvium (AL 01)	4 to 12 (Shallow)	2.16 to 7.85	2.41 to 4.8	6.1 to 45.21	40.815	2.1×10^{-4} to 8.8×10^{-4}
Sandstone with shale (ST 02)	18 to 102	17.71 to 88		0.21 to 3.48	10.5 to 250.29	5.0×10^{-4} to 9.0×10^{-4}

Fig. 3.15: Aquifer map of Cachar district, Assam

Chapter 4.0
Groundwater Resources

Dynamic Groundwater Resources of Cachar district has been estimated based on the methodology recommended by Groundwater Estimation Committee (GEC'2015). The present methodology used for resources assessment is known as Ground Water Resource Estimation Methodology – 2015 (GEC'2015). GEC 2015 recommends estimation of Replenishable and in-storage ground water resources for both unconfined and confined aquifers. In GEC'2015, two approaches are recommended – water level fluctuation method and norms of rainfall infiltration method. The resources computed for the groundwater year 2019-20. The following sub-units are recommended for the computation of various figures in the methodology and these are considered in details below:

Hilly Area: Area with more than 20% slope has been excluded for the recharge computation. As per NESAC, total recharge worthy area in the district is 273358 Ha

Command and Non-Command Area- The methodology envisages computation of various figures separately for command & non-command area. In the district, there is no major or medium canal irrigation scheme and thus the entire rechargeable area has been considered as a non-command area.

Recharge from Rainfall- has been computed separately for monsoon and non-monsoon periods for the entire district. The recharge from rainfall during monsoon season has not been computed using water level fluctuation method (WLFM) as Ground Water Monitoring Wells (GWMW) in the district is very few. The rainfall recharge estimated for non-command area of the entire district and the details are shown in Annexure 5.1.

Recharge from All Sources- Total recharge to groundwater has several components, rainfall being the major one. The other components include seepage from canals, return flow from surface water irrigation, return flow from groundwater irrigation, seepage from tanks/ ponds etc.

Recharge from various sources has been calculated for monsoon as well as non-monsoon periods and details have been shown in Table 4.1.

Table 4.1- Groundwater recharge from various sources (Ham).

Assessment Unit/ District	Command/ Non-Command/ Total	Recharge from rainfall during monsoon season	Recharge from other sources during monsoon season	Recharge from rainfall during non-monsoon season	Recharge from other sources during non-monsoon season	Total Annual Ground Water Recharge	Provision for Natural Discharge	Annual Extractable Ground Water
Cachar	Non-command	52156.05	4199.83	26550.05	606.85	83512.78	8351.27	40443.75
	Total	52156.05	4199.83	26550.05	606.85	83512.78	8351.27	40443.75

4.1 Groundwater extraction for Various Purposes

Groundwater extraction for domestic use has been estimated based on number of households using groundwater (Census 2011 data). Groundwater draft for domestic purpose is 4019.91 ham, for irrigation 0 ham and for industrial use 10.56 ham. It was found that groundwater draft for all uses in the district is 4030.47 ham.

4.2 Stage of Groundwater extraction & Categorization of the Blocks

The district falls under "SAFE" category. The stage of GW extraction is 9.97%. Summary of groundwater resources, stages of development and categorization are given in Annexure 5.1.

4.3 Summarized results of dynamic ground water resources of Cachar district as on March 2020

The summarized results of dynamic ground water resources estimation of Cachar district as on March 2020 is shown in the Table 4.2.

Table 4.2:Summarized results of dynamic ground water resources of Cachar district as on March 2020

Sl. No.	**ITEM**	**Year,** **2019-20**
	Methodology	**GEC 2015** **(in ham)**
1	Total Annual Ground Water Recharge	83512.79
2	Total Natural Discharges	8351.28
3	Annual Extractable Ground Water Resource	40443.75
4	Total annual Ground water extraction	4030.47
5	Annual GW Allocation for for Domestic Use as on 2025	4552.83
6	Net Ground Water Availability for future use	35880.36
7	Stage of GW Development (%)	9.97

Chapter 5.0

Ground Water Related Issues

The main groundwater issues in the study area are its vulnerability issue. These include areas vulnerable to water logging as well as prone to water logging conditions along with high Iron and Arsenic concentration in ground water above the WHO permissible limit. The vulnerability map of Cachar district has been shown in Figure 6.1.

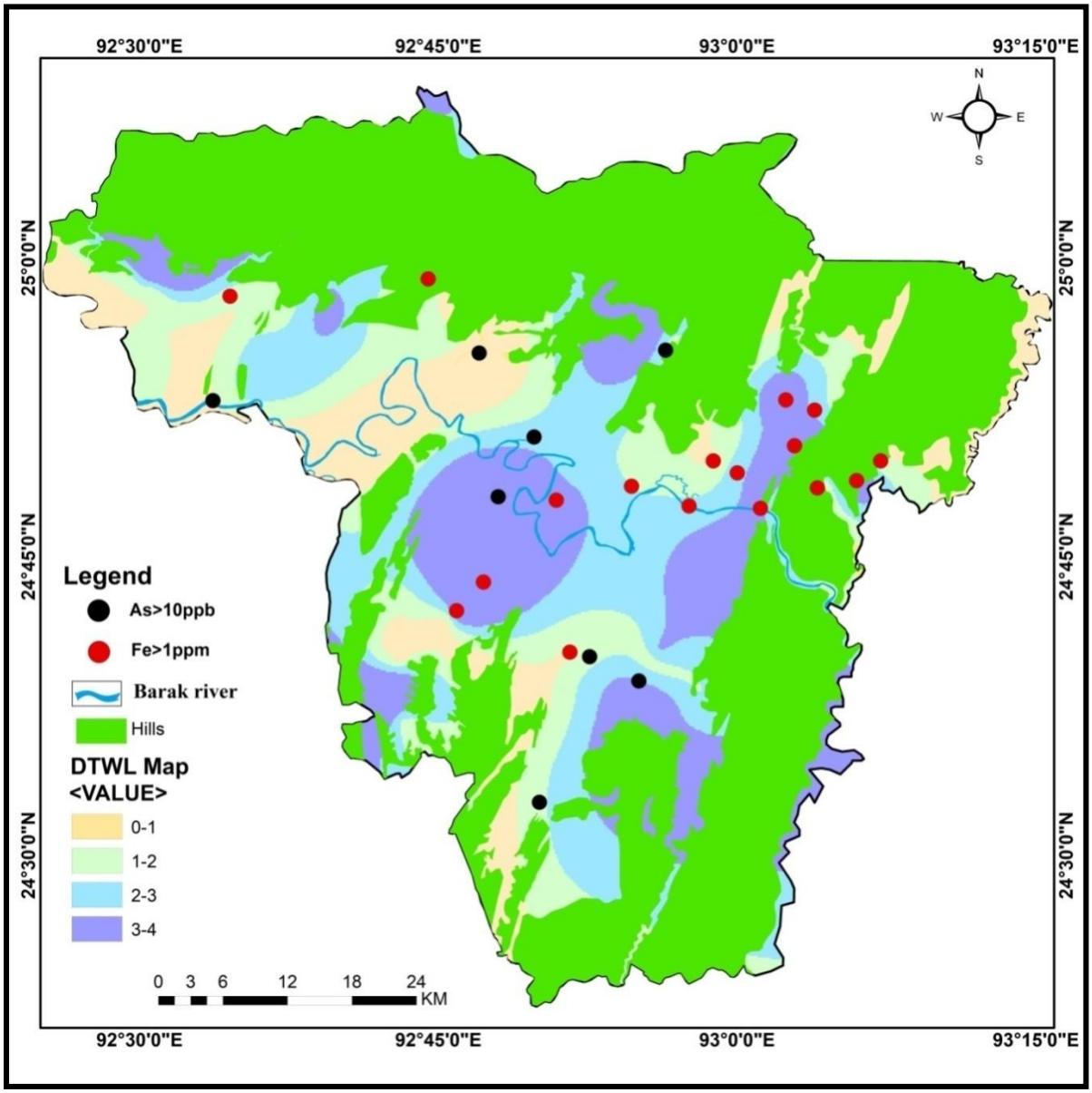


Fig 5.1: Vulnerability map of Cachar district.

5.1 Low stage of ground water development

As per ground water resource estimation 2020, the stage of ground water extraction is just 9.97 %. All the irrigation schemes in the district are dependent upon the surface water resources. Under PMKSY scheme shallow tube wells(<50m depth) are constructed in the district irrigating around 27259 Ha area. However there is enough scope for future development of ground water in the study area to bring more area under irrigation

practice.However according to the exploration data of CGWB some area in the district has clay layer upto a depth of 50m. So, construction of shallow tube wells in those areas will be a failure. In those areas deep tube wells more than 50m depth can be constructed.

5.2 High Iron Concentration

As per water quality analysis data, 37.5% of the water samples collected during pre-monsoon and 41.46% of the post monsoon samples from both dug well and tube well shows high concentration of Iron (i.e., >1ppm), which is above the permissible limit set by WHO for drinking water.

6.3 High Arsenic Concentration

As per water quality analysis data, 14.28% of water samples collected from both dug wells and tube wells shows high concentration of Arsenic (i.e., >10ppb), which is above the permissible limit set by WHO for drinking water. Most of the samples showing As values more than 10ppb in the study area tapped shallow aquifer, i.e. less 50m depth.

6.4 Water logging

As per the pre monsoon water level data around 250Km² of the district has depth to water level from 0-2m. As a result, this portion of the district remains water logged. In the Fig 5.1 it can be seen that the most of the water-logged area is spread in the western and south western part of the district. The alluvium cover in the area is mainly clayey in nature which prevents the water to percolate downward. High rainfall and low stage of ground water development also results in water logging in the area. Around 441 Km2 of the study area is prone to water logging condition. Such area has pre monsoon depth to water level of 2-3m.

6.5 Water borne diseases

A large population of the district living in the villages of the district does not get potable water during the lean season. As a result, a large population living in those areas suffers from many water borne diseases during that season.

Chapter 6.0

Management Strategies

6.1 Low Stage of Groundwater Extraction and Water Logging

As per dynamic ground water resource estimation of Cachar district for 2019-20, annual extractable ground water is 40443.75Ham and stage of ground water extraction is only 9.97%. The district is having balance net ground water availability for future development in the tune of 35880Ham. If an irrigation plan is made to develop 60% of the balance dynamic ground water resources available, then 21528Ham of groundwater resources is available in the district for the future irrigation uses. From this available resource (planned for future development) 8970 nos. of shallow tube wells (considering a unit draft of 2.4Ham/year) can be constructed in the district. Depth to water level map reveal that around 25000 ha area of the district is water logged and 44100ha area is prone to be water logged.

Net area sown in the district is 111056 ha. Present land under irrigation is only 27259 Ha which is only 24.5% of the net sown area. 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.To use the groundwater for irrigation purpose a cropping plan has been designed for the district by using CROPWAT model developed by FAO. Cropping pattern data for the district is presented in Table 7.1.

During dry season, summer paddy and autumn paddy are cultivated in 8865Ha and 8346Ha respectively. These paddies are cultivated in areas near to beels and haors, especially in Chatlabeel area, which remain inundated for 6-7 months during rainy season. Irrigation from both surface and ground water is very less. During Kharif season, 93845 ha area is cultivated for paddy and after that major part of this area remains fallow in want of irrigation facilities. CGWB has constructed 4 nos. of shallow exploratory tube wells and 13 Observation Wells/Piezometer within 50 m bgl under Tipaimukh project. Average discharge from shallow tube well was 4.4m^3/hr for the whole district which is very low to be used for irrigation. Considering all these facts, a plan is formulated to bring about 37% of this fallow land of about 35000 Ha under assured irrigation during Rabi season and increase cropping intensity up to 200%. The rest 63% of the area can be irrigated with the perennial surface streams. The district is drained by many perennial streams/rivers which can easily be tapped for irrigation purpose.

In rice fallow, pulses, potato, mustard and rabi vegetables can be grown with the support of irrigation. Present cropping pattern, proposed cropping pattern, intended increase in cropping intensity were shown in Table 7.2a and 7.2b.

Table 6.1 - Cropping pattern data for Cachar district

CROPPING PATTERN DATA
(File: untitled)

Cropping pattern name: Cachar

No.	Crop file	Crop name	Planting date	Harvest date	Area %
1	...Data\CROPWAT\data	Rice	04/06	01/10	12
2	...Data\CROPWAT\data	Rice	11/06	08/10	13
3	...Data\CROPWAT\data	Rice	18/06	15/10	13
4	...Data\CROPWAT\data	Rice	25/06	22/10	12
5	...CROPWAT\data\crop	Small Vegetables	15/10	17/01	10
6	...a\CROPWAT\data\cr	Pulses	20/10	06/02	10
7	...\CROPWAT\data\cro	Potato	25/10	03/03	10
8	...a\CROPWAT\data\cr	Pulses	30/10	16/02	5
9	...CROPWAT\data\crop	Small Vegetables	07/11	09/02	5
10	rape__mustard.CRO	Mustard	15/11	24/03	10

Table 6.2a:Cropping pattern, proposed cropping pattern, intended cropping intensity, Cachar district

Cropping pattern (s)				
1. Rice 2. Rice-Pulses 3. Rice-Vegetables 4. Rice-Potato	**Present Cultivated area (Ha)**	**Area to be cultivated (%)**	**Area to be cultivated (Ha)**	**Irrigation requirement (Ham)**
	1	2 (= % of 1)	3	4
Rice (main crop)	35000		35000	5447.96
Pulses	0	30	10500	940.8
Mustard	0	20	7000	924.7
Potato	0	20	7000	1061.2
Vegetables	0	30	10500	1254.05
Net cultivated area	35000		**35000**	
Gross cultivated area (1+potato/+mustard/+Veg)	35000		**70000**	
Net irrigation requirement				9628.71
Gross irrigation requirement (considering 70% Irrigation Efficiency)				13755.3
Cropping intensity	**100% (Present)**		**200% (Intended)**	

Table 7.2b:Proposed cropping pattern with water deficit months and IWR,Cachar district

Crop	Growing period (Months)	Periods/months of water deficit	Irrigation requirement (Ham)
Rice	4	1-3	5447.96
Pulses	5	5	940.8
Potato		4	1061.2
Vegetables	4	3-4	1254.05
Mustard	4-5	4	924.7

It is planned to utilize rice fallow of 35000Ha for the cultivation of pulses, potato, and vegetables. It is considered to cultivate Vegetables in 10500 ha, Pulses in 10500 ha, mustard in 7000haand potato in 7000ha each. The peak water requirement for irrigation for rice is in the month of May-June, and for potato, mustard and pulses it is in the month of January and vegetables in December – January.

Crop-wise and month-wise irrigation water requirement (Precipitation deficit) has been taken from CROPWAT after giving necessary meteorological, soil, crop plan inputs and the same has been shown in Table 7.3. Crop-wise and month-wise Irrigation water requirement in Ham has been further calculated in Table 7.4.

Both CGWB and PHED has constructed successful tube wells in the district and established the presence of exploitable aquifers. Under ground water exploration programme, CGWB has drilled 13 nos. of exploratory (including observation wells) tube wells in the district down to the depth of 300 m bgl. It has been established that deeper aquifer in most part of the valleys in the district is having moderate potentiality, having an average discharge of about 35 m^3/hr and can be sustainably developed and use for irrigation purpose. However PHED has constructed many tube wells in the district within 100m depth yielding 15-25m^3/hr. CGWB has also constructed 2 nos. of shallow exploratory tube wells and 4 Observation Wells within 50 m bgl under Tipaimukh project in the northern part (Pangram and Kalain areas). Average discharge from a shallow tube well was 7m^3/hr. Whereas shallow tube wells drilled in the southern part(Silkuri) has a discharge of 2.16 m^3/hr.Under PMKSY GW Irrigation schemes, Assam Govt. is constructing shallow tube well within 50 m depth in the district.

Thus in the northern part of the district shallow tube wells can be constructed by using 8// diameter housing pipe and a casing pipe down to 25 m. A shallow tube well having discharge of 10 m^3/hr, if runs for 8 hours a day and for 120 days, will create a draft of 0.96 Ham. Thus in 17500 Ha area, 3269 shallow tube wells can be constructed (considering 200m distance between any two tube well). 3269 nos. of shallow tube wells can extract 3138 Ham of water annually. As CGWB has confirmed the occurrence of arsenic from shallow aquifer zone in the northern part of the district so ground water quality must be analyzed before using water for irrigation purpose. In such arsenic affected areas surface irrigation from ponds or other water bodies must be considered for irrigation.

In the southern part of the district as the thickness of granular zones is less and the discharge of the shallow tube well is also very less thus deep tube wells upto 100m depth can be constructed. A deep tube well within a depth of 100m, is expected to provide a discharge of 20m^3/hr. Such a tube well if runs for 8 hours a day and for 120 days will create a draft of 1.92 Ham. Thus in 52500 Ha area, 3380 nos. of deep tube wells can be constructed (considering 200m distance between any two tube well). 3380 nos. of deep tube wells can extract 6490 Ham of water annually.

Annual irrigation water requirement (IWR) considering 70% irrigation efficiency is 13755.3 Ham while irrigation water requirement during dry season spanning from October to March is 4260 Ham. The expected discharge from both the shallow and deep tube well is around 9629 Ham. So, there is a gap of 4126.3 Ham between annual IWR and expected total

discharge from shallow and deep tube wells. However, during Rabi season entire considered area can be covered from ground water irrigation. Therefore, to bring this rice fallow area under double cropping conjunctive use of groundwater and surface water will be useful which will create less stress on ground water. Construction of tube wells for irrigation purposes will also have a positive impact in water logging area by lowering the water levels. In the southern part of the district beyond Palanghat area there are no granular zones encountered upto a depth of 50m.In absence of any granular zones within 50m depth in such areas, surface water irrigation will be useful. CGWB has not drilled any tube wells in the western part of the district near Haritikar area, so in this area more geophysical surveys.

(VES) should be employed to ascertain the granular zones before undertaking any ground water irrigation projects.

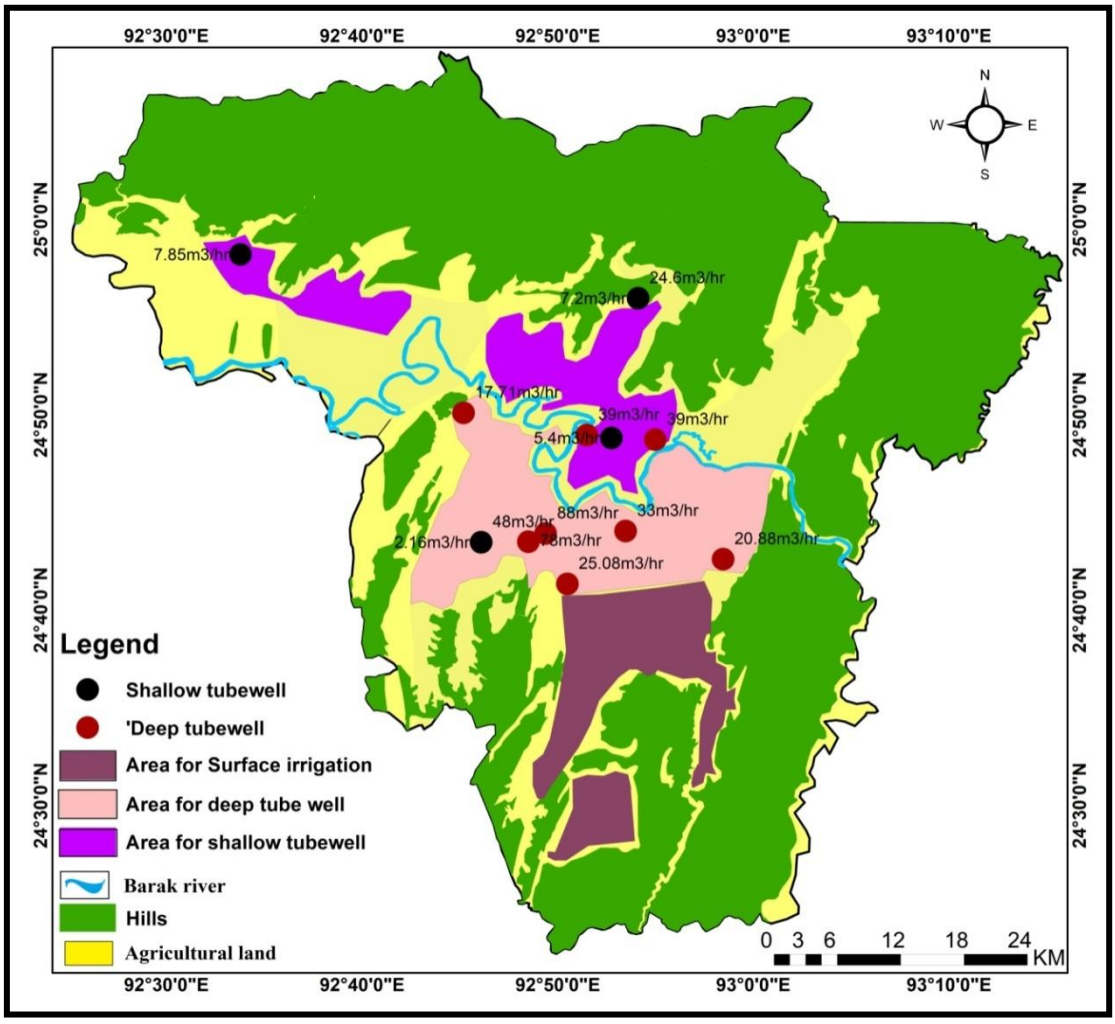


Fig 6.1: Map showing area considered for irrigation in the management plan.

Table 6.3: Crop-wise and month-wise precipitation deficit (IWR) from CROPWAT 8, Cachar district.

Crop	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Precipitation deficit (mm)												
1. Rice	0	0	0	0	147.2	63.2	0	0	0	3.3	0	0
2. Rice	0	0	0	0	49.6	98.0	0	0	0	0	0	0
3. Rice	0	0	0	0	49.7	62.7	0	0	0	0	0	0
4. Rice	0	0	0	0	0	147.1	0	0	0	6.1	0	0
5. Small Vegetables	24.5	0	0	0	0	0	0	0	0	0	29.0	60.0
6. Pulses	46.9	1.3	0	0	0	0	0	0	0	1.4	17.8	65.2
7. Potato	55.1	25.2	0	0	0	0	0	0	0	0	12.1	59.2
8. Pulses	54.9	8.4	0	0	0	0	0	0	0	2.6	7.5	58.6
9. Small Vegetables	48.9	9.9	0	0	0	0	0	0	0	0	19.4	53.1
10. Mustard	38.5	21.1	0	0	0	0	0	0	0	0	3.8	26.7

Table 6.4: Irrigation Water Requirement (in Ham), Cachar District

	% of 70000 ha	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1. Rice	12	0.00	0.00	0.00	0.00	1236.48	530.88	0.00	0.00	0.00	27.72	0.00	0.00	1795.08
2. Rice	13	0.00	0.00	0.00	0.00	451.36	891.8	0.00	0.00	0.00	0.00	0.00	0.00	1343.16
3. Rice	13	0.00	0.00	0.00	0.00	452.27	570.57	0.00	0.00	0.00	0.00	0.00	0.00	1022.84
4. Rice	12	0.00	0.00	0.00	0.00	0.00	1235.64	0.00	0.00	0.00	51.24	0.00	0.00	1286.88
5. Small Vegetables	10	171.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	203	420	794.5
6. Pulses	10	328.3	9.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.00	9.8	124.6	478.8
7. Potato	10	385.7	176.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	84.7	414.4	1061.2
8. Pulses	5	192.15	29.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.1	26.25	205.1	462
9. Small Vegetables	5	171.15	34.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	67.9	185.85	459.55
10.Mustard	10	269.5	147.7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	135.8	371.7	924.7
Total		1518.3	397.25	0.00	0.00	2140.11	3228.89	0.00	0.00	0.00	95.06	527.45	1721.65	9628.71

6.2 Groundwater Quality

CGWB has confirmed the occurrences of arsenic and iron in the groundwater. However, it is observed that arsenic is detected only from shallow aquifer within 50 m depth. Therefore, tube wells can be constructed down to a depth of 100 m tapping lower 50m granular zones. From the 2D disposition of aquifer diagram it is observed that clay layers are present in many areas. These confining layers can be utilized to separate the arsenic occurrence zone by adopting proper well construction technique. Deep tube well in the flood plain and arsenic affected areas may be constructed by proper cement sealing and clay filling as shown in Fig. 7.2.

In arsenic affected areas, surface water bodies like river, lakes, ponds/tanks should be used for drinking purpose (after suitable treatment/ filtering). If surface water sources are not available then groundwater can be extracted by following the measures described above.

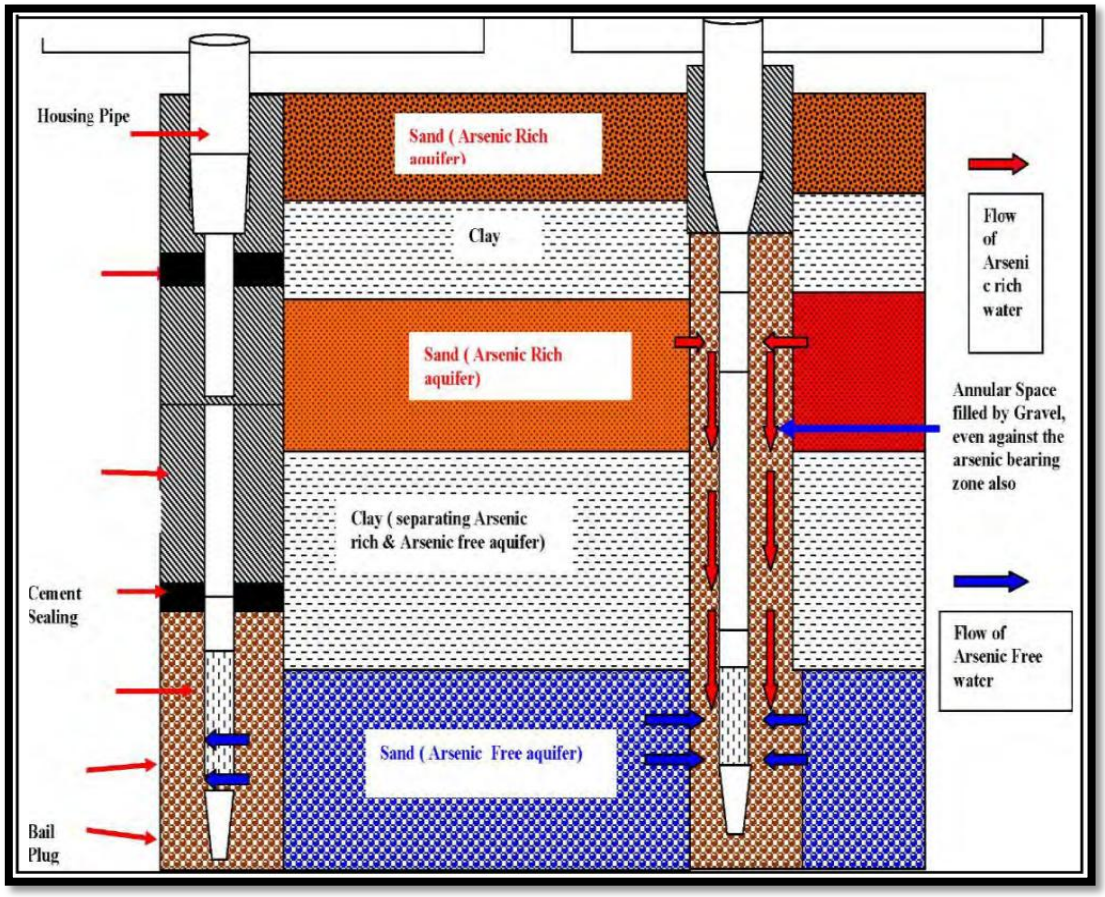


Fig.6.2- Tube-well design of a deep tube well tapping safe deeper aquifer

(Source: Concept note on geogenic contamination of groundwater in India Groundwater from both shallow and deep aquifers is infested with iron.)

So, iron removal plants (compact/ traditional) should be installed before supplying water.

Annexure :1

Details of the granular zones delineated by electrical logging

EXPLORATORY WELL	GRANULAR ZONES IDENTIFED FROM ELECTRICAL LOGGING(DEPTH BELOW GROUND LEVEL)
BASKANDI EW	12.19-48.76 53.34-65.53
KASHIPUR EW	10.06-15.24, 28.34-34.44, 35.66-123.44(with clay intercalations), 129.23-134.11, 134.68-144.17, 152.4-154.83, 156.36- 161.54, 177.36- 181.91, 185.31- 197.51, 199.64-204.21, 208.78- 213.36, 237.13-242.92, 251.46- 263.65, 278.87-281.63, 286.5- 291.08
DHALCHARA EW	6.09- 17.98, 20.11- 39.62(with clay at 30.78- 31.39) 42.36- 51.51, 52.73- 57.3, 59.43- 65.53
SILKURI EW	14.63- 17.07, 23.47-26.52, 30.43-38.10, 45.72-75.60, 99.06- 217.35
SONAIMUKH EW	29.81-34.56, 44.19- 55.65, 60.96- 77.0, 88.39- 91.75, 94.68- 110.67, 147.0- 153.0, 175.68- 185.0, 191.71-207.26, 223.99- 233.0, 250.84- 252.38, 253.84- 265.86, 274.79- 277.79, 289.9- 292.95

Annexure 2

Pre & Post Monsoon DTWL and fluctuation data of Key wells

Location	Pre monsoon DTW (mbgl)	Post-monsoon DTW(mbgl)	Fluctuation
Badribasti	3.4	1.62	1.78
Tarapur	1.06	0.21	0.85
Shivtila	2.63	2.35	0.28
Poilapool	1.35	1.05	0.3
Dewanbagan	2.97	2	0.97
Barthal	4.36	3.1	1.26
Razabazar	2.58	1.91	0.67
Kamranga	6.1	3.2	2.9
Fulertal	3.12	2.37	0.75
Chalitatal	0.98	1.12	-0.14
Jirighat	4.12	3.22	0.9
Kashipur	2.63	1.7	0.93
Atalbasti	6.26	4.68	1.58
Sadhutila	4.74	3.36	1.38
Chaltabasti/Kathaltila	4.46	2.06	2.4
Dargakona	0.94	0.6	0.34
Borjalenga	0.24	0.1	0.14
Dwarbond	6.1	2.9	3.2
Dwarbond PHC	1.81	2.05	-0.24
Nayabil 1	2.55	2	0.55
Nayabil 2	1.15	1	0.15
Katigora	2.25	1.55	0.7
Digarkhal	7.9	0.68	7.22
Kalain	1.65	1.35	0.3
Nagdirgram	1.54	1.14	0.4
Kachudaram	3	1.23	1.77
Ganganagar	2.28	1.2	1.08
Sachinpur	5.3	1.6	3.7
Palanghat	2.5	0.9	1.6
Panibhora	0.96	2.3	-1.34
Sarbantila	2.1	2	0.1
Tikal TE	2.3	1.8	0.5
Shiverband	1.3	1.45	-0.15
Thaligram	4.4	3.7	0.7
Ghungorbond	4.1	2.5	1.6
Khalkuri	3.83	3.6	0.23
Dolu	-0.03	-0.18	0.15
Boromampur	0.99	1.02	-0.03
Balachara	0.87	1.28	-0.41
Puthichara	1.15	1.23	-0.08
Borkhola LP school	2	2.2	-0.2
Borkhola	1.4	1.4	0
Dolchera	1.8	1.65	0.15
Behara	3.38	3.32	0.06
Burunga	1.35	1.95	-0.6
Hilara	1.9	3.7	-1.8
Srikona/Masimpur	1.51	2.31	-0.8
Masimpur	1.2	0.9	0.3
Kalyanpurpatshala	0.94	3.6	-2.66
Haritikar	1.32	0.92	0.4
Chandinagar	1.78	1.5	0.28
Kandigram	1.44	1.24	0.2
Jalalpur	2.3	3.3	-1
Jalalpur TE	1.24	1	0.24

Annexure:3

Chemical data of Ground water monitoring station of Cahardistrict (pre-monsoon)

Location	Lat DMS	Long DMS	Source	Temp (ºC)	pH	EC (µs/cm) 25^0C	Turbidity (NTU)	TDS	CO_3^{2-}	HCO_3^{1-}	TA (as $CaCO_3$)	Cl^-	SO_4^{2-}	NO_3^{-1}	F^-	Ca^2	Mg^{2+}	TH (as $CaCO_3$)	Na	K	Fe	As (in µg/L)
								(in mg/L)														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Badripar	24.80	92.85	TW	25	7.7	267.20	BDL	176.35	BDL	177.04	177.04	28.36	13.26	BDL	0.02	28.02	13.34	125.00	31.41	6.98	2.59	2.10
Badribasti	24.80	92.86	DW	23.5	7.1	192.50	BDL	127.05	BDL	42.73	42.73	67.36	6.45	3.26	BDL	8.01	14.56	80.00	18.87	8.81	0.15	0.68
Baskandi	24.81	92.91	TW	20.8	6.0	104.30	BDL	68.84	BDL	30.52	30.52	49.63	3.20	2.39	BDL	6.00	14.56	75.00	7.32	4.49	0.16	0.57
Tolangram	24.79	92.96	TW	23.3	7.1	106.90	BDL	70.55	BDL	79.36	79.36	35.45	10.65	BDL	BDL	6.00	16.99	85.00	7.93	1.56	19.63	4.51
Tarapur	24.83	92.98	DW	24.6	4.7	291.10	0.10	192.13	BDL	42.73	42.73	63.81	3.05	4.27	BDL	6.00	20.63	100.00	12.42	11.33	0.06	0.79
Shivtila	24.82	93.00	DW	23.3	7.0	197.10	BDL	130.09	BDL	73.26	73.26	31.91	4.11	10.06	BDL	8.01	9.70	60.00	17.29	13.60	0.95	1.01
Poilapool	24.83	93.12	DW	20.9	7.1	191.30	BDL	126.26	BDL	48.84	48.84	42.54	19.29	BDL	0.13	12.01	13.34	85.00	15.69	4.20	3.62	1.23
Barthal	24.88	93.04	DW	24.4	6.4	127.20	BDL	83.95	BDL	30.52	30.52	42.54	2.11	0.98	BDL	6.00	12.13	65.00	6.79	8.68	0.13	1.44
Razabazar	24.87	93.06	DW	23.3	7.6	188.50	BDL	124.41	BDL	103.78	103.78	17.73	15.32	0.96	0.01	14.01	14.56	95.00	15.68	5.31	0.19	0.90
Kamranga	24.84	93.05	DW	23.3	7.3	147.70	0.20	97.48	BDL	67.15	67.15	31.91	4.13	BDL	BDL	8.01	14.56	80.00	11.03	2.70	0.38	1.23
Fulertal	24.79	93.02	DW	24.2	7.0	202.90	0.10	133.91	BDL	61.05	61.05	35.45	3.46	4.40	0.06	8.01	8.49	55.00	23.70	6.08	0.38	0.57
Chalitatal	24.81	93.07	DW	22.8	7.1	124.60	BDL	82.24	BDL	61.05	61.05	28.36	10.48	0.88	BDL	6.00	12.13	65.00	15.79	2.99	0.45	0.79
Jirighat	24.81	93.10	DW	22.7	6.9	83.29	BDL	54.97	BDL	30.52	30.52	28.36	5.63	BDL	BDL	10.01	7.28	55.00	6.08	3.36	0.12	0.68
Lalmati 2	24.81	92.71	DW	20.8	7.4	198.30	BDL	130.88	BDL	79.36	79.36	39.00	25.28	5.49	BDL	18.01	12.13	95.00	16.41	6.89	0.62	1.01
Noonkhuli	24.80	92.71	Spring	23.8	8.4	25670.0	BDL	16942.2	84.0	2582.3	2666.3	850.8	0.83	BDL	BDL	32.03	30.32	205.0	8008.5	129.0	0.15	2.21
Nagdirgram /Kabuganj	24.67	92.86	TW	26.1	7.9	368.50	BDL	243.21	BDL	158.73	158.73	21.27	3.06	1.36	0.26	8.01	15.77	85.00	25.27	7.53	0.15	0.90
Nagdirgram-I	24.67	92.88	TW	26	6.7	516.00	BDL	340.56	BDL	305.24	305.24	17.73	BDL	BDL	BDL	14.01	23.05	130.00	28.49	14.34	22.15	27.98
Palanghat	24.65	92.88	DW	21.1	7.9	358.00	BDL	236.28	BDL	140.41	140.41	35.45	23.40	26.66	0.06	44.04	13.33	165.00	22.38	2.91	0.48	2.87
Boali	24.65	92.92	TW	25.6	6.6	451.70	BDL	298.12	BDL	268.61	268.61	14.18	18.79	BDL	BDL	14.01	14.56	95.00	36.13	25.76	22.41	16.33
Ganganagar	24.62	92.96	DW	22.5	7.8	307.40	BDL	202.88	BDL	152.62	152.62	17.73	27.22	BDL	0.02	28.02	24.26	170.00	9.42	3.70	_	_
Sachinagar	24.61	92.94	DW	24	7.9	221.40	0.10	146.12	BDL	122.10	122.10	17.73	0.24	BDL	0.02	36.03	3.62	105.0	9.88	2.43	0.46	1.88
Panibhora	24.64	92.84	DW	22.6	8.0	518.10	BDL	341.95	BDL	213.67	213.67	67.36	12.6	3.40	0.01	14.0	40.04	200.0	37.92	7.73	1.22	2.43
Bhagabazar	24.54	92.83	TW	22.6	7.5	307.20	BDL	202.75	BDL	109.89	109.89	49.63	BDL	BDL	0.02	20.02	12.13	100.00	13.83	2.91	22.52	55.53
Kalyanpur	24.88	92.56	DW	25.2	7.9	380.20	0.30	250.93	BDL	213.67	213.67	49.63	15.40	1.25	0.14	44.04	24.25	210.0	26.84	3.95	7.28	41.4
Katigora	24.89	92.59	DW	23.2	7.4	141.80	BDL	93.59	BDL	42.73	42.73	49.63	6.30	BDL	0.01	16.01	15.77	105.0	6.02	2.73	1.02	4.95
Kalain	24.97	92.57	DW	23.5	7.8	667.80	BDL	440.75	BDL	189.25	189.25	113.44	19.12	3.23	0.01	40.03	30.32	225.0	49.60	20.50	6.00	6.06
Jayashree TE school) /Jalalpur	24.99	92.49	DW	24.2	7.2	107.70	BDL	71.08	BDL	36.63	36.63	28.36	22.33	BDL	0.01	10.01	13.34	80.00	5.00	2.23	0.16	4.84

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Jayashree TE 1 /Jalalpur TE	25.00	92.45	DW	23.3	6.3	621.30	BDL	410.06	BDL	61.05	61.05	63.81	0.17	12.88	BDL	30.02	8.48	110.0	21.29	5.94	0.05	4.73
Digarkhal	25.00	92.51	DW	25.3	7.3	379.10	0.10	250.21	BDL	54.94	54.94	63.81	65.42	1.18	0.02	26.02	7.27	95.00	41.39	8.07	1.59	3.09
Kalain-I	24.97	92.58	TW	24.1	6.6	128.40	0.10	84.74	BDL	30.52	30.52	60.27	12.67	BDL	0.01	10.01	9.70	65.00	19.79	2.52	6.64	0.35
Atalbasti	24.78	92.79	DW	25.6	6.9	161.40	BDL	106.52	BDL	30.52	30.52	63.81	14.76	BDL	0.01	10.01	9.70	65.00	30.76	7.74	0.15	0.24
Sadhutila	24.75	92.80	DW	24.4	7.4	145.90	BDL	96.29	BDL	73.26	73.26	21.27	0.87	7.58	0.01	18.01	9.70	85.00	7.40	3.30	1.14	1.33
Silkuri	24.73	92.79	TW	24.6	6.8	47.29	BDL	31.21	BDL	30.52	30.52	17.73	31.39	6.76	0.01	10.01	3.64	40.00	13.66	2.44	3.94	5.73
Mithapani	24.70	92.77	TW	26	6.5	21.54	BDL	14.22	BDL	24.42	24.42	17.73	29.98	BDL	BDL	6.00	6.07	40.00	12.93	2.63	1.99	1.23
Mithapani	24.71	92.76	DW	24.8	6.8	42.05	BDL	27.75	BDL	36.63	36.63	14.18	11.56	BDL	BDL	8.01	7.28	50.00	3.01	4.04	0.86	1.12
Chaltabasti	24.70	92.77	DW	26	6.4	64.27	BDL	42.42	BDL	24.42	24.42	35.45	1.69	BDL	BDL	12.01	4.85	50.00	9.57	2.35	0.59	BDL
Irongmara	24.98	92.74	TW	26.4	6.4	60.03	0.10	39.62	BDL	12.21	12.21	17.73	29.79	19.64	0.07	6.00	8.49	50.00	16.49	3.08	0.31	BDL
Nayabil 2	24.67	92.75	DW	22.4	7.1	197.70	BDL	130.48	BDL	73.26	73.26	31.91	2.19	BDL	BDL	20.02	6.06	75.00	13.27	3.56	1.95	0.03
Borjalenga	24.67	92.72	DW	24.2	7.2	94.58	BDL	62.42	BDL	54.94	54.94	17.73	0.30	BDL	BDL	10.01	7.28	55.00	4.01	8.86	0.59	0.03
Chutojalenga	24.65	92.71	TW	28.5	7.4	118.80	BDL	78.41	BDL	79.36	79.36	10.64	BDL	13.25	0.13	12.01	7.28	60.00	9.87	10.26	1.50	3.94
Dwarbond	24.63	92.71	DW	23.3	7.6	453.70	BDL	299.44	BDL	122.10	122.10	85.08	BDL	2.37	BDL	36.03	9.69	130.0	42.22	13.34	0.36	BDL
Bordukan /Dwarbond PHC	24.61	92.72	DW	23.1	7.4	195.30	BDL	128.90	BDL	79.36	79.36	35.45	20.55	22.55	BDL	20.02	7.27	80.00	31.19	4.41	0.45	BDL
Moinarbond	24.85	92.83	DW	24.1	7.8	285.40	BDL	188.36	BDL	177.04	177.04	21.27	BDL	BDL	0.17	24.02	14.55	120.0	25.36	3.23	3.19	37.61
Udharband	24.89	92.88	TW	25.6	7.5	160.30	BDL	105.80	BDL	85.47	85.47	14.18	19.61	BDL	0.28	8.01	7.28	50.00	29.22	3.07	1.36	0.94
Salganga	24.92	92.94	TW	24.1	8.3	467.70	0.20	308.68	15.0	299.14	314.14	21.27	1.11	8.26	0.08	32.03	18.19	155.0	81.45	3.91	1.16	17.82
Shiverband	24.93	92.95	DW	24.9	7.4	292.10	BDL	192.79	BDL	115.99	115.99	46.09	7.92	BDL	0.03	16.0	7.27	70.00	50.10	4.06	0.97	0.55
Thaligram	24.93	92.92	DW	23.4	7.7	316.10	BDL	208.63	BDL	146.52	146.52	28.36	1.99	2.36	0.03	28.02	3.63	85.00	36.81	6.77	3.84	0.94
Dolu	24.92	92.78	DW	24.3	6.4	142.20	BDL	93.85	BDL	30.52	30.52	46.09	2.89	BDL	BDL	8.01	8.49	55.00	16.43	5.08	0.50	18.61
Balachara	24.95	92.76	DW	22.2	7.4	352.40	BDL	232.58	BDL	97.68	97.68	46.09	3.31	6.25	BDL	20.02	18.19	125.0	15.32	7.72	0.45	0.42
Borkhola	24.95	92.73	DW	22.3	7.1	169.30	BDL	111.74	BDL	24.42	24.42	49.63	13.25	9.07	BDL	8.01	19.41	100.0	5.12	7.51	0.87	2.77
Silkuri camp	24.72	92.78	TW	25.5	7.0	123.10	BDL	81.25	BDL	36.63	36.63	31.91	13.91	20.62	BDL	6.00	19.41	95.00	6.76	4.40	0.59	BDL
Silchar	24.82	92.78	TW	23	7.4	133.20	BDL	87.91	BDL	61.05	61.05	17.73	3.74	BDL	0.02	6.00	9.71	55.00	10.87	3.58	0.40	0.55
Chandrapur	24.80	92.78	TW	26.7	6.8	247.30	BDL	163.22	BDL	177.04	177.04	10.64	8.98	11.96	0.01	16.01	3.63	55.00	40.14	15.11	0.31	0.16
Silchar 1	24.80	92.80	TW	27	7.1	141.40	BDL	93.32	BDL	61.05	61.05	7.09	28.36	22.20	0.01	10.01	9.70	65.00	19.99	4.00	0.40	18.61
Rongpur	24.84	92.84	TW	24.1	7.0	97.07	0.10	64.07	BDL	54.94	54.94	21.27	2.90	BDL	0.02	10.01	6.06	50.00	12.52	3.95	0.36	3.55
Ramnagar	24.83	92.74	TW	28.4	7.9	365.20	BDL	241.03	BDL	238.09	238.09	21.27	63.00	32.17	0.01	14.01	33.97	175.0	35.41	28.20	0.36	1.72
Surtara	24.83	92.69	TW	26.1	7.9	287.80	BDL	189.95	BDL	128.20	128.20	17.73	16.58	BDL	0.02	26.02	7.27	95.00	18.43	4.74	0.40	0.55

Annexure: 4

Chemical data of Ground water monitoring station of Cahar district (post-monsoon)

Location	Lat DMS	Long DMS	Source	Temp (ºC)	pH	EC (µs/cm) 25C	Turbidity (NTU)	TDS	CO_3^{2-}	HCO_3^{1-}	TA (as $CaCO_3$)	Cl^-	SO_4^{2-}	NO_3^{1-}	F^-	Ca^{2+}	Mg^{2+}	TH (as $CaCO_3$)	Na	K	Fe	As (in µg/L)
								(in mg/L)														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Lalmati 1	24.81	92.71	DW	23.8	8.56	544.90	BDL	359.63	BDL	250.30	262.30	109.90	26.13	BDL	0.07	52.04	25.48	230.00	79.93	36.46	23.08	1.143
Lalmati 2	24.81	92.71	DW	25.3	8.50	506.90	BDL	334.55	BDL	225.88	243.88	95.72	26.13	BDL	BDL	44.04	24.27	200.00	58.56	16.99	22.33	0.214
Shiverbond	24.93	92.95	DW	26.9	8.46	447.10	BDL	295.09	BDL	207.57	231.57	85.08	21.15	BDL	BDL	38.03	24.25	155.00	45.42	15.07	22.30	1.531
Borkhola	24.95	92.73	DW	26.3	8.40	348.20	BDL	229.81	BDL	183.15	183.15	85.08	18.18	BDL	BDL	34.03	21.84	145.00	33.95	14.78	14.74	0.28
Kalain	24.97	92.57	DW	26.2	8.39	322.50	BDL	212.85	BDL	164.83	176.83	74.45	17.03	BDL	BDL	32.03	21.83	135.00	33.30	10.06	14.46	0.28
Digarkhal	25.00	92.51	DW	26	8.39	308.20	BDL	202.16	BDL	152.62	167.62	70.90	15.18	BDL	BDL	30.02	21.82	135.00	32.38	9.25	14.12	0.508
Katigora	24.89	92.59	DW	25.8	8.31	306.30	BDL	194.24	BDL	146.52	146.52	70.90	12.51	BDL	BDL	30.02	19.41	135.00	32.01	9.11	13.84	BDL
Atalbasti	24.78	92.79	DW	27.5	8.18	294.30	BDL	185.70	BDL	128.20	128.20	67.36	10.71	BDL	BDL	28.02	19.41	125.00	31.65	8.59	12.49	BDL
Mithapani	24.71	92.76	DW	27.5	7.83	288.10	BDL	183.35	BDL	115.99	118.89	56.72	9.29	BDL	BDL	26.02	18.20	125.00	31.30	8.49	10.94	BDL
Badribasti	24.80	92.86	DW	26.6	7.80	277.80	BDL	173.90	BDL	115.99	115.99	49.63	9.21	BDL	BDL	26.02	16.98	125.00	30.12	7.36	10.24	BDL
Rajabazar	24.87	93.06	DW	26.5	7.68	256.10	BDL	158.73	BDL	109.89	115.99	46.09	7.91	BDL	BDL	24.02	16.98	115.00	29.86	7.29	9.51	0.28
Fulertal	24.79	93.02	DW	26.9	7.66	240.50	BDL	152.90	BDL	109.89	109.89	42.54	7.36	BDL	BDL	24.02	15.77	115.00	28.02	6.97	9.26	BDL
Chailtatal	24.81	93.07	DW	26.6	7.65	203.90	BDL	134.57	BDL	109.89	109.89	42.54	7.17	BDL	BDL	22.02	15.76	110.00	25.33	6.66	4.08	BDL
Jirighat	24.81	93.10	DW	26.7	7.60	199.10	BDL	131.41	BDL	103.78	109.68	42.54	7.06	BDL	2.03	20.02	14.56	105.00	24.19	6.54	1.92	BDL
Ganganagar	24.62	92.96	DW	26.7	7.57	189.60	BDL	125.14	BDL	103.78	103.78	42.54	6.37	55.50	1.23	18.01	14.56	105.00	19.90	6.35	1.61	0.963
Sachinagar	24.61	92.94	DW	27	7.46	188.40	BDL	120.05	BDL	97.68	103.78	42.54	6.02	19.81	0.84	18.01	14.55	105.00	19.04	5.84	1.43	BDL
Palanghat	24.65	92.88	DW	26	7.41	181.90	BDL	116.69	BDL	91.57	91.57	42.54	4.53	11.85	0.82	16.01	14.55	105.00	17.69	5.71	1.27	0.508
Panibhora	24.63	92.84	DW	26	7.33	181.20	BDL	114.70	BDL	91.57	91.57	39.00	4.20	10.28	0.70	14.01	13.34	100.00	15.46	5.32	0.97	10.498
Masimpur	24.83	92.73	DW	25.6	7.30	176.80	BDL	113.59	BDL	85.47	85.47	39.00	3.35	8.63	0.68	14.01	12.13	100.00	14.68	5.10	0.63	0.622
Badripar	24.80	92.85	TW	25.4	7.30	172.10	BDL	108.50	BDL	85.47	85.47	39.00	2.99	8.56	0.68	14.01	12.13	95.00	14.65	5.03	0.60	0.613
Tolangram	24.79	92.96	TW	23.5	7.29	161.20	BDL	103.03	BDL	85.47	85.47	35.45	2.83	7.18	0.66	14.01	12.13	95.00	14.47	4.99	0.59	2.199
Ujantarapur	24.81	92.97	TW	24.3	7.29	156.10	BDL	101.24	BDL	79.36	79.36	35.45	2.80	6.63	0.63	12.01	12.12	90.00	14.33	4.84	0.56	0.214
Shivtilla	24.82	93.00	TW	25.6	7.29	153.40	BDL	96.82	BDL	73.26	73.26	31.91	2.11	6.48	0.62	12.01	10.92	85.00	14.14	4.82	0.42	12.41
Nizjoynagar	24.89	92.73	TW	22.4	7.27	147.40	BDL	88.52	BDL	67.15	67.15	31.91	1.73	6.44	0.61	12.01	9.69	80.00	13.57	4.63	0.36	1.275
Jatinga Bazar 1	24.89	92.73	TW	22.9	7.20	131.00	BDL	86.46	BDL	61.05	61.05	31.91	1.57	6.43	0.56	12.01	7.28	75.00	12.99	4.58	0.32	9.287

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Jatinga Bazar 2	24.89	92.73	TW	23.5	7.18	124.13	BDL	81.93	BDL	61.05	61.05	31.91	1.41	5.25	0.53	12.01	7.28	75.00	12.09	4.57	0.28	0.745
Pelladore	24.89	92.73	TW	24.6	7.18	124.10	BDL	81.91	BDL	54.94	54.94	28.36	1.40	5.15	0.50	10.01	6.07	75.00	11.89	4.53	0.28	61.815
Barjatpur	24.90	92.71	TW	22.2	7.15	108.90	BDL	71.87	BDL	54.94	54.94	28.36	1.21	4.42	0.50	10.01	6.07	75.00	11.71	4.15	0.28	1.672
Monpur	24.93	92.64	TW	24	7.11	106.30	BDL	70.16	BDL	54.94	54.94	24.82	1.09	3.66	0.49	10.01	6.06	60.00	11.27	4.15	0.26	0.745
Kalain	24.97	92.58	TW	25.2	7.08	105.40	0.40	69.56	BDL	48.84	48.84	24.82	1.06	3.30	0.48	10.01	6.06	55.00	10.48	4.14	0.25	BDL
Kalain 1	24.97	92.58	TW	24.5	6.81	101.40	0.30	66.92	BDL	42.73	42.73	21.27	1.02	3.26	0.48	10.01	6.06	55.00	8.75	4.01	0.24	7
Silchar	24.82	92.78	TW	23.3	6.70	96.82	0.30	58.41	BDL	42.73	42.73	21.27	1.00	2.92	0.46	10.01	4.85	50.00	7.25	3.78	0.22	1.408
Chandrapur	24.80	92.78	TW	25.7	6.60	88.50	0.20	58.30	BDL	36.63	36.63	21.27	1.00	2.90	0.36	8.01	4.85	50.00	7.21	3.27	0.19	1.275
Silkuri	24.73	92.79	TW	27.3	6.59	79.84	0.20	47.77	BDL	36.63	36.63	21.27	0.82	2.65	0.30	8.01	4.85	50.00	5.88	3.10	0.18	23.827
Silkuri camp	24.72	92.78	TW	25.8	6.57	62.82	0.10	41.46	24.00	36.63	36.63	21.27	0.78	2.55	0.27	8.01	4.84	40.00	5.66	2.83	0.15	1.804
Mithapni	24.70	92.77	TW	26.4	6.56	55.61	0.10	36.70	18.00	36.63	36.63	21.27	0.74	2.37	0.17	6.00	3.63	35.00	5.39	2.41	0.14	1.54
Irongmara	24.98	92.74	TW	25.8	6.54	51.01	0.10	30.53	15.00	30.52	30.52	21.27	0.72	2.37	0.16	6.00	2.42	35.00	4.89	2.37	0.14	1.408
Baskandi	24.81	92.91	TW	28.9	6.46	46.25	0.10	30.34	12.00	30.52	30.52	17.73	0.40	2.36	0.14	6.00	2.42	35.00	4.03	2.17	0.12	4.032
Nagdirgram	24.67	92.88	TW	26.6	5.96	45.00	0.10	29.70	12.00	24.42	24.42	17.73	0.39	1.39	0.13	6.00	2.41	35.00	3.69	2.09	0.10	25.073
Boali	24.65	92.92	TW	26.9	5.45	37.48	0.10	24.74	12.00	24.42	24.42	17.73	0.37	1.26	0.10	6.00	1.21	30.00	3.04	1.86	0.10	17.626
Bhagabazar	24.54	92.83	TW	28.7	4.84	22.10	0.10	14.59	9.00	18.31	18.31	17.73	0.37	0.16	0.02	4.00	1.21	25.00	2.87	0.34	0.08	52.19
Noonkhuli	24.80	92.71	Spring	24.2	8.30	22370.0	BDL	14764.2	96.00	2197.76	2293.76	8649.8	2.27	34.69	1.35	84.07	7.24	240.00	2801.75	44.25	8.35	1.41