केंद्रीय भूमि जल बोर्ड

जल संसाधन, नदी विकास और गंगा संरक्षण

विभाग, जल शक्ति मंत्रालय

भारत सरकार

Central Ground Water Board

Department of Water Resources, River Development and Ganga Rejuvenation, Ministry of Jal Shakti

Government of India

AQUIFER MAPPING AND MANAGEMENT OF GROUND WATER RESOURCES

TINSUKIA DISTRICT, ASSAM

उत्तर पूर्वी क्षेत्र, गुवाहाटी

North Eastern Region, Guwahati

AQUIFER MAPPING AND MANAGEMENT PLAN OF TINSUKIA DISTRICT, ASSAM

ANNUAL ACTION PLAN, 2022-23

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CENTRAL GROUND WATER BOARD

North Eastern Region

Guwahati

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Chapter 1

1.0 Introduction

Central Ground Water Board, North Eastern Region has carried out Aquifer Mapping and Management plan in the district of Tinsukia under National Aquifer Mapping and Management (NAQUIM) program in the AAP 2020-2021. Systematic mapping is very much effective in building up our knowledge on the geologic framework of aquifers, their hydrologic characteristics, and water levels in the aquifers with periodic fluctuations and the occurrence of natural and anthropogenic contaminants in the groundwater and how they affect the whole system. Aquifer mapping at the appropriate scale can help to prepare, implement and monitor the efficacy of various management interventions aimed at long-term sustainability of our precious ground water resources, which will help achieving the drinking water security, improved irrigation facilities and sustainability in water resources development.

1.1 Objectives

The objectives of this project are; to understand the aquifer systems up to 200 m depth, to demarcate the aquifer geometry, delineate type of aquifers, ground water regime behaviours, hydraulic characteristics and to establish groundwater quality, quantity, sustainability and to estimate the dynamic and static resources accurately through a multidisciplinary scientific approach on 1:50000 scale and finally formulate a complete, sustainable and effective management plan for ground water extraction for future use.

1.2 Scope of the Study

Tinsukia district is blessed with many major rivers like the Lohit River, Siang River, Buridihing River etc; so this district has a huge volume of groundwater and surface water resources. Proper hydrogeological knowledge is required for the sustainable development of groundwater and systematic management plan for the ground water utilizations.

1.3 Approach and Methodology

The activities carried out for completion of the Aquifer Mapping and management plan can be envisaged as follows:

1.3.1. Data Collection and Data Gap Analysis

Collection and synthesis of large volume of data is the foremost criteria during the specific studies carried out by Central Ground Water Board and various state Government organizations with fresh generation of a new data to describe an aquifer system completely. The data were assembled, analyzed, examined, synthesized and interpreted from available sources. These sources were predominantly non computerized data, which was converted into computer-based GIS data sets. On the basis of available data, data gaps were identified.

1.3.2. Data Generation

There is a strong requirement for generation of additional data to fill the data gaps in achieving the target of aquifer mapping. This was achieved by multiple activities such as hydro-geochemical analysis, remote sensing studies, and detailed hydrogeological surveys to delineate multi aquifer system, to bring out the efficacy of various geophysical signatures in different hydrogeological environments various geophysical techniques are used for aquifer mapping.

1.3.3. Aquifer Map Preparation

After integration of all the collected data generated from various studies of hydrogeology, aquifers have been delineated and characterized in terms of quality and potential. Various maps have been prepared for the characterization of Aquifers, which can be termed as Aquifer maps providing spatial variation (lateral & vertical) in reference to aquifer extremities, quality, water level, potential and vulnerability (quality & quantity).

1.3.4. Aquifer Management Plan Formulation

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

1.4 Area details

Tinsukia, one of the 33 administrative districts in the state of Assam is located in the upper part of Assam. The district lies between Latitudes 27.962502 N and 27.229162 N and Longitudes; 95.217562 E and 96.019842 E., occupying south-eastern part of the north-east India. It was declared as the 23rd district of Assam on 1st October 1989 when it was split from Dibrugarh. It has three sub divisions Tinsukia, Margherita, and Sadiya. The ancient name of Tinsukia was Bangmara which was originally known as ChangmaiPathar. Tinsukia is an industrial district of Assam. The Oldest oil refinery in India is situated at Digboi and places like Margherita and Ledo are famous for open cast coal mining. Tinsukia is one of the premier commercial centres in Assam. The study area covers the entire Tinsukia district with mapable area 3790 Sqkms to be covered under NAQUIM program during AAP 2020-21. Hilly areas covered around 72.43 Sqkms.. The area falls partly or fully in the quadrants of Survey of India Toposheet bearing nos. 83M/2, 83M/3, 83M/5, 83M/6, 83M/7, 83M/8, 83M/9, 83M/10, 83M/11, 83M/12, 83M/13, 83M/14, 83M/15, 92A/3. The base map of the district is shown in fig.1.1. The north, East and south of the state is bounded by states of Arunachal Pradesh, and North-west and West border of this district bounded by Dhemaji and Dibrugarh district of Assam respectively. The state of Arunachal Pradesh is linked with the rest of the district with National Highway NH-37, which enters through Sadiya in the district and is the longest NH passing through the district. Apart from the national highway, there are state highways and other village roads which connect various parts of the state. Apart from roads, the district is also connected by rail and Tinsukia railway station at the centre point of the district.

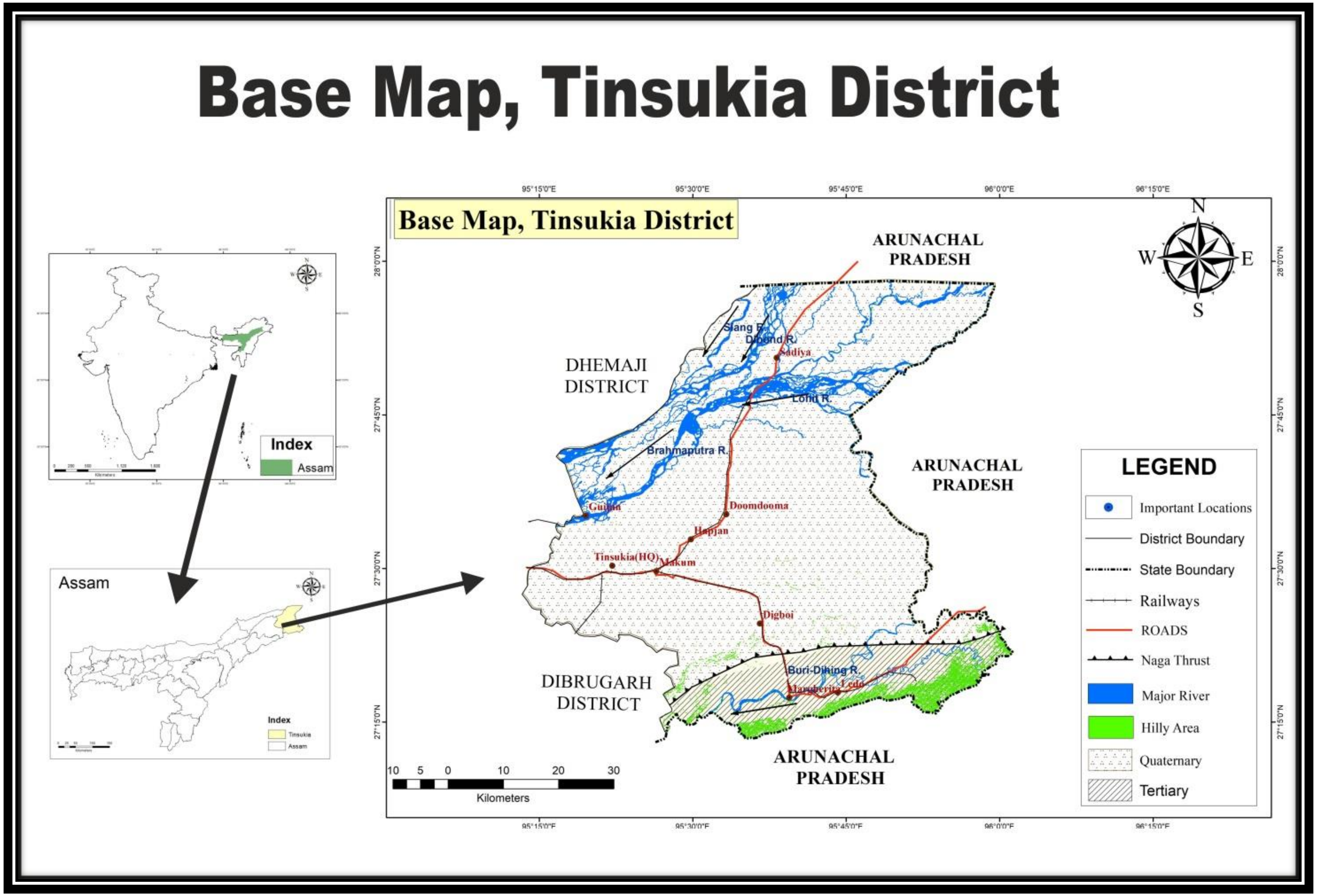

Fig.: 1.1.Base map of Tinsukia District.

1.5 Data availability, data adequacy and data gap analysis

Aquifer mapping and management plan is carried out through collaboration of different data. The required data on various attributes of the study are collected from the available literatures of Central Ground Water Board, State Departments of Assam and various Central and State Government agencies.

Table 1.1. Data Availability and Data Gap Analysis in Aquifer Mapping Studies Area

SN	Theme	Type	Data available	Data gap	Data generation	Total	Remarks
1	Borehole Lithology Data		09	10	01	10	Max. depth of well is 248.27 mbgl
2	Geophysical data		7	13	Nil	7	
3	Groundwater level data	Dug well	7	13	13	20	
		Piezometer Aquifer-I	4	3	Nil	4	
4	Groundwater quality data	Dugwell-Aquifer-I	7	13	13	20	
		Piezometer Aquifer-I	1	6	Nil	1	
5	Specific Yield		Nil	Nil	Nil	Nil	
6	Soil Infiltration Test		Nil	1	2	2	

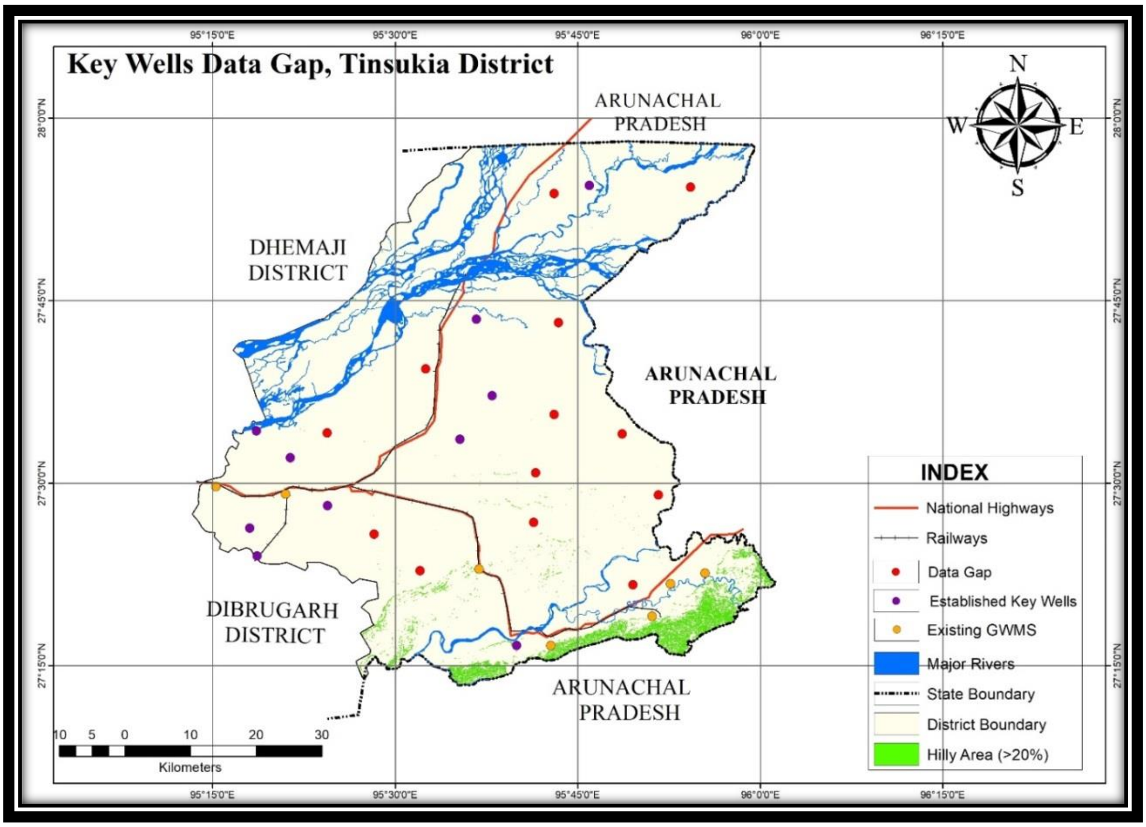

Fig.1: 2. Key Wells Data Gap, Tinsukia District.

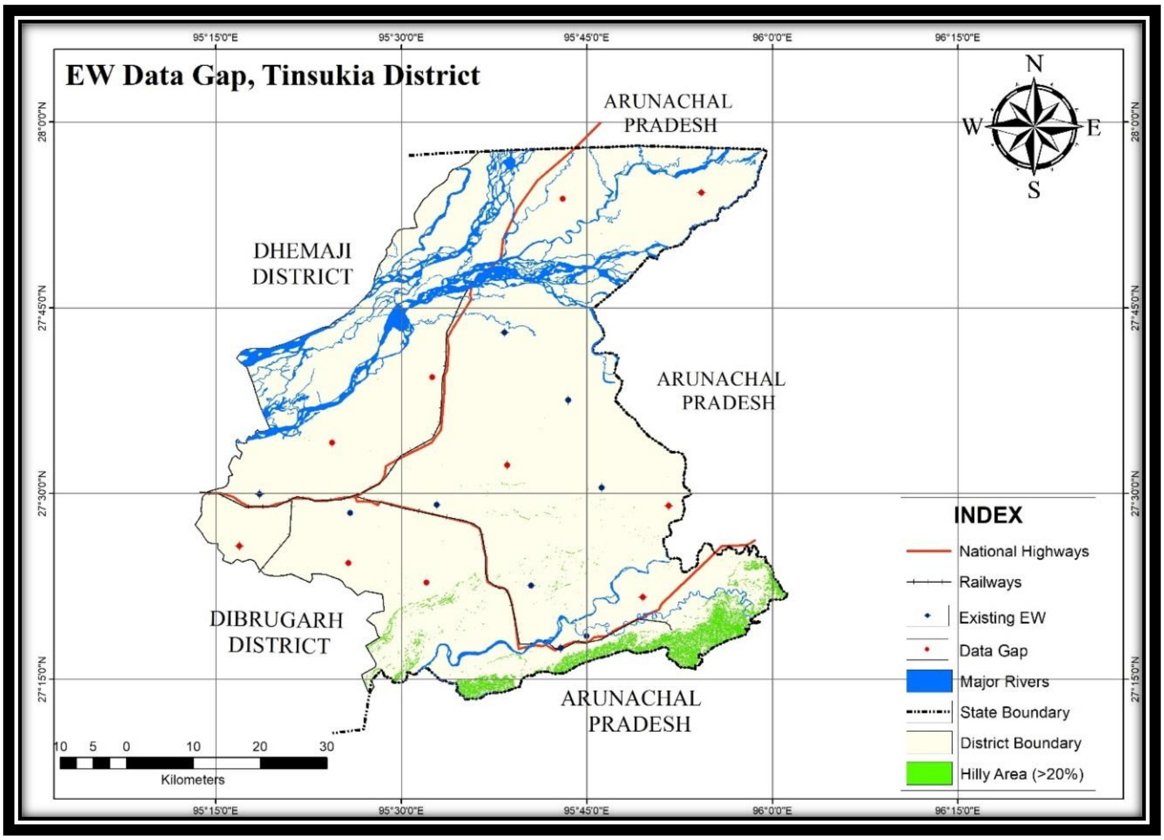

Fig.1.3: EW Data availability, data gap and data generation in Tinsukia District

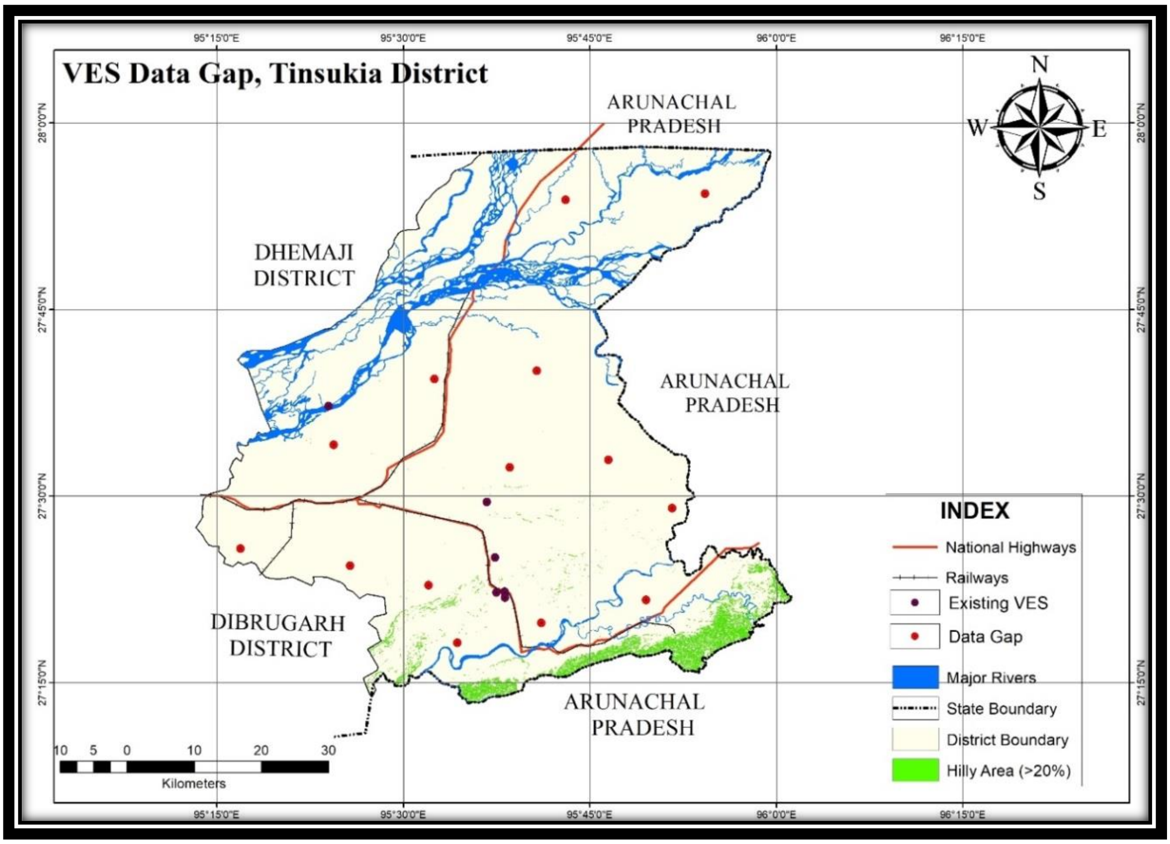

Figure1. 4. VES Data availability, data gap in Tinsukia District

1.6 Demography

Tinsukia is divided into four revenue circle, based on geographical distribution of race, tribe and culture. Tinsukia town is the head quarter of this district. There are 7 CD blocks which comprises 1168 villages including 32 uninhabited villages. The Tinsukia District has a total population of 1,327,929 as per Census 2011, out of which male population is 680,231and female population is 647,698. The density of population is 350 persons per sq.km. The rural population constitutes 80.063 % of the total population. Decadal growth rate or variation between 2001 & 2011 is 15.47 %. Where male growth rate is 13.16 % and female is 17.99 % as per census handbook 2011. Margherita block has the highest population of 2,53,725 while Sadiya block has the lowest population of 1,02,434. In urban population, total population is 1,86,593 with 40,375 number of households.

1.7 Communication

The study area is linked with the rest of the state with NH 37 with the state of Arunachal Pradesh. NH-37 enters the district through Panitola and passes through Tinsukia district towards north to Sadiya and then enters Arunachala Pradesh State. Apart from the national highway, there are state highways and other village roads which connect various parts of the state. Apart from roads, the state is also connected by rail.

1.8 Climate and Hydrometeorology

The district experiences sub-tropical humid climate where winter temperature goes up to 37^{o} C. The maximum temperature in summer days is as high as 96°F. The climate of the district is characterised by the absence of a dry hot summer season, the highest temperatures being experienced during the monsoon season along with abundant rains. Winter starts from December and end in February which is followed by a season of thunder storms from March to May. From June to the beginning of October is the season of south-west monsoon and October and November are marked as post monsoon season. The South West monsoon sets in the month of June and lasts up to September. Out of 2323 mm normal annual rainfall, about 65 percent rain is received from monsoon. Graphical illustration of the rainfall data shown in the figure below.

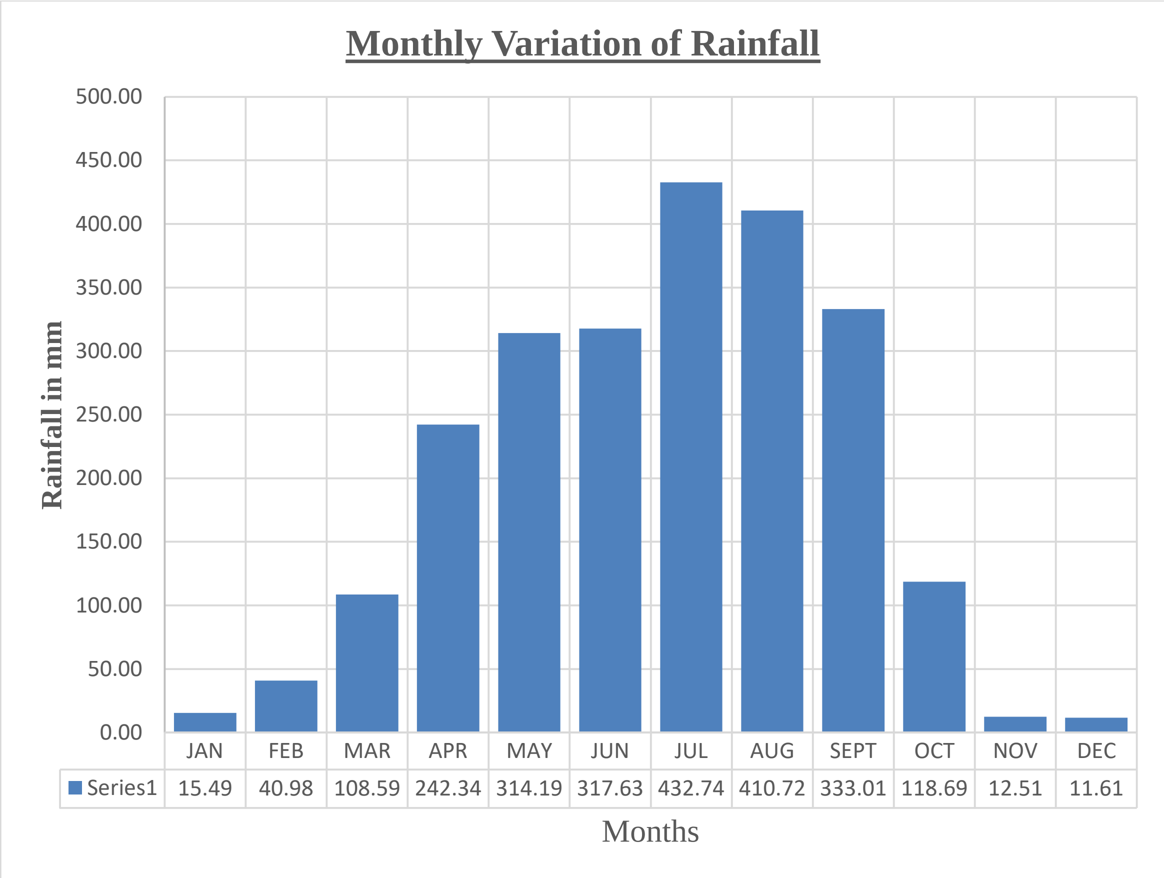

Fig. 1.5: Monthly variation of rainfall. (Source-IMD)

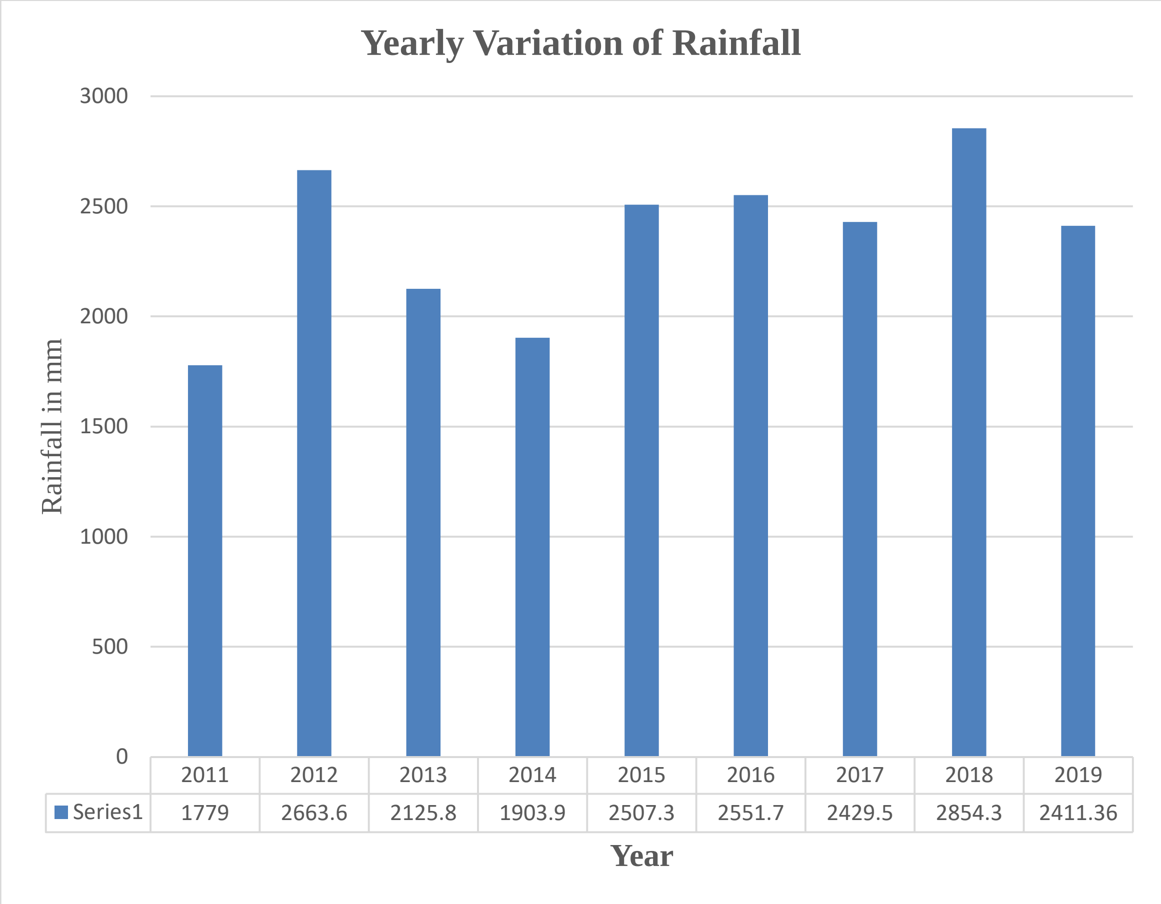

Fig. 1.6: Yearly variation of rainfall. (Source-IMD)

1.9. **Physiographic Setup**

The district physiographically divided into four distinct parts i.e. (i) the flood plains (ii) younger and older alluvium plains (iii) the terrace deposit at the foothills in the south and south eastern parts and (iv) Hillocks of the tertiary groups in the south and south western side. The flood plain and the alluvial plains only show gentle undulations at places. The elevation of the plains only ranges from 87 to 152 meters above mean sea level. Tea gardens are developed in the higher Terrace deposit plains than the adjoining cultivated flood plain areas. In the southern and south eastern parts, the elevation of the land and hill ranges varies from 115 to 350 meters mean sea level.

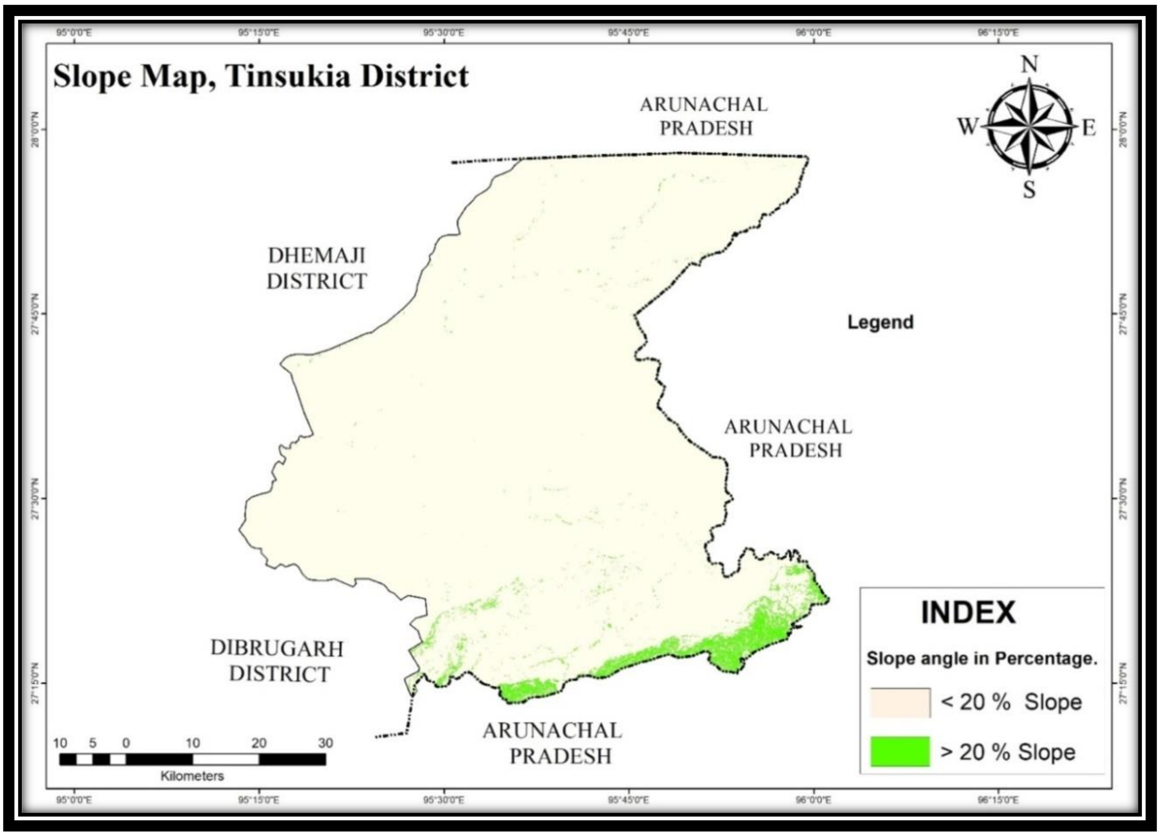

Fig. 1.7: Slope Map, Tinsukia District

1.10 **Drainage and Morphometry**

The drainage of the area is formed by the Brahmaputra River and its numerous tributaries originating from Naga-Patkai range located at the north, drains the district and flows towards west and southwest direction. The important river is Buri-Dihing in the south. High degree of meandering of the Buri-Dihing river give rise to ox-bow lakes, point bars and channel bars. Floods and bank erosion are common features in these rivers. The entire area covering Lakhimpur, Lohit and Tirap.Tinsukia and Dibrugarh districts have been affected by neotectonic movements, which remain active even today. These movements give rise to dynamics for extensive bank erosion by rivers.

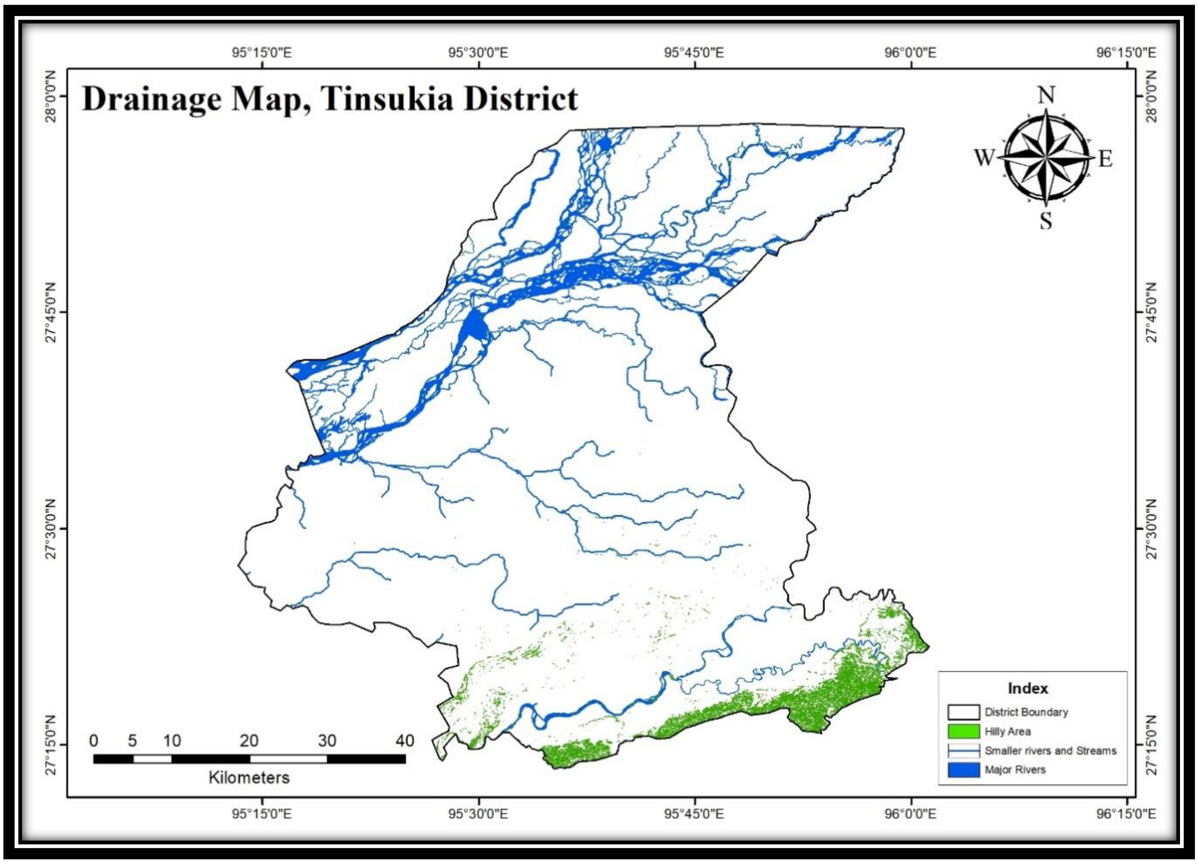

Fig. 1.8: Drainage Map, Tinsukia District, Assam.

1.11 **Geology**

Tinsukia district forms part of the vast stretch of alluvial tract of the Brahmaputra valley with some variation towards south and south east. The Quaternary sedimentation represented by the recent and older alluvium influenced by the geological activities. Two entirely different tectonic domains namely the Misimi block of Lohit Himalaya comprising high grade metamorphites and the Tertiary folded belt of the Naga-Patkai range with low grade metasediments are brought juxtaposition by the Misimi thrust in Arunachal Pradesh and Margherita thrust in Tinsukia district. These stratigraphic, lithological and tectonic domains have their distinct imprint on the nature of sediments. A generalized geological succession is given below.

Table 2.General geology of Tinsukia district.

Epoch	**Group**	**Formation**	**Rock types**
Recent	Quaternary	New Alluvium	Clay, Sand, and Silt
------------------------Unconformity----------------------			
Pleistocene	Quaternary	Older Alluvium	Clay, Coarse sand and gravels
------------------------Unconformity----------------------			

Pliocene	Dihing	Dihing Boulder bed	Pebbles, Sandstone with greyish clay and conglomorate
-------------------------Unconformity-----------------------			
Miopliocene	Namsang	Namsang	Fine to coarse grained sandstone with clay beds
-------------------------Unconformity-----------------------			
Miocene	Tipam	Girujan clay	Mottled clay with greyish soft sandstone
		Tipam Sandstone	Ferrugenuos, fine to coarse grained sandstone.
-------------------------Unconformity-----------------------			
Oligocene	Barail	Tikak Parbat	Greyish white sandstone sandy shale and coal seam.
		Borgolai	Greyish to blusih grey mudstone, shale, sandstone and thin coal seams.
		Naogaon	Compact, fine grained, dark grey sandstone.
Eocene	Disang		Splintery dark grey shales and sandstone interbands.

The Diasang Group is the lowermost formation comprising a thick succession of dark grey shale interbedded with thin bands of fine-grained sandstone. The unconformably overlying Barail Group comprising mainly arenaceous, argillaceous and carbonaceous materials cover large area. The Tipam group overlies unconformably the Tikak Parbat formation of Barail Group, which consists of Girujan clay and Tipam sandstone formations which are oil bearing in Digboi area of the district. The Namsang formation lies unconformably over the Girujan clay and consists of fine to coarse grained soft sandstone and thin bands of clay, grit and conglomerate. The Dihing group unconformably overlies the Namsang formation and comprises alternate bands of pebble bed and sandstone. Quaternary group of rocks cover major part of the district and are represented by Recent and Older alluvium. The thickness of this group of rock is estimated to be more than 100m.

1.12. Sub-Surface Geology

Sub-surface geology from lithological logs of deep tube wells, show that unconsolidated alluvial forms the main aquifer zones followed by Tipam sands aquifers in the extreme southern parts. On the basis of available information, panel diagram showing sub-surface strata has been prepared. It shows that in northern parts, monoaquifer system comprising different grades of sand and pebbles exist from 5 – 10 meters to more than 100meters below ground level. Tube wells located in central and southern parts show existence of two to four clay horizons which have separated aquifers. In Sadiya block there were no tube wells constructed previously. In this current AAP 2020-21 a well is constructed at PHED, Chapakhowa, Sadiya block with depth of 16.1meters and the geology up to that depth is mostly of sand and gravelly formations.

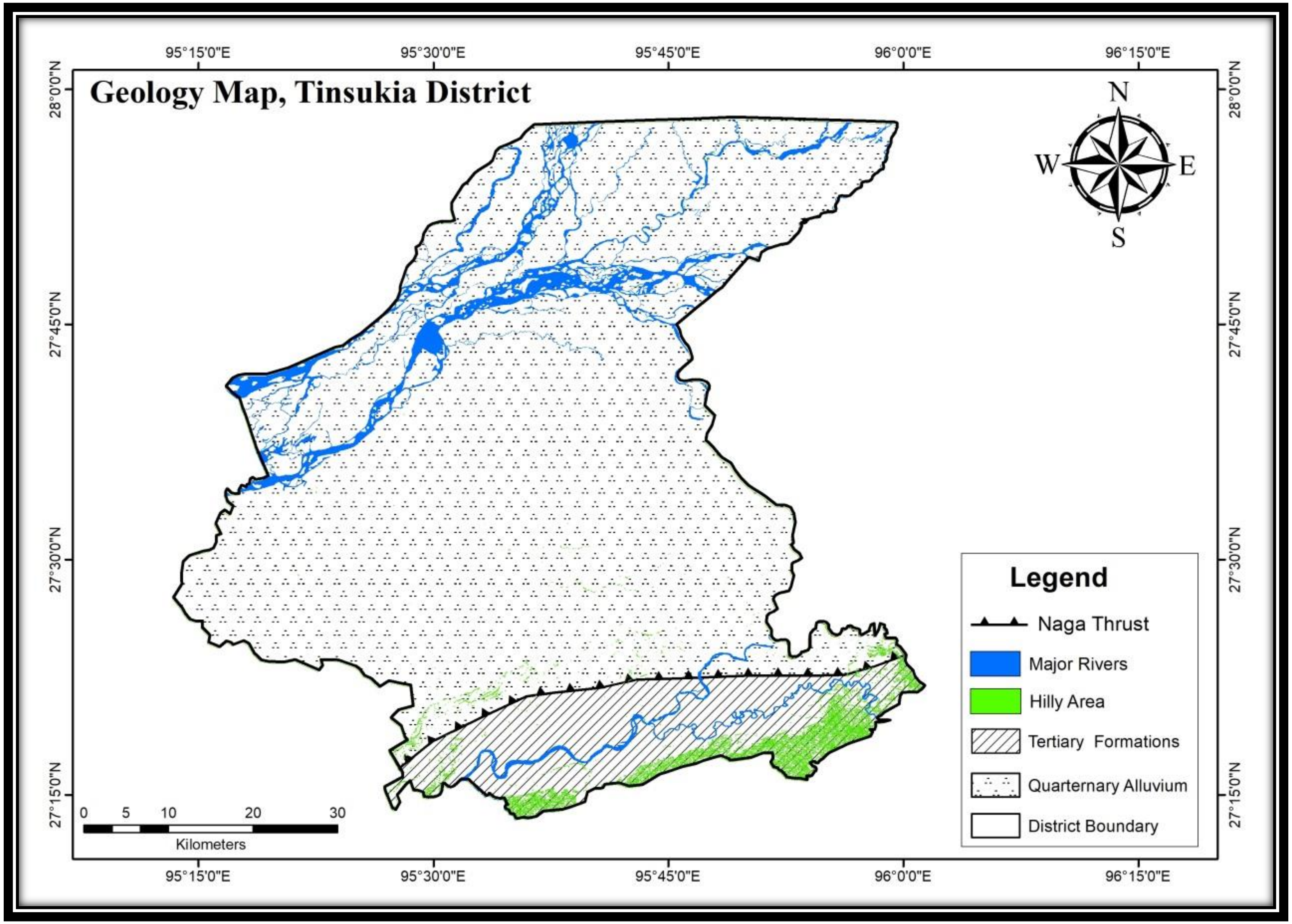

Fig. 1.9: Geological Map, Tinsukia District, Assam.

1.13 Geomorphology

Major part of the district is underlain by thick alluvial deposits and Tertiary sedimentary formation occurs in southern and south-eastern parts. The topography is generally flat with a gentle slope toward north. The gradient plain is relatively steeper in the northern part of the district immediately below the foothill of the Himalayas. The gradient of the terrain becomes gentler in the central and southern parts of the district. The general slope of the area is towards SSW. Based on different criteria, the physiography of the state can be grouped into the following distinct physiographic and geomorphic units.

i. Active Flood Plain

ii. Older Flood Plain

iii. Younger Alluvial Plain

iv. Pediment Pediplain Complex

v. Structural Hills and Valleys

The flood plain and the alluvial plains only show gentle undulations at places. The elevation of the plains only ranges from 87 to 152 meters above mean sea level. Tea gardens are developed in the higher Terrace deposit plains than the adjoining cultivated flood plain areas. In the southern and south-eastern parts, the elevation of the land and hill ranges varies from 115 to 350 meters mean sea level.

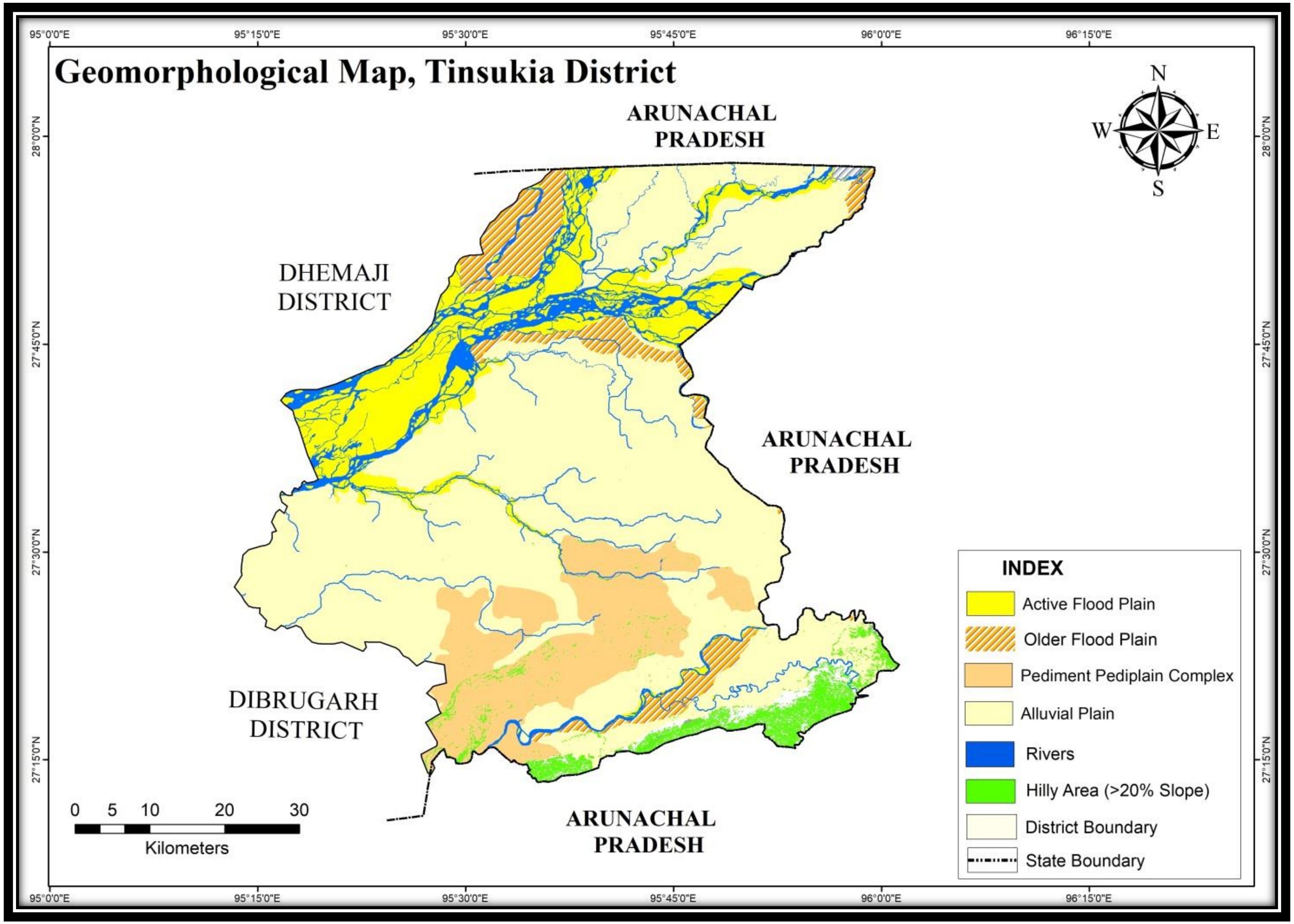

Fig. 1.10: Geomorphological Map, Tinsukia District.

1.14Land use

Out of total geographical area of 379,000 hectares of land in Tinsukia district, about 29.9% of the land is not available for cultivation and 9.4% is categorised as other non-cultivated land. Further, about 34.9% is under forests. The net area shown in the district is about 24.3% of the total geographical area. The following table shows the area of land put to different uses and their percentages to the total areas.

Table 3. Land use statistics in Tinsukia

Name of Block	Area Under Agriculture				Area under Forest (Ha)	Area under Waste land (Ha)	Area under other uses (Ha)
	Gross Cropped Area	Net Sown Area	Area Sown more than once	CI (%)			
Sadiya	28600	25929	2671	110	12575.2	1022	65449.2
Saikhowa	17053	13154	3899	129.6	1062	907	39281
Hapjan	14004.4	11260.5	2744	124	23650	423	16731
Kakapathar	19810	17173	2637	115.3	87	4993	78120
Guijan	7920	6133	1787	129.1	225	364	20407
Itakhuli	11343	8577	2766	132	7703	415	30642
Margherita	24279.4	18704.2	5575.17	129.8	0	2438	113899
Total	**123010**	**100931**	**22079.2**	**122**	**45302.2**	**10562**	**364529.2**

Source: District irrigation Plan, Tinsukia(2015)

1.15 Soil

Total 27 soil series have been mapped in Tinsukia district. 25.94 % area of the district are cultivated followed by deciduous forest (24.75%), orchard plantation (18.87%), plantation (14.97%) and grass land (4.53%). Soil of the district are highly suitable for variety of crops and horticulture crops like Rice, Wheat, Maize, Pulses, oilseeds, Sugarcane, Potato, Jute, Banana, Coconut, Areca nut, Orange, Pineapple. The cropping intensity can be increased by ensuring timely irrigation and balance fertilizer and manures. Major soil erosion of the district is moderate erosion (55.16%), followed by slight to moderate erosion (27.85%), moderate to severe erosion (5.61%) and some areas are none to slight erosion (3.61%). Alluvial plains (67.37%) are the major physiography of the district followed by piedmont plain (10.02%) flood plain (7.39%). and hilly terrain on shale landscape (3.92%). ϖ Soils of the district fall in seven slope classes. Out of which 54.49% area are very gently to gently slope followed by nearly level to very gently slope (27.90%) gentle to moderately slope (5.93%), very steep to extremely steep slope (2.06%), strongly to moderately steep slope (0.93%) and moderately steep to steep slope (0.63%). Land suitable for cultivation, moderately good land to good land with moderate limitations i.e LCC II-III covers the maximum area 271726 ha (71.59%) followed by LCC III is 22536ha (5.94%) and LCC II is 17311ha (4.56%). Soils of the area are taxonomically classified into four orders i.e. Alfisols, Inceptisols, Entisols and Ultisols. Twenty-seven soils series identified in the area are further classified into 8 sub-orders, 11 great groups, 22 subgroups and 27 families. The climate, vegetation and parent rock types, topography, occurrence of flood and other biotic factors have considerably influenced the genesis of soil and consequently great variation in soil types have been observed in different parts of the district. Based on the soil test results, it has been found that the soil of Tinsukia district is mainly acidic. Micronutrients, especially Zn, Bo, Mo and Cu etc. were found in almost all parts of the district.

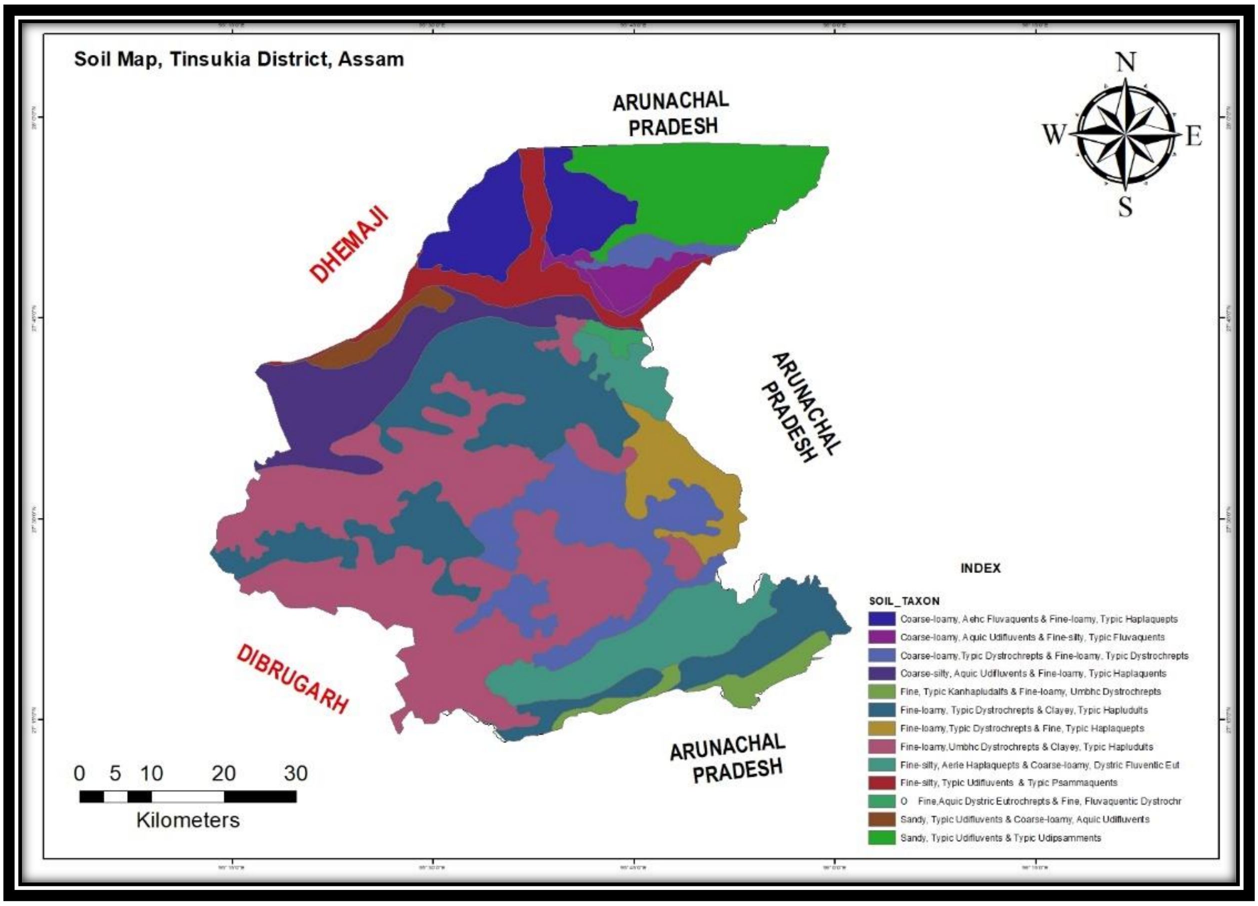

Fig 1.11.: Soil Map, Tinsukia District.

i. **Alfisols**: These are the base-rich mineral soils of sub-humid and humid region. They have light coloured surface horizon over clay enriched sub –surface horizon. This type of soil order is found on the western flank of the State bordering Assam. They are of fine-to-fine loamy texture.

ii. **Entisols:** These are recently developed, mineral soils with no diagnostic horizon. This may be due to either exceedingly unfavourable conditions or because of limiting time available for development. This type of soil is found occur on the Western and North Western part of the State on the low hill slope and narrow river valleys. This soil horizon is moderate to deep, well drained, fine to fine loamy textured soils.

iii. **Inceptisols:** This order of soil represents the beginning stage of soil formation which belongs to that of Entisols but still short of the degree of development found in Alfisols.

This soil dominates the entire State having fine loamy, fine clay, clay loam etc. and soil textures with moderately shallow to deep soils which is moderate to excessively drain.

iv. **Ultisols:** These are base-poor mineral soils of humid region developed under high rainfall and forest vegetation. The Ultisols are similar with Alfisols, except for having low base saturation on the exchange complex due to advance stage at weathering. This soil is sparsely scattered in all parts of the State having fine loam, clay loam and clayey texture.

The climate, vegetation and parent rock types, topography, occurrence of flood and other biotic factors have considerably influenced the genesis of soil and consequently great variation in soil types have been observed in different parts of the district. Based on the soil test results, it has been found that the soil of Tinsukia district is mainly acidic. Micronutrients, especially Zn, Bo, Mo and Cu etc. were found in almost all parts of the district. Soil map of the area is given in Fig 1.10.

1.16 Agriculture & Irrigation

Water has unique characteristics that determine both its allocation and use as a resource by agriculture. Agricultural use of water for irrigation is itself contingent on land resources.

Tinsukia is one of the leading districts in India on tea cultivation. Major portion of the world-famous quality tea of Assam are produced in this district. There are 280 nos. of registered large tea gardens covering an area of 68,207 ha producing about 141million kg tea annually. Rice, the major cereal crop, covers 68434 hectares. Other cereals like maize, wheat, small millets are having negligible area. Rapeseed and mustard are the important oilseed crops; Sesamum and linseed are also grown to a limited extent. Black gram, green gram and pea are the main pulse crops of the district. Among fibre crops, jute is grown is grown in only some limited pockets. The district has net and gross cropped areas of 123009.8 hectares and 100930.7 hectares respectively, the net cropped area being just 24 percent of the total geographical area. About 22,079.17 hectares out of the gross cropped areas is put under multiple cropping with an average cropping intensity 122 percent as against 152.43 percent for the state. According to 2011 census, agriculture provides full time employment to 9.02 percent of total workers. There are about 1,02,840 cultivators and 19,483 agricultural labourers in the district. Heterogeneity in cultivation practices and diversity of cropping patterns are the important features of agriculture in the district.

The agro climatic condition of the district is very much conducive for raising all types of crops. Besides rice, rapeseed, mustard seed, black gram and green gram, vegetables etc. are other important agricultural products of the area. The chief horticultural crops are various citrus fruits, banana, and pineapple, areca nut and various Rabi and Kharif vegetables. By default, majority of the crops both agricultural and horticultural are grown organically. So, the district has the scope of becoming pioneer in organic farming system, particularly in case of agricultural crops like paddy and horticultural crops like Citrus, pineapple, banana, areca nut, etc. In fact majority of fruit crop production can be considered as organic produce.

The irrigation potential in the district is developed both from the surface and ground water sources. The irrigation department is responsible for creation of major, medium and minor irrigation schemes. The agriculture department has also created irrigation potential in different cultivable area by way of installation of shallow tube well schemes. Gross irrigated area and net irrigated area in the district are 5,261 hectares and 4,033 hectares. Thus, just 4% of the gross cropped area is irrigated while remaining 96% of the gross cropped area is rainfed.

Agriculture, irrigation and Soil Conservation departments of the district have proposed to bring additional 91345 hectares of land under irrigated cultivation system. Government of India launched PradhanMantriKrishiSinchayeeYojana (PMKSY) to address the constraints in providing assured irrigation as well as increasing efficiency and productivity of current water use to bring more prosperity to the rural areas. Margherita block has the highest canal command area which is 1916 hectares while the lowest canal command area is for Guijan block which is 241 hectares only. In this region, due to high availability of the ground water, ground water extraction can increase the irrigated area.

Table 4.Irrigation land details in Tinsukia

Block	**Irrigated (Area in Ha)**		**Rainfed (Area in Ha)**	
	Gross Irrigated Area	Net Irrigated Area	Partially Irrigated/Protective Irrigation	Un-Irrigated or Totally Rainfed
Sadiya	25	25	NA	22310.5
Saikhowa	765	513	NA	13737
Hapjan	396	265	NA	15338
Kakapathar	2870	2250	NA	69403
Guijan	28	20	NA	8190
Itakhuli	730	545	NA	9815
Margherita	447	415	NA	26170
Total	**5261**	**4033**	NA	**164963.5**

Source: Agriculture Department, Tinsukia

1.17 Industries

The coal industry in Assam is more than one hundred-year-old. The existence of coal deposits in Upper Assam had been known from early days of the British Rule. As early as in 1828 a good quantity of coal is dug in this district. The Makum coal field near Margherita is 30 kms. long and 5 kms. wide. The working collieries found in the district are at Borgolai, Ledo, Namdang and Tipong. Assam produces about 1.3% of the total Indian output of coal of which about 85% comes from Makum coal fields. Due to its inferior quality of Assam coal, it becomes less attractive for the markets elsewhere in India. But whole of it goes to tea gardens and railways. The oil found in Tinsukia district had led to the installation of the first oil refinery at Digboi. By 1916 more than a million tons of crude oil has been supplied by the Digboi oil fields and current production stands between 170000 to 180000 tonnes a year. Apart from coal and oil industries there are many other industries are established in Tinsukia District.

1.18 Hydrology

The Brahmaputra, the Buri-Dihing, the Tingrai Rivers, are major rivers in Tinsukia district. Numerous rivers originating from Naga-Patkai range located at the south drain the district and flows towards north and northwest. The source of the water to these rivers is precipitation and consequently discharge of the rivers depends on distribution of rainfall. The excessive rainfall in Arunachal Pradesh and at foothill regions and melting of snow at higher altitude contribute heavy discharge to these rivers. Along with the reivers the district also covered by the surface water bodies are shown in the following Table.

Table 5. Water bodies in Tinsukia District

S. No.	**Resources**	**Area (ha)**
1	Ponds and tanks	3815.50
2	Derelict water bodies	2449
3	Beel fisheries	2295
Total		**8559.50**

Source: Statistical Hand Book of Assam, 2019

Chapter 02

2.0. Data Collection and Generation

2.1 Data collection

2.1.1 Hydrogeological data

The entire study area is covered by regular monitoring of 29 nos. of GWMS. Water level data were collected.

2.1.2 Exploration data

Central ground water board, North Eastern Region, Guwahati had undertaken exploration work in the district since 1978-79 and drilled 9 exploratory wells till 2011.

2.1.3 Meteorological Data

Meteorological data is collected from Tea Estates in the district and accessed free data of IMD.

2.1.4 Population and agriculture data

Population and groundwater dependency were collected from census 2011. All the data pertaining to agriculture were collected from District Irrigation Plan of Tinsukia District for 2016-20 prepared by NABARD.

2.2 Data Generation

Water level data: 29 nos. of key wells have been established to fill up the data gap.

Table 2.6. Key wells location details.

Village	Latitude	Longitude	Establishment date	RL (mamsl)	Total depth of Pz/DW (mbgl)	Type (DW/Pz/ Spring)	Aquifer group	Measuring point (magl)	Source/Agency
Tinsukia	27.4853	95.3498	NHNS Well	150	7.78	DW	Alluvium	0.94	Private
Bordubi Radhanagar	27.4004	95.3108	Key well	136	3.23	DW	Alluvium	0	Private
Digboi	27.3824	95.6149	NHNS Well	185	4.10	DW	Alluvium	0.74	Govt.
Bargolai Sainagar	27.2776	95.7130	NHNS Well	159	3.50	DW	Alluvium	0.7	Private
Tipong	27.3177	95.8517	NHNS Well	165	7.00	DW	Alluvium	0.88	Govt.
Lekhapani	27.3204	95.8184	NHNS Well	150	5.70	DW	Alluvium	0.9	Private
Rampur	27.3619	95.8772	Key well	157	8.08	DW	Alluvium	0.07	Private
Jagun	27.3768	95.9243	Key well	166	7.09	DW	Alluvium	0.4	Private
Makuumbagan, Garaland	27.2775	95.6662	Key well	175	4.40	DW	Alluvium	0.93	Private
Kumsan Seleguri	27.6199	95.6330	NHNS Well	141	5.73	DW	Alluvium	0.56	Private
Chapakhowa	27.9077	95.7660	Key well	140	3.02	DW	Alluvium	0.94	Govt.
Do no Megla	27.7243	95.6112	Key well	132	6.03	DW	Alluvium	0.75	Private

Akanimuria	27.4990	95.2983	Key well	121	5.20	DW	Alluvium	0.84	Govt.
Gelapukhuri	27.5348	95.3565	Key well	124	5.20	DW	Alluvium	0.6	Private
Rangaguda	27.5715	95.3097	Key well	118	5.90	DW	Alluvium	0.4	Private
Lohari Bangaligaon	27.4691	95.4075	Key well	124	5.23	DW	Alluvium	1.2	Private
Hillikaguri	27.4383	95.3005	Key well	125	6.34	DW	Alluvium	0.72	Private
Badlabeta TE	27.5601	95.5887	Key well	138	9.15	DW	Alluvium	1.08	Private
Borgaon	27.5483	95.7017	Key well	146	4.53	DW	Alluvium	0.95	Private
Panitola	27.4954	95.2545	NHNS Well	122	6.79	DW	Alluvium	0.93	Govt.
Halaukia	27.6276	95.5069	Key well	141	7.62	DW	Alluvium	0	Private
Baghjan	27.5929	95.4308	Key well	125	12.19	DW	Alluvium	0.55	Private
Khasijan	27.6192	95.7017	Key well	142	6.27	DW	Alluvium	0.95	Govt.
Lalmaati	27.4217	95.7682	Key well	162	4.88	DW	Alluvium	0.75	Private
Kana pathar no. 2	27.4919	95.8698	Key well	159	3.94	DW	Alluvium	0.75	Private
Khauji	27.5737	95.8477	Key well	153	4.94	DW	Alluvium	0.87	Private
TippaniMeri Gaon	27.6191	95.7867	Key well	145	2.96	DW	Alluvium	0.5	Private
Kangkong DW	27.9719	95.7561	NHNS Well	161	11.71	DW	Alluvium	0.7	Private
Sunpura	28.0327	95.8119	Key well	181	4.46	DW	Alluvium	0.76	Govt.

Table 6.7. Water level measurement of key wells

Location	**Month & depth-to-water level in mbgl**		
	Nov-20	**Jan-21**	**Mar-21**
Tinsukia	2.41	3.77	4.32
Bordubi Radhanagar	0.94		1.16
Digboi	1.14	1.84	1.56
Bargolai Sainagar	1.00	1.43	4.19
Tipong	4.07	4.99	4.72
Lekhapani	2.36	4.72	4.09
Rampur	1.31	3.00	3.00
Jagun	2.16	5.29	5.44
Makuumbagan, Garaland	2.15	2.99	1.87
Kumsan Seleguri	1.71	3.03	4.34
Chapakhowa	1.30	2.05	2.19
Do no Megla	3.15	4.11	4.73
Akanimuria	1.51	2.58	3.06

Gelapukhuri	1.36	2.57	3.68
Rangaguda	2.9	3.72	4.11
Lohari Bangaligaon	1.65	2.77	3.00
Hillikaguri	2.02	3.37	4.66
Badlabeta TE	4.35		5.41
Borgaon	2.09	2.84	3.86
Panitola	0.77	2.64	3.45
Halaukia		2.90	3.81
Baghjan		5.13	5.57
Khasijan		3.8	4.23
Lalmaati		2.39	2.69
Kana pathar no. 2		1.49	1.66
Khauji		2.59	2.89
Tippani MeriGaon		2.36	2.23
Kangkong DW		8.33	11.16
Sunpura		1.27	1.34

2.3. Soil Infiltration studies

2.3.1Infiltration test

Salient features of the test sites are provided in Table 2.3 & 2.4. A perusal of the table shows that the tests have been conducted only in barren land and the soil types encountered in the sites are sand admixtures. The infiltration test was conducted for 145 mins.

Table 2.8. Salient features of the test sites

Site	**Location**	**Land use**	**Soil type**	**RL (mamsl)**	**Latitude**	**Longitude**
Chapakhowa	PHED Water supply campus, Chapakhowa	Barren Land	Clay	161	27.914941	95.764701
Margherita	Town High School campus, Margherita	Barren Land	Sand	150	27.289529	95.659774

Table 2.9. Summary of Infiltration Test

Site	Land use	Soil type	Infiltration rate (mm/hr)	Duration of test (min)	Total Quantum of water added (in m)	IF = (4) / (6) *100
Chapakhowa	Barren Land	Clay	3	200	185	1.62
Margherita	Barren Land	Sand	105	145	754	13.93

2.4. Water Quality

To understand the chemical quality of groundwater in the study area and its suitability for domestic, drinking and agricultural utilization, and existing quality data of CGWB were collected. Water samples were collected from monitoring wells/ key wells for detailed analysis of iron, heavy metals and arsenic etc.

Table 2.10. Water quality data of samples collected during Post-monsoon

Well Number	Lab code	State	Location	District	Lat DMS	Long DMS	Type of sample (EW or DW)	NHNS/Exploratory/Aquifer mapping	Date of collection	Tem pºC	pH	EC (µs/cm) 25C	Turbidity (NTU)	TDS	CO3-2	HCO3-1	TA (as CaCO3)	Cl-	SO4-2	NO3-1	F-	Ca+2	Mg+2	TH (as CaCO3)	Na	K	Fe	U	As
														mg/L														µg/L	
NQTN01	C1111	Assam	Tinsukia	Tinsukia	27.48527	95.34985	Dug well	Aquifer Mapping	12.11.2020	23.3	7.623	602.90	BDL	343.40	BDL	24.42	24.42	67.36	135.31	8.11	0.24	64.05	15.75	225.00	21.61	11.35	0.6570	0.3823	BDL
NQTN02	C1112	Assam	Bordubi Radhanagar	Tinsukia	27.40042	95.31076	Hand Pump	Aquifer Mapping	08.11.2020	24.6	7.776	205.60	BDL	117.20	BDL	128.20	128.20	21.27	10.47	5.32	0.32	12.01	25.48	135.00	3.23	1.57	12.8980	0.1575	BDL
NQTN03	C1113	Assam	Digboi	Tinsukia	27.38241	95.61487	Dug well	Aquifer Mapping	09.11.2020	24.6	7.364	181.20	BDL	104.00	BDL	115.99	115.99	10.64	17.59	1.02	0.22	32.03	6.05	105.00	5.59	1.61	0.0970	0.2796	BDL
NQTN04	C1114	Assam	Bargolai Sainagar	Tinsukia	27.27757	95.71296	Dug well	Aquifer Mapping	09.11.2020	25.5	6.875	355.10	BDL	202.80	BDL	24.42	24.42	31.91	196.06	2.48	BDL	32.03	13.33	135.00	41.98	19.14	0.2810	0.4000	BDL
NQTN05	C1115	Assam	Tipong	Tinsukia	27.31772	95.85167	Dug well	Aquifer Mapping	09.11.2020	26.4	6.750	135.70	BDL	77.45	BDL	42.73	42.73	14.18	38.10	1.17	0.10	16.01	7.27	70.00	7.29	3.47	0.0970	0.1484	BDL
NQTN06	C1116	Assam	Lekhapani	Tinsukia	27.32043	95.81839	Dug well	Aquifer Mapping	09.11.2020	27.2	7.063	103.00	0.30	58.91	BDL	73.26	73.26	10.64	17.41	0.38	0.17	22.02	3.63	70.00	11.22	3.64	1.1440	0.5320	BDL
NQTN07	C1117	Assam	Rampur	Tinsukia	27.36193	95.87724	Dug well	Aquifer Mapping	09.11.2020	25.6	7.046	90.52	BDL	51.47	BDL	61.05	61.05	14.18	11.07	0.24	0.15	16.01	7.27	70.00	3.43	2.19	0.5620	0.1870	BDL
NQTN08	C1118	Assam	Jagun	Tinsukia	27.37676	95.92432	Dug well	Aquifer Mapping	09.11.2020	26.2	6.922	76.26	BDL	43.55	BDL	54.94	54.94	14.18	17.21	1.13	0.10	14.01	9.70	75.00	2.79	1.52	0.4670	0.1366	BDL
NQTN09	C1119	Assam	Makuumbagan, Garaland	Tinsukia	27.27754	95.66623	Dug well	Aquifer Mapping	06.11.2020	24.7	7.682	611.00	BDL	348.60	BDL	286.93	286.93	56.72	68.83	2.45	0.31	44.04	25.46	215.00	47.70	29.06	0.6570	0.3489	BDL
NQTN10	C1120	Assam	Kumsan Seleguri	Tinsukia	27.61986	95.63297	Dug well	Aquifer Mapping	10.11.2020	25.4	7.023	114.20	0.10	65.31	BDL	67.15	67.15	17.73	15.14	0.17	0.18	12.01	7.28	60.00	17.45	3.60	0.0070	0.1273	BDL
NQTN11	C1121	Assam	Chapakhowa	Tinsukia	27.90766	95.76597	Dug well	Aquifer Mapping	10.11.2020	27.5	7.352	227.10	BDL	130.10	BDL	152.62	152.62	17.73	20.24	0.73	0.27	36.03	12.12	140.00	8.51	3.10	0.3740	BDL	0.4580
NQTN12	C1122	Assam	Do no Megla	Tinsukia	27.72427	95.61122	Dug well	Aquifer Mapping	10.11.2020	29.2	7.052	178.70	0.10	102.30	BDL	109.89	109.89	21.27	13.04	0.75	0.32	16.01	10.91	85.00	14.14	7.51	0.2810	BDL	BDL
NQTN13	C1123	Assam	Talap	Tinsukia	27.67301	95.56625	Hand Pump	Aquifer Mapping	10.11.2020	26.2	7.286	106.60	BDL	60.40	BDL	79.36	79.36	10.64	3.17	0.87	0.24	12.01	12.13	80.00	3.55	1.72	1.8560	BDL	BDL
NQTN14	C1124	Assam	Akanimuria	Tinsukia	27.49898	95.29827	Dug well	Aquifer Mapping	11.11.2020	24.5	7.067	175.20	BDL	100.30	BDL	79.36	79.36	24.82	12.59	1.84	0.17	16.01	13.34	95.00	13.82	0.93	0.1890	BDL	BDL
NQTN15	C1125	Assam	Gelapukhuri	Tinsukia	27.53477	95.35652	Dug well	Aquifer Mapping	11.11.2020	23.5	7.206	325.40	BDL	187.70	BDL	140.41	140.41	35.45	65.03	0.56	0.26	36.03	13.33	145.00	18.91	21.02	0.0070	0.1406	BDL
NQTN16	C1126	Assam	Rangaguda	Tinsukia	27.57146	95.30967	Dug well	Aquifer Mapping	11.11.2020	26.4	7.268	132.70	BDL	76.11	BDL	103.78	103.78	14.18	15.06	0.59	0.19	24.02	7.27	90.00	13.73	1.44	1.0450	BDL	BDL
NQTN17	C1127	Assam	Lohari Bangaligaon	Tinsukia	27.46907	95.40752	Dug well	Aquifer Mapping	11.11.2020	26.5	7.110	129.90	0.20	74.01	BDL	67.15	67.15	17.73	20.48	0.80	0.19	10.01	9.70	65.00	13.78	4.85	1.6490	BDL	BDL
NQTN18	C1128	Assam	Hillikaguri	Tinsukia	27.43828	95.30046	Dug well	Aquifer Mapping	11.11.2020	25.1	7.586	467.50	BDL	259.47	BDL	238.09	238.09	53.18	14.24	1.15	0.34	38.03	14.54	155.00	45.25	18.37	0.1890	0.0036	BDL
NQTN19A	C1129	Assam	Badlabeta TE	Tinsukia	27.56013	95.58874	DTW	Aquifer Mapping	12.11.2020	28.2	7.252	188.30	BDL	106.90	BDL	103.78	103.78	21.27	13.42	3.03	0.30	14.01	18.20	110.00	10.34	1.25	0.4670	BDL	BDL
NQTN19B	C1130	Assam	Badlabeta TE	Tinsukia	27.56013	95.58874	Hand Pump	Aquifer Mapping	12.11.2020	27.5	6.972	94.59	BDL	53.43	BDL	48.84	48.84	10.64	17.36	2.76	0.16	8.01	9.70	60.00	4.59	3.57	3.8540	BDL	BDL
NQTN20	C1131	Assam	Borgaon	Tinsukia	27.54828	95.7017	Dug well	Aquifer Mapping	12.11.2020	27.5	7.360	95.29	BDL	54.06	BDL	30.52	30.52	14.18	24.34	1.40	0.22	10.01	9.70	65.00	4.40	0.80	0.0070	0.0509	0.0790
NQTN21	C1132	Assam	Panitola	Tinsukia	27.49538	95.25446	Dug well	Aquifer Mapping	13.11.2020	23.4	7.385	272.80	BDL	154.30	BDL	195.36	195.36	17.73	30.66	0.55	0.31	48.04	9.69	160.00	16.07	6.44	0.8490	0.5558	0.0790
NQTN22	C1133	Assam	Panitola	Tinsukia	27.58156	95.63329	Dug well	Aquifer Mapping	14.11.2020	24.3	7.436	371.60	0.10	211.70	BDL	128.20	128.20	60.27	48.09	0.90	0.25	34.03	15.76	150.00	36.34	1.94	8.4250	0.1896	BDL

Table 2.11. Water quality data of samples collected during Pre-monsoon

Well No.	State	Location	District	Lat DMS	Long DMS	Type of sample (EW or DW)	NHNS/Aquifer mapping	Date of collection	TempºC	pH	EC (µs/cm) 25C	Turbidity (NTU)	TDS	CO3-2	HCO3-1	TA (as CaCO3)	Cl-	SO4-2	NO3-1	F-	Ca+2	Mg+2	TH (as CaCO3)	Na	K	Fe
NQTN01	Assam	Tinsukia	Tinsukia	27.48527	95.34985	Dug well	Aquifer Mapping	06.03.2021	20.2	8.24	897.30	BDL	446.00	15.00	201.46	216.46	106.35	104.08	12.22	0.31	14.01	63.10	295.00	54.64	13.72	1.24
NQTN02	Assam	Bordubi Radhanagar	Tinsukia	27.40042	95.31076	Hand Pump	Aquifer Mapping	26.02.2021	22.2	7.74	207.70	BDL	102.10	BDL	115.99	115.99	17.73	13.06	5.13	0.51	14.01	18.20	110.00	6.56	2.07	14.08
NQTN03	Assam	Digboi	Tinsukia	27.38241	95.61487	Dug well	Aquifer Mapping	04.03.2021	23.6	7.79	209.60	BDL	104.80	BDL	109.89	109.89	14.18	11.98	0.34	1.10	8.01	16.99	90.00	12.23	1.49	0.80
NQTN04	Assam	Bargolai Sainagar	Tinsukia	27.27757	95.71296	Dug well	Aquifer Mapping	04.03.2021	22.2	3.51	623.10	0.20	308.60	BDL	12.21	12.21	53.18	147.60	0.56	0.00	10.01	31.55	155.00	22.00	5.43	30.39
NQTN05	Assam	Tipong	Tinsukia	27.31772	95.85167	Dug well	Aquifer Mapping	08.03.2021	23.5	7.93	203.90	BDL	101.50	BDL	30.52	30.52	21.27	82.24	1.26	0.26	14.01	10.92	80.00	19.21	6.03	0.36
NQTN06	Assam	Lekhapani	Tinsukia	27.32043	95.81839	Dug well	Aquifer Mapping	08.03.2021	20.3	7.42	171.50	BDL	85.07	BDL	54.94	54.94	14.18	50.02	0.69	0.21	14.01	12.13	85.00	4.07	3.12	7.98
NQTN07	Assam	Rampur	Tinsukia	27.36193	95.87724	Dug well	Aquifer Mapping	08.03.2021	23.7	7.91	111.00	BDL	55.04	BDL	54.94	54.94	14.18	15.08	0.26	0.26	10.01	7.28	55.00	5.31	1.18	o*
NQTN08	Assam	Jagun	Tinsukia	27.37676	95.92432	Dug well	Aquifer Mapping	08.03.2021	22.6	7.90	114.90	BDL	57.24	BDL	54.94	54.94	17.73	17.55	1.06	0.39	14.01	12.13	85.00	3.70	1.83	0.92
NQTN09	Assam	Makuumbagan, Garaland	Tinsukia	27.27754	95.66623	Dug well	Aquifer Mapping	04.03.2021	20.9	9.03	669.50	BDL	328.10	18.00	244.20	262.20	63.81	44.70	4.42	0.61	12.01	46.11	220.00	38.78	26.82	1.24
NQTN10	Assam	Kumsan Seleguri	Tinsukia	27.61986	95.63297	Dug well	Aquifer Mapping	27.02.2021	22	7.50	184.10	BDL	88.95	BDL	67.15	67.15	24.82	9.63	0.48	0.39	16.01	8.49	75.00	12.97	5.46	0.67
NQTN11	Assam	Chapakhowa	Tinsukia	27.90766	95.76597	Dug well	Aquifer Mapping	06.03.2021	20.7	7.84	267.40	BDL	132.40	BDL	140.41	140.41	17.73	22.00	0.97	0.17	34.03	13.33	140.00	5.73	3.42	0.42
NQTN12	Assam	Do no Megla	Tinsukia	27.72427	95.61122	Dug well	Aquifer Mapping	03.03.2021	23.7	8.17	135.80	BDL	66.52	BDL	61.05	61.05	14.18	18.61	0.67	0.36	4.00	10.92	55.00	12.92	4.87	0.36
NQTN13	Assam	Talap	Tinsukia	27.67301	95.56625	Hand Pump	Aquifer Mapping	03.03.2021	24	7.53	182.20	BDL	88.92	BDL	61.05	61.05	24.82	36.83	1.89	0.43	8.01	12.13	70.00	19.02	2.35	0.30
NQTN14	Assam	Akanimuria	Tinsukia	27.49898	95.29827	Dug well	Aquifer Mapping	02.03.2021	23.1	7.44	122.00	0.10	59.58	BDL	48.84	48.84	14.18	2.70	0.72	0.40	16.01	2.42	50.00	6.25	1.28	2.84
NQTN15	Assam	Gelapukhri	Tinsukia	27.53477	95.35652	Dug well	Aquifer Mapping	02.03.2021	22.2	8.95	416.10	BDL	204.10	12.00	189.25	201.25	39.00	3.07	1.82	0.68	12.01	29.12	150.00	15.28	21.94	1.68
NQTN16	Assam	Rangaguda	Tinsukia	27.57146	95.30967	Dug well	Aquifer Mapping	02.03.2021	20.1	7.68	197.90	BDL	97.22	BDL	103.78	103.78	10.64	19.25	0.56	0.52	22.02	10.91	100.00	4.22	2.30	0.49
NQTN17	Assam	Lohari Bongaligaon	Tinsukia	27.46907	95.40752	Dug well	Aquifer Mapping	02.03.2021	22.5	7.30	155.00	BDL	74.85	BDL	54.94	54.94	14.18	28.61	1.24	0.36	8.01	7.28	50.00	13.79	4.76	2.71
NQTN18	Assam	Hillikaguri	Tinsukia	27.43828	95.30046	Dug well	Aquifer Mapping	02.03.2021	21.4	7.84	384.20	BDL	188.40	BDL	152.62	152.62	42.54	19.91	0.21	0.50	18.01	16.98	115.00	31.06	14.73	2.00
NQTN19A	Assam	Halaukia	Tinsukia	27.62756	95.5069	Dug well	Aquifer Mapping	06.03.2021	20.9	7.72	132.00	BDL	65.35	BDL	12.21	12.21	28.36	11.61	3.85	0.17	10.01	3.64	40.00	7.54	6.76	0.36
NQTN19B	Assam	Badlabeta TE	Tinsukia	27.56013	95.58874	DTW	Aquifer Mapping	07.03.2021	21.7	7.66	233.10	BDL	115.50	BDL	91.57	91.57	21.27	20.93	1.86	0.54	16.01	15.77	105.00	11.64	3.44	0.55
NQTN20	Assam	Badlabeta TE	Tinsukia	27.56013	95.58874	Hand Pump	Aquifer Mapping	07.03.2021	20.8	7.44	134.20	0.10	66.71	BDL	48.84	48.84	17.73	10.85	2.57	0.37	6.00	9.71	55.00	5.57	2.60	1.81
NQTN21	Assam	Borgaon	Tinsukia	27.54828	95.7017	Dug well	Aquifer Mapping	07.03.2021	22.2	7.40	130.90	BDL	64.28	BDL	67.15	67.15	14.18	10.73	1.09	0.36	10.01	9.70	65.00	5.88	0.86	7.91
NQTN23	Assam	Baghjan TE	Tinsukia	27.59293	95.43084	Dug well	Aquifer Mapping	06.03.2021	22.8	7.42	168.30	BDL	82.92	BDL	61.05	61.05	10.64	36.63	3.12	0.31	16.01	9.70	80.00	4.87	1.92	2.26
NQTN24	Assam	Panitola	Tinsukia	27.49538	95.25446	Dug well	Aquifer Mapping	05.03.2021	21.9	8.75	400.00	0.10	197.00	12.00	177.04	189.04	24.82	38.32	0.47	0.52	14.01	29.12	155.00	23.16	12.19	0.55
NQTN25	Assam	Khasijan	Tinsukia	27.61921	95.70167	Dug well	Aquifer Mapping	27.02.2021	22.5	8.89	254.40	BDL	131.50	12.00	164.83	176.83	10.64	8.77	0.68	0.51	16.01	24.26	140.00	10.51	3.80	0.11
NQTN26	Assam	Lalmati	Tinsukia	27.42168	95.76823	Dug well	Aquifer Mapping	07.03.2021	24.3	7.54	138.80	BDL	68.98	BDL	61.05	61.05	14.18	3.82	0.78	0.38	20.02	6.06	75.00	1.50	1.83	1.11
NQTN27	Assam	Kana pathar no. 2	Tinsukia	27.49188	95.86983	Dug well	Aquifer Mapping	07.03.2021	21.3	7.70	216.20	BDL	108.00	BDL	91.57	91.57	17.73	23.16	0.92	0.28	8.01	21.84	110.00	3.59	9.41	0.24

2.5. Geophysical survey:

- A total 15 nos. of VES have been conducted (as per record) and all the interpreted results have been discussed.
- The thickness of the aquifers varies from 1.0 – 166.8 m.
- The maximum aquifer thickness is found to be respectively at PNJB Road, Bapapung and Maliabari.
- The expected ground water bearing potential aquifers are in the depth ranges 1.5 – 166.8 mbgl.

Table 2.12. Electrical Resistivity carried out till date in Tinsukia along with interpreted results.

VES	**Location**	**Altitude** in m	Longitud e	Latitude
1	Golf Ground, 100m West of club, Digboi	158	95.63583	27.37167
2	In front of Blow-82, Left side of Golf gate, Digboi	152	95.63639	27.37028
3	Golf Ground 100m SW of Trijunction, Digboi	147	95.63639	27.36389
4	180m NE of Dibru river, 50m N of Footpath, Nazirating	127	95.61222	27.49167
5	S part of Dibru river, 200m E of shop	118	95.39972	27.62028
6	PNGB road, Maliabari, Bapapung	141	95.62333	27.41722
7	DPS – Existing well	156	95.62500	27.37083

2.6. Exploratory Drilling

Central Ground Water Board, North Eastern Region, Guwahati had began exploration in the district since 1981 and drilled 9 exploratory wells till 2011**.** During AAP 2020-21 exploration activity initiated in the district focussing mainly to cover unexplored Sadiya block adjacent to Lohit river, a major tributary of river Brahmaputra and one exploratory well was constructed in the area.

A list of wells constructed in the area was prepared incorporating location, well designs, etc.

Table 2.8: Details of exploratory wells in Tinsukia District, Assam

Village / Location	Longitude	Latitude	Type of well	Formation	Depth of Drilled (mbgl)	Depth of constr. (mbgl)	Source/ Agency
Philobari	95.68	27.38	TW	Alluvium	147.03	140.00	CGWB
Margherita	95.75	27.31	TW	Alluvium	112.43	53.00	CGWB
Hapjan	95.43	27.47	TW	Alluvium	50.09	35.00	CGWB
Loina	95.64	27.72	TW	Alluvium	146.30	128.14	State Govt.
Nunpuria	95.31	27.50	TW	Alluvium	147.82	136.36	State Govt.
Tingrai	95.55	27.49	TW	Alluvium	143.35	126.31	State Govt.
Buri -Dihing	95.77	27.51	TW	Alluvium	143.29	132.82	State Govt.
DhallaKhola	95.73	27.63	TW	Alluvium	149.39	138.17	State Govt.
Borgolai	95.72	27.29	TW	Alluvium	157.34		CGWB
Chapakhowa	95.76	27.96	TW	Alluvium	16.01	16.01	CGWB

CHAPTER 3.0

3.0 Data Interpretation, Integration and Aquifer Mapping

3.1. Geophysical Exploration and Aquifer Characterization

The interpreted results of VES curves has shown that in some areas top soil has resistivity value ranges from 118.3 to 2647 Ωm being approximately 2m thick comprises soil with boulders of compact nature. The layer below the top soil in the depth range of 5m and 20m with resistivity in the range of 103 Ohm m and 176.2 Ohm m is indicative of saturated formation comprising sands and pebbles etc. The consecutive layer is with resistivity around 473.4 to 490 Ohm m is indicative of the probably the saturated formation comprising pebbles with sands and clays occasionally with boulders. Comparatively lesser resistivity within 37.3-87.5 Ohm m is indicative of clays predominance intercalated with thin bands of sands etc. The summary result of resistivity survey is shown in Table: 2.1.

The result of VES survey has shown that the subsurface formation is sand or gravel dominated and clay occur as intercalations with sand.

3.2. Aquifer Dispositions.

The subsurface geology of Tinsukia District is interpreted based on exploration data of CGWB and exploration data of Irrigation department and DGM, Govt. of Assam. From the examination of this litholog it is observed that down to a maximum explored depth of 100m the sequence is dominated by gravel, sand, clay and boulders. In the southern most part the boulder layer stats from 50m depth in the Borgolai EW. The lithologs and the lithology identified in VES survey are used to understand 2D and 3D disposition of aquifer.

The drilled depth of CGWB's exploratory well ranges from 16.1 to 248.27 mbgl whereas Irrigation departments exploratory well depth ranges from 143.29 to 149.39 mbgl. Distribution of well as per drilling depth indicates that 80% of exploratory wells depth ranges from 110 to 170mbgl (Table 3.1).

Table 3.13. Distribution of EW based on drilled depth.

Depth	Within 50m	50- 100m	100-150	150-200	200-250	250-300	Total
No. of wells	1	0	6	2	1	0	10
% Of well	10	0	60	20	10	0	100

Plotting of EW locations in the geomorphologic map indicate that majority of wells were constructed younger alluvial plain and rest were located in Pediment and Pediplain complex. As per the geometry the aquifers have been classifies in to shallow and deeper aquifer on the basis of their depth of occurrences.

a. Shallow Aquifer – Depth ranges up to 50m bgl.
b. Deeper Aquifer – Depth range below 50m bgl.

Top clay layer followed by sandy layer with a thickness of 15 to 45 m occurs down to a depth of 50 m below ground level in most part of the district but in flood plain area, top clay layer is encountered with occasional silt down to a depth of 50 m.

Zones extending below 50 m depth are considered deeper aquifer. Central Ground Water Board drilled five tube wells at Hapjan, Margherita, Philobari, Borgolai and Chapakhowa. The wells drilled by State organisations at Nunpuria, Loina, Tingrai, Dhala Khola and Buridihing. Lithological sections and panel diagram prepared on the basis of lithological logs of deep tube wells. It is seen that in the northern part of the district, sand is dominant.

The lithologs of drilling data and the lithology identified in VES survey are used to understand 2D and 3D disposition of aquifer.

A. 2D disposition

Three sections are constructed to visualize the aquifer disposition

(i) A North -South section from Loina to Borgolai in the Younger alluvial plains to Pediment Pediplain complex (Fig. 3.1)

(ii) An East - West section from Nunpuria to BuriDihing in the younger alluvial plains (Fig. 3.2).

(iii) A West to South West section from Nunpuria to Margherita in the younger alluvial plains to older alluvial plains through Pediment Pediplain complex (Fig. 3.3).

In the alluvial plains sand formation is dominated and the thickness of sand formation is decreasing towards south and lie over the tertiary boulder formation at the extreme southern potion near Borgolai area. Presence of gravelly sand formation with a very good thickness around 100 m in Dhalla Khola and the thickness decreases towards south and found to be 30m to 40 metres in Philobari and gradually diminishes at the southern portion. Greyish Sand mixed with boulders and pebbles marked a good thickness of horizon. The lower part of the zone is entirely boulders with very little clay and sands.

In the north-south section from Loina to Borgolai, a thick gravelly sand formation is found to extend from near Dhalla Khola to Philobari. This gravelly layer attains a thickness of around 100m at Dhalla Khola and gradually decreases its thickness towards the south near Borgolai. The top and bottom of the gravelly horizon is marked by confining layers at Philobari. Tertiary bouldey formation is encountered at Borgolai.

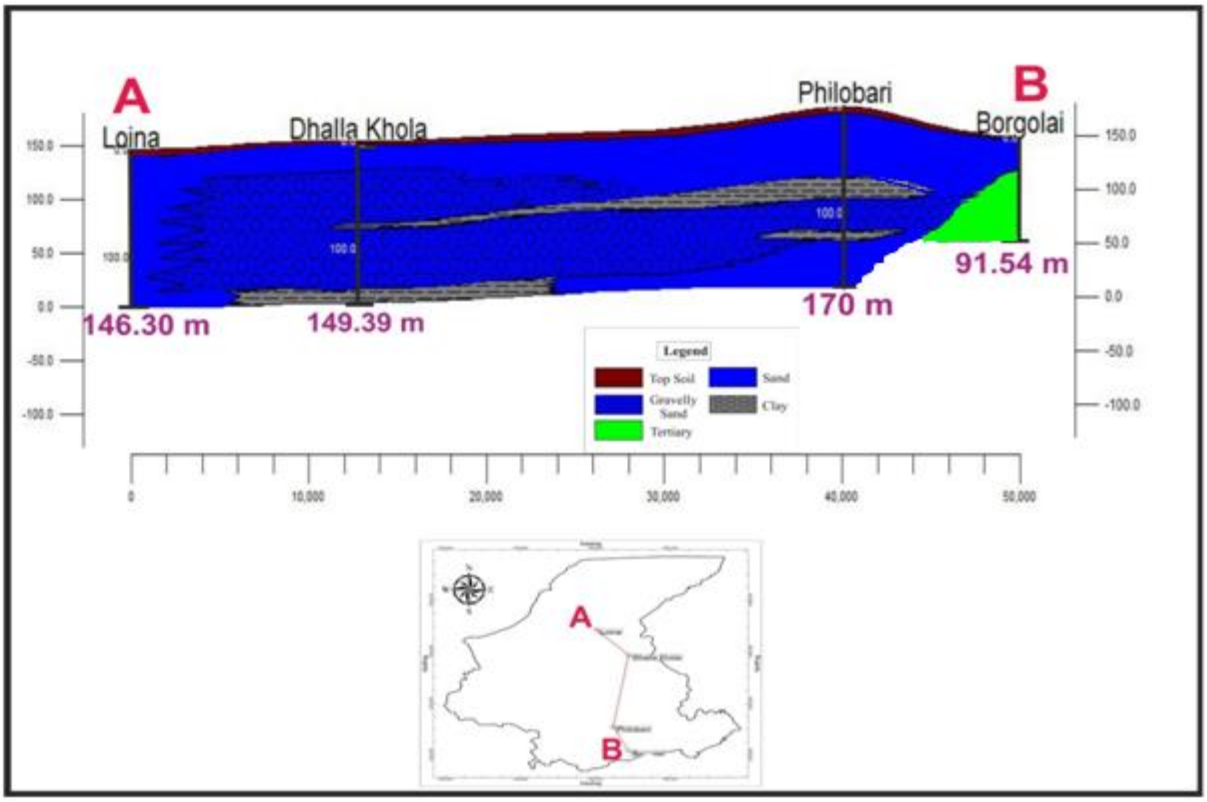

Fig. 3.12: 2D disposition along North-South direction.

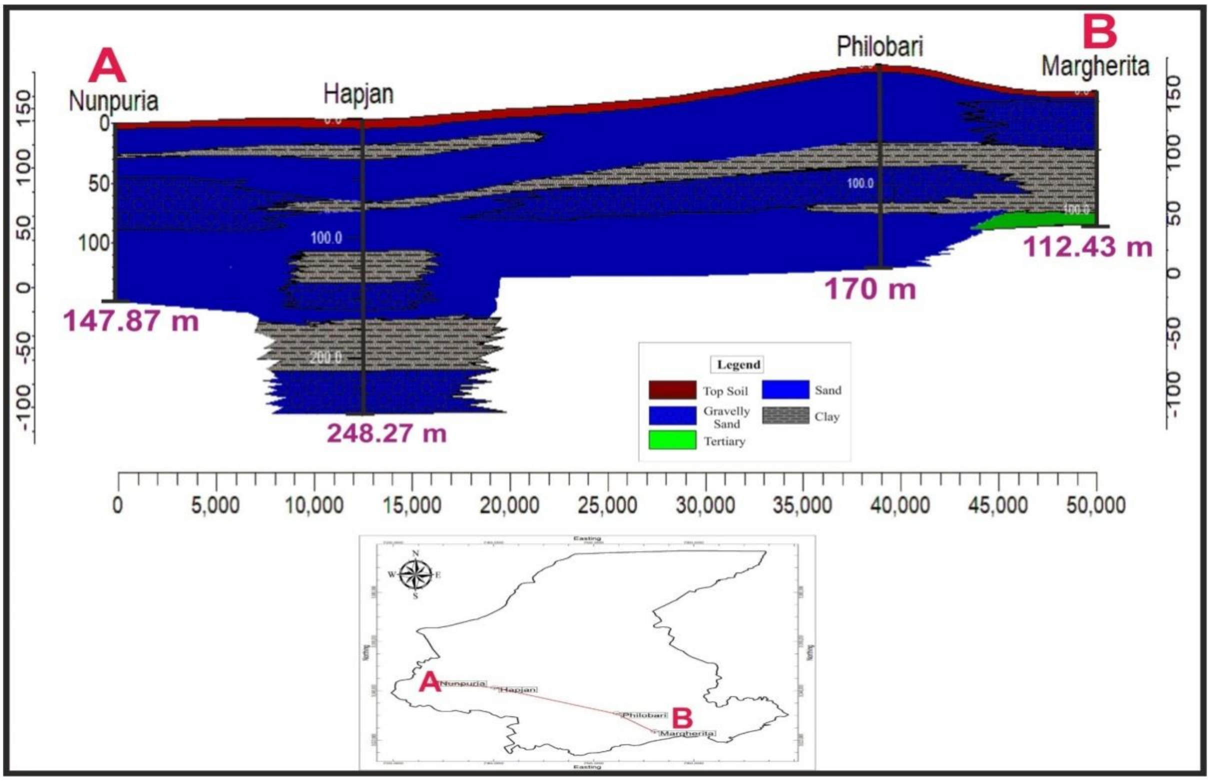

Fig. 3.13: D disposition along West to South-East direction.

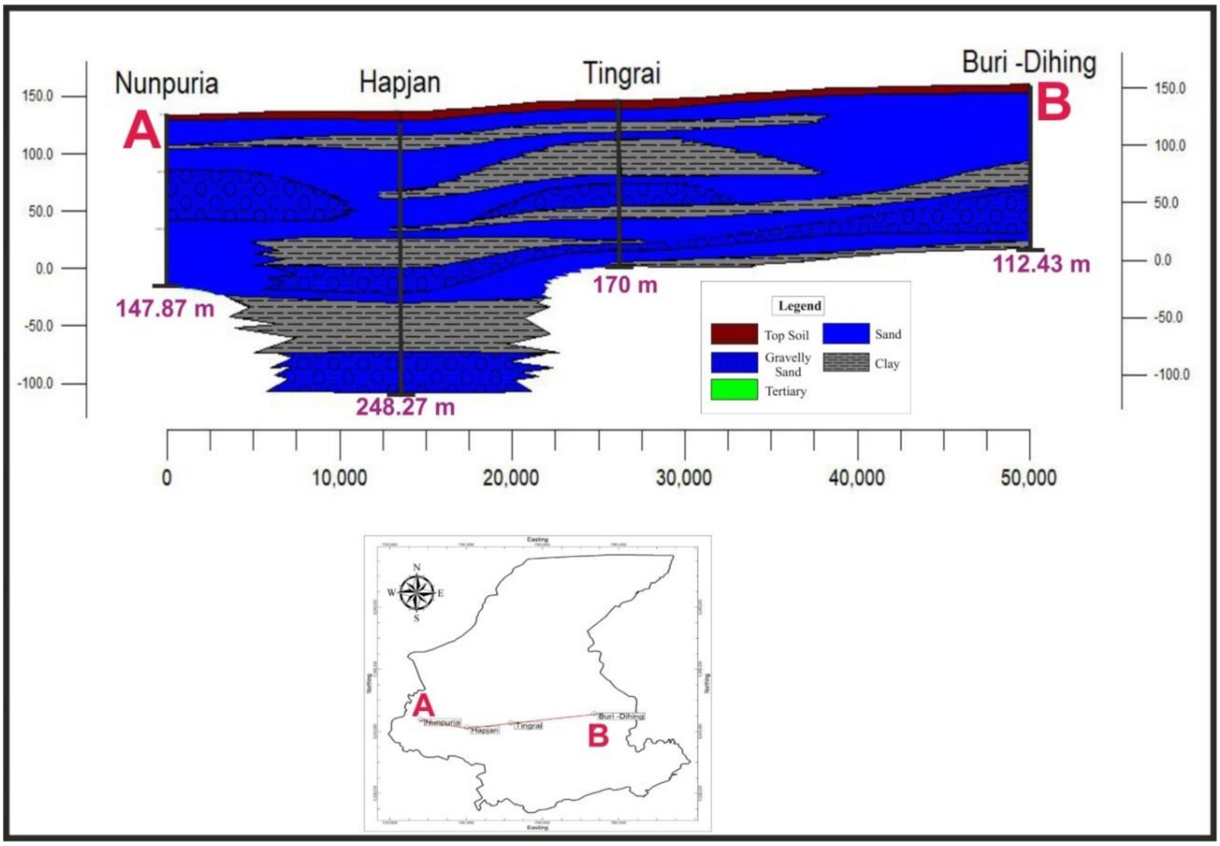

Fig 14.3: 2D disposition along West to South-East direction.

The East to West directions the wells have been constructed in the younger alluvial pains. Sandy formations are clearly dominated towards both the end portions of the district where as in the middle portion good thickness of clay horizon found to occur. The thickness of clay zone is around 55 metres to 85 metres Apart from the clay horizon sand and sand with gravel zones are present in the middle position which demarcate the aquifer system. Maximum depth of the well is 248.27 metres in the Hapjan Exploratory well. Three prominent clay layers are prominent in the Hapjan well and Tingrai well.

The well found in the Pediment-Pediplain complex has very good thickness of sandy formations throughout the entire depth of well separated by thin clay layers. Gravelly sand is present sandwiched between two clay layers but is horizontal extension make this zone unconfined. But in this part, this single aquifer system is separated into a multiple aquifer system by thick clay partings. In the Nunpuria well at a depth range of about 147 mbgl., possibility of Tertiary semi-consolidated rocks as bedrock.

Sub-surface geology and ground water conditions are described in chapter 01. It shows that aquifer in the area can be classified into two groups; i.e. i) shallow aquifer system and ii) Deeper aquifer system.

i) Shallow aquifer system

Shallow aquifer system is considered to be within 50 m below ground level. Within this depth total thickness of aquifer ranging from 35 to 40 m in the younger alluvium 26 to 31 m in older alluvium and 1 to 40 m in Tertiary formations are available for ground water development. The aquifer geometry of younger alluvium is similar of flood plain deposits. However, in older alluvium thickness of aquifer is less due to presence of clay horizon at the depth of 22 m to 27 m in some places. The Tertiary formation aquifers are not uniform. Ground water structures contains in flood plain, younger and older alluvium in shallow aquifer zones can give yield varies from 40 to 120 m^3/hr for economic draw down.

ii) Deeper Aquifer System:

Deeper aquifer system in the depth ranges 50 to more than 160 m possess multiple aquifers having cumulative thickness of more than 50 m. These tube wells are giving yield of 140 to 380 m^3/hr; irrespective of flood plain, older and younger alluvium. The discharge capacity however observed to be lesser in case of deep tube well-constructed at Tertiary formation, which ranges from 15 to 40 m^3/hr for higher draw down.

B. 3D disposition of aquifer

The aquifer disposition of the area in the 3D block diagram indicates presence of single aquifer system with multiple zones separated by clay layers.

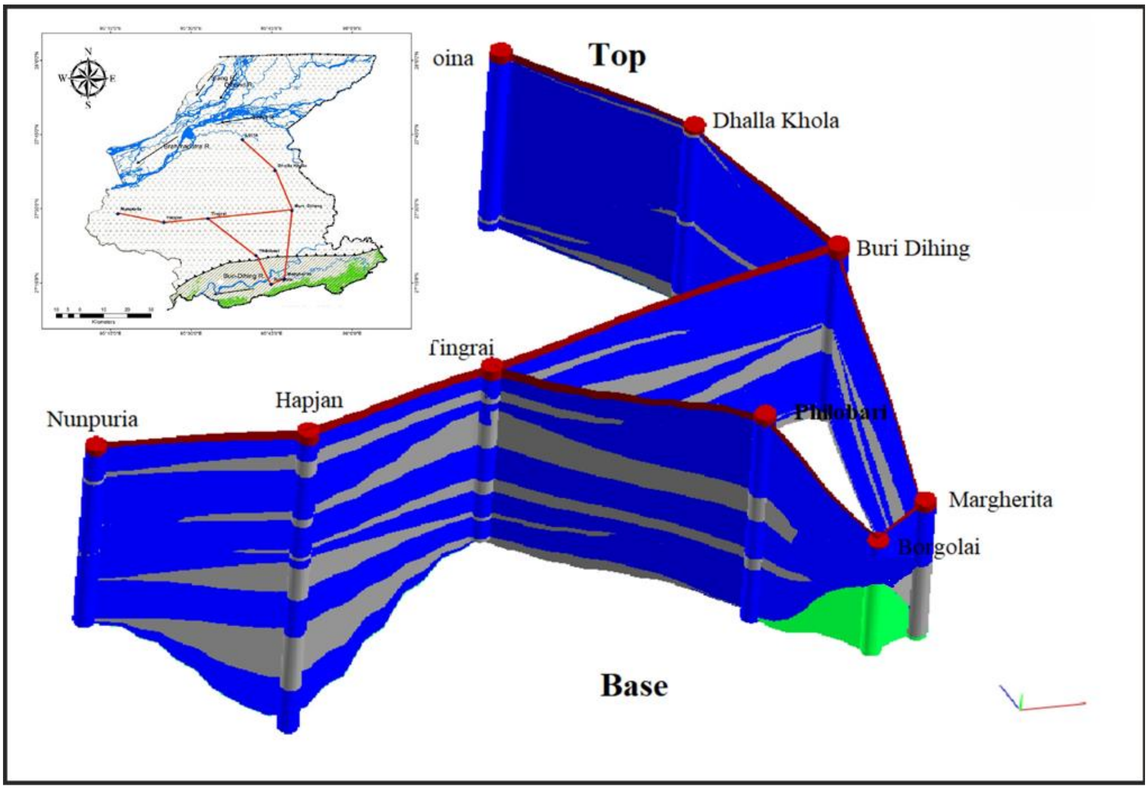

Figure 3.15. 3D disposition of aquifer in the study area.

3.2. Ground water level

CGWB, NER has 07 nos. of groundwater monitoring stations in the district. During NAQUIM study 13 nos. of key wells were established covering most of the blocks of the district. During AAP 2020-21, water level of the GWMS was measured three times in a groundwater year. The key wells were established in November, 2020 and the water levels of the key wells were monitored during November 2020 and March 2021. Water level data of the district were summarized in Table 3.3.

Table 3.2. Pre- and Post-monsoon depth-to-water level and fluctuation of water level

SN	Locations	Pre-monsoon DTW (mbgl)	Post-monsoon DTW (mbgl)	Fluctuation(m)
1	Tinsukia	2.41	4.32	1.91
2	BordubiRadhanagar	0.94	1.16	0.22
3	Digboi	1.14	1.56	0.42
4	BargolaiSainagar	1.00	4.19	3.19
5	Tipong	4.07	4.72	0.65
6	Lekhapani	2.36	4.09	1.73

7	Rampur	1.31	3.00	1.69
8	Jagun	2.16	5.44	3.28
9	Makuumbagan, Garaland	2.15	1.87	0.28
10	KumsanSeleguri	1.71	4.34	2.63
11	Chapakhowa	1.30	2.19	0.89
12	Do no Megla	3.15	4.73	1.58
13	Akanimuria	1.51	3.06	1.55
14	Gelapukhuri	1.36	3.68	2.32
15	Rangaguda	2.9	4.11	1.21
16	LohariBangaligaon	1.65	3.00	1.35
17	Hillikaguri	2.02	4.66	2.64
18	Badlabeta TE	4.35	5.41	1.06
19	Borgaon	2.09	3.86	1.77
20	Panitola	0.77	3.45	2.68

The pre-monsoon water level in the younger and older alluvium varies from 1.16 to 5.41 mbgl and in the Pediment pediplain complex it varies between 1.56 to 1.87mbgl. In the structural valley pre-monsoon water level 4.09 to 5.44m bgl respectively. (Table 3.3)

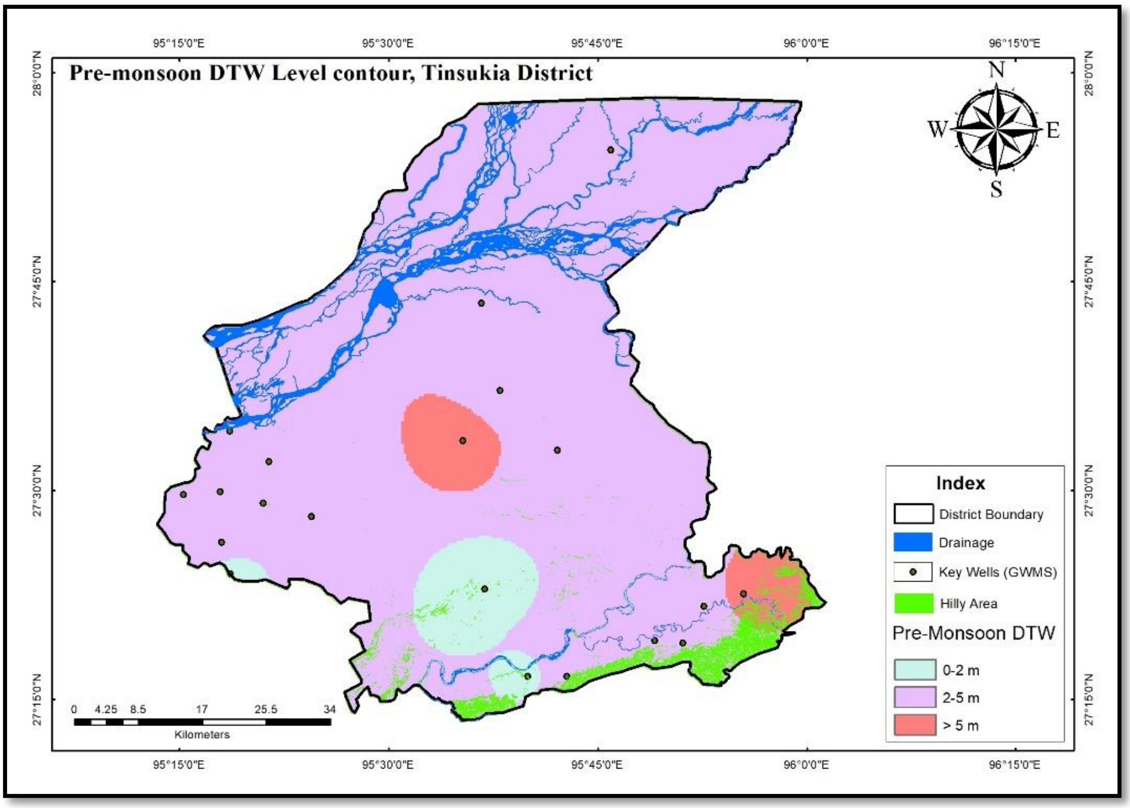

Figure 3.16Pre-monsoon DTW level contourTinsukia District, Assam

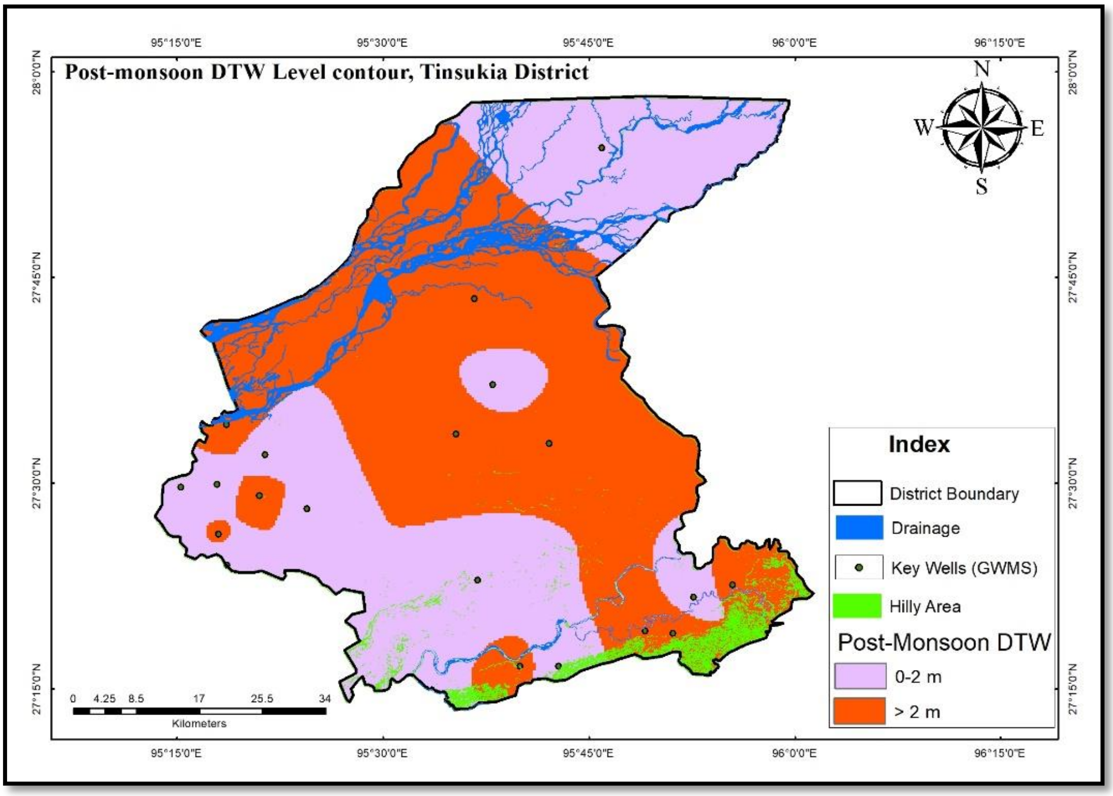

Figure 3.17Post-monsoon DTW level contour of Tinsukia District, Assam

The post-monsoon water level in the younger and older alluvium varies from 0.77 to 4.35 mbgl and in the Pediment pediplain complex it varies between 1.0 to 2.15 mbgl. In the structural valley pre-monsoon water level 1.0 to 4.07 m bgl respectively. (Table 3.3)

Fluctuation of water level in the younger and older alluvium varies from 0.22 to 2.68 mbgl and in the Pediment pediplain complex it varies between 0.3 to 0.42 mbgl. In the structural valley pre-monsoon water level 0.65 to 3.28 m bgl respectively. (Table 3.3 & fig 3.8)

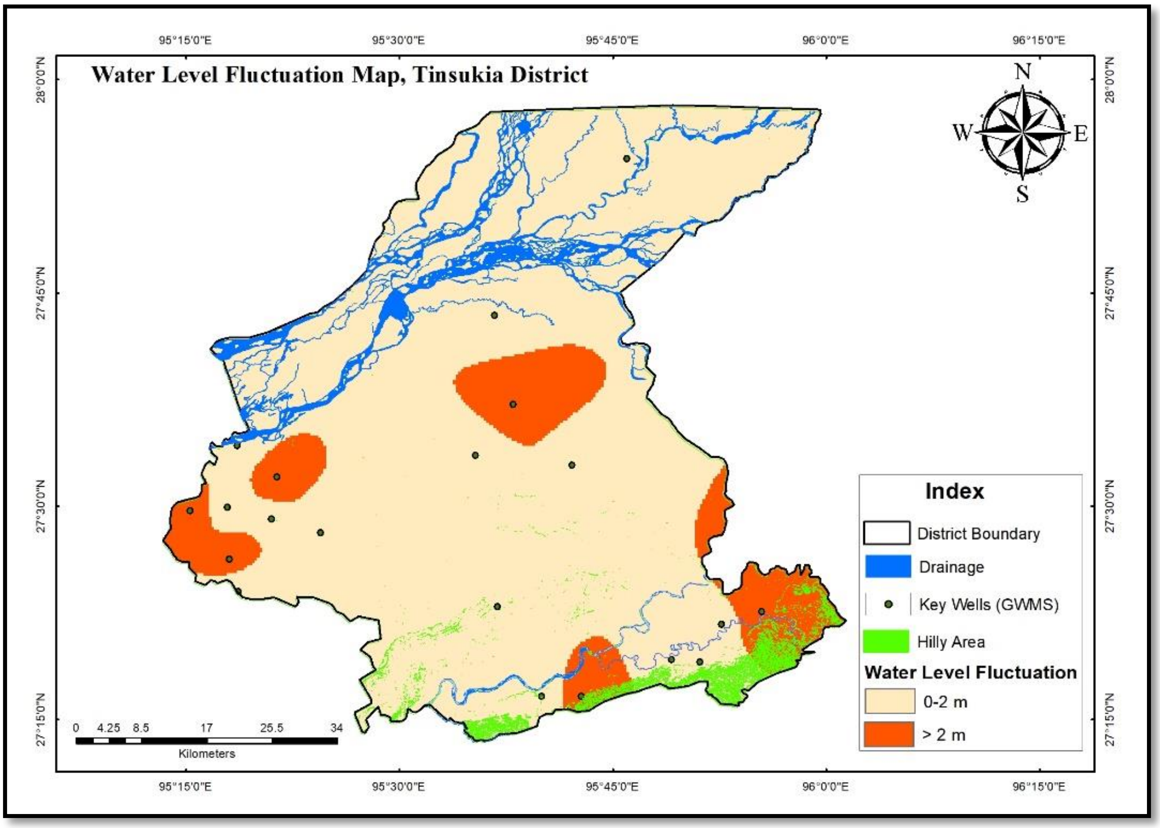

Figure 3.7. Water level fluctuation of Tinsukia District, Assam

3.2.2. Ground Water Movement

The water table contour of phreatic aquifer has been prepared based on water level data with respect to elevation of ground water monitoring stations from mean sea level (Fig. 3.9). The contour map shows that water table contour of Tinsukia district varies from 160m to 120m above mean sea level (Fig.3.8). In general groundwater movement is towards North-West, i.e., toward the river Brahmaputra and conforms to the general topography of the district. The Lohit, Siang and other tributaries of the Brahmaputra are effluent in nature i.e., they receive ground water.

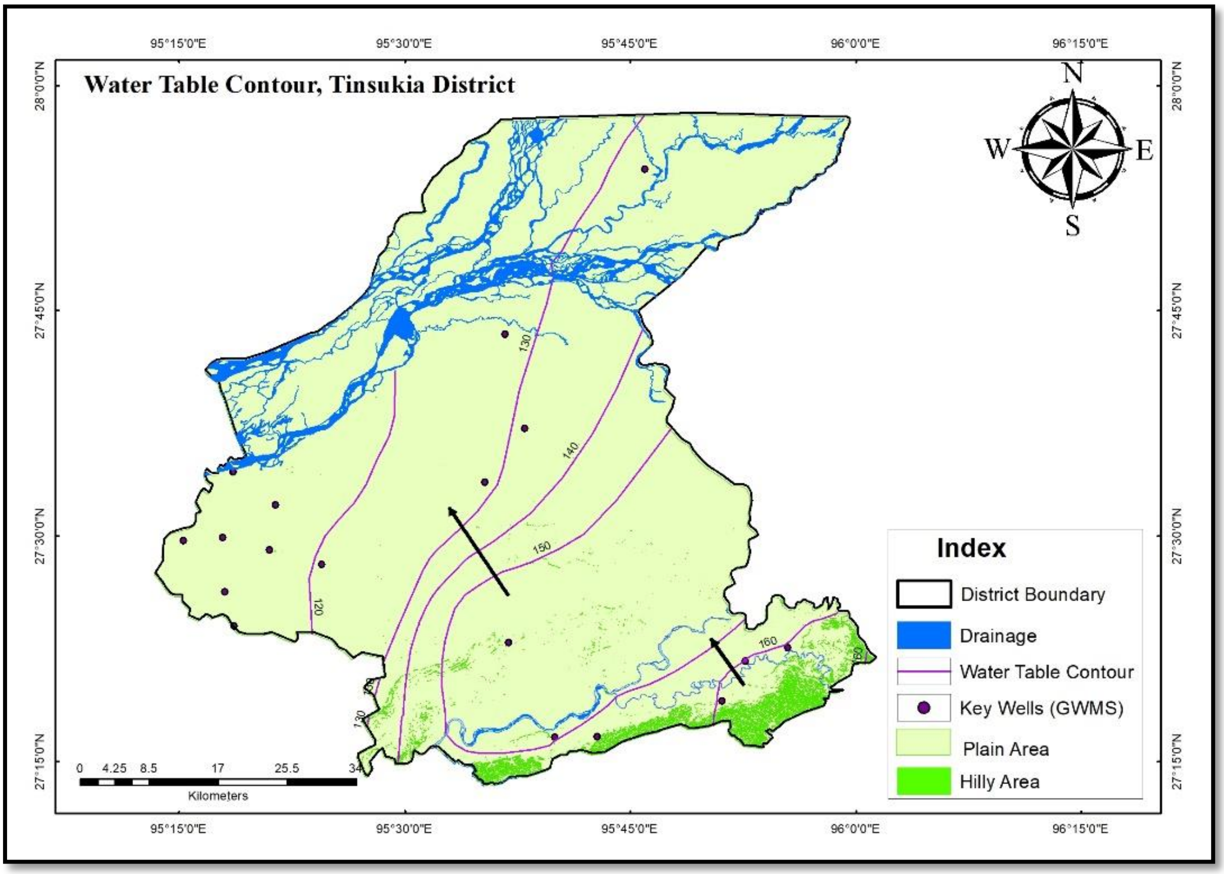

Figure 3.8. Water table contour of Tisukia District, Assam

3.2.3. Water level trend analysis

For analysis of long-term behavior of ground water level, data from Ground Water Monitoring Stations (GWMS) are utilized. Historical depth-to-water level data (in m bgl) are plotted as individual hydrographs and are shown in Figure 3.9 and Table 3.4.

Table 3.3. Trend of Water levels in GWMS Wells

SN	Well No	Locality/Name	No. of years	Water Level Trend	
				Slope	**Remark**
1	83M3C2	Borgolai	10	-0.031	Fall
2	83M3C1	Digboi	10	0.086	Rise
3	ASTS22	KumsangSelenguri	8	0.215	Rise
4	83M3C3	Ledo	10	0.184	Rise
5	83M3D1	Lekhapani	10	0.011	Similar
6	83M3B4	Panitola	10	0.149	Rise
7	83M3B2	Tinsukia	10	0.012	Similar

8	83M3C7	Philobari	10	-0.101	Fall

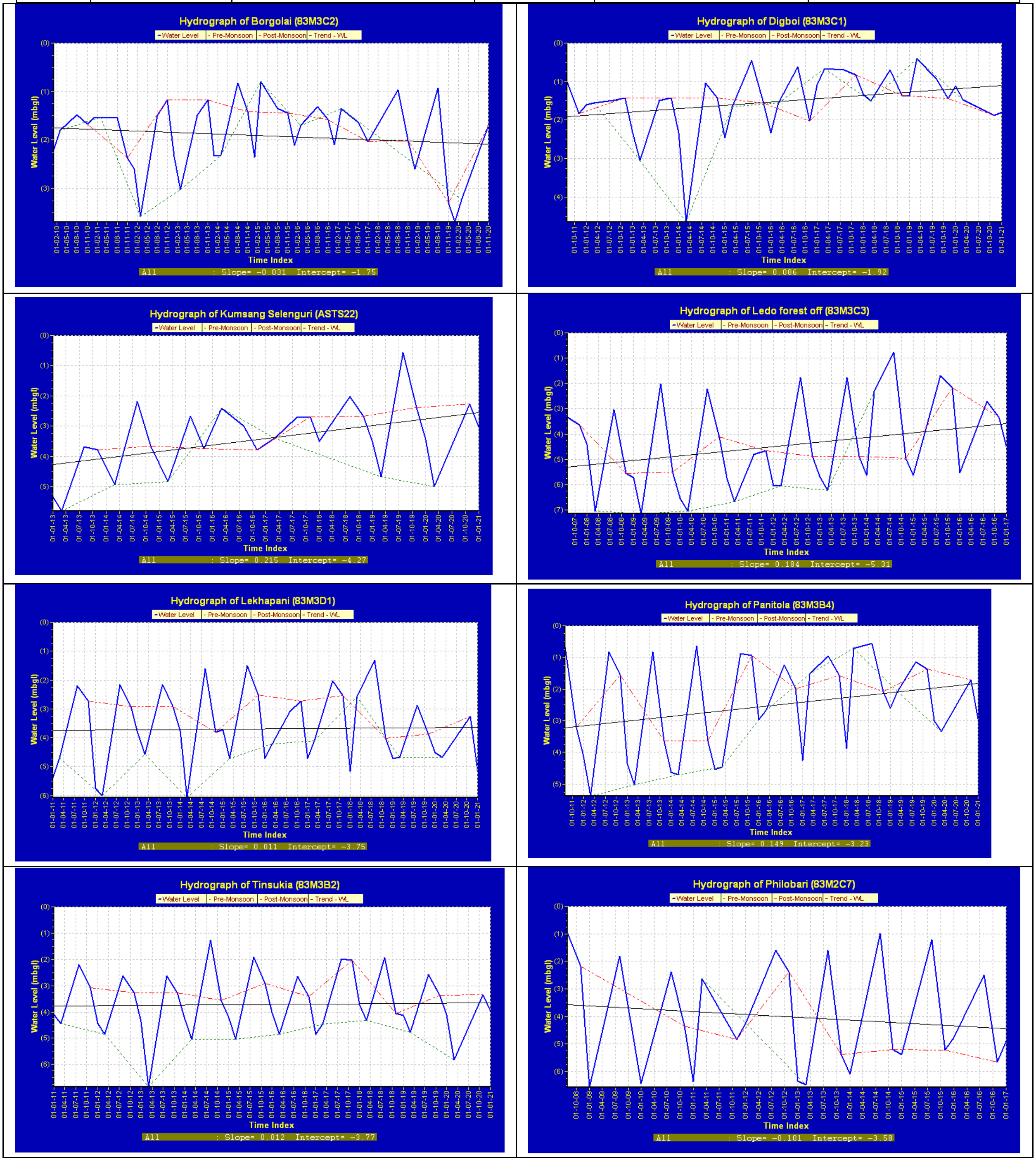

Figure 3.9. Hydrograph of Ground Water Monitoring Stations in Tinsukia District, Assam

3.3. **Ground water quality**

To study the ground water quality of Tinsukia district chemical analysis of collected ground water samples were carried out in the NABL accredited regional chemical laboratory of Central Ground Water Board, North Eastern Region, Guwahati. From the entire district 28 samples have been collected in the Pre-monsoon of which 23 from dug well, 4 from hand pump and 1 from deep tube well whereas 23 samples in the Post-monsoon out of which 18 samples were from dug wells and 4 samples from hand pump of 20-30m depth and 1 from deep tube well. The chemical analysis data during Pre-monsoon and Post-monsoon season are given in the Table 4.2 and Table 4.3 respectively. Summary of the analyzed data are given below in the table 4.4 and 4.5.Table 4.5 – Summarized chemical quality of water samples collected during Post-monsoon.

Table 3.4. Summarized chemical quality of water samples collected during Pre-monsoon.

Sl. No.	**Chemical constituents and other parameters**	**Unit**	**Maximum**	**Minimum**
1	pH		7.776	6.750
2	EC	**(µs/cm) 25°C**	611.00	76.26
3	Turbidity	**NTU**	0.30	BDL
4	TDS	**mg/l**	348.60	43.55
5	CO3-2		BDL	BDL
6	HCO3-1		286.93	24.42
7	TA (as CaCO3)		286.93	24.42
8	Cl-		67.36	10.64
9	SO4-2		196.06	3.17
10	NO3-1		8.11	0.17
11	F-		0.34	BDL
12	Ca+2		64.05	8.01
13	Mg+2		25.48	3.63
14	TH (as CaCO3)		225.00	60.00
15	Na		47.70	2.79
16	K		29.06	0.80
17	Fe		12.898	0.0070
18	U	**µg/l**	0.5558	BDL
19	As		0.4580	BDL

Table 3.5. Summarized chemical quality of water samples collected during Post-monsoon.

Sl. No.	Chemical constituents and other parameters	Unit	Maximum	Minimum
1	pH		8.95	7.30
2	EC	(µs/cm) 25°C	897.30	111.00
3	Turbidity	NTU	0.2	BDL
4	TDS	mg/l	446.00	55.04
5	CO3-2		18	BDL
6	HCO3-1		244.20	12.21
7	TA (as CaCO3)		262.20	12.21
8	Cl-		106.35	10.64
9	SO4-2		147.60	2.70
10	NO3-1		12.22	0.21
11	F-		1.1	0
12	Ca+2		34.03	4.00
13	Mg+2		63.10	2.42
14	TH (as CaCO3)		295.00	40.00
15	Na		54.64	1.50
16	K		26.82	0.86
17	Fe		30.39	0.11

Table 3.6. Summarized chemical quality of water samples collected during Pre-monsoon.

Type of Structure	No. of Sample analysed	Conc. Of Iron(mg/l)		pH value	
		< 1	> 1	<6.5	6.5 to 8.7
Dug wells	24	14	10	1	23
Hand Pump	3	1	2	0	3
Deep Tube Well	1	1	0	0	1

Table 3.7. Summarized chemical quality of water samples collected during Post-monsoon.

Type of Structure	No. of Sample analysed	Conc. Of Iron(mg/l)		pH value	
		< 1	> 1	<6.5	6.5 to 8.7
Dug wells	18	15	3	0	18
Hand Pump	4	0	4	0	4
Deep Tube Well	1	1	0	0	1

3.3.2. Ground water quality of Dug wells and hand pump

A total of 28 samples in Pre-monsoon and 23 samples were collected from dug well during post monsoon. The range is given in the table 4.3 and 4.4 respectively.

From the analyzed data it can be known that all the from dug wells and hand pump both during pre-monsoon and post monsoon have pH value ranges from 6.5 to 7.7. This show the nature of the groundwater in the dug wells in this season to be neutral to lightly alkaline. The concentration of iron in 14 dug wells in pre-monsoon and 15 dug wells in post monsoon are found to be with in the permissible limit (<1.0 mg/l by WHO), 10 dug wells and 2 hand pumps in pre-monsoon and 3 dug wells, 4 hand pump in post-monsoon shows iron conc. beyond the permissible limit (i.e> 1 mg/l). Apart from these parameters all the parameters analyzed are within the permissible limit.

i. Ground Water quality assessment

Various chemical diagrams like Piper diagram, Wilcox diagram are prepared by using the Aquachem software to assess the quality of ground water of Tinsukia district.

A. Piper Diagram

Piper trilinear diagram is an effective graphical procedure to segregate the analytical data to understand the sources of the dissolved constituent in water. In chemical equilibrium cations and anions are present in the water. The analyzed sample falls under the magnesium bicarbonate type, few samples fall under mixed type origin and only two samples in the calcium chloride type. From the plot in the cation triangle, we can see most of the samples from post monsoon are falling under no dominant type and calcium type where as pre monsoon samples are under no dominant and magnesium type. In the anion triangle all the pre-monsoon and post monsoon samples are falling under bicarbonate to no dominant type. By the extrapolation of cations and anions in to the diamond field represents the hydro-chemical facies of groundwater samples. The facies reflect the response of chemical processes operation within the lithologic framework and flow pattern. This diagram represents for both pre monsoon and post monsoon most of the samples are falling under Magnesium bicharbonate type to mixed type. Only 5% samples are under calcium type.

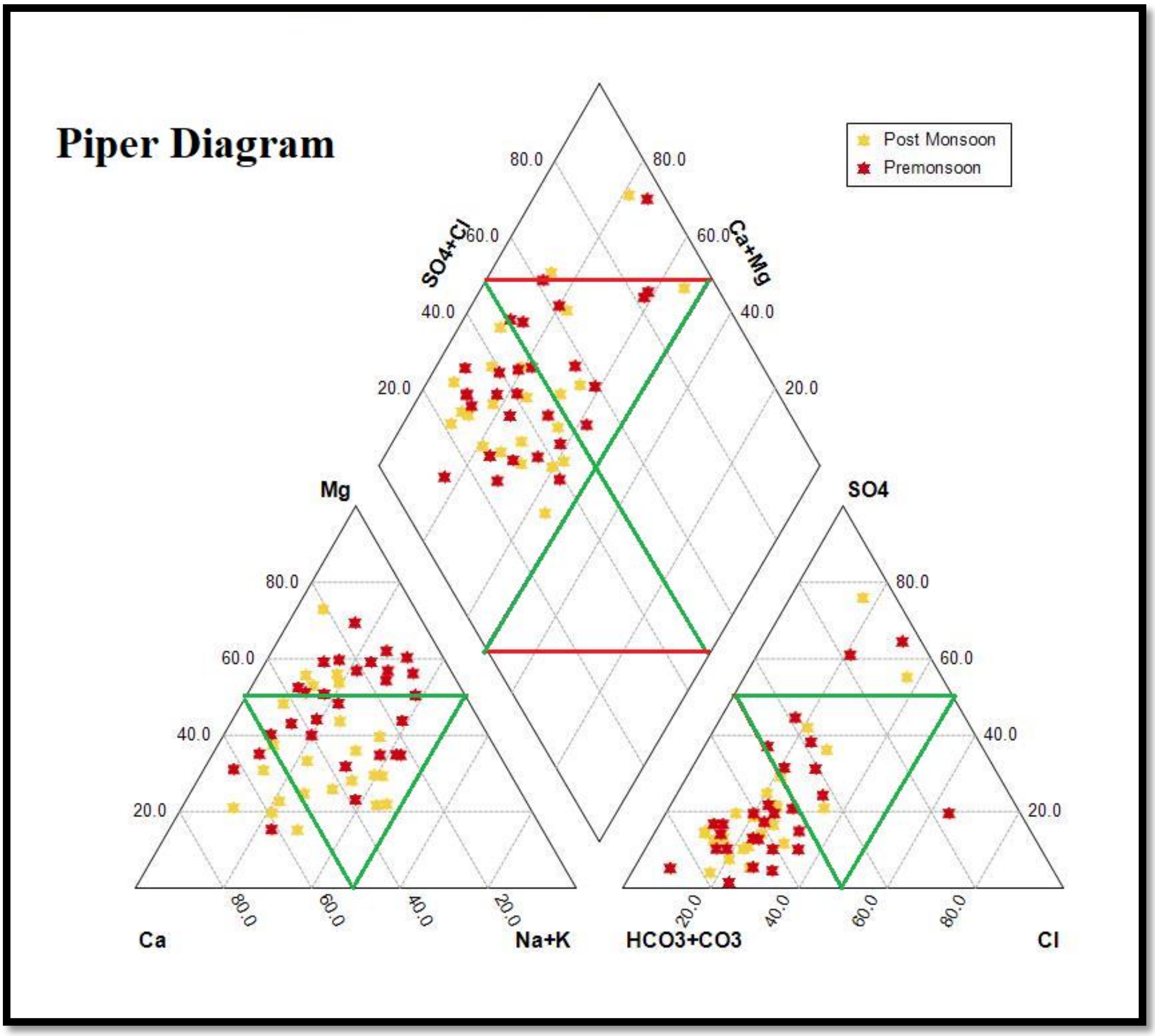

Figure 3.10. Piper trilinear Diagram

B. Wilcox diagram

According to Wilcox diagram (US Salinity Laboratory's diagram) in Figure 4.2, salinity and alkalinity hazard class of water samples were determined . The result shows that a majority of the ground water samples possess low salinity with low sodium (C1–S1) and (C2-S1) field. Only one sample from pre monsoon season falls in the (C3-S1) field. Samples falling under (C1–S1) field shows that this water can be used directly for irrigation purpose. However, water samples falling in medium salinity and low sodium class (C2-S1) and (C3-S) should be treated before using for irrigation purposes.

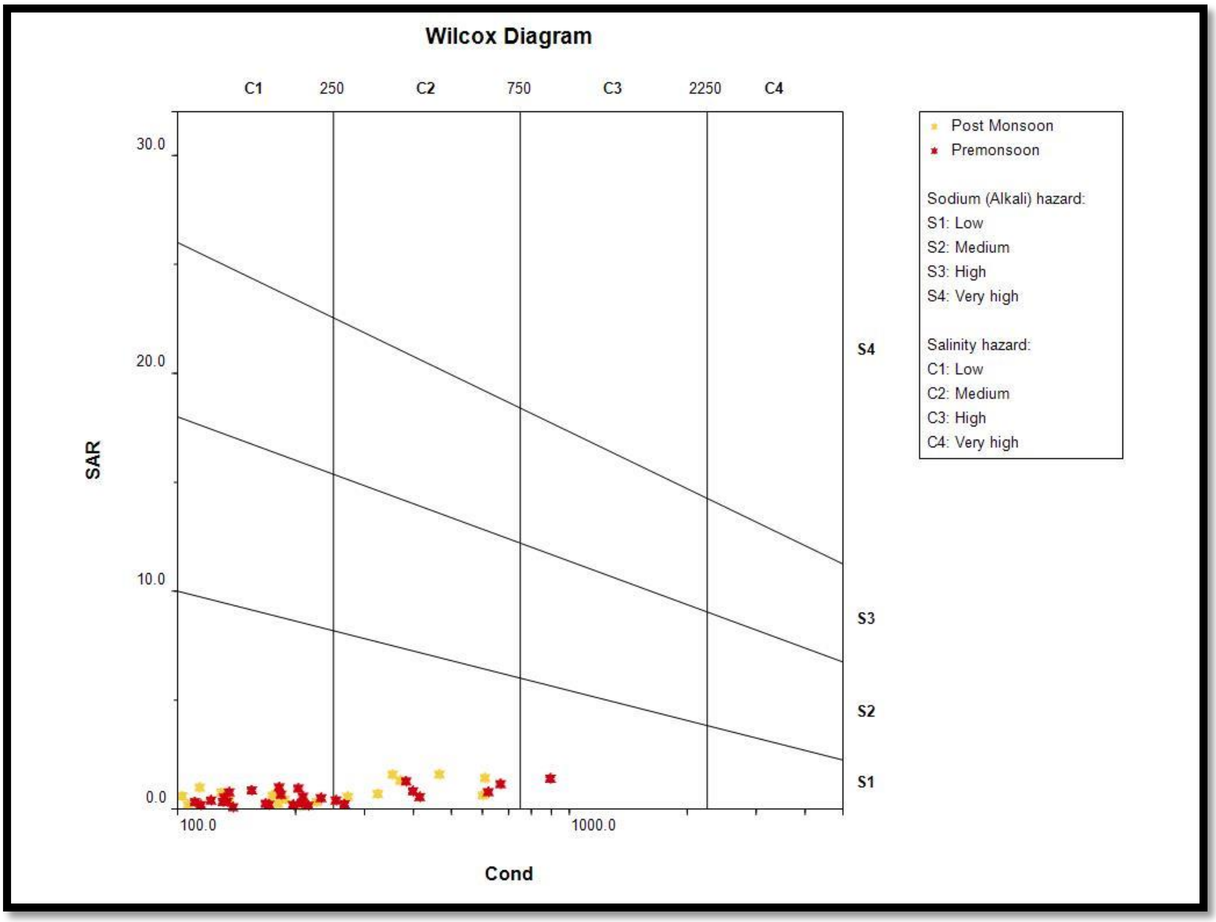

Figure 3.11. Wilcox Diagram, Wilcox, L.V. (1955)

ii. Ground water quality assessment for irrigation

To study the groundwater quality for irrigation 28 samples in the pre-monsoon and 23 samples in the post monsoon have been collected from the entire district respectively. Various parameters like Alkalinity hazard or Sodium Absorption ratio (SAR), Magnesium Hazard (MH), Residual Sodium carbonate (RSC), Permeability Index (PI), Kelly ratio have been calculated from the anlysed chemical components.

a. Alkalinity Hazard (SAR)

Sodium Absorption ration is calculated to determine the alkalinity index for the classification of the groundwater. In the pre-monsoon season the SAR value ranges from 0.93meq/L to 4.09meq/L whereas in the post monsoon season the value ranges from 2.03meq/L to 5.79meq/L. From the plot given below we can see all the samples from pre-monsoon and post-monsoon falls below 10meq/l which means the ground water is in the excellent quality for irrigation.

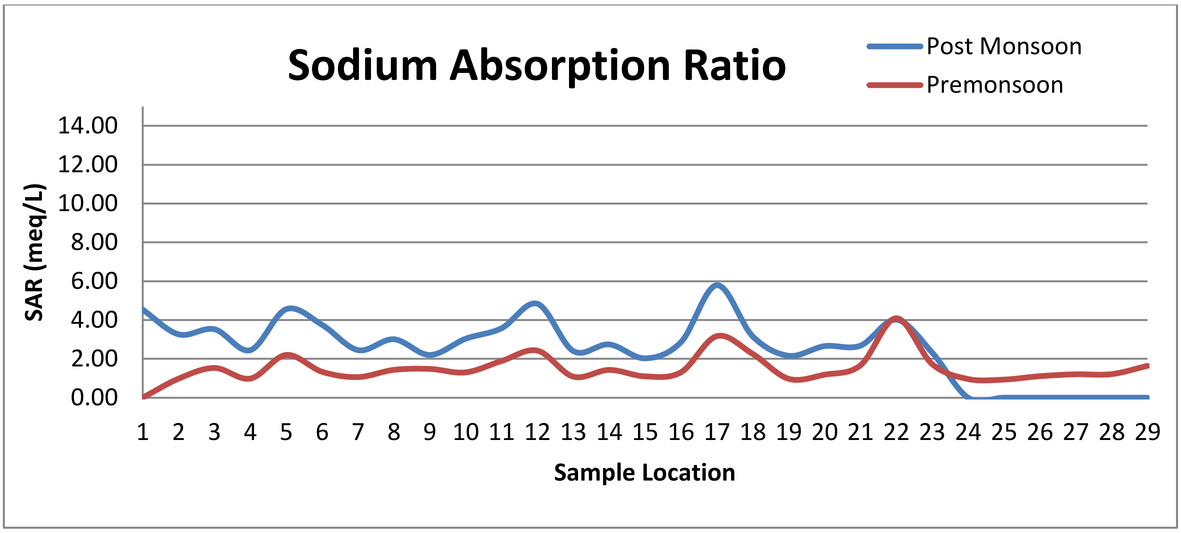

Figure 3.12. Sodium Absorption Ratio Diagram

b. Salinity Hazard

Electric conductivity values represent the saline conditions of the groundwater. Above plotted Wilcox diagram clearly indicates that the EC values of the collected samples are within 750µS/cm i.e with in the field of C2. Majority of samples are with in the C1 field which makes them very good in terms of quality water for irrigation and Samples falling in C2 filed are good for irrigation (Wilcox, L.V. (1955)).

c. Residual Sodium carbonate

RSC index of irrigation water or soil used to indicate the alkalinity hazard for soil. Both from the pre monsoon and post monsoon the RSC value ranges from -4.10 to 0.80 maximum. From the diagram it clearly indicates that all the samples are falling below 1.25meq/L which makes them best suitable for irrigation.

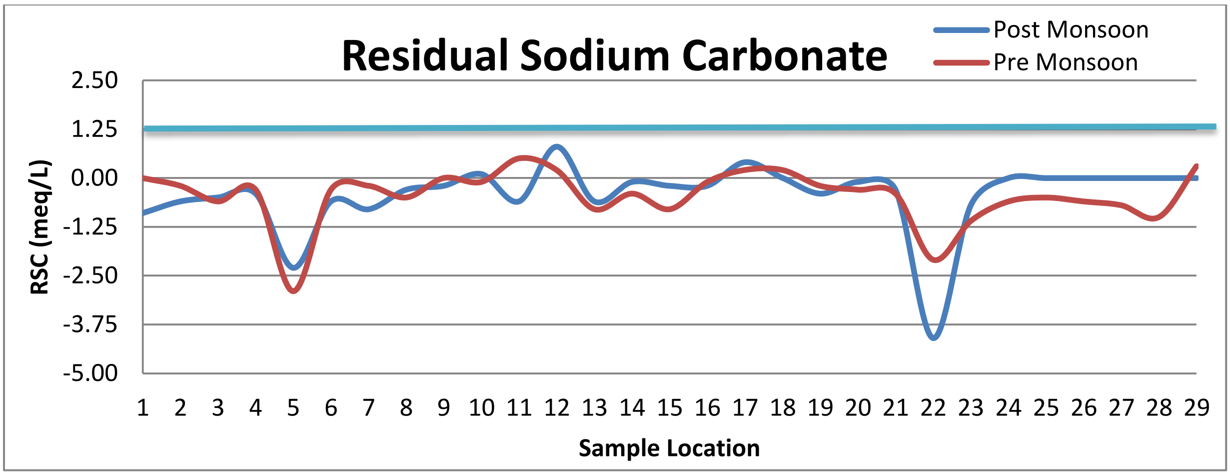

Figure 3.13. Residual Sodium Carbonate diagram

d. Kelly Ratio

This ratio is calculated from considering sodium ion concentration against calcium and magnesium ion concentration. It is an important parameter in determining the quality of irrigation water. KR value less than 1meq/L is considered to be excellent for irrigation purpose. From the diagram it is clearly indicated that the KR value of all the samples from premonsoon and post monsoon are under 1 meq/L which makes the water suitable for irrigation.

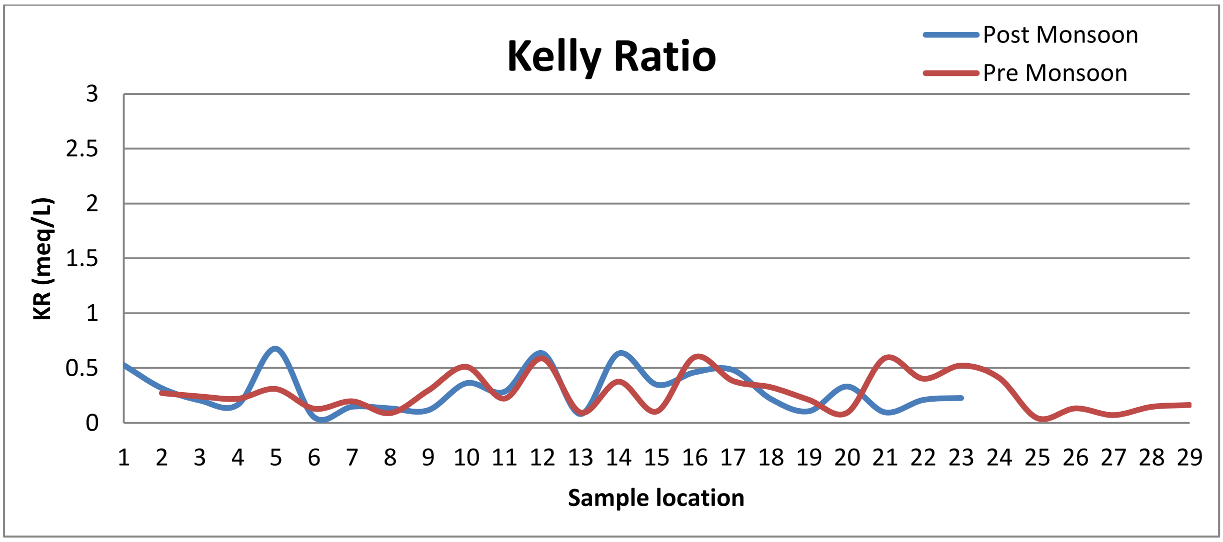

Figure 3.14. Kelly Ratio

From all the calculated parameters from the analyzed data it is clearly indicated that all the samples Tinsukia district are suitable for the irrigation purposes. A tabular summary is given below for all the parameters and their classification for irrigation suitability.

Parameters	**Range**	**Classification**	**Pre monsoon (No. samples)**	**Post monsoon (No. samples)**
Total Dissolved Solid (TDS) (mg/L)	<1000	Non-saline	28	23
	1000-3000	Slightly saline		
	3000-10000	Moderately saline		
	>10000	Very saline		
Salinity Hazard (EC) (μS/cm)	<250	Excellent	20	16
	250-750	Good	7	7
	750-2000	Permissible	1	
	2000-3000	Doubtful		
	>3000	Unsuitable		
Alkalinity Hazard (SAR)	<10	Excellent	28	23
	10-18	Good		
	18-26	Doubtful		
	>26	Unsuitable		
Kelly's Index (KI)	<1	Suitable	28	23
	>1	Unsuitable	-	-
Residual Sodium Carbonate (RSC)	<1.25	Suitable	28	23
	1.25-2.5	Marginally suitable		
	>2.5	Unsuitable		

CHAPTER 4.0

4.1. Ground water Resources

The rechargeable area of Tinsukia district with slope ≤20% is identified by downloading 30m resolution DEM of Shuttle Radar Topography Mission (SRTM) from http://earthexplorer.com.

The rechargeable area is found to be 371757 ha. As block boundary is not available, it was not possible to carry out block wise resource calculation. Here district wise resource calculation is presented.

The computation of ground water resources available in the district has been done using GEC 2015 methodology.

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

1) Rainfall recharge has been computed by both RIF and WLF methods. Rainfall infiltration factor of 22% for valley fill as per norms is taken for calculation. In WLF method, specific yield has been taken as 0.16 for valley fill deposit following the norms recommended by GEC'2015. The rainfall of Tinsukia district is 1960 mm.
2) Water level data has been considered for 2019-20. Water level fluctuation based on data of May (Pre monsoon) and November (post monsoon) has been considered. The average pre- and post-monsoon water level of Tinsukia district is 3.91 mbgl and 2.75 mbgl. The average water level fluctuation is 1.16 m
3) The population figures were collected from Census, 2011and projected to 2020. The per capita domestic requirement is considered as 60 lpcd.
4) Recharge from other sources includes recharge from minor surface and ground water irrigation.

Recharge: The aquifers of the study area are recharged by rainfall. The area experiences south-east monsoon. Monsoon rainfall contributes approximately 74 percent of total rainfall (June, July, August, September) while share of post and pre monsoon rainfall are approximately 26 percent each.

Previous records show that the rainfall occurs almost in every month of a year. The month November to December has the minimum number of rainy days in any year and the period June to September has maximum number of rainy days.

The monsoon recharge of the 89590.28 ha of recharge worthy area is 371757 ham while non-monsoon recharge is 50623.41 ham. Recharge from other sources is 6076.15 ham. Total ground water recharge is 146289.84 ham.

Extraction: The agriculture in the area generally rainfed. 4% of cropped area has irrigation facilities and groundwater irrigation is nearly 96% of total irrigation. Total groundwater extraction for irrigation purpose is 4033.68 ham. Total industrial extraction is 27.25 ham. So ground water is extracted only for domestic use. Total groundwater extraction of Tinsukia district is 7067.56 ham

Allocation of resources up to 2025:

The net ground water resource is allocated for domestic use 3311.78 ham. Net available resource for future use is 108326.73 ham.

Stage of groundwater development: Groundwater is mainly utilized for domestic purposes. The stage of groundwater extraction in the district is 6.11%.

Table 4.1: shows the net groundwater availability, existing draft and stage of development for the year 2020.

Recharge worthy area Ha	Total annual GW recharge Ham	Environmental flow Ham	Annual extractable GW resource Ham (2-3)	Existing gross GW extraction for all uses Ham	Stage of GW extraction [(5/4)*100%]
1	2	3	4	5	6
371757	146290	30591	115699	7069.21	6.11%

Extraction from unconfined aquifer/deeper aquifer: Groundwater in the district is utilized for (a) irrigation, (b) drinking or domestic purposes and (c) industrial purpose.

68% of irrigation demand is met by groundwater. Groundwater is extracted by installing shallow tube wells. As per district irrigation plan of Tinsukia, there are 179 nos of tube wells (govt.), 156 nos. of bore wells (govt.), and 95 nos, of bore wells (private) in the district utilized for irrigation. A total of 91345 ha of Irrigation potential is proposed to be created under PMKSY. Thus, 54% of cultivable area would be brought under the command of assured irrigation.

The shallow tube wells tapping aquifers within 50 m depth are capable of yielding 20 – 50 m3/hr at drawdown of less than 3 m. Medium to heavy duty tube wells constructed down to 100 – 150 m depth tapping 25 – 30 m of granular zones are yielding 50 – 100 m3/hr.

In domestic sector, dug wells and hand pumps are main source of groundwater extraction. Public health Engineering Dept. supplies water through groundwater and also by surface water. Generally the groundwater extracted from shallow aquifer.

4.2. Potential resource:

(i) Shallow water table areas: Potential resource due to shallow water table areas was estimated from aquifer area where depth-to-water level was within 5mbgl. The area within depth-to-water level 0f 5mbgl is 3293 sq.km which is 87% of total area of the district. The potential resource of shallow water table areas is 43074.66ham.

(ii) Flood prone area: As per GWRE 2020, the flood prone area of the district is 74345 ha and it is considered that flood water remained in the area for at least 15days. Potential resource in flood prone area is 3122.49ham.

(iii) Total potential resource of Tinsukia district is 46197.15ham.

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

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

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

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

Where, Y = Static ground water resources,

A = Area of ground water assessment unit

Z_1 = Thickness of saturated unconfined aquifer below ground level

Z_2 = Pre-monsoon water level

Sy = Specific yield of the unconfined aquifer

Table 4.3: Salient information of static resource of Tinsukia district, Assam

Type of rock formation	Alluvium
Total Geographical Area (Ha)	379000
Assessment Area (Ha)	371757
Bottom of the unconfined aquifer (m)	45
Average Pre- monsoon Water Level (m)	3.91
Thickness of the saturated zone of the un-confined aquifer below WLF zone (m) [(5)-(6)]	41.09
Volume of Saturated zone of the unconfined aquifer below WLF zone (ham)	15275495.1

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

= 15275495.1 X 0.12= 1,833,059.41ham

CHAPTER 5.0

5.0. Groundwater Related Issues

5.1.1. Identification of issues

The main groundwater issues identified in the area are-low stage of groundwater extraction, areas under water logging and flood as well as high iron concentration, arsenic and uranium detection.

5.1.2. Low stage of groundwater extraction

Compared to vast dynamic groundwater resource of Tinsukia district, groundwater extraction for domestic, irrigation and industrial purposes is low. Vast tract of agricultural land remain fallow after harvesting of paddy only due to lack of irrigation facility. The stage of groundwater extraction is only 6 %.

5.1.3. Water logged area

Water logged areas are observed mostly in Margherita and Guijan block. The post monsoon depth-to-water level varies from 0.77 to 1.71. The pre-monsoon depth-to water level varies from 1.16 to 1.87 mbgl. Water logged area is 38970 ha. Water logged areas are found in the alluvial plain and flood plain. Occurrence of water logging conditions in the region is due to high rainfall, shallow water level and a meagre ground water draft in vast flood plains of the Brahmaputra and Dibru&Burhi-Dihing river system. Generally it is observed that water logged areas of the district in most of the blocks coincides with the flood prone areas (Fig. 5.1)

5.1.4. Area vulnerable to arsenic pollution

Arsenic is detected in some groundwater samples. However, in all the samples arsenic concentration is within permissible limit. In most cases arsenic present in water logged areas.

5.1.5. Area vulnerable to uranium pollution

Uranium is detected in some groundwater samples. However, in all the samples uranium concentration is within permissible limit.

5.1.6. Area vulnerable to iron pollution

Iron content in ground water, above permissible limit is found in some areas.

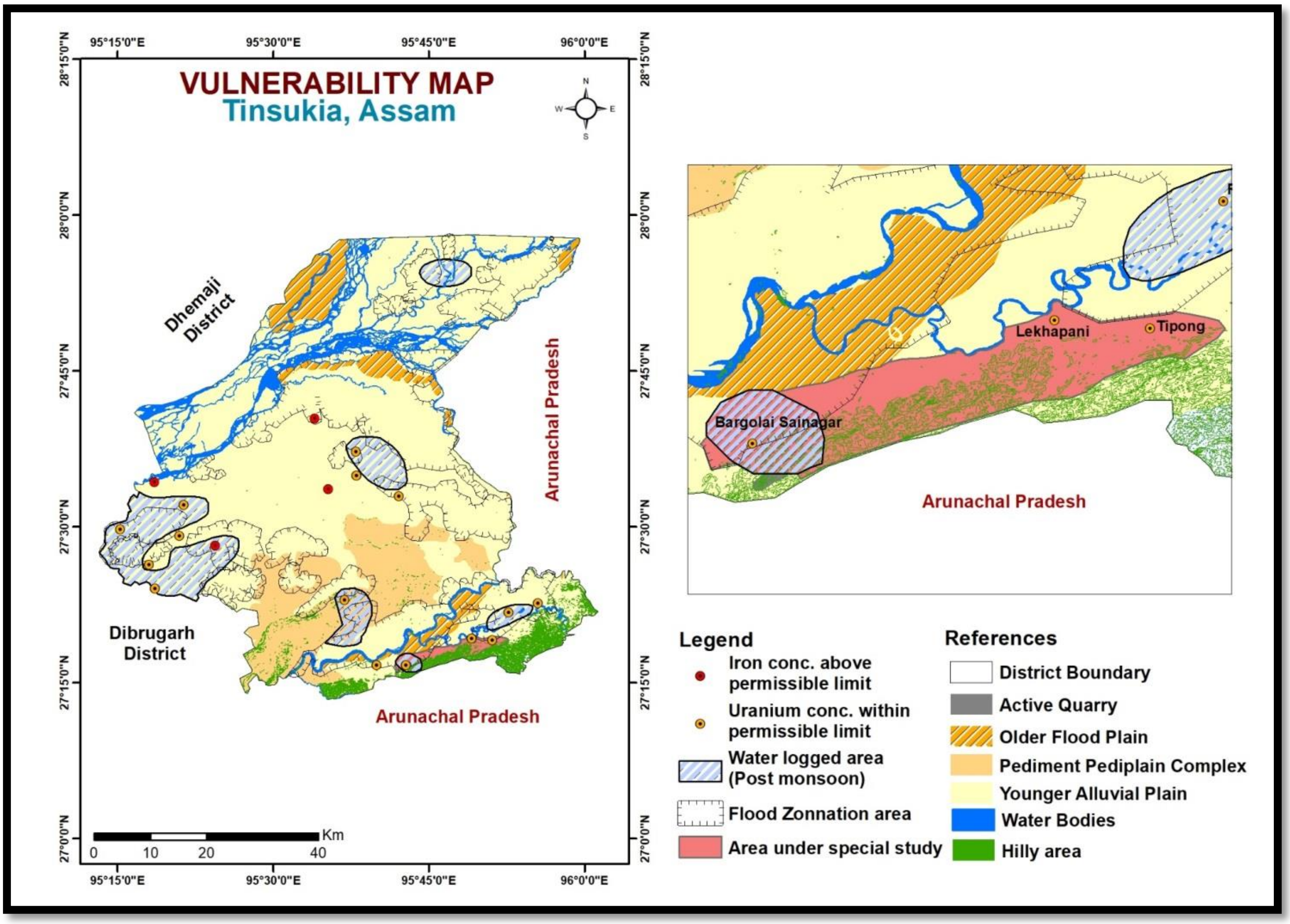

Figure 5.1. Vulnerability map of Tinsukia district, Assam.

5.2. Future demand

Future demand of ground water is analyzed for domestic purpose and for irrigation purpose.

5.2.1. Domestic purpose

The domestic requirement is worked out for projected block population and requirement is considered as 60litre per person per day. The block wise requirement up to 2025 is worked out and tabulated (Table 5.1)

5.2.2. Agriculture purpose:

Future Water demand of the district for agricultural sector is assessed by projecting cropping intensity to 200% through assured irrigation in agricultural field. As per District Irrigation Plan, 2016-20, Tinsukia, the net sown area of the district is 100931ha and area sown more than once is 22079ha. The gross cropped area of the district is 123010ha and the cropping intensity is nearly 122%. The rainfed or un-irrigated area of the district is 164964ha and net irrigated area is 4033ha. In the district, Itakhuli block has the maximum cropping intensity of 132 % only and Sadiya block has the least cropping intensity of 110 %.

The crop water requirement for unirrigated area of the district is estimated based on soil condition, flooding and geomorphic classification using FAO’s Cropwat 8.0 software following guidance of Assam Agriculture University.

Figure 5.18. Projected population and water demand for domestic purpose of the area.

Blocks	Census 2011 Population	Decadal growth	Projected Population		Projected water demand (ham)	
			2020	2025	2020	2025
Sadiya	102434	15.47	116775	125994	235	254
Saikhowa	110957	15.47	126491	136477	255	275
Kakapathar	211137	15.47	240696	259699	485	523
Hapjan	214707	15.47	244766	264090	493	532
Guijan	124113	15.47	141489	152659	285	308
Itakhuli	124263	15.47	141660	152843	285	308
Margherita	253725	15.47	289247	312082	583	629
Urban Centres	186593	15.47	212716	229509	429	462
Total			1513839	1633353	3050	3291

5.2.3. Stress Aspects of aquifer

Figure 5.19. Total water requirement for the district.

District	Drinking water requirement up to 2025 Ham	Water requirement to increase cropping intensity to 200% (Ham)	Water allocated for drinking and domestic purposes up to 2025 (Ham)	Water allocated for future use Ham
Tinsukia	3291	26363	3312	108327

5.2.4. Supply and demand gap

It is observed that drinking water allocation is sufficient to meet the future demand and it will not give additional stress in the aquifer.

The demand of groundwater in irrigation sector can sufficiently be met from future allocation of resources.

Figure 5.20. Supply and demand gap in drinking water sector.

District	Drinking water demand up to 2025 Ham	Water allocated for drinking and domestic purposes up to 2025 Ham	Gap between supply and demand Ham
Tinsukia	3291	3312	21

Figure 5.21. Supply and demand gap in irrigation.

District	Total irrigation demand Ham	Water allocated for future use Ham	Gap between supply and demand Ham
Tinsukia	4034	108327	104293

CHAPTER 6.0

6.0. Management Strategy

The groundwater regime of Tinsukia district is influenced by lithological variation and geomorphologic set up. The district can be divided into two slope classes, viz., slope >20% and slope <=20%. Areas with slope more than 20% are found in southern extremities of the district. Geomorphologically these areas include structural hills in southern, south-eastern and south-western side. Areas with slope less or equal to 20% slope include pediment pediplain, younger alluvial plain and older flood plain. Water logged areas are found in alluvial plain.

Sustainable Management Plan of Resource: Some important points have to be taken into consideration during preparation of aquifer management plan.

- From flood zonation map it becomes clear that barring the structural hills most of the area of the district is ravaged by flood.
- Stage of groundwater development in the district is just 6 % leaving vast scope for groundwater development.
- Irrigated area is still in nascent stage of 4% only and requires boasting for agricultural purpose.
- Groundwater quality data indicates that the deeper aquifer contains iron of high concentration in some pockets.

Management of resources for agricultural sector: The crop water requirement for unirrigated area of the district is estimated based on soil condition, flooding and geomorphic classification and the estimation is carried out in accordance to the suggestion of Assam Agriculture University. AAU has identified characteristics cropping sequence for different geomorphologic conditions. The cropping pattern suitable for flood prone area is shown below.

Table 6.14. Cropping pattern of un-irrigated areas of Tinsukia district

CROPPING PATTERN DATA
(File: C:\Users\water board\Desktop\Tinsukia\CROP PLAN RICE.PAT)

Cropping pattern name: TINSUKIA_RICE

No.	Crop file	Crop name	Planting date	Harvest date	Area %
1	...Data\CROPWAT\data	Rice	10/05	06/09	7
2	...Data\CROPWAT\data	Rice	25/05	21/09	12
3	...Data\CROPWAT\data	Rice	10/06	07/10	16
4	...Data\CROPWAT\data	Rice	20/06	17/10	7
5	...Data\CROPWAT\data	Rice	10/07	06/11	8
6	...Data\CROPWAT\data	Rice	16/10	12/02	2
7	...Data\CROPWAT\data	Rice	05/11	04/03	3
8	...Data\CROPWAT\data	Rice	17/11	16/03	6
9	...Data\CROPWAT\data	Rice	25/11	24/03	5
10	...a\CROPWAT\data\cr	Pulses	20/11	09/03	2
11	...ata\CROPWAT\data\	MAIZE (Grain)	25/10	26/02	2
12	...ata\CROPWAT\data\	MAIZE (Grain)	10/04	12/08	3
13	...PWAT\data\crops\F	Mustard	15/10	27/05	2
14	...PWAT\data\crops\F	Mustard	10/11	22/06	3
15	...CROPWAT\data\crop	Small Vegetables	10/10	12/01	4
16	...CROPWAT\data\crop	Small Vegetables	10/11	12/02	4
17	...CROPWAT\data\crop	Small Vegetables	10/03	12/06	3
18	...CROPWAT\data\crop	Small Vegetables	20/03	22/06	3
19	...\CROPWAT\data\cro	Potato	10/11	19/03	4
20	...\CROPWAT\data\cro	Potato	20/11	29/03	4

Cropwat 8.0 Bèta Page 1

The water demand of agricultural sector to provide assured irrigation potentiality to un-irrigated areas will be calculated using Cropwat 8.0 software of FAO. AAU suggested cropping sequence can be followed which will provide water logging affected people assured irrigation facility.

As per information, Net sown area of the district is 100930 ha and out of which 5261 ha only is under irrigation (District Irrigation Plan 2015-16). It is observed that un-irrigated area associated with kharif paddy (winter rice) is 56126 ha which is sown during summer time from May-July. For further utilization of groundwater seeing the vast scope for ground water development in the area, summer rice with area of 17960 ha is introduced taking around 30% of the area of kharif paddy. Remaining 70% area of kharif paddy will be used for other crops like winter vegetables, summer vegetables, potato, pulse, maize, and oil seed.

A management plan has been prepared for un-irrigated crop land based on cropping pattern suggested by Assam Agriculture University (Table 6.2)

Table 6.15. Water requirement for un-irrigated areas of Tinsukia district

Winter Rice -Summer Rice--Winter Rice	Present Cultivated area **(ha)**	Area to be cultivated **(%)**	Area to be cultivated **(ha)**	Irrigation requirement **(ha m)**
Winter Vegetables-Summer Vegetables-Pulses--Potato-Oilseed				
Cultivated Area	56126			
	1	2 (= % of 1)	3	4
Rice (main crop)	56126		56126	
Winter Rice	56126	50	56126.0	9169.6
Summer Rice		16	17960.4	6356.1
Winter Vegetables		8	8980.2	786.5
Maize		5	5612.6	216.3
Pulse		2	2245.0	159.1
Potato		8	8980.2	828.6
Oilseed		5	5612.6	869.1
Summer Vegetables		6	6735.1	68.8
		50		18454.1
Net cultivated area	56126			
Gross cultivated area (Paddy/+ Maize/+ Pulses+ oilseed + vegetables)	112252			
Total irrigation requirement (70% irrigation efficiency)				**26362.95**
Cropping Intensity	**200% (Intended)**			

Sowing season of winter rice is October-November and can be harvested during summer season. Winter rice sowing month is fixed as May-July depending upon cessation of flood water from the crop land. If flood water retains in paddy field during July and August then the winter rice may not be cultivated, instead other crops like vegetables, wheat, pulses and potato can be cultivated with assured irrigation facilities provided by construction of tube wells.

Table 6.3. Precipitation deficiency

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Precipitation deficit												
1. Rice	0	0	0	48.9	98	0	0	0	0	0	0	0
2. Rice	0	0	0	0	197.3	0	0	0	3.2	0	0	0
3. Rice	0	0	0	0	49.5	98	0	0	0	0	0	0
4. Rice	0	0	0	0	48.4	98	0	0	0	0	0	0
5. Rice	0	0	0	0	0	48.8	98	0	0	6.5	8.1	0
6. Rice	37.8	13.2	0	0	0	0	0	0	48.8	160	54.4	47.9
7. Rice	39.5	22.3	0.7	0	0	0	0	0	0	154.5	105.8	47.5
8. Rice	39.5	25.5	16	0	0	0	0	0	0	49.7	208.9	47
9. Rice	39.4	26.6	18.8	0	0	0	0	0	0	0	246.7	46.8
10. Pulses	38.8	22	0	0	0	0	0	0	0	0	4.1	16.1
11. MAIZE (Grain)	41.8	6.5	0	0	0	0	0	0	0	0	11.3	43.1
12. MAIZE (Grain)	0	0	0	1.1	0	0	0	2.6	0	0	0	0
13. Mustard	28	13.6	14	0	0	0	0	0	0	0	29.9	36.2
14. Mustard	28	13.6	14	0	0	2.8	0	0	0	0	11	30.1
15. Small Vegetables	13.9	0	0	0	0	0	0	0	0	2.2	38.4	42.5
16. Small Vegetables	34.2	12.4	0	0	0	0	0	0	0	0	23	33.6
17. Small Vegetables	0	0	2.1	0	0	6.5	0	0	0	0	0	0
18. Small Vegetables	0	0	2.4	0	0	6.5	0	0	0	0	0	0
19. Potato	39.8	25	5.3	0	0	0	0	0	0	0	13.3	25.5
20. Potato	36.9	27.3	14.7	0	0	0	0	0	0	0	6.6	16.5

Table 16. Actual monthly requirement (Ham) for different crops for unirrigated area

Crop	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Crop wise Total IWR (Ham)
Winter Rice	0.0	0.0	0.0	356.8	715.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1071.8
Winter Rice	0.0	0.0	0.0	0.0	2879.2	0.0	0.0	0.0	46.7	0.0	0.0	0.0	2925.9
Winter Rice	0.0	0.0	0.0	0.0	902.9	1787.6	0.0	0.0	0.0	0.0	0.0	0.0	2690.5
Winter Rice	0.0	0.0	0.0	0.0	353.1	715.0	0.0	0.0	0.0	0.0	0.0	0.0	1068.2
Winter Rice	0.0	0.0	0.0	0.0	0.0	427.3	858.1	0.0	0.0	56.9	70.9	0.0	1413.2
Summer Rice	82.7	28.9	0.0	0.0	0.0	0.0	0.0	0.0	106.8	350.2	119.1	104.8	792.6
Summer Rice	86.5	48.8	1.5	0.0	0.0	0.0	0.0	0.0	0.0	338.2	231.6	104.0	810.6
Summer Rice	288.2	186.1	116.7	0.0	0.0	0.0	0.0	0.0	0.0	362.6	1524.2	342.9	2820.8
Summer Rice	201.2	135.9	96.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1260.0	239.0	1932.2
Pulse	76.2	43.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.1	31.6	159.1
Maize	82.1	12.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	22.2	84.7	201.7
Maize	0.0	0.0	0.0	4.3	0.0	0.0	0.0	10.2	0.0	0.0	0.0	0.0	14.5
Oil seed	110.0	53.4	55.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	117.5	142.2	**478.1**
Oil seed	110.0	53.4	55.0	0.0	0.0	11.0	0.0	0.0	0.0	0.0	43.2	118.3	390.9

Winter Vegetables	54.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.6	150.9	167.0	381.1
Winter Vegetables	134.4	48.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	90.4	132.0	**405.5**
Summer Vegetables	0.0	0.0	8.3	0.0	0.0	25.5	0.0	0.0	0.0	0.0	0.0	0.0	33.8
Summer Vegetables	0.0	0.0	9.4	0.0	0.0	25.5	0.0	0.0	0.0	0.0	0.0	0.0	35.0
Potato	156.4	98.2	20.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	52.3	100.2	427.8
Potato	145.0	107.3	57.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.9	64.8	400.7
Total	**1527.3**	**816.7**	**420.6**	**361.1**	**4850.3**	**2992.0**	**858.1**	**10.2**	**153.5**	**1116.6**	**3716.2**	**1631.6**	**18454.1**
Gross Irr. Req. (70% Irr. Eff.)	**2181.9**	**1166.7**	**600.8**	**515.9**	**6929.0**	**4274.3**	**1225.8**	**14.6**	**219.3**	**1595.1**	**5308.8**	**2330.8**	**26362.9**

Total unirrigated area of the district is 164963 ha and out of which 56126 ha is kharif paddy. Total water requirement to bring the un-irrigated area of the district and water availability for future use are summarized in Table: 6.5

Table 6.5:

Table 6.5.Summarised results of water requirement.

Area	Net Cultivated area (Ha)	Irrigation water requirement (Ham)	Water allocated for future use (Ham)
Kharif paddy	56126	26363	108327

No. of days requiring irrigation has been determined on the basis of precipitation deficit in respective months, summarised in Table 6.6

Table 6.6. Rainfall deficit and Irrigation requirement in the months of Nov-Dec and Jan-March

Month Interval	Area to be cultivated (Ha)	Rainfall deficit (in mm)	Irrigation Requirement (in ham)
Nov- Dec	34798	1194	5348
Jan -March	6735	714	3949

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

Discharge of the tube wells constructed by CGWB tapping 15 to 35m of the sub unit 1 of the older alluvial aquifer varies from 19.70 to 150 m3/hr. It is expected that tube wells of 50m depth tapping 15 to 30m of granular zones of the sub unit 1 of the older alluvial aquifer can yield 30 to 60 m3/hr. If the well is allowed to run 8 hrs a day for 150 days then a tube well having discharge of 45 m3/hr will extract 5.4 ham groundwater annually.

Total numbers of shallow tube wells require to construct in the district to fulfil the irrigation requirement of 26363 ham, is found to be 4882 nos. On the other hand consideration of safe distance of 200m permits to construct 14032 nos.

Extraction of 26363 ham of groundwater will increase the stage of groundwater extraction to 29%. Potential resource of the district is 46197.15 ham.

Sustainable management plan should take care to increase recharge of rain water artificially. Increase recharge will fill the aquifer as well as lower surface run-off and soil erosion.

6.2 Demand side management:

Demand side management implies sustainable management of water. In irrigation and in drinking water supply also sufficient quantity of water loss occurs.

Water use efficiency should be high in all sectors particularly in the irrigation sector. Loss in irrigation water will increase water logged area.

Irrigation efficiency can be increased by

- reducing convenience loss
- improving water application efficiency

Following demand side interventions will increase water use efficiency

- Use of water efficient irrigation method: Drip and sprinkler irrigation methods are very useful in saving water. Both of them save conveyance losses and improve water application efficiency by applying water near the root-zone of the plant. Drip systems convey water in small quantities through drippers/micro-tubes while sprinklers are pressurized systems where a fountain or spray of water is released by the sprinkler connected by pipes, resulting in foliar irrigation. Drip irrigation can increase crop yield per hectare and also saves water up to 70% than conventional irrigation.
- Water loss through supply canals can be minimized by proper lining in the canals.
- Adopting water saving rice irrigation: In this method instead of submerging the paddy field for longer duration, the rice field have to provide water through irrigation only after a certain number of days when the ponded water disappears. This technology is known as alternate wetting and drying (AWD) irrigation. With the optimal management, this technology reduces the amount of water required by about 25% without reduction in yields.

Therefore, groundwater resource of the district is sufficient to meet drinking water demand and also irrigation and other industrial demands under different condition.

Following recommendations are suggested

- Water distribution mechanism should minimize water loss by using lining distribution canals. Locally available materials are to be preferred as these materials are cheap and eco-friendly.
- Conservation of rain water in the up dip of cultivated field. During rabi season the conserved water can be drained to paddy field through gravity.

- In some pockets iron content is very high. The sources of iron pollution in deeper aquifer can be attributed to geogenic origin. It needs removal before human consumption.

Rain water harvesting in the technique collection and storage of rainwater at surface or in sub-surface aquifer, before it is lost as surface runoff further aggravating water logging condition. Therefore, existing and abandoned dug wells may be utilized as recharge structure after cleaning