केंद्रीय भूमि जल बोर्ड

जल संसाधन, नदी विकास और गंगा संरक्षण

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भारत सरकार

Central Ground Water Board

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

AQUIFER MAPPING AND MANAGEMENT OF GROUND WATER RESOURCES

TIRAP DISTRICT, ARUNACHAL PRADESH

उत्तर पूर्वी क्षेत्र, गुवाहाटी

North Eastern Region, Guwahati

MINISTRY OF JAL SHAKTI

जल शक्ति मंत्रालय

Department of Water Resources, River Development and Ganga Rejuvenation

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GOVERNMENT OF INDIA

भारतसरकार

(AAP 2022-2023)

By

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REPORT ON AQUIFER MAPPING AND MANAGEMENT PLAN OF **TIRAP DISTRICT, ASSAM**

ANNUAL ACTION PLAN, 2022-23

NORTH EASTERN REGION

उत्तर पूर्वी क्षेत्र

GUWAHATI

गुवाहाटी

March 2023

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CHAPTER-1.0

INTRODUCTION

Central Ground Water Board, North Eastern Region has carried out Aquifer mapping and management plan in Tirap district, Arunachal Pradesh as per the Annual Action Plan 2022-23 and the area covered is 130 sq.km. Under National Aquifer Mapping and Management (NAQUIM) program, combination of geologic, hydrologic and hydrochemical information is applied to characterize the quantity, quality and sustainability of ground water aquifers. Systematic aquifer mapping will improve our understanding of the geologic framework of aquifers, their hydrogeologic characteristics, quality and also quantifying the available ground water resources potential and proposing plans appropriate to the scale of demand and the institutional arrangements for management. Aquifer mapping at the appropriate scale can help to prepare, implement and monitor the efficacy of various management interventions aimed at long-term sustainability of our precious ground water resources, which, in turn, will help achieve drinking water security, improved irrigation facilities and sustainability in water resources development.

1.1 Objectives

The objectives of this project are to understand the aquifer systems up to 200 m depth, to define the aquifer geometry, type of aquifers, ground water regime behaviors, hydraulic characteristics and to establish groundwater quantity, quality, and sustainability, and to estimate the dynamic and static resources accurately through a multidisciplinary scientific approach on 1:50,000 scale and finally formulate a complete, sustainable and effective management plan for ground water development.

1.2 Scope of the study

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

4. **Data Compilation & Data Gap Analysis:**

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

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

Aquifer Map Preparation: On the basis of integration of data generated from variousstudies of hydrogeology, aquifers have been delineated and characterized in terms of quality and potential. Various maps have been prepared bringing out characterization of Aquifers, which can be termed as Aquifer maps providing spatial variation (lateral & vertical) in reference to aquifer extremities, quality, water level, potential and vulnerability (quality & quantity).

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

1.3 Approach and Methodology

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

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

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

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

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

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

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

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

1.4 Area Details

The mountainous Tirap district of Arunachal Pradesh has a geographical area of 2362 sq k.m. The district is located within N. Latitudes 26˚38′ to 27˚47′ and E. Longitude 95˚40′. The study area is located within N. Latitudes 26˚57′8.2584” to 27˚15′51.90” and E. Longitude 95˚11′31.35” to 95˚38′15.32”. The district is having a mappable area of 125 sq.km. District area falls partly or fully in the quadrants of Survey of India Toposheets bearing nos. 83M/7, 83M/8, 83M/11, 83M/12 and 83N/5, 83N/9. The district lies in the southern side of the Brahmaputra River and in the southern part of the state. Northern part of the district is bounded by Sibsagar district of Assam, eastern side by Changlang district of Arunachal Pradesh, western part by Mon district of Nagaland and southern side by Myanmar. Khonsa, the headquarters of Tirap district is approachable from both Tinsukia (120km) and Dibrugarh (125km) town of Assam. The district is divided into 4 administrative sub-divisions which are further divided into 6 blocks (Khonsa, Deomali, Lazu, Niausa, Pongchau Wakka, Kanubari). Total population of the district is 111,997 as per Census 2011. The decadal growth rate (2001-2011) is 11.63% and population density is 47 per sq.km. and bounded by Sivsagar district in the East, Nagaland in the south, Golaghat district in the West and Lakhimpur district in North.

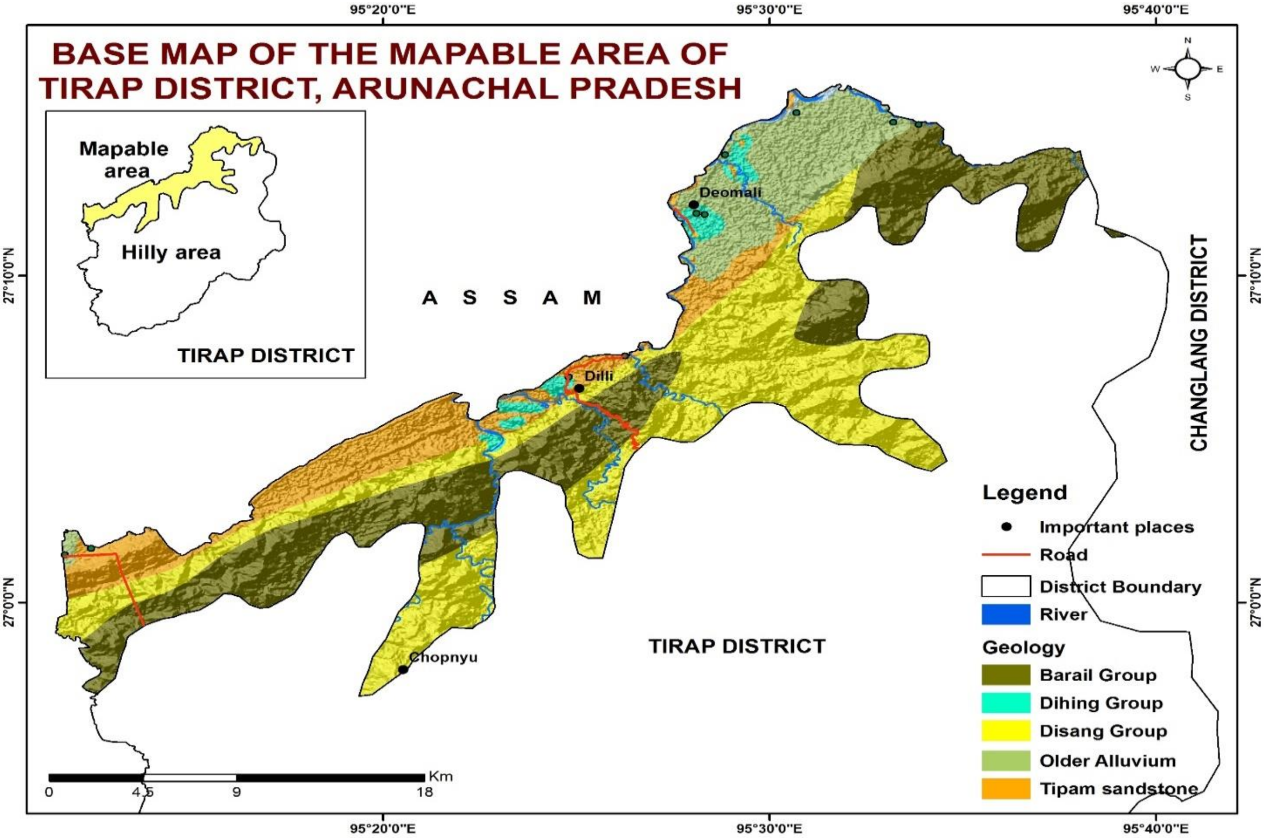


Figure 1.1: Index Map of Study Area

1.5 Administrative set up of the study area

Tirap district was one of the oldest district of Arunachal Pradesh which was formed during the British time. Later on, the erstwhile Tirap district was bifurcated to form Changlang district in the year 1987. Tirap was again bifurcated to create a new district named Longding. The present district consists of seven CD Blocks, Eleven circles and three towns. There are four Arunachal Pradesh Legislative Assembly constituencies located in Tirap district- Namsang, Khonsa-East, Khonsa-West, and Borduria-Bogapani. The number of Villages in Tirap district is 118.

Table 1.1: List of circles, CD blocks and major towns of Tirap, Arunachal Pradesh.

Circles	CD Blocks	Towns
i. Khonsa	i) Khonsa	i) Namsang
ii. Longding	ii) Namsang	ii) Khonsa
iii. Pangchao	iii) Kanubari	iii) Longding
iv. Namsang	iv) Niausa	
v. Wakka	v) Pangchao	
vi. Laju	vi) Wakka	
vii. Kanubari	vii) Laju	
viii. Dadam		
ix. Lawnu		

x. Pumao xi. Soha		

Data Source- Census 2011

1.6 Rainfall and Climate

The average annual rainfall recorded from 2017 to 2021 in Tirap district is 1922.76 mm. Rainfall during January to April contributes nearly 15.32 % to the total rainfall whereas the rainy season which commences from May and continues up to September contributes 77.40%. October to December rainfall makes up the rest. December receives least rainfall and maximumrainfall occurs during June. The climate of the district varies from place to place due to its diverse topography.It is largely influence by the elevation and terrain of a place. The climate condition ranges from hot and humid in the lower belt plain portion bordering Assam like Kanubari and Deomali in summer and to cold in winter. The places like Laju, Pongchao and Wakka on the hills have mountain type of climate. The climate of Khonsa, the district headquarters, is moderate and pleasant.Winter season starts from the later part of November to February. Pre-monsoon season starts from March to May. Thunderstorm is frequent during pre-monsoon period. Very heavy and frequent monsoon showers continue from May to middle of September. The average maximum and minimum temperature is 32°C and 25°C during summer and 23° C and 10°C during winter respectively.

Table 1.2: Rainfall variations of Tirap district from 2017 -2021

Year	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2017	1.58	59	120.17	252.01	236.56	230.96	329.59	335.55	223.55	185.6	11.07	0.73
2018	15.4	71.7	190.84	119.71	237.65	368.38	328.06	210.85	202.44	60.99	17.02	27.13
2019	16.33	65.68	112.43	142.35	487.1	323.57	454.7	171.16	291.11	102.06	13.04	9.61
2020	40.27	14.88	37.1	116.04	281.44	530.08	263.96	352.15	292.82	156.18	46.68	0
2021	10.28	3.9	28.29	55.49	327.89	278	247.5	336.05	100.53	50.82	6.37	11.42
Monthly Average	16.772	43.032	97.766	137.12	314.13	346.198	324.762	281.152	222.09	111.13	18.836	9.778

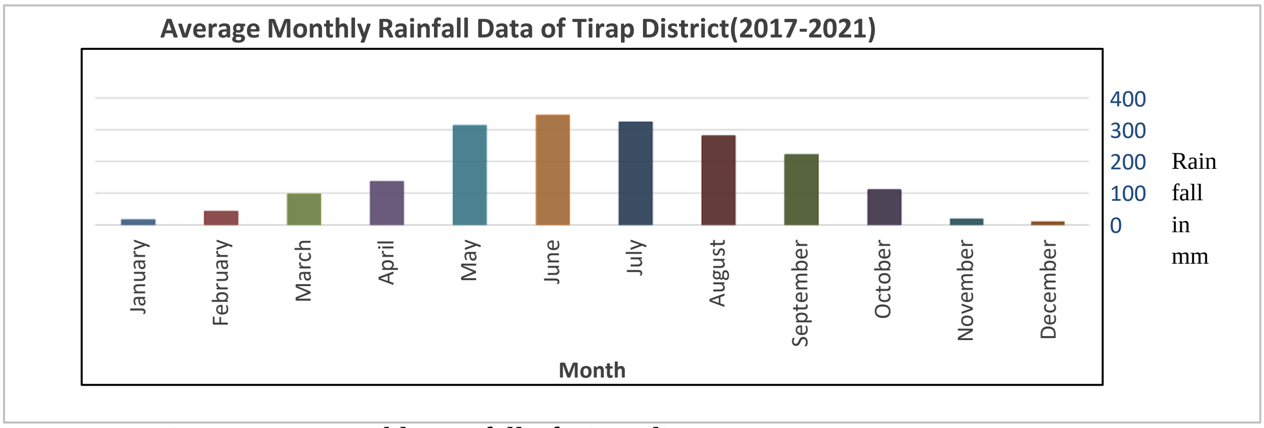


Figure 1.2: Average monthly rainfall of Tirap district

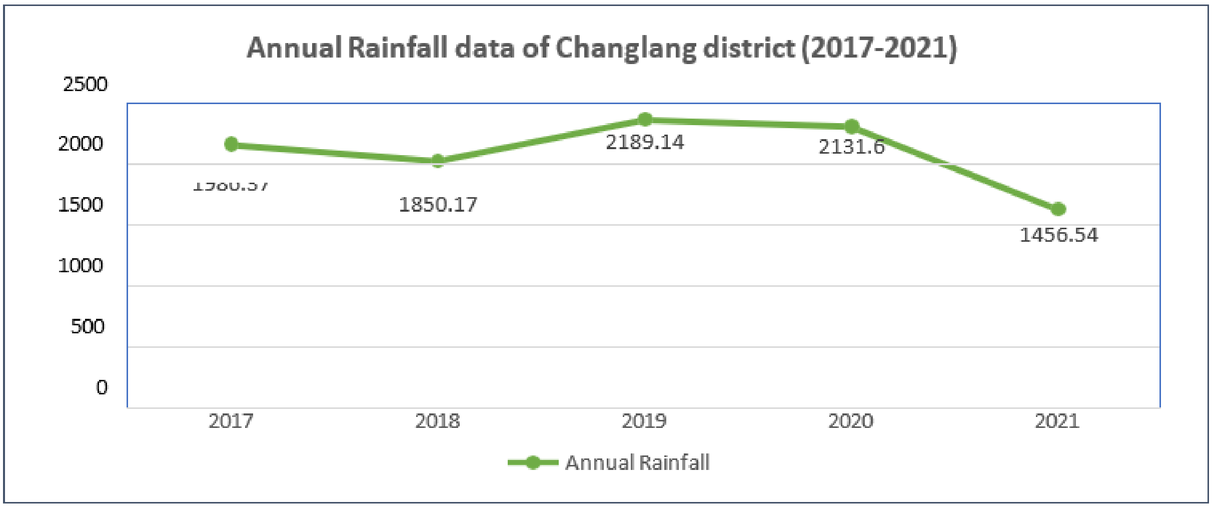


Figure 1.3: Annual rainfall variations of Tirap district.

1.7 Physiographic set up

The district is predominantly hilly and the altitude varies from 500 metres above sea level to 4615 metres above sea level in the north eastern part of the district. Main rivers are Tirap, Tissa, Tissing and Chatju. The district headquarter of Khonsa is about 1278 metres above sea level. The topography of the district ranges from gentle slopes in the lower elevations to difficult and steep slopes in the upper reaches with almost no extensive rolling plains.

The foothills are adjacent to the plains of Assam and Changlang district of comprising the paddy growing area of district along the stretches of plain land like Namsang Block. The middle range comprises of thick forest areas and has low stretches of plains and valleys. Presently efforts are on to convert as far as practicable the major portion of such land in to terraced cultivable field. The proposed area fall within Namsang block. Higher reaches of Namsang Block are hill covered with dense forests which are permanent source of forest products. The district has the following regions on the basis of its physiography.

(i)Namchik-Tirap River Valley (ii) Namsang-Dirak River Valley (iii) Tissa River Valley

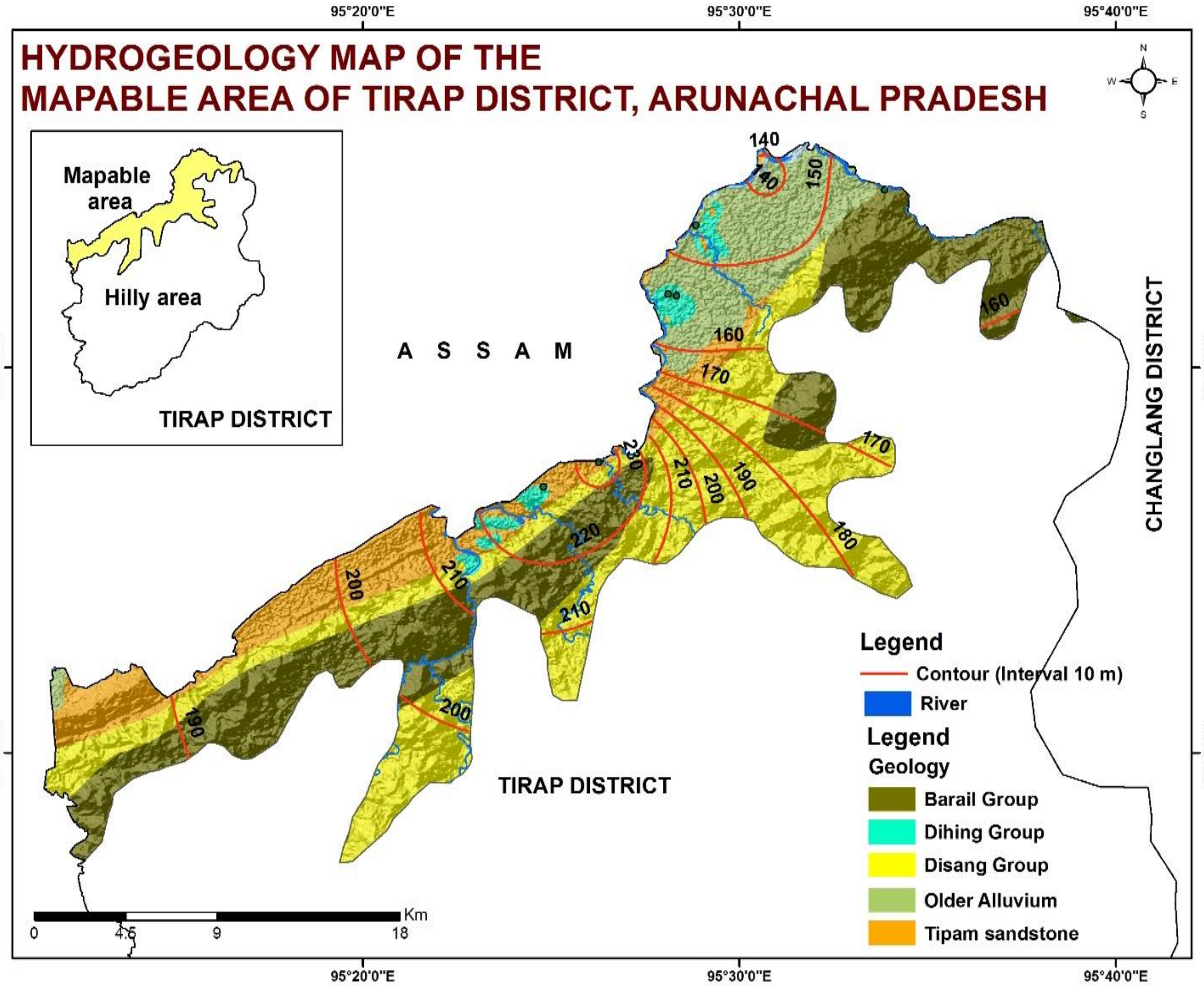


Fig 1.4: Hydrogeology map of Tirap district

1.8 Geology

The district is covered by alluvium deposited by the river Brahmaputra and its tributaries. The Tertiary and Quaternary sediments of the Naga-Patkoi belt extend north-eastward in Changlang and Tirap districts of south-eastern Arunachal Pradesh. Namdhapa Crystalline Complex: This crystalline complex occupies the highest tectonic level. The main lithological variant of this package is a well foliated, mesocratic, biotite granitoid gneiss that is divisible into three textural types' viz. augen gneiss, homophanous gneiss and streaky gneiss. Among these, augen gneiss forms the dominant constituent, banded gneiss is rare. In some localities, particularly in Laboi Hka, profuse developments of migmatites are found. The dominant migmatitic structures in these zones can be termed as phlebitic (vein type injection gneiss), stromatic (banded gneiss),schlierric and nebulitic (in the diatextits of the migmatitic zones).

Amphibolite and mica schist are present as enclaves. This litho-package is frequently traversed by late phase leucocratic and pegmatitic granite veins. This late phase activity is particularly prevalent along the sole of this litho-package. The area comprises of various rock types belonging to Alluvium, Disang, Barail, Tipam and Dihing group which is interrupted with the presence of Unconfirmity.

The Barail group consists mainly of Sandstone, shale, Siltstone, clay and coal seams. The Dihing Group comprises of Pebbles, Conglomerate, Sandstone and Tipam group consists of sandstone, shale and clay. The other group like Disang consist of shale, quartzitic sandstone and siltsone.

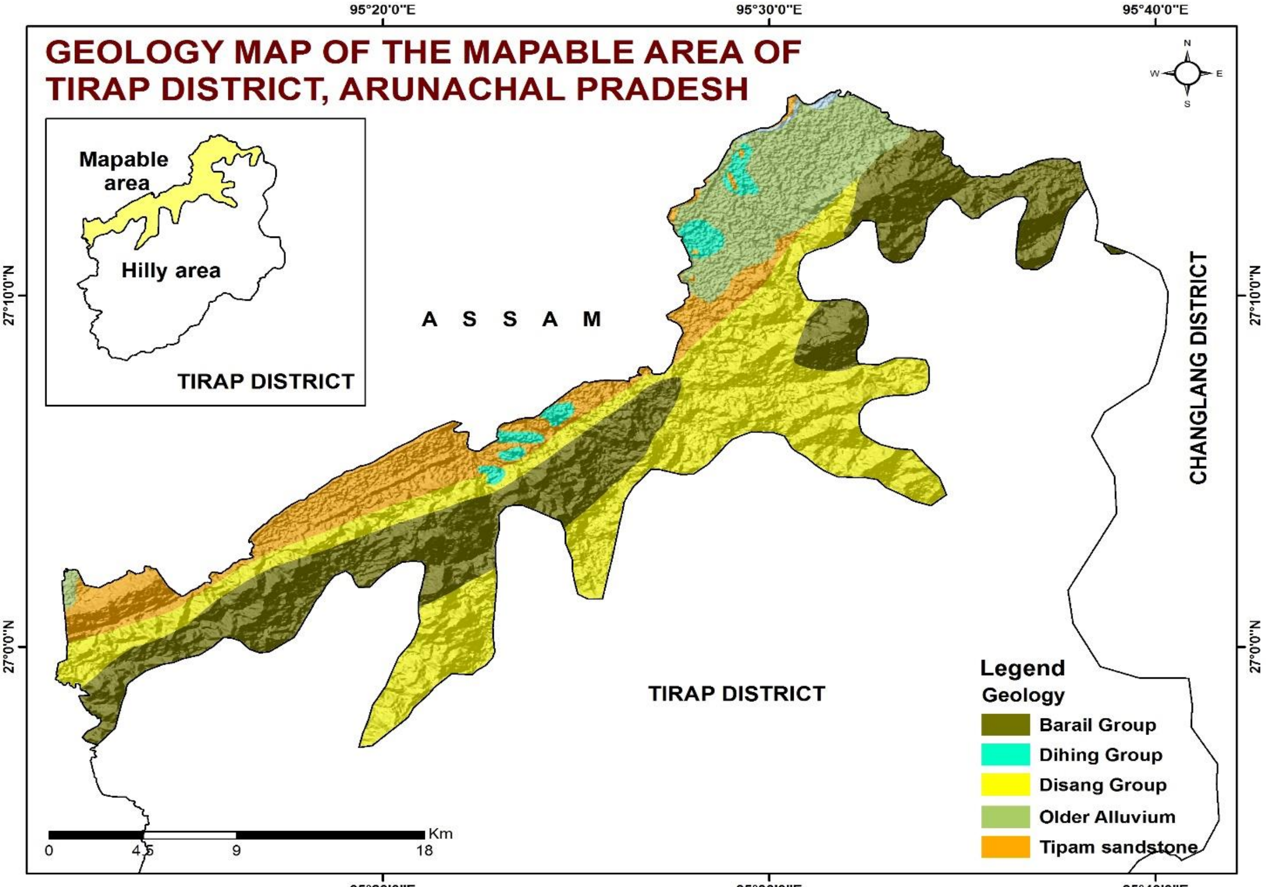


Fig 1.5: Geological map of Study area, Tirap.

1.9 Geomorphologic Features and Landforms

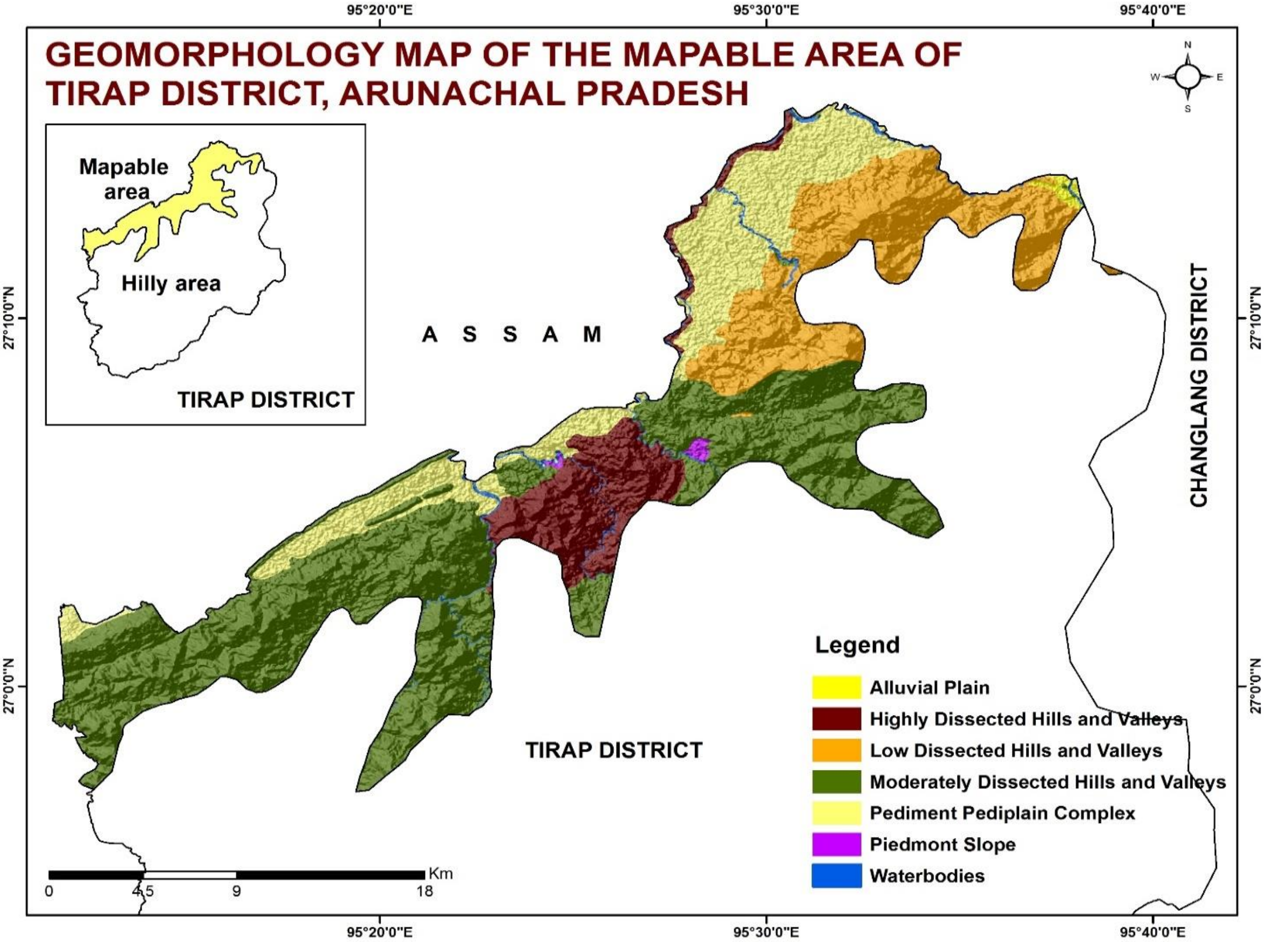


Fig 1.6: Geomorphological Map of Tirap District, Arunachal Pradesh.

The area has three distinct hydrogeomorphic units:

i) Denudostructural hills: Occupy 90% of the area comprising Barail and Disang formations. Lithologically both the formations comprise shales, compact sandstones and siltstones. This unit represents a high runoff zone and has little importance from ground water development point of view.

ii) Linear ridges: Exposures of Tipam sand stone group in the form of linear ridges are found in the north-western part of the district. This hydrogeomorphic unit comprises sanstone, shales and clay and represents a good source for ground water.

iii)

Valleys: Alluvium of the river Namsang in the north-western part of the district occurs as valleys. This hydrogeomorphic unit is also of importance from ground water development point of view

1.10 Slope-

The area is dominantly under more than 20% slope. The area covered under less than 20% slope of the mappable area of 125 sq. km is 47.5 sq. km and more than 20% is 77.5 sq.km

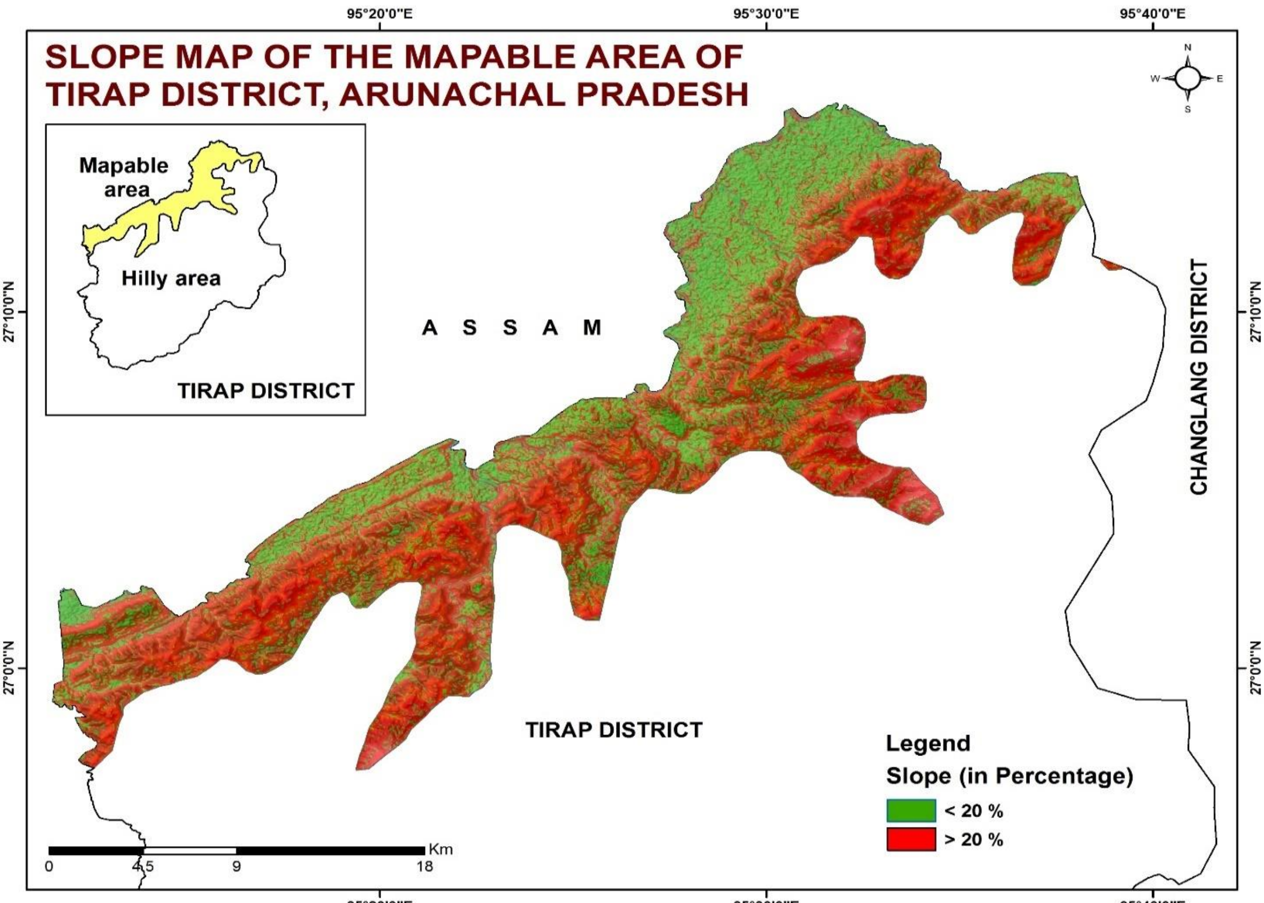


Figure 1.7: Slope Map of Tirap District, Arunachal Pradesh

1.11 Land use Pattern

Majority of the area in Tirap district falls under forest area, which is not easily cultivable. The high slope area of the district makes it difficult for cultivation. The total geographical area of the district is 2362 Sq. Km.

Table 1.3: Land Use Pattern in Tirap District

Sl. No.	Land put to different uses	Area in hectares
1	Total Geographical area	236200
2	Forest area	17830
3	Land not available for cultivation	153
a	Land put to non-agriculture uses	98
b	Barren and un-cultural land	55
4	Other non-cultivated land excluding fallow land	2663
a	Permanent pastures and other grazing land	377

b	Land under misc, trees, groves etc. not included in net area	1078
c	Cultivable waste land	1208
5	Fallow land	2807
a	Fallow other than current fallow	2189
b	Current fallow	618
6	Net area sown	1349
7	Total cropped area	1545

Source: 2011-12 Stats Directorate of Economics and Statistics, Ministry of Agriculture, Govt. of India

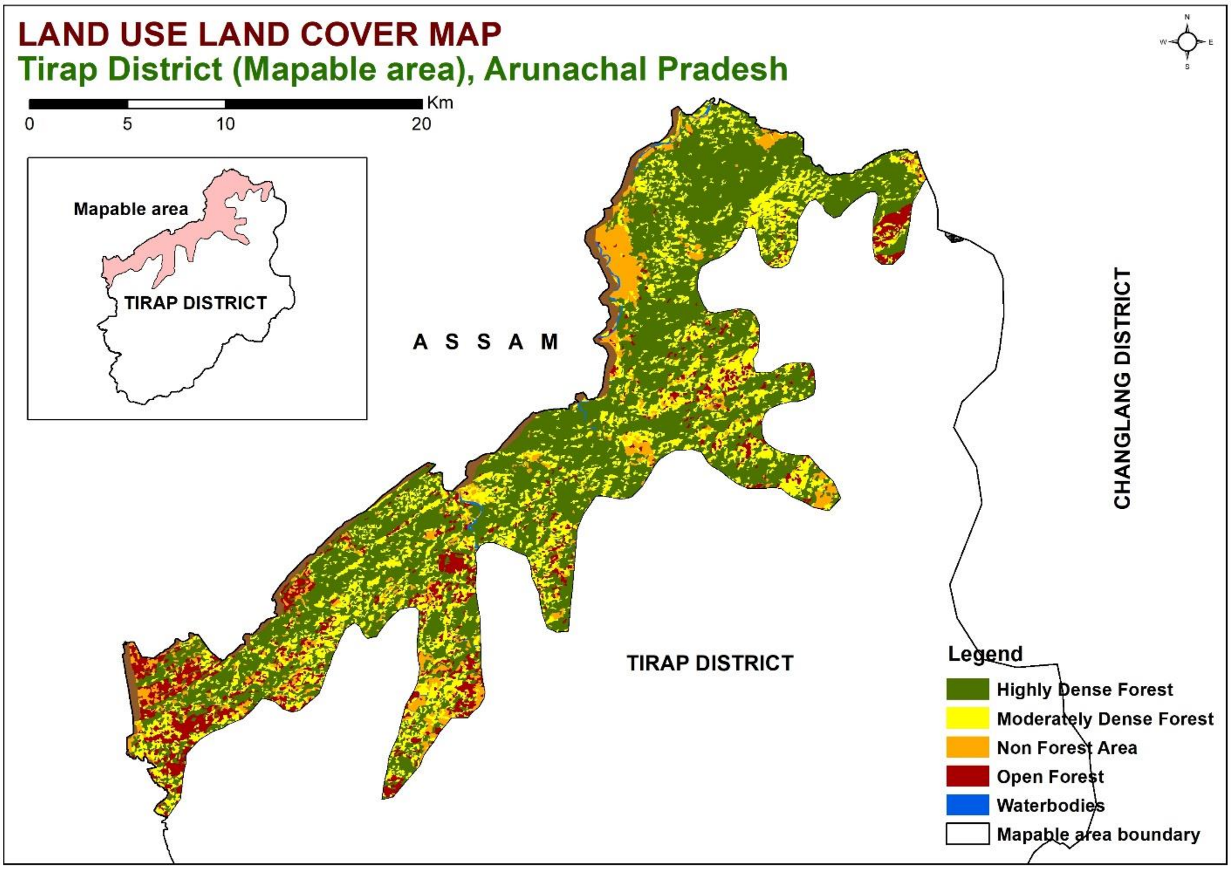


Fig 1.8: Land use Map of Tirap District.

1.12 Soil

Soil in the district is highly acidic due to heavy rainfall. Soil in the hilly regions contains high humus and nitrogen due to existence of forest cover. Large areas of Namsang Block have this type of soil. Soil in the foot hill is alluvial in nature and either loamy or sandy loam mixed with pebbles brought down by rain from higher altitude. Soil in the valley is silt clayey alluvium and rich in organic contains. In general, the soil of the district is suitable for growing paddy, jute, wheat, mustard, sugarcane, tea, coffee, pulses and vegetables. The Coffee Board of India have tested the soil in Deomali area and found the soil most suitable for coffee plantations and best coffee can be produced in this area.

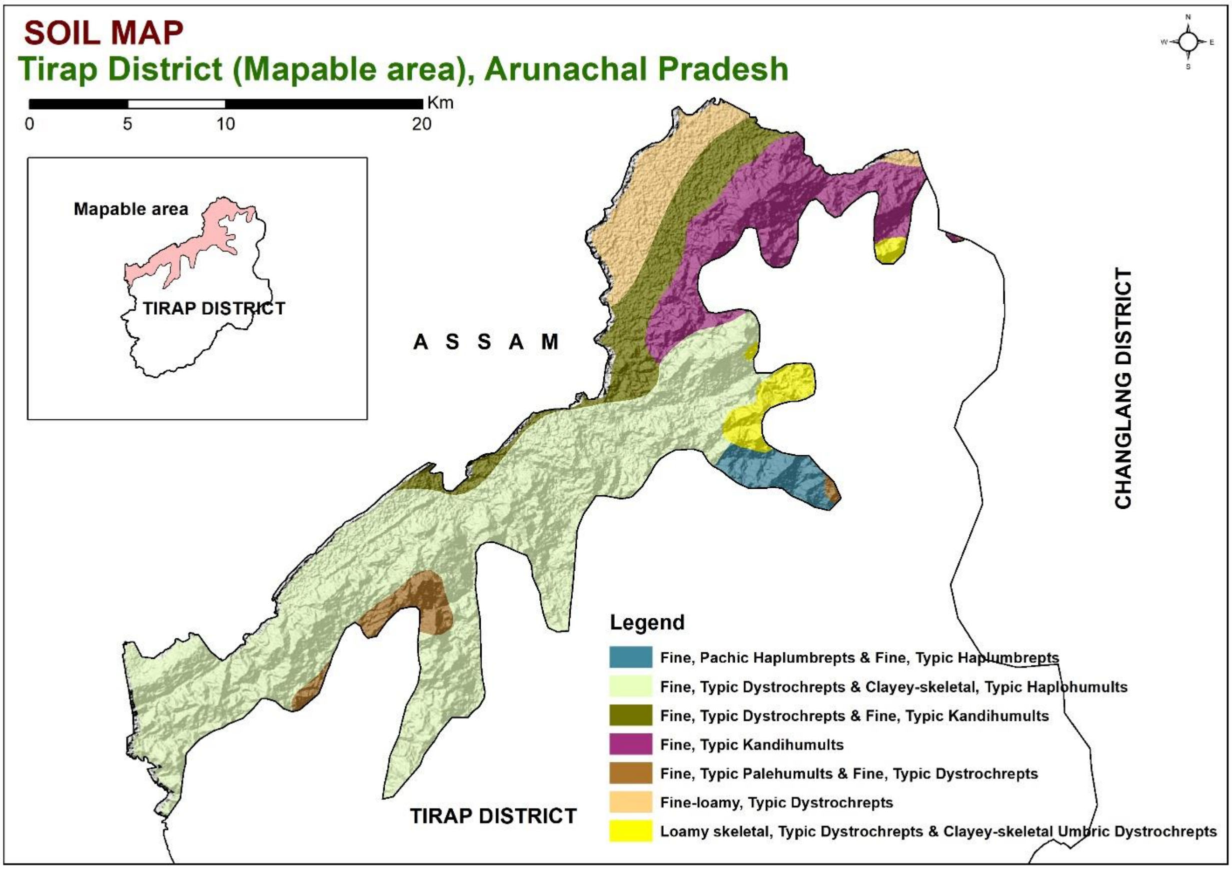


Fig 1.9: Soil Map of Tirap District, Arunachal Pradesh

1.13 Hydrology and Drainage

The natural drainage system in the district run from the East to the West and ultimately falls into the mighty Brahmaputra. The "Tirap" is the principal river of the district which flows through the main land starting from the west to north until it falls in to the Buri-Dihang river near Ledo of Assam while other rivers like Tissa, Tissingju, Tewai and Tekan, Charju etc. flow into Brahmaputra. Tirap district is a part of the Tirap basin. Namsung is the major river of the district. It flows into Buri Dihing forming a natural boundary of some length between the district of Tirap and the state of Assam. Other important rivers of the district are Tissa, Chetum, Tirat, Dirok, Chatjo and Borap. Drainage pattern is dendritic- sub-dendritic to sub- parallel.

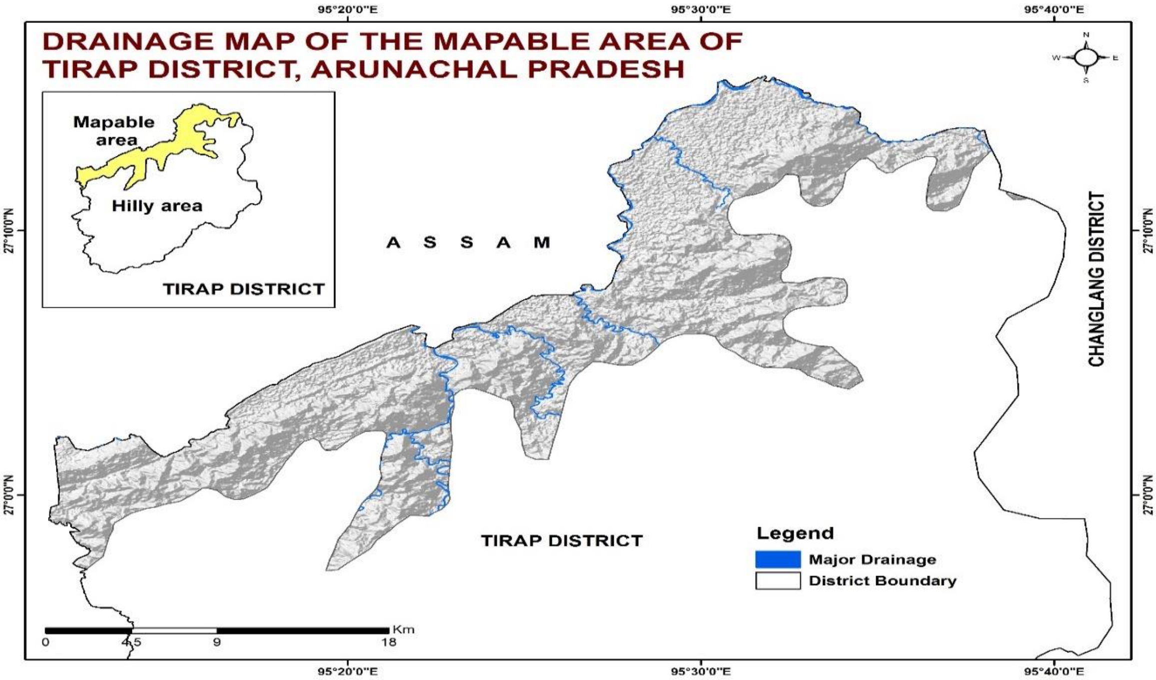


Figure 10: Drainage Map of Study area, Arunachal Pradesh

1.14 Agriculture and Plantation

Agriculture is the main stay of the population of the district. About 90 percent of the population of the district are engaged in agriculture and allied activities for their livelihood. Although agriculture is the main occupation of the villagers, it is of a subsistence nature only. The soils of the district are fertile and suitable for cultivation but due to non-availabilityof flat lands, people generally follow the traditional method of jhum cultivation and only a minor section in the lower area is engaged in permanent cultivation. Majority of the famers are engaged in cultivation of Paddy, Maize, and Millet. Along with paddy, Maize also forms a substantial part of the staple food in the district. A combination of Paddy and Maize is taken as a regular food item by the tribal population of the district. Among the horticultural crop Orange, Pineapple, Banana are grown in the district. Vegetable are also grown in the district, which includes tapioca, colocasia, ginger, pea, Chilli, Potato are the main crops. The ginger grown in the district is of very good quality. Tirap district also have a history of Tea cultivation. Adjacent to the border of Assam, the area under the district is suitable for tea cultivation.

CHAPTER- 2.0

DATA COLLECTION AND GENERATION

2.1 Hydrogeological data

The entire study area is covered by regular monitoring of 03 nos. of GWMS and another 08 wells have been established. All the water level data were collected and the wells are monitored periodically.

2.2 Exploration data

CGWB has constructed 02 nos of exploratory wells and 01 observatory well in this area earlier and during current annual action plan (2022-2023), no exploration well has been constructed.

2.3 Meteorological Data

Meteorological data is collected from accessed free data of WRIS IMD.

2.4 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 Tirap District for 2016-21 prepared by NABCONS under PMKSY.

2.5 Data Generation:

Water level data: 08 nos of key wells have been established to fill up the data gap. All these wells are under periodic monitoring after establishment.

Table 2.1: Key wells location details

Name of Village/Site	**Latitude**	**Longitude**	**Establishment date**	**RL (ma msl)**	**Total depth of Pz/Dw (mbgl)**	**Type (DW/Pz/Spring)**	**Aquifer group**	**Measurement point (magl)**	**Source/ Agency**
Dirok chk gate	27.24382	95.56433	Established Well	159	7.62	DW	Alluvium	2.43	Private
Namsangmukh	27.24979	95.51154	Established Well	143	9.75	DW	Alluvium	6.51	Private
Namsangmukh	27.24979	95.51154	Established Well	143	>30m	TW	Alluvium	4.54	Private
Cofffee board	27.22838	95.48075	Established Well	145	8.21	DW	Alluvium	4.45	Private
Deomali	27.19853	95.46844	NHNS	156	9.18	DW	Alluvium	2.69	Private
Borduria	27.11519	95.41314	NHNS	235	8.48	DW	Alluvium	5.02	Private
Hukanjuri	27.1258	95.43769	NHNS	241	12.24	DW	Alluvium	7.51	Private
Mopaya	27.24496	95.55319	Established Well	152	9.75	DW	Alluvium	2.79	Private
WRD Deomai	27.19786	95.47206	Established Well	159	6.60	DW	Alluvium	3.8	Private
Kanubari	27.02434	95.196	Established Well	128	10.66	DW	Alluvium	5.37	Private
Mopakhat	27.0277	95.20718	Established Well	121	6.55	DW	Alluvium	5.21	Private

N. B.: (1)Private well means wells constructed by individual household, Tea Garden, Petrol Pump, Temple, Masjid, etc.

Table 2.2: Water level measurement of key wells

Location	Jan-22	Apr-22	Aug-22	Nov-22
Dirok chk gate		0.16		2.43
Namsangmukh		8.26		6.51
Namsangmukh		9.86		4.54
Cofffee board		3.18		4.45
Deomali	4.33	2.13	2.79	2.69
Borduria	4.99	3.69	3.15	5.02
Hukanjuri	7.61	2.63	2.52	7.51
Mopaya				2.79
WRD Deomai		2.64		3.8
Kanubari				5.37
Mopakhat				5.21

2.6 Soil Infiltration Studies: Infiltration Test

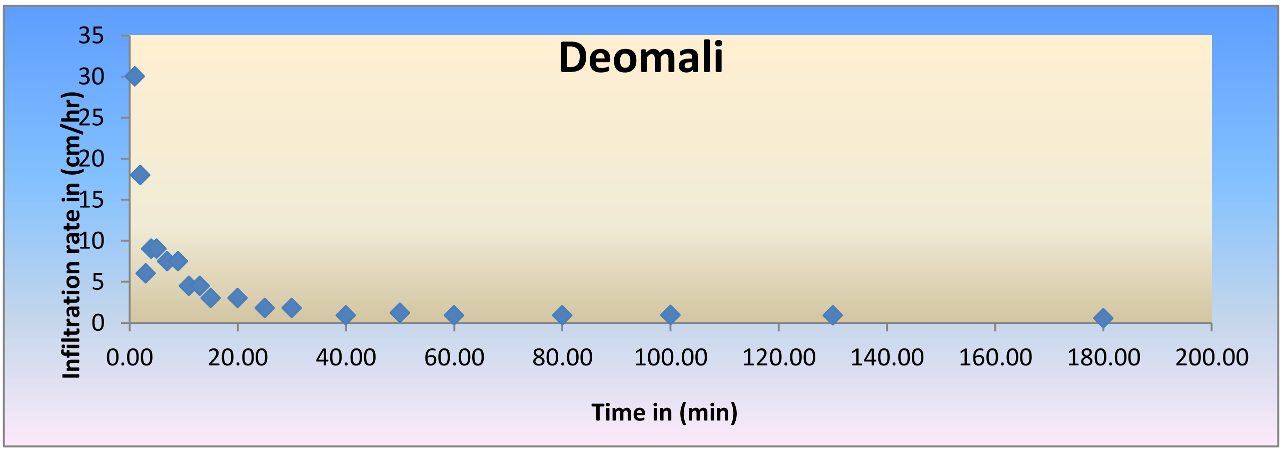
Salient features of the test sites are provided in Table 2.3 & 2.4. A perusal of the table shows that the tests have been conducted only in barren land and the soil types encountered in the sites are silty/Sandy loam. The infiltration test was conducted for 165 – 180 mins.

Table 2.3: Salient features of the test sites

Site	Location	Land use	Soil type	Latitude	Longitude
Deomali	In the campus of WRD division, Deomali	Barren Land	Silty loam	27° 6' 57.5352" N	95° 24' 46.2456" E
Borduria	In the campus of Borduria Range area, Tirap	Barren Land	Sandy loam	27° 11' 51.1512" N	95° 28' 16.8924" E

Table 2.4: 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)
Deomali	Barren Land	Silty loam	55.9	180	0.18	3.44
Borduria	Barren Land	Sandy loam	37.5	165	0.16	6.61



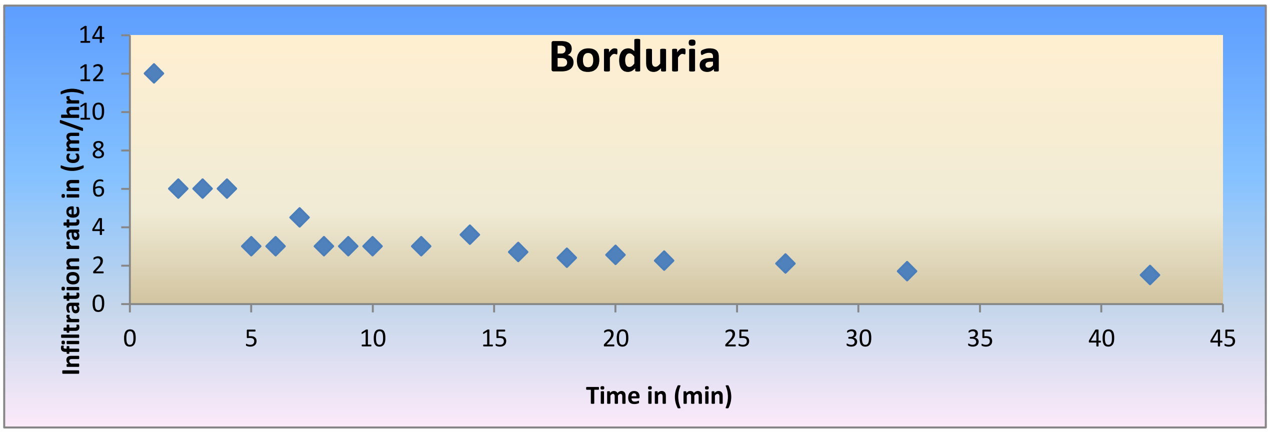


Fig 2.1: Time Vs Soil infiltration rate plot.

Geophysical Survey: No Geophysical Survey has been carried out in the district before and during NAQUIM study.

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 for detailed, iron, heavy metals and arsenic.

Exploratory Drilling: During AAP 2022-23, no well have been drilled by CGWB in study area. 02 nos of Exploratory wells and 01 no. of observatory well drilled by CGWB before NAQUIM are examined for preparation of section/3D disposition of aquifer. A list of wells constructed in the area was prepared incorporating location, well designs, etc.

Table 2.5: Details of Exploratory wells in Tirap District, Arunachal Pradesh

Sl. No.	Location	Block	Lat	Long	RL	Depth (m)	Discharge m3/hr
1	Mopakhat	Kanubari	27.025	95.20556	121	113.6	2.016
2	Kanubari EW	Kanubari	27.025	95.18889	122	111.3	39.06
3	Kanubari OW	Kanubari	27.025	95.18889	122	111.3	39.06

Fig 2.2: (a) Measuring of water level from dug well (b) measuring of in-situ chemical parameter by water quality testing kit (c) Collection of water sample (d) Soil infiltration test.

CHAPTER-3.0

DATA INTERPRETATION, INTEGRATION AND AQUIFER MAPPING

3. Data Interpretation

The subsurface geology of Tirap District is interpreted based on exploration data of Central Ground Water Board (CGWB). The drilling depth of CGWB's exploratory well ranges from 111.3 to 113.6 mbgl.

Depth	< 50m	50-100m	100-150 m	150-200 m	200-300 m	>300 m
No of wells	0	0	2	0	0	0
% of wells	0	0	100	0	0	0

Table 3.1: Distribution of EW based on drilled depth.

From the examination of available litholog, it is observed that down to a maximum explored depth of 113.6m. The sequence is dominated by, sand, clay, sandstone of tertiary age. Available data indicate major aquifer of the district is Alluvium of quaternary age, the mappable area which is upper part of the district is occupied by older alluvium, Tipam sandstone, Barail and Dihing group.

3.1 Aquifer Disposition:

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

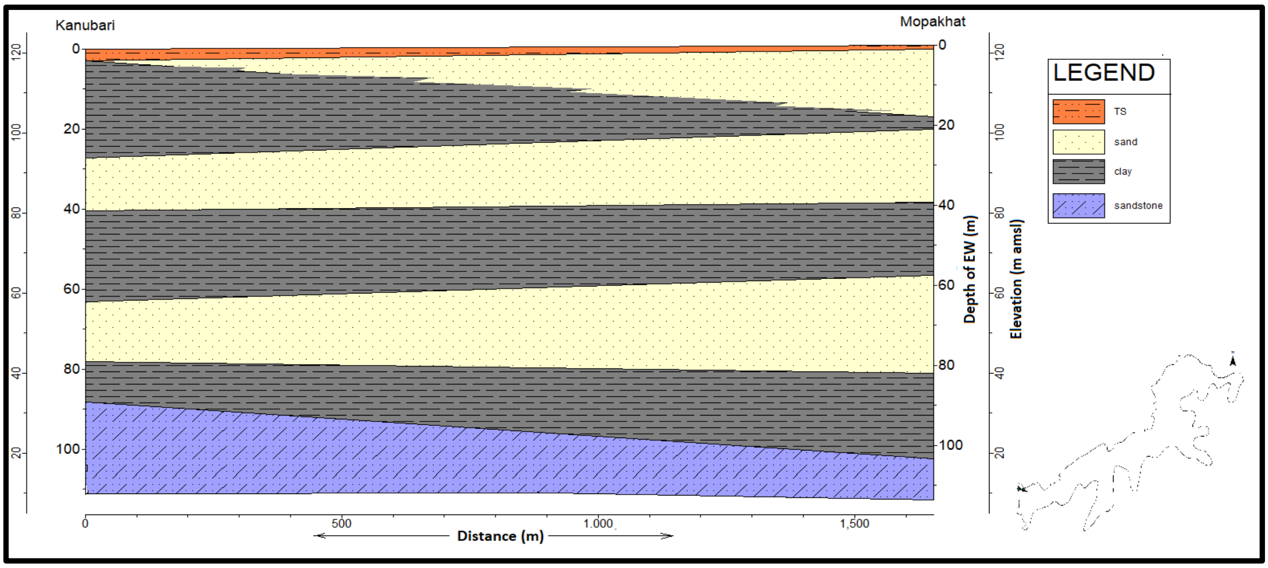


Fig 3.1: Cross sections between Kanubari-Mopakhat.

Cross section between Kanubari-Mopakhat- Section prepared in upper NW part of the district shows that the area is composed of alternating layers of sand and clay of various thickness. The thickness of the aquifer decreases towards kanubari in the upper 20 metres. Although it again starts from 30 m subsurface, which is marked by a clay layer of about 20 m thickness at a depth of 40m. The aquifer is in semi-confined to confined condition. At the depth of 90 m near Kanubari, the clay layer encounter sandstone of tertiary age and at about 110 m near mopakhat area.

3.2 Aquifer Characteristics:

Major aquifer of district is older alluvium. The aquifer of the district broadly can be divided into two groups. Shallow aquifer depth limit is 50m and below which deeper aquifer exists. The cumulative thicknesses of both shallow and deeper aquifers are given in Table 1.

Table 3.2: Granular zones encountered in exploratory wells in Tirap District, Arunachal Pradesh

Village/Location	Drilled Depth (m)	Granular Zones/ Potential Zones Encountered	Cumulative thickness of granular zones (m)	
			GL to 50 m	50 to 300 m and above
Kanubari	111.30	29-39, 66-69, 72-77, 90-100	10	17
Mopakhat	113.6	36-39, 58-64, 67-82	3	21

Shallow Aquifer zone: In shallow aquifer granular zone thickness varies from 0m to 50 m, and granular zone thickness increasing toward Kanubari to Mopakhat. The presence of clay formation in the depth of 50 m poses problem in storage of ground water in shallow aquifer. Aquifer property Storativity, Transmissivity, of shallow aquifer upto depth of 50m not known.

Deeper Aquifer Zone: Two exploratory wells have completed 110m of drilling and cumulative thickness of deeper aquifer up to a depth of 110 m is 21m in mopakhat and 17m in kanubari. The thickness of granular zone decreasing toward south west. Groundwater within this depth range occurs under semi-confined to confined condition. The storativity value for kanubari is 5.3x 10-4. Transmissivity value is 132 m2 /day. Discharge varies from 2.02 m3/hrs to 39.06 m3/hrs, for drawdown of 13.30m to 22m.

Table 3.3: Aquifer properties of deeper aquifer zones.

Depth Range	**SWL (mbgl)**	**Discharge (m3/hr)**	**Drawdown (m)**	**T (m2/day)**	**Permeability (m/day)**
111.3-113.6 m	4.70 to 8.88	2.02-39.06	13.30 – 22	132	4.88

3.3 Ground water level of shallow aquifer zone

To study ground water regime, depth to water level from 11 monitoring stations (GWMS 03, Key well 08) are measured seasonally. In pre-monsoon, the depth-to-water level varies from 0.16 to 9.86 mbgl and in post monsoon depth-to-water level varies from 2.43 to 7.51 mbgl. In pre- monsoon highest water level recorded in Namsangmukh, Namsang block and lowest at Dirok of namsang Block. In post- monsoon highest water level recorded in Hukanjuri of Borduria block and lowest at Dirok of namsang. (Fig. 3.2 and 3.3).

Water table Fluctuation: Seasonal fluctuation of water level ranges from -0.56 m to 5.32 m. Highest fluctuation observed in Namsangmukh, Namsang block and deomali, namsag block of the district. Most of area showing water level fluctuation less than 1.0 m. (Fig. 3.4).

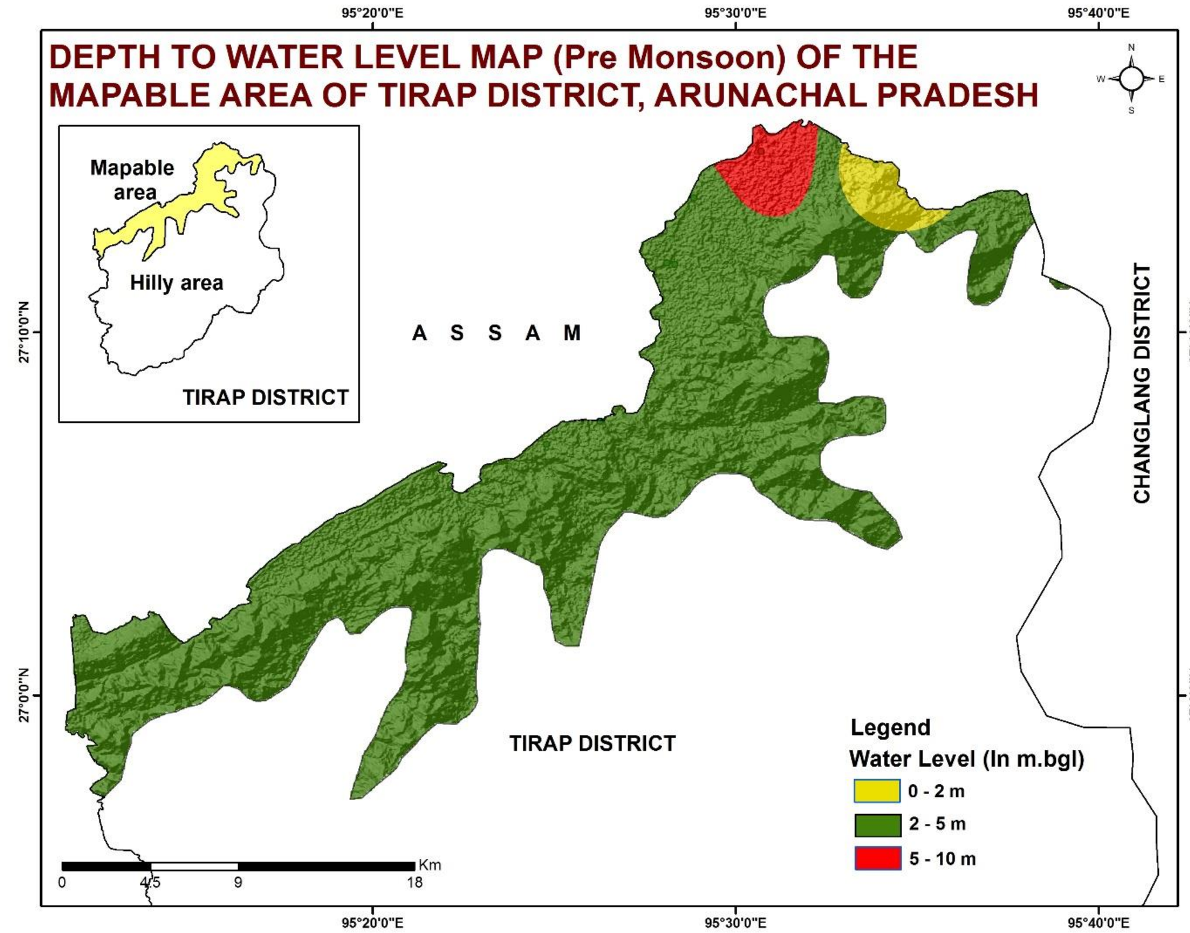


Fig 3.2: Pre- Premonsoon groundwater level map shallow aquifer of the study area.

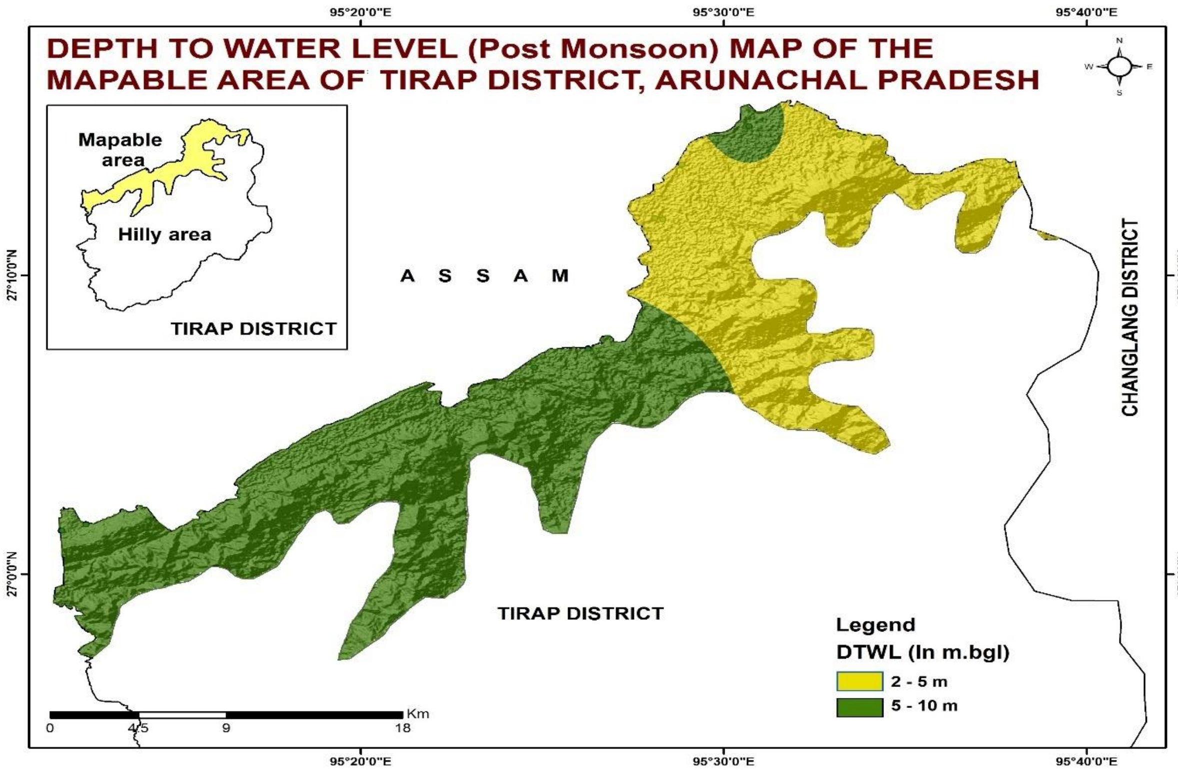


Fig 3.3: Post-monsoon groundwater level map shallow aquifer of the study area.

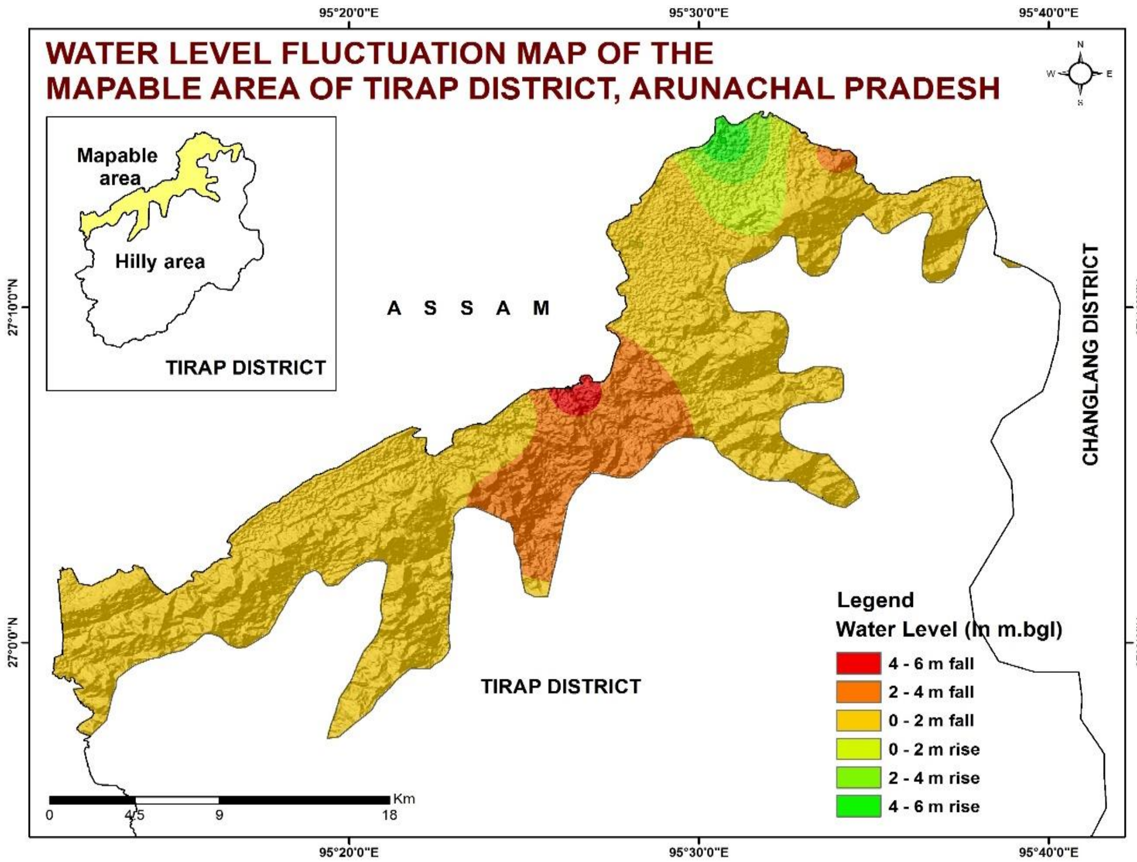


Fig 3.4: Water Level Fluctuation map of the study area

3.4 Ground Water Movement

The water table contour has been prepared based on water level of ground water monitoring stations which is shown in Fig.24. The ground water flow direction is bi-directional and radially outward from the center. The flow direction is parallel to the Brahmaputra River. The highest water table is 220 m and lowest water table 120 m above the mean sea level.

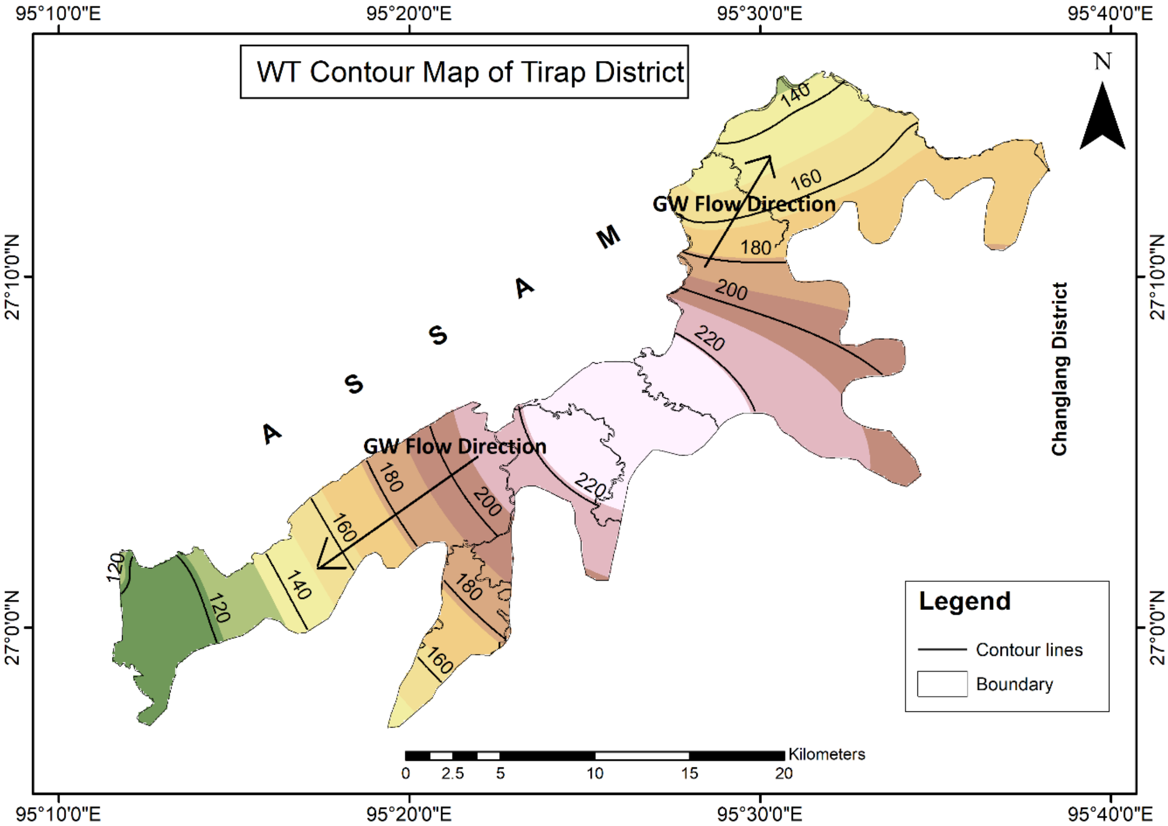


Fig 3.5: Water table contour map of the study area.

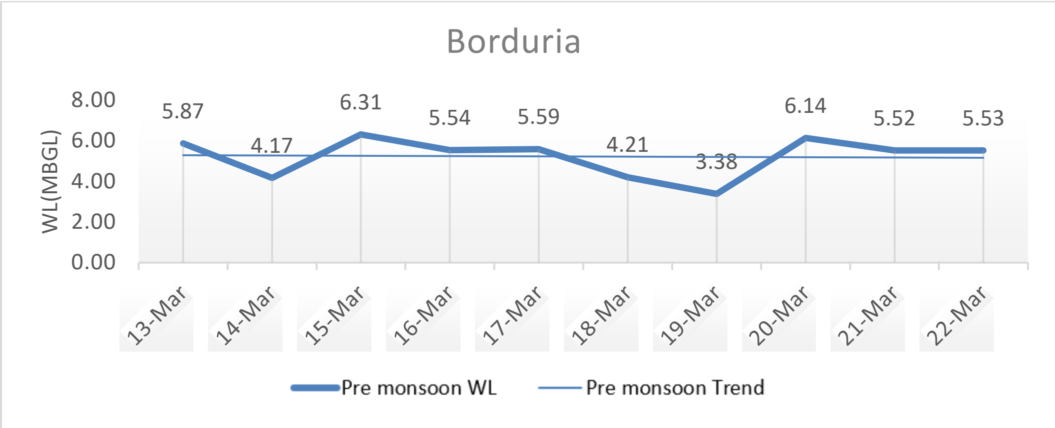
3.5 Water level trend analysis

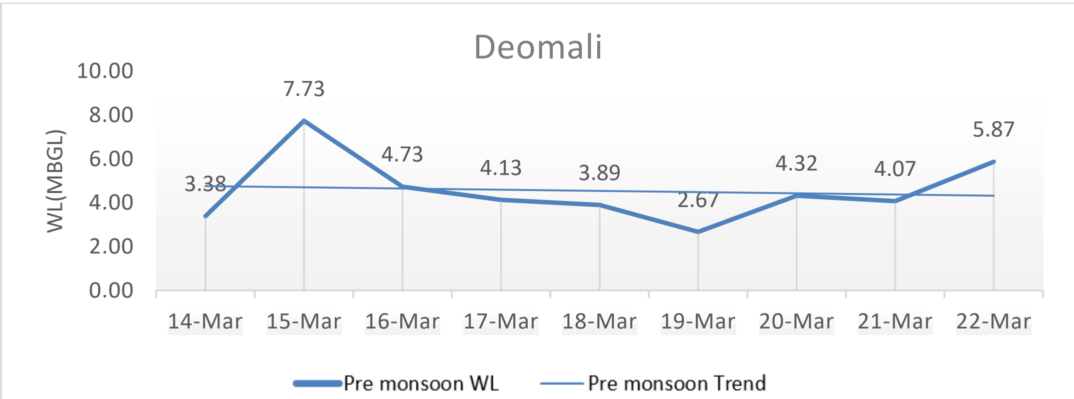
For analysis of long-term behavior of ground water level, data from Ground Water Monitoring Stations (GWMS) are utilized. Historical depth-to-water level data (in mbgl) are plotted as individual hydrographs and are given in Figure 3.6, 3.7 and Table 3.4 showing overall trend of water levels in GWMS wells of Tirap district, Arunachal Pradesh.

Table 3.4: Trend of Water levels in GWMS Wells

SN	Locality/Name	No. of years	Water Level Trend	
			Post-monsoon	Pre-monsoon
1	Deomali	9+8	No significant change	Fall
2	Hukanjuri	9	Rise	Fall

3	Borduria	9+10	Rise	No significant change





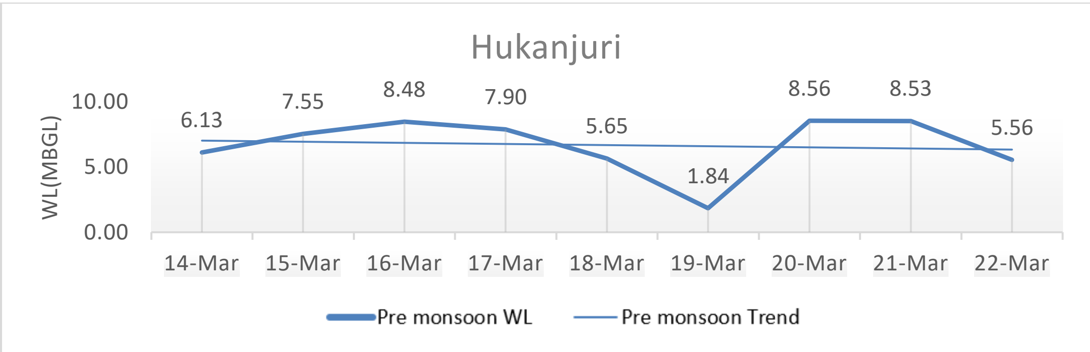
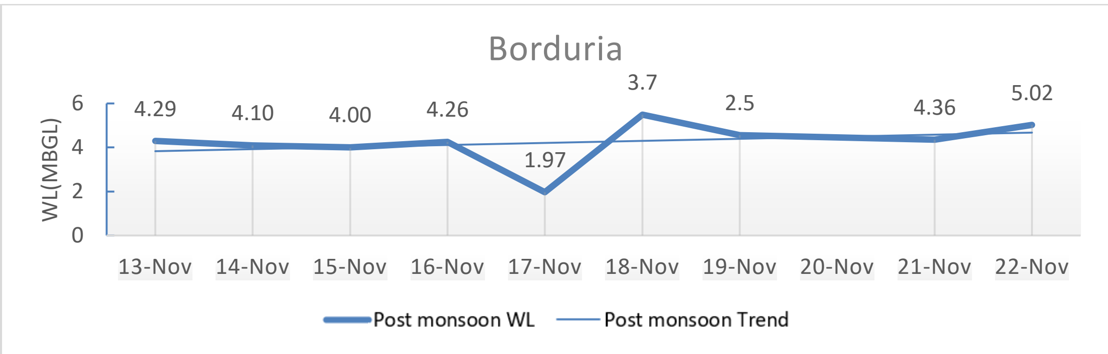
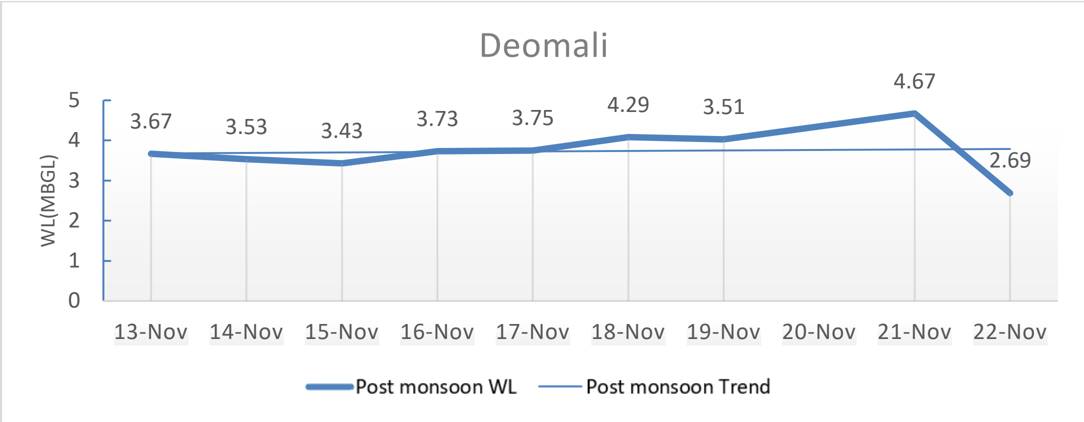


Fig 3.6: Pre-monsoon hydrograph of GWMS wells of Tirap district





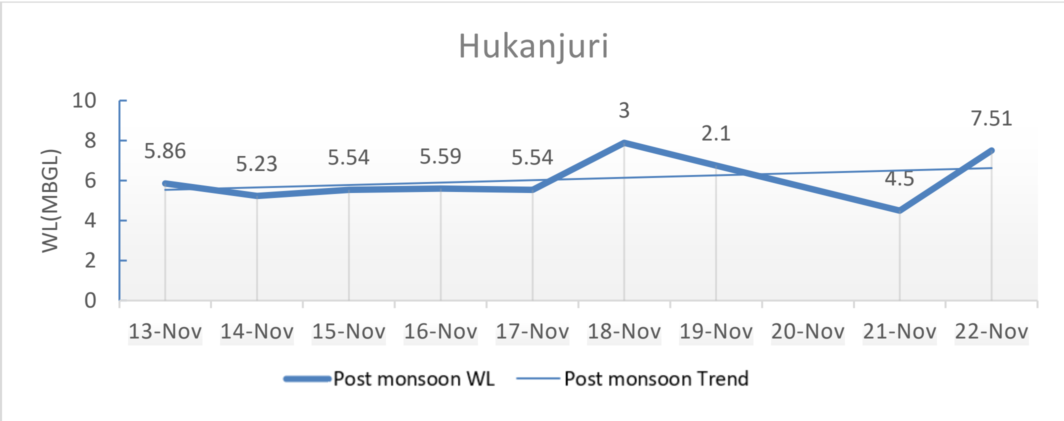


Fig 3.7: Post monsoon Hydrograph of GWMS wells of study area.

3.6 Ground water quality

During AAP 2022-23, 06 nos of Shallow aquifer Groundwater samples were collected from dug well/ hand pump/tube well during post monsoon and 04 nos sample in pre-monsoon for water quality study of Tirap district. Temperature, Ec, pH, and salinity were measured using portable digital quality kit on site. Chemical analysis of ground water samples are carried out by regional chemical laboratory of Central Ground Water Board, North Eastern Region, Guwahati. In the present study the quality of water with respect to major ion, heavy metals, iron, arsenic and uranium, TDS, TH etc. was estimated and various parameter analyzed to evaluate the suitability of ground water in the study area for human consumption and agriculture practices.

Table 3.5: Minimum, Maximum and Mean values of hydro chemical parameters of groundwater samples.

Parameter	**Unit**	**Post Monsoon**				**Pre Monsoon**			
		No of Samples	Average	Max	Min	No of Samples	Average	Max	Min
pH	No unit	6	7.57	8.14	7.20	4	6.15	6.50	5.83
EC	(µs/cm)	6	59.48	117.80	29.04	4	98.78	122.60	73.45
Turbidity	No unit	6	0.11	0.18	0.04	4	0.14	0.15	0.11
TDS	mg/l	6	39.26	77.75	19.17	4	65.19	80.92	48.48
Carbonate	mg/l	6	0.00	0.00	0.00	4		0.00	0.00
Bicarbonate	mg/l	6	39.68	91.57	18.31	4	35.10	48.84	18.31
TA	mg/l	6	39.68	91.57	18.31	4	35.10	48.84	18.31

Chloride	mg/l	6	10.04	17.73	7.09	4	15.07	21.27	10.64
Sulphate	mg/l	6	3.20	9.18	1.21	4	7.72	15.28	2.14
Nitrate	mg/l	6	7.45	24.76	1.26	4	16.21	28.56	7.85
Flouride	mg/l	6	0.01	0.01	0.00	4	0.04	0.06	0.03
Calcium	mg/l	6	9.34	32.03	4.00	4	9.51	10.01	8.01
Magnesium	mg/l	6	4.04	8.49	1.20	4	2.73	3.64	1.21
TH	mg/l	6	40.00	85.00	20.00	4	35.00	40.00	30.00
Sodium	mg\	6	5.67	9.26	2.93	4	12.90	17.03	4.56
Potasium	mg/l	6	1.87	3.46	0.81	4	3.41	5.55	1.14
Iron	mg/l	6	0.14	0.21	0.07	4	0.02	0.04	0.01
As	mg/l	6	0.47	0.71	0.23	4	BDL	BDL	BDL
SAR	No unit	6	0.45	0.81	0.14	4	0.95	1.35	0.34
PI	%	6	106.58	137.53	74.17	4	102.45	122.11	83.19
RSC	meq/l	6	-0.15	0.00	-0.50	4	-0.12	0.20	-0.40
Na%	%	6	31.10	48.79	9.35	4	46.26	59.05	26.57
KR	No unit	6	0.44	0.81	0.08	4	0.81	1.24	0.28
MH	%	6	48.45	74.99	5.81	4	31.36	42.83	16.61
PS	meq/l	6	0.32	0.51	0.22	4	0.51	0.62	0.34

3.7 Drinking Water Quality:

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

All the chemical parameters of sample analyzed for Pre and Post monsoon are within the permissible limit including Iron and Arsenic. (Chemical data enclosed in Annexure-I)

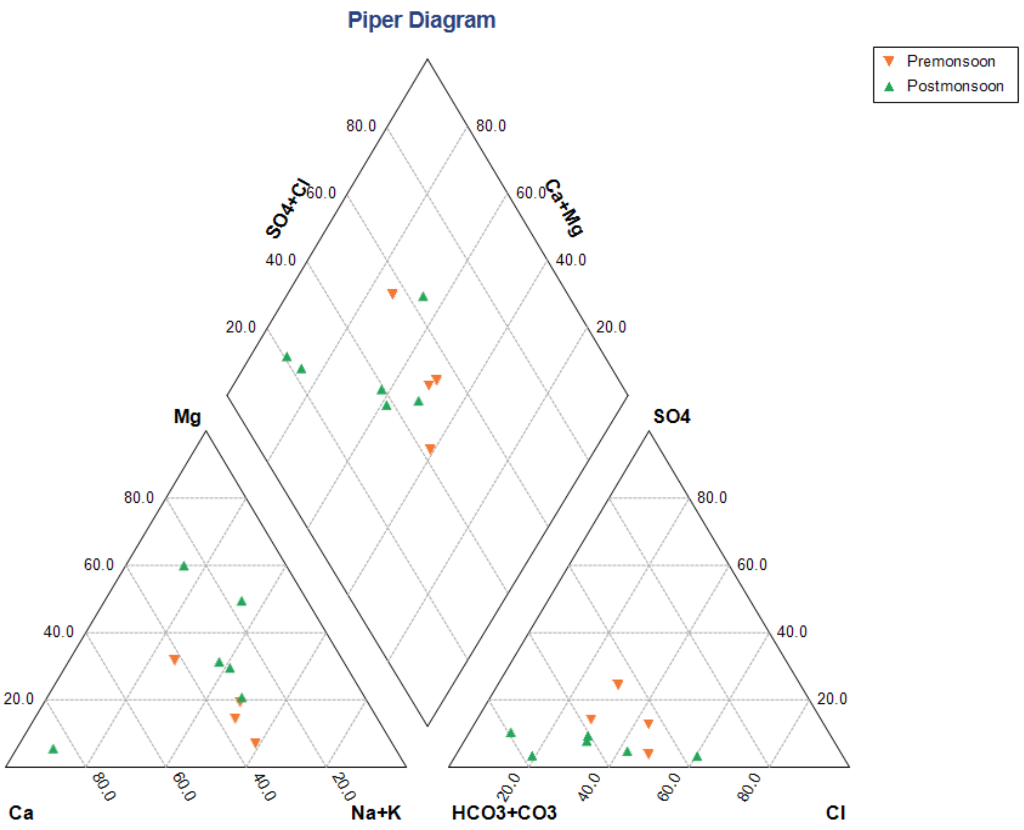


Fig 3.8: Major Hydrochemical facies of Groundwater

Hydrochemical analysis data is plotted in Piper diagram (fig 28). In the present study majority of samples are plotted in Calcium Magnesium Bicarbonate field and few samples fall in Na-Cl and mixed type field.

Table 3.6: Suitability of groundwater for drinking purposes of study area.

			Post Monsoon		**Pre Monsoon**	
Parameter	**Unit**	**Permissible Limit BIS (2012)**	**% of sample under Permissible limits**	**% of sample exceeding Permissible limits**	**% of sample under Permissible limits**	**% of sample exceeding Permissible limits**
pH	No unit	6.5- 8.5	100	0	75	25
TH (as COCO3)	mg/l	600	100	0	100	0
TDS	mg/l	2000	100	0	100	0
Turbidity	NTU	5	100	0	100	0
Calcium	mg/l	200	100	0	100	0
Magnesium	mg/l	100	100	0	100	0
Chloride	mg/l	1000	100	0	100	0
Sulphate	mg/l	400	100	0	100	0
Flouride	mg/l	1.5	100	0	100	0
Nitrate	mg/l	45	100	0	100	0
Iron	mg/l	1	100	100	100	0

3.8 Irrigation Water Quality:

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

Table 3.7: Suitability of groundwater (Shallow aquifer) for irrigation in study area.

Based on EC		Post Monsoon	Pre Monsoon
EC (µs/cm)	**Water Class**	**% of samples**	
<250	Excellent	100	**100**
250-750	Good	0	**0**
750-2000	Permissible	0	**0**
2000-3000	Doubtful	0	**0**
>3000	Unsuitable	0	**0**
Based on RSC			
RSC meq/l	**Water Class**	**% of samples**	
<1.25	Good	100	**100**
1.25-2.5	Doubtful	0	**0**
>2.5	Unsuitable	0	**0**
Based on SAR			
SAR	**Water Class**	**% of samples**	
<10	Excellent	100	100
10.0 -18.0	Good	0	0
18.0 - 26	Doubtful	0	0
> 26	Unsuitable	0	0
Based on Na%			
Na%	**Water Class**	**% of samples**	
<20	Excellent	33.34	0
20-40	Good	33.33	25
40-60	Permissible	33.33	75
60-80	Doubtful	0	0
>80	Unsuitable	0	0
Based on PI			
PI in %	**Water Class**	**% of Samples**	
>75	Class-I, Suitable	83.33	100
25-75	Class-II, Good	16.67	0
<25	Class-III, unsuitable	0	0
Based on Kelly Index			
KI	**Water Class**	**% of Samples**	
<1	Recommended	100	75
>1	Not recommended	0	25
Potential Salinity			

PS in meq/l	Water Class	% of samples	
<3.0	Suitable	100	100
>3.0	Unsuitable	0	0

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

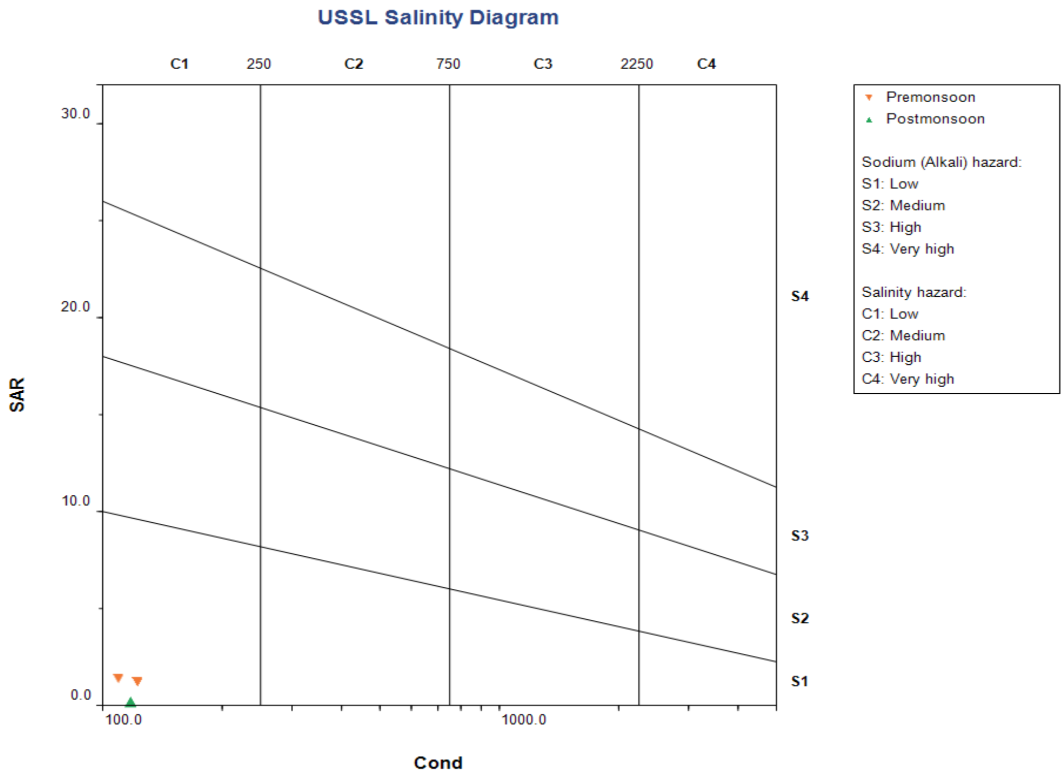


Fig 3.9: US Salinity diagram showing suitability of groundwater for irrigation based on SAR and EC.

CHAPTER-4.0

GROUND WATER RESOURCES

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

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

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

2) Last ten years rainfall data is considered for groundwater resource calculation. Water level data has been considered for 2020-21.

3) Water level fluctuation based on data of March (Pre monsoon) and November (post monsoon) has been considered since deepest water levels are recorded during the month of March.

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

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

4. Recharge

Total area of assessment unit 236200 Ha, out of which 12500 Ha considered for recharge worthy area. The aquifers of the study area are recharged through a) infiltration of rainfall b) seepage from the tanks and ponds c) subsurface inflow across the up dip margin. The area experiences south-east monsoon. Monsoon rainfall contributes approximately 76 percent of total rainfall (May, June, July, August, and September). Previous records show that the rainfall occurs almost in every month of a year. The month November to December has the minimum number of rainy days in any year. The monsoon recharge of recharge worthy area from rainfall is 7142.72 ham while non-monsoon recharge is 1658.42 ham. Recharge from other sources during monsoon is 264.64ham and during non-monsoon is 161.88 ham. Total ground water recharge is 9227.65 ham.

Ground Water Extraction

The ground water extraction of unconsolidated aquifer is created by natural discharge like seepages and draft created by human interference, viz., (a) withdrawals for irrigation and industry and (b) public-supply wells. In the district total natural discharge is 922.77 ham of thetotal groundwater recharge. Total irrigation extraction created is 77.4 ham, for industry 0 hamand extraction for domestic uses is 68.03 ham. Total groundwater extraction for all uses is only 145.43 ham. The water trend analysis shows that there is no significant change in the water level forboth post-monsoon periods.

Allocation of resources up to 2025

The net ground water resource is allocated for domestic uses are 71.23 ham while 8156.26 ham resources are available for future use.

Stage of Ground Water Extraction

The area has very little irrigation facilities. Similarly there is no industrial development in the area. Groundwater is mainly utilized for domestic purposes. The stage of groundwater extraction in the district is 1.75%.

Table 4: Groundwater Resources Estimation 2022

PARAMETER	VALUES
Total geographical area (Ha)	236200
Recharge worthy area (Ha)	12500
Rainfall Recharge (monsoon) (Ham)	7142.72
Rainfall Recharge (non-monsoon) (Ham)	1658.42
Annual Recharge from Other Sources (monsoon) (Ham)	264.64
Annual Recharge from Other Sources (non- monsoon) (Ham)	161.88
Annual G. W. Recharge (Ham)	9227.65
Total Natural discharge (Ham)	922.77
Annual extractable Ground Water Resource (Ham)	8304.89
Current annual gross G.W. Extraction for domestic use (Ham)	68.03
Current annual gross G.W. Extraction for irrigation (Ham)	77.4
Current annual gross G.W. Extraction for industrial use (Ham)	0.00
Current annual gross G.W. Extraction for All uses (Ham)	145.43
Annual G.W. Allocation for Domestic water supply as on 2025 (Ham)	71.23
Net Annual G.W. availability for future use (Ham)	8156.26
Stage of GW Extraction (in %)	1.75
Quantity Categorisation for Future GW extraction (Safe/Semi-Critical /Critical /Over Exploited)	Safe

CHAPTER-5.0

GROUNDWATER RELATED ISSUES

5. Identification of issues:

The main groundwater issues identified in the area are-low stage of groundwater extraction and non-availability of potable water in the area.

Low stage of groundwater extraction: Compared to vast dynamic groundwater resource of Tirap district, groundwater extraction for domestic, irrigation and industrial purposes is low. Vast tract of agricultural land remains fallow after harvesting of paddy only due to lack of irrigation facility. The stage of groundwater extraction is only 1.75%.

Non availability of groundwater in some areas: Due to underlying geological condition, the area faces water crisis during various seasons. Presence of shales and clays imposes restriction to store and transmit groundwater to the population. In spite of abundant groundwater resource in many areas, there is shortage of groundwater in many locations. People of the district depends on spring and government water supply in hilly areas. As there is dependency on spring, it is essential to develop spring and source of water to receive flow of water throughout the year.

CHAPTER-6.0

MANAGEMENT STRATEGIES

The groundwater management involves the optimum utilization of sub-surface water based on geological, hydrological, economic, ecological and legal consideration for the welfare and benefit of the society. The objective of Groundwater management is to utilize the available ground water resources to fulfill human needs and also to boost economy of an area without hampering the interest of future generation. That objective can be achieved by finding out the demand of various sectors and adjusting the demand with available resource.

As per dynamic ground water resources 2021-2022, the annual extractable groundwater of Tirap district is 8304.88 ham. The current annual groundwater extraction accounts for 257.15ham and the stage of ground water extraction is only 1.75%. The district is having a balance net ground water availability for future irrigation use in the tune of 8156.25 ham. If an irrigation plan is made to develop 60% of the balance dynamic ground water resources available, then 4893.75 ham of groundwater resources is available in the district for future irrigation uses. Hence, there is ample scope for ground water development for irrigation purpose which will help the district in achieving self-reliance on food grain.

According to Agricultural census, 2015-2016, the district has a net sown area of 7073ha, and grossed cropped area of 8250 ha with a cropping intensity of 117%. The net sown area included field crops as well as horticulture and plantation crops. Cropping intensity is calculated generally from field crops, which are of short duration whereas horticulture (like citrus, banana, pineapple) and plantation crops like spices are long duration crops.

According to Agricultural census, 2015-2016, the land under cultivation during the Kharif season is 646 ha. After growing and harvesting the Kharif crops, the land remains fallow and uncultivated during the Rabi season. The intention of this plan is to utilized and bring this fallow land of 646 ha under assured irrigation during Rabi season which will help to increase the gross cropped area to 1292 ha and thereby increase the cropping intensity upto 200%. Since the stage of groundwater extraction is only 1.75 %, this area of 646 ha can easily be covered by constructing groundwater-based irrigation projects. In rice fallow, pulses, potato, mustard and rabi vegetables can be grown with the support of irrigation.

To use the groundwater for irrigation purpose a cropping plan has been designed for the district by using CROPWAT model developed by FAO. Suitable cropping plan was prepared and the cropping pattern, proposed cropping pattern, targeted increase in cropping intensity were shown in tabular form (Table 1). Crop wise and month wise precipitation deficit has also been estimated using the same software after giving necessary meteorological, soil data and crop plan inputs and the same has been shown in the Table 2. Crop wise and month wise Irrigation Water Requirement (IWR) in ham has been further calculated in Table 3.

Table 6.1: Cropping pattern, proposed cropping pattern and intended cropping intensity

Cropping pattern (s)				
Summer Rice-Autumn Rice-Winter Rice-Winter Rice	Present Cultivated area(**ha**)	Area to be cultivated (%)	Area to be cultivated (**ha**)	Irrigation requirement (**ham**)
Winter Vegetables-Summer Vegetables-Pulses--Potato-Oilseed				
Cultivated Area	**646**			
	1	2 (= % of 1)	3	4
Rice (main crop)	646		646	
Winter Rice	646	100	646	115.38
Potato		30	199.2	22.58
Pulses		20	132.8	12.47
Oil Seed		20	132.8	14.46
Maize (Grain)		10	66.4	5.4
Winter vegetables		20	132.8	9.23
Net cultivated area	646	100		179.52
Gross cultivated area (Paddy/+Wheat+Pulses)			1292	
Total irrigation requirement				**179.52**
70% irrigation efficiency				**256**

Table 6.2: Precipitation deficiency (mm) in Tirap district, Arunachal Pradesh

Precipitation deficit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Winter Rice	0	0	0	0	0	147	0	0	0	6.1	2.6	0
Winter Rice	0	0	0	0	0	48.8	98	0	0	6.8	8.3	0
Winter Rice	0	0	0	0	0	49	98	0	0	7.5	14.1	0
Winter Rice	0	0	0	0	0	0	147	0	0	9.2	33.9	0
Winter Rice	0	0	0	0	0	0.4	146.4	0	0	9.6	43.3	0
Potato	37.1	8.5	0	0	0	0	0	0	0	1.6	28.8	48.2
Potato	39.8	25	5.3	0	0	0	0	0	0	0	13.3	25.5
Pulses	19.3	0	0	0	0	0	0	0	0	1.3	32.9	48.4
Pulses	40	14	0	0	0	0	0	0	0	0	8.4	28.8
MAIZE (Grain)	38.8	28.6	3.7	0	0	0	0	0	0	0	1.6	10.9
Mustard	28	13.6	14	0	0	1.4	0	0	0	2.3	17.3	35.2
Small Vegetables	26.4	20.8	7.8	0	0	0	0	0	0	0	0	16.4

Table 6.3: Actual monthly water requirement (Ham) for different crops

Crops	Area %	Jan IWR	Feb IWR	Mar IWR	Apr IWR	May IWR	Jun IWR	Jul IWR	Aug IWR	Sep IWR	Oct IWR	Nov IWR	Dec IWR	Total IWR	Total
Winter Rice	10	0	0	0	0	0	9.5	0	0	0	0.39	0.17	0	10.06	115.38
Winter Rice	20	0	0	0	0	0	6.3	12.66	0	0	0.88	1.07	0	20.91	
Winter Rice	20	0	0	0	0	0	6.33	12.66	0	0	0.97	1.82	0	21.78	
Winter Rice	30	0	0	0	0	0	0	28.49	0	0	1.78	6.57	0	36.84	
Winter Rice	20	0	0	0	0	0	0.05	18.91	0	0	1.24	5.59	0	25.79	
Potato	15	3.59	0.82	0	0	0	0	0	0	0	0.16	2.79	4.67	12.03	22.58
Potato	15	3.86	2.42	0.51	0	0	0	0	0	0	0	1.29	2.47	10.55	
Pulses	10	1.25	0	0	0	0	0	0	0	0	0.08	2.13	3.13	6.59	12.47
Pulses	10	2.58	0.9	0	0	0	0	0	0	0	0	0.54	1.86	5.88	
MAIZE (Grain)	10	2.51	1.85	0.24	0	0	0	0	0	0	0	0.1	0.7	5.4	5.4
Mustard	20	3.62	1.76	1.81	0	0	0.18	0	0	0	0.3	2.24	4.55	14.46	14.46
Small Vegetables	20	3.41	2.69	1.01	0	0	0	0	0	0	0	0	2.12	9.23	9.23
Total	200							Gross irrigation Requirement with 70% Efficiency							**256**

Based on available groundwater resources and subsurface condition, the approximate numbers of tube wells that can be constructed in the district is worked out. Groundwater draft is calculated for well discharge of 22 m^3/hr. If the well is allowed to run for 8 hours a day for 120 days of a year then a tube well having a discharge will create a draft of 2.12 ham. To meet irrigation demand of 256 ham area, 122 numbers of shallow tube wells can be constructed to cover an unirrigated area of 1292 ha area. It is also considered on the basis of total unirrigated area and 200 m safe distance between each wells from all sides. Here, the number of shallow tube wells that needs to be constructed is 162 in the area of 646 ha. Therefore, the management plan is proposed following the lowest number of wells which is based on discharge of the wells in the area. The current total extraction of ground water in Tirap district is 77.40 ham resulting in a stage of groundwater development of 1.75 %. In extracting additional requirement of 256 ham, stage of groundwater development in Tirap will increase from 0.66 % to 4.01 %.

As per the study conducted in the area for hydrogeological investigation in the year 2016 by CGWB. Hydrogeologically, the study area is underlain by various formation which act as aquiclude like clay and shale where availability of ground water is meagre. In this context, the problem of water crisis in those areas needs to be addressed holistically. This holistic approach means harnessing the available water sources, implementing roof top rainwater harvesting and artificial recharge programme and undertaking test drilling to explore the thickness of weathered zone, fracture identification as well as determining their water potentiality and spring water development.

During study a few springs were observed which needs to be developed. The spring source area must be recharged by rain water harvesting. Hence, identification of spring source/catchment area, its protection and development are necessary.

The principle underlying concept of spring source area development by means of rain water harvesting means impeding the speed of running water using soil moisture conservation works, vegetative and social measures, so that there is an augmented discharge in the springs down slope. This will help to reduce the surface run-off of rainwater in the spring source area and more water will infiltrate underground to recharge the spring.

Annexure I: Concentration range of chemical constituents in groundwater

Pre/Post monsoon	Location	Lat	Long	Type of sample (EW or DW)	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	As
							mg/l															
Pre monsoon	Dirok	27.24382	95.56433	DW	5.83	89.36	0.15	58.98	BDL	36.63	36.63	14.18	15.28	7.85	0.03	10.01	2.42	35.00	13.00	5.55	0.047	BDL
Pre monsoon	Coffee board	27.22838	95.48075	DW	6.26	73.45	BDL	48.48	BDL	18.31	18.31	10.64	4.13	19.48	0.04	8.01	3.64	35.00	4.56	2.13	0.013	BDL
Pre monsoon	Deomali	27.19786	95.47207	DW	6.50	122.60	0.15	80.92	BDL	36.63	36.63	21.27	2.14	28.56	0.06	10.01	3.64	40.00	17.03	1.14	0.012	BDL
Pre monsoon	Borduria	27.11519	95.41314	DW	6.02	109.70	0.11	72.40	BDL	48.84	48.84	14.18	9.32	8.94	0.03	10.01	1.21	30.00	17.02	4.82	0.011	BDL
Post monsoon	Dirok	27.24382	95.56433	DW	8.14	117.8	0.08	77.748	0	91.5732	91.5732	7.09	9.1823	1.2611	0.01	32.0256	1.198058	85	2.93	1.86	0.209	0.70
Post monsoon		27.44964	95.55319	DW	7.82	53.36	0.08	35.2176	0	48.83904	48.83904	7.09	1.5574	4.4511	0.01	6.0048	8.492233	50	3.38	1.01	0.108	0.23
Post monsoon	Coffee board	27.22838	95.48075	DW	7.36	29.04	0.04	19.1664	0	24.41952	24.41952	7.09	2.3391	4.8688	0	4.0032	2.425243	20	5.76	1.26	0.074	BDL
Post	Deomali	27.19	95.47	DW	7.2	71.8	0.12	47.4	0	18.31	18.31	17.	1.2	24.7	0	4.0032	7.279	40	7.59	3.4	0.0	B

monsoon		786	207			8		408		464	464	725	086	627			612			6	91	DL
Post monsoon	Borduri	27.11519	95.41314	DW	7.39	33.06	0.18	21.8196	0	24.41952	24.41952	7.09	2.8801	2.6214	0	4.0032	2.425243	20	5.12	0.81	0.142	BDL
Post monsoon	Kanubari	27.02434	95.196	DW	7.514	51.75	0.15	34.155	0	30.5244	30.5244	14.18	2.0403	6.7517	0.01	6.0048	2.424272	25	9.26	2.84	0.209	BDL