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

DIMAPUR DISTRICT, NAGALAND

उत्तर पूर्वी क्षेत्र, गुवाहाटी

North Eastern Region, Guwahati

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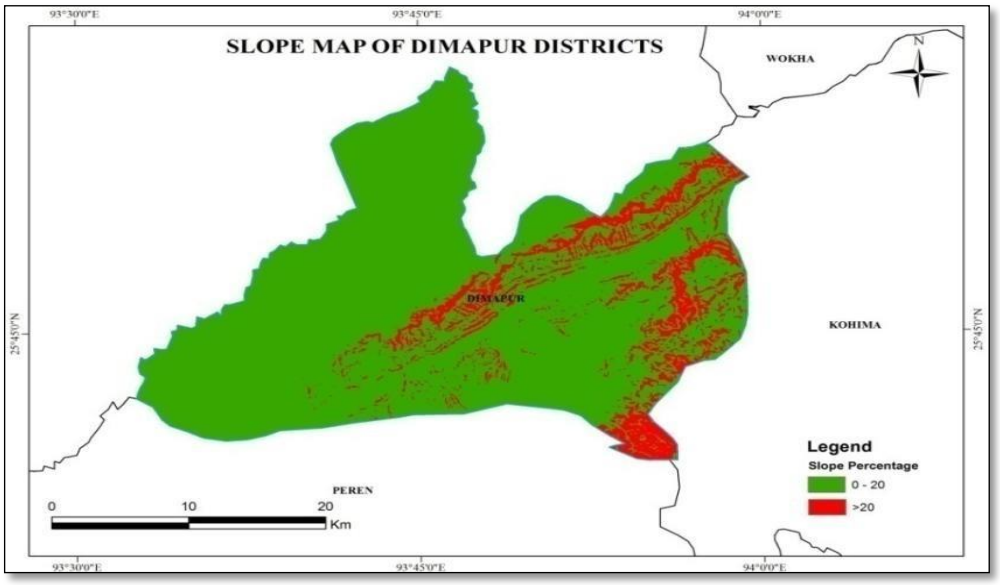
REPORT ON AQUIFER MAPPING AND MANAGEMENT IN DIMAPUR DISTRICT, NAGALAND

ANNUAL ACTION PLAN, 2017-18



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GOVERNMENT OF INDIA

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GUWAHATI

गुवाहाटी

March 2019

REPORT ON AQUIFER MAPPING AND MANAGEMENT IN DIMAPUR DISTRICT, NAGALAND

ANNUAL ACTION PLAN, 2017-18

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CHAPTER I

1.0 INTRODUCTION

Aquifer mapping is a process wherein a combination of geologic, geophysical, hydrologic and chemical field and laboratory analyses are applied to characterize the quantity, quality and sustainability of ground water in aquifers. The primary objective of the Aquifer Mapping can be summed up as "Know your Aquifer, Manage your Aquifer". Central Ground Water Board, North Eastern Region has carried out Aquifer mapping in Dimapur district, Nagaland during AAP 2012-13 and 2017-18 covering an area of 910 sq. km. under National Aquifer Mapping and Management (NAQUIM) program. Combination of geologic, geophysical, hydrologic and hydro chemical 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, to define the aquifer geometry, delineate type of aquifers, ground water regime behaviour, hydraulic characteristics and to assess the status of quality and to estimate the dynamic resources through a multidisciplinary scientific approach and its sustainability 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

Present study aims to discuss ground water scenario under different geological and geomorphological set up of the area.

1.3 Approach and Methodology

Aquifer mapping has been carried out by adopting a multidisciplinary approach:

- Geophysical surveys through Vertical Electrical Sounding (VES)
- Exploratory drilling
- Ground water regime monitoring by establishing monitoring wells
- Pumping test of tube wells
- Soil infiltration test
- Collection of various technical data from the field covering aquifer mapping area and also from the concerned State Govt. agencies and other Institutes dealing with ground water.
- Analysis of various data
- Formulation of a aquifer management plan for ground water development.

Aquifer Map Preparation-On the basis of integration of data generated from various studies 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.

1.4 Area Details

An area of 910 sq km in Dimapur district of Nagaland was covered as per the Annual Action Plan 2012-13 & 2017-18 of Central Ground Water Board, North Eastern Region, Guwahati (Fig.1). According to 2011 census Dimapur district has a population of 379,769.

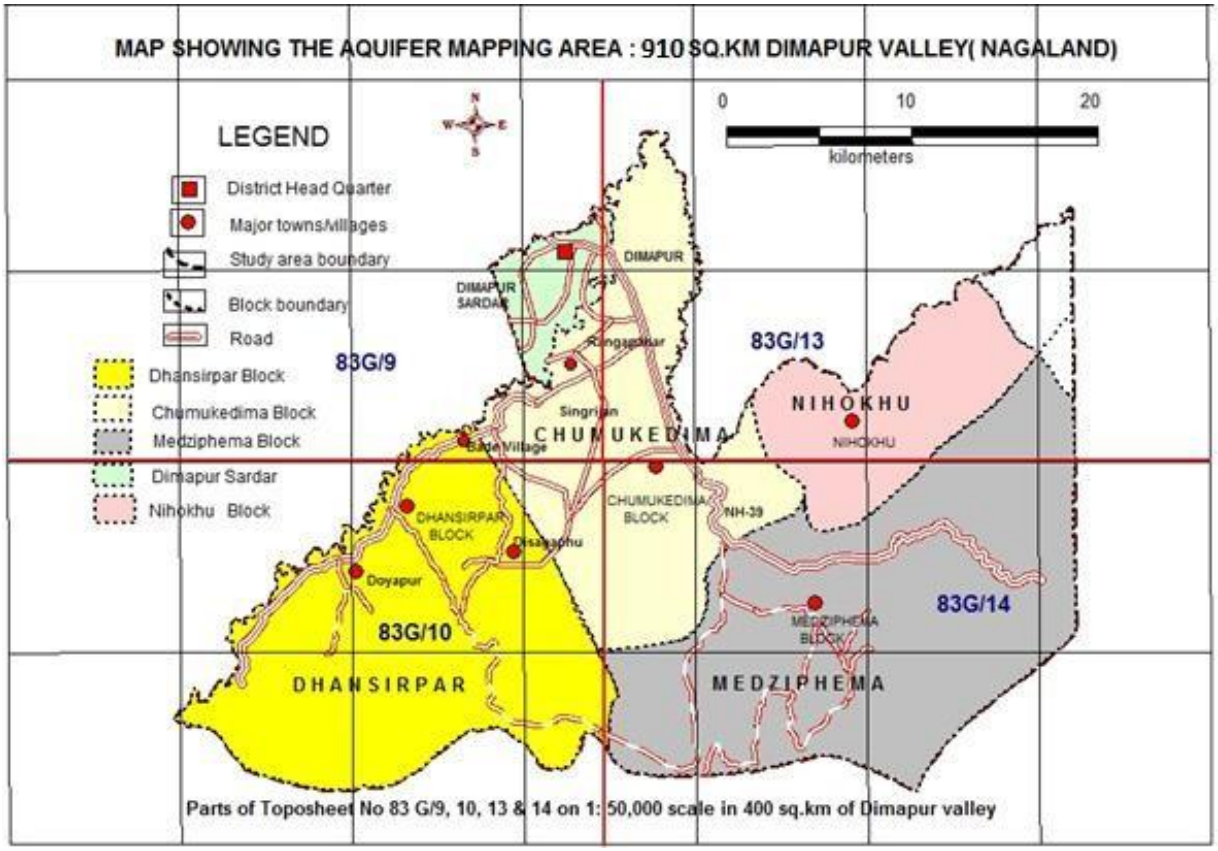


Fig.1.1: Administrative set ups of Dimapur district

The study area covers Dimapur valley falling under Survey of India toposheets no. **83G/5, 83G/9,**G/10,G/13, G/14 **and 83F/8** lies between north latitudes 25^0 $54^/$ $45^{//}$& $26^0 17^/$ $06^{//}$ and east longitudes $93^0 44^/$ $30^{//}$& $94^0 15^/$ $03^{//}$.The average elevation of the district is 260 meters above mean sea level. The study area forms part of Dhansiri and Doyang Sub-basins of the Brahmaputra Basin.

1.5. Data availability, data adequacy, data gap analysis & data generation

One of the important aspect of aquifer mapping programme 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, analysed, 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. Data availability map is shown in Fig.2.

Data Generation: There was also a need for generating additional data to fill the data gaps to achieve the task of aquifer mapping. This was achieved by activities such as exploratory drilling, geophysical study, soil infiltration test, ground water quality analysis besides detailed hydrogeological surveys.

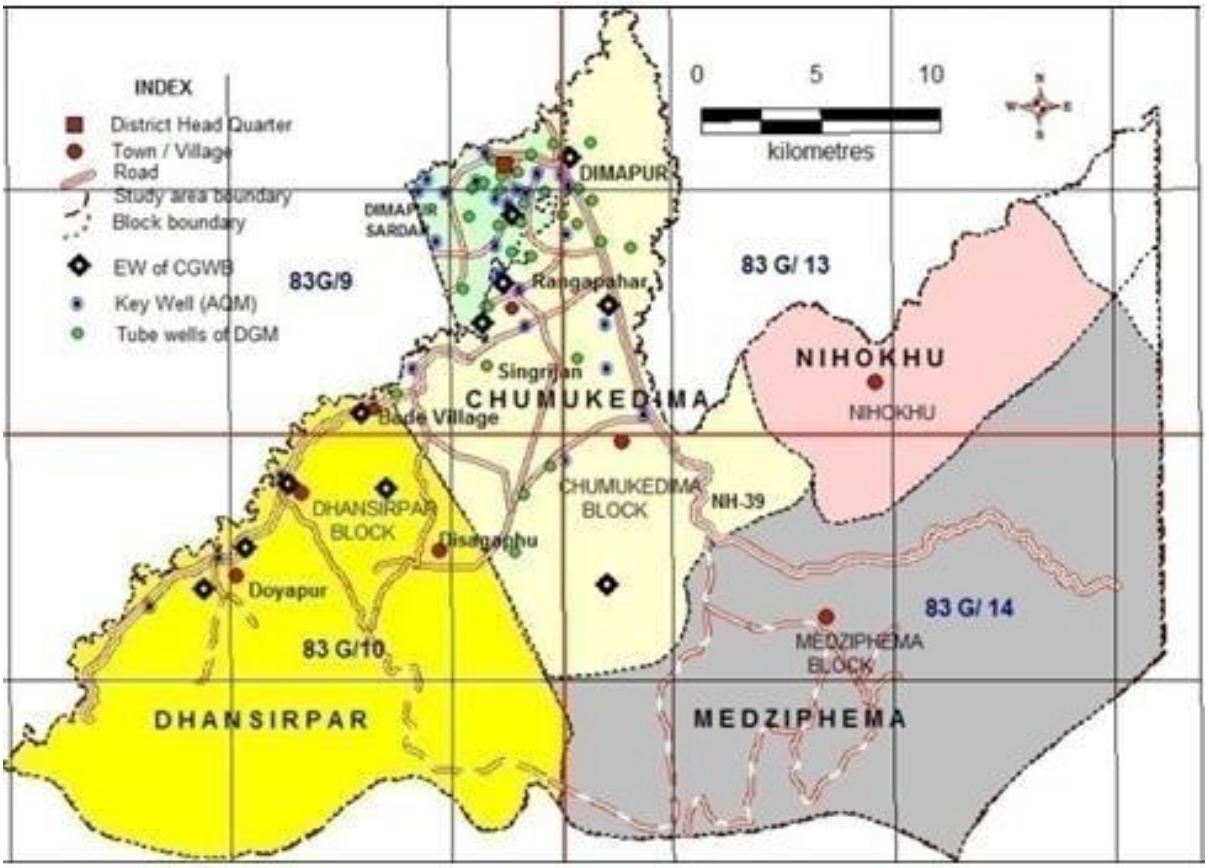


Fig.1.2: Data availability map

1.6 Rainfall

Dimapur district enjoys sub-tropical humid climate with maximum temperature reaching up to 36^{o} C and minimum winter temperature going down to 3.2^{o}C. Humidity is very high ranging from 74 to 87%. The area experiences phenomenal influence of the south-west tropical monsoon which persists from May to September with occasional winter showers. The average annual rainfall of the State is recorded to be 2000 to 2500 mm. The average number of rainy days in the state is around 135 days, varying from 60 to 190 days. The average annual rainfall for the last seven years (2006-2015) recorded for Dimapur district is 1236.93 mm. The average annual rainfall for the year 2017 is 2148.6 mm.

1.7 Physiography

Dimapur district forms a part of the intermontane alluvial plain in the North of Naga hill ranges. The land surface possesses a general slope from South to North with considerable local undulations. The maximum elevation of the hill ranges in the south is 1854 m amsl and the minimum elevation is 126 m amsl towards north (Fig.3).

The area around Dimapur lies in front of the outermost over thrust block of the Naga hill ranges. The Naga Thrust can be traced trending NE-SW near Nichuguard, about 10 km SSE of Dimapur. The rocks of the Surma Group are seen exposed near Nichuguard on the Kohima road. North of it up to Dimapur, the Younger Quaternary sediments form the undulating plain. Tipam Group of rocks are exposed in the low hills West and Northwest of Dimapur. The rocks of the Quaternary age have variable thicknesses and found in and around Dimapur valley.

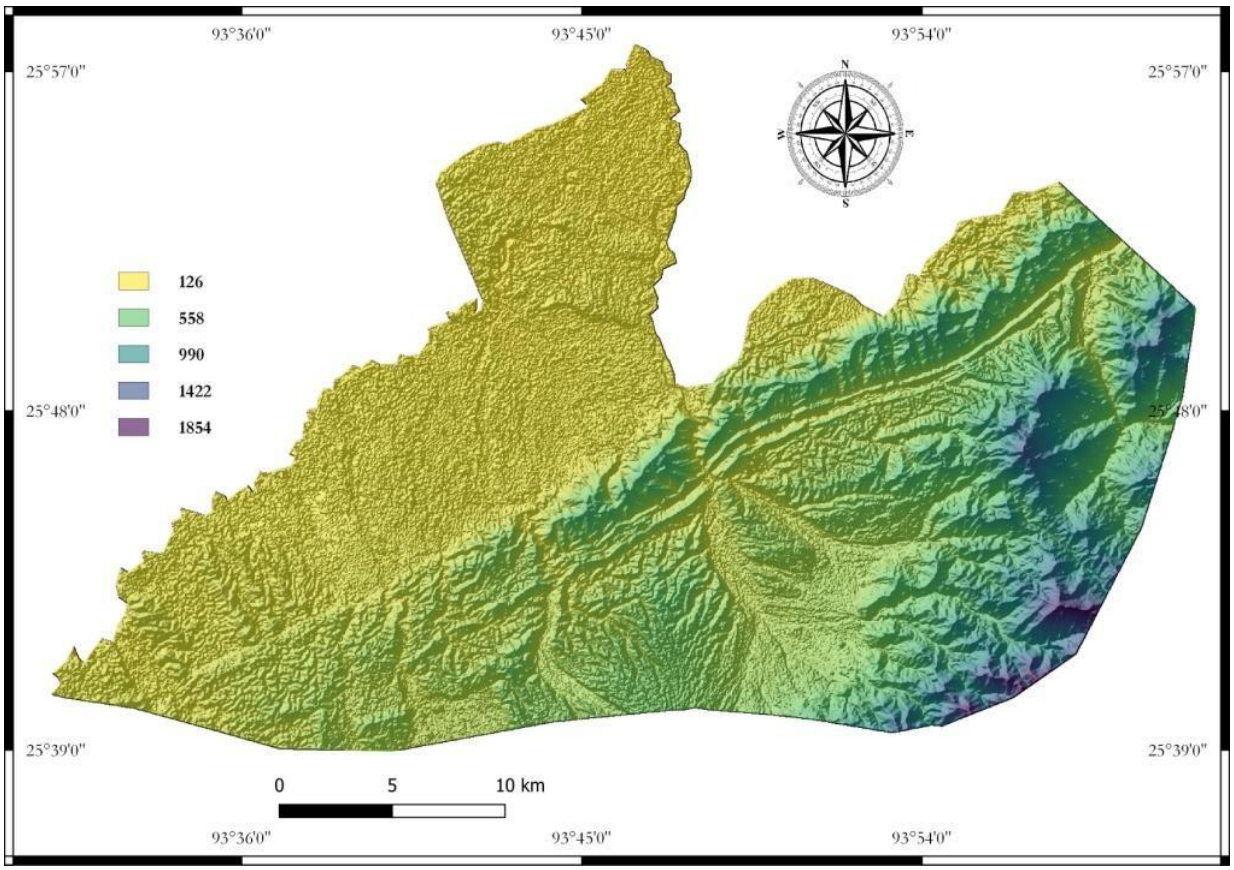


Fig.1.3: Hill shade map of Dimapur district

1.8 Geomorphology

The study area can be divided into several geomorphic units, such as alluvial plains, structural hills, residual hills, valleys and flood plains. The alluvial plain and structural hills cover most part of the study area. The alluvial plain is found in the northern part of the study area whereas the structural hills occupy the southern part. The residual hills are the remnants of weathering and denudation. The flood plains show very good potential for ground water. The intermontane valley fills and alluvial plains also hold good potential for ground water. The structural hills and the residual hills act as runoff zones and thus are poor sites for ground water.

1.9 Land use

As 95% of the total area of the State is covered by hills, shifting and terrace cultivations are practiced in the State of Nagaland. However, in relatively flat stretches of land in Dimapur valley, irrigated fields have been developed. Most areas of the State are covered by dense forest. Rain fed agriculture is practiced in the State and the ground water withdrawal for irrigation purpose is practically nil. However, there is a total of 357.05 sq. km. net irrigated area in Dimapur district from surface water sources. Dimapur district has 8.12 sq. km. of area covered by forest.

1.10 Soil

Soils in the project area are derived from Tertiary group of parent rocks being sandstones, shale, siltstone and mudstone. Soils are generally acidic, very rich in organic carbon, poor in available phosphate and potash content. Soils are fertile and can be categorised into Alluvial and Residual Soils.

Available Soils are classified into two categories.

a) **Recent Alluvial Soils (Entisols):** These occur in the valleys and form continuous sheet along the banks of streams and rivers. The soil comprises of clay, silt and sand and found mainly in the Dimapur valley.

b) **Older Alluvial Soils (Oxisol and Ultisol):** These are found to occur in the foothill areas and intermontane valleys. They are comprised of sand, gravel, pebble, boulder with clay, silt and their admixture. The foothill areas of Dimapur valley show abundance of Older Alluvial Soils.

Residual Soils are classified into following three groups – Lateritic Soils (Oxisol and Ultisol), Brown Forest Soils (Mollisol and Inception and Podzolic Soils (Spodisol).

Dhansiri, Diphu and Dayang rivers form the major drainage Sub-basins of the mighty Brahmaputra. These rivers are fed by a number of 2^{nd} and 3^{rd} order streams emerging from the hills in the south forming conspicuous dendritic pattern flowing to the north. A number of patches of swampy land are observed in the southeast and southwest parts of the area. Dhansiri flows through the south western part of the state through Rangapahar-Dimapur Plains of Dimapur District. This river receives almost all the western and southern drainages of Nagaland.

1.11 Drainage

Dhansiri, Diphu and Dayang rivers form the major drainage Sub-basins of the mighty Brahmaputra. Dhansiri flows through the south western part of the state through Rangapahar-Dimapur Plains of Dimapur District. Its main tributaries are river Dzuza and Diphu. These rivers are fed by a number of 2nd and 3rd order streams emerging from the hills aredendritic to sub-dendritic in the hilly terrain and locally is sub-parallel in the plains. A number of patches of swampy land are observed in the southeast and southwest parts of the area Dhansiri and Diphu (Chathe) rivers and their tributaries serve as the main source of water for irrigation and domestic purposes in Dimapur valley.Dhansiri river bed consists mainly of fine to sandy loam whereas the Diphu River bed id mostly made up of mantle of boulders, cobbles and gravels due to its fast flowing rate.

1.12 Geology

Geologically Dimapur district represents the frontal tract of Western Naga Thrust, striking in a NE-SW direction. The area is covered by Quaternary Alluvium and Tertiary rocks. The Quaternary sediments consist mainly of clays, sand and pebbles whereas the Tertiary rocks consist mainly of sandstones and shales. The thickness of Quaternary sediments gradually increases towards North West of Naga Hills. Present study covers the area having Quaternary deposit. Only one exploration could be carried out in Tertiary formation i.e. at Tenifi village. Geological map of the study area is shown in Fig.4.

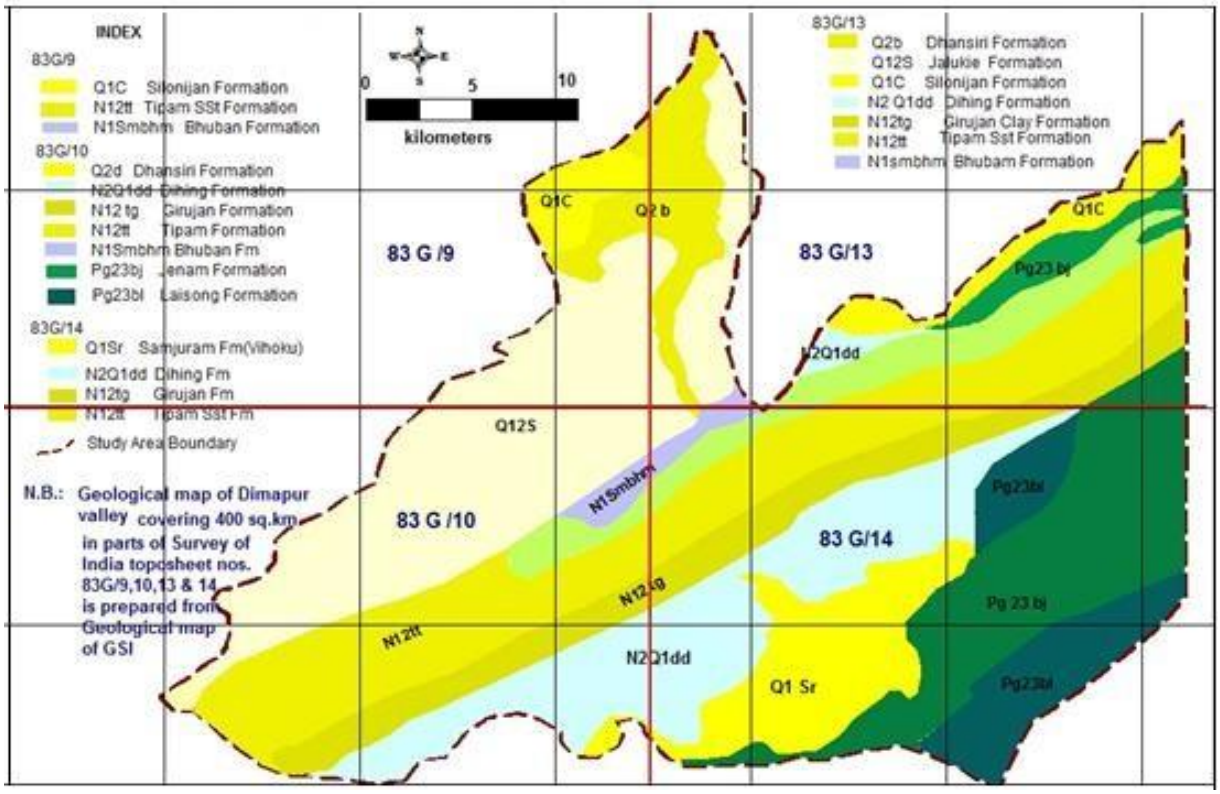


Fig.1.4: Geological map of Dimapur district

CHAPTER II

2.0 DATA COLLECTION AND GENERATION

2.1 Data Collection:

2.1.1 Exploration:

To know the aquifer disposition in the study area, exploratory wells data from DGM, Govt. of Nagaland were collected and utilized (**Table 2.1**).

Table: 2.1 Tube Wells constructed in the Dimapur Valley by DGM, Govt of Nagaland

Sl.No	Location	Depth (in m)	Discharge (LPM)	No. of Benefited persons (in No)	Remarks (6 hrs pumping/day)
1	Rangapahar Army Cantonment	131	166	1000	Drinking
2	Sericulture Dept.Signal	50	166	1000	Drinking
3	BSNL Complex Signal	190	107	500	Drinking
4	Industrial Estate	65	450	2000	Multi-purposed
5	Sewak Complex	126	88	700	Drinking
6	PHED Office Complex	53	416	1500	Drinking
7	Forest Colony	56	133	500	Drinking
8	DGM Colony _I	56	107	600	Drinking
9	DGM Office	57	50	400	Drinking
10	DMC Office Complex	61	466	2300	Drinking
11	Amar Flour Mill	78	650	3000	Drinking
12	Burma camp	104	333		Irrigation
13	Half Nagarjan	75	533		Irrigation
14	Power Grid Nagarjan	61	533	2500	Drinking
15	Lungwiram full Nagarjan	60	80	800	Drinking
16	Narhabri	30	85		Irrigation
17	ISBT Purana Bazar for NST	86	333	1700	Multi-purpose
18	Justice & Law Deptt, Purana Bazar	79	166	1000	Drinking
19	Doshehe Village-I	93	100	600	Drinking
20	Doshehe Village-II	120	166	1000	Drinking
21	Kushibill Village	97	533		Irrigation
22	Domokhia Village	90	159	900	Irrigation
23	Tolovi Village	67	450	2000	Multi-purpose
24	Solar Mill 4th Mile	85	220	900	Multi-purpose
25	NEZCC Complex	65	266	1000	Drinking
26	Model Village 5th Mile	85	220	900	Drinking
27	Tenephe Village	32	180	1000	Drinking
28	Seiruza Colony, Chumukedima	45	97	500	Drinking
29	ART Hospital Sokhuvi	100	95	800	Drinking

Source: DGM, Dimapur, Govt. of Nagaland

2.1.2 Cropping pattern and area under different crops (Rabi & Kharif)

Cropping pattern and area under different crops (Rabi & Kharif) are collected from Directorate of Agriculture, Kohima, Nagalnd. These information are utilized during preparation of ground water management plan using “CROPWAT”.

2.2 Data Generation

2.2.1 Exploration

In Dimapur valley, CGWB has drilled 11 EWs within a depth range of 100 to 301 m. A thin layer of discontinuous clay beds occur at surface all over the alluvial deposit ranging in thickness from 5 to 10 m. The tube wells drilled in alluvial deposits show alternate thick beds of sand, gravel and thin beds of clay. Exploration location with aquifer parameters are given in **Table.2.2**

Table.2.2 Exploration in Dimapur District, Nagaland.

SI No	Location	Block	Depth (m)	Latitude	Longitude	Drawdown (m)	Transmissivity (m2/day)	Storativity/ S.Yield	Specific Capacity (lpm/m of dd)
1	Puranabazar	Dimapur Sardar	300.0	26.92	93.76	11.5	301	$1.54 X 10^{-3}$	89.13
2	Lumithi colony	Chumukedima	300.0	25.89	93.73	24.9	4.75	$3.8 X 10^{-3}$	5.02
3	Rangapahar	Chumukedima	301.0	25.85	93.72	3.5	14.45	$3.18 X10^{-4}$	14.86
4	Disgapho	Dhansirpar	285.0	25.79	93.68	30.2	75.98	$1.14 X 10^{-3}$	13.97
5	Dhansirpar	Dhansirpar	301.0	25.79	93.63	18.79	13.66	$2.97 X 10^{-4}$	14.1
6	Diphupar	Chumukedima	300.0	25.86	93.77	14.81	112.74	$9.22 X 10^{-4}$	43.95
7	Tenyephe	Medziphema	100.0	25.75	93.77	28.91	8.9	$3.02 X 10^{-4}$	22.5
8	Sewak	Medziphema	104.4	25.91	93.72	8.99	45.01	$2.54 X10^{-4}$	22.5
9	Bade village	Dhansirpar	187.0	25.83	93.69	N.A	N.A	N.A	N.A
10	Dimapur stadium	Dimapur sardar	143.5	25.91	93.71	N.A	N.A	N.A	N.A
11	Bamunpukhuri-i village	Chumukedima	202.0	25.93	93.77	N.A	N.A	N.A	N.A

2.2.2 Water level

The main objective of the study is to delineate the horizontal and vertical disposition of aquifer as well as to study the aquifer character. In this connection 22 key wells including existing CGWB monitoring stations (dug well) were monitored in different season. Pre and post monsoon water level from NHNS atations and Key wells for NAQUIM is given in **table2.3** and **table2.4** respectively.

Table.2.3Depth to Water Level (in mbgl) for the NHNS stations in Dimapur valley

Sl. No.	Village	Well Type	Pre-monsoon	Post- monsoon
1	Dhansipar	Dug well	3.7	1.62
2	Doyapur DMC	Dug well	6.71	4.71
3	Maibiram GH	Dug well	4.95	2.4
4	Bade Bazar	Dug well	5.13	3.55
5	Singrijan	Dug well	6.4	3.58
6	ThilaxuBlk-II	Dug well	11.05	8.35
7	3 Mile Bazar	Dug well	12.9	4.35
8	Surja colony	Dug well	5.7	2.85
9	Chumukedema Bamboo Factory	Dug well	3.04	1.34
10	7th Mile colony	Dug well	11.54	5.43
11	Diphupar	Dug well	4.57	2.13
12	Zakesatho colony	Dug well	5.78	4.15
13	Rilayan colony	Dug well	20.3	3.73
14	Marwari Colony	Dug well	5.16	0.93

Table.2.4 Depth to Water Level (in mbgl) of Key wells in Dimapur valley

Sl.No	Location	Well Type	Pre-monsoon	Post-monsoon
1	Patkai Christian College	Dug well	1.48	1.81
2	Noune Resort	Dug well	4.51	4.34
3	Khehoyi village	Dug well	3.61	2.05
4	United village	Dug well	7.18	5.97
5	Medziphema	Dug well	5.77	5.62
6	Sovima Village	Dug well	4.97	4.96
7	Kevijau	Dug well	3.31	3.2
8	Khashiram	Dug well	1.29	1.08

2.3 Geophysical Study

Geophysical studies have been carried out in Dimapur valley. As part of the geophysical studies, Vertical electrical sounding (VES) have been conducted at 6 location of the valley by CGWB as per requirement of Aquifer mapping.

Interpretation of VES curves, correlation of the data with hydrogeological details of exploratory boreholes and taking into account the apparent resistivity following conclusions have been drawn in Dimapur valley.

i. The top soil with resistivity in the range of 30 and 260 Ohm with thickness within 10m comprises top soil with clays / hard clays etc.

ii. The underlying layers below the top soil in the depth below the top soil layer with varying resistivity within 60 Ohm m in general is indicative of sandy formation intercalated with clays / hard clays etc. Comparatively high resistivity above 100 Ohm m is indicative of the hard clay/semi-consolidated or consolidated formation.

2.4 Ground Water Quality

To know the water quality of the study area, water sampling done from both shallow and deeper aquifers. Twenty-three (23)key observation wells of the NAQUIM area in Dimapur valley have been selected for determination of chemical constituents in the existing ground water abstraction structures. The sampling sites are the major sources of drinking for the locals, which are dug well/deep tube well water samples. The analytical results of various parameters of water quality in the area are highlighted to integrate in the aquifer mapping. Various physico-chemical parameters viz., temperature, pH, total dissolved solids, electrical conductivity, alkalinity, hardness, nitrate, chloride, sulphate, fluoride, sodium, potassium and total iron content in the groundwater were analyzed. Among the various parameters recorded, the overall water temperature ranged from 21ºC to 24ºC; total dissolved solids from 39.70 mgL^{-1} to 626.8 mgL^{-1}; pH from 5.25 to 8.5; electrical conductivity varied from 79.10 µs cm^{-1} to 949.80 µs cm^{-1}; chloride values ranged from 13.8 mgL^{-1} to 198.5 mgL^{-1}; total alkalinity varied from 10.0 mgL^{-1} to 375 mg L-1; total hardness ranged from 25.0 mgL^{-1} to 727.3 mgL^{-1}; sulphate values ranged from 1.46 mgL^{-1} to 78.62 mgL^{-1}; nitrate from 0.1 mgL^{-1} to 11.87 mgL^{-1}; fluoride values ranged from 0.02 mgL^{-1} to 6.3 mgL^{-1}; sodium varied from 1.84 mgL^{-1} to 99.61 mgL^{-1}; potassium value ranged from 0.85 mgL^{-1} to 32.93 mgL^{-1}; while iron values varied from 0.02 mgL^{-1} to 1.99 mgL^{-1}. Water sample analyzed from exploratory wells at Dhansiripar, Purana Bazar, Rangapahar and Lumthi colony shows concentration of iron is at 1.99 mgL^{-1}, 0.5 mgL^{-1}, 1.38 mgL^{-1} and 1.27 mgL^{-1} respectively. Chemical quality data of ground water samples collected are given in **Annexure I.**

2.5 Soil Infiltration Studies

The salient features of the soil infiltration and its summary is given in **table 2.6** and **table 2.5** respectively. 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 and sandy loam. In general, infiltration test was conducted for duration of130 minutes.

Table 2.5: Salient features of the soil infiltration test sites

Site	Location	Land use	Soil type	Latitude	Longitude
1	Bible college, Rangapahar	Open area	Sand	26˚48′46″	94˚35′43.3″
2	Star ex kindergarden, Seithekema	Open area	Sandy loam	26^{o}03’50	94^{o}34’57”

Table 2.6: Summary of Infiltration Tests

S.N.	Site	Land use	Soil type	Duration of test (min)	Total Quantum of water added in m	Infiltration rate (m/hr)
1	Bible college, Rangapahar	Open area	Sand	130	0.524	0.078
2	Star ex kindergarden, Seithekema	Open area	Sandy loam	130	0.500	0.031

CHAPTER III

3.0 DATA INTERPRETATION, INTEGRATION AND AQUIFER MAPPING

3.1 Ground Water Exploration

In Dimapur valley, CGWB has drilled 11 EWs within a depth range of 100 to 300 m. The exploration reveals presence of unconsolidated alluvial aquifer down to the explored depth of 301m bgl.

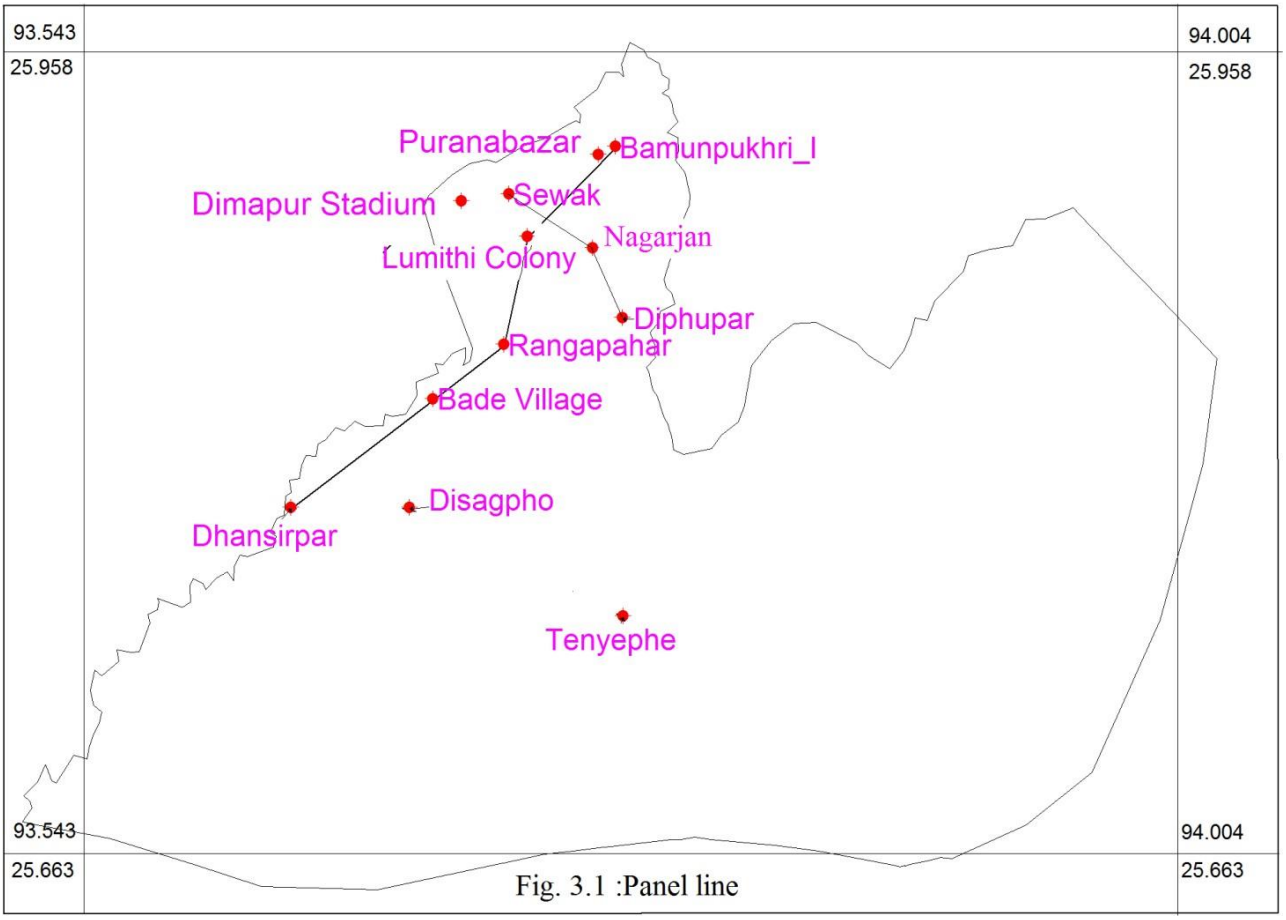


Fig. 3.1 :Panel line

It can be deciphered from the available data that a thin layer of discontinuous clay beds occur at surface all over the alluvial deposit ranging in thickness from 5 to 10 m. The tube wells drilled in alluvial deposits show alternate thick beds of sand, gravel and thin beds of clay. Some of the exploration findings are as under:

The aquifer is comprised mainly of medium to coarse sand. Within 50 m depth, assorted pebble/boulder in matrix of sand/clay/silt is predominant in south-central part extending to east. Clay intercalation between granular zones often misguides to interpret the aquifer into a multiple aquifer system. These clay beds are mostly in lensoid shape and pinches out within a short distance. Location of the exploratory wells showing panel line is given in **Figure 3.1**. 2D aquifer disposition is given in **Fig.3.2** and 3D aquifer disposition is shown in **Fig.3.3**.

Fig.3.2: Aquifer disposition along : Bamunpukhuri –Dhansiripar

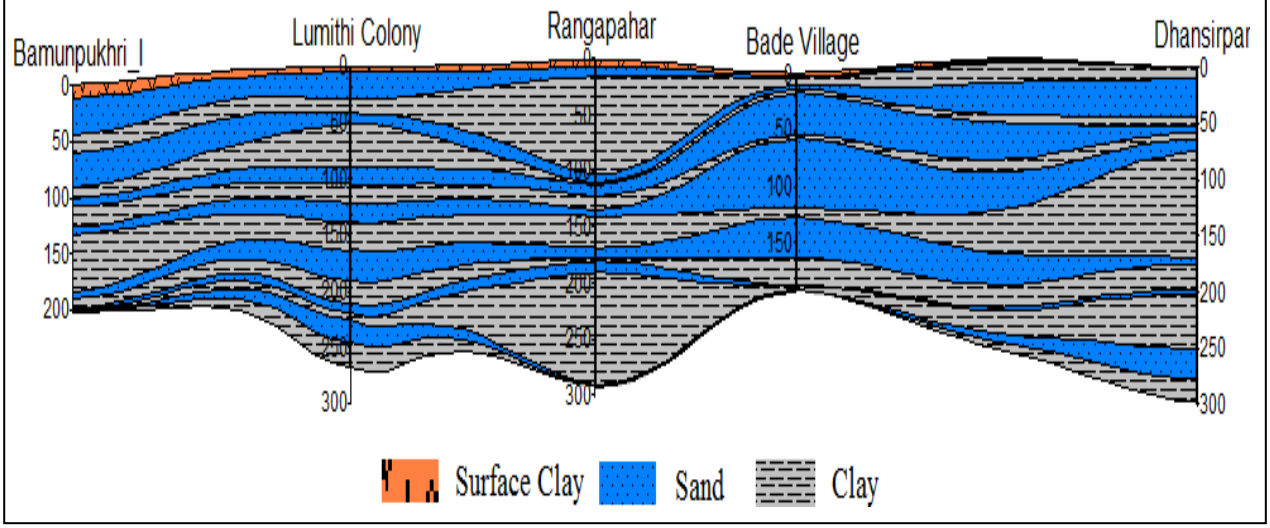
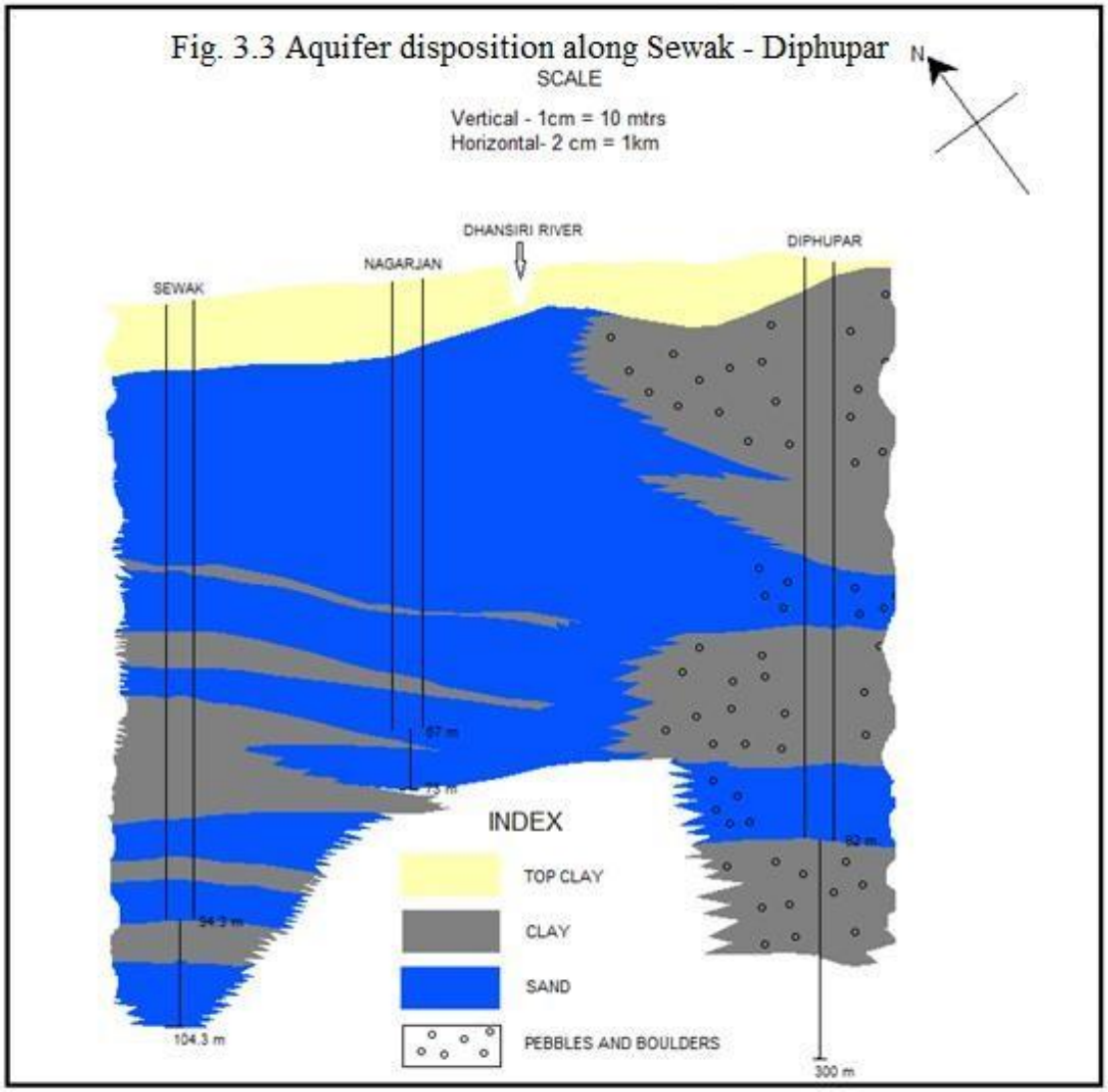
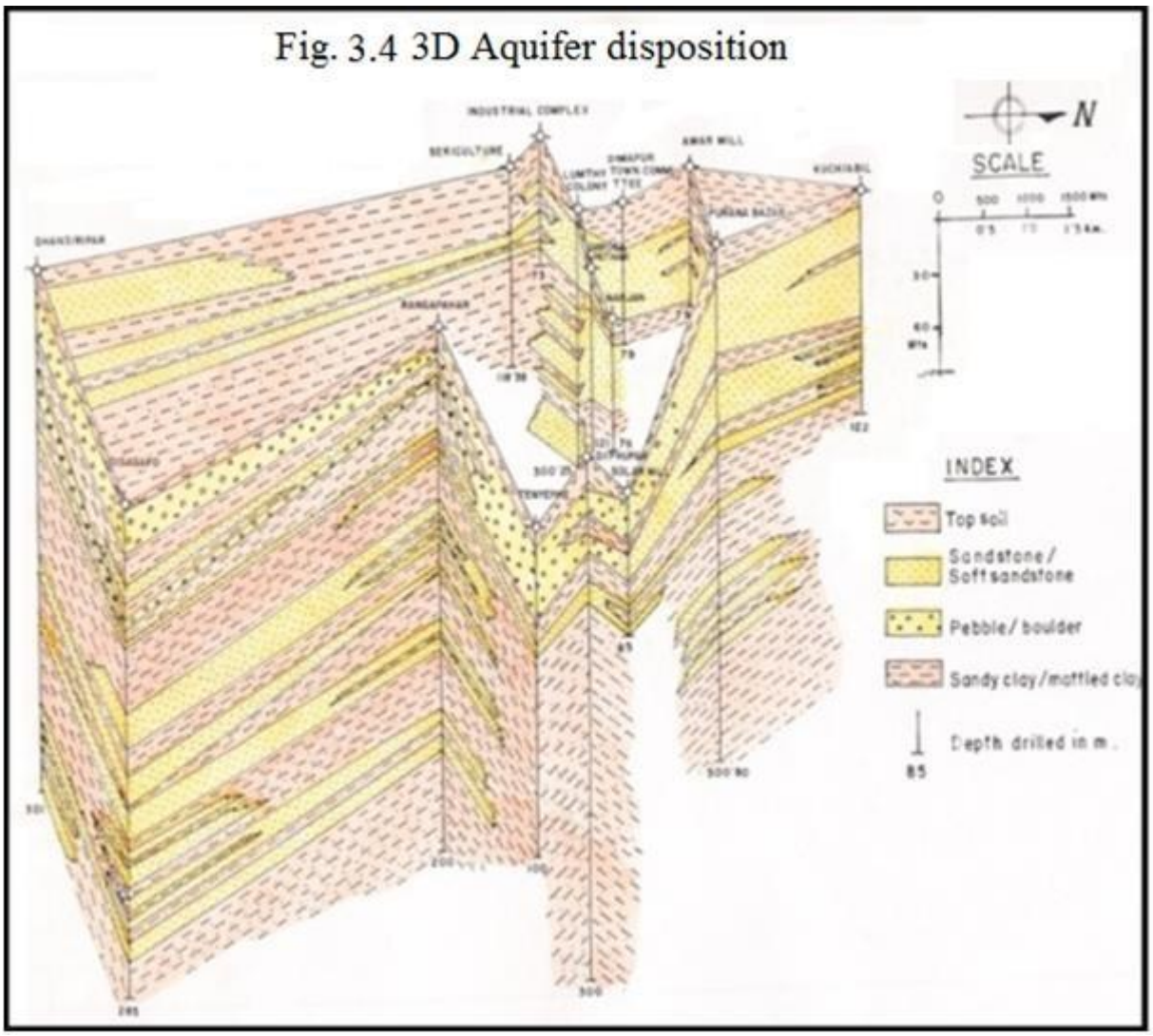


Fig. 3.3 Aquifer disposition along Sewak - Diphupar





- The yield of the exploratory tube wells constructed by CGWB ranges from 2 to 476.93 m^3/hr for a drawdown of 3.18 to 46 m. Auto flow wells constructed by CGWB at Lumthi Colony and Rangapahar yields 3.5-24.9 m^3/hr
- Transmissivity ranges from 13.66 -450 m^2/ day, permeability ranges from 0.07-158.40 m/day, Specific capacity ranges from 0.014-165 lpm/m and Storage co-efficient ranges from 1.53 X 10^{-3} to 9.22 x 10^{-4}
- From the grain size analysis data the following inferences can be drawn:
  Grain sizes of the aquifers are mostly of finer nature. Due to the finer nature of the aquifer material, the slot size of the wells to be constructed in the area should be of 0.50 – 0.75 mm. Artificial gravel packing is necessary to arrest the sand ingress into the well. However, within the depth range of 30-50 m bgl, heterogeneous assemblages of sediments are prevalent. Distribution of granular zones is given in **Table.3.1**

Table.3.1Distribution of granular zone in various depths

Depth Range	Within 50 m	50 - 100 m	100– 200 m	200 – 300 m
Thickness of Granular zone	8-46 m	10 – 64 m	8 – 57 m	Up to 47 m

- Drilling samples are utilized for sieve analysis to analyze slot size requirement. Grain size analysis data is given in **Table.3.2.**Grain size analysis of the aquifer material shows that the

samples are mostly of finer nature. Due to the finer nature of the aquifer material, the slot size of the wells to be constructed in the area should be of 0.50 – 0.75 mm. Artificial gravel packing is necessary to arrest the sand ingress into the well. However, within the depth range of 30-50 m bgl, heterogeneous assemblages of sediments are prevalent.

Table.3.2Grain size analysis of the aquifer material

Sl No	Location	Effective size (mm)	Slot size (mm)	Uniformity co-efficient	Aquifer character
1	Dhansiri	0.025 - 0.072	0.16 – 0.54	0.29	Uniformly fine
2	Disagafo	0.039 – 0.07	0.25 – 0.57	0.16	Uniformly fine to very fine
3	Rangapahar	0.024 – 0.052	0.106–0.15	0.34	Uniformly fine to very fine
4	Lumthi Colony	0.085 – 0.175	0.158–1.65	0.22	Uniformly fine to very fine
5	Purana Bazar	0.10 – 0.22	1.00 – 1.59	0.14	Uniformly fine to very fine
6	Sewak	0.06 – 0.17	0.19 – 0.33	2.60	Uniformly fine to very fine

3.2 Depth to Water level

In the dug wells water level ranges from 1.29 to 20.03 m bgl during pre-monsoon and from 0.93 to 8.35 m bgl during post-monsoon period. The Pre and post monsoon depth to water level is shown in figure3.5 and figure 3.4.

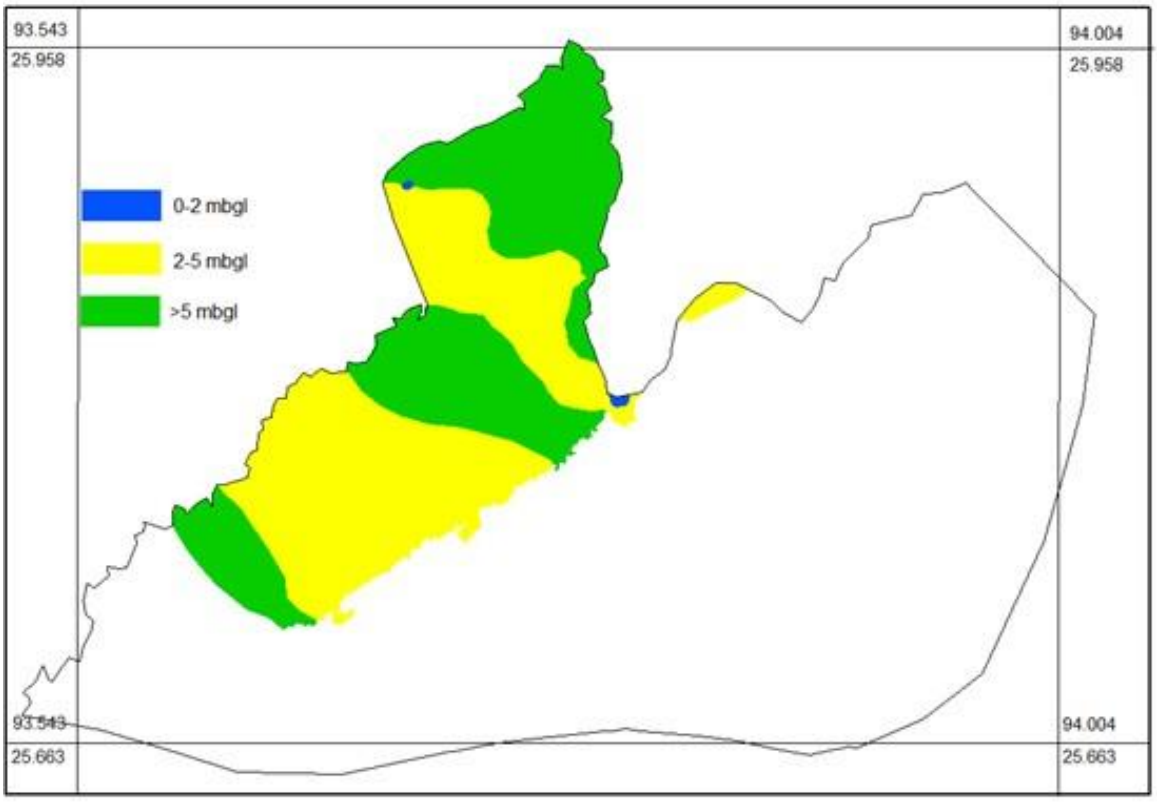


Fig.3.5: Pre-monsoon depth to water level map

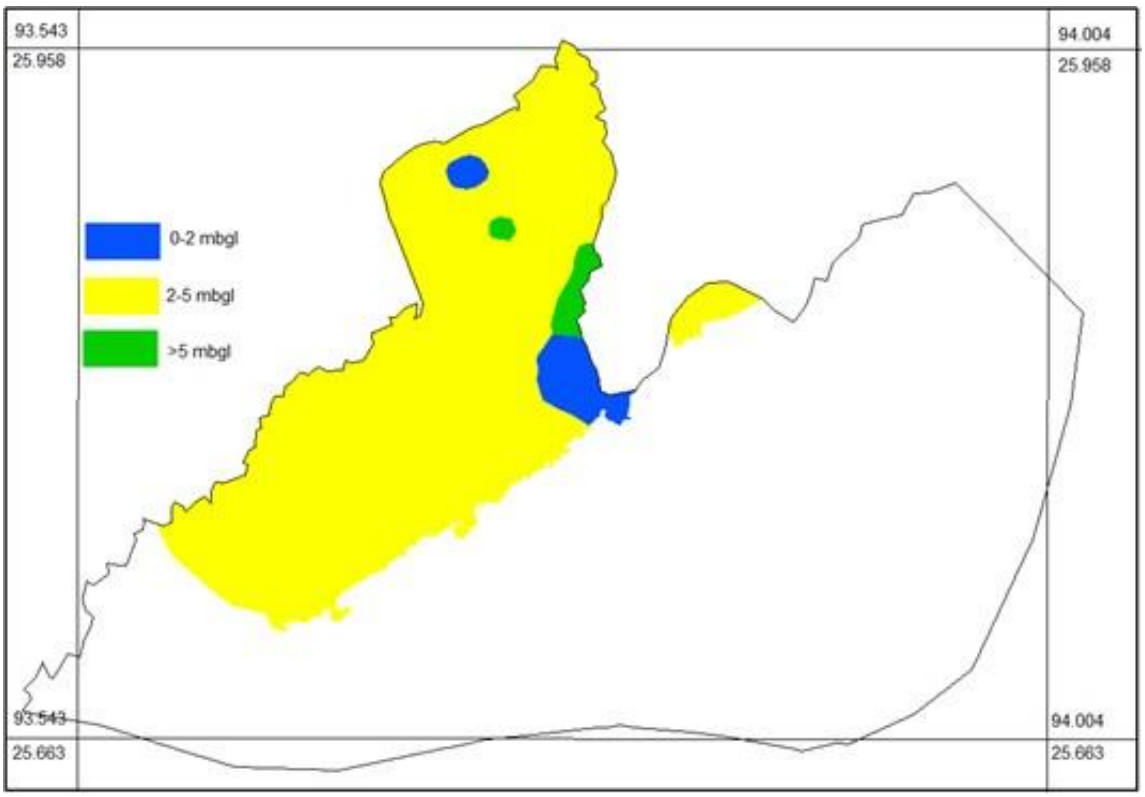


Fig.3.6: Post-monsoon depth to water level map

3.3Ground water flow direction

Ground water flow is from SE to NW in the south-eastern part with a gradient of 8.55 m/km up to Diphupar-Rangapahar area. Towards west in Doyapur-Dhansiripar area the gradient is around 2.55 m/km and is prevalent up to Rangapahar. From Rangapahar to NE part of the valley, the gradient is approximately 1.54 m/km. The changes in gradient reflect the inherent character of sub-surface litho-formations which bear importance in recharge-discharge conditions of the area. In Dhansiri river area the ground water flow is influent in nature whereas it shows effluent nature in Diphupani area. Disposition of granular zones encountered in exploratory well in Dimapur valley is depicted in panel diagram.

3.4 Ground water quality

- ✓ In general, ground water of the study area is slightly alkaline to neutral in nature.
- ✓ Electrical conductivity & total dissolved solids are within the permissible limit.
- ✓ Fluoride content beyond permissible limit is found from wells nearPatkai Christian College, Khehoyi village and at United village (in the shallow zones). These areas are closer to KarbiAnglong district of Assam.
- ✓ Iron content beyond permissible limit observed both in Shallow and deeper aquifers.

The Chemical quality map showing the distribution of fluoride (F) and iron (Fe) in sampling points are illustrated in Figure 3.7.

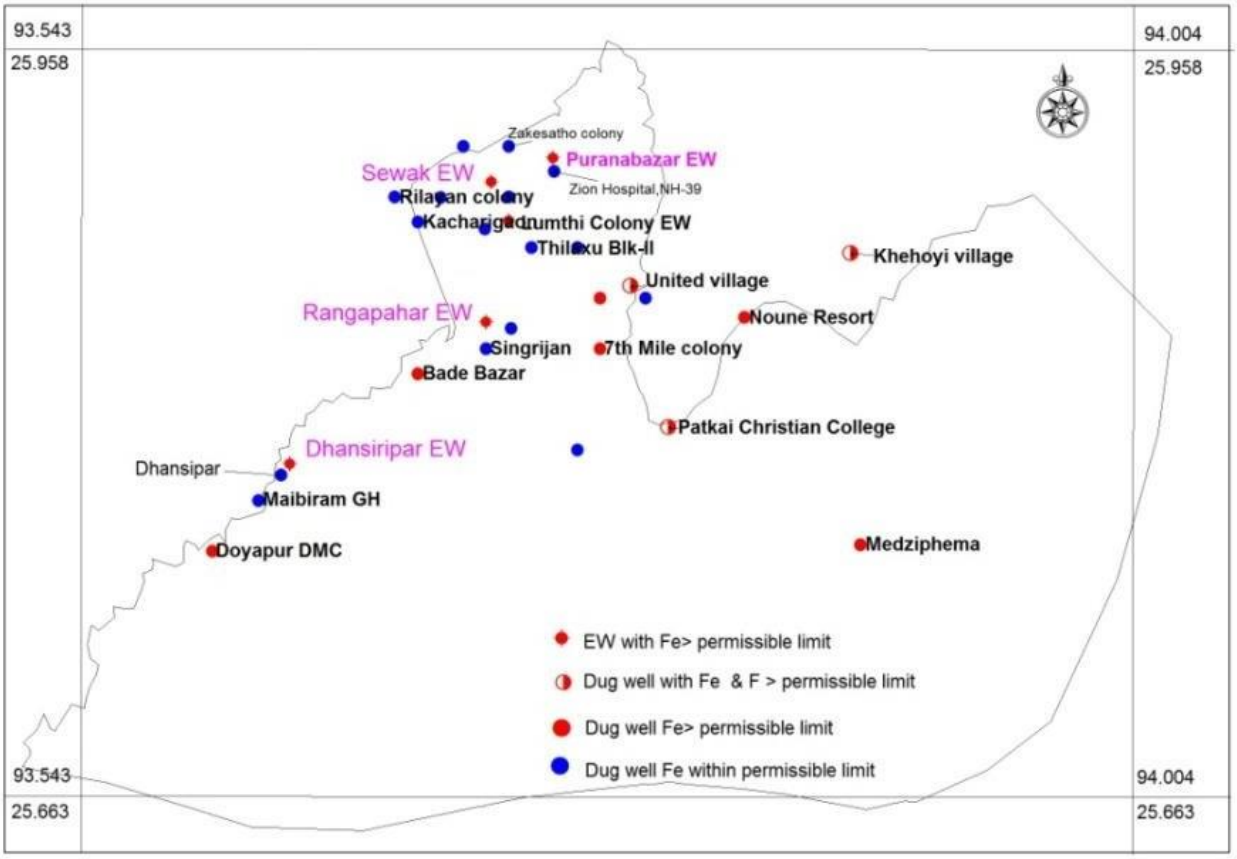
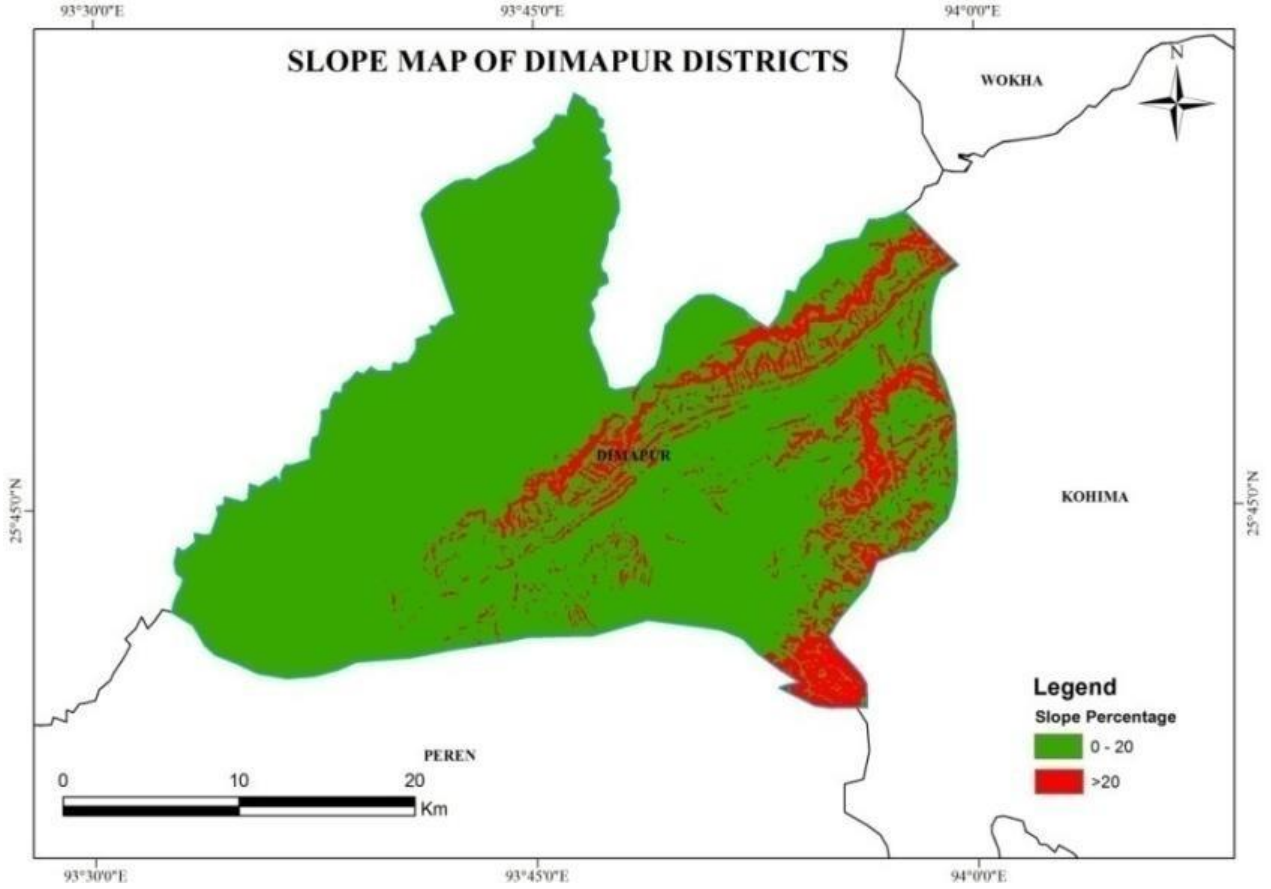


Fig.3.7: Distribution of Fluoride & Iron in ground water samples, Dimapur district

CHAPTER IV

4.0 GROUND WATER RESOURCES

Ground water resource of the district has been estimated based on GEC'2015 methodology. For obtaining the rechargeable area hilly areas having slope more than 20% are deducted from the total area to get the area suitable for recharge.



Since there is no saline/ brackish water infested area in the Aquifer Mapping area, the entire assessment area has been considered as fresh water bearing area.

Groundwater recharge: The resources assessment during monsoon season is estimated as the sum total of the change in storage and gross draft. The change in storage is computed by multiplying water level fluctuation between pre and post monsoon periods with the area of assessment and specific yield. During non-Monsoon season, rainfall recharge is computed by using Rainfall Infiltration Factor (RIF) method. Recharge from other sources is then added to get total non-Monsoon recharge.

Groundwater extraction: Extraction for domestic, industrial and irrigation sectors are estimated based on guidelines as recommended in the GEC'2015.

Allocation of ground water resource for utilization: The net annual ground water availability is to be apportioned between domestic, industrial and irrigation uses. Among these, as per the National Water Policy, 2012, requirement for domestic water supply is to be accorded priority. The ground water requirement for domestic water supply is to be kept based on projected population to 2025. The GEC' 15 methodology provides following empirical formula for allocation of ground water for domestic requirement

$$A = 22 * N * L_g$$

Where,

A = Allocation for domestic in mm/year.

N = Projected Population density in assessment unit in thousands per square kilometer.

L_g= Fractional Load on ground water for domestic and industrial water supply

(≤ 1.0)

The net ground water available for future use is obtained by deducting the allocation for domestic use and current extraction for Irrigation and Industrial uses from the Annual Extractable Ground Water Recharge.

A salient finding of the ground water resource of the study area is given in **Table 4.**

Table.4. Ground water resource as on March 2017 and availability for future use

Annual Extractable Ground Water Resource (in hectare meters)	Existing Ground Water extraction for Irrigation (in hectare meters)	Stage of Ground Water development (%)	Current annual gross ground water extraction for all uses (in hectare meters)	Annual GW Allocation for Domestic Use upto 2025 (in hectare meters)	Net Ground Water Availability for future use (in hectare meters)
11866.194	208.84	8.12	963.38	893.85	10762.93

CHAPTER V

5.0 GROUND WATER RELATED ISSUES

5.1 Identification of issues

Major groundwater related issues found in the study area are:

- Low stage of development. Infrastructure for irrigation in the study area is very meager. Rain fed agriculture is practiced in the area and the groundwater withdrawal for irrigation purpose is practically nil.
- In places, high concentration of iron beyond permissible limit in the groundwater.

5.2 Future demand scenario and stress aspects of the aquifer

Domestic Water Supply Demand: Future demand of water in the area will mainly come from domestic sector. Public Health Engineering Department supplies water using both surface and ground water sources.

Current demand of ground water in domestic sector is 753.97ham. Water demand in this sector is calculated by projecting the population upto 2025 and allocating 60lpcd water. The ground water demand is found to be 893.85 ham up to 2025. The demand of water in 2025 is also calculated by allocating 135lpcd water and demand rises to 2011ham.

5.3 Future demand for agriculture

Future demand of water for agriculture is estimated in the present analysis by projecting the cropping intensity upto 200%. As per 2011 agricultural census net sown area in the district is 58346 ha while irrigated areais 357.05 ha.The present analysis estimated water requirement in agriculture to increase the cropping intensity to 200% by providing assured irrigation in agricultural field. The whole calculation for projection of cropping intensity to 200% is carried out by use of Cropwat 8.0 software of FAO.

The main crop of the district is paddy and about 65% of the net sown area is occupied by paddy cultivation. Other cultivation aremustard, maize, pulses, potato etc. The common cropping sequence is rice followed by Rabi Vegetables and in some parts Rape & Mustard. The present season wise cropping pattern of the district is shown in Table 6.1.

5.4 Stress Aspects of aquifer

The stress aspects of aquifer is worked out after finding water requirement in various sector and comparing the requirement with allocation of dynamic groundwater in various sector up to 2025.

Therefore the water requirement for the area can be summed up as follows (**Table. 5.1**):

Table 5.1: Water requirement for all sectors

Drinking water requirement up to 2025 (ham.)	Water requirement to increase the cropping intensity to 200% (ham.)	Water allocated for domestic purposes up to 2025(ham.)	Water allocated for future use up to 2025 (ham.)
893.85	8772.00	893.85	10762.93

5.5 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. Irrigation water demand can suitably be met from future allocation of resources. Details of supply gap analysis for drinking water and for irrigation are given in Table**. 5.2& 5.3** respectively.

Table 5.2: Supply and demand gap in drinking water sector

Drinking water demand up to 2025 Ham	Water allocated for drinking and domestic purposes up to 2025 Ham	Gap between supply and demand (+ve for surplus supply and –ve for deficit supply) Ham
893.85	893.85	No shortage

Table 5.3: Supply and demand gap in irrigation

Total irrigation demand Ham	Water allocated for irrigation up to 2025 Ham	Gap between supply and demand (+ve for surplus supply and –ve for deficit supply) Ham
8772	10762.93	(+) 1990.93

CHAPTER VI

6.0 MANAGEMENT STRATEGIES

Dimapur district has extractable ground water resource of11,866 ham and its stage of ground water development is 8.12% (As per ground water resource estimation 2017). The district has a balance of 10,762.93 ham ground water availability for future use. From the available resource (planned for future development) 5483 nos. of tube wells (considering a unit draft of 1.6 ham/year) can be constructed. Therefore, there is enough scope for future development of ground water in the study area to bring more area under irrigation practice.

Present minor irrigation schemes are using surface water sources only and irrigation from ground water sources is almost nil. Hence, there is ample scope for ground water development for irrigation purpose which will bring prosperity to the society and help the district in achieving self-reliance on food grain. To use the groundwater for irrigation purposes a cropping plan has been designed for the district by using CROPWAT model developed by FAO. A suitable cropping plan for the district was prepared in consultation with Water Management Division of ICAR. Cropping pattern data for the district is presented in **Table 6.1**.

During 2010-11(Source: Agricultural Census: 2010-11), net sown area in the district is 58346 ha and cropping intensity is 114%. The net sown area included field crops as well as horticulture and plantation crops cultivated on hills and their slopes. Again crops grown on Dimapur hills like pineapple, turmeric and ginger are having negligible or nil irrigation requirements. During kharif season, paddy is cultivated in 37,100ha. After Kharif crops are over major portion of this area remains fallow during Rabi season. The purpose of this plan is to utilize the fallow land (total kharif crops area is 37,100 ha and total rabi crops area is 12,900 ha) of about 24200 ha under assured irrigation during Rabi season which will help to increase gross cropped area to 48400 ha and thereby increase cropping intensity up to 200%. In rice fallow, mustard, maize, pulses, potato and small vegetables can be grown with the support of irrigation. Present cropping pattern, proposed cropping pattern, targeted increase in cropping intensity were shown in **Table 6.2.& 6.3**

Crop-wise and month-wise precipitation deficit has been estimated using CROPWAT after giving necessary meteorological, soil, crop plan inputs given in **Table 6.4**. Crop-wise and month-wise Irrigation water deficit and requirement in ham has been further calculated in **Table 6.5**.

Table 6.1: Cropping pattern of Dimapur district, Nagaland

CROPPING PATTERN DATA

Cropping pattern name: dimapur

No.	Crop file	Crop name	Planting date	Harvest date	Area %
1	...Data\CROPWAT\data	Rice	01/06	28/09	13
2	...Data\CROPWAT\data	Rice	09/06	06/10	12
3	...Data\CROPWAT\data	Rice	17/06	14/10	13
4	...Data\CROPWAT\data	Rice	25/06	22/10	12
5	...UR\CROPWAT1111\cr	MAIZE (Grain)	30/10	03/03	10
6	...CROPWAT1111\crops	Rape & mustard	09/11	18/03	10
7	...CROPWAT1111\crops	Rape & mustard	18/11	27/03	10
8	...\CROPWAT1111\crop	Pulses	28/12	16/04	10
9	...ROPWAT1111\crops\	Small Vegetables	08/12	12/03	5
10	...\CROPWAT1111\crop	Potato	16/12	24/04	5

Source: CROPWAT

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

Cropping pattern (s)				
Rice based cropping pattern				
1. Rice- Maize 2. Rice- Mustard 3. Rice-Pulses 4. Rice- Vegetables 5. Rice- Potato	Present Cultivated area (**ha**)	Area to be cultivated (**ha**)	Area to be cultivated (**%**)	Irrigation requirement (**ha m**)
	1	2	3(= % of 1)	4
Rice (main crop)	24200	24200		3962
Maize	0	4840	20	653
Rape & Mustard	0	9680	40	1346
Pulses	0	4840	20	632
Small Vegetables	0	2420	10	331
Potato	0	2420	10	385
Net cultivated area	24200	**24200**		
Gross cultivated area (1+maize/+ mustard /+ pulses/+ Veg /+potato)		**48400**		
Total irrigation requirement				7309
Cropping intensity	**100% (Present)**	**200% (Intended)**		
Total (Dimapur district)	Considering irrigation efficiency as 80 %			8772

Table 6.3. Proposed cropping pattern with water deficit months and IWR, Dimapur district

Rice based cropping pattern			
Crop	**Growing period (Months)**	**Periods/months of water deficit**	**Irrigation requirement (ha m)**
Rice	4	2	3963
Maize	4	5	653
Rape & Mustard	6	5	1346
Pulses	4	5	632
Small Vegetables	3	4	331
Potato	5	5	385
		Total	7310
	Considering irrigation efficiency as 80 %		**8772**

The total area of rice cultivation is comprised of (24200 ha) 50 % of the targeted cultivated area of 48400 ha. During kharif season, rice is cultivated from June to mid-July. Since this huge area cannot be cultivated in a single day (one planting date), so it is considered/ planned to cultivate rice in four stages (two stages covering 12% each and another two stages covering 13% each) during this period.

Potato and mustard cultivation are done in the month of November-December to March-April, pulses are cultivated during October to November. Vegetables are cultivated from September to December and again from February to April.

The plan is to utilize rice fallow of 24,200 ha for the cultivation of maize, potato, mustard, pulses and vegetables. It is contemplated to cultivate mustard in an area of 9,680 ha mustard, maize and pulses in an area covering 4,840 ha each and Potatoes and vegetables in an area of 2420 ha each.

The peak water requirement for irrigation of rice is in the month of June, for potato it is in the month of March and for mustard, pulses during the month of March and vegetables the peak requirement is in the month of February.

Table 6.4: Crop-wise and month-wise precipitation deficit (mm) using CROPWAT 8 for Dimapur district

Crop	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Precipitation deficit												
1. Rice	0	0	0	0	204.7	0	0	0	0	0	0	0
2. Rice	0	0	0	0	49	98	0	0	0	0	0	0
3. Rice	0	0	0	0	50.3	98	0	0	0	0	0	0
4. Rice	0	0	0	0	0	147.1	0	0	0	5.7	0	0
5. MAIZE (Grain)	53.6	29.4	0	0	0	0	0	0	0	1.8	5.7	44.4
6. Rape & mustard	49.4	48.9	8.2	0	0	0	0	0	0	0	5.9	25.2
7. Rape & mustard	45.4	51.1	22.7	0	0	0	0	0	0	0	4.8	16.4
8. Pulses	14.5	48.6	63.5	0.7	0	0	0	0	0	0	0	3.2
9. Small Vegetables	40.6	47.4	22.3	0	0	0	0	0	0	0	0	26.6
10. Potato	25.5	52.3	62.7	8.4	0	0	0	0	0	0	0	10

Table 6.5: Irrigation water requirement (ham) of Dimapur district

Crop	% of total area of 48400 ha	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1. Rice	13	0	0	0	0	1287.972	0	0	0	0	0	0	0	1287.972
2. Rice	12	0	0	0	0	284.592	569.184	0	0	0	0	0	0	853.776
3. Rice	13	0	0	0	0	316.4876	616.616	0	0	0	0	0	0	933.1036
4. Rice	12	0	0	0	0	0	854.3568	0	0	0	33.1056	0	0	887.4624
5. Maize (Grain)	10	259.424	142.296	0	0	0	0	0	0	0	8.712	27.588	214.896	652.916
6. Rape & mustard	10	239.096	236.676	39.688	0	0	0	0	0	0	0	28.556	121.968	665.984
7. Rape & mustard	10	219.736	247.324	109.868	0	0	0	0	0	0	0	23.232	79.376	679.536
8. Pulses	10	70.18	235.224	307.34	3.388	0	0	0	0	0	0	0	15.488	631.62
9. Small Vegetables	5	98.252	114.708	53.966	0	0	0	0	0	0	0	0	64.372	331.298
10. Potato	5	61.71	126.566	151.734	20.328	0	0	0	0	0	0	0	24.2	384.538
Total	**100**	**948.398**	**1102.794**	**662.596**	**23.716**	**1889.052**	**2040.157**	**0**	**0**	**0**	**41.8176**	**79.376**	**520.3**	**7308.206**

The combined analysis of the groundwater exploration data of CGWB, NER and DGM, Nagaland in the district has established that the aquifer in most parts the district is having low to moderate potentiality, having an average discharge of about 23 m^3/hr and can be sustainably developed and used for irrigation purposes.

The ground water potentiality of the area is low to moderate, especially in the low-lying valley areas which are feasible for sustainable ground water development. Therefore, those areas can be brought under irrigation by developing ground water through bore wells or large diameter dug wells.

A tube well in the area is expected to yield 20 m^3/hr. If such a tube well runs for 8hrs/day for 100 days, then it will create a draft of 1.6 ham. Tube wells can be designed within a depth of 80m.

In the considered net sown area of 24,200 ha, 5483 nos. of tube wells can be constructed. It is recommended to keep at least 200m safe distance between any two tube well.

Annual irrigation water requirement is 8772 ham while irrigation water requirement during dry season spanning from October to March is 3347 ham and considering 80 % irrigation efficiency the requirement becomes 4184 ham. Annual extractable resource available for future use is10,762.93ham which is enough to provide irrigation for the area under consideration as per the proposed cropping plan.

Conjunctive use of surface and ground water is highly recommended. Groundwater development may be regulated by permitting development only in the areas where water supply from surface water source is not sufficient. Further, rainwater harvesting techniques should be encouraged and brought to practice.

Annexure I

Ground Water Quality of shallow aquifer (Dug well), Dimapur District, Nagaland

Sl. No.	Village	Well Type	PH	EC (mS/cm)	TDS	TH	Ca	Mg	Na	K	CO_3	HCO_3	SO_4	NO_3	Cl	F	Fe
					← mg/litre →												
1	Dhansiripar	DW	7.50	107.00	60.00	92.00	12.80	14.56	33.10	2.04	BDL	120.0	5.38	1.40	9.93	0.20	0.56
2	Doyapur DMC	DW	7.14	162.80	107.45	68.05	10.21	10.32	239.0	3.73	BDL	575.0	1.84	3.83	39.00	0.23	1.16
3	Maibiram GH	DW	7.50	255.50	168.63	114.84	17.01	17.55	20.17	1.93	BDL	120.00	15.20	0.90	21.27	0.53	0.31
4	Bde Bazar	DW	6.71	184.40	121.70	76.56	18.71	7.23	34.36	2.38	BDL	30.00	52.00	1.21	42.54	0.21	1.07
5	Singrijan	DW	7.42	123.10	81.25	68.05	13.61	8.26	8.89	3.51	BDL	30.00	20.72	3.00	24.82	0.23	0.47
6	ThilaxuBlk-II	DW	7.43	363.50	239.91	195.66	49.34	17.55	14.14	3.71	BDL	70.00	71.85	9.94	49.63	0.25	0.05
7	Kacharigaon	DW	7.10	312.00	174.00	156.00	35.20	16.50	84.20	9.52	BDL	68.00	12.11	3.90	198.50	0.35	0.04
8	3 Mile Bazar	DW	7.79	949.80	626.87	727.33	85.07	124.92	1.84	1.66	BDL	80.00	78.62	11.87	184.34	0.71	0.37
9	Surja colony	DW	7.27	482.30	318.32	165.88	22.12	26.84	43.33	10.52	BDL	20.00	66.85	9.75	116.99	0.25	0.02
10	Chumukedema Bamboo Factory	DW	7.19	636.90	420.35	263.71	52.74	32.00	19.88	1.36	BDL	75.00	21.80	6.61	134.71	0.21	0.15
11	7th Mile colony	DW	6.68	232.20	153.25	63.80	8.51	10.32	40.26	19.94	BDL	15.00	67.79	10.06	49.63	0.22	1.06
12	Diphupar	DW	7.28	588.20	388.21	127.60	28.92	13.42	99.61	6.35	BDL	30.00	63.14	3.52	159.53	0.28	0.05
13	Zakesatho colony	DW	7.91	663.20	437.71	204.16	45.94	21.68	45.93	32.93	BDL	130.00	73.89	3.92	92.17	0.57	0.23
14	Rilayan colony	DW	8.10	357.30	235.82	216.92	68.05	11.36	7.23	7.67	BDL	115.00	57.97	5.29	42.54	0.32	0.10
15	ThilaxuBlk-II	DW	6.80	255.40	130.60	60.00	18.00	3.64	9.85	19.39	BDL	50.00	1.99	4.50	35.45	0.49	0.06
16	Patkai Christian College	DW	8.27	604.60	319.60	190.00	42.00	20.63	31.01	30.91	BDL	335.00	9.10	0.50	21.27	3.30	0.77
17	Noune Resort	DW	8.06	207.00	136.62	65.00	18.00	4.85	3.81	2.98	BDL	65.00	4.91	1.90	17.73	0.68	1.08
18	Khehoyi village	DW	8.50	440.90	290.99	125.00	26.00	14.56	23.11	32.93	40.00	155.00	4.62	0.50	31.91	6.30	1.15
19	United village	DW	8.10	295.80	195.23	90.00	28.00	4.85	4.38	1.67	BDL	65.00	11.47	1.00	24.82	1.50	1.10
20	Medziphema	DW	5.87	184.10	121.51	25.00	4.00	3.64	12.53	1.06	BDL	20.00	17.81	3.10	14.18	0.49	1.40
21	Sovima Village	DW	6.78	166.50	109.89	55.00	20.00	1.21	3.56	28.89	BDL	95.00	2.67	1.50	14.18	0.16	0.61
22	Kevijau	DW	7.42	209.30	138.14	50.00	8.00	7.28	18.80	12.27	BDL	65.00	3.67	1.30	35.45	0.28	0.10
23	Khashiram	DW	7.04	534.30	352.64	80.00	22.00	6.07	48.86	4.58	BDL	10.00	52.62	8.10	74.45	0.74	0.04

Annexure II

Ground Water Quality of deeper aquifer (Tube well), Dimapur District, Nagaland

Sl. No.	Village	Well Type	PH	EC (mS/cm)	TDS	TH	Ca	Mg	Na	K	CO_3	HCO_3	SO_4	NO_3	Cl	F	Fe
					← mg/litre →												
27	Dhansiripar-EW	EW	8.30	251.00	145.00	56.00	4.80	10.60	35.30	2.87	16.00	124.00	2.71	BDL	13.80	0.17	1.99
28	Lumthi Colony-EW	EW	8.10	110.60	55.40	68.00	20.80	3.88	36.80	6.30	0.00	44.00	1.77	BDL	43.99	0.57	1.66
29	Purana Bazar-EW	EW	8.05	79.10	39.70	84.00	20.80	7.77	8.04	3.40	24.00	48.00	1.46	BDL	14.00	0.59	BDL
30	Rangapahar-EW	EW	7.80	417.40	238.90	90.00	20.00	9.71	29.64	12.87	0.00	40.00	20.47	0.10	82.47	0.11	1.38
31	Sewak-EW	EW	5.25	114.80	75.77	38.28	6.81	5.16	27.08	0.85	BDL	40.00	2.15	4.83	42.54	0.02	1.27

EW : Exploratory Well