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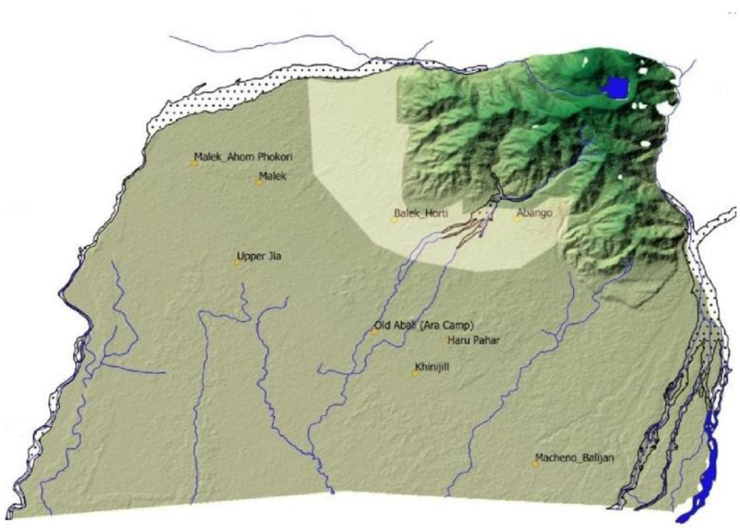
AQUIFER MAPPING REPORT OF PART OF LOWER DIBANG VALLEY DISTRICT, ARUNACHAL PRADESH

ANNUAL ACTION PLAN 2017-18



GOVERNMENT OF INDIA

भारत सरकार

MINISTRY OF JAL SHAKTI

जल शक्ति मंत्रालय

Department of Water Resources, River Development and Ganga Rejuvenation

जल संसाधन, नदी विकास और गंगा संरक्षण विभाग

Central Ground Water Board

केंद्रीय भूमिजल बोर्ड

NORTH EASTERN REGION

उत्तर पूर्वी क्षेत्र

GUWAHATI

गुवाहाटी

March 2019

AQUIFER MAPPING REPORT OF PART OF LOWER DIBANG VALLEY DISTRICT, ARUNACHAL PRADESH

ANNUAL ACTION PLAN 2017-18

by

Dr. D. J. Khound
Assistant Hydrogeologist
&
R. K. Kalita
Scientist D

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CHAPTER 1.0
INTRODUCTION

1.0 Introduction

1.1 Objectives: As part of national aquifer mapping programme, 434sq.km of the unconsolidated alluvial aquifer of Lower Dibang Valley district of Arunachal Pradesh was taken for study. (Fig. 1)

The objective of the study can be defined as follows:

a) to define the aquifer geometry, type of aquifers, ground water regime behaviours, hydraulic characteristics and geochemistry of aquifer systems in 1:50,000 scale and
b) Existing scenario of groundwater regime in shallow/deep aquifer
c) to work out a management plan for sustainable development of ground water.

1.2 Scope of the study

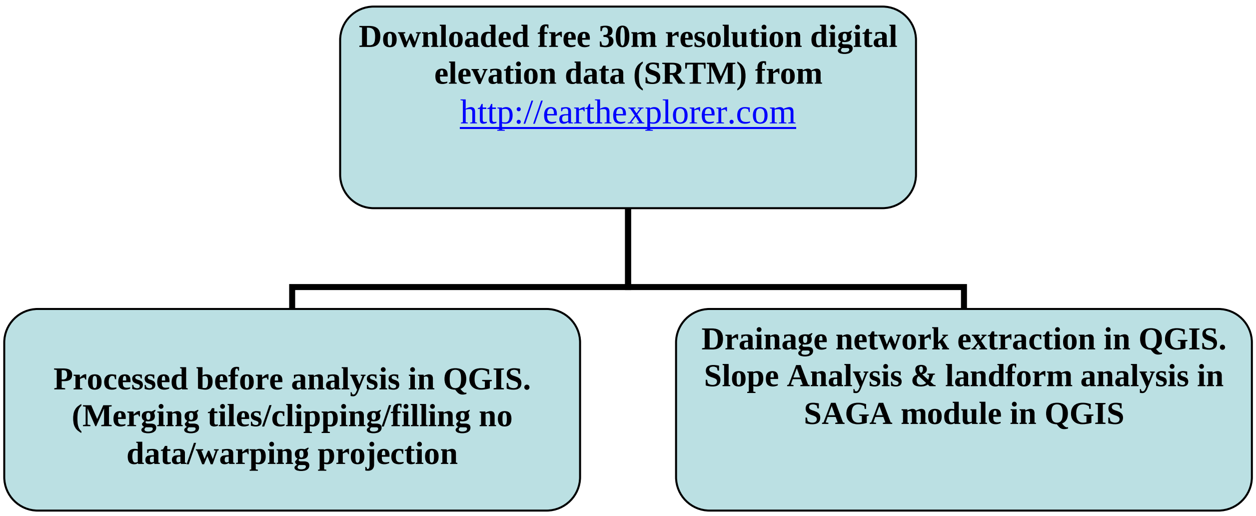
Present study aims to discuss ground water scenario under different geological and geological and geomorphological set up of the area. Scope exists to discuss surface and ground water interaction to formulate a sustainable management plan for the study area.

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

The methodology can be illustrated as follows:

Data compilation and data gap analysis: The preliminary works consisted of collection and review of all existing hydrogeological and exploration data of CGWB and State Groundwater Departments. All data were plotted in the base map on GIS Platform. On the basis of available data, data gaps were identified.

Digital Elevation Data: Digital Elevation Data is a very useful for terrain analysis and also to identify drainage. In this study an attempt has been made to classify the landform of the study area from digital elevation data. SRTM (shuttle radar topographic mission) 30m resolution elevation data downloaded from http://earthexplorer.com . The elevation data is processed in QGIS software. The terrain analysis was performed in SAGA module of QGIS. The work flow is shown in the flow chart.



Data Generation: Efforts were made to fill the data gaps by multiple activities such as exploratory drilling, geophysical techniques, hydro-geochemical analysis, water level monitoring, yield tests and soil infiltration studies.

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

Aquifer Management Plan Formulation: Based on aquifer map and analysis of present requirement and future demand, a sustainable development plan of the aquifer is formulated

1.4 Area Details: The area chosen for aquifer mapping is bounded by 95^{0}40'51"E to 95^{0}59'46"E longitude and 27^{0}57'45"N to 28^{0}09'54"N latitude and the area is included in Survey of India toposheet numbers 82P/12, 82P/16, 83M/9 and 83M/13 (all in parts) (Fig. 1.1).

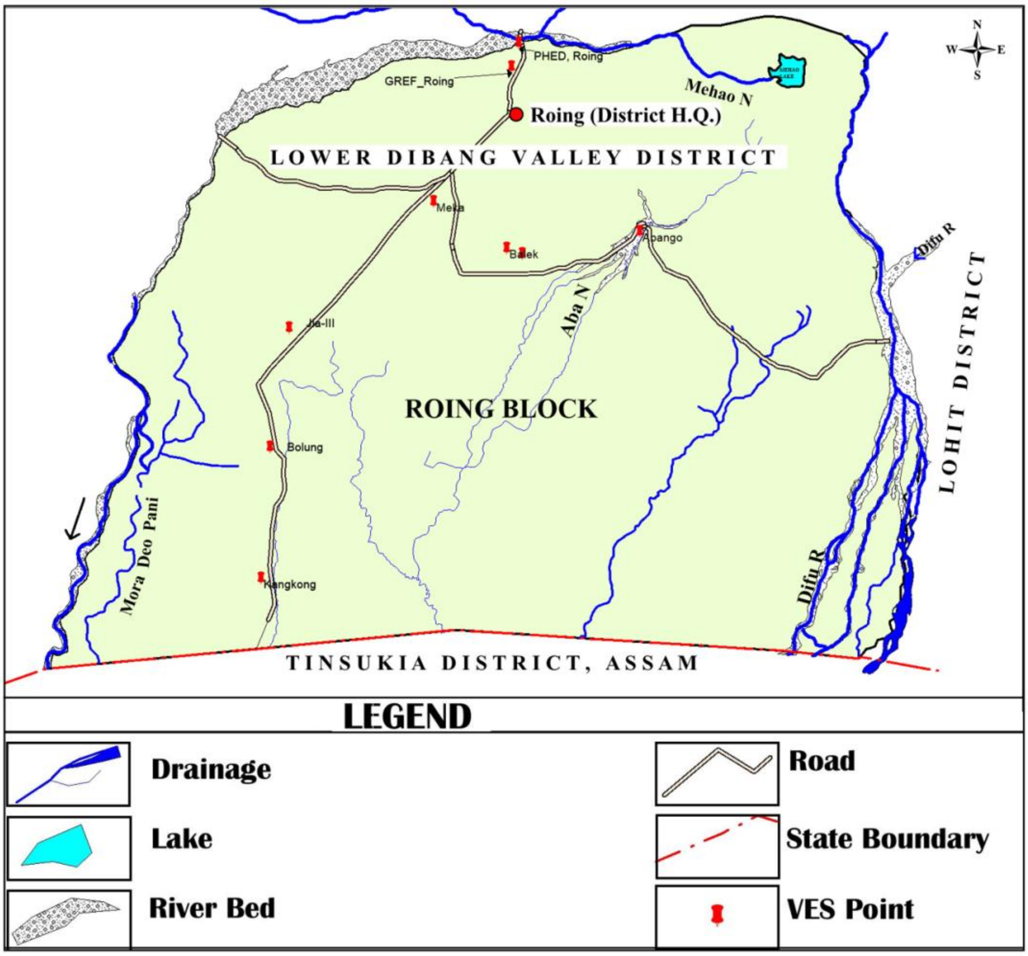


Fig. 1.1: Base map of the study area

Table 1.1: Administrative area (Source: Lower Dibang Valley Statistical Handbook 2011)

Block	Population	Female	Male	No. of villages	Toposheet
Roing	30607	15817	14790	157	82P/12, 82P/16, 83M/9, 92A/2

The district head quarter Roing is connected with rest of the country by road.

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

The preliminary works consisted of collection and review of all existing hydrogeological and exploration data of CGWB, State Groundwater Departments. All data were plotted in base map on GIS Platform.

The available data, data gap and data generation work is tabulated in Table: 1.2 and shown in Fig. 1.2 to 1.3.

Table 1.2: Data availability, data gap and data generation in part of Lower Dibang Valley district of Arunachal Pradesh

SN	Theme	Type	Data available	Data gap	Data generation	Total	Remarks
1	Borehole Lithology Data		14	10	Nil	10	14 TWs belong to State Govt (WRD). Maximum depth of TW is only 76m.
2	Geophysical data		9	5	Nil	14	CGWB conducted 9 VES during AAP 2008-09
3	Groundwater level data	Dug well (Aquifer-1)	Nil	10	6	10	GW abstraction structures are not available in the entire area.
		Spring (Aquifer-1)	Nil				
4	Groundwater quality data	Dugwell-Aquifer-I	Nil	10	6	10	GW abstraction structures are not available in the entire area.
		Spring (Aquifer-I)	Nil				
5	Specific Yield		Nil	5	Nil	5	
6	Soil Infiltration Test		Nil	5	2	5	

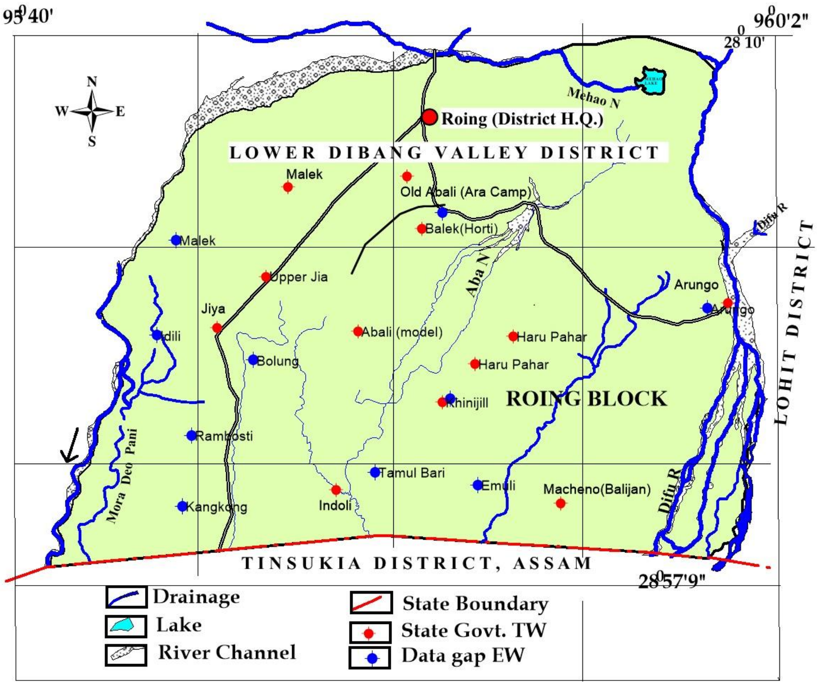


Fig. 1.2: EW data availability and data gap. Only lithologs of TW constructed by Water Resources Dept., Govt. of Arunachal Pradesh are available. CGWB is yet to start exploration.

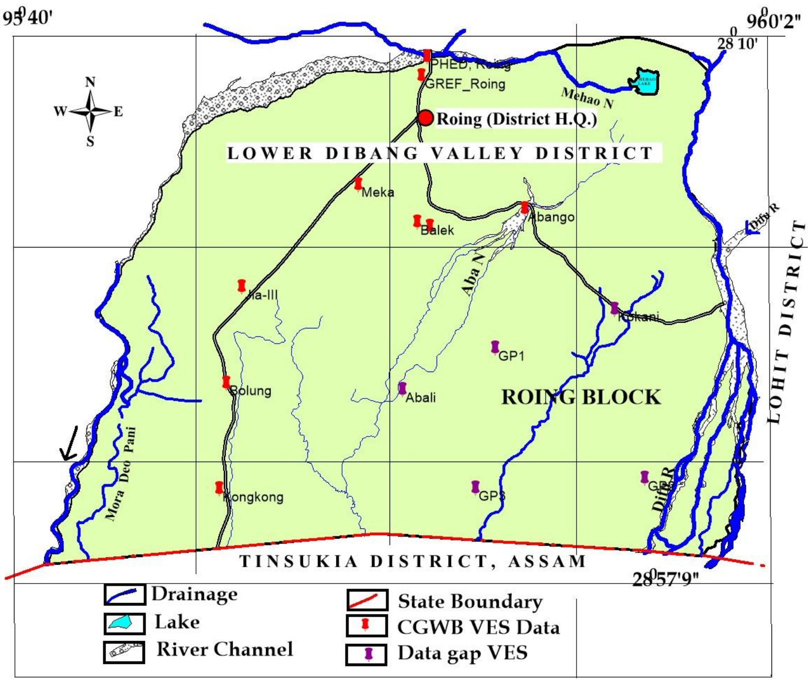


Fig. 1.3: VES data gap in the study area.

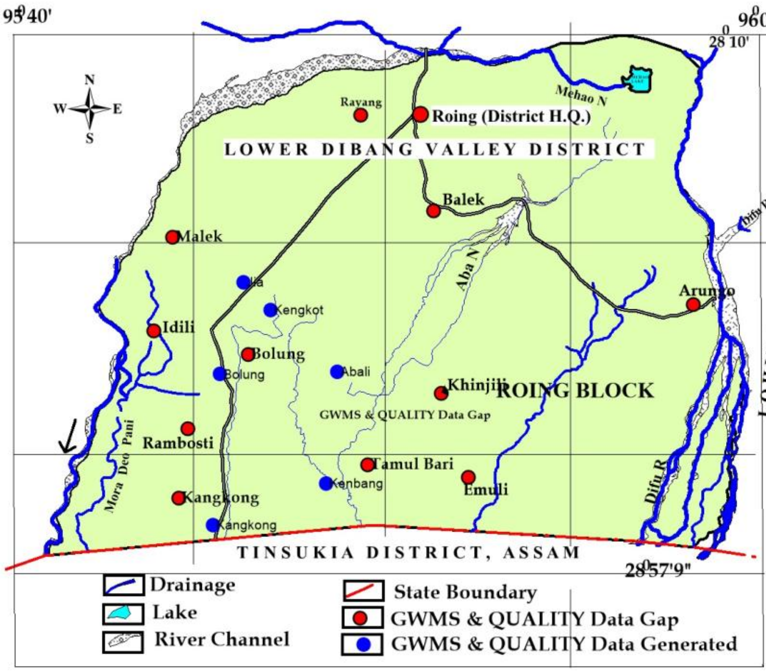


Fig. 1.4: Water level monitoring station and water quality data gap and generation in the study area.

1.6 Rainfall-spatial, temporal and secular distribution: The rainfall distribution of the area is influenced by altitudinal difference. The average rainfall of the area is 3580mm.

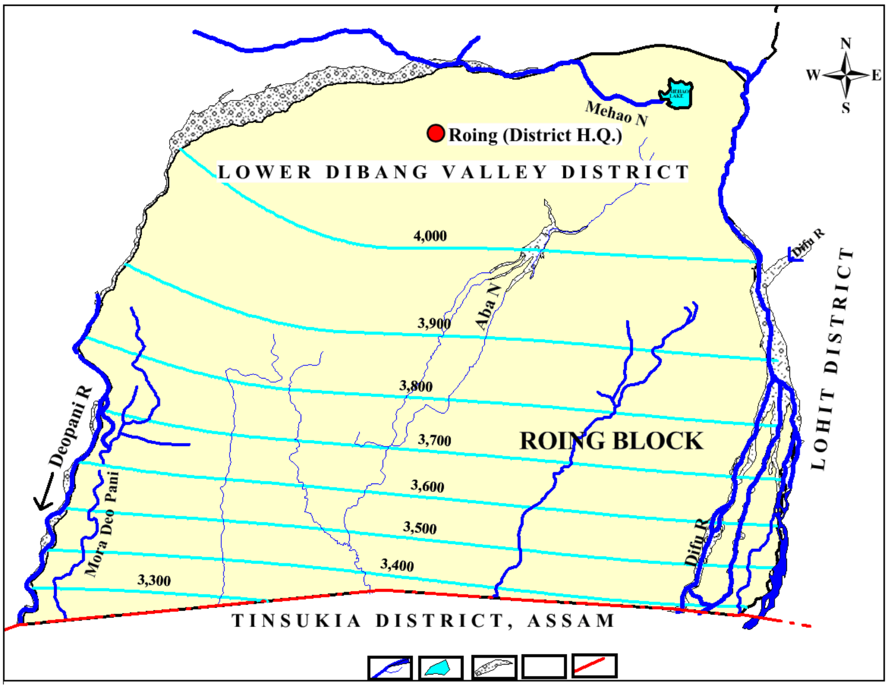


Fig. 1.5: Isohytal map of the area

Isohytes were constructed on the basis of rainfall data of four rain gauge stations viz., Namsai of Lohit district, one rain gauge station in the campus of Central Horticulture College at Pasighat and another rain gauge station of Rural Works Dept. Govt., of Arunachal Pradesh near Pasighat, East Siang district, Roing of Lower Dibang Valley district (Fig.1.5). It is observed that rainfall increases towards northeastern direction of the study area and decreases towards Assam Plains. The entire northern part of the study area coincides with the Himalayan Foothill. Dhar and Nandargi (2004) opined that Himalayan foothill receives highest precipitation due to the fact that most of the moisture is precipitated after encountering the foothills and the next few higher ranges of the Himalayas. Thereafter, the moisture-holding capacity of the air decreases rapidly as the southerly winds encounter the higher ranges of the Himalayas to the north.

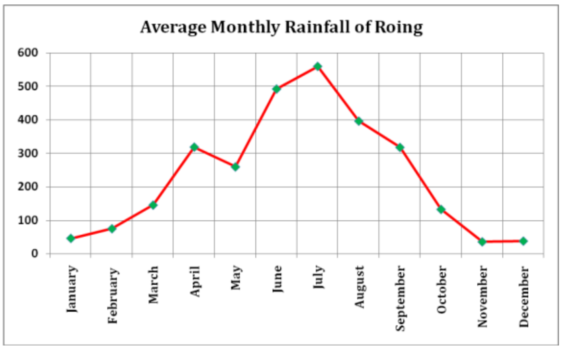


Fig. 1.6a: Monthly rainfall distribution

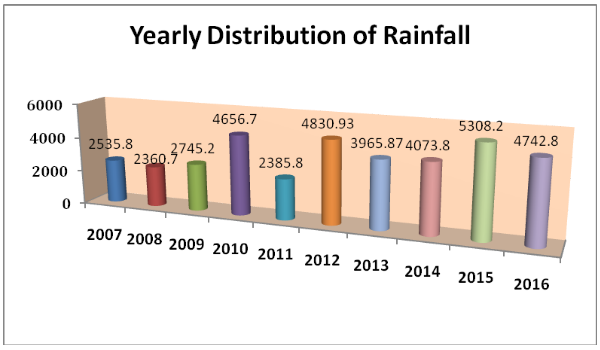


Fig. 1.6b: Yearly rainfall distribution

The post-monsoon season continues from October to December while March to May constitutes pre-monsoon season. Monsoon season starts from June and continues up to September. The monsoon rainfall distribution is in general bi-model in nature where the first peak rainfall is generally observed in July and second is generally observed in September (Fig. 1.6a). Pre-monsoon average maximum temperature ranges from 27.3 to 30.2^{0}C and minimum temperature ranges from 15.5 to 21.3 ^{0}C. Post monsoon average maximum temperature ranges from 23.3 to 29.8^{0}C and minimum temperature ranges from 13.4 to 20.6 ^{0}C. Monsoon maximum temperature remains above 30^{0}C and minimum temperature above 20^{0}C.

1.7 Physiographic set up: Physiographically the area can broadly be divided into three parts, i.e., the hilly tract, the piedmont and the flood plain. The hilly tracts are characterized by low to high relief hills and corrugated landform. The hill ranges in the northeast part of the study area rising to about 1260mamsl. The slope of the area drops from northern corner towards south. The topography of these hills is rugged with deep V-shaped valleys. Piedmont areas are characterized by river terraces, alluvial fans, channel bars and point bars. Flood plain is found in south western and south eastern parts of the study area and it merges with the Assam Plain (Fig. 1.7).

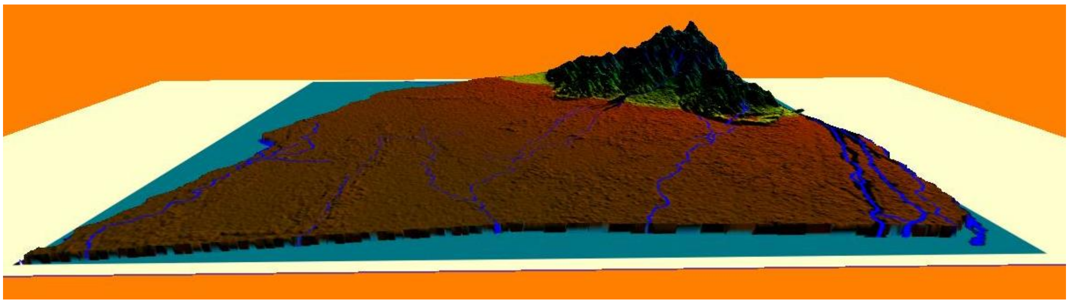


Fig. 1.7: Three dimensional view of the study area

1.8 Geomorphology/Landforms: Geomorphology can be defined as landforms description and classification. GIS based analysis of Digital Elevation Data helps to classify landform. In this study downloaded and processed DEM is classified into 10 classes based on Terrain Power Index (TPI) (Fig.1.8). Area under different landforms are shown in Table: 1.3

Using TPI at different scales, plus slope, users can classify the landscape into both slope position (i.e. ridge top, valley bottom, mid-slope, etc.) and landform category (i.e.

steep narrow canyons, gentle valleys, plains, open slopes, mesas, etc.). The TPI is the basis of the classification system and is simply the difference between a cell elevation value and the average elevation of the neighborhood around that cell. Positive values mean the cell is higher than its surroundings while negative values mean it is lower.

The degree to which it is higher or lower, plus the slope of the cell, can be used to classify the cell into slope position. If it is significantly higher than the surrounding neighborhood, then it is likely to be at or near the top of a hill or ridge. Significantly low values suggest the cell is at or near the bottom of a valley. TPI values near zero could mean either a flat area or a mid-slope area, so the cell slope can be used to distinguish the two.

Table 1.3: Area under different landform

TPI CLASS	NAME	Area (Ha)	% area
1	Streams	1280.54	2.95
2	Midslope Drainages	902.07	2.08
3	Upland Drainages	376.55	0.87
4	Valleys	1010.85	2.33
5	Plains	33059.92	76.17
6	Open Slopes	3392.22	7.82
7	Upper Slopes	751.56	1.73
8	Local Ridges	319.55	0.74
9	Midslope Ridges	1039.69	2.4
10	High Ridges	1267.05	2.92
	Total	43400	100.01

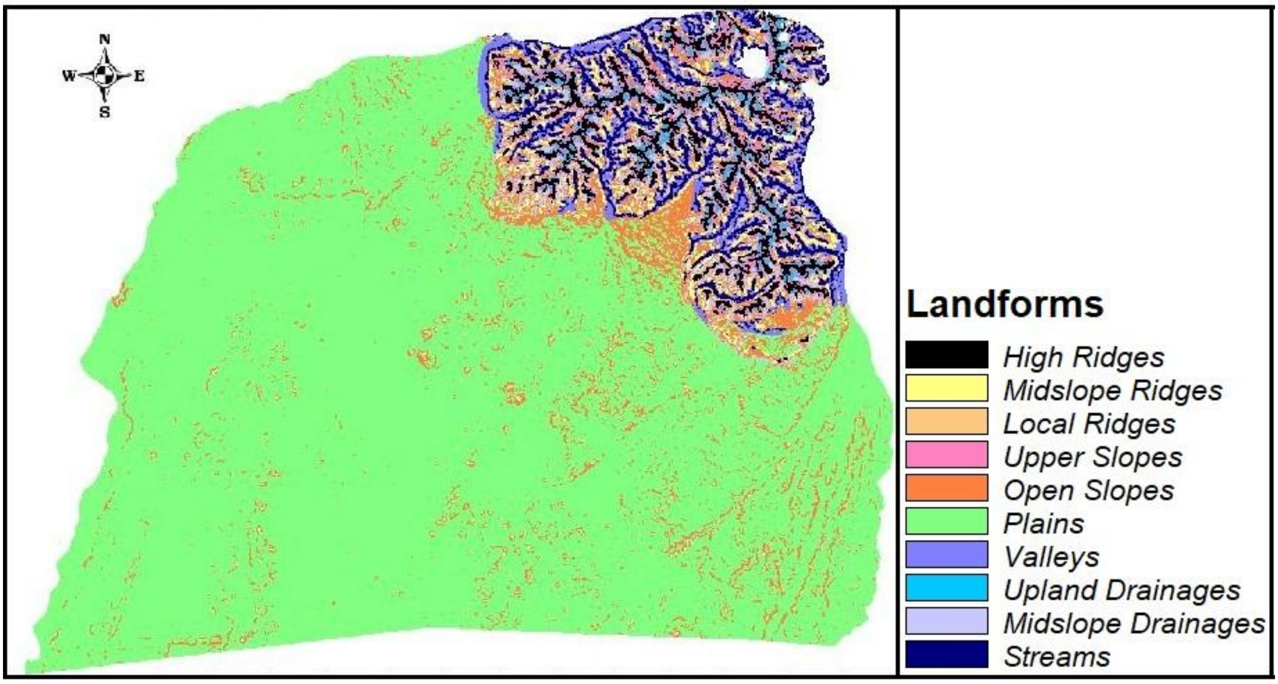


Fig. 1.8: Landform classification in the study area.

From the figure and table it becomes clear that majority of the area is classified as plains.

Slope: In this study attempt has been made to classify the study area based on slope

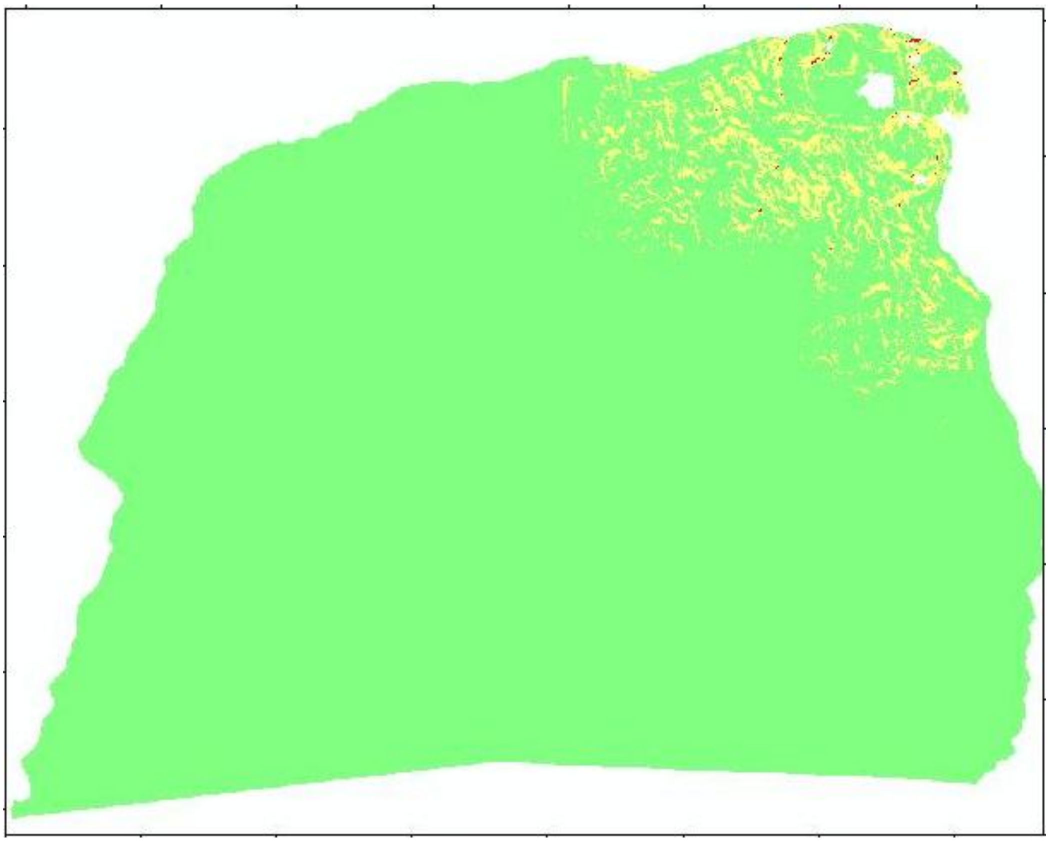


Fig. 1.9: Slope map of the study area

Table 1.4: Slope based classification of the study area

Legend	Slope % From	Slope % To	Terminology	Area (Ha)
(green)	0	5	Very gentle slope	41685
(yellow)	5	20	Moderate slope	1702
(cyan)	20	70	Steep slope	0
(red)	>70		Very steep slope	14
			Total area	43400

1.9 Land use Pattern: Block wise land use data is available in 2010-11 agriculture census. The land utilization pattern of the study area is given in Table: 1.5

Table: 1.5 Land utilization pattern, as per 2010-2011 agricultural census (Area in Hect)

Block	Total Area	Net Area Sown	Area Under Current Fallows	Net Cultivated Area (2+3)	Other Uncultivated Land Excluding Fallow Land	Fallow Land Other than Current Fallows	Culturable Waste Land	Total Uncultivated Land (5+6+7)	Land Not Available for Cultivation
	1	2	3	4	5	6	7	8	9
Roing	9670	2113	123	2235	761	2702	3077	6540	985

Area in Hectare

Note: Total May not Tally Due to Rounding off (Agriculture Census 2010-11)

1.10 Soil: The soil developed in each physiographic unit has their distinct morphological and other related properties. It indicates a good soil-landform relationship in this region. Taxonomically the soils of the district are divided into 28 classes (Fig. 1.9 & Table 1.6).

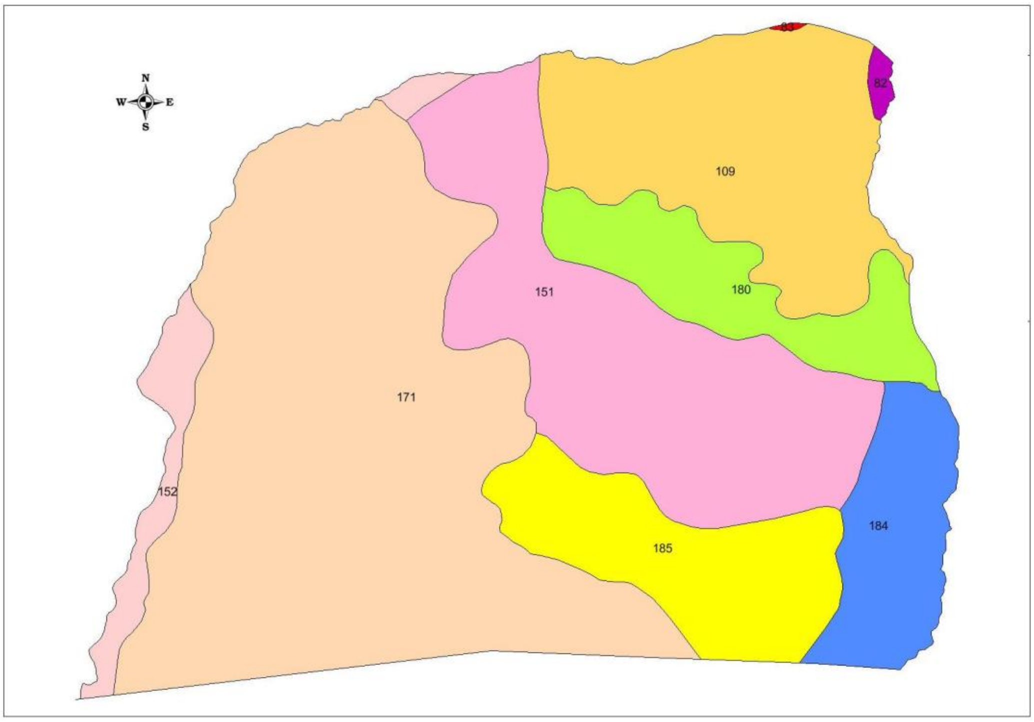


Fig. 1.9: Soil Map of the study area

Table 1.6: Description of soil map of the study area

SN	Symbol	ID	Soil Texture	Description
1		82		Rocky mountains covered with perpetual snow and glaciers
2		83	Loamy-skeletal, Lithic Udorthents & Loamy-skeletal. Dystric Eutr	Shallow, excessively drained, loamy-skeletal soils on steeply sloping summits having loamy surface with severe erosion hazard and slight stoniness: associated with; Moderately deep, somewhat excessively drained, loamy-skeletal soils on moderately steeply
3		109	Coarse-Sitty Aerie Fluvaquents & Coarse-loamy Fluventic Dystroch	Deep, imperfectly drained, coarse-silty soils on very gently sloping active flood plain having loamy surface with severe erosion and severe flooding hazards: associated with: very deep, moderately well drained, coarse-loamy soils with moderate erosion an
4		151	Fine-loamy Pachic Haplumbrepts & Fine, Typic Palehumults	Very deep, well drained, fine-loamy, soils on moderately sloping side slope of hills having loamy surface with moderate erosion hazard and slight stoniness: associated with; Very deep, well drained, fine soils with moderate erosion hazard
5		152	Coarse-loamy, Umbric Dystrochrepte & Coarse-loamy, Dystric Eutro	Very deep, well drained, coarse-loamy soils on very gently sloping upper piedmonts having loamy surface with moderate erosion hazard and slight stoniness: associated with: Deep, well drained, coarse-loamy soils with severe erosion and slight flooding haz
6		171	Coarse-loamy, Aerie Haplaguepts &	Very deep, imperfectly drained, coarse-loamy soils on level to nearly level plain having loamy surface with slight erosion and moderate flooding hazards:

			Fine-silty ' Typic Haplaquepts	associated with: Very deep, imperfectly drained, fine-silty soils with slight erosion and moderate f
7		180	Loamy-skeletal, Typic Udorthents & Coarse-loamy, Entic Haplumbre	Moderately shallow, well drained, loamy-skeletal soils on very gently sloping upper piedmonts having loamy surface with severe erosion and slight flooding hazard: associated with: Moderately deep, well drained, coarse-loamy soils with moderate erosion ha
8		184	Coarse-Sitty Aerie Fluvaquents & Coarse-loamy Fluventic Dystroch	Deep, imperfectly drained, coarse-silty soils on very gently sloping active flood plain having loamy surface with severe erosion and severe flooding hazards: associated with: very deep, moderately well drained, coarse-loamy soils with moderate erosion an
9		185	Fine-loamy, Typic Dystrochrepts & Flne-loamy Fluventic Dystroch	Very deep, well drained, fine-loamy soils on very gently sloping plain having loamy surface with moderate erosion hazard: associated with: Very deep, moderately well drained, fine-loamy soils with moderate erosion and slight flooding hazard

1.11 Hydrology and drainage: The Deopani River a tributary of the Dibang River is originated from the hills in the northeast of the study area. The Deopani River is flowing almost in a north-south direction after joining with the Dolang Korong River and it marks the northern and western boundary of the study area. The Difu River also originates in the northeastern hills and flows towards south. The river marks the eastern boundary of the study area. Some other streams flowing through the area are Jia, Aba, Enju Pani and they are flowing in a northeast-southwest direction and debouch to the great Lohit River in the south.

The Mehao Lake is the source of most of the rivers of the study area. The lake is situated in the northeastern hills at a height of 1600mamsl. The drainage pattern in the hills is radial around Mehao Lake. Drainage pattern in the hill is generally dendritic and also have high drainage density. The drainage density in the piedmont is low. In the Piedmont plain the drainage channels are nearly straight and sub- parallel.

1.12 Agriculture: As per agriculture census 2010-11, net sown area is nearly 10000 ha. Paddy is the principal crops followed by maize, millet. Vegetables, mustard and fruits like orange are also cultivated in these villages. Details of the area of food crops in Roing-Koronu Block, Lower Dibang Valley District is shown in Table: 1.5.

Table 1.7: Area under major crops in Roing-Koronu Block, Lower Dibang Valley District

Area in hectare					
Paddy	Maize	Millet	Cereals	Pulses	Vegetable
1877	117	42	2039	6	231

Source: Agriculture Census 2010-11

As per Agriculture Census of 2010-11, the areas do not have any canal, well or any conventional sources of irrigation rather there is other sources of irrigation.

CHAPTER 2.0

Data Collection and Generation

2.1 Data collection

Data collection includes collection of rainfall data from state government, litholog collection from state groundwater departments, compilation of CGWB's earlier survey data. Population data is collected from Census of India website. Agricultural data is collected from Agriculture Census 2010-11.

CGWB has not initiated exploration in the area. Water Resource Department, Govt. of Arunachal Pradesh had constructed number of tube wells in the area. Rainfall data was collected from Rural Works Department, Govt. of Arunachal Pradesh, Itanagar. CGWB does not have any groundwater monitoring station in the area.

During AAP 2008-09, CGWB carried out nine Vertical Electrical Sounding in this area. Data of these VES are collected and utilized in the present study.

2.2 Data Generation

2.2.1 Hydrogeological data: Groundwater abstraction structures are found in the southern part of the study area. From village Jia to Roing town dug wells are not found. Due to this reason entire study area could not be covered by establishing new water level monitoring stations.

Water level data: The location details of water level monitoring stations are given in Table 2.1.

Table 2.1: Water level monitoring stations and spring locations

Unique ID	Name of village/ site	Longitude	Latitude	RL (mamsl)	Total depth of Pz/DW (mbgl)	Type (DW/Pz/ Spring)	Aquifer group	Measuring point (magl)	Source /Agency
LDVR_01	Jia	95.7699	28.06811	118	7.88	DW	Unconsolidated (I-Aquifer)	0.26	Private
LDVR _02	Kengkot	95.782	28.05706	116	1.6	DW		3.6	Private
LDVR _03	Bolung	95.759	28.03172	159	5.68	DW		53	Private
LDVR _04	Kangkong	95.756	27.97192	135	10.31	DW		0.7	Private
LDVR _05	Kenbang	95.807	27.98833	179	2.6	DW		90	Private
LDVR _06	Abali	95.812	28.03269	202	6.12	DW		1.64	Institutional

Table 2.2 Water level of monitoring stations

Unique		Date	Depth		Unique		Date	Depth
1		2	3		4		5	6
LDVR_01	Jia	28/04/2017	3.46		LDVR _03	Bolung	27/04/2018	3.94
		23/08/2017	1.05		LDVR _04	Kangkong	28/04/2017	8.86
		10/11/2017	3.21				23/08/2017	8.85
		06/01/2018	6.17				10/11/2017	9.55
		27/04/2018	3.87				06/01/2018	9.9
LDVR _02	Kengkot	28/04/2017	0.70				27/04/2018	9.96
		23/08/2017	NA		LDVR _05	Kenbang	28/04/2017	1.8
		10/11/2017	0.20				23/08/2017	NA
		06/01/2018	NA				10/11/2017	2.27
		27/04/2018	0.94				06/01/2018	NA
LDVR _03	Bolung	28/04/2017	4.27				28/04/2017	2.1
		23/08/2017	3.81		LDVR _06	Abali	29/04/2017	4.66
		10/11/2017	4.13				10/11/2017	5.45
		06/01/2018	4.48				28/04/2017	4.10

2.2.2 Soil Infiltration studies: Infiltration test: Salient features of the test sites are provided in Table 2.4 &2.5. 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 silt and sand admixtures. In general, infiltration test was conducted for duration of 210 minutes.

Table 2.3: Salient features of the soil infiltration test sites

Site	**Location**	**Land use**	**Soil type**	**Latitude**	**Longitude**
Bolung	Open Ground	Barren Land	Sandy soil	**27.957781**	**95.20884**
Kangkong	Open Ground	Barren Land	Sandy soil	28° 0'33.4"N	95° 27'39.8"E

Summary of the infiltration tests is given in Table .2.4

Table 2.4: Summary of Infiltration Tests

S.N.	Site	Land use	Soil type	Duration of test (min)	Total Quantum of water added in m	Total Quantum of water infiltrated in m	Specific Yield (Sy)	Total quantum of water recharged in m (5X6)	IF = Recharged water/ added water
1	**2**	**3**	**4**		**8**	**5**	**6**		**7**
1	Bolung	Barren Land	Sandy gravel	141	0.299	0.23	0.16	0.0368	12.31
2	Kangkong	Barren Land	Sandy gravel	231	0.334	0.311	0.16	0.04976	14.90

2.2.3 Water Quality:

To understand the chemical quality of groundwater in the study area and its suitability for domestic, drinking and agricultural uutilization, water quality data of spring and existing quality data of CGWB were collected. Water samples were collected from monitoring wells for detailed, iron, heavy metals and arsenic. However, heavy metal and arsenic analysis data are yet to be received. Available chemical analysis report of ground water is provided in Table 2.5.

2.2.4 Geophysical survey

VES survey could not be conducted due to non-availability of geophysicist in NER office. VES survey was carried out in the area during AAP 2008-09 and the data were compiled. During that period all total nine VES survey was conducted in the area with maximum available current electrode separation AB/2 = 200m.

The location of these VES survey is given in Table 2.6.

Table 2.6: Location of VES survey

SN	Name of the site	Latitude	Longitude	RL (mamsl)	Agency	VES/TEM	Depth of interpretation
1	Balek	28.091	95.846	244.24	CGWB	VES	200
2	Roing	28.089	95.851	294.84	CGWB	VES	200
3	Abango	28.096	95.893	386.36	CGWB	VES	200
4	PHED, Roing	28.155	95.85	449.09	CGWB	VES	200
5	Meka	28.105	95.82	264.54	CGWB	VES	200
6	Jia-III	28.065	95.768	174.84	CGWB	VES	200
7	Kongkong	27.986	95.758	141.51	CGWB	VES	200
8	Bolung	28.028	95.761	158.48	CGWB	VES	200
9	GREF_Roing	28.148	95.848	405.75	CGWB	VES	150

Table 2.5: Post monsoon water quality data of ground water and surface water of East Siang District, Arunachal Pradesh

SN	Location	Type of sample (EW or DW)	pH	EC (µs/cm) 25C	TDS	CO_3^{-2}	HCO_3^{-1}	TA (as CaCO3)	Cl^-	SO_4^{-2}	NO_3^{-1}	F^-	Ca^{+2}	Mg^{+2}	TH (as CaCO3)	Na	K	Fe
1	Kangkong	DW	7.60	165.3	99.62	0	55	55	10.635		15.9074	0.32	25.52	10.32	106.34	6.74	9.89	0.18
2	Bolung	DW	7.33	231.1	143.6	0	75	75	17.725		17.1597	0.33	28.92	12.34	123.34	6.79	28.06	0.2
3	Jia	DW	7.23	113.3	69.14	0	60	60	10.635		0	0.5	20.42	12.38	102.08	2.11	4.08	0.05
4	Kenbang	DW	7.31	194.3	119.9	0	80	80	14.18		3.2419	0.43	22.12	11.36	102.08	10.26	22.67	0.25

TA =Total alkalinity(HCO_3^{-1}+ CO_3^{-2})
(tendency to neutralise acidity of water)

2.2.5 Exploratory Drilling

No exploration was carried out by CGWB in the past and present also. Data generated during drilling carried out by Water Resources Departmment, Govt. of Arunachal Pradesh are utilised in the present study.

Table 2.6: Details of tube wells constructed by Water Resources Department, Govt. of Arunachal Pradesh

Village/ Location	Taluka / Block	District	Toposheet No.	Lat	Long	Type of well	Depth (m)	SWL (mbgl)	Dia (mm)	Source / Agency
Haru Pahar	Roing-Konaru	Lower Dibang Valley	83P/16	28.036	95.869	TW	75	12		WRD
Macheno (Balijan)			83M/13	27.984	95.908	TW	36	19		WRD
Malek			83P/16	28.107	95.787	TW	66	1		WRD
Balek(Horti)			83P/16	28.091	95.846	TW	60			WRD
Upper Jia			83P/16	28.072	95.777	TW	53	12		WRD
Old Abali (Ara Camp)			83P/16	28.042	95.837	TW	71.5	26		WRD
Abango			83P/16	95.90	28.091	TW	78	25		WRD
Rukmo			83M/13	27.955	95.854	TW	42	Auto flow		WRD
Malek (Ahom Phokori)			83P/16	28.116	95.759	TW	40	8		WRD
Khinijill			83P/16	28.024	95.855	TW	30.5	4		WRD

CHAPTER 3.0

Data Interpretation, Integration and Aquifer Mapping

3.1 Data Interpretation

Geophysics and aquifer Characterization

The interpreted VES results have indicated a four to five layered geoelectric model. Thickness of top soil generally increases towards southern and eastern part of the study area. Maximum thickness of top soil is found at Kangkong at the southern extremity of the study area bordering Assam.

VES study indicates that down to a depth of 200mbgl sand mixed with boulder, pebble, cobble and gravel exists in the sub-surface of the study area. No confining layer is present. Water Resource Department (TW & GW), Roing also informed that down to a depth of 80m boulder or gravel of various size grade encountered during drilling.

Based on geophysical and information disseminated by WRD (TW & GW), Roing it can be said that there exists a single aquifer system of the area down to a depth of 200m or more. The size of aquifer materials indicates high energy condition during the deposition.

Aquifer 1: **Unconsolidated Quaternary Aquifer**

Unconsolidated Quaternary aquifer consists of older and recent alluvium. The aquifer is characterized by coarse grained materials ranging in size from gravel to boulder and scanty clay. Grain size distribution indicates high energy condition throughout the area. Since Water Resources Department (TW & GW), Roing did not conduct any pump test, no aquifer parameters are determined for the aquifer (Table 2.6).

Description of 2D sections: VES study in Roing area identified four to five geo-electrical sections in the sub-surface. As per VES study, sub-surface materials can be classified in following way

Top soil: Dry top soil
Bouldery layer
Sand mixed with pebbles, cobbles and gravels
Bouldery layer

Based on the above classification of sub-surface section 2D cross-sections and fence diagram are constructed.

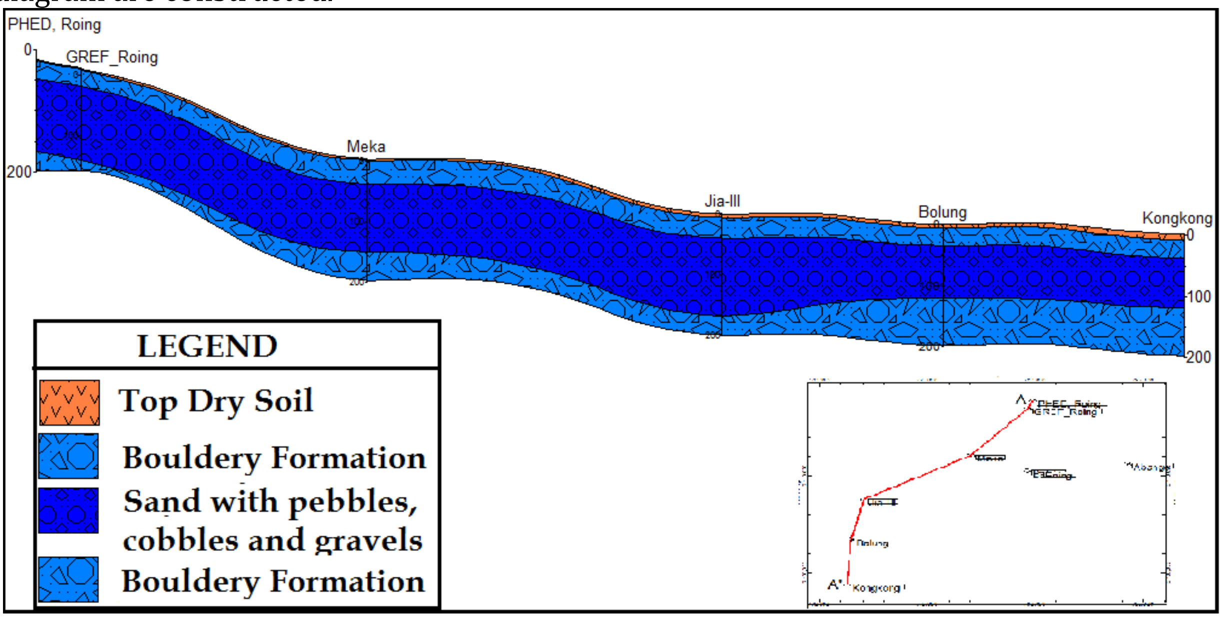
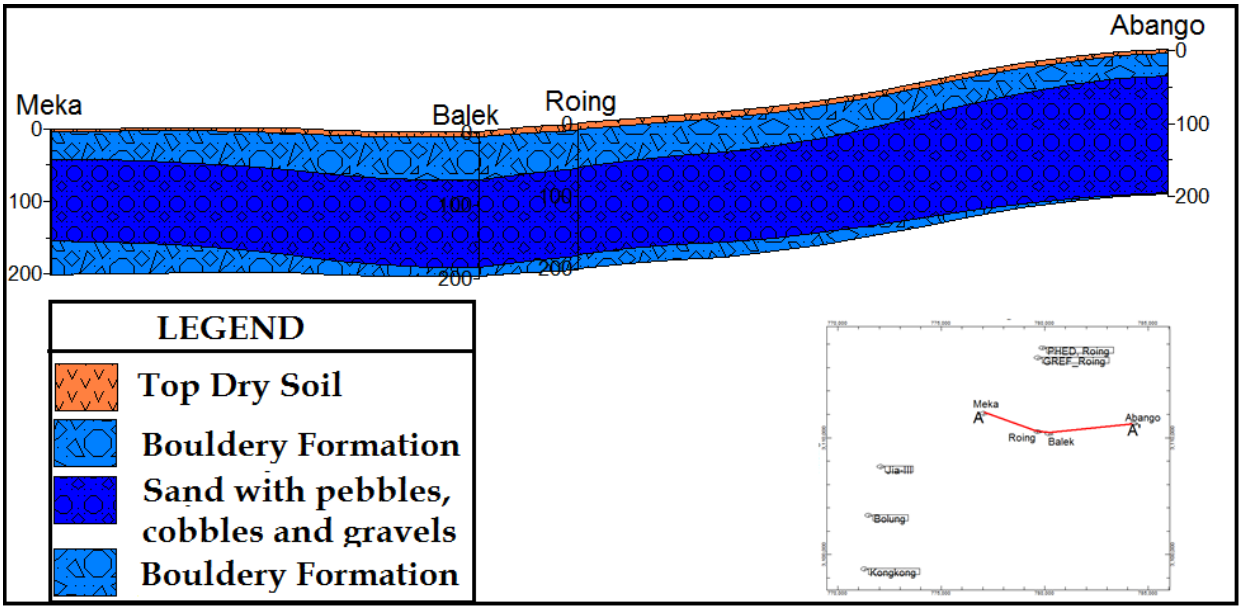


Fig. 3.1(a)

A northeast-southwest section of the area connecting VES point at sedimentation tank of Public Health & Engineering Dept., at Roing to Kangkong near Assam border shows that the thickness of sandy layer with pebble, cobble and gravel decreases toward south. The thickness of lower bouldery layer is increasing towards southern part of the study area, i.e, towards Assam Plain. Thickness of top soil layer is also increasing toward south.



(b)

Fig. 3.1 (a & b): 2D disposition of Quaternary aquifer

Another west-east section depicts pinching out of lower bouldery layer and increase of thickness of sand layer with pebbles, cobbles and gravels towards east (Fig. 3.1(b)). The upper bouldery layer thickness is almost uniform throughout the area.

The fence diagram of the area depicts the subsurface geometry of the area

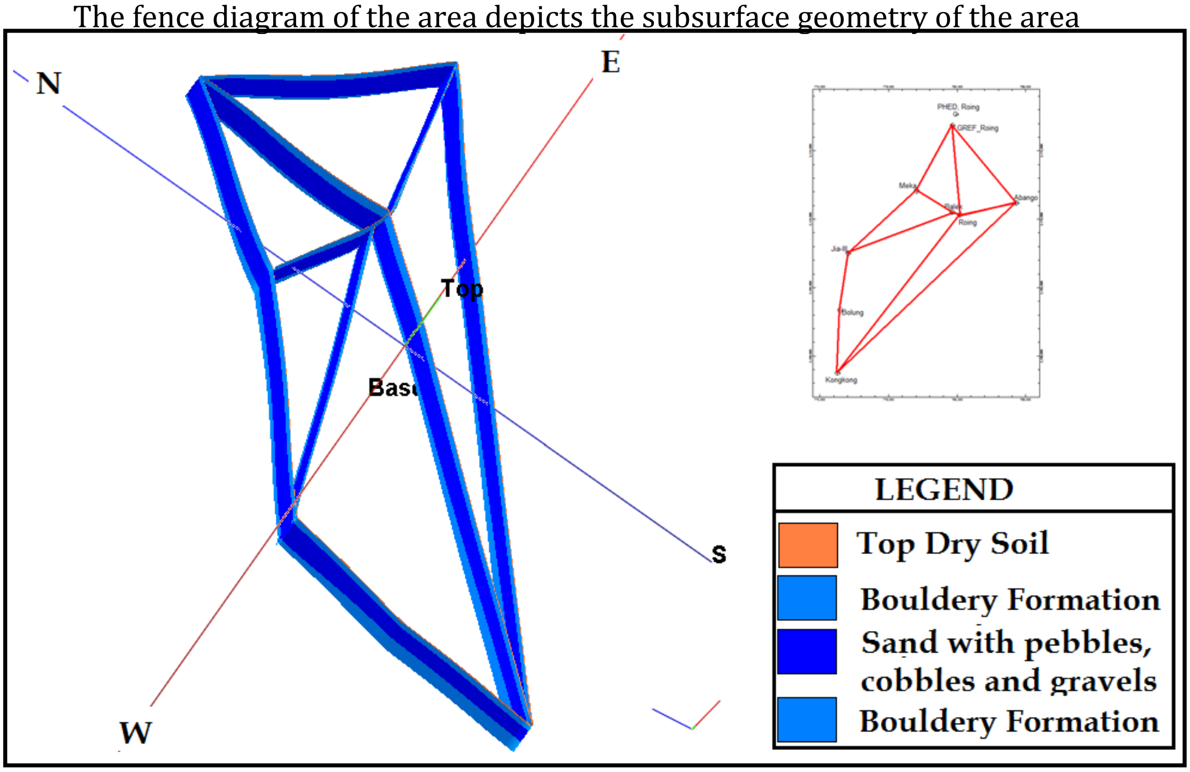


Fig. 3.2: 3D disposition of Quaternary aquifer

Ground water occurs mostly under unconfined condition. The discharge of the tube wells constructed by WRD varies from 1.0m^3/hr to 205m^3/hr.

Aquifer thickness: A perusal of fence diagram and cross-section (Fig. 3.1) indicate that

(i) bouldery materials are dominant in the subsurface formation.
(ii) Two bouldery layers are found in the subsurface and these two layers are separated by a sand plus gravelly layers.
(iii) The bottom bouldery layer pinching out towards east and thickness of the middle sandy and gravelly layer increases towards east.
(iv) The top boulder layer thickness is almost uniform in the entire area while bottom boulder layer thickness is increasing towards south.
(v) No clay or confining layer is found in the subsurface.

Depth to water level (DTW)

In the study area deepest pre-monsoon water level is observed during the month of March to April. From Fig 3.3 it is observed that deeper water level condition is found in the north and southern parts of the study area and shallow water level condition is found in the northeast and southwest parts.

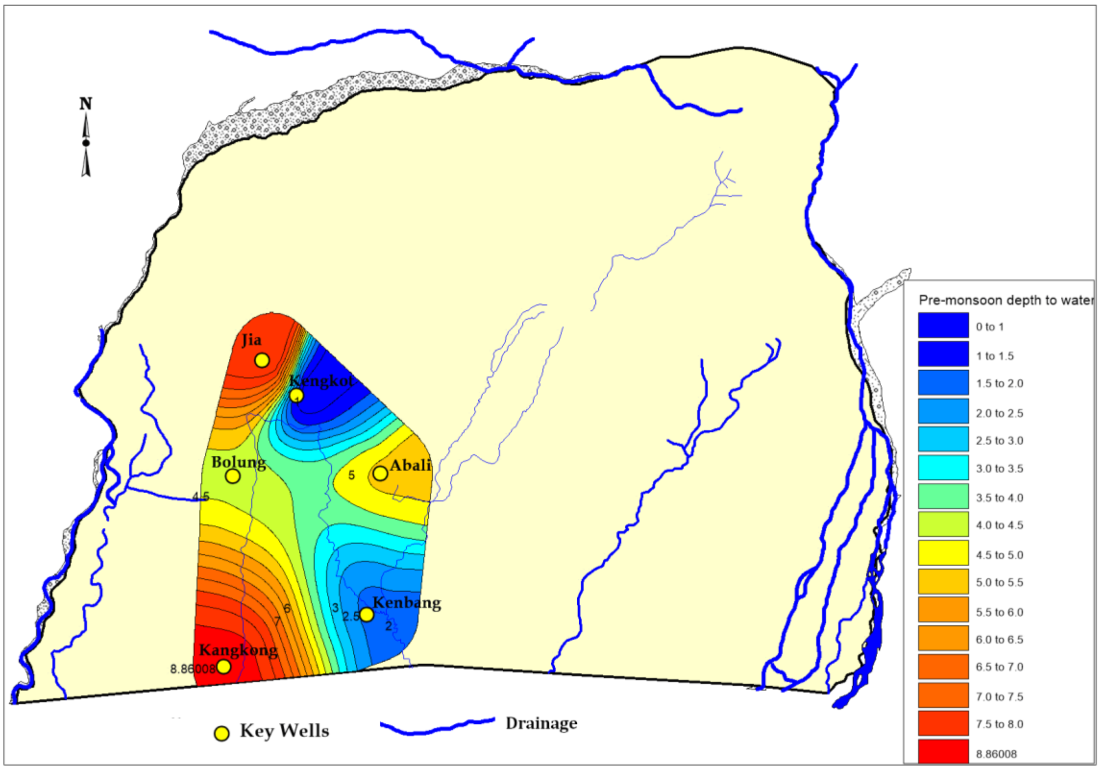


Fig. 3.3: Pre-monsoon depth to water level map

During post-monsoon deepest water level condition is found toward the southern part of the study area bordering Assam (Fig, 3.4)

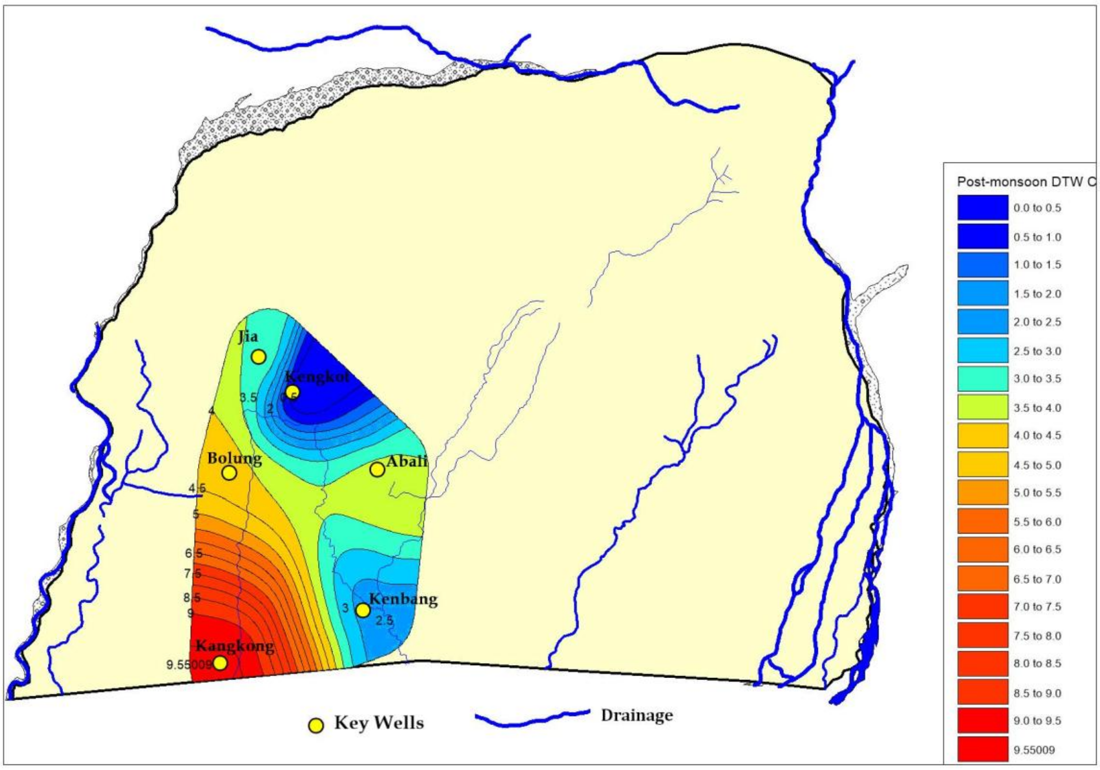


Fig. 3.4: Post-monsoon depth to water level map

Water level fluctuation: Pre- and post -monsoon water level difference is maximum in the north and the difference is decreasing towards south (Fig. 3.5)

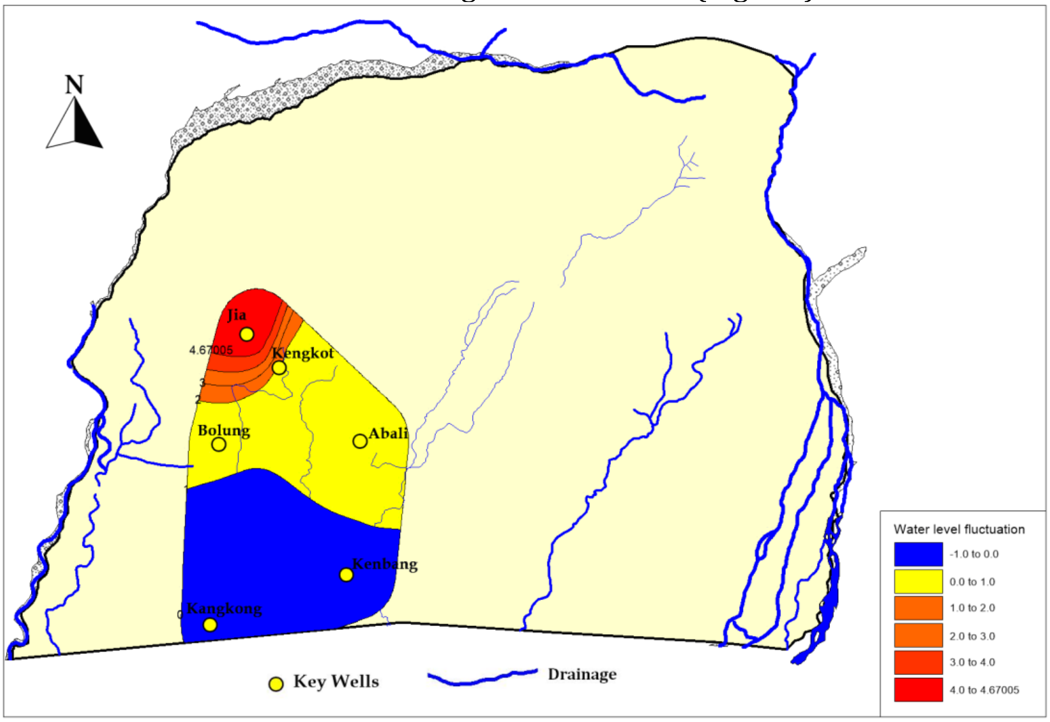


Fig. 3.5: Water level fluctuation map

Water level trend: Since there is no ground water monitoring stations in the district, ground water level trend could not be determined.

3.2 Ground Water Movement

Water table contour map is prepared by adjusting pre-and post-monsoon water level data against mean sea level (Fig. 3.6 and 3.7). A perusal of water table contour maps indicates that ground water flows almost north to south, i.e., towards Assam. Shape of water table contours clearly indicate that the aquifer is recharged in the northern part by rivers while towards the southern part near Assam border rivers becomes effluent by gaining water from aquifer.

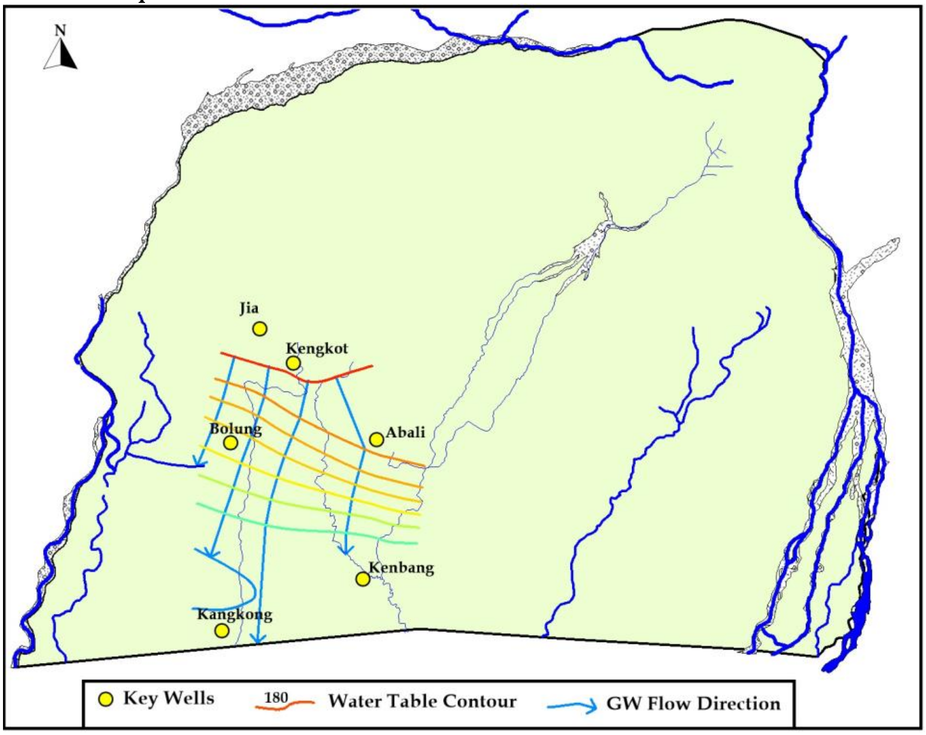


Fig. 3.9: Pre-monsoon water table contour

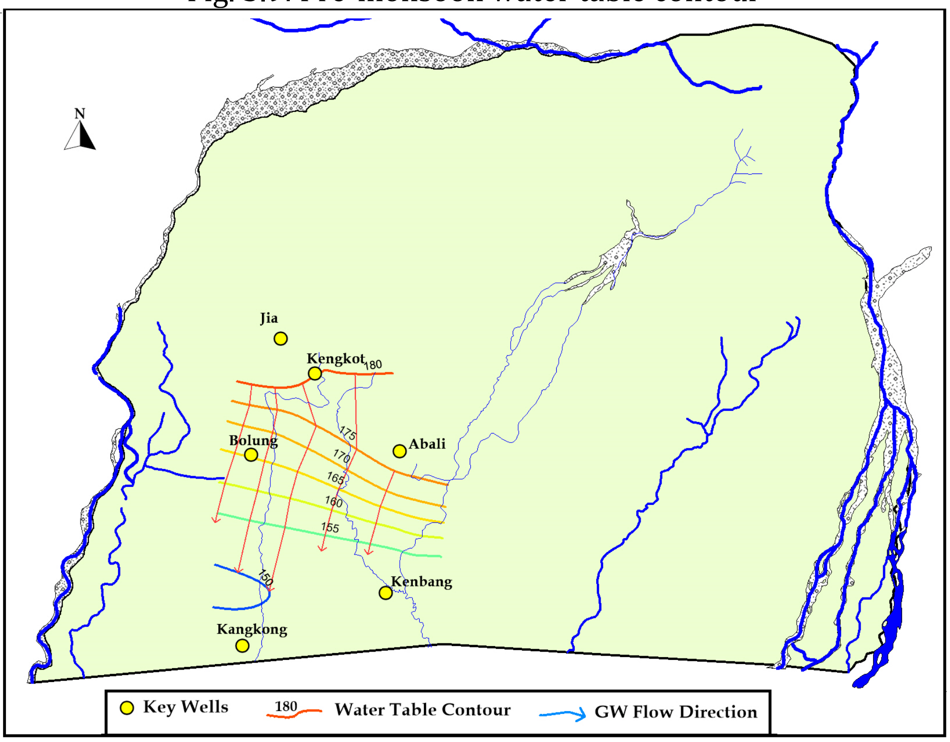


Fig. 3.10: Post-monsoon water table contour

Water quality: All total 4 numbers of samples from dug wells representing phreatic aquifer were collected and were analyzed for major ions (Table 3.5). pH of dug well samples ranges from 7.23 to 7.60. The Electrical conductivity of dug well samples ranges from 113.3 to 231.1 uS/cm. Total dissolved solids in the groundwater ranges from 69.14 to 143.6mg/l. Low EC and TDS indicate that the recharged juvenile groundwater has got little residence time. The water is soft. The pH of the samples ranges from 7.23 to 7.60 indicating the ground water of phreatic aquifers is alkaline in nature.

The other chemical constituents are within permissible limit. Iron content in groundwater ranges from 0.05 to 0.25mg/l. The EC infers that the Phreatic aquifer is fresh and is suitable for drinking, domestic and Irrigation purpose.

Aquifer map of the area: The study area has distinct geologic, geomorphologic expression and hydrogeological characteristic (Fig.: 3.41).

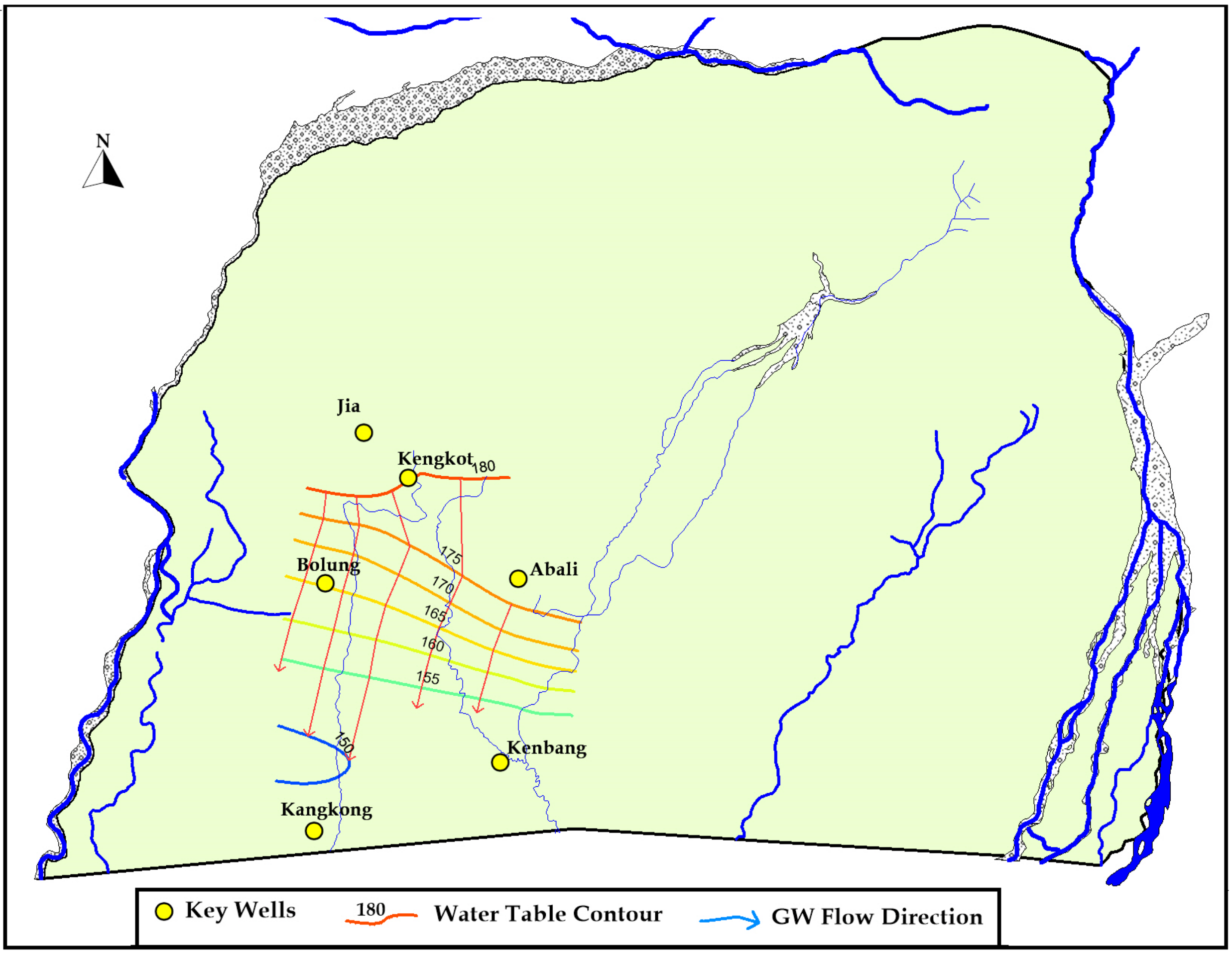


Fig. 3.41: Hydrogeological Map of the study area.

Geology and geomorphology: The area consists predominantly of Quaternary fan and flood plain deposits. The Roing Formation of East Siang district is continued to this part of Lower Dibang Valley district.

ROING FORMATION: The formation is predominantly a composite alluvial fan surface, comprising rudaceous sediments range in size from boulders to pebbles, in a highly oxidised sandy silt matrix. The formation is deposited in Siwalik foothills and extends downwards.

The formation has a distinct southerly and southeasterly sloping, gently undulating surface. It shows a very coarse drainage with a few discontinuous channels which ephemeral in nature.

It is the oldest Quaternary geologic/geomorphic formation/surface of the area.

Hydrogeology: The Roing Formation can be correlated with bhabar deposit of East Siang district. The hydrogeologic characteristics of this division are discussed below:

Bhabar Zone: The deepest pre and post monsoon water levels are noticed in bhabar zone and maximum water level fluctuation is also noticed in this zone. The average pre- and post-monsoon depth to water level is 4.8mbgl and 4.97mbgl respectively. The average water level fluctuation is -0.18m. The water table contour map indicates that the aquifer is recharged by streams and near the Assam border the aquifer is contributing to those streams. (Fig. 3.41).

Moreover, dry stream in the up slope get water in the down slope. The stream becomes dry as the stream flow losses in the subsurface due to highly porous formation materials of this zone.

The available litholog of tube wells constructed by Water Resources Department, Govt. of Arunachal Pradesh indicates presence of bouldery zone for the entire drilled depth. Lithology inferred from CGWB's earlier VES survey clearly indicates presence of bouldery formation down to a depth of 200mbgl.

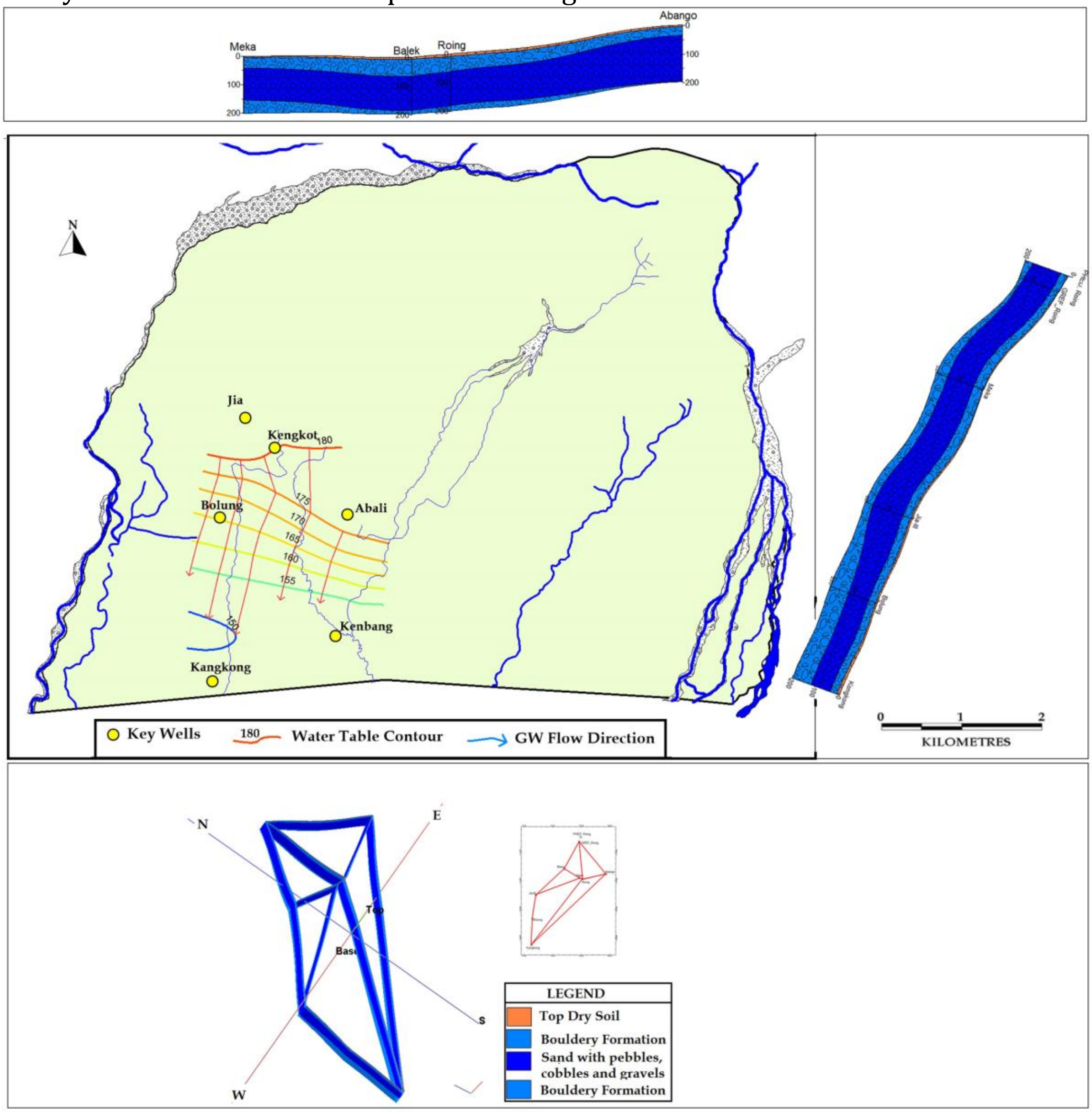


Fig. 3.44: Aquifer Map of Lower Dibang Valley (Roing-Konaru Block) District, Arunachal Pradesh

CHAPTER 4.0
Groundwater resources

The study area covers Roing block of Lower Dibang Valley district. The total rechargeable area of the district is 120000ha. The area considered for aquifer mapping is 434sq.km. The rechargeable area with slope ≤20% is identified by downloading 30m resolution DEM of Shuttle Radar Topography Mission (SRTM) from http://earthexplorer.com (Table 1.4 and Fig. 1.8). The area suitable for recharge is 433.86sq.km after deducting the northeastern hilly part with slope ≥20%. Again the stream area identified by landform map is deducted from rechargeable area (Table 1.3 and Fig. 1.7).

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

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

1) Rainfall recharge has been computed by both RIF and WLF methods. Soil infiltration tests were conducted in the study area as part of value addition to the present study. Analysis of soil infiltration data shows that value of infiltration factor varies between 12.31 and 14.9 percent. Average infiltration factor value of 13.61% is taken for calculation. In WLF method, specific yield has been taken as 0.16 for valley fill deposit following the norms recommended by GEC'2015. The normal rainfall of Lower Dibang Valley district is the average of rainfall data of 1991 to 2016 and is 2812.62 mm.
2) There is no GWMS of CGWB or State Departments dealing with ground water. Therefore, water level data of only 2017-18 groundwater year is considered. Water level fluctuation based on data of May (Pre monsoon) and November (post monsoon) has been considered. The average pre- and post-monsoon water level of the study area is 4.80mbgl and 4.97mbgl. The average water level fluctuation is 0.14m
3) The population figures were collected from Census, 2011and projected to 2017. The per capita domestic requirement for the district is considered as 60 lpcd.
4) Recharge from water conservation structure is not estimated as latest data (MIS 2013-14) is not available
5) Ground water extraction for irrigation and industrial use is considered as nil as no data is available.

Recharge: The aquifers of the study area are recharged by rainfall. The area experiences south-east monsoon. Monsoon rainfall contributes approximately 63 percent of total rainfall (June, July, August, September) while share of post and pre monsoon rainfall are approximately 7 and 30 percent respectively.

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

The monsoon recharge of the 40826.84hectre of recharge worthy area is 6592ham while non-monsoon recharge is 4259ham. Total ground water recharge is 10609ham.

Extraction: The agriculture in the area generally rain fed and whatever irrigation potential created and utilized is by surface source only. Moreover, industrial activity in the district is almost nil and as such ground water extraction for irrigation and industry is considered as nil. So ground water is extracted only for domestic use. Dependency on ground water is calculated from village amenities part of census 2011. Dependency is the ratio of number of household extracting groundwater from various sources (covered well, uncovered well, hand pump, tube well and spring) to the total number of households. The dependency of Roing-Koronu block on ground water is 40.82%. Ground water extraction is estimated by consumptive use is 28.42ham.

Resultant flow: Resultant flow includes lateral flow across boundary, vertical flow, evaporation and transpiration loss. There is no aquifer parameter to estimate the lateral as well as vertical flow in the aquifer and these two parameters are not estimated. However, from DTW contours up to 3.5mbgl, evaporation and transpiration losses were calculated considering 1mm/day evaporation and transpiration loss.

The resultant loss during monsoon is 138ham and during non-monsoon it was estimated as 242ham. Domestic allocation up to 2025 is 98.8 ham considering per capita water consumption to be 60lpcd.

Allocation of resources up to 2025: The net ground water resource is allocated for domestic use 98.8ham. Net available resource for future use is 9448.94ham and per hectare availability is nearly 231.44mm.

Stage of groundwater development: Groundwater is mainly utilized for domestic purposes. The stage of groundwater development in the district is mere 0.29%.

Table 4.1: shows the net groundwater availability, existing draft and stage of development for 2013.

District	Recharge worthy area Ha	Total annual GW recharge Ham	Environmental flow Ham	Annual extractable GW resource Ham (3-4)	Existing gross GW draft for all uses Ham	Stage of GW development [(6/5)*100 %]
1	2	3	4	5	6	7
Lower Dibang Valley	40826.84	10609	1061	9548	28.42	0.29

Extraction from unconfined aquifer/deeper aquifer: Groundwater in this area is utilized mainly for drinking or domestic purposes. Dug wells are the main groundwater abstraction structures. In the bhabar zone dug wells depth ranges from 3.0 to 11mbgl. There is no dug well in the Roing town.

Water Resources Department, Govt. of Arunachal Pradesh had constructed 30 tube wells ranging in depth from 30 to 78m. Shallow tube wells are also found in the area and its depth is limited to 50mbgl. Few tube wells of 50 to 100m are also constructed.

Very few tube wells have so far constructed in the area. The construction of tube wells is again a costly affair due to bouldery nature of the formation particularly in the bhabar zone.

5.0 Groundwater Related Issues

5.1 Identification of issues: The rechargeable area of the district has vast groundwater as well as surface water resources due to its unique geological and geomorphological condition. Still there is little water use in this area for agricultural as well as industrial activities.

As per present groundwater resource estimation extractable ground water availability is 234mm per hectare. However, this resource is little used and is evident from stage of ground water extraction which is less than 0.5%. Ground water extraction for irrigation and industrial use is almost nil. The vast agricultural lands remain fallow during non-monsoon period.

The construction of tube wells becomes a costly affair due to frequent encounter of boulder in bhabar. Many tube wells are drilled without success due to improper site selection. As such ground water extraction is low in the area.

Quality issue: The water quality of the area is generally good for all uses.

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. The dependency on ground water in this block as per 2011 census is 40.82%.

Current demand of ground water in domestic sector is 28ham. Water demand in this sector is calculated by projecting the population to 2025 and allocating 60 lpcd water. The ground water demand is found to be 98.8ham up to 2025. The demand of water in 2025 is also calculated by allocating 135lpcd water and demand rises to 221.69ham.

Future demand for agriculture: Future demand of water for agriculture is estimated in the present analysis by projecting the cropping intensity to 200%. The whole calculation for projection of cropping intensity to 200% is carried out by use of Cropwat 8.0 software of FAO.

Agriculture is the main means of livelihood of the people in the district and covering about 80% of the total population. As per ICAR, agro-ecological sub-regions of the district are Assam-Bengal plain, hot sub-humid to humid (Inclusion of Perhumid) Eco-Region. The climatic condition of the district is conducive for cultivation of temperate and subtropical crops. As per Krishi Vigyan Kendra, Lower Dibang Valley, paddy and maize are cultivated in nearly 80% of net sown area. Vegetables, Pulses, Oilseeds, Tuber crops are also sown in the district. Generally three types of cropping sequence are observed, viz., maize-mustard-maize, wet rice cultivation-black gram-vegetables and winter maze-jhoom paddy. The present season wise cropping pattern of Roing-Koranu block of Lower Dibang Valley district is shown in Table 6.1.

Table 5.1: Season wise cropping pattern of Lower Dibang Valley district

(Source: KVK Lr. Dibang Valley, CHF, CAU, Roing, Arunachal Pradesh-791102)

S N	Main Crop	**Sowing season**					
		Kharif		Summer		Rabi	
		Rainfed	Irrigated	Rainfed	Irrigated	Rainfed	Irrigated
1	Paddy	May to June	-		-	-	-
2	Maize	Mid March to April	-		-	**Mid of Sept to October**	-
3	Oilseed		-		-	**Sept to Oct**	-
4	Potato		-		-	1st week of September to 4th week of September	-
5	Ginger		-		-	**March to April**	-

Table 5.2: Area under different crops (KVK, Lower Dibang Valley District)

Crop	**Area (Ha)**	**% of Total Area**
Summer paddy	11180	44.85
Mustard	5150	20.66
Potato	310	1.24
Rabi vegetables	200	0.8
Kharif vegetables	200	0.8
Maize	7885	31.63
Total	**24925**	100

Present land under irrigation is 1292 ha. Present minor irrigation schemes are using surface water sources only. As per KVK contingency plan of 2015, there are two ponds and three springs for irrigation. Present irrigation from ground water sources is almost nil. Hence, there is ample scope for ground water extraction for irrigation purpose which will bring prosperity to the society and help the district in achieving self-reliance on food grain. To use groundwater for irrigation purpose a cropping plan has been designed for the district by using CROPWAT model developed by FAO (Food & Agricultural Organisation). CROPWAT 8.0 for Windows is a computer program for the calculation of crop water demand/requirements and irrigation demand/requirements based on soil, climate and crop data. In addition, the program allows the development of irrigation schedules for different management conditions and the calculation of scheme water supply for varying crop patterns. FAO defined water requirements of various crops as the depth (or amount) of water needed to meet the water loss through evapotranspiration. The crop water need can be calculated using the following formula.

ETcrop = ETo * Kc

Where: ETcrop = Crop water need (mm/unit time)

ETo = Reference crop evapotranspiration (mm/unit time) [Influence of climate]

Kc = Crop factor [Influence of crop type and growth stage]

CALCULATION OF REFERENCE EVAPOTRANSPIRATION (ETo): The FAO Penman-Monteith method is the recommended method for determining reference crop evapotranspiration (ETo).In this method ETo of reference crop is calculated by considering maximum and minimum temperature data of received from Central Horticulture College, Pasighat as no FAO's climatic station exists to estimate by Climewat 2.0 software (Table 6.3).

Table 5.3: Month wise evapo-transpiration determined by Cropwat 8.0 from climatic data

Climatic Station: Roing			Longitude	95.85E	Latitude	28.08N	El:295m
Month	Min Temp	Max Temp	Humidity	Wind	Sun	Rad	ETo
	°C	°C	%	km/day	hours	$MJ/m^2/day$	mm/day
January	10.3	20.1	77	173	5.8	11.8	2.03
February	12.6	24.2	74	173	7	15.2	2.79
March	14.1	25.6	75	173	7.5	18.3	3.44
April	20.6	29.3	80	173	6.2	18.3	3.88
May	23.2	29.1	85	173	4.3	16.4	3.53
June	26.4	33.2	84	173	5.3	18.1	4.34
July	25.1	28.2	92	173	1.4	12.1	2.67
August	27.5	34.3	84	173	5.1	17	4.13
September	27.1	33.2	85	173	4.3	14.4	3.6
October	24.8	29.5	88	173	2.8	10.5	2.6
November	18.5	24.7	84	173	3.8	10	2.17
December	14.3	23.1	79	173	5.3	10.7	2.12
Average	20.4	27.9	82	173	4.9	14.4	3.11

Irrigation requirement: Etc - Effective Rainfall

Effective rainfall is defined as the portion of the rainfall which is available to the root zone. Run-off and deep percolation of rainfall are not effective for crop. Effective rain fall is calculated by empirical method provided by USDA soil conservation service where

Effective rainfall= (rainfall*(125-0.2*3*rainfall))/125 for P<=250/3mm

P_{eff}=125/3+0.1P for P>250/3mm .

The effective rainfall for different months for Pasighat station as calculated by Climwat 2.0 is shown in Table 6.4:

Table 5.4: Effective rainfall estimated by Crowat 8.0

Month	Rain (mm)	Eff rain (mm)
January	37.4	12.4
February	58.9	25.3
March	126.4	77.1
April	850.2	656.2
May	385.8	284.6
June	494.6	371.7
July	930.3	720.2
August	920.7	712.6
September	722.5	554
October	102.1	57.7
November	46.9	18.1
December	30.3	8.2
Total	4706.1	3498.2

Cropping Plan: During kharif season, paddy is cultivated in 11180 ha and maize is cultivated in 7885 ha of land. After Kharif crops were grown major portion of this area remains fallow during Rabi season.

The intention of the proposed plan is to bring this fallow land under assured irrigation during Rabi season which will help to increase gross cropped area to 4226 ha and thereby increase cropping intensity up to 200%. This can be achieved by growing potato, mustard and rabi vegetables in rice and maize fallow with the support of irrigation. Present cropping pattern, proposed cropping pattern, intended increase in cropping intensity were shown in tabular form (Table 6.5)

Table 5.5: Cropping pattern, proposed cropping pattern, intended cropping intensity

Rice-Pulse-Vegetables	Present Cultivated area	Area to be cultivated	Area to be cultivated **(ha)**	Irrigation requirement (**ha m**)
Maize-Mustard-Maize	(**ha**)	(**%**)		
Rice-Vegetables				
Rice-Millet				
Maize-Millet	1	2 (= % of 1)	3	4
Rice (main crop)	1713		1729	306.42
Potato	78	25.31	535	95.05
Millet	42	14	288	4.28
Pulses	6	18	370	33.08
Oilseed	16	25.31	535	146.24
Vegetables	141	25.31	535	47.08
Maize (main crop)	117		124	7.37
Net cultivated area	1830	3660	4116	
Gross cultivated area (Paddy/+Maize/+Oilseed+ Vegetables+Potato+Pulses+Millet)	2113			
Total irrigation requirement				639.52
With 70% irrigation efficiency				913.6
Cropping intensity			**200% (Intended)**	

Table 5.6: Crop-wise and month-wise precipitation deficit (IWR) from CROPWAT 8

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Precipitation deficit (mm)												
1. Rice	0	0	0	142	60.4	0	0	0	0	0	0	0
2. Rice	0	0	0	49.1	98	0	0	0	3.5	0	0	0
3. Rice	0	0	0	0	147	0	0	0	3.2	0	0	0
4. Rice	0	0	0	0	146.9	52.2	0	0	0	5.8	0	0
5. Rice	0	0	0	0	27.8	132.9	0	0	0	0	0	0
6. MAIZE	0	0	10.6	0	0	0	1.6	0	0	0	0	0
7. MAIZE	24.8	0	0	0	0	0	0	0	0	22.4	45.4	62.1
8. MILLET	0	0	0	0	0	0	0	0	0	0	0	0
9. MILLET	0	0	0	0	0	0	0	0	0	34.5	0.2	0
10. Pulses	0	0	0	0	0	0	0	0	0	55	34.3	0
11. Small Vegetables	0	0	0	0	0	0	0	0	0	0	0	0
12. Small Vegetables	25.3	0	0	0	0	0	0	0	0	28	35.9	56.1
13. Small Vegetables	50.6	2.2	0	0	0	0	0	0	0	3.4	29.8	53.1
14. Potato	15.3	0	0	0	0	0	0	0	0	46.4	52.6	57.3
15. Potato	57.8	46.2	12.3	0	0	0	0	0	0	4.9	16.7	53.3
16. Mustard	45.3	42.3	51.9	0	0	0	0	0	0	44.6	39.9	49.3

Table 5.7: Actual monthly water requirement for different crops in Roing-Konaru Block of Lower Dibang Valley district, Arunachal Pradesh

Actual monthly water requirement for different crops in Lower Dibang Valley district, Arunachal Pradesh														
Crop	Net sown area (Ha)	Area (%)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total IWR (Ham)
1. Rice		5	0	0	0	29.22	12.43	0	0	0	0	0	0	0	41.65
2. Rice		6	0	0	0	12.13	24.2	0	0	0	0.86	0	0	0	37.19
3. Rice		11	0	0	0	0	66.56	0	0	0	1.45	0	0	0	68.01
4. Rice		15	0	0	0	0	90.7	32.23	0	0	0	3.58	0	0	126.51
5. Rice		5	0	0	0	0	5.72	27.35	0	0	0	0	0	0	33.07
6. MAIZE		2	0	0	0.87	0	0	0	0.13	0	0	0	0	0	1
7. MAIZE	4116	1	1.02	0	0	0	0	0	0	0	0	0.92	1.87	2.56	6.37
8. MILLET		4	0	0	0	0	0	0	0	0	0	0	0	0	0
9. MILLET		3	0	0	0	0	0	0	0	0	0	4.26	0.02	0	4.28
10. Pulses		9	0	0	0	0	0	0	0	0	0	20.37	12.71	0	33.08
11. Small Vegetables		5	0	0	0	0	0	0	0	0	0	0	0	0	0
12. Small Vegetables		5	5.21	0	0	0	0	0	0	0	0	5.76	7.39	11.55	29.91
13. Small Vegetables		3	6.25	0.27	0	0	0	0	0	0	0	0.42	3.68	6.56	17.18
14. Potato		9	5.67	0	0	0	0	0	0	0	0	17.19	19.49	21.23	63.58
15. Potato		4	9.52	7.61	2.03	0	0	0	0	0	0	0.81	2.75	8.78	31.5
16. Mustard		13	24.24	22.63	27.77	0	0	0	0	0	0	23.86	21.35	26.38	146.23
	Total	100	51.91	30.51	30.67	41.35	199.61	59.58	0.13	0	2.31	77.17	69.26	77.06	639.56
Gross irr. Requirement with 70% irr. Efficiency			74.16	43.59	43.81	59.07	285.16	85.11	0.19	0	3.3	110.24	98.94	110.09	913.66
GIWR (HAM)			74.16	43.59	43.81	59.07	285.16	85.11	0.19	0	3.3	110.24	98.94	110.09	913.66

The irrigation requirement for different crops is estimated after projecting the cropping intensity to 200% and assuming that the entire irrigation water will be supplied by ground water. The irrigation requirement of the entire district is found to be 639.66ham and if the irrigation scheme efficiency is 70% then the gross irrigation water requirement will be 913.66ham.

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 5.8: Water requirement for all sectors

District	Drinking water requirement up to 2025 Ham	Water requirement to increase the cropping intensity to 200%	Water allocated for domestic purposes up to 2025 Ham	Water allocated for future use up to 2025 Ham
Lower Dibang Valley	98.8	913.66ham	98.8	**9448.94**

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.

Table 5.9: Supply and demand gap in drinking water sector

Drinking water demand up to 2025 (@60lpcd) 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
98.8	98.8	No shortage
308.9		

Table 5.10: 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
913.66	9449	(+) **8535.34**

CHAPTER 6.0
Management Strategies

The objective of 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 demand of various sectors and adjusting the demand with available resource.

The demands of various sectors in the study area under Roing-Konaru block is worked out and it is observed that the available dynamic ground water resources of this area is sufficient to meet the demand of domestic as well as agricultural and industrial sectors. Various issues pertaining to the management of ground water resources will be discussed in the following paragraphs.

Numbers tube well required for irrigation: A tube well of 60 to 70m depth tapping 20m saturated thickness of aquifer can yield $18m^3$/hr. If the well is allowed to run for 8hrs for 120days, it will create a draft of 1.7ham. To meet irrigation demand of 914ham, 529 numbers of TW can be constructed.

Drilling: In this area percussion rig is useful as bouldery formation is encountered in the area. Combination rig is more useful. Private party use odex drilling technology. Although the drilling rate is fast, non-use of slotted pipe reduces the life of the well and also the yield.

Well Construction: Tube wells can be designed for a depth range of 60 to 70m depending upon geological and geomorphological set up of the area. Tube wells can be constructed by using 8// dia. Housing pipe down to 30 m. A tube well tapping 20m granular zone can expected to yield 15 to $20m^3$ /hr.

Perennial spring source may be nurtured properly to increase yield by constructing spring box and to take spring shed development programme wherever possible.

Site selection for drilling and aquifer tapping: Water Resources Department, Govt. of Arunachal Pradesh had constructed numbers of tube wells in the area. From the litholog and CGWB's VES survey clearly indicates that the ground water potentiality from Balek to Roing and towards northern part of the study area is bleak. Therefore tube well sites need to be selected south of Balek. Even in southern part of Balek there are numbers of local ridges as evident from the landform map and these areas should not be selected for site selection.

WRD's high discharge wells have zones within the gravelly layer. The top bouldery layer may not be selected for tapping the aquifer.

Aquifer wise availability of unsaturated zone: Aquifer wise availability of unsaturated zone is worked out from the area enclosed by 5.0mbgl to 10.0mbgl post monsoon water level contour (Manual of Artificial Recharge: CGWB, 2007). The area is found to be 2830.1ha (Table 6.1).

Table 6.1: Estimation of Sub-surface Storage Capacity

Block	Geographical area (ha)	Area identified for artificial recharge (ha)	Depth to Water level (Post monsoon) below cut-off level (m)	Volume of unsaturated zone ham	Average Specific yield (%)	Total subsurface storage potential as volume of water (ham)
Roing-Konaru	43400	2830.1	5	14150.5	0.16	2264.08

The area identified for recharge is piedmont zone. The unconfined aquifer may be recharged by construction of recharge pits or percolation tanks.

However, the permeability of the subsurface formation is high and also the slope of the area is such that the recharge water will immediately move down and create water logging condition in the valley area. Therefore it is not recommended to recharge in this area.

Demand side management: Demand side management implies sustainable management of water. In irrigation and in drinking water supply also sufficient quantity of water loss occurs. In the study area there is no groundwater irrigation and the surface water irrigation is provided through unlined canals. Although cost of preparation of unlined canals is less, there is considerable water loss through unlined canals.

Irrigation efficiency can be increased by

(i) reducing convenience loss

(ii) improving water application efficiency

Traditional Techniques: Water loss through supply canals can be minimized by proper lining in the canals. The wet rice cultivation of Apatani tribe in Zero Valley of Lower Subansiri is an example of efficient water management. The Apatanis utilized bamboo pipe or wooden lining in the distribution channel to effectively utilize the water resource for cultivation. Therefore, wooden or locally available materials can be utilized for lining canals.

Use of water efficient irrigation method: Drip and sprinkler irrigation methods are very useful in saving water. Both of them save conveyance losses and improve water application efficiency by applying water near the root-zone of the plant. Drip systems convey water in small quantities through drippers/micro-tubes while sprinklers are pressurized systems where a fountain or spray of water is released by the sprinkler connected by pipes, resulting in foliar irrigation. Drip irrigation can increase crop yield per hectre and also saves water up to 70% than conventional irrigation.

Adopting water saving rice irrigation: In this method instead of submerging the paddy field for longer duration, the rice field have to provide water through irrigation only after a certain number of days when the ponded water disappears. This technology is known as alternate wetting and drying (AWD) irrigation. With the optimal management, this technology reduces the amount of water required by about 25% without reduction in yields.

International Rice Research Institute (IRRI) has developed a simple tool to help farmers make decisions on when to irrigate. They found that when field water level recedes to 15 cm below the soil surface, soil water tension in the root zone is always <10 kPa, ensuring good yield. Thus a practical way to implement safe AWD is to monitor the depth of ponded water using a field water tube/ pipe This tube can be made of plastic pipe or bamboo 30 cm long and 15 cm or more in diameter and having perforations on all sides (Figure 1). After transplanting, farmers would keep the field submerged for about 2 weeks to suppress weed growth. The tube is then inserted into the soil by leaving 10 cm above the soil surface. Soil inside the tube is then taken out.

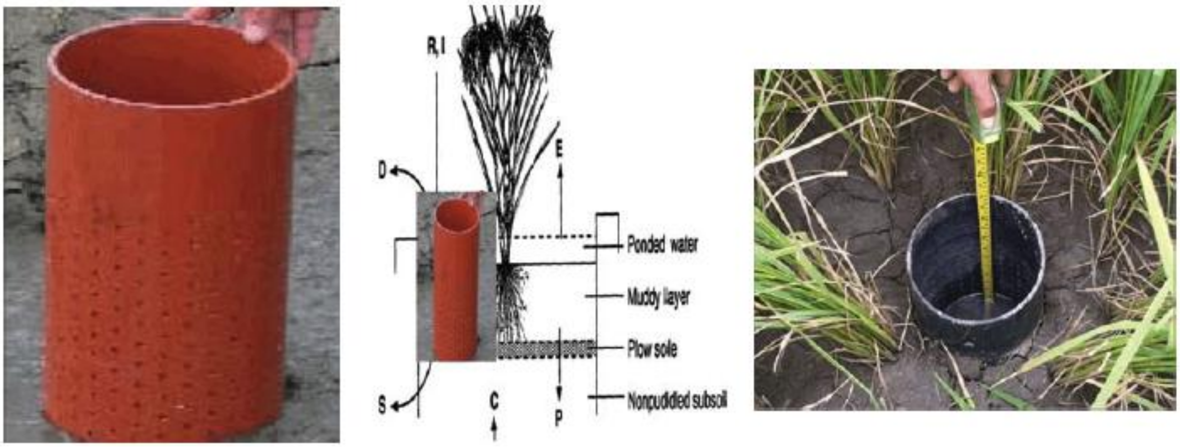


Fig. 6.2: A simple perforated pipe (water tube) installed in the rice field allows farmer to monitor water level beneath the soil surface (Kulkarni, 2011)

Reduce losses of water during leveling: As per Food Agriculture Organization, 200mm of water per hectre is required to level the rice field by traditional method. However, use of laser land leveler help in fine leveling of rice field by eliminating unnecessary depression and elevated contour. It saves 40 to 50% water. A uniformly leveled field allows uniform spreading of irrigated water. It is reported that in Punjab 100% use of laser land leveler in the existing cropping pattern (rice-wheat) can prevent 19cm groundwater draft in entire state (Aggarwal, et. al., 2010).

Approximate Water saving through use of Laser Land Leveler in the rice cultivated area of the district

Block	Paddy cultivated area (as per Dept. of Agriculture) (ha)	40% reduction of water for land leveling by the use laser land leveler	Approximate saving of water ham
Roing-Konaru	1713		137

Use of laser land leveler is also help in preventing water logging condition as it reduces water use during preparation of field for cultivation.

Stress aspect future demand: As mentioned earlier numerical modelling and aquifer simulation study could not be done due to paucity of various data, it was not possible to test a model under different stress conditions.

However, stress aspects of aquifer is analyized for different situations.

Stress on aquifer due to drinking water supply: The population of the study area has been projected based on 2011 census data up to 2025. Based on this projected population drinking water demand of the area is calculated.

There will be no deficiency to cater domestic need in the study (Table 5.6).

Irrigation: The total water requirement to bring the present unirrigated area under irrigation is well within quantity of the allotted dynamic groundwater resource for irrigation.

Even though the supply is more than demand, for sustainability following strategy is suggested.

1) Conserve and improve traditional irrigation techniques. Traditionally perennial streams are used as source water for irrigation. Wherever irrigation from perennial stream exists they need to be preserved and modified so that cropping intensity can be increased.
2) Ground water abstraction structure for irrigation is feasible only in lower southern part of bhabar and comparatively younger terraces. Tube wells of 60 to 70m depth tapping granular zone 20m will expect to yield 15 to 20m^3/hr. These structures can be utilized where there is no perennial stream source for irrigation.
3) Water distribution mechanism should minimize water loss by using lining distribution canals. Locally available materials are to be preferred as these materials are cheap and eco-friendly.
4) Conservation of rain water in the up dip of cultivated field. During rabi season the conserved water can be drained to cultivated land through gravity.