केन्द्रीय भूमि जल बोर्ड

जल संसाधन, नदी विकास और गंगा संरक्षण

विभाग, जल शक्ति मंत्रालय

भारत सरकार

Central Ground Water Board

Department of Water Resources, River Development and Ganga Rejuvenation,

Ministry of Jal Shakti

Government of India

AQUIFER MAPPING AND MANAGEMENT OF GROUND WATER RESOURCES

ALIPURDUAR DISTRICT
WEST BENGAL

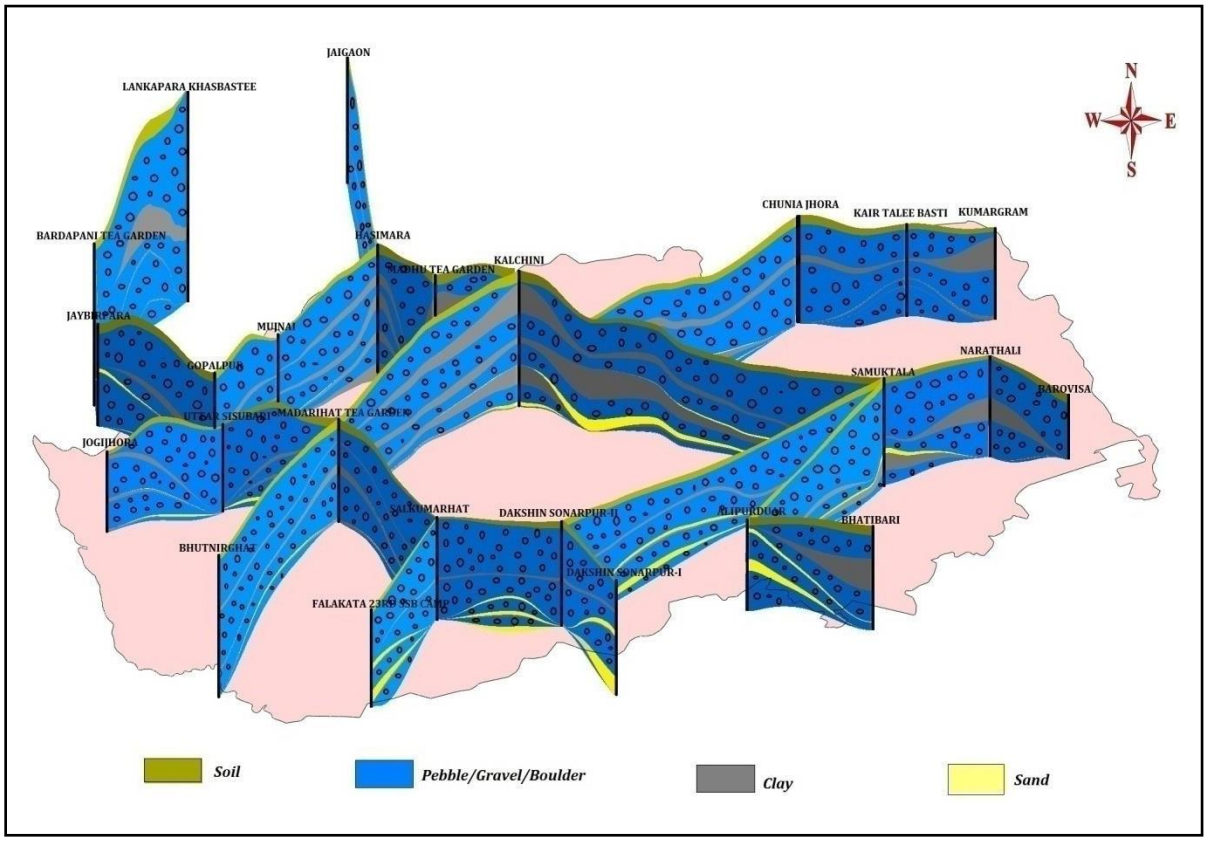
पूर्वी क्षेत्र, कोलकाता

Eastern Region, Kolkata

GOVERNMENT OF INDIA
MINISTRY OF WATER RESOURCES, RIVER DEVELOPMENT AND GANGA REJUVENATION

AQUIFER MAPPING AND MANAGEMENT PLAN IN ALIPURDUAR DISTRICT, WEST BENGAL

(AAP 2021-2022)



By:
Monisha Baruah (Sc-B) & Zumchilo T. Ezung (Sc-B)

CENTRAL GROUND WATER BOARD
EASTERN REGION, KOLKATA

AUGUST 2022

FOREWORD

To understand the nature and occurrences of groundwater, Aquifer geometry, dispositions & characteristics and management of groundwater resource, National Aquifer Mapping & Management Programme (NAQUIM) has been taken up by CGWB under XIIth Plan. During the Annual Action Plan 2021-2022, Aquifer Mapping studies & Management plan was taken up in Alipurduar district.

The study under the aegis of NAQUIM includes four major components namely; Data gap analysis, Data generation, Data collection & compilation and preparation of Aquifer maps and Aquifer Management Plan.

This report is presented in three parts, where Part-I embodies general report for the study area, Part-II include Block Management Plans and Part-III comprises Data Gap Analysis done for the district. Relevant data in respect of the said subjects have been collected from different departments and their publications, viz. Public Health Engineering Dept., State Water Investigation Dept., Agri.-Irrigation Dept., Bureau of Economics & Statistics, Land & Land Reforms Dept., Data of Indian Meteorological Dept., National Bureau of Soil Survey & Land Use Planning, etc. of Govt. of India have also been used. Hydro-geological data is sourced from the scientific studies of CGWB pertaining to groundwater explorations, hydrogeological surveys, chemical analysis and outsourcing explorations being taken up for data generation.

Compilation of this report, evaluation of data and preparation of relevant maps, 2D cross-sections & 3D models of aquifers and their reproduction in the form of present report is outcome of the efforts given by Miss Monisha Baruah, Scientist-B and Miss Zumchilo T. Ezung, Scientist-B.

Effective method of dissemination of the existing technical information to different user agencies is an important aspect of NAQUIM which plays a very vital role in the safe and optimal development of groundwater resources in our country. In this regard, Central Ground Water Board has taken up a great initiative in incorporating NAQUIM project since 2012 to fulfill this directive. It is much anticipated that, this report will become an important tool not only for various user agencies, Engineers, Scientists, Administrators, Planners and others involved in groundwater planning, development and management but also to the common people to make them aware of local groundwater issues and its sustainable management.

(Dr. Anadi Gayen)

Scientist-E/HOO, CGWB, ER, Kolkata

EXECUTIVE SUMMARY

The study area comprises of 6 blocks of Alipurduar district of West Bengal. The present study area covers a total geographical area of 2667 sq. km.It is bounded by the north latitudes of 26°23'34" and 26°52'22"& east longitudes of 89°02'20" & 89°53'13" in Survey of India, Toposheet no. 78F/1, 78F/2, 78F/5, 78F/6, 78F/7, 78F/9, 78F/10, 78F/11, 78F/14, 78F/15. Alipurduar-I is the district headquarter. The total population of the district is **1491250** as per 2011 Census with rural population accounting for almost 79% and the rest 21% as urban population.

The normal annual rainfall for the study area is 3320 mm. The intensity and degree of monsoon rainfall vary from 2200-4000 mm. About 80% of the total rainfall is recorded during this monsoon period.

Physiographically, the districts can be divided into three units: (a) Sub-Himalayan ranges in the north with rugged topography of hard rock terrain, which slopes towards south and merges with the alluvial plain (b) Sub-mountain tract, known as 'Bhabar' characterized by flat but steep step-like terraces (c) Gently southerly sloping alluvial terrain known as Tarai'. Alipurduar District shows elevation variation from 35m to 1550m amsl. Geomorphologically, the area is a part of the Teesta, Jaldhaka and Torsa inter-fluve belt. Locally the northern part of the area is called 'Duars' and is a part of the piedmont plains at the foothills of the Himalayas. This gradually merges into alluvial plain further south. These alluvial fans deposits are fluvio-glacial in origin as evidenced by huge boulders. Later stage fluvial activities can be observed in the form of terraces where cobble to clay size materials do appear. Several major and minor rivers drain the district. The major rivers are Torsa, Raydak, Kaljani and Angabarsha. These rivers are generally southerly flowing. The soil in the district are mostly clayey-loam, loam, sandy loam and acidic. The pH value ranges from 4.5 to 6.6 and are deficient in micronutrients.

Paddy is the principal crop of the district. Other important crops are jute, wheat, mustard seeds, potato, and til. Irrigation on a large scale is surface water dependent due to the non-availability of adequate ground water owing to its discrete hydrogeological settings. Irrigation plays a major role in district's agricultural sector through tube wells of various depths. Sources of irrigation are Canals, River Lift Irrigation (RLI) structures, Deep Tubewells (heavy duty tubewells), Shallow tubewells (medium duty and low duty tubewells) and a few tanks. Out of the 49.36 % of the cultivable land in the study area, 13.3 % has been brought under surface water irrigation and only 6.28 % of the area is under groundwater irrigation. Remaining of the area is mostly rain-fed.

The district of Alipurduar is underlain mainly by the alluvial deposits brought about by the south flowing Mountain Rivers and streams. Age of rocks ranging from Cambrian to Paleozoic to Tertiary is also found along the northern boundary of the district. The oldest rock type, the Dalings, are represented by quartzites, Phyllites, Chlorite-Sericite-schists and Carbonaceous Mica schists and are found to occur as thin strips along north of Buxaduar. The Dalings are followed to the south by the buxas which are represented by Variegated Quartzites, Dolomites and Phyllites. Further south the Gondwanas are sandwiched between the Buxas in the north and by the Siwaliks in the south. The Older Alluviums (Bhabar Formations) generally comprises of unconsolidated sediments consisting of boulders, pebbles, gravels with sand, silt and calcareous and limonitic concretions. These Older Alluviums occupies the high grounds forming elevated/raised terraces (Bhabar Formation) and mostly cover the southern portion of the foothills. The new Alluvium (Terai Formations) is confined south of the raised terraces and they gradually merges with the axial plain of the south. This Formation particularly comprises of coarse to fine sand, gravel and clay intercalations.

Groundwater in the district is primarily restricted to the alluvial tracts of Bhabar and Terai regions. The zones in the upper northern regions where it is underlain by hard rock terrains, groundwater generally occurs in the upper weathered zone and in the deeper fractured zones. Based on their depth of occurrences, the aquifer in the area is broadly categorized into two: (a) **Shallow aquifer or Aquifer-I** (within 50 mbgl). The thickness of the individual zones in this zone ranges from 3 to 22 meters. The yield of the wells tapping from these zones is in tune of 5.34 to 113.5 m^3/hour. The transmissivity range is from 165 to 300 m^2/day. **(b) Deeper aquifer or Aquifer-II** (within 50 to150 mbgl). The thickness of the individual zones ranges from 3 to 30 meters. The yield from the wells tapping from these zones yield in tune of 38.80 to 177.16 m^3/hour. The transmissivity range is from 10 to 2500 m^2/day.

The pre-monsoon period Water level for Aquifer-I rests mostly at depths ranging from 2.03 to 8.78 mbgl and for Aquifer-II, the water level ranges from 2.42 to 8.15 mbgl. Water level for Aquifer-I during the post-monsoon generally rests within the depth range of 2.2-8.33 mbgl and for Aquifer-II, the water level ranges from 2.53-7.25 mbgl. The water level fluctuation in the area generally rests between -1 to1 m for both Aquifer-I & II. Water level fluctuation of more than 2 metres is recorded from some parts in Alipurduar-I. The water level data for the last 10 years show a rising trend during the pre-monsoon period for almost all the blocks. This suggests that the long-term change in water level in the district is insignificant and a stable groundwater regime has been existing over the years.

As per the computation, the net ground water availability for recharge for Alipurduar district was estimated at **124952.93** ham. The total extraction for all uses was estimated at

5824.04 ham. The total in-storage for the district is **1750822** MCM. The stage of groundwater development in the district stands at 4.66%, categorized as 'Safe'.

Very high concentration of iron (Fe) in groundwater has been reported from this district. The concentration of iron in groundwater from the shallow aquifers ranges from 0.18 to 11.20 mg/l. In Chechakhata at Alipurduar-II block, iron concentration as high as 11.20 mg/l is reported. The concentration of iron in deeper aquifers range from BDL to 11.4 mg/l. Very high iron concentration of 9.5 mg/l is reported from Uttara Haldibari area in Kumargram block and 11.4 mg/l from Chilapat of Alipurduar-I block. Another issue in the district is in regard to very deep water level in the Bhabar areas where the water level goes very deep during the lean period as the declination of water level starts immediately after monsoon due to the high effluent nature of the river and the whole area becomes devoid of sufficient amount of water at a shallow level.

The level of groundwater development is very low with an average of **4.66**%, and is categorized as "Safe". Therefore, there is a huge scope for further utilization of groundwater through construction of new abstraction structures for irrigation. Development of groundwater in the study area can be done mostly through shallow tube wells and deep tube wells. In Bhabar areas, large diameter dug-wells and heavy duty tube-wells are recommended for irrigation. In Terai zones dug wells, medium duty and heavy duty irrigation tube-wells are recommended to increase groundwater development. A high concentration of iron in groundwater (above maximum permissible limit of 1.0 mg/I) has been reported from several pockets in the districts and therefore, it needs proper attention, and iron removal plants may be installed.

Emphasis should be given to rainwater harvesting with suitable structures. Conservation of rainwater can be done both from the rooftop and from the land. The water that can be available from rooftops can be stored in cemented and PVC tanks. Before conserving, the water should be sand filtered. The rainwater available from any land surface can be stored in any ponds and in this case, sites, as well as the design of ponds, are to be finalized considering local hydrogeological and terrain conditions. As per the district wise Master Plan of West Bengal, 596 no.s of percolation tanks, 1191 no.s of REET with RS and 596 no.s of injection wells have been proposed in four blocks of the Alipurduar district namely- Alipurduar-II, Kalchini, Kumargram and Madarihat at an estimated cost of 1788 lakhs.

CONTRIBUTORS

Data Acquisition	:	Monisha Baruah (Scientist-B)
		Zumchilo T Ezung (Scientist-B)
Data Processing	:	Monisha Baruah (Scientist-B)
		Zumchilo T Ezung (Scientist-B)
Data Compilation & Editing	:	Monisha Baruah (Scientist-B)
		Zumchilo T Ezung (Scientist-B)
Data Interpretation	:	Monisha Baruah (Scientist-B)
		Zumchilo T Ezung (Scientist-B)
GIS & Thematic Map Preparation	:	Monisha Baruah (Scientist-B)
		Zumchilo T Ezung (Scientist-B)
		Mahashweta Mukherjee (YP)
		Rajyashree Nandi(YP)
Chemical Analysis & Interpretation	:	Dr. Suparna Dutta (Asst. Chemist)
Report Compilation	:	Monisha Baruah (Scientist-B)
		Zumchilo T Ezung (Scientist-B)
Report Processing	:	Chirashree Mohanty (Scientist-D)
Technical Guidance	:	Sandhya Yadav (Scientist-E)
		Dr. Indranil Roy (Scientist-D)
Overall Supervision	:	Dr. Anadi Gayen, Scientist-E/HOO

CONTENTS

Part I

AQUIFER MAPPING STUDIES IN ALIPURDUAR DISTRICT, WEST BENGAL

Page No.

Part II

BLOCK WISE AQUIFER MANAGEMENT PLAN FOR ALIPURDUAR DISTRICT

WEST BENGAL

Page No.

Part III

DATA GAP ANALYSIS FOR ALIPURDUAR DISTRICT OF WEST BENGAL

LIST OF TABLES

PART-I

PART-II

PART-III

LIST OF FIGURES

PART-I

PART-II

PART-III

Part-I

AQUIFER MAPPING STUDIES IN ALIPURDUAR DISTRICT, WEST BENGAL

CHAPTER-1

INTRODUCTION

Groundwater is one of the prime sources of fresh water contributing significantly for the survival of mankind. However, overexploitation, surface runoff, subsurface groundwater discharge has depleted the fresh groundwater availability considerably. Assessing the groundwater potential zone is extremely important for the protection of water quantity & quality, and the management of groundwater system. In this context, the National Aquifer Mapping& Management Programme (NAQUIM) has been taken up by Central Ground Water Board (CGWB) under XIIthPlan. As per the revised annual action plan groundwater management studies in 6 blocks of Alipurduar district was taken up by CGWB, ER, Kolkata. In this report the salient features of aquifer geometry, characteristics; ground water occurrences, availability, resource vis-a-vis quality, development & management, scope of ground water etc. of the six (06) blocks have been covered.

1.1. OBJECTIVE:

The broad objective of the study is to establish the geometry of the underlying aquifer systems in horizontal and vertical domain, its resource potential in respect of quality & quantity, aquifer characterization, scope for development potential and prepare aquifer-wise management plans.

1.2. SCOPE OF STUDY:

The scope of the present study is broadly within the framework of National Aquifer Mapping & Management Programme (NAQUIM) being implemented by CGWB. There are four major components of this activity viz.: (i) Data gap analysis (ii) Data generation (iii) data collection / compilation and (iv) Preparation of aquifer maps and management plan to achieve the primary objective. Data compilation included synthesis of database of various agencies, such as the Survey of India, Geological Survey of India of the Union Govt. and offices of the Govt. of West Bengal (W.B.), computerization and analyses of all acquired data, and preparation of data bases of different themes. Identification of Data Gap included ascertaining requirement for further data generation in respect of hydro-geological, geophysical, chemical, hydrological, hydro-meteorological studies, etc. Relevant data in respect of the said subjects have been collected from different authorities, viz. Public Health Engineering Dept., State Water Investigation Dept., Agri.-Irrigation Dept., Bureau of economics & Statistics, Land & Land Reforms Dept., Data of Indian Meteorological Dept., National Bureau of Soil Survey & Land Use Planning, etc. of Govt. of India have also been used. The existing data of hydro-geological data including those of exploratory wells, piezometers, slim holes, etc. by erstwhile E.T.O., CGWB as well as chemical quality data

including trace elements in ground water, either by in-situ or out-sourcing, lying in the Central Ground Water Board, Eastern Region have been thoroughly studied. Besides, data have been generated by hydro-geological surveys and collection of water samples, followed by their laboratory analyses for all major parameters. Additional data pertaining to sub-surface lithology and aquifer parameters were obtained through site specific drilling of exploratory wells, pumping tests, etc.

1.3. APPROACH & METHODOLOGY:

An approach and methodology adopted to achieve the major objective have been shown below step-wise.

I. Compilation of existing data
II. Identification of data gaps
III. Data generation based on data gaps
IV. Preparation of thematic maps on GIS platform
V. Preparation of 2D/3D aquifer disposition maps
VI. Compilation of Block-wise Aquifer Maps and Management Plan

1.4. LOCATION, EXTENT AND THE ACCESSIBILITY:

The study area comprises of 6 blocks of Alipurduar district of West Bengal. The present study area covers a total geographical area of 2667 sq. km.It is bounded by the north latitudes of 26°23'34" and 26°52'22"& east longitudes of 89°02'20" & 89°53'13" in Survey of India, Toposheet no. 78F/1, 78F/2, 78F/5, 78F/6, 78F/7, 78F/9, 78F/10, 78F/11, 78F/14, 78F/15.

The district is situated in the northern part of West Bengal. It is bounded by Jalpaiguri District in the West; Coochbehar District in the South; Assam in the East and in the north, the district shares an international border with Bhutan. The district headquarter is at Alipurduar-I and is connected with state capital Kolkata, by railways (Northeast-Frontier Railways) and road (NH-31) networks. The district is also connected to Assam via National Highway-31. Apart from this, state highways, other narrow metalled roads connect all the other important towns in this district and the all-weatherroads connect almost all the villages.

The administrative map for Alipurduar district is given in **Figure-1.1.**

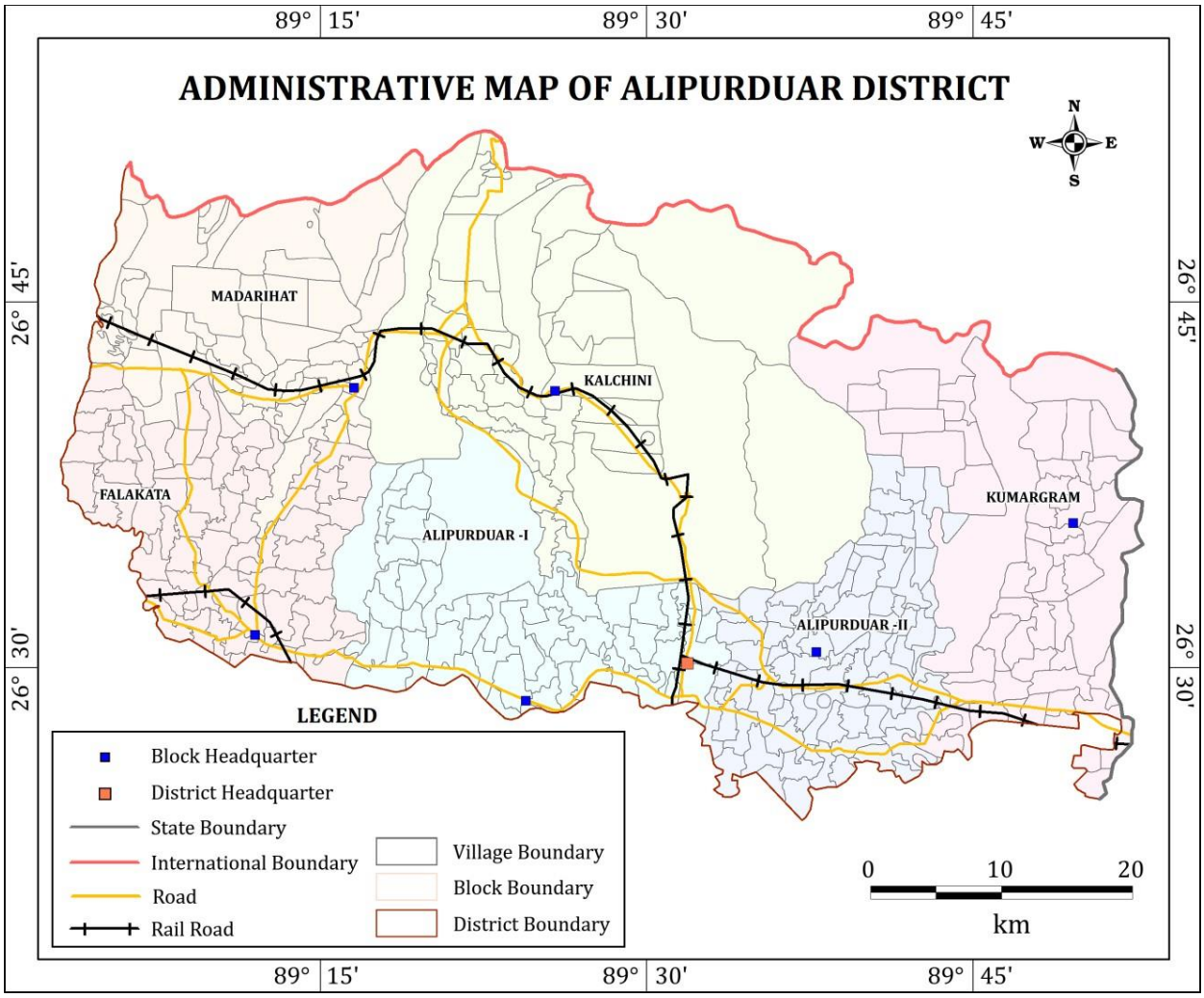


Figure- 1.1: Administrative map for Alipurduar district of West Bengal.

1.5. ADMINISTRATIVE DIVISION AND POPULATION:

The district consists of 6 blocks namely 1)Kumargarm2) Falakata 3) Madarihat 4) Kalchini 5) Alipurduar-I 6) Alipurduar-II. The district has one municipal town at Alipurduar-II. The administrative detail of the district is presented in **Table-1.1**and **Table-1.2.**

Table-1.1: Major administrative division for Alipurduar district of West Bengal.

District	Block	Geographical Area (Sq.Km)	Mappable Area (Sq.Km)
Alipurduar	Kumargram	517.68	324
	Falakata	353.93	266
	Madarihat	376.75	287
	Kalchini	711.61	361
	Alipurduar-I	388.39	226
	Alipurduar-II	318.92	172
Total		**2667.28**	**1636**

**Geographical area: District Statistical Handbook, 2014.*

The study area covers a total of 6 panchayat samity, 66 gram panchayat, 998 gram sansad, 338 mouzas, 327 inhibited village, 335253 households, 1 municipality, 20 wards and 20 census towns.

Table 1.2: Major administrative division for Alipurduar district of West Bengal.*

Block / Municipality	Panchayat			Mouzas	Inhabited Villages	House-holds	Town		
	Samity	Gram	Gram Sansad				Municipality		Census Town (2011)
				(2001)	(2011)	(2011)	No.	Ward	
Kumargram	1	11	144	55	53	44997	-	-	3
Falakata	1	12	206	63	60	65571	-	-	4
Madarihat	1	10	139	50	48	44149	-	-	2
Kalchini	1	11	193	43	41	62737	-	-	4
Alipurduar-I	1	11	155	48	47	50211	-	-	5
Alipurduar(M)	-	-	-	-	-	15556	1	20	-
Alipurduar-II	1	11	161	79	78	52032	-	-	2
Total	**6**	**66**	**998**	**338**	**327**	**335253**	**1**	**20**	**20**

**Source- District Statistical Handbook, 2014*

Distribution of population of the study area is presented in**Table-1.3**.

Table-1.3: Distribution of population in the administrative units of Alipurduar district.

Block/ Municipality	Rural Population			Urban Population			Total Population		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Kumargram	89456	84602	174058	13136	12415	25551	102592	97017	199609
Falakata	125691	118470	244161	23935	22626	46561	149626	141096	290722
Madarihat	94531	93734	188265	7005	6756	13761	101536	100490	202026
Kalchini	105633	106175	211808	49196	37454	86650	154829	143629	298458
Alipurduar-I	82878	77882	160760	28500	27671	56171	111378	105553	216931
Alipurduar(M)	-	-	-	33137	32095	65232	33137	32095	65232
Alipurduar-II	105403	99249	204652	7031	6589	13620	112434	105838	218272
TOTAL	**603592**	**580112**	**1183704**	**161940**	**145606**	**307546**	**765532**	**725718**	**1491250**

**Source- District Statistical Handbook,2014.*

Table-1.4: Distribution of Population over different Categories of Worker and Non-Workers in Alipurduar district of West Bengal.

Block/ Municipality	Total Workers(TW)		Class of Total Workers								Main workers		Marginal workers		Non-workers		Total Population
	Number	P.C.	Cultivators		Agricultural Labourers		Household Ind.Workers		Other Workers		Number	P.C.	Number	P.C.	Number	P.C.	
			No.	PC to TW	No.	PC to TW	No.	PC to TW	No.	PC to TW							
Kumargram	79099	39.63	12190	15.41	20744	26.23	2901	3.67	43264	54.70	54081	27.09	25018	12.53	120510	60.37	199609
Falakata	112686	38.76	23309	20.68	43693	38.77	1875	1.66	43809	38.88	89294	30.71	23392	8.05	178036	61.24	290722
Madarihat	81669	40.42	7171	8.78	9714	11.89	1406	1.72	63378	77.60	57338	28.38	24331	12.04	120357	59.58	202026
Kalchini	120238	40.29	7459	6.20	8487	7.06	2256	1.88	102036	84.86	89666	30.04	30572	10.24	178220	59.71	298458
Alipurduar-I	89224	41.13	16670	18.68	30686	34.39	992	1.11	40876	45.81	67510	31.12	21714	10.01	127707	58.87	216931
Alipurduar(M)	22876	35.07	161	0.70	113	0.49	572	2.50	22030	96.30	21289	32.64	1587	2.43	42356	64.93	65232
Alipurduar-II	86276	39.53	18842	21.84	32502	37.67	2658	3.08	32274	37.41	62037	28.42	24239	11.10	131996	60.47	218272

**Source- District Statistical Handbook,2014.*

Note: Total workers= Main workers+ Marginal workers

P.C= Percentage to respective total population

P.C to TW= Percentage to respective total workers.

Ind.= Industry

1.6. LAND-USE, CROPPING PATTERN AND IRRIGATION:

Land-use and land-cover:

Primarily the land in the study area is used for cultivation. Land-use pattern of urban and rural areas depends mainly on socio-economic factors. The land-use pattern of the study area is explained by the following points:

90% population of the study area is directly or indirectly dependent on cultivation for their livelihood and the economy predominantly revolves around agriculture. About 139801 ha land is under cultivation which makes up 49.36 % of the study area. The rapid growth of population demands rapid boost in agricultural products. In this regard cropping pattern plays an important role as "Boro" paddy cultivation is gaining more importance day by day and multiple cropping models is being adopted.

Tea, Tobacco and timber are the main agro-based industries of the area. Tea plantation is widely practiced in the northern part of the study area where abundant rainfall and good drainage exists.

The district is blessed with rich reserves of forest resources.These forests, covering about 114607 hectares of land which is 40.47 % of the total reporting area, are home to a variety of flora and fauna. The vegetation is mostly deciduous semi-evergreen with Sal as the dominant species.Area under non-agricultural uses includes settlement area which makes 10 % of the study area.The details of the land-use pattern are presented in **Table-1.5.** below:

Table-1.5: Areas under different land use in Alipurduar district of West Bengal.

Block	Reporting Area	Forest Area	Area Under Non-Agricultural Waste	Barren and Un-culturable land	Land under misc tree crops	Culturable wastes	Fallow land Other than current fallow	Current fallow	Net area sown
Kumargram	50441	23893	5019	68	198	26	-	68	21169
Falakata	35487	3110	5318	9	276	95	-	555	26124
Madarihat	38086	8774	2627	23	160	-	-	308	26194
Kalchini	89273	63254	3084	13	80	34	16	395	22397
Alipurduar-I	38311	15576	5620	8	347	-	-	492	16268
Alipurduar-II	50441	23893	5019	68	198	26	-	68	21169
Total	**283202**	**114607**	**28654**	**140**	**1985**	**187**	**17**	**2277**	**135335**

**Source- Directorate of Agriculture, Govt. of West Bengal.*

Cropping pattern:

The majority of the people of the district are engaged in agriculture. The economy of the district is mainly dependent on agriculture and plantation activity. Paddy is the principal crop of the district. Other important crops are jute, wheat, mustard seeds, potato, and til. Three varieties of paddy viz. *Aus*, *Aman* and *Boro* are grown. Amongst the three varieties, *Aman*is highest grown crop both in terms of area and production. Gradually more and more areas are coming under wheat production in the district. Pulses like *musur*, *mug*, gram, *maskalai*, *khesari*and *arhar* are also grown.

Alipurduar is famous for its tea and timber. Tea stands as the most valuable agro-product of the district.A large variety of fruits such as mango, Banana, Oranges, Papaya, jackfruit etc. is grown under moderate rainfall.The cultivation pattern is mostly bi-cropped followed by single cropped and in few small areas it is tri-cropped.The details of the crops grown, the production and yield are presented in tabular form in **Table-1.6** below.

Table-1.6: Type of crops cultivated in Alipurduar district of West Bengal.

Name of Block	Aus			Aman			Boro			Wheat			Maize^			Jute			Musur		
	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.*	Yield**	Area	Prod.	Yield
Kumargram	2507	4.806	1917	10536	21.175	2010	339	0.868	2562	1272	3.466	2725	222	1.730	7795	823	11.004	13.37	520	0.278	535
Falakata	8598	15.024	1747	1908	3.036	1591	1581	4.622	2923	1965	4.456	2268	322	2.510	7795	2343	31.584	13.48	703	0.472	671
Madarihat	1267	3.017	2381	5663	12.369	2184	262	0.555	2119	229	0.682	2977	817	1.843	2255	718	10.224	14.24	20	0.007	360
Kalchini	377	0.724	1920	34551	80.464	2329	175	0.329	1883	106	0.265	2502	471	4.665	9905	199	3.033	15.24	-	-	-
Alipurduar-I	2850	4.974	1745	1297	2.506	1932	482	1.295	2686	1945	3.486	1792	189	0.610	3226	1590	15.39	9.68	15	0.003	183
Alipurduar-II	3938	6.405	1627	2151	4.192	1949	982	1.986	2022	2035	5.414	2660	300	2.338	7795	2788	37.74	12.46	365	0.194	533

Name of Block	Maskalai			Khesari			Mustard			Til			Potato			Sugarcane		
	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield
Kumargram	106	0.080	751	118	0.119	1007	470	0.332	706	8	0.006	759	2483	64.503	25798	-	-	-
Falakata	754	0.453	600	154	0.146	950	180	0.088	490	62	0.047	759	8459	215.341	25457	9	0.921	102366
Madarihat	12	0.004	356	70	0.043	618	671	0.382	569	-	-	-	1151	26.130	22702	-	-	-
Kalchini	40	0.013	329	-	-	-	107	0.075	701	-	-	-	185	3.757	20310	-	-	-
Alipurduar-I	20	0.005	239	30	0.024	800	995	0.724	728	5	0.004	759	4965	127.427	25665	-	-	-
Alipurduar-II	101	0.024	237	10	0.009	949	2583	1.971	763	24	0.018	759	1409	32.562	23110	-	-	-

** Source- District Statistical Handbook, 2014*

Area = hectare, * **Production** = thousand million tones, **Yield**= Kg/hect.
****Yield**-In Bales per hectare, **^ Bhadui Maize only***

Irrigation:

Irrigation facility plays an important role for agricultural production along with the development of cropping intensity. Out of the 49.36 % of the cultivable land in the study area, 13.3 % has been brought under surface water irrigation and only 6.28 % of the area is under groundwater irrigation. Remaining of the area is mostly rain-fed. The sources of irrigation are Canals, River Lift Irrigation (RLI) structures, Deep Tube-wells (heavy duty tube-wells), Shallow tube-wells (medium duty and low duty tube-wells) and a few tanks. Block-wise data regarding area under irrigation from different sources in the study area are given in **Table-1.7**.

Table-1.7: Area (in hectares) irrigated by different sources Alipurduar district of West Bengal.

Name of Block	Canal	Tank		RLI		DTW		STW		ODW	
	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area
Kumargram	1655	1	125	28	625	1	40	139	695	114	395
Falakata	3216	1	250	45	1140	4	160	540	2630	-	-
Madarihat-Birpara	2158	1	52	34	840	-	-	131	655	18	55
Kalchini	1242	1	50	18	450	-	-	72	360	6	21
Alipurduar-I	2465	2	226	37	1000	4	150	351	1675	25	89
Alipurduar-II	1590	1	176	42	1340	1	40	386	1730	24	84
TOTAL	**12326**	**7**	**879**	**204**	**5395**	**10**	**390**	**1619**	**7745**	**187**	**644**

** Source- District Statistical Handbook, 2014*

***Note:RLI**= River Lift Irrigation, **DTW**= Deep Tube-well, **STW**= Shallow Tube-well, **ODW**= Open Dug well.*

For groundwater irrigation mostly shallow (Low Duty Tube Wells and Medium Duty Tube Wells) and deep tubewells (Heavy Duty Tube Wells) are being used. Electric motors of 5 to 30 H.P are used for lifting groundwater from these sources. These deep tube-wells (heavy duty) are designed for yielding 75-220 m3/hr of water to irrigate 40.46 ha (100 acres) each. Medium duty tube-wells usually gives a discharge ranging from 20 to 45 m3/hr, are designed for irrigating an area of 2.02 to 2.83 ha (5 to 7 acres). Large number of private owned shallow tube-wells is also operating for irrigation purposes with a general capacity of yielding 10 to 30 m3/hr and irrigating 3 to 5 acres of land per each well. Large diameter wells (Dug wells) are very few in number in the study area. They have a maximum depth of 10 mbgl and an irrigation potential of 2 to 8 ha. **Table-1.8**, explains that the total culturable command area created so far by ground water and surface water irrigation schemes. 31910.32ha of cultivable land is brought under culturable command area, among which 58 % of total area by ground water-based schemes and 41.8 % by surface water schemes.

Table-1.8: Irrigation potential created by surface water and ground water in Alipurduar district of West Bengal.

Block Name	Dug well		Shallow Tube-well		Medium Tube-well		Deep Tube-well		Surface Flow		Surface Lift		Irrigation Potential(ha.)		Total Irrigation Potential (ha.)
	No.	Irrigation Potential (ha.)	No.	Irrigation Potential (ha.)	No.	Irrigation Potential (ha.)	No.	Irrigation Potential (ha.)	No.	Irrigation Potential (ha.)	No.	Irrigation Potential (ha.)	Ground Water	Surface Water	
Alipurduar-I	0	0.00	964	4633.31	1	5.00	6	82.00	1	5.00	19	724.92	4720.31	729.92	5450.23
Alipurduar-II	0	0.00	1686	4342.10	0	0.00	7	35.00	18	90.00	63	1884.00	4377.10	1974.00	6351.10
Falakata	3	15.00	1641	4085.00	0	0.00	7	78.00	4	20.00	49	858.00	4178.00	878.00	5056.00
Kalchini	0	0.00	100	203.00	0	0.00	0	0.00	1	5.00	46	1126.00	203.00	1131.00	1334.00
Kumargram	0	0.00	723	1959.90	0	0.00	3	24.00	10	50.00	34	973.00	1983.90	1023.00	3006.90
Madarihat	0	0.00	169	497.80	0	0.00	0	0.00	2	10.00	31	992.00	497.80	1002.00	1499.80
TOTAL	**3**	**15**	**5283**	**15721.11**	**1**	**5**	**23**	**219**	**36**	**180**	**242**	**6557.92**	**15960.11**	**6737.92**	**22698.03**

*Source: 5th MI Census

Table-1.9: Culturable command area created by surface water and ground water in Alipurduar district of West Bengal.

Block Name	Dugwell		Shallow Tube-well		Medium Tube-well		Deep Tube-well		Surface Flow		Surface Lift		CCA (ha.)		Total CCA (ha.)
	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	Ground Water	Surface Water	
Alipurduar-I	0	0.00	964.00	3165.00	1	5.00	6	90.00	1	5.00	19	3554.43	3260.00	3559.43	6819.43
Alipurduar-II	0	0.00	1686.00	3782.87	0	0.00	7	38.00	18	90.00	63	3584.49	3820.87	3674.49	7495.36
Falakata	3	15.00	1641.00	3695.00	0	0.00	7	111.00	4	20.00	49	779.00	3821.00	799.00	4620.00
Kalchini	0	0.00	100.00	220.00	0	0.00	0	0.00	1	5.00	46	1386.90	220.00	1391.90	1611.90
Kumargram	0	0.00	723.00	1779.10	0	0.00	3	30.00	10	50.00	34	3576.40	1809.10	3626.40	5435.50
Madarihat	0	0.00	169.00	406.31	0	0.00	0	0.00	2	10.00	31	5511.82	406.31	5521.82	5928.13
TOTAL	**3**	**15**	**5283**	**13048.28**	**1**	**5**	**23**	**269**	**36**	**180**	**242**	**18393.04**	**13337.28**	**18573.04**	**31910.32**

**Source: 5th MI Census*

1.7. URBAN AREA, INDUSTRIES & MINING ACTIVITIES:

The study area comprises of only one municipality i.e.,Alipurduar Municipality in Alipurduar I block. The rapid urbanization in the district has led more and more areas to come under residential and industrial sector. The major industry developed in the districtis tea.

The district is not very rich in mineral resources and there are no large mines in the district as such. However, collection of sand, stone and gravels from the river-bed of the hilly torrents are the minor mineral sources. These materials are primarily utilized for construction purpose.

CHAPTER-2

CLIMATE

Alipurduar district experiences subtropical climate, which is characterized by hot summer from March to May and well distributed southwest monsoon rainfall from June to October months. Winter season in the area is marked by dry and cold weather during the month of November to February. Normal annual rainfall of this area is 3320 mm.

2.1 RAINFALL:

The normal annual rainfall for the study area is 3320 mm. Torrential rain in tune of more than 200 mm in 24 hours are often recorded. The intensity and degree of monsoon rainfall vary from 2200-4000 mm. About 80% of the total rainfall is recorded during this period causing devastating flood in many of the parts of the district.

Details of rainfall data of ten years (from 2011 to 2021) is furnished in **Table-2.1**. A graph plot is also given in **Figure-2.1**. From this data it can be addressed that the actual rainfall does not show any major deviation from the normal rainfall. For the year 2020, excess rainfall of almost 1034 mm from the normal has been recorded.

Year	Normal Annual Rainfall (mm)	Actual Annual Rainfall (mm)	Percent Deviation
2011	3320	3056.37	-7.94
2012	3320	3940.86	18.70
2013	3320	3185.47	-4.05
2014	3320	3128.75	-5.76
2015	3320	3685.8	11.01
2016	3320	3820.01	15.06
2017	3320	3849.59	15.95
2018	3320	3537.5	6.55
2019	3320	3669.14	10.51
2020	3320	4354.15	31.15
2021	3320	3033.86	-8.62

** Source: Rainfall Data from WRIS*

Table-2.1: Details of rainfall data for ten years (from 2011 to 2021) for Alipurduar district of West Bengal.

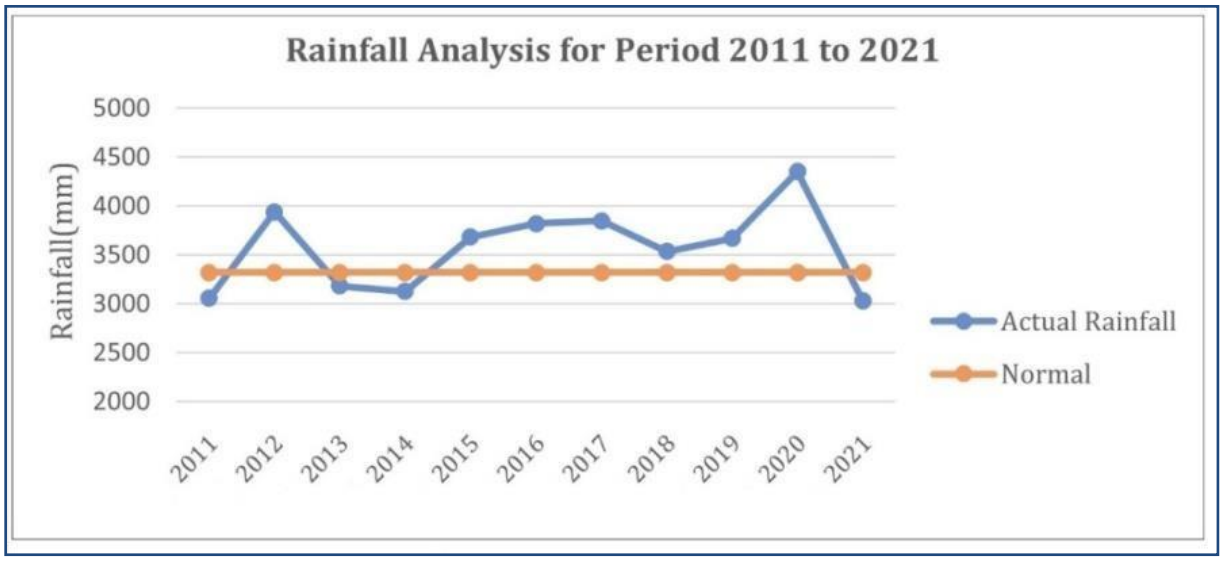


Figure- 2.1: Plot of rainfall data for the period 2011 to 2021 for Alipurduar district of West Bengal.

2.2 TEMPERATURE:

With an average of 27.5°C, August is the hottest month. January has the lowest average temperature of the year. The maximum and minimum temperature recorded in the district is 38°C and 6.8°C respectively. Monthly average temperature distribution of Alipurduar district is furnished in **Table-2.2**. Graphical representation of average temperature for Alipurduar district is shown in **Figure-2.2.**

Table-2.2: Monthly average temperature distribution for Alipurduar district of West Bengal.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Avg Temp (°C)	17.3	20.1	24	25.6	26.2	27	27.3	27.5	26.9	25	21.7	18.7
Avg Min Temp (°C)	11.7	14.5	17.8	20.9	22.7	24.5	25.1	25.1	24.2	20.8	16.6	13.2
Avg. Max Temp (°C)	22.9	25.5	29.8	30.3	29.8	29.9	30	30.4	29.9	29	26.9	24.3

**Source: climate-data.org.*

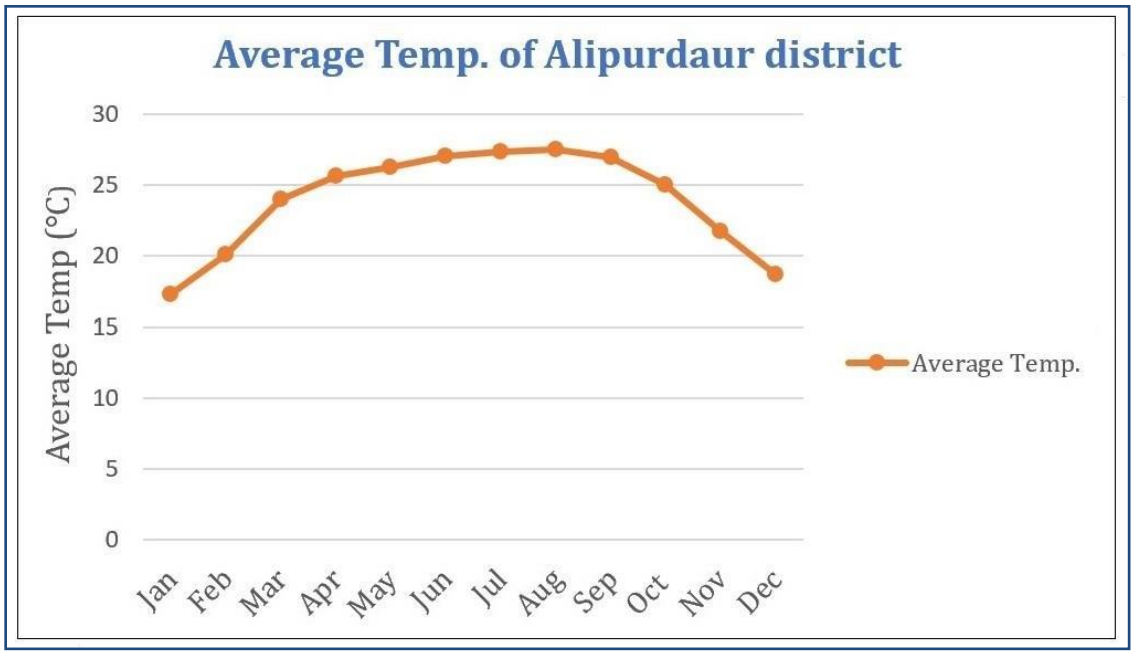


Figure- 2.2: Graphical representation of average temperature for Alipurduar district of West Bengal.

2.3 HUMIDITY, WIND SPEED AND WIND DIRECTION:

The entire district experiences a high relative humidity. It ranges between 49-87%. The monsoon months from June to August experiences the highest relative humidity between 86-87%. The drier months of December to March are less humid with the values ranging between 49-65%. The monthly relative humidity of Alipurduar district is furnished in **Table-2.3.**

Humidity	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	65%	58%	49%	66%	79%	86%	87%	86%	85%	77%	65%	63%

**Source: climate-data.org.*

Table-2.3: Monthly relative humidity of Alipurduar district of West Bengal.

Surface winds of the district are generally from the Northwest during the winter months. But during summer the wind direction is from the South. During the monsoon, the prevailing direction is from Southeast. At Alipurduar, the average wind speed does not generally exceed 9 Km/hour.

CHAPTER-3

PHYSIOGRAPHY

Physiographically, the districts can be divided into three units:

i. The sub-Himalayan ranges in the north with rugged topography of hard rock terrain, which slopes towards south and merges with the alluvial plain.
ii. The sub-mountain tract, known as 'Bhabar' characterized by flat but steep step-like terraces
iii. The gently southerly sloping alluvial terrain known as Terai'.

The physiographic map of the Alipurduar District shows elevation variation from North to South. Madarihat, Kalchini and Kumargram blocks show elevation difference from 1550 m to 69 m. The elevated regions in the blocks of Falakata, Alipurduar-I and Alipurduar-II show an elevation variation from 100 m to 35 m.

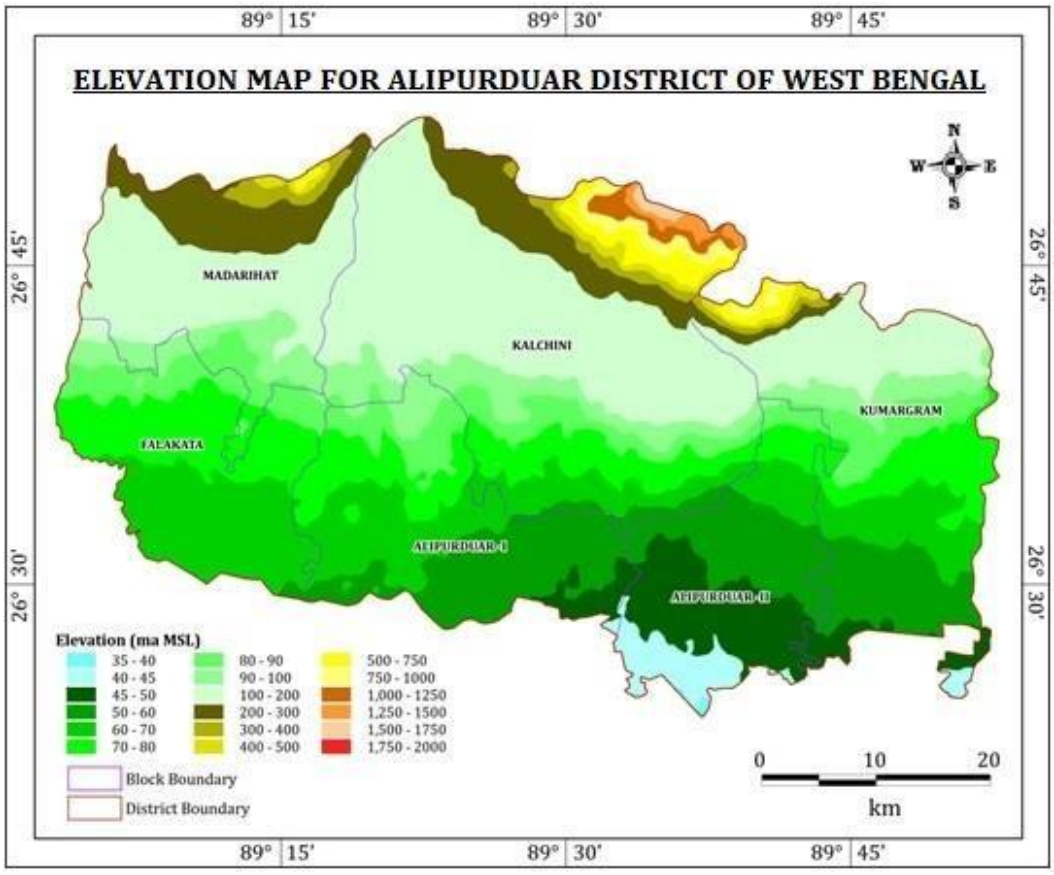
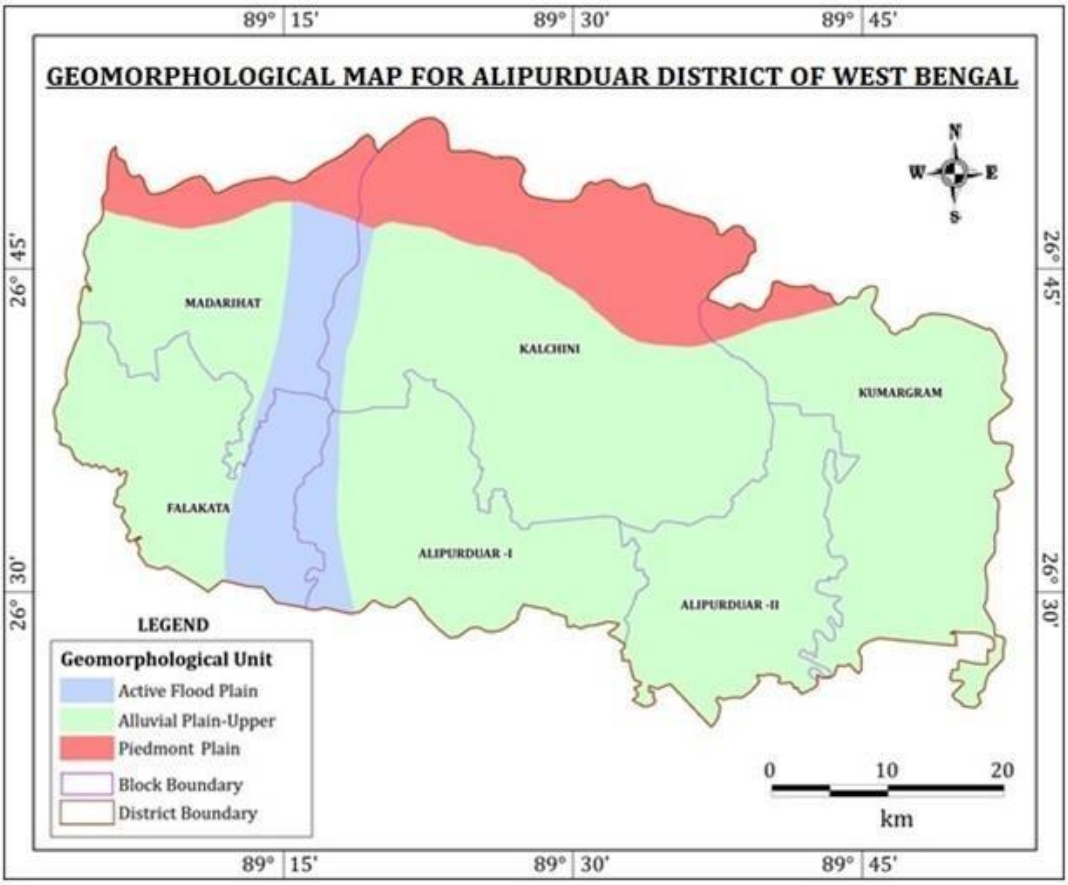


Figure- 3.1: Physiographic map for Alipurduar district of West Bengal.

3.1 GEOMORPHOLOGY:

Geomorphologically, the area is a part of the Teesta, Jaldhaka and Torsa interfluve belt. Locally the northern part of the area is called 'Duars' and is a part of the piedmont plains at the foothills of the Himalayas. This gradually merges into alluvial plain further south. The piedmont region is dissected by the major rivers and their tributaries. The northern part of the area is characterized by alluvial fans and the ancient deposits are fluvio-glacial in origin as evidenced by huge boulders. Later stage fluvial activities can be observed in the form of terraces where cobble to clay size materials do appear. Hill and gully erosion over a long period of time produced a dissected undulating surface. Retreat of glacier, expected sea level rise and subsequent upliftment resulted in growth of an extensive Quaternary fluvial deposit. The geomorphological map of the study area is shown in **Figure-3.2.**



(Source: CGWB, ER, Kolkata)

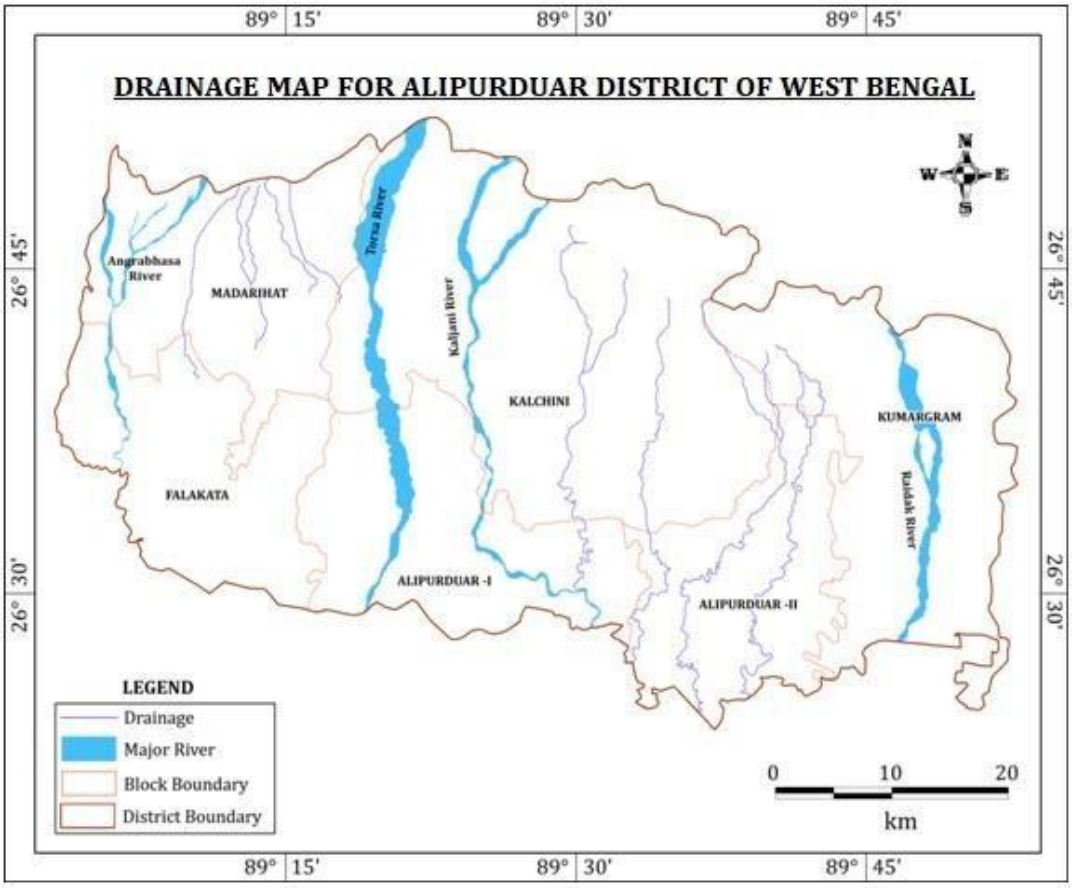
Figure-3.2: Geomorphological map for Alipurduar district of West Bengal.

3.2 DRAINAGE:

A large of number of rivers and rivulets originate from the mountains of Bhutan. The major rivers are Torsa, Raydak, Kaljani and Angabarsha. All these rivers are southerly flowing.

These rivers flowing over steeply sloping land surface during monsoon carry a huge quantity of boulders, pebbles, cobbles, etc and these are deposited in the southern part as the topographic slopes become gentler.

The minor streams emerging from the Himalayas generally dry up completely after each rainy spell enriching the unconfined ground water body in "Bhabar" formation. The drainage characteristics of the study area indicate presence of neo-tectonic activities which ultimately control the changing river characteristics and the sediment load content of the rivers. The neotectonics also control the geomorphology and physiography of the region which also contributes to the drainage characteristics of the district. The drainage map of the study area is shown in **Figure-3.3.**



(Source: CGWB, ER, Kolkata)

Figure-3.3: Drainage map for Alipurduar district of West Bengal

3.3 SOIL CHARCTERISTICS:

The soil in the district are mostly clayey-loam, loam, sandy loam and acidic. The pH value ranges from 4.5 to 6.6 and are deficient in micronutrients. The soil in this region varies from alluvial soil to sandy and hard black clayey. The upper region in the north of Dooars,

the soil is mainly black and clayey. This soil is suitable for growing tea, which is a major cash crop of this district. In the lower plain, the soil consists of a mixture of both clay and sand. The alluvial soil is fertile enough for crops like paddy, wheat, jute, potato, pulses, oilseeds, sugarcane etc. to be grown. According to National Bureau of Soil Survey and Land Planning, The soils of the district can be classified into three main types:

i. **Soils of Indo-Gangetic Plain:** These are coarse to fine loamy soil occurring on gently sloping upper piedmont plains to nearly level lower piedmont plain. These soils are imperfectly drained and associated with moderate erosion.
ii. **Soils of Active Alluvial Plain**: These are coarse to loamy soil occurring on active alluvial plain. These are poor to moderately drained, associated with flooding.
iii. **Soils of Recent Alluvial Plain:** these are fine loamy soils occurring in recent alluvial plain. These soils are poorly drained.

The soil map of the study area is shown in **Figure- 3.4.**

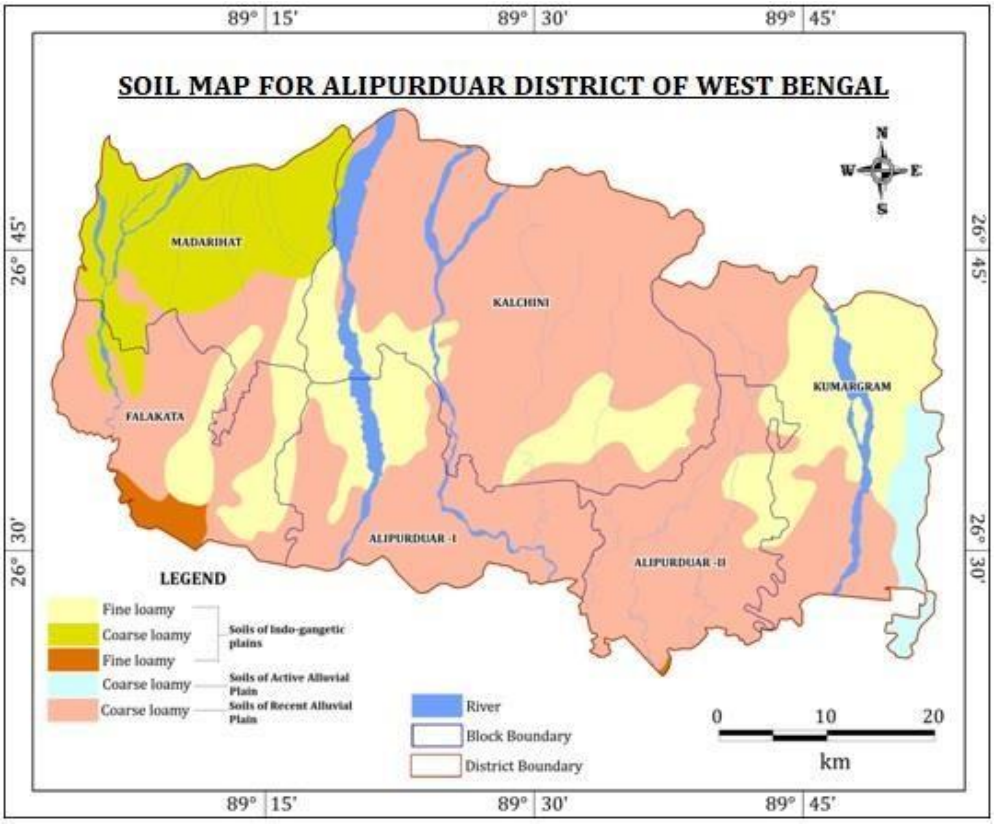


Figure-3.4: Soil map for Alipurduar district of west Bengal.

CHAPTER-4

GEOLOGY

4.1. General Geology:

The district of Alipurduar is underlain mainly by the alluvial deposits brought about by the south flowing Mountain Rivers and streams. Age of rocks ranging from Cambrian to Paleozoic to Tertiary is found along the northern boundary of the district near Buxaduar and Jainti hill. A generalized stratigraphic succession for the study area is given below.

Age	Formations	Lithology	Area
Quaternary Sub-Recent to Recent	Younger Alluvium	Clay, Sand and gravel	Alipurduar, Southern parts of FalakataandKumargram blocks.
Pleistocene	Older Alluvium	Boulders, gravels, pebbles and sand with lime concretions	Madarihat, Jaigaon, Kaichini, northern parts of Falakata and Kumargram blocks.
	----------Unconformity----------		
Tertiary Mio-Pliocene	Siwaliks	Pebble beds and Conglomerates with Coarse micaceous sandstones with clays	Northernmost parts of Kumargram, Kalchini and Jaigaon blocks.
	----------Main Boundary Fault----------		
Paleozoic Permo-Carboniferous	Gondwanas	Carbonaceous shales and micaceous flaggy sandstones and coal	Northernmost parts of Kumargram, Kalchini and Jaigaon blocks.
	----------Tectonic/Erosional Contact----------		

Algonkian	Buxa Formation	Variegated Quartzites, Dolomites and Phyllites	Parts of Madarihat block, northern most parts of Kumargram, Kalchini and Jaigaon blocks.
Pre-Cambrian	Daling Formation	Quartzites, Phyllites, Chlorite-Sericite-schists and Carbonaceous Mica schists	Northernmost parts of Kumargram

(*Source; Geological Survey of India*)

The oldest rock type, the Dalings, are represented by quartzites, Phyllites, Chlorite-Sericite-schists and Carbonaceous Mica schists and are found to occur as thin strips along north of Buxaduar. The Dalings are followed to the south by the buxas which are represented by Variegated Quartzites, Dolomites and Phyllites. Further south the Gondwanas are sandwiched between the Buxas in the north and by the Siwaliks in the south. The Gondwanas are represented by extremely carbonaceous shales, carbonaceous and micaceous flaggy sandstones, lenticles of crushed and powdery coal. The Gondwanas are followed southward by the Siwaliks which are abruptly cut off towards the north by the main boundary Fault. The southern boundary of the Siwaliks is an erosional one and is covered by alluvial plain. The Siwaliks comprises of coarse grained micaceous sandstones with pellets of clay and lenses of lignite coal. Pebble beds and conglomerates are conspicuous in the upper part of the Siwaliks.

The Older Alluviums generally comprises of unconsolidated sediments consisting of boulders, pebbles, gravels with sand, silt and calcareous and limonitic concretions. These Older Alluviums occupies the high grounds forming elevated/raised terraces (Bhabar Formation) and mostly cover the southern portion of the foothills. The Bhabar Formations lying immediately south of the Siwaliks is formed of integrated alluvial fan deposits as a result of the turbulent streams which flows rapidly from the Himalayan foothills. The new Alluvium (Terai Formations) is confined south of the raised terraces and they gradually merges with the axial plain of the south. This Terai Formation particularly comprises of hard clays intercalated with beds, bars and lenses of coarse sand and gravel. The deposits upon the surface are generally thick and extensive and are mixed with hard clay and kankar.Gravel beds, in general, the most important constituent of water bearing natural formation, occur significantly. The geological map for Alipurduar district is given in **Figure-4.1.**

4.2. Sub-surface Geology:

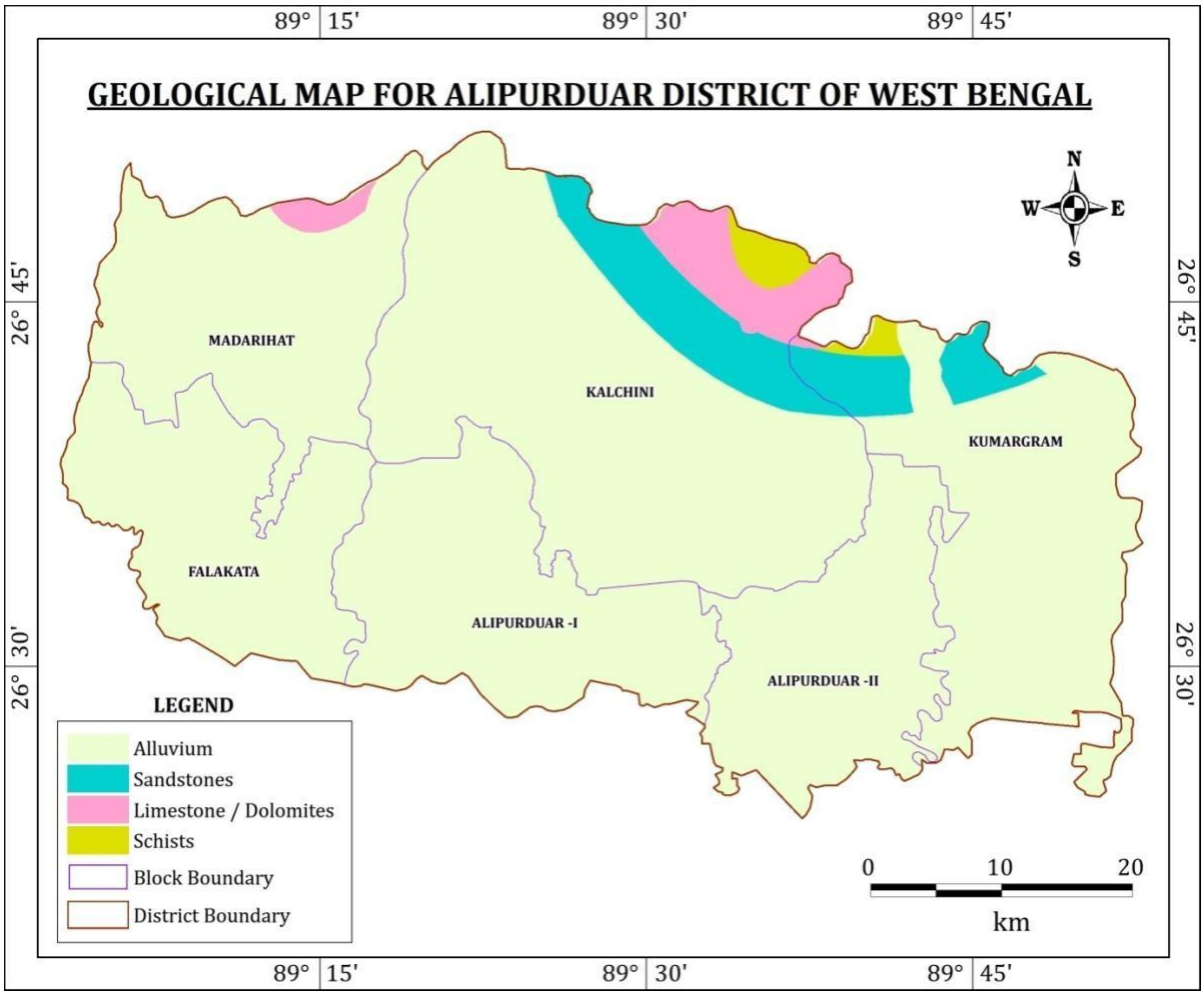
The sub-surface geology of the study area could be visualized through the study of the lithological logs prepared from the drilling records of bore wells that have been sunk to a maximum depth of 188 mbgl in the northern and north-western part (Bhabar zone) and up to 330 mbgl in the central and southern part of the study area. The exploratory works has been carried out by Central Ground water Board as well as by other private and state government agencies.

The Alluvial sediments have been laid down as flood-plain deposits by the torrential mountain rivers and streams. These water bearing sediments consists of assorted boulders, pebbles, gravels and coarse to medium sand intercalated occasionally with lenses of clay or clay horizons which are found inconsistent and often pinch out within short distances. In general, the sediments are poorly sorted but the degree of sorting slightly improves towards the south. The boulders, pebbles and gravels are well rounded and are mainly derived from the Pre-Cambrian Dalingquartzites and granites, etc. The sand grain grades from fine to coarse, are sub-rounded and micaceous (muscovite). No definite correlation could be attempted in the area as none of the bore wells show similarity in their sequence ofdeposition or assortment. There are no definite clay horizons as such. These clay layers have maximum reported thickness of 7 m, normally grey to black in colour. However, it may be noted that the proportion of gravels, pebbles and large clastics as well as the thickness of clay layers which decreases towards the south proves the theory that these sediments were deposited by turbulent mountain streams/rivers.

The drill cut samples reveals the succession of top sandy or silty clay followed by fine to medium to coarse sand and gravels in downward direction. Cemented sand and kankar also have been observed in some places. No basement Formation has been encountered till date in any of the boreholes.

4.3. Structures

The area is influenced by tectonic activities prevalent from the Pliocene to the Recent time, which took place in the eastern Himalayas. The northern part of the area is characterized by alluvial fan deposit which coalesces to form the piedmont zone. The area is traversed by a number of transverse faults and faults parallel to the Himalayan arc. The evidence of faulting could be found in the piedmont scarp which were at a high angle and cut across a number of rivers which had a linear shift in their course at those sections.



(Source: CGWB, ER, Kolkata)

Figure-4.1: Geological map for Alipurduar district of West Bengal

CHAPTER-5

GEOPHYSICS

Geophysical study in field can be broadly divided into two categories, namely surface geophysical investigation or resistivity survey (VES and profiling) and borehole electrical logging.

Surface geophysical investigation is the pre- drilling approach and in ground water exploration it has many fold objectives that depends on formation characteristics likely unconsolidated, semi-consolidated and consolidated formations.

In hard rock terrain it is required to identify a) Saturated fractures/joints, faults, shear zones, dykes, quartz veins and reefs which may control the ground water occurrence/movement at varied depths, b) Thickness of the water bearing overburden (weathered residuim), c) depth to the bed rock and resistivity values and d) delineation of water filled cavities in limestone.

In alluvial areas identification of granular and non-granular formations, thickness of the individual layers and their resistivity values, identification of saline/fresh water interface etc. are required to be done. Lithology, resistivity, formation factor, formation resistivity, porosity, permeability, specific yield of water bearing formations, chemical and physical characteristics of water of a particular formation of interest can also be calculated.

Electrical resistivity investigation is also adopted in exploratory drilling program to locate a tube/bore-well site due to its wide simplicity in field proceedings and low cost of operation. To pin point an exploratory drilling site in hard rock areas in most of the cases deep fractures are identified with the help of curve break technique (Ballukarya). It also helps for mapping potential aquifers in buried stream channels and also demarcating the areas suitable for artificial recharge and prone to water logging.

The geophysical logging of water wells is a post-drilling approach to optimize the design and development of the wells in unconsolidated sediments. The main objective of geophysical logging include demarcation of boundaries between granular and non-granular zones, identification of potential aquifer zones, decisions pertaining proper positioning of screens against productive aquifers and against the caving formations, planning and management of potable ground water resources, identification of fresh/saline

As part of short term water supply investigation by CGWB, 5 no.s VES were carried out within the complex of Makrapara Tea Estate, Birpara block. 6 no.s VES were also carried out in Falakata block. The main aim of the study was to delineate aquifer depth in Bouldery Formation.

The study revealed the existence of potential aquifer zones at depth range of 150-180, 170-200, 165-195 and 210-240 mbgl.

As per CGWB records, no electro-log for the boreholes have been carried out till date.

CHAPTER-6

HYDROGEOLOGY

6.1 Occurrence and movement of Groundwater:

The district of Alipurduar is underlain mainly by the alluvial deposits of Quaternary, Holocene and Pleistocene age. The Older Alluvium (Aquifer code: AL03) mostly covers the Bhabar regions and are comprised of clay, sand and gravel. The Younger Alluvium (Aquifer code: AL01) covers the Terai regions and are comprised of Boulders, gravels, pebbles and sand with lime concretions. The small upper northern regions are underlain by rocks in the likes of variegated quartzites, dolomites and phyllites chlorite-sericite schists,carbonaceous mica schists, carbonaceous shales, micaceous flaggy sandstones and coal of Palaeozoic to Pre-Cambrian age.

Groundwater is primarily restricted to the alluvial tracts of Bhabar and Terai regions. The zones in the upper northern regions where it is underlain by hard rock terrains, groundwater generally occurs in the upper weathered zone and in the deeper fractured zones.

The topographic slope and direction of flow of the rivers indicates that groundwater movement is from North- South.

6.2 Aquifer properties and Yield, water bearing Formations:

The aquifers in the study area are grouped into two categories based on their depth of occurrence; (a) Shallow aquifer, those which occur within 50 mbgl and (b) Deeper aquifer, those that occur at depth beyond 50 mbgl.

Shallow aquifers (Aquifer-I): This layer within the depth range of within 50 mbgl is generally composed of coarse sand mixed with gravel, boulders, cobbles and pebbles. The groundwater in this zone occurs under unconfined to semi-confined conditions and is generally tapped through a system of dug wells and shallow tubewells. The thickness of the individual zones ranges from 3 to 22 meters. The yield from the wells tapping from these zones yield in tune of 5.34 to 113.5 m^3/hour. The transmissivity range is from 165 to 300 m^2/day.

Deeper aquifers (Aquifer-II): The deeper aquifers in Bhabar and Terai region in general,arecomposed of sand, gravel and pebbles with regional extent and are occasionally separated by thin clay layers of limited extent. These aquifers occur under unconfined to semi-confined conditions. Groundwater is developed through shallow and medium depth tube wells. The thickness of the individual zones ranges from 3 to 30 meters. The yield

from the wells tapping from these zones yield in tune of 38.80 to 177.16 m^3/hour. The transmissivity range is from 10 to 2500 m^2/day.

The hydrogeological map of the study area is shown in **Figure-6.1**.The aquifer parameters for different litho-units in Alipurduar district is given in **Table-6.1.**

Table-6.1: Aquifer parameters for different litho units in Alipurduar district of West Bengal.

Block	Geology	Depth range (mbgl)		Zones Tapped		Yield (m^3/hour)		T (m2/day)	
		Aquifer I	Aquifer II	Aquifer I	Aquifer II	Aquifer I	Aquifer II	Aquifer I	Aquifer II
Alipurduar-I	Younger Alluvium	27.59 - 67.4	50.32 - 125	27.59 - 42.67, 36.96 - 43.12, 45.44 - 67.4, 46.2 - 56.98	50.32 - 74.6, 52.36 - 67.67, 54.25 - 78.25, 56.38 - 71.48, 66.22- 78.61, 67 - 90, 72 - 96.3, 94 - 100, 119 - 125	5.34 - 104.69	53.37 - 152.64	165-300	10-2500
Alipurduar-II	Younger Alluvium/ Older Alluvium	28 - 48	58 - 93.42	28 - 48	58 - 82, 60.38 - 81.38, 69.15 - 93.42	68.14	60.56 - 71.64	165-300	10-2500
Falakata	Younger Alluvium	27.87 - 56.98	50 - 119.2	27.87 - 36.86, 40.04 - 56.98, 44 - 47	50 - 62, 65 - 68, 69.15 - 93.42, 74 - 80, 84.47 - 108.87, 86 - 92, 93 - 119.2	68.32	60.56 - 177.16	165-300	10-2500
Kalchini	Younger Alluvium/ Older Alluvium/Sandstone/Limestone/Dolomite/Shale	46.88 - 53.03	55.05 - 100.8	46.88 - 53.03	55.05 - 85.05, 56.38 - 71. 82, 61 - 67, 64 - 79, 66 - 74, 73 - 85, 76.8 - 100.8, 80 - 96, 82 - 91	19.14 - 25	38.80 - 68.13	165-300	10-2500
Kumargram	Younger Alluvium/Sandstones	45.44 - 67.44	56.65 - 91	45.44 - 67.44	56.65 - 78, 67.1- 91	113.5	66.48 - 73.13	165-300	10-2500
Madarihat	Younger Alluvium/ Older Alluvium/Sandstone/Limestone/Dolomite/Shale	49.7 - 67.7	53.4 - 167.48	49.7 - 67.7	53.4 - 77.4, 79 - 88, 114 - 123, 131 - 134, 132 - 156, 133.8 - 160.8, 137 - 164, 158 - 167.48	63.59	3.22 - 75.6	165-300	10-2500

Table-6.2: Details of exploratory drillings carried out by CGWB, ER, Kolkata in Alipurduar District.

Sl. No.	Block	Location	Latitude	Longitude	Depth of Well Constructed (mbgl)	Zone tapped (mbgl)	S.W.L. (mbgl)	Discharge (lpm)	Drawdown (m)	T (m2/day)
1	Alipurduar-I	Baganbari	26.5315	89.1964	128	45.00-51.00 67.00-90.00 94.00-100.00 119.00-125.00	3.11	2544	3.59	379.33
2	Falakata	Falakata SSB 23rd Battalion	26.5672	89.3231	71	44.00-47.00 50.00-62.00 65.00-68.00	5.08	1138.8	7.87	2000
3	Kalchini	Jaigaon	26.8541	89.3778	93	64.00-79.00 82.00-91.00	--	720	--	--
4	Kalchini	Hasimara A/F	26.6851	89.3374	100	66-74, 80-96	4.37	900	--	--
5	Kalchini	Kalchini	26.6892	89.4296	109	61-67, 73-85	11.55	1060.8	2.45	--
6	Madarihat	Madarihat	26.6945	89.2746	72	--	--	--	--	--
7	Madarihat	Lankapara	26.8156	89.2294	159	79.00-88.00 132.00-156.00	90	1260	--	--

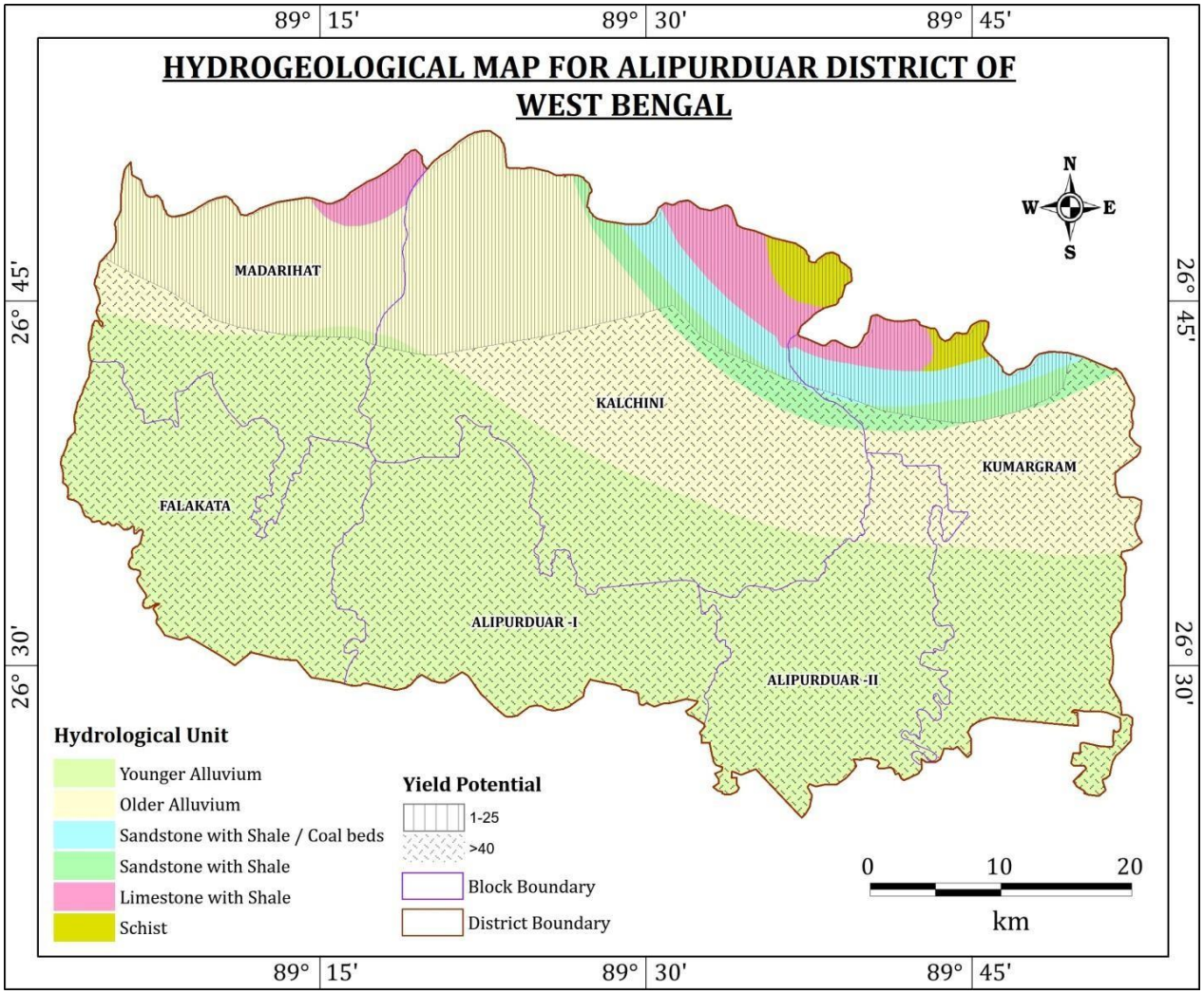


Figure- 6.1: Hydrogeological Map for Alipurduar District of West Bengal.

Discharge is comparatively higher for the wells constructed in Bhabar and Terai regions, where the Formation is basically the Younger and Older Alluviums. Less yield are recorded from wells tapping the upper northern regions of the district which are basically underlain by hard rocks (sandstones/limestones/dolomites/shale/schists). This may be attributed to the fact that the chances of encountering fractures in hard rock are highly uncertain and their yield prospect is generally very low in nature.

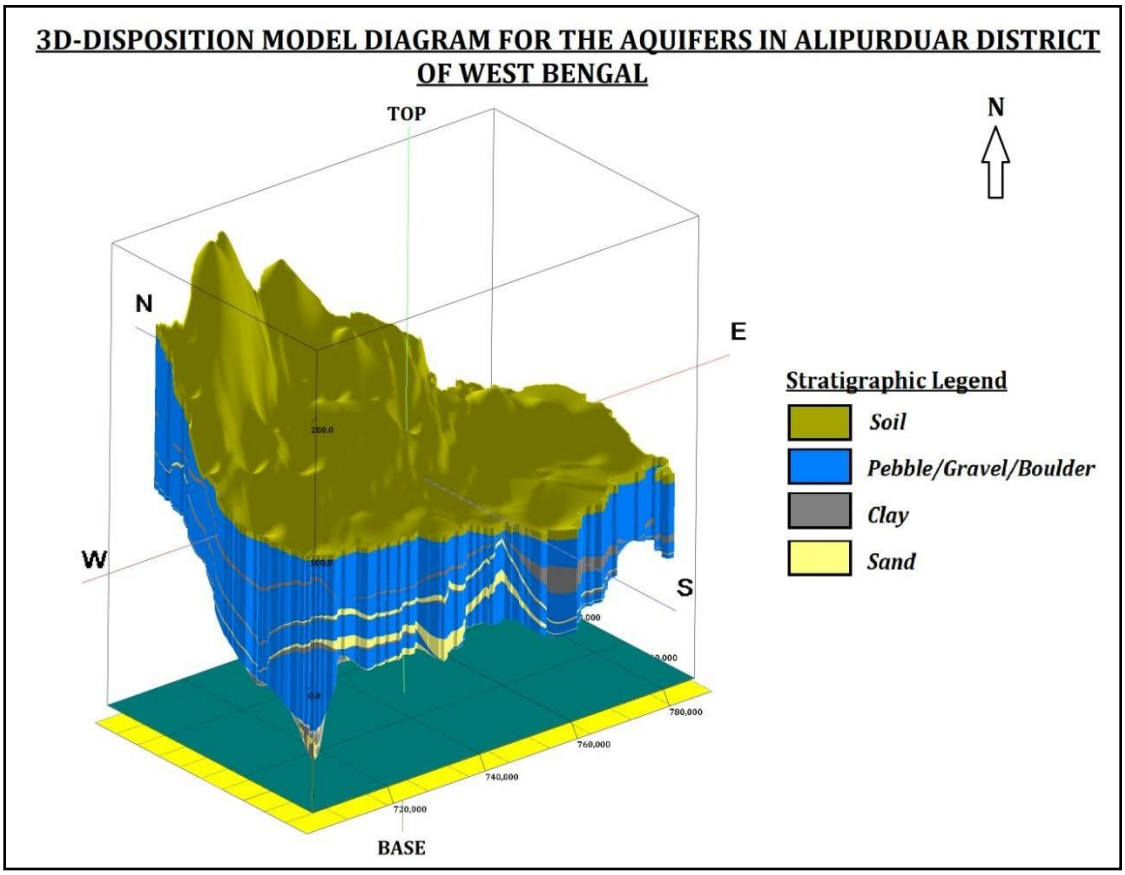


Figure- 6.2: 3D Aquifer disposition model diagram for the Aquifers in Alipurduar District of West Bengal

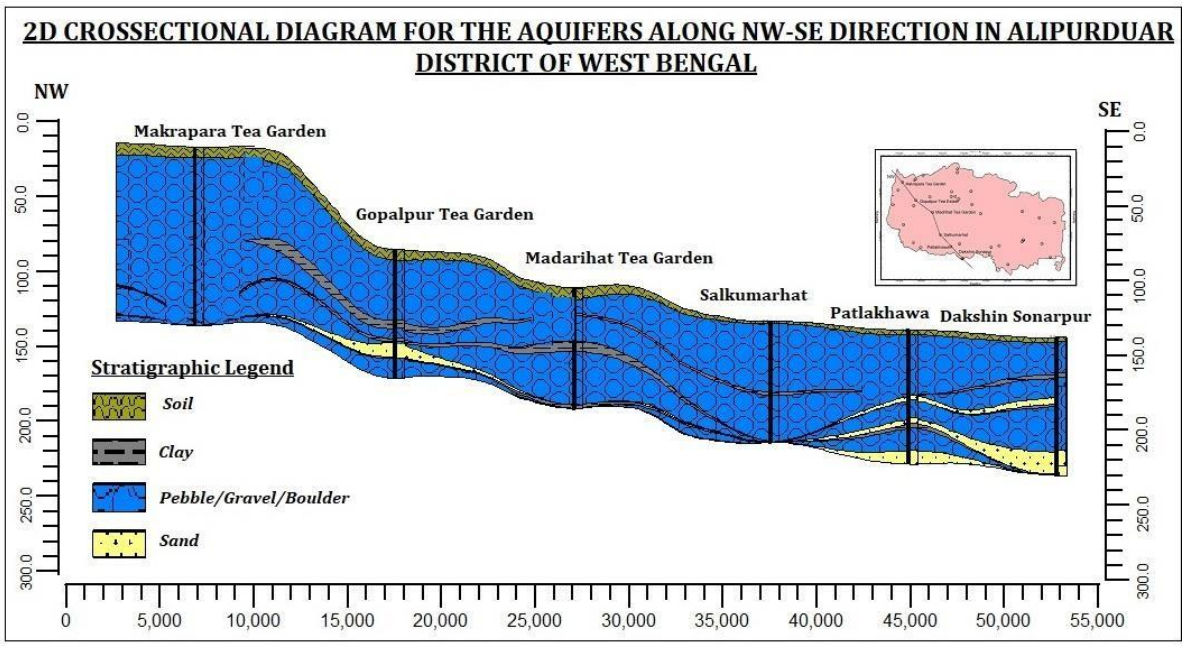


Figure- 6.3: 2D Aquifer Crossectional Diagram along NW – SE direction in Alipurduar District of West Bengal

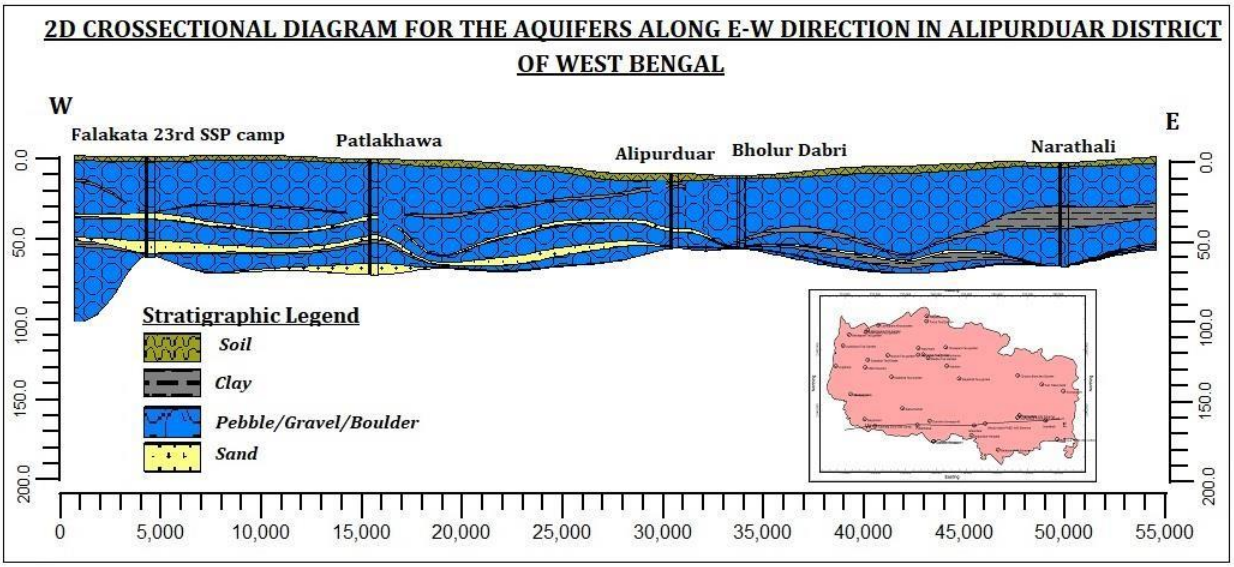


Figure-6.4: 2D-crossectional diagram for the aquifers along E – W direction in Alipurduar district of west Bengal.

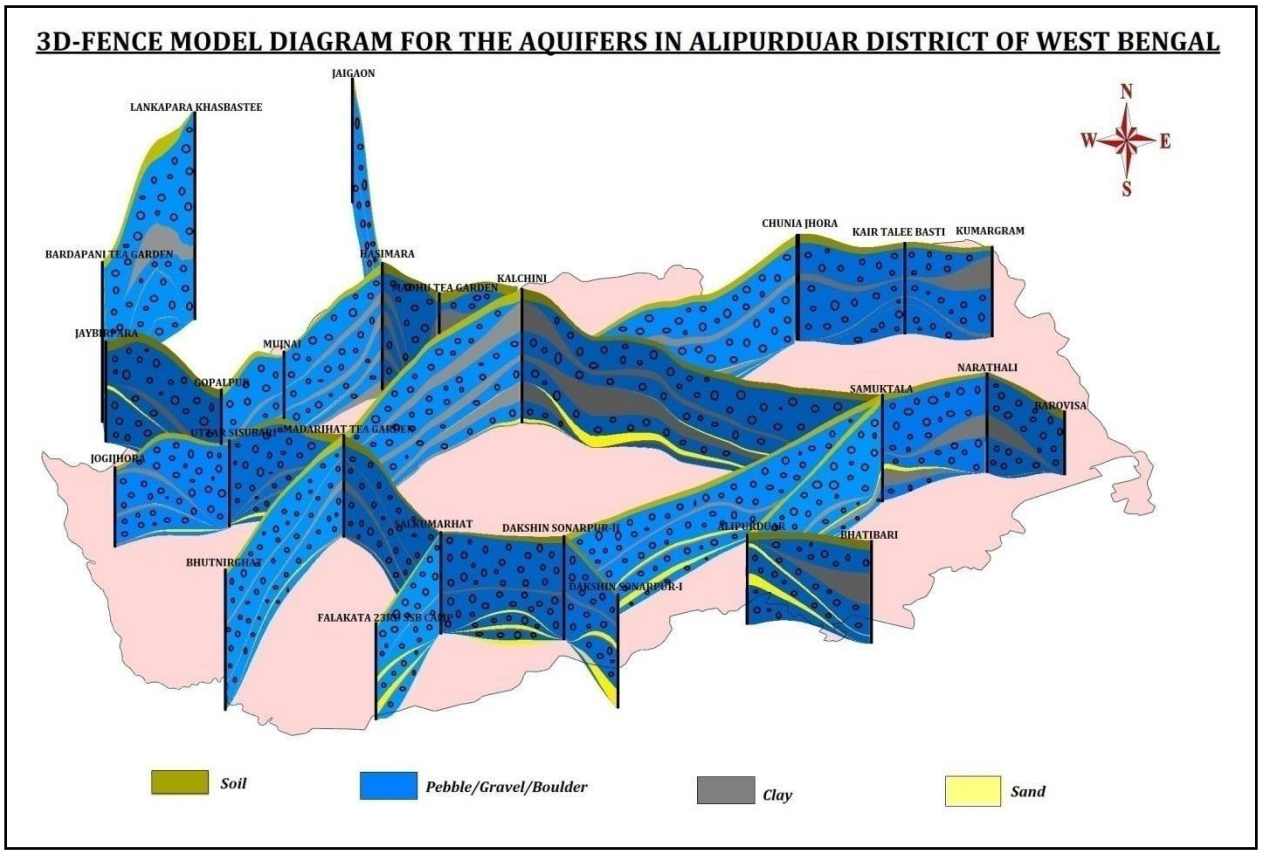


Figure-6.5: 3D-Fence model diagram for the Aquifers in Alipurduar district of west Bengal.

6.3 Ground water Regime, Depth to water level, Wells and Fluctuations

The annual water levels during pre-monsoon and post-monsoon periods were studied from 60 Key wells established all over the district. The pre-monsoon period Water level for Aquifer-I rests mostly at depths ranging from 2.03 to 8.78 mbgl, being deeper (10.08 to 21.1 mbgl) in some isolated pockets in the northern part of the district and for Aquifer-II, the water level ranges from 2.42 to 8.15 mbgl, being deeper at 13.92 to 75 mbgl. Water level for Aquifer-I during the post-monsoon generally rests within the depth range of 2.2-8.33 mbgl, being deeper (12.62-20.82 mbgl) in the upper northern region and for Aquifer-II, the water level ranges from 2.53-7.25 mbgl being deeper in some pocket of the northern part of the district where the water level rests between 13.8 to 74 mbgl. The deepest water level is recorded from Hantupara top line, Madarihat block (75 mbgl during pre-monsoon). The water level fluctuation in the area generally rests between -1 to1 m for both Aquifer-I & II. Water level fluctuation of more than 2 metres is recorded from some parts in Alipurduar-I, Falakata, Madarihat and Kalchini blocks.

The water level contour maps, water table contour maps and fluctuation maps for both Aquifer-I & II are given in the following pages.

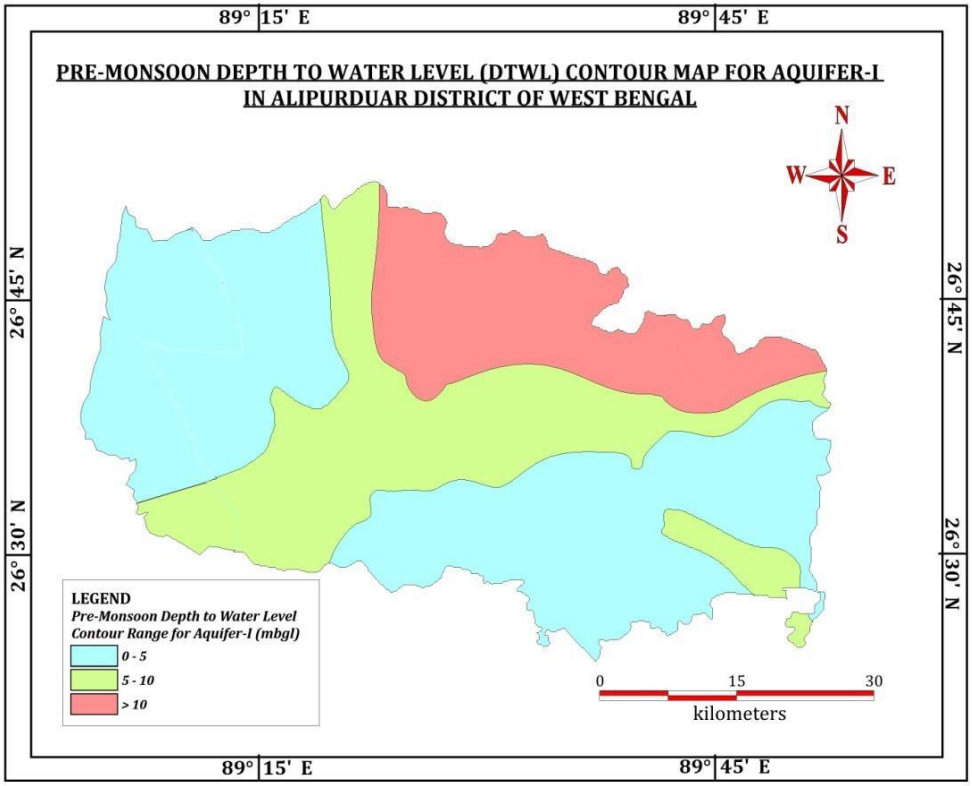
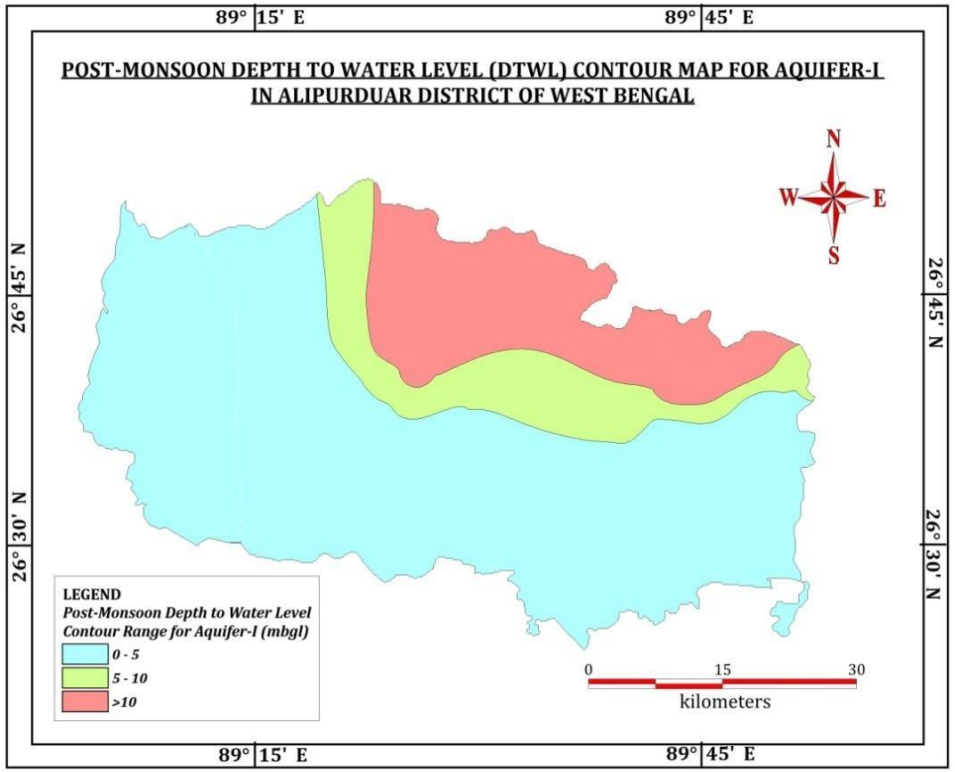


Figure-6.7: Post-Monsoon Depth to water level contour map for Aquifer-I in Alipurduar district of west Bengal.

Figure-6.6: Pre-Monsoon Depth to water level contour map for Aquifer-I in Alipurduar district of west Bengal.



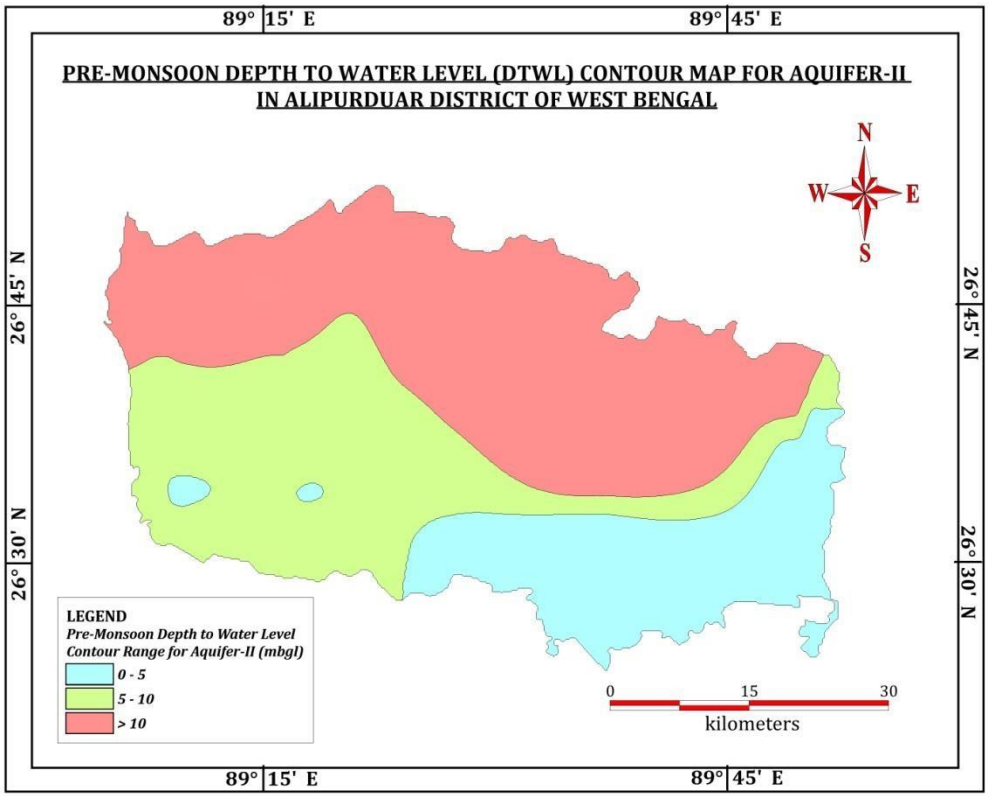


Figure-6.8: Pre-Monsoon Depth to water level contour map for Aquifer-II in Alipurduar district of west Bengal.

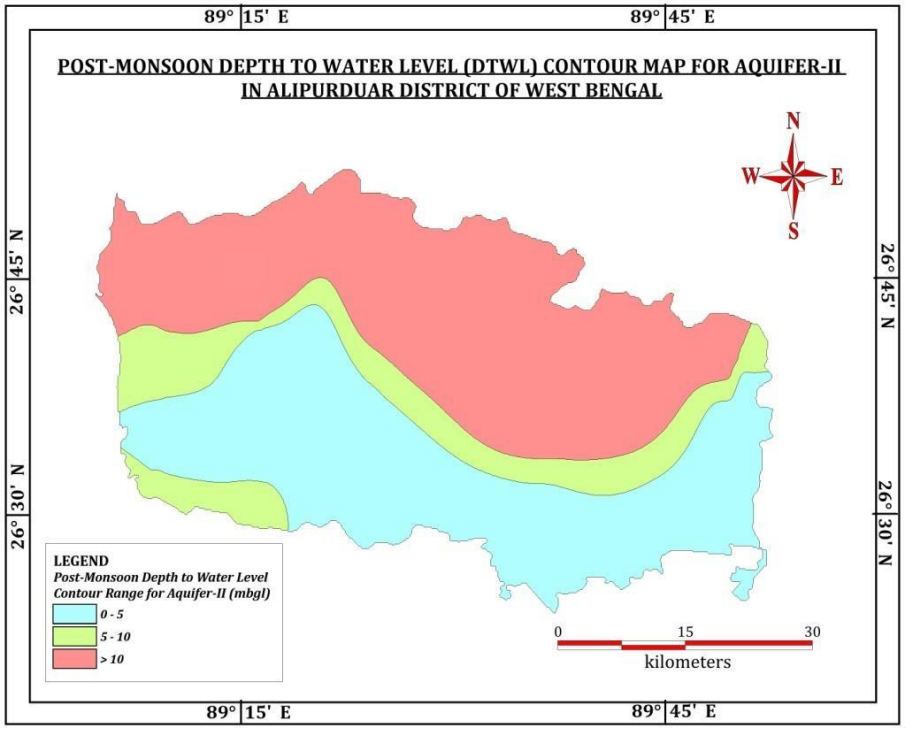


Figure-6.9: Post-Monsoon Depth to water level contour map for Aquifer-II in Alipurduar district of west Bengal.

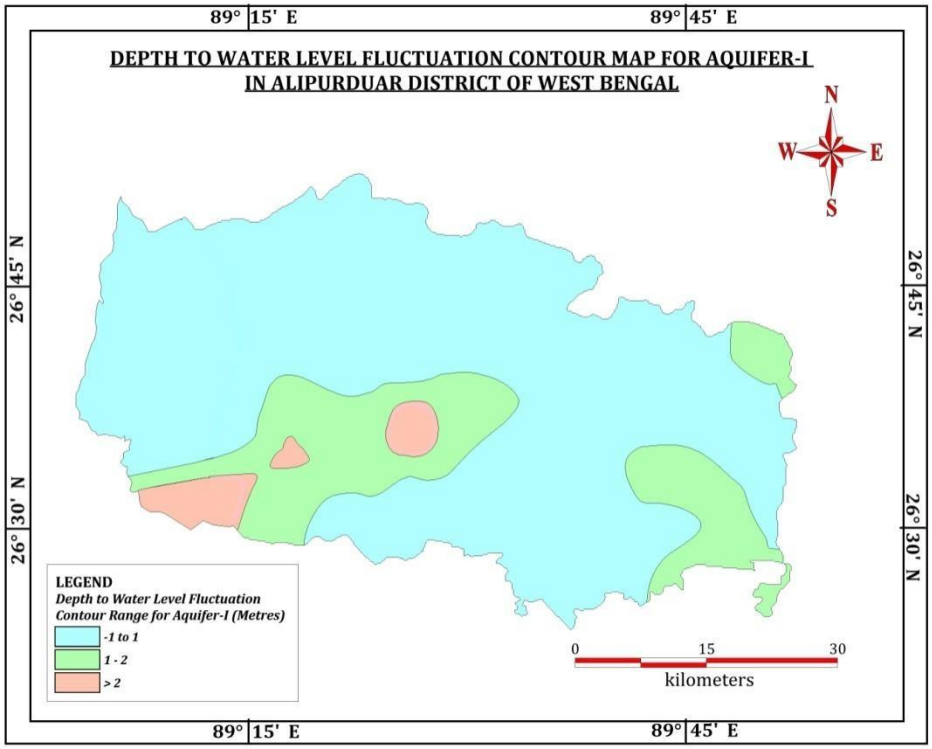


Figure-6.10: Depth to water level fluctuation contour map for Aquifer-I in Alipurduar district of west Bengal.

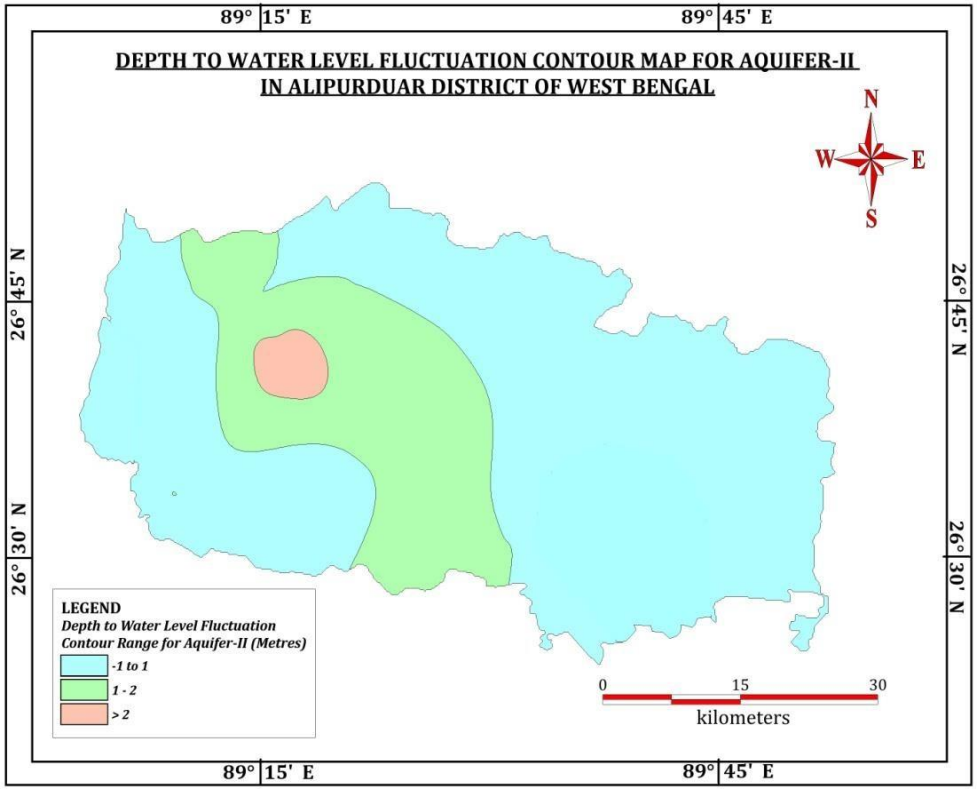


Figure-6.11: Depth to water level fluctuation contour map for Aquifer-II in Alipurduar district of west Bengal.

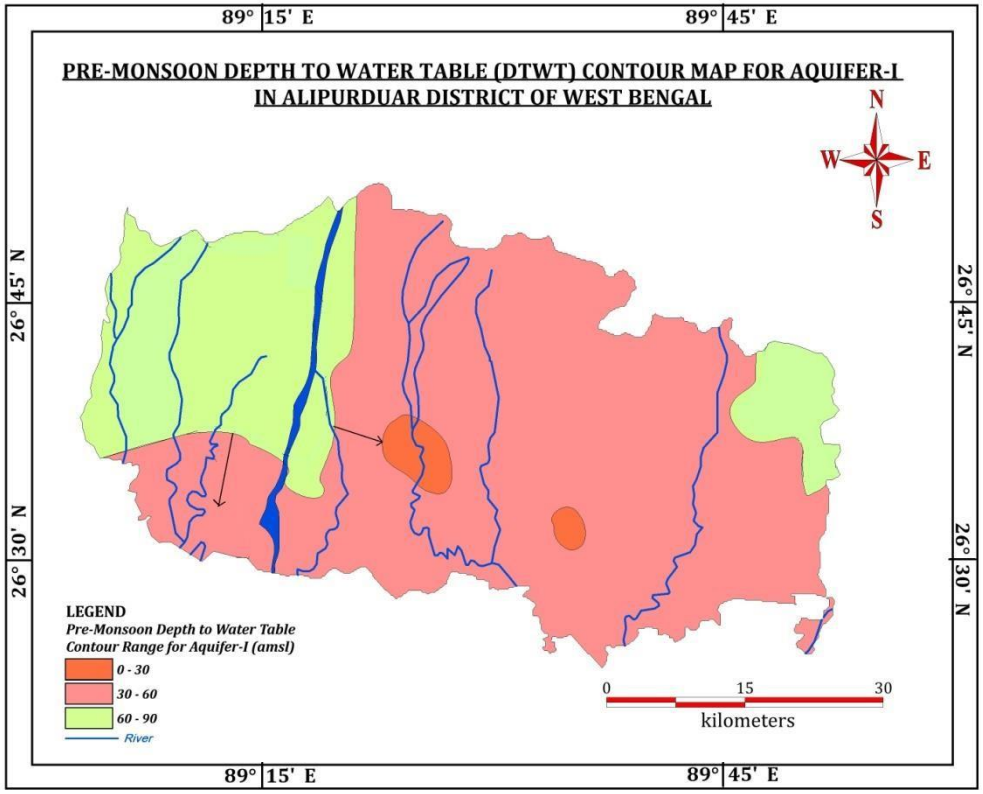


Figure-6.12: Pre-Monsoon Depth to water table contour map for Aquifer-I in Alipurduar district of west Bengal.

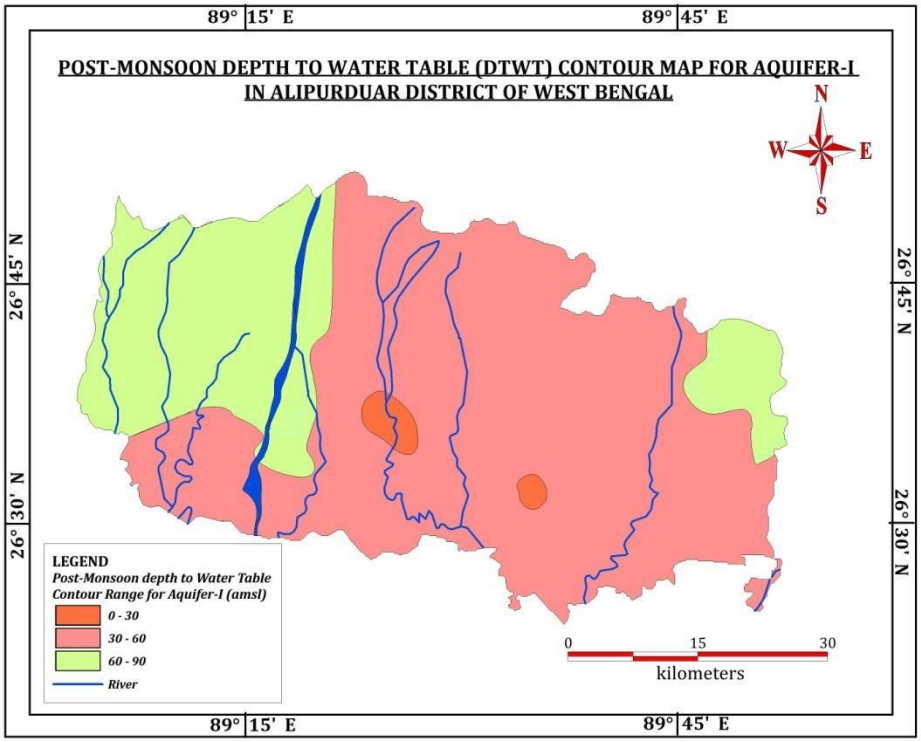


Figure-6.13: Post-Monsoon Depth to water table contour map for Aquifer-I in Alipurduar district of west Bengal.

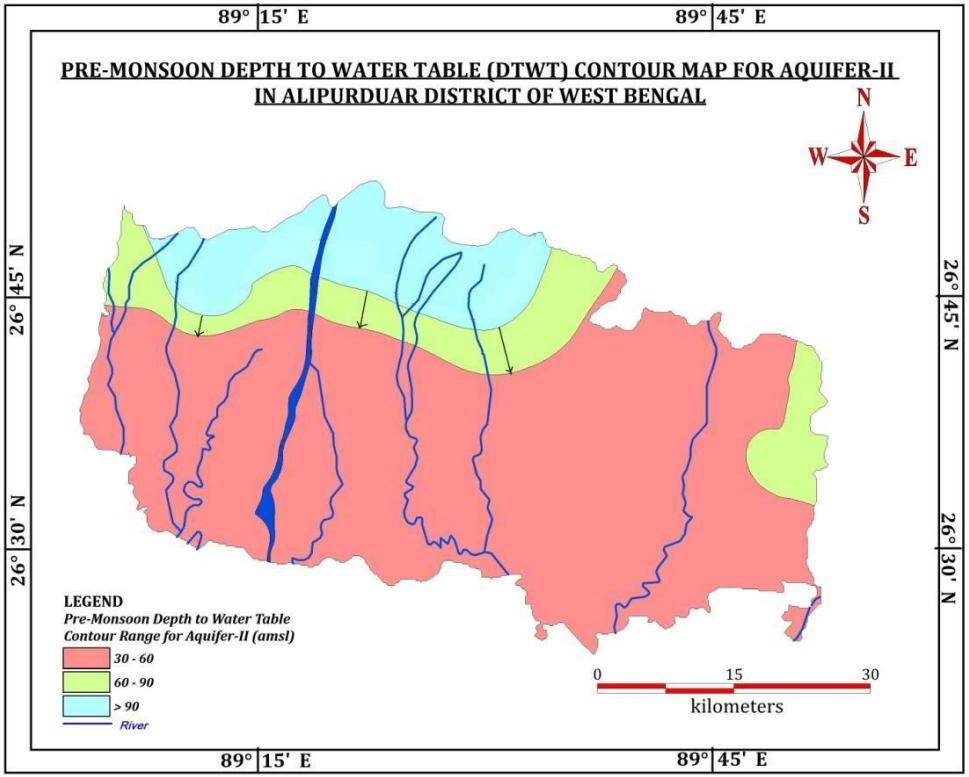


Figure-6.14: Pre-Monsoon Depth to water table contour map for Aquifer-II in Alipurduar district of west Bengal.

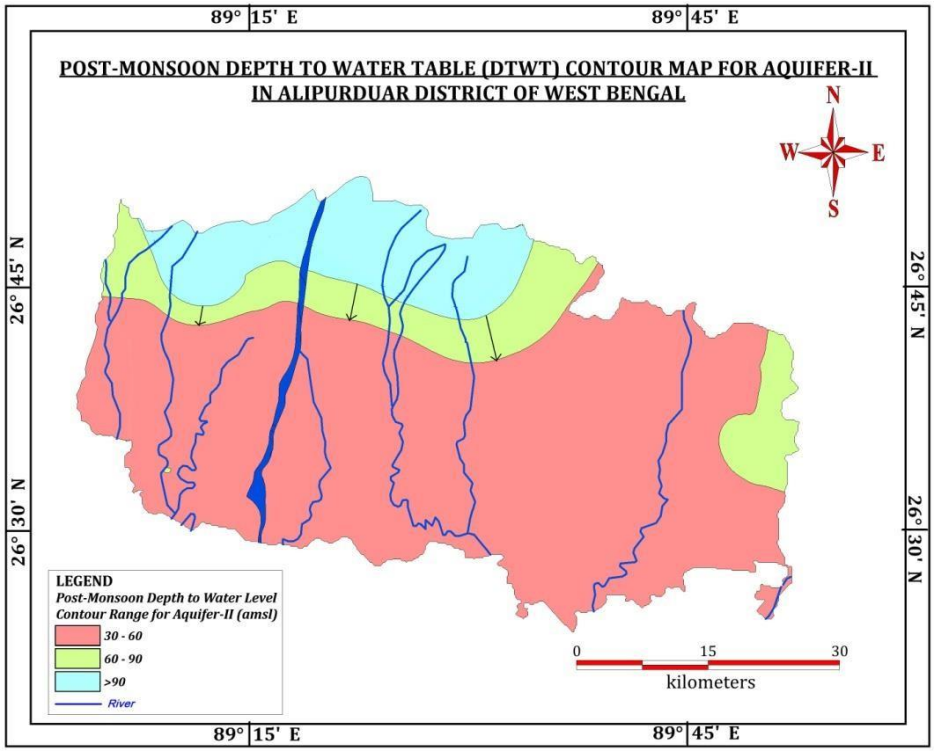


Figure-6.15: Pre-Monsoon Depth to water table contour map for Aquifer-II in Alipurduar district of west Bengal.

The historical data on water level of the monitoring wells of CGWB have been analyzed. The monitoring wells were categorized on the basis of their depth. The available water level data for this district is only for Aquifer-I. The block wise average pre and post monsoon water level for each year has been plotted to find out the long-term behavior of water level in the individual aquifer. The data do not show any major water level declining/falling trend in any of the blocks. Most the blocks show pre-monsoon rise to the tune of 0.085-0.236 m/year and a post-monsoon fall to the tune of 0.082-0.134 m/year.

The hydrographs of representative well for each block is given in the following pages.

Table-6.3: Water Level and Long-term trends (10 years) for Aquifer-I & II during Pre-monsoon and post-monsoon season in Alipurduar district.

Block	Aquifer	Pre-monsoon WL/Trend			Post-monsoon WL/ Trend		
		WL Range (mbgl)	Rise (m/year)	Fall (m/year)	WL Range (mbgl)	Rise (m/year)	Fall (m/year)
Alipurduar-I	I	0.51-5.95	0.085	--	2.59-4.56	--	0.117
	II	--	--	--	--	--	--
Alipurduar-II	I	2.30-44.82	0.099	--	1.84-44.03	--	0.134
	II	--	--	--	--	--	--
Falakata	I	2.79-59	0.094	--	3.95-58.90	0.088	--
	II	--	--	--	--	--	--
Kalchini	I	1.58-8.59	0.231	--	1.14-5.70	--	0.082
	II	--	--	--	--	--	--
Kumargram	I	0.76-46.62	0.236	--	1.62-46.22	--	0.974
	II	--	--	--	--	--	--
Madarihat	I	0.85-3.20	--	0.012	0.79-2.48	0.003	--
	II	--	--	--	--	--	--

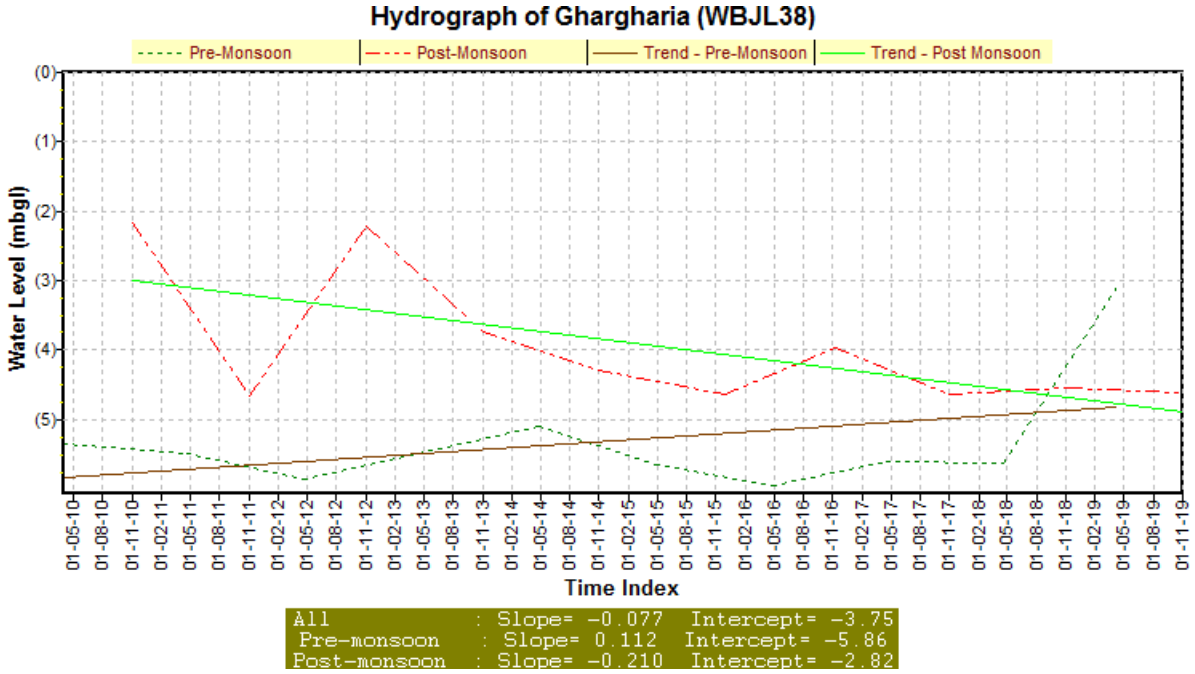


Figure-6.16: Hydrograph of Ghargharia (WBJL-38), Alipurduar-I Block.

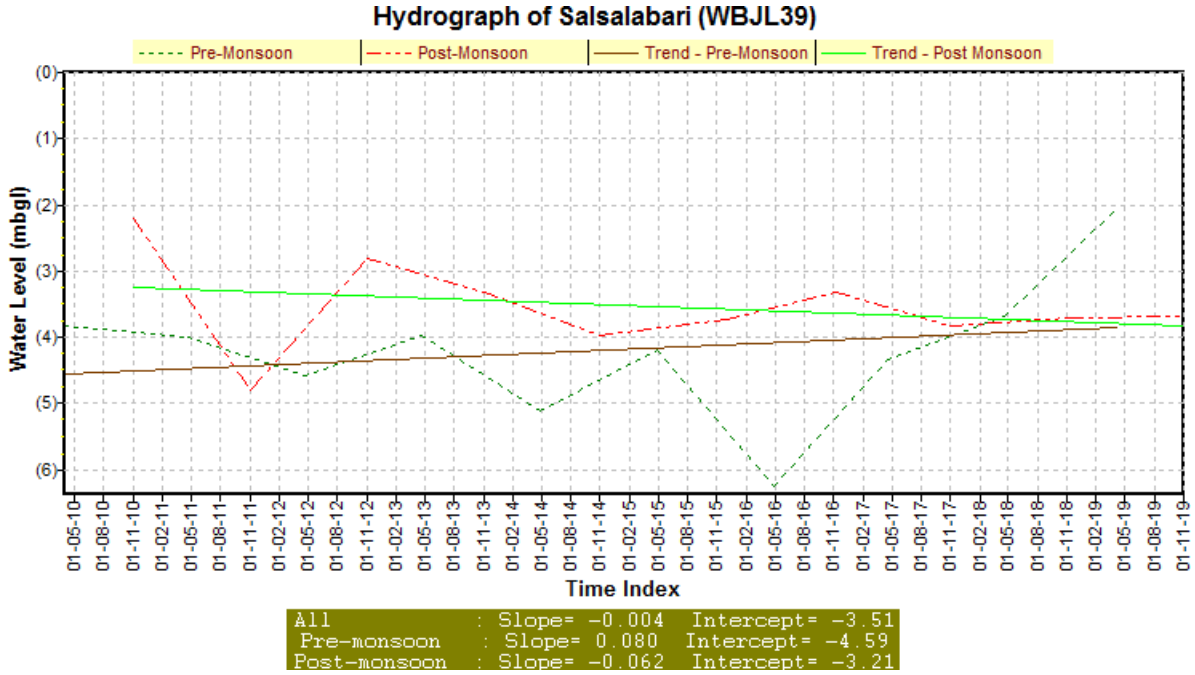


Figure-6.17: Hydrograph of Salsalabari (WBJL-39), Alipurduar-II block.

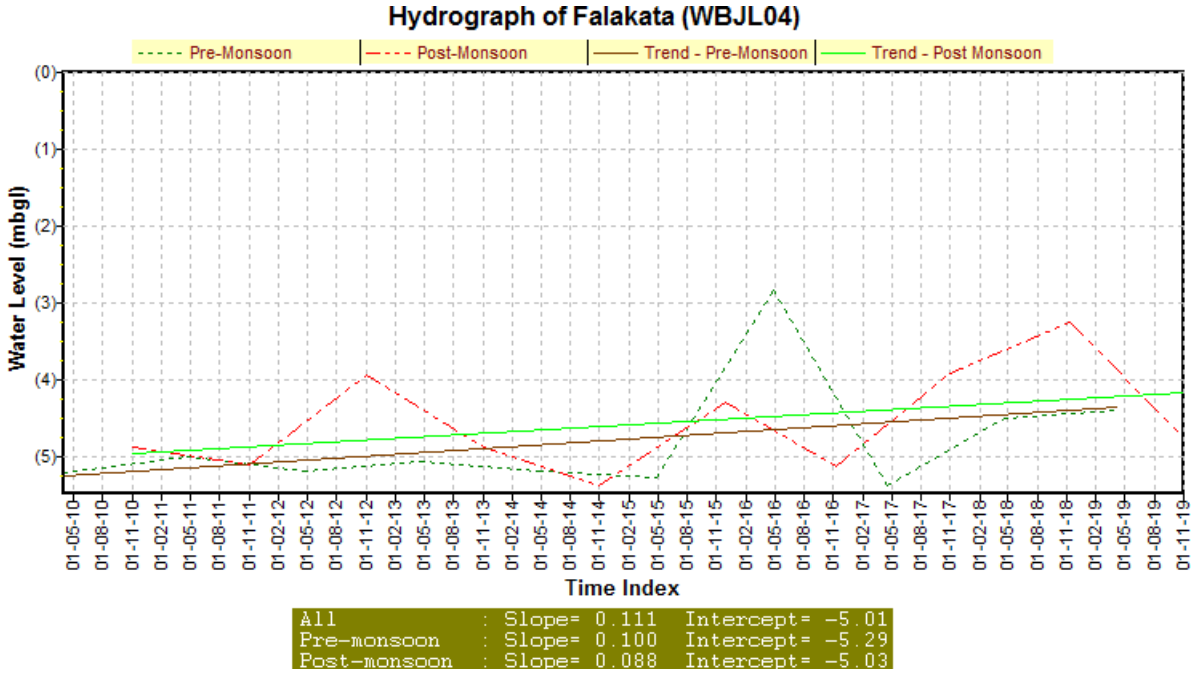


Figure-6.18: Hydrograph of Falakata (WBJL-04), Falakata block.

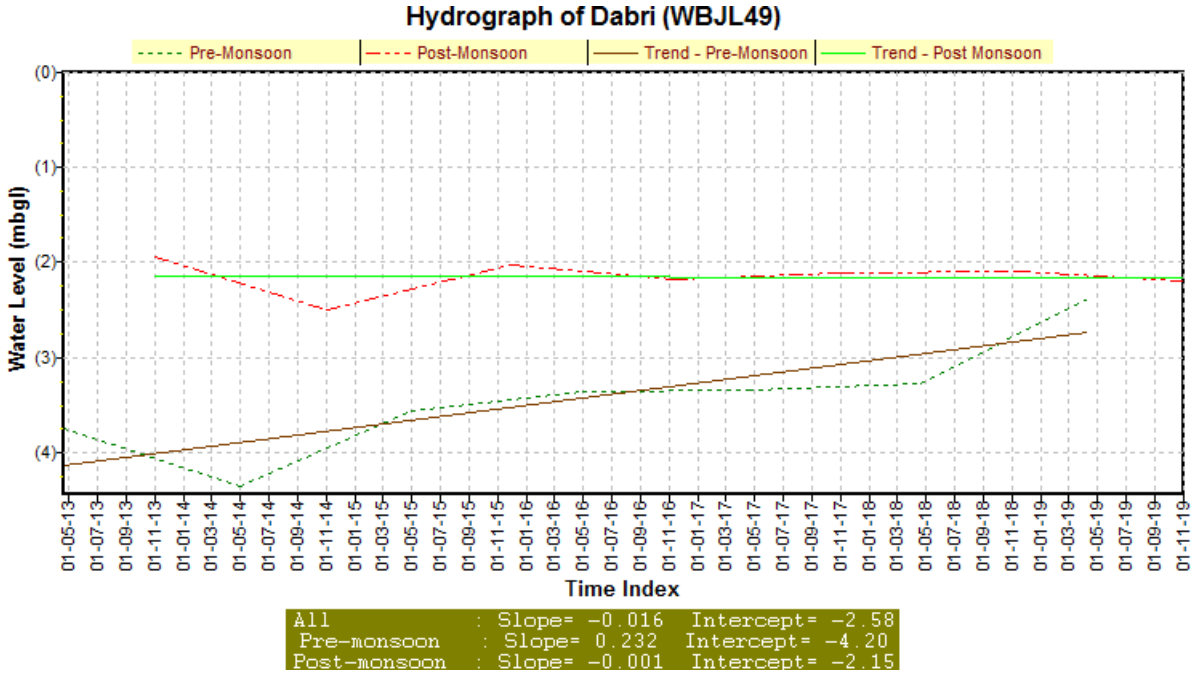


Figure-6.19: Hydrograph of Kalchini (WBJL-49), Kalchini block.

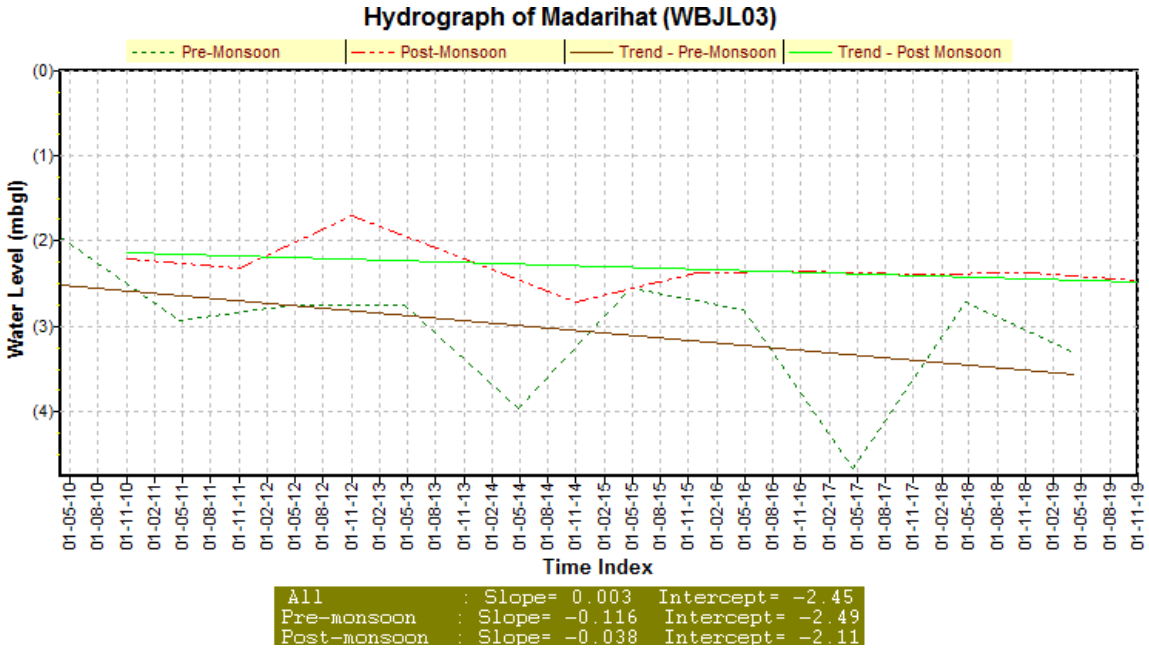


Figure-6.20: Hydrograph of Madarihat (WBJL-03), Madarihat block.

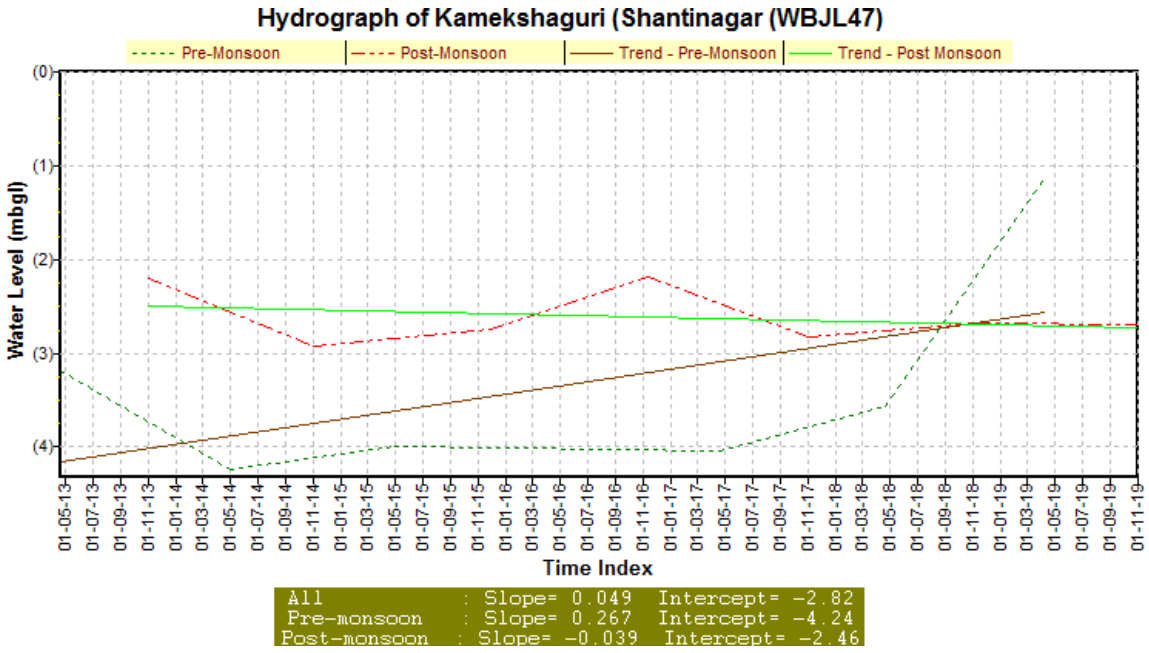


Figure-6.21: Hydrograph of Kamekshaguri, Shantinagar (WBJL-47), Kumargram block.

The nature of occurrences of aquifers, the yield prospect and the structures feasible in each block is given through the following table (**Table-6.4**).

Table-6.4: Nature of occurrence of aquifers, yield & Structures feasible for each block of Alipurduar district of West Bengal.

Block	Occurrence of aquifers & its potentiality (as per data available with CGWB)	Feasibility of Ground Water Abstraction Structures
Alipurduar-I	Fairly thick and regionally extensive in confined / semi confined aquifers down to 190.00 m.	Both shallow and deep tube wells are feasible low duty tube wells yield 10-20 m^3/hr and that of heavy tube wells range between 100 & 200 m^3/hr
Alipurduar-ll	Fairly thick and regionally extensive in confined / semi confined aquifers down to 190.00 m.	Both shallow and deep tube wells are feasible, low duty tube wells yield 10-20 m^3/hr and that of heavy tube wells range between 100 & 200 m^3/hr
Falakata	Fairly thick and regionally extensive unconfined / semi confined aquifers down to 190.00 m.	Both shallow and deep tube wells are feasible, low duty tube wells yield 10-20 m^3/hr and that of heavy tube wells range between 100 & 200 m^3/hr.
Kalchini	Fairly thick and regionally extensive unconfined aquifers down to 190 -200 m bgl.	Both shallow and deep tube wells are feasible shallow tube wells yield 10-20 m^3/hr
Kumargram	Fairly thick and regionally extensive unconfined aquifers down to 190-200 m.	Both shallow and deep tube wells are feasible, Shallow tube wells yield 7-20 m^3/hr, Deep tube wells yield 50- 100 m^3/hr.
Madarihat	Fairly thick and regionally extensive unconfined aquifers down to 190-200 m.	Both shallow and deep tube wells are feasible. Shallow tube wells yield 10-20 m^3/hr

CHAPTER-7

GROUND WATER RESOURCES

7.1 Dynamic water resource

The present estimation of the dynamic resources of the State of West Bengal has been carried out for the assessment year 2010-2011. The estimation work was taken up for 269 blocks and two (02) Municipality Area of the State leaving out 13 mountainous/sub-mountainous blocks and 59 blocks in the coastal saline tract of the state.

The methodology, GEC'97 has incorporated a number of changes as compared to the recommendation of the previous Ground water Estimation Committee-1984. These modifications include-

- Watershed has been recommended as the assessment unit in hard rocks.
- Assessment is to be made separately for command and non-command area and areas of poor quality to be treated separately
- Ground water recharge is to be assessed separately for monsoon and non-monsoon seasons
- Norms for return flow from irrigation are to be based on the source of irrigation i.e., ground water or surface water, type of crops and depth to water level below ground level.
- Categorization of areas for ground water development is based on the stage of ground water development and long term trends of ground water levels.
- Allocation for domestic and industrial water supply is recommended based on the population density and relative load on ground water for the purposes.

The irrigation potential created data of 4th Minor Irrigation Census, block wise demographic data of 2011 Census, CGWB water level data, cropping pattern, annual monsoon rainfall and normal rainfall provided the basic input for calculating the resources of the state. Block wise (Groundwater assessment unit) geographical area, area under different hydro-geological sub-provinces (sub-units), area under command and non-command, poor ground water quality area and ground worthy recharge area has also been considered. Gross current draft for all uses, recharge from rainfall, recharge from other sources like tanks, ponds, canal seepages, return flow from ground water and surface irrigation has all been considered. The number of abstraction structures and their unit draft has been taken into account for computation of irrigation draft. The projected population of 2025 (based on census 2011) and per capita consumption (60 lpcd) have been considered for computation and 70 % of the obtained figure is taken as the domestic and industrial draft. The categorization of the blocks has been done based on their Stage of Development and long term water level trend.

As per the computation, the net ground water availability for recharge for Alipurduar district was estimated at **124952.93** ham. The total extraction for all uses was estimated at **5824.04** ham. The district falls under 'safe' category.

7.1.1 Ground water recharge and resource

Recharge from ground water through a system of abstraction structures like deep tube wells, shallow tube wells and dug wells, surface water irrigation by surface lift and flow modes and rainfall has been separately calculated for both monsoon and non-monsoon periods. It is evident from the table (**Table 7.1**), that the annual recharge for the block, Kumargram is the highest among all the other blocks but at the same time it may be noted that the natural discharge is also highest for the block. The reason may be attributed to the low moisture/water retention capacity of the soil, rapid infiltration of rain water, very high surface run-offs as the area has relatively high relief, percolation of water into the deeper level as ground water recharge which is later discharged as base flows. Maximum recharge in this district is from monsoon rainfall.

7.1.2 Ground water draft

Groundwater draft has been computed on the basis of quantum of water likely to be used for domestic, irrigation and industrial purposes. The estimate is done by projecting the population and the number of ground water abstraction structures. The total extraction for the blocks stands at **5824.04** Ham.

7.1.3 Stage of development and category

The level of ground water development of the study area is very low as compared to state average of 42%. The district stands at an average of 4.66%. Kumargram block has the lowest stage of development among all the blocks and the SOD stands at just 1.72%. All the blocks in the study area is declared 'Safe' based on their low stage of groundwater development and steady water levels over the years.

Table-7.1: Ground water Recharge, Resource and Stage of Development for Alipurduar district of West Bengal.

Block Name	Total Annual Ground Water Recharge (Ham)	Total Natural Discharges (Ham)	Annual Extractable Ground Water Resource (Ham)	Total Extraction	Annual GW Allocation for Domestic and Industrial Use as on 2025	Net Ground Water Availability for future irrigation use	Stage of Ground Water Extraction (%)	Categorization
Alipurduar-I	30410.39	3041.04	27369.35	1384.11	651.03	25818.52	5.06	Safe
Alipurduar-II	25681.41	2568.14	23113.27	1855.13	474.57	21136.60	8.03	Safe
Falakata	28344.11	2834.41	25509.70	1888.61	612.58	23464.22	7.40	Safe
Kumargram	40517.03	4051.70	36465.33	696.20	428.94	35659.29	1.72	Safe
TOTAL	**124952.93**	**12495.29**	**112457.64**	**5824.04**	**2167.12**	**106078.62**	**4.66**	**Safe**

7.2 Static water resource/In-storage

Computation of in-storage is essential not only for estimation of emergency storage available for utilization in case of natural extremities like drought conditions but also for assessment of storage depletion in over-exploited areas for sensitizing stakeholders about the damage done to environment. The in-storage for the blocks under study area is listed in the table below (as of 2009).

Table -7.2: Total In-storage of groundwater for Alipurduar district of West Bengal

Sl_No	District	Block	Formation	In-storage
1	Alipurduar	Alipurduar-I	Alluvium	345151.91
2	Alipurduar	Alipurduar-II	Alluvium	491356.08
3	Alipurduar	Falakata	Alluvium	450659.5
4	Alipurduar	Kumargram	Alluvium	463654.04
TOTAL				**1750822**

CHAPTER-8

HYDROCHEMISTRY

Major Ion Chemistry and Hydro-geo-chemical Facies of the Study Area

A total of 33 samples tapping Aquifer-I and 11 samples tapping Aquifer-II have been considered for analysis by CGWB (ER), Chemical laboratory. The results of the chemical analysis for groundwater in the district have been tabulated aquifer-wise in **Table-8.1** and **Table-8.2**.

For demarcating the hydro-chemical facies existing in the phreatic and confined aquifer systems, Piper (1953) and modified Piper diagram by Chadha (1999) have been used. The sample plotting results are discussed below.

- *Cation facies*: The Piper's trilinear diagram **(Figure-8.1)** shows that all the groundwater samples fall in Calcium and Magnesium type. This indicates that the samples from the study area show dominance of Calcium and Magnesium cation.
- *Anion facies*: All the samples fall into HCO_3^- type reflecting HCO_3^-as the dominant anion.

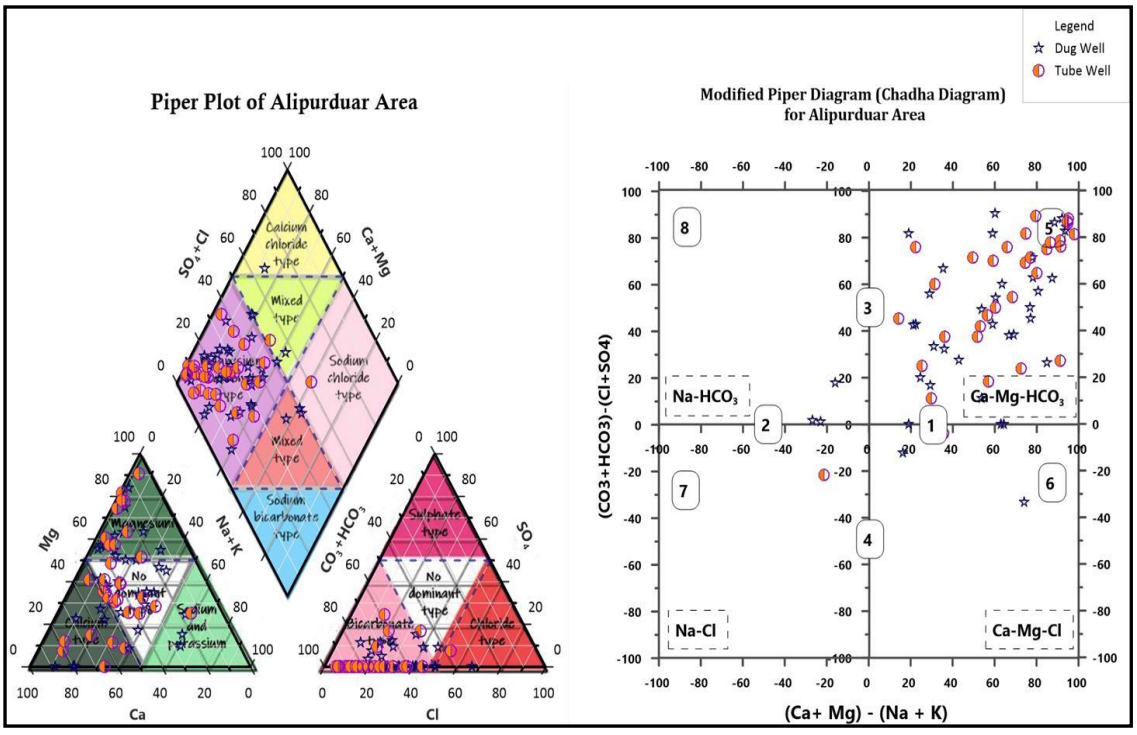


Figure-8.1: Groundwater samples from Phreatic aquifers of the Study Area plotted on (A) Piper tri-linear diagram (B) Modified Piper Diagram (Chadha,1999) for identification of hydro-geo-chemical facies.

- The plot of chemical data on diamond shaped tri-linear diagram reveals that all the groundwater samples fall in the fields of 'alkaline earth exceeds alkalies' and 'weak acids(CO_3 + HCO_3)exceeds strong acids(SO_4 + Cl)'.

- Facies classification shows that the groundwater in the study area belong to Ca-Mg--HCO_3type **{Figure-8.1 (B)}** type indicating Recharge water with temporary hardness.

Rock-water interaction

Rock-water interaction has been assessed using Gibbs Diagram (Gibbs, 1970), which is a widely used method for establishing the relationship of water composition and source conditions/characteristics. Three distinct fields such as precipitation dominance, evaporation dominance and rock-water interaction dominance areas are shown in the Gibbs diagram **(Figure-8.2)**. The distribution of samples in the rock dominance region of the plot in Gibbs diagram suggests that the major ion chemistry of groundwater is controlled by chemical weathering of rock forming minerals as well as precipitation.

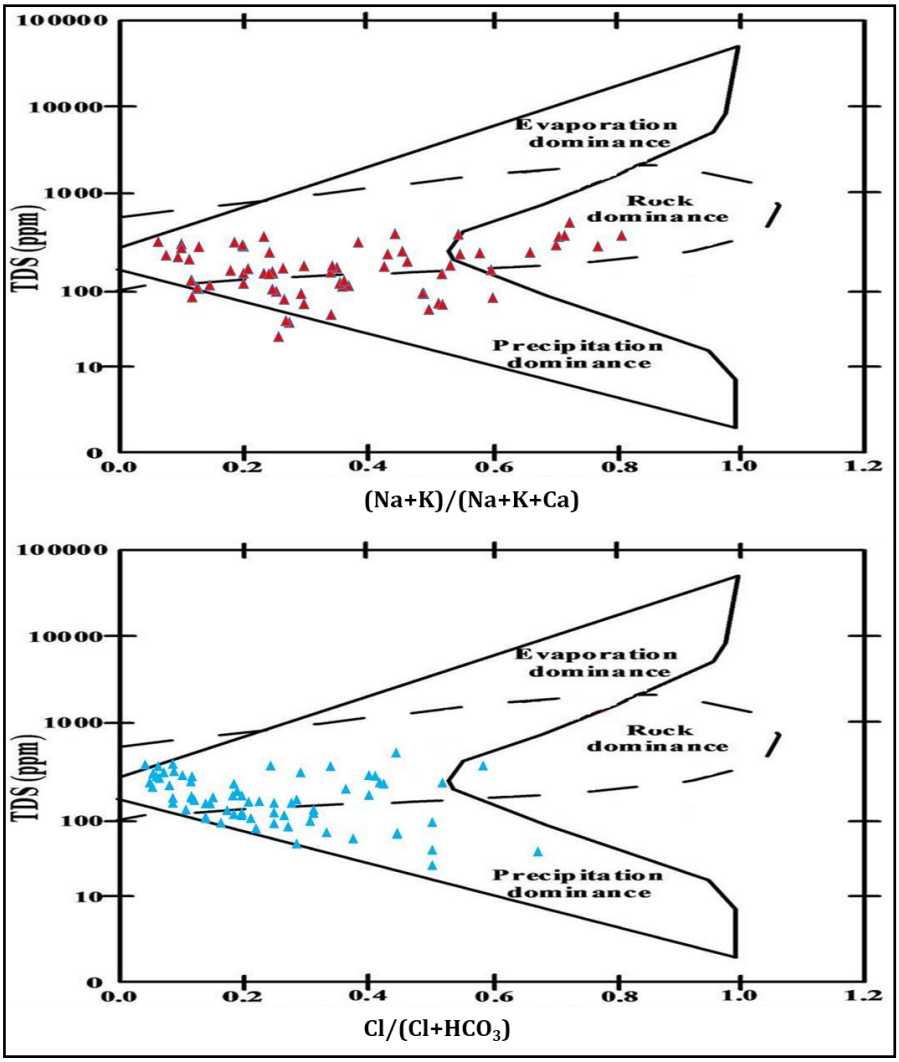


Figure-8.2: Gibbs diagram for controlling factor of groundwater quality.

Suitability for Irrigation Uses

In the present study the suitability of the groundwater for irrigation has been assessed by considering the irrigation indexes like Conductivity (EC), Soluble Sodium Percentage (SSP), Sodium Adsorption Ratio (SAR)along with the USSL salinity and Wilcox diagrams.

Wilcox diagram has been used to study the quality of groundwater suitability for irrigation purpose. EC and percentage of Na values for the groundwater samples of the study area were plotted in the graphical representation **{Plate 8.3(B)}.**All the samples fall in the Excellent to good category.

The samples have also been plotted using USSL diagram. In this diagram, EC is plotted against the percentage of SAR. Majority of the samples are C1S1 C2S1 type, having low to medium salinity hazard.

The ground water in the study area is suitable for the irrigation purpose.

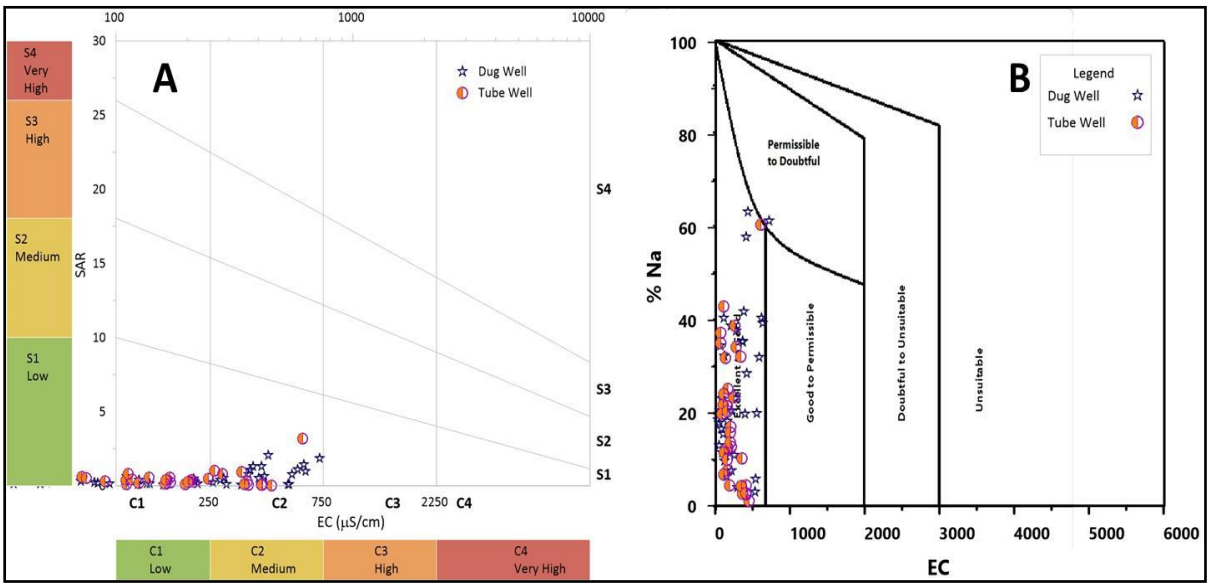


Figure-8.3: (A) United States Salinity Laboratory (USSL) and (B) Wilcox Diagram for assessing the Irrigation water quality of the study area.

Aquifer-wise findings in Water Quality Assessment of the study area

Shallow Aquifer (Aquifer-I):

- The pH value ranges from 7.16 to 8.43. This indicates that all the samples lie within the permissible limit of BIS standard i.e., within 6.5 to 8.5.
- EC value ranges from 84 to 632 µS/cm at 25°C.
- All the sample locations were found to have the TDS concentration between 58 to 328 mg/l which is within the desirable limit of 500 mg/l.

- The total hardness (TH) varies from 45-295 mg/l indicating soft water types. Hardness of the water is attributable to the presence of alkaline earths elements, i.e., Ca^{2+} andMg^{2+}.
- The average NO_3^- values for all the locations shows within the range value of BDL to 6.20 which is well within the BIS (2012) permissible limit of 45 mgL^{-1}.
- The aquifer in the area is by and large rich in iron. As per BIS-2012, the permissible limit for iron in drinking water is 1.0 mgL^{-1} ,beyond which the water is deemed not suitable for drinking purposes without prior treatment. The concentration of iron in groundwater of the study area ranges from 0.18 to 11.20 mg/l. In Chechakhata at Alipurduar-II block, iron concentration as high as 11.20 mg/l is reported.

Deeper Aquifer (Aquifer-II):

- The pH of groundwater in deeper aquifer ranges from 7.42 to 7.87 which is within the permissible limit of 6.5 to 8.5 according to BIS standard. This indicates that the groundwater is neutral to slightly alkaline in nature.
- The EC values are ranges from 125 to 614 µS/cm at 25°C.
- TDS concentration ranges from 79 to 318.3 which is within the desirable limit of 500 mg/l.
- The Nitrate range is between BDL to 10 mg/l which is within the desirable limit of 45 mg/l.
- The concentration of iron in the study ranges from BDL to 11.4 mg/l. Very high iron concentration of 9.5 mg/l is reported from Uttara Haldibari area in Kumargram block and 11.4 mg/l from Chilapat of Alipurduar-I block.

The aquifer-wise spot value maps of iron and EC maps for the study area has been shown in the following pages (**Figure- 8.4, 8.5, 8.6 & 8.7**).

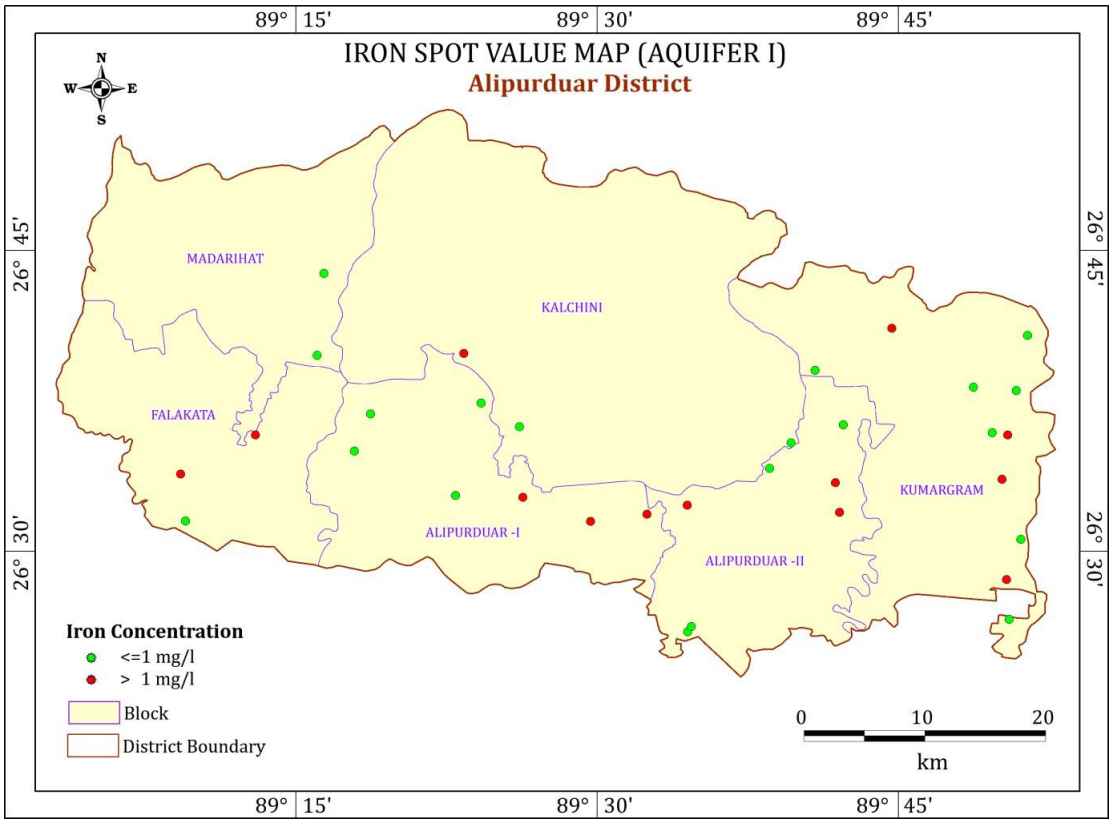


Figure-8.4: Iron spot value map for Aquifer-I in Alipurduar district of West Bengal.

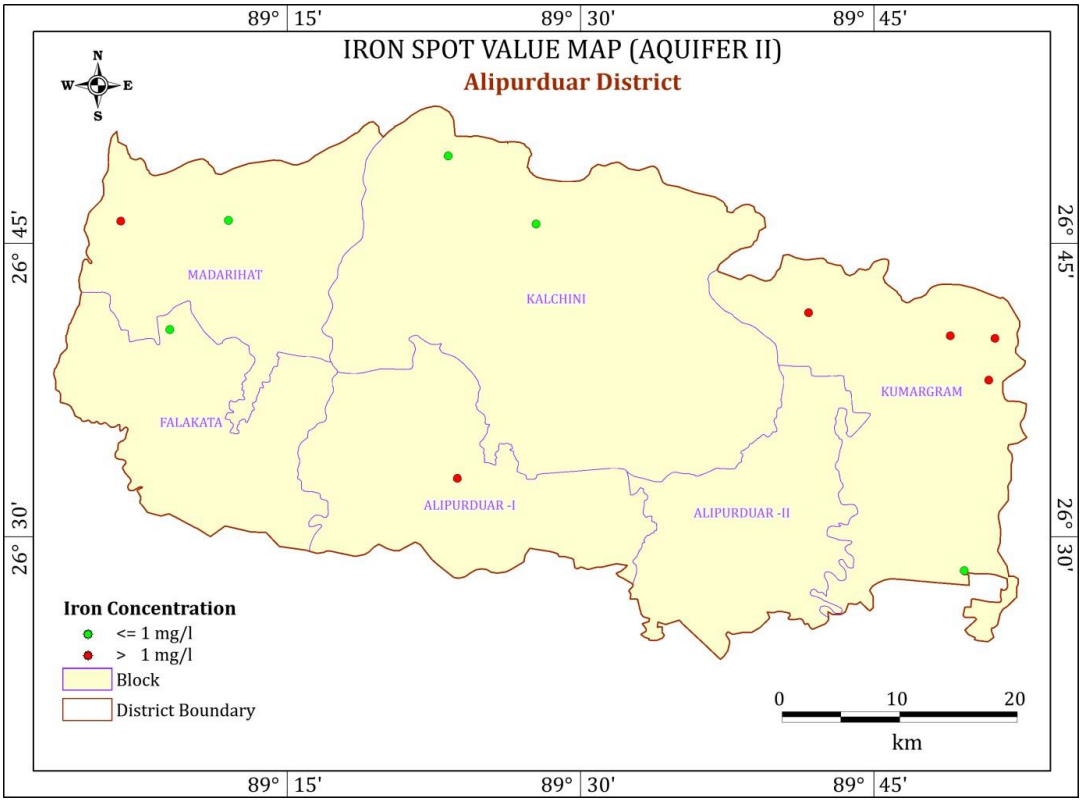


Figure-8.5: Iron spot value map for Aquifer-II in Alipurduar district of West Bengal.

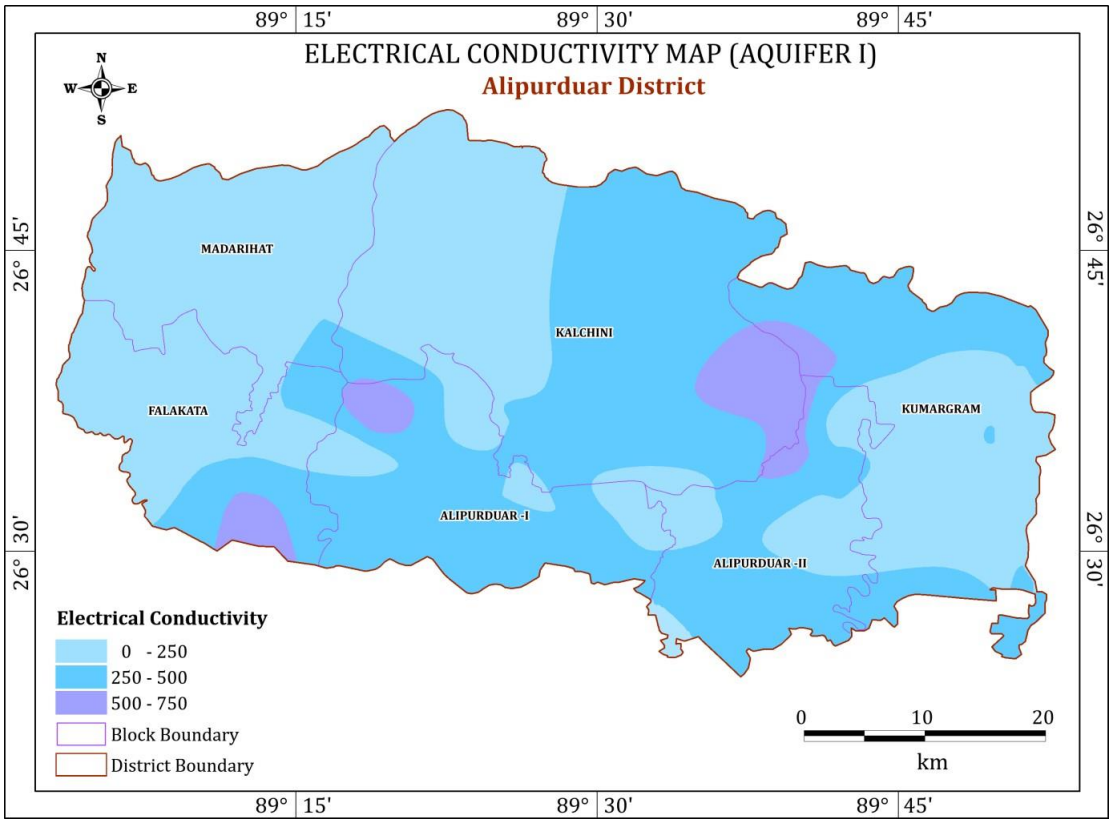


Figure-8.6: EC contour map for Aquifer-I in Alipurduar district of West Bengal.

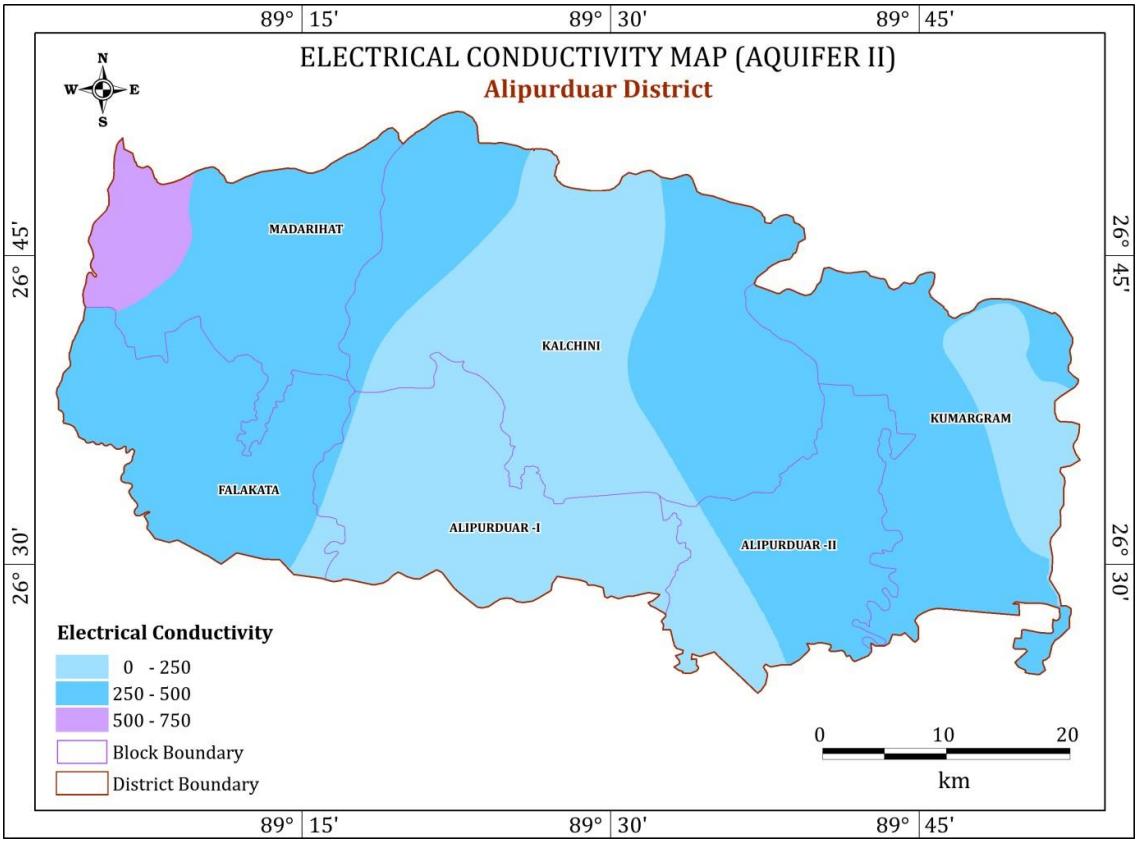


Figure-8.7: EC contour map for Aquifer-II in Alipurduar district of West Bengal.

Table-8.1: Chemical parameters for Aquifer-I in Alipurduar district of West Bengal.

Sl. no.	Location	Block	Well	Lat	Long	pH	EC	TH	Ca	Mg	Na	K	HCO3	TA	Cl	NO3	SO4	TDS	Fe	Ur
1	Natunpara	Alipurduar-I	Dug-Well	26.6142	89.3116	7.54	632	175	18	31.59	29.24	39.18	225.7	185	42.54	6.2	12.5	316.93	BDL	2.34
2	Salkumarhat	Alipurduar-I	Dug-Well	26.5832	89.2981	7.4	139	65	10	9.72	2.25	2.51	73.2	60	7.09	0	0	76.22	BDL	6.45
3	Chilapata	Alipurduar-I	Dug-Well	26.5464	89.3823	7.47	368	125	14	21.87	26.77	7.8	128.1	105	53.18	1.2	0	201.76	BDL	3.05
4	Uttar Madarbari	Alipurduar-I	Dug-Well	26.6232	89.4036	7.6	84	45	10	4.86	2.86	2.15	42.7	35	7.09	0	5.5	58.51	BDL	1.24
5	Banchukamari	Alipurduar-I	Dug-Well	26.5248	89.4942	7.25	284	75	16	8.51	10.34	17.97	91.5	75	35.45	0	0	144.08	1.5	0.37
6	Patkapara	Alipurduar-I	Mark-II	26.5447	89.4381	7.77	214	110	12	19.44	6.6	1.35	134.2	110	14.18	0	0	135.43	5.09	0.1
7	Satbaki P.S	Alipurduar-II	Mark-II	26.4331	89.5748	7.55	245	75	18	7.29	9.69	1.5	91.5	75	14.18	3.1	9.5	119.08	0.31	0.93
8	Purba Barachouki	Alipurduar-II	Dug-Well	26.4374	89.5779	7.5	363	110	20	14.58	18.89	15.17	158.6	130	21.27	2.9	5.8	195.36	0.21	1.71
9	Dakshin Mahakalguri	Alipurduar-II	Dug-Well	26.5323	89.7009	7.33	135	75	16	8.51	2.73	3.08	73.2	60	14.18	0	0	89.15	1.5	4.1
10	Lokenathpur	Alipurduar-II	Dug-Well	26.6052	89.704	7.43	158	75	12	10.94	1.08	2.09	79.3	65	10.64	0	0	85.11	BDL	0.76
11	Kohinoor	Alipurduar-II	Mark-II	26.557	89.6976	7.91	416	240	18	47.39	4.01	1.77	256.2	210	17.73	0	0	245.17	3.93	0.22
12	Uttar Shibkata	Alipurduar-II	Dug-Well	26.569	89.6429	7.92	531	260	14	54.68	2.86	1.3	292.8	240	14.18	0	0	265.62	BDL	1.95
13	Pinialguri	Alipurduar-II	Mark-II	26.5383	89.5744	7.76	170	90	16	12.15	5.24	1.27	122	100	7.09	0	0	116.17	10.91	0.22
14	Chechakhata	Alipurduar-II	Mark-II	26.5308	89.541	7.83	208	95	22	9.72	8.37	1.06	134.2	110	10.64	2	0	133.65	11.21	0.51
15	Talukertari	Falakata	Mark-II	26.5967	89.2161	7.46	204	95	22	9.72	6.33	3.13	103.7	85	17.73	0	0	122.16	5.33	3.59
16	Dalimpur	Falakata	Mark-II	26.5641	89.1542	7.56	202	95	20	10.94	5.98	1.6	73.2	60	14.18	3.5	15.6	116.55	8.51	1.91
17	Bhutnirghat	Falakata	Dug-Well	26.5251	89.158	7.82	584	205	16	40.1	36.76	13.19	225.7	185	67.36	0	0	311.08	0.61	5.01
18	Dangi	Kalchini	Dug-Well	26.5901	89.6608	7.94	554	240	20	46.17	26.8	1.17	366	300	10.64	2.5	0	328.04	BDL	0.28
19	Nimti Domohani	Kalchini	Dug-Well	26.6035	89.4352	7.78	276	115	16	18.23	10	9.95	128.1	105	17.73	0	10.2	160.24	BDL	0.81
20	Dakshin Satali	Kalchini	Mark-II	26.6644	89.3891	7.7	163	105	16	15.8	2.82	1.95	128.1	105	10.64	0.45	0	125.34	11.21	0.26
21	Baruipara	Kumargram	Dug-Well	26.4435	89.8418	7.54	411	85	14	12.15	27.95	44.33	140.3	115	56.72	0	0	240.73	0.17	2.81

22	Volka High School	Kumargram	Dug-Well	26.4764	89.8396	7.4	110	55	12	6.08	3.24	2.34	54.9	45	14.18	0	0	71.32	1.11	2.57
23	Purba Salbari	Kumargram	Dug-Well	26.51	89.8515	7.25	213	70	12	9.72	9.45	18.73	91.5	75	21.27	0	0	126.99	0.17	10.26
24	Sankos	Kumargram	Dug-Well	26.6795	89.8572	7.65	293	160	26	23.09	2.37	1.12	195.2	160	7.09	0	0	178.74	BDL	3.05
25	Amarpur	Kumargram	Dug-Well	26.6363	89.812	7.34	124	60	18	3.65	1.73	2.1	67.1	55	10.64	0	0	77.04	BDL	2.94
26	Uttara Haldibari B.F.P	Kumargram	Dug-Well	26.6337	89.8477	7.16	221	105	14	17.01	3.28	1.2	79.3	65	17.73	2.5	12	116.09	0.09	12.27
27	Kumargram BDO	Kumargram	Dug-Well	26.5987	89.8276	7.53	256	120	14	20.66	5.28	2.51	134.2	110	17.73	0	0	142.03	0.02	3.15
28	Pukharigaon,	Kumargram	Dug-Well	26.5966	89.8406	7.34	165	65	10	9.72	4.52	3.67	73.2	60	10.64	0	0	83.2	2.55	0.1
29	Baghmara	Kumargram	Dug-Well	26.5599	89.8359	7.59	215	90	36	0	5.36	9.05	122	100	7.09	0	0	131.92	1.96	0.29
30	Chunia Jhora	Kumargram	Dug-Well	26.6504	89.6807	7.87	537	295	24	57.11	3.35	8.41	335.5	275	14.18	0	0	311.7	BDL	0.26
31	Turturi Khanda	Kumargram	Sub-TW	26.6852	89.7445	7.83	363	230	22	42.53	1.83	1.57	244	200	10.64	1.3	0	227.4	1.14	0.31
32	Uttar khairbari	Madarihat	Mark-II	26.7308	89.2731	8.43	111	80	18	8.51	1.85	1.41	97.6	80	7.09	0	0	96.39	0.13	0.61
33	Purba Madarihat	Madarihat	Mark-II	26.6629	89.2672	8.02	359	180	26	27.95	7.72	2.92	213.5	175	7.09	0	0	201.91	0.18	0.22

Table 8.2: Chemical parameters for Aquifer-II in Alipurduar district of West Bengal.

Sl. no.	Location	Block	Type	Lat	Long	pH	EC	TH	Ca	Mg	Na	K	HCO3	TA	Cl	NO3	SO4	TDS	Fe	Ur
1	Chilapata	Alipurduar-I	Mark-II	26.5498	89.3946	7.42	165	60	12	7.3	7	0.9	48.8	40	7.1	10	15.6	89.8	11.4	10
2	Dalgaon	Falakata	Mark-II	26.6767	89.1496	7.81	412	235	22	43.7	1.5	2.2	286.7	235	10.6	0	0	254.9	BDL	2.9
3	Toorsa Tea Garden	Kalchini	Sub-TW	26.8246	89.3871	7.97	349	190	4	43.7	3	1.5	225.7	185	17.7	0	0	207.6	BDL	0.5
4	Radharani Tea Garden	Kalchini	TW	26.7666	89.4619	7.65	161	75	26	2.4	2.9	1.6	85.4	70	10.6	0	0	95.6	--	0.3
5	Barobisha pump house	Kumargram	TW	26.4713	89.8266	7.67	261	70	24	2.4	19.8	1	134.2	110	10.6	0	0	139.8	BDL	5
6	Sankos	Kumargram	M-II	26.6691	89.853	7.83	338	175	30	24.3	2.2	0.9	195.2	160	10.6	0	0	187.1	3.8	10
7	Newlands Tea Garden	Kumargram	TW	26.6712	89.8148	7.42	125	60	22	1.2	2.9	1.1	73.2	60	7.1	0	0	79	1.3	9.9
8	Uttara Haldibari B.F.P School	Kumargram	Mark-II	26.6334	89.8476	7.75	196	150	22	23.1	2.6	0.9	128.1	105	42.5	0	0	169.3	9.5	0.2
9	Jayanti Tea Garden	Kumargram	Mark-II	26.6911	89.6941	7.74	455	260	18	52.2	1	0.6	298.9	245	17.7	0	0	271.9	8.2	0.8
10	Dekhlapara	Madarihat	Mark-II	26.7688	89.108	7.62	614	110	16	17	76.5	2.3	128.1	105	102.8	6	19.4	318.3	2.4	0.1
11	Ramjhora	MAadarihat	Sub-TW	26.7697	89.1996	7.87	414	230	18	45	1.4	2.7	262.3	215	10.6	0	0	237.7	BDL	3.2

CHAPTER-9

GROUNDWATER RELATED ISSUES

9.1 Ground Water Quality Problems (Geogenic)

The concentration of iron (Fe) in ground water above the permissible limit of 1 mg/L in both shallow unconfined aquifers as well as in deeper semi-confined to confined aquifers within the depth range of 8 to 90 metres has been reported from this district.

9.2 Quantity problem

The ground water level in the district goes very deep during lean period as the declination of water level starts immediately after monsoon due to the high effluent nature of the river and the whole area become devoid of sufficient amount of water at a shallow level from which it can be withdrawn economically. Low moisture/water retention capacity of the soil, rapid infiltration of rain water, very high surface run-offs, percolation of water into the deeper level as ground water recharge which are later discharged as base flows are some of the many factors affecting ground water availability in the study area.

9.3 Acidity in soil

The brown forest soil in Bhabar and Terai regions have high soil fertility but crop yield is poor due to low soil depth, high acidity and low temperature. The soil is also light textured, highly porous and very poorly drained. The incomplete process of decomposition of the organic content in soil brings about high acidity to the soil. The concentration of organic matter (Carbon), available phosphates and Potash are also medium to low. The soil is also inherently low in micro-nutrients and in addition to this; the enhanced use of chemical fertilizers along with limited use of organic manures in the present day is contributing to its further decline.

9.4 Abolition of shallow Dug wells

In present scenario, dug wells are getting abolished and the local are bound to drink water from the tube wells. The concept established is that, water from the dug wells is generally free from iron contamination whereas, the water from the shallow tube wells within a depth of 100 metres has every possibility of producing iron contaminated water.

Special mention must be made about the occurring of floods in the Alipurduar district. These districts are flood-prone and three main reasons for floods in these districts are excessive rainfall of small duration on small catchments, continuous rainfall for several days on bigger catchments and the district being situated in the Himalayan foothills and being crisscrossed by the Himalayan rivers. It is observed that the melted snow of the high mountains also causes overflowing the perennial rivers which adds to the worry of

common people. History reveals that the district hasn't escaped from the floods in any single decade. All the riverbeds in the district have risen to the height of 1 to 2.5 metres in between 1985 and 1999. River bank erosion has caused diversion of the course of almost all the rivers between 1993 and 1999.The riverbeds of the district have expanded by 2 to 4 times in the last 100 years and if the destruction of the environment continues at the present rate, probably by the year 2050, creation of a coalescing mega valley consisting of some rivers within the radius of 3 to 15 km. at the Himalayan foothills will occur. This would mean forever destruction of two-third of the tea gardens and forestry of these districts (Source: District census handbook 2011).

CHAPTER - 10

GROUNDWATER DEVELOPMENT AND MANAGEMENT

Groundwater development in an area is regarded as an index of groundwater use in different sectors like domestic, agricultural, industrial and mining, etc. The level of development of groundwater for any given area is always highly dependent upon the availability and occurrences of groundwater under favorable hydro-geological settings. Chronic water scarcity over an area owing to adverse geological conditions often prevents expansion of agricultural and economic growth. In such a situation, strategic use of groundwater resource is essentially needed for its sustainability. And in this, the role of management occupies a primary role that would be an obvious practice in groundwater sectors.

10.1 Rural and Urban water supply schemes:

The Indo-Gangetic Plain consists of coarse sand, gravel, pebble, cobble and boulders in the northern part (Bhabar zone) that becomes finer (up to gravel size) southwards. Because of porous geology, the Bhabar zone is the potential area for groundwater recharge, but there is restricted water availability due to deeper water table. In the extreme northern region of the district which is underlain by hard rocks, groundwater availability as a source of drinking water supply is a perpetual crisis. A large number of privately owned dug wells are available along with very limited Gov.dug wells in both rural and urban areas. Considerable amount of hand pumps (Mark-II) have been installed by the Panchayat and PHED for the benefit of the local public yet there is still a need for adequate supply of water in this part of the district. Though several rivers are draining through the areas, the people residing in these areas have to suffer from water scarcity for drinking purposes. There is limited agricultural land and the area has to depend only on rain-fed irrigation because of lack of proper water management in the area. Furthermore, the population along the foothill areas has also been increasing in the recent time. In this regard, it is extremely necessary to explore and exploit groundwater resources in the Bhabar zone as well as in the Terai zones so as to meet the drinking and irrigation water demand.

At present there are a total of 766476 populations that is covered by commissioned piped water supply Scheme by PHED, Govt. of west Bengal.

10.2 Future Ground Water Development and Management:

Considering the steep surface gradient of the study area, there is minimum scope of recharge to ground water by rainfall through natural process, particularly in blocks of Madarihat and Kalchini as rainwater flows away mostly as surface runoff. High seasonal water level fluctuations, particularly during summer seasons and especially in the northern part of the district causes drying of many open wells/ tube wells during summer seasons.

There is reduction of discharges from many wells and also from many springs as such. Wide variations in depth to water levels are also existent in this part of the state.

The net availability of ground water for future irrigation development in the district ranges from 21136.60 to 35659.29 ham (see **chapter-7**). The level of groundwater development stands at an average of 4.66 %, categorized "Safe". Therefore, despite of the area's adverse hydro-geological constraint, there is still some scope for further utilization of groundwater through construction of new abstraction structures for irrigation. However, it should be done judiciously protecting the environment. The design of tube wells and dug wells should also be done considering high seasonal water level fluctuation in the 'Bhabar zone'

Development of groundwater for irrigation in all blocks of the study area except in those portions lying at the foot hills of the Bhutan Himalayas can be done through shallow tube wells and deep tube wells, as well as by dug wells. The water bearing saturated granular zones comprising of sand, gravel, pebble occurring down to the depth of 189 mbgl form very promising ground water reservoir in the study area. The ground water abstraction structures in the study area are dug wells whose depth range is within 10 mbgl with saturated granular zone thickness of 7 to 8 metres, shallow tube wells with depth range within 25 mbgl and saturated granular thickness zones between the range of 13 to 21 metres and deep tube wells having depth range from 70 to 188 mbgl with saturated granular thickness between 18 to 30 metres. These low duty tube wells may sustain yield within the range of 10-20 m3/hr and that of the heavy tube wells between 100 & 200 m 3/hr. In the northern portion of Madarihat-Birpara, Kalchini and Kumargram blocks where Tea gardens are abundant, irrigation facilities can be increased by sinking heavy duty deep tube wells. In the southern and middle portions i.e., Falakata and Alipurduar-I & II blocks, dug wells, shallow tube wells and deep tube wells can be constructed for irrigation purpose.

In areas north of the spring line, groundwater development should be such that discharges from springs should not be affected, considering the high seasonal water level fluctuation. The design of the tube wells and dug wells, particularly in the Bhabar area should be done in ways where the high seasonal water level fluctuation during summer season should not hamper the production of water from tube wells and dug wells. Depth to water level during pre-monsoon period, drawdown, discharge etc for that particular area should be understood properly to obtain the best fit well design.

The spacing between production wells should be proper so that during simultaneous pumping from tube wells/dug wells, interferences among the wells is negligible or does not occur at all.

The area is mainly bi-cropped and the net irrigated area is very less. Creation of more irrigation potential with considerable command area from ground water is required, where there will be a land available for growing a third crop in a year. The farmers in

the region can be encouraged to adopt multiple cropping systems which will upgrade the economic condition of the people.

The acidity of the soil in the study area can be mitigated to some extend by applying measured amount of dolomite/limestone which is locally known as 'soil conditioners'.

High concentration of iron in groundwater (above maximum permissible limit of 1.0 mg/I) has been reported from certain pockets in the districts and therefore, it needs proper attention and iron removal plants may be installed for drinking purposes.

Rain Water Harvesting through conservation and/or artificial recharge is the best option for augmenting the ground water resource in the area. Conservation of rainwater will save same quantum of ground water from withdrawal which in other words will recharge same amount of water to the aquifer indirectly.

10.3 Artificial Recharge and Rainwater Harvesting

The district wise Master Plan has been prepared for the state of West Bengal. Accordingly, the feasible area for recharge in different parts of Alipurduar district has been identified. Considering the local hydrogeological conditions in the district the following recharge structures are being proposed mainly for the alluvial terrain. The suitable structures are as follows:-

i. Percolation Tank
ii. REET with RS
iii. Injection wells

It is recommended that percolation tank, Re-Excavation of Existing Tanks with Recharge Structures (REET with RS) and injection wells may be constructed as recharge structures in different hydrogeological set-up where water scarcity is felt. In those areas where percolation tanks are not feasible for all practical implementation, provisions may be made by construction of new tanks or desiltation of existing tanks for creation of additional surface storage and recharge to the ground water. At present, 596 no.s of percolation tanks, 1191 no.s of REET with RS and 596 no.s of injection wells is found to be feasible in four blocks of the Alipurduar district namely- Alipurduar-II, Kalchini, Kumargram and Madarihat. The total cost of construction for all these structures is projected at 1788 lakhs.

Overall, emphasize should be given on rain water harvesting with suitable structures. Conservation of rainwater can be done both from the rooftop and from the lands. The water that can be available from rooftops can be stored in cemented and PVC tanks. Before conserving, the water should be sand filtered. The rain water available from any land surface can be stored in any ponds and in this case, sites as well as design of ponds are to be finalized considering local hydrogeological and terrain condition.

10.4 Strategies for Water Conservation, Rainwater Harvesting & Artificial Recharge – Based on Non-committed runoff (CGWB):

Based on component wise distribution of non-committed surface runoff, a number of different structures have been recommended. The status for the same along with their cost of construction and area identified for recharge is given through the following table.

District	Block	Area feasible for AR (Sq.km)	Utilizable surface non committed monsoon run off (MCM)	Allocation of Utilizable Recource(MCM)			Number of Recharge Structures feasible			Cost of Recharge structures (Rs. In lakhs)		
				Percolation Tanks	REET with RS	Injection Well	Percolation Tanks	REET with RS	Injection Well	Percolation Tanks	REET with RS	Injection Well
Alipurduar	Alipurduar-II	44.25	35.508	17.75	7.10	10.65	36	71	36	288	284	108
	Kalchini	342.50	274.82	137.41	54.96	82.45	275	550	275	2200	2200	825
	Kumargram	288.77	231.704	115.85	46.34	69.51	232	463	232	1856	1852	696
	Madarihat	66.58	53.42	26.71	10.68	16.03	53	107	53	424	428	159
TOTAL		**742.09**	**595.45**	**297.73**	**119.09**	**178.64**	**596**	**1191**	**596**	**4768**	**4764**	**1788**

Table-12.1: Area suitable for recharge, Structures proposed and cost of construction in Alipurduar district

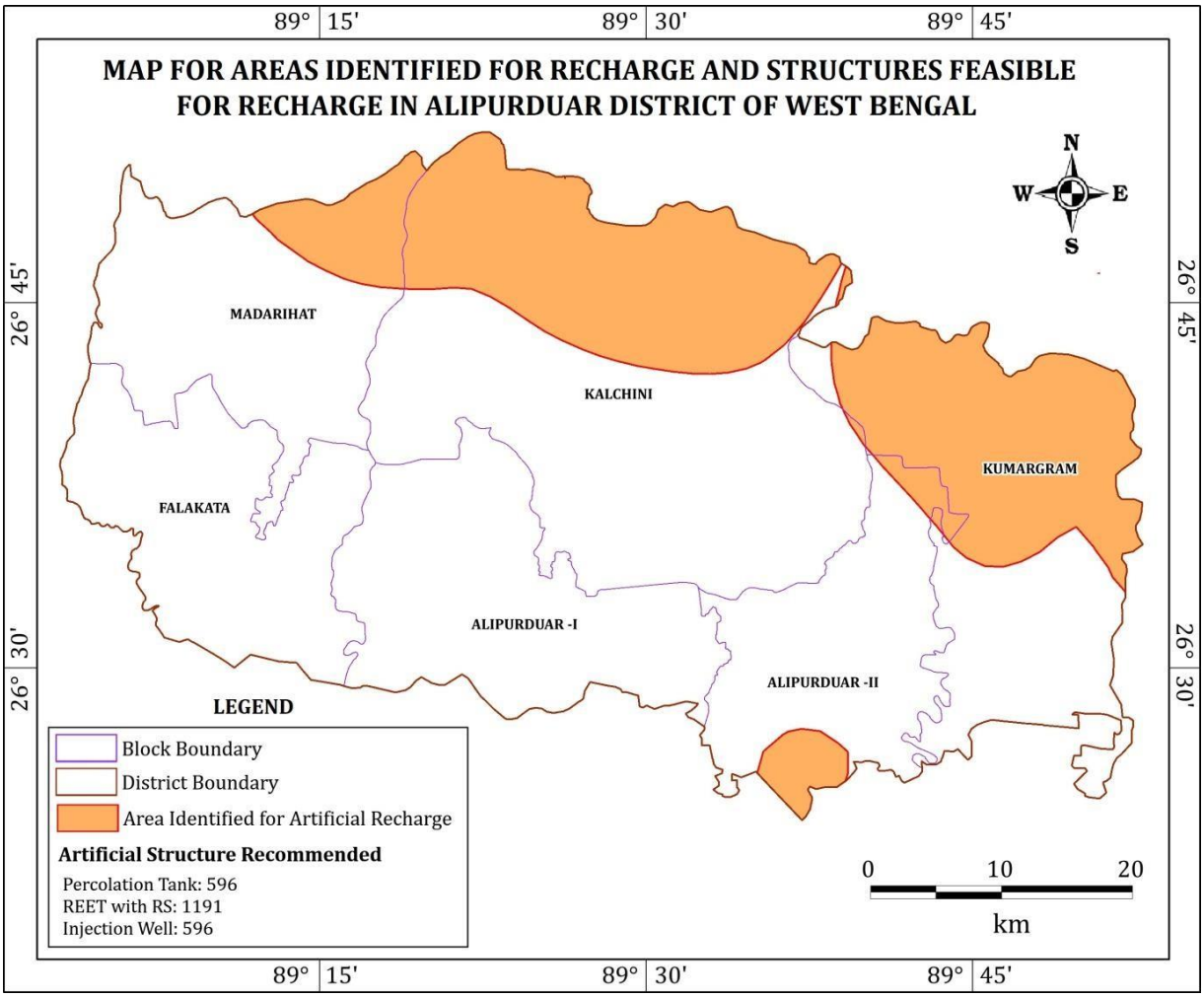


Figure-12.1: Artificial Recharge map for Alipurduar district of West Bengal

PART-II

BLOCKWISE MANAGEMENT PLAN FOR ALIPURDUAR DISTRICT OF WEST BENGAL

1. ALIPURDUAR-I

SALIENT INFORMATION

Block Name : Alipurduar-I

Geographical area (sq. km): 388.39

Mappable area (sq. km) : 324

District : Alipurduar

State : West Bengal

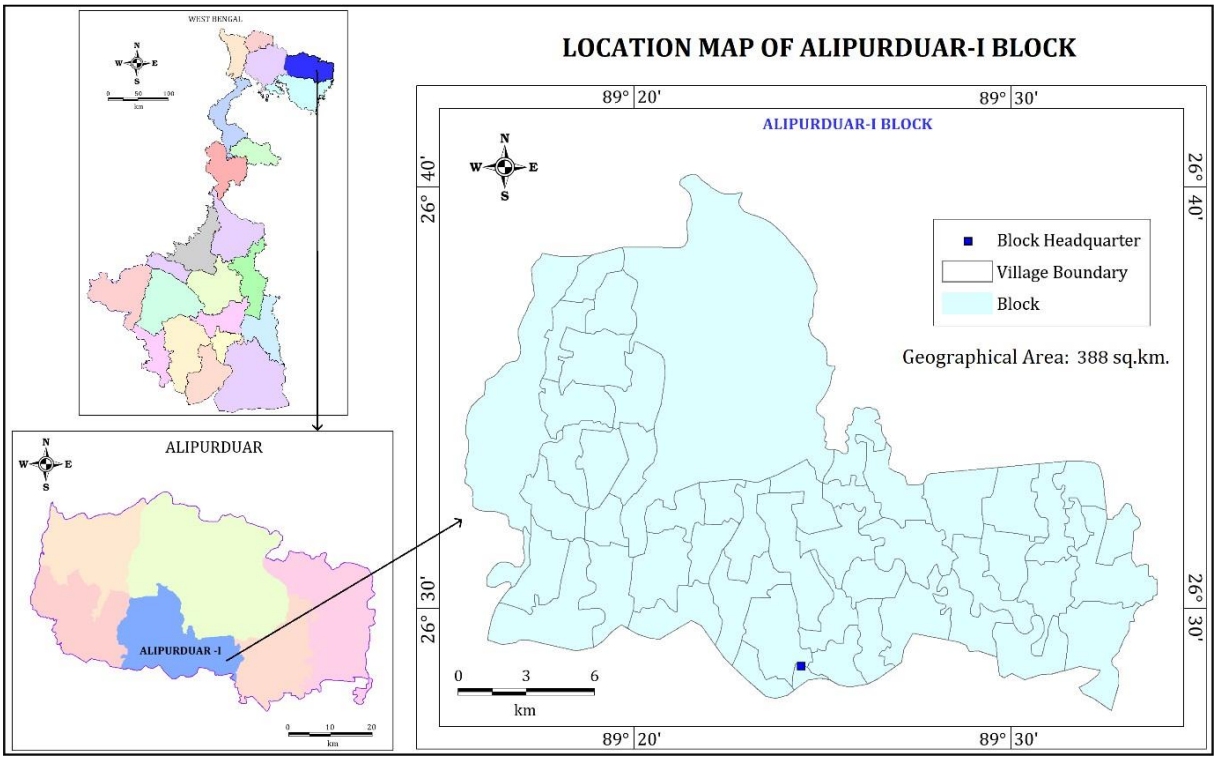


Figure-1.1: Location Map for Alipurduar-I block of Alipurduar district

Population (as on 2011):

Table-1.1: Details of population in Alipurduar-Iblock of Alipurduar district.

Rural	Urban	Total
160760	121403	282163

Rainfall: Average annual rainfall for the period 2017 -21 is 3688.85 (in mm).

Table-1.2: Details of Annual Rainfall for the last five years in Alipurduar-I block of Alipurduar district.

Block	District Normal	District Actual (Annual)				
		2017	2018	2019	2020	2021
Alipurduar-I	3320	3849.59	3537.5	3669.14	4354.15	3033.86

Agriculture & Irrigation (area in ha):

Table-1.3: Salient Land use features in Alipurduar-I block of Alipurduar district.

Name of the Block	Geographic Area	Cultivable area	Total CCA	Area to be brought under CCA	Forest Land
Alipurduar-I	38839	17107	6819.43	10287.57	15576

Ground Water Resource:

Table-1.4: Details of Ground WaterResource Availability and Utilization in Alipurduar-Iblock of Alipurduar district.(As on 31.03.2013)

Dynamic Ground Water Resources	
Annual Replenishable Ground Water Resource (HaM)	30410.39
Annual Extractable Ground Water Resource (HaM)	27369.35
Gross Ground Water Abstraction for all uses (HaM)	1384.11
Net Ground Water Availability for future use (HaM)	25818.52
Stage of Ground Water Development (%)	5.06
Category	Safe
Annual GW Allocation for Domestic and Industrial use as on 2025 (HaM)	651.03
In-storage Ground Water Resources	
In-storage Resource beneath Ground Water Fluctuation Zone upto a depth of 300 mbgl (HaM)	345151.91

Disposition of Aquifers:

The principal aquifer systems encountered in this Block is **Alluvium.** Major aquifer systems are **Younger Alluvium (AL01).**

Table-1.5: Details of aquifer disposition in Alipurduar-I block of Alipurduar district.

Block	Geology	Depth range (mbgl)		Granular zones/Zones tapped	
		Aquifer-I	Aquifer-II	Aquifer-I	Aquifer-II
Alipurduar-I	Younger Alluvium	27.59 - 67.4	50.32 - 125	27.59 - 42.67, 36.96 - 43.12, 45.44 - 67.4, 46.2 - 56.98	50.32 - 74.6, 52.36 - 67.67, 54.25 - 78.25, 56.38 - 71.48, 66.22-78.61, 67 - 90, 72 - 96.3, 94 - 100, 119 - 125

Table-1.6: Aquifer-wise parameters in Alipurduar-I block of Alipurduar district.

Block	Aquifer Type	Discharge (m^3/hr)	Drawdown (m)	SWL (m)	T (m^2/day)
Alipurduar-I	Aquifer-I	5.34 - 104.69	≈3.59	3.11-6	165-300
	Aquifer-II	53.37 - 152.64	--	--	10-2500

Table-1.7: Details of Aquifer Wise Water Level Ranges & seasonal long term water level trends in Alipurduar-I block of Alipurduar district.

Block	Aquifer	Pre-monsoon Trend			Post-monsoon Trend		
		WL Range (mbgl)	Rise (m/year)	Fall (m/year)	WL Range (mbgl)	Rise (m/year)	Fall (m/year)
Alipurduar-I	I	0.51-5.95	0.085	-	2.59-4.56	-	0.117
	II	--	--	--	--	--	--

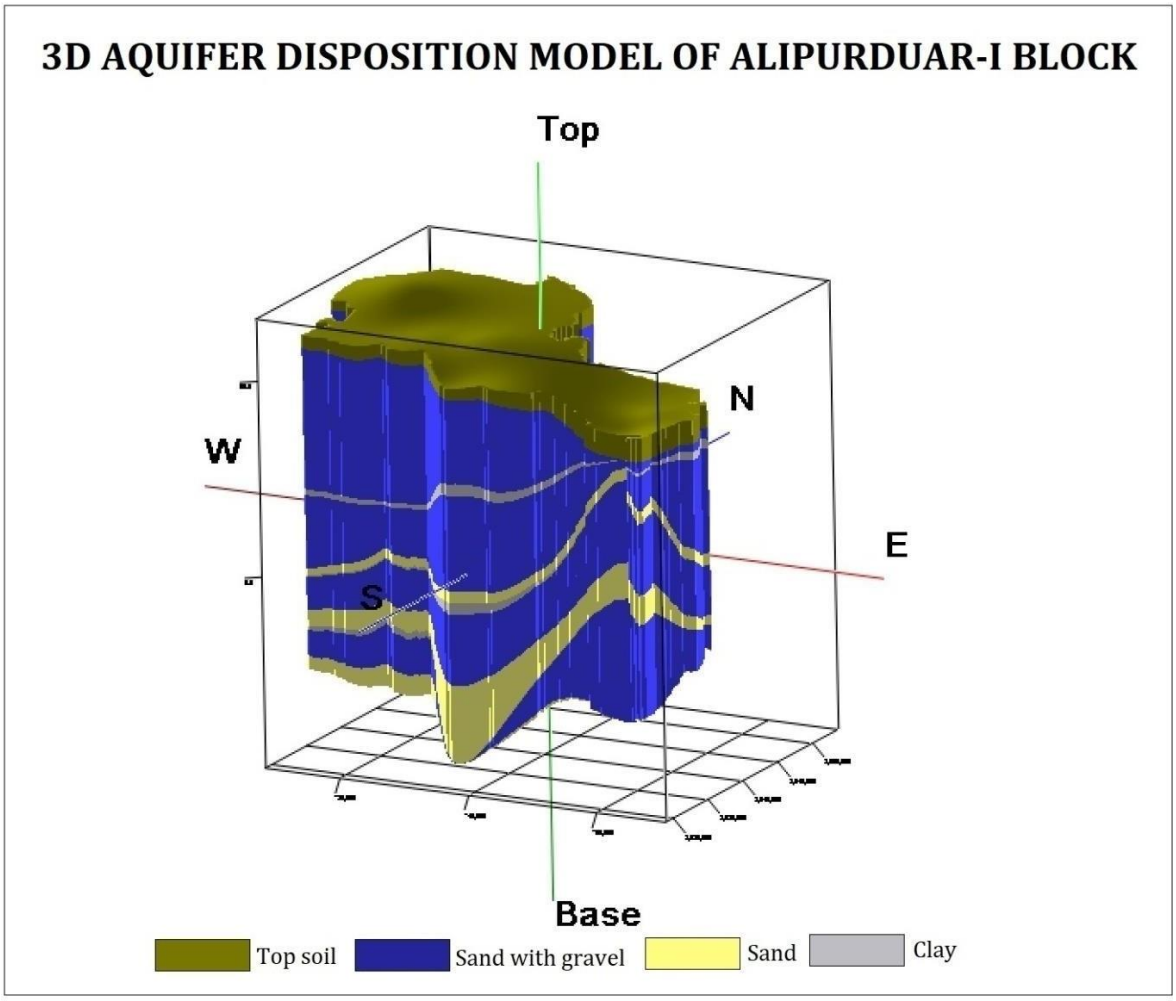


Figure-1.2: 3D disposition model diagram for the aquifers in Alipurduar-I block of Alipurduar district.

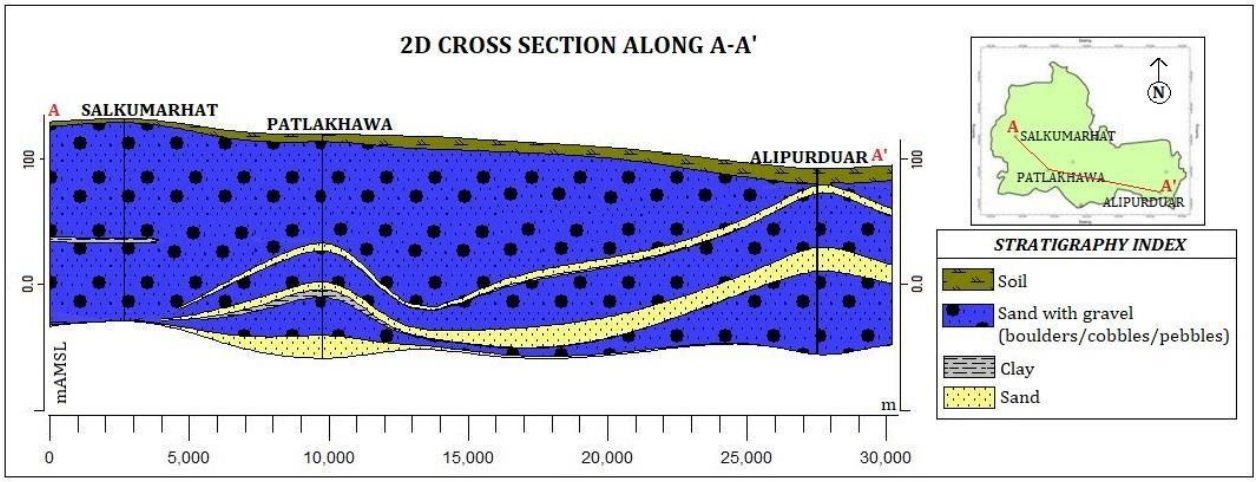


Figure-1.3: 2D crossectional diagram for the aquifers in Alipurduar-I block of Alipurduar district.

Ground water quality and issues:

The range of chemical parameter in groundwater for Alipurduar-I block is given in the table below-

Table-1.8: Range of chemical parameters in groundwater for Alipurduar-I block of Alipurduar district.

Block	Aquifer Type	pH	EC (µS/cm)	Na (mg/l)	Cl (mg/l)	F (mg/l)	NO_3 (mg/l)	SO_4	Fe (mg/l)	Measured Hardness (mg/l)	Ur (ppb)
Alipurduar-I	Aquifer-I	7.25-7.77	84-632	2.25-29.24	7.09-53.18	0-0.13	0-6.2	0-12.5	1.5-5.05	45-174	0.09-6.44
	Aquifer-II	7.42	165	7.04	7.09	--	10.1	15.6	11.42	60	10

Aquifer Management Plan:

Issue-1: Very high concentration of iron is reported from both Aquifer-I and Aquifer-IIin the block.

Management strategy:

- Iron removal plants should be installed at places where high iron content is reported in order to make the water potable. The water should be filtered properly before distribution through public supply.
- Dug wells can be used for both domestic and drinking purposes after proper filtration. Water from dug wells is usually free from iron hence, their revival and maintenance is very highly recommended.
- Rain water harvesting methods should be adopted
- In Terai zones dug wells, medium duty and heavy duty irrigational tube-wells are recommended. The water level in this zone is shallow; yield from the aquifers is high and therefore gives substantial amount of water to wells.
- Use of sprinkler and drip irrigation especially in the tea gardens is recommended in order to minimize the load on use of groundwater, particularly during the lean periods.
- Conjunctive use of both groundwater and surface water for irrigation should be encouraged.

Water Conservation, Rainwater Harvesting & Artificial Recharge

According to the Artificial Recharge Master Plan prepared by CGWB, no such areas in Alipurduar-I block has been identified for artificial recharge. However, water conservation by open area rainwater harvesting in rural areas and rooftop rainwater harvesting in municipality areas can be practiced.

The normal monsoon rainfall is relatively high in this part of the state and conservation of rainwater can be done through roof tops and also from the lands. The water from the roof tops can be conserved in PVC/cemented tanks and can later be used for drinking

purpose after proper filtering. This water can also be utilized for other non-drinking purpose which consumes maximum water in domestic sector.

The population in the area should follow strict conservation measures. The traditional water sources can be renovated. The abandoned dug wells can be cleaned and used as recharge points. Planting trees in those non-cultivable wastelands can be done to increase the forest cover. Municipal bodies should create awareness on conservation of water. The rainwater stored should be used effectively and run-offs from surface should be managed properly. The irrigation over the area should be done in a planned manner. Contour farming and contour ploughing, contour furrows, retention ditches and planting pits can be made for effective use of soil water reserve.

2. ALIPURDUAR-II

SALIENT INFORMATION

Block Name : Alipurduar-II

Geographical area (sq. km) : 319

Mappable area (sq. km) : 266

District : Alipurduar

State : West Bengal

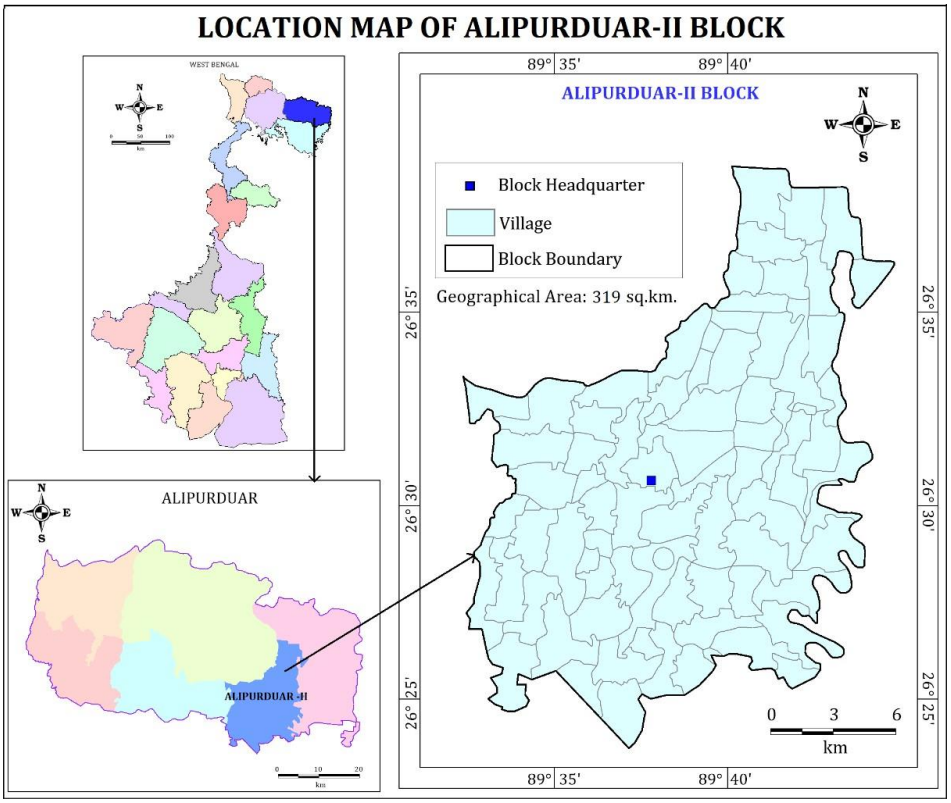


Figure-2.1: Location Map for Alipurduar-II block of Alipurduar district

Population (as on 2011):

Table-2.1: Details of population in Alipurduar-II block of Alipurduar district.

Rural	Urban	Total
204652	13620	218272

Rainfall: Average annual rainfall for the period 2017 -21 is 3688.85 (in mm).

Table 2.2: Details of Annual Rainfall for the last five years in Alipurduar-II block of Alipurduar district

Block	District Normal	District Actual (Annual)				
		2017	2018	2019	2020	2021
Alipurduar-II	3320	3849.59	3537.5	3669.14	4354.15	3033.86

Agriculture& Irrigation (area in ha):

Table-2.3: Salient Land use features for Alipurduar-II block of Alipurduar district.

Name of the Block	Geographic Area	Cultivable area	Total CCA	Area to be brought under CCA	Forest Land
Alipurduar-II	31900	24599	7495.36	13965.64	--

Ground Water Resource:

Table-2.4: Details of Ground Water Resource Availability and Utilization in Alipurduar-II Block of Alipurduar district.(As on 31.03.2013)

Dynamic Ground Water Resources	
Annual Replenishable Ground Water Resource (HaM)	25681.41
Annual Extractable Ground Water Resource (HaM)	23113.27
Gross Ground Water Abstraction for all uses (HaM)	1855.13
Net Ground Water Availability for future use (HaM)	21136.60
Stage of Ground Water Development (%)	8.03
Category	Safe
Annual GW Allocation for Domestic and Industrial use as on 2025 (HaM)	474.57
In-storage Ground Water Resources	
In-storage Resource beneath Ground Water Fluctuation Zone upto a depth of 300 mbgl (HaM)	491356.08

Disposition of Aquifers:

The principal aquifer systems found in this Block is **Alluvium.** Major aquifer systems are **Younger Alluvium (AL01)** and **older Alluvium(AL03).**

Table-2.5: Details of aquifer disposition in Alipurduar-II block of Alipurduar district

Block	Geology	Depth range (mbgl)		Granular zones/Zones tapped	
		Aquifer-I	Aquifer-II	Aquifer-I	Aquifer-II
Alipurduar-II	Younger Alluvium/ Older Alluvium	28 - 48	58 - 93.42	28 - 48	58 - 82, 60.38 - 81.38, 69.15 - 93.42

Table-2.6: Aquifer-wise parameters in Alipurduar-II block of Alipurduar district

Block	Aquifer Type	Discharge (m^3/hr)	Drawdown (m)	SWL (m)	T (m^2/day)
Alipurduar-II	Aquifer-I	68.14	--	≈1.85	165-300
	Aquifer-II	60.56 - 71.64	--	≈2	10-2500

Table-2.7: Details of Aquifer Wise Water Level Ranges & seasonal long term water level trends for Alipurduar-II block of Alipurduar district.

Block	Aquifer	Pre-monsoon Trend			Post-monsoon Trend		
		WL Range (mbgl)	Rise (m/year)	Fall (m/year)	WL Range (mbgl)	Rise (m/year)	Fall (m/year)
Alipurduar-II	I	2.30-44.82	0.099	--	1.84-44.03	--	0.134
	II	--	--	--	--	--	--

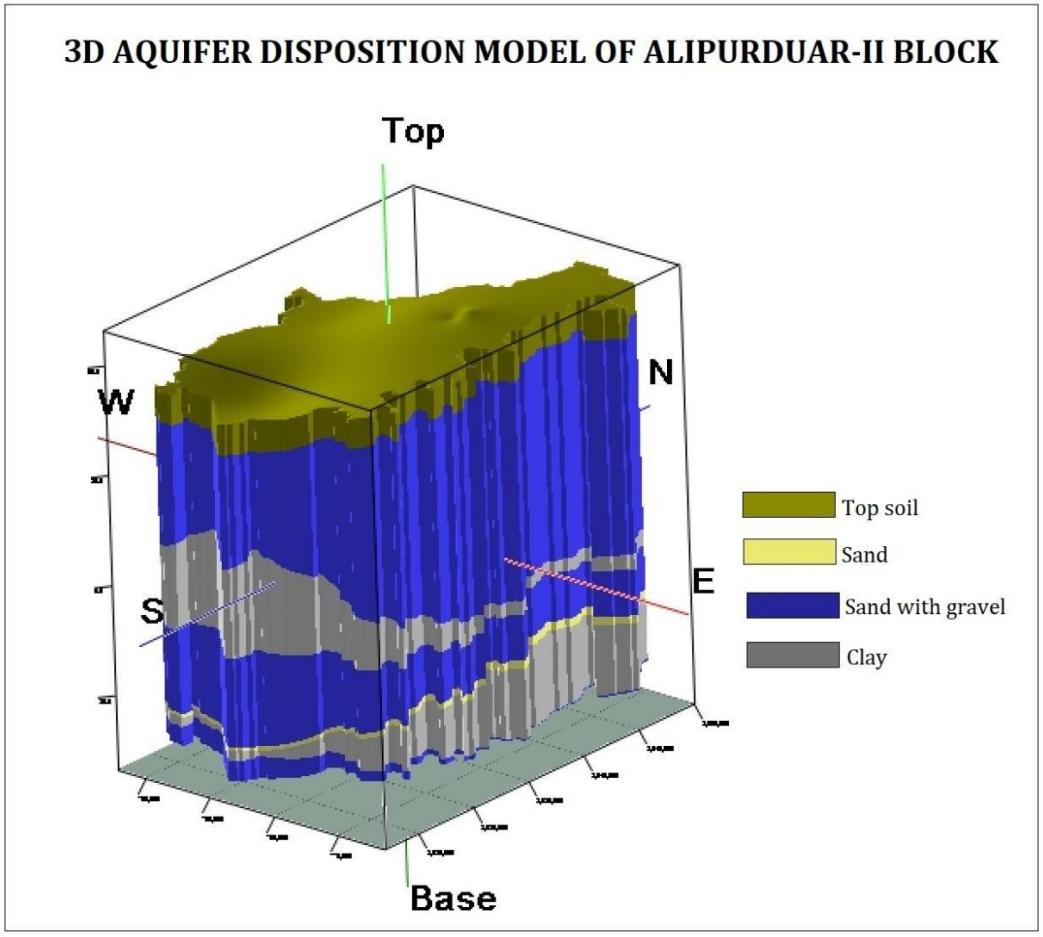


Figure-2.2: 3D disposition model; diagram for the aquifers in Alipurduar-II block of Alipurduar district

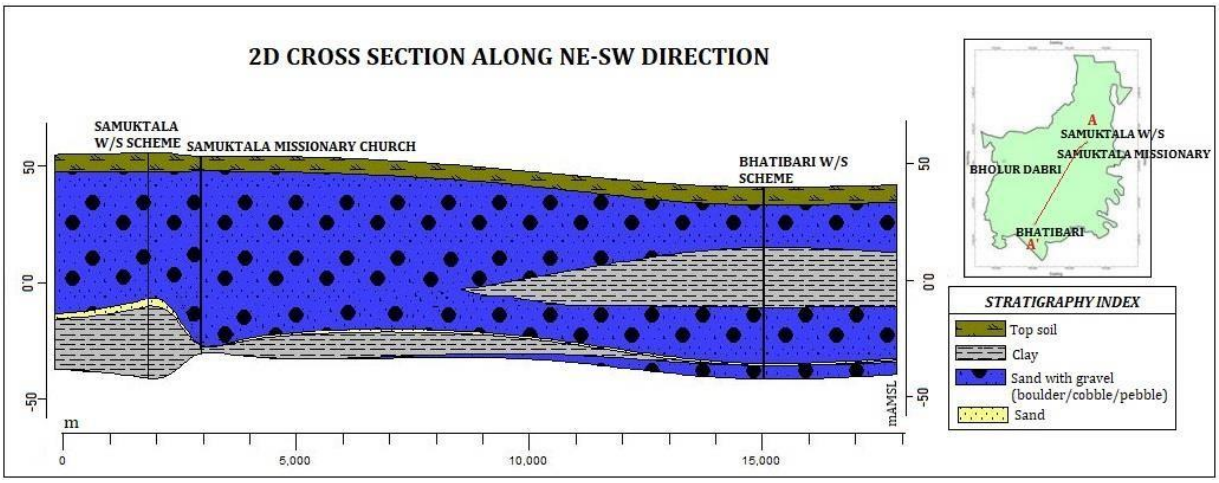


Figure-2.3: 2D Crossectional diagram for the Aquifers in Alipurduar-II block of Alipurduar district.

Ground water quality and issues:

The range of chemical parameter in groundwater for Alipurduar-II block is given in the table below-

Table-2.8: Range of chemical parameters in groundwater for Alipurduar-II block in Alipurduar district

Block	Aquifer Type	pH	EC (µS/cm)	Na (mg/l)	Cl (mg/l)	F (mg/l)	NO_3 (mg/l)	SO_4	Fe (mg/l)	Measured Hardness (mg/l)	Ur (ppb)
Alipurduar-II	Aquifer-I	7.33-7.92	135-531	1.08-18.89	7.09-21.27	0-0.1	0-3.1	0-9.5	0.2-11.25	75-260	0.21-4.1
	Aquifer-II	--	--	--	--	--	--	--	--	--	--

Aquifer Management Plan:

Issue-1: High content of iron in many sample points in Aquifer-II of the study area.

Management strategy:

- Iron removal plants should be installed at places where high iron content is reported in order to make the water potable. The water should be filtered properly before distribution through public supply.
- Dug wells can be used for both domestic and drinking purposes after proper filtration. Water from dug wells is usually free from iron hence, their revival and maintenance is very highly recommended.
- Rain water harvesting methods should be adopted
- In Terai zones dug wells, medium duty and heavy duty irrigational tube-wells are recommended. The water level in this zone is shallow; yield from the aquifers is high and therefore gives substantial amount of water to wells.
- Use of sprinkler and drip irrigation especially in the tea gardens is recommended in order to minimize the load on use of groundwater, particularly during the lean periods.
- Conjunctive use of both groundwater and surface water for irrigation should be encouraged.

Water Conservation, Rainwater Harvesting & Artificial Recharge

Based on component wise distribution of non-committed surface runoff, a number of different structures have been proposed for the block under study. The area identified for recharge, number of structures proposed and their cost of construction is given in **Table-2.9**.

The area feasible for artificial recharge is shown in **Figure-2.4.**

Table-2.9: Area suitable for recharge, Structures proposed and cost of construction in Alipurduar-II block of Alipurduar district.

Block	Area feasible for AR (Sq.km)	Utilizable surface non committed monsoon run off (MCM)	Allocation of Utilizable Recource(MCM)			Number of Recharge Structures feasible			Cost of Recharge structures (Rs. In lakhs)		
			Percolation Tanks	REET with RS	Injection Well	Percolation Tanks	REET with RS	Injection Well	Percolation Tanks	REET with RS	Injection Well
Alipurduar-II	44.25	35.508	17.75	7.10	10.65	36	71	36	288	284	108

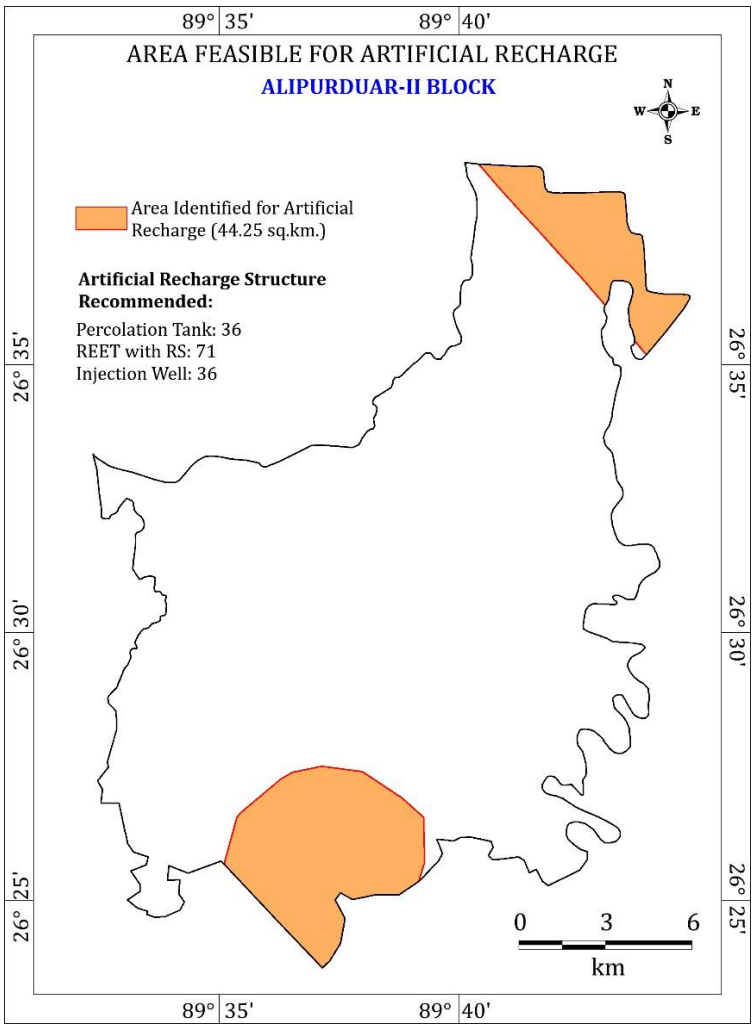


Figure-2.4: Artificial recharge map for Alipurduar-I block of Alipurduar district.

3. FALAKATA

SALIENT INFORMATION

Block Name : Falakata

Geographical area (sq. km): 354

Mappable area (sq. km) : 287

District : Alipurduar

State : West Bengal

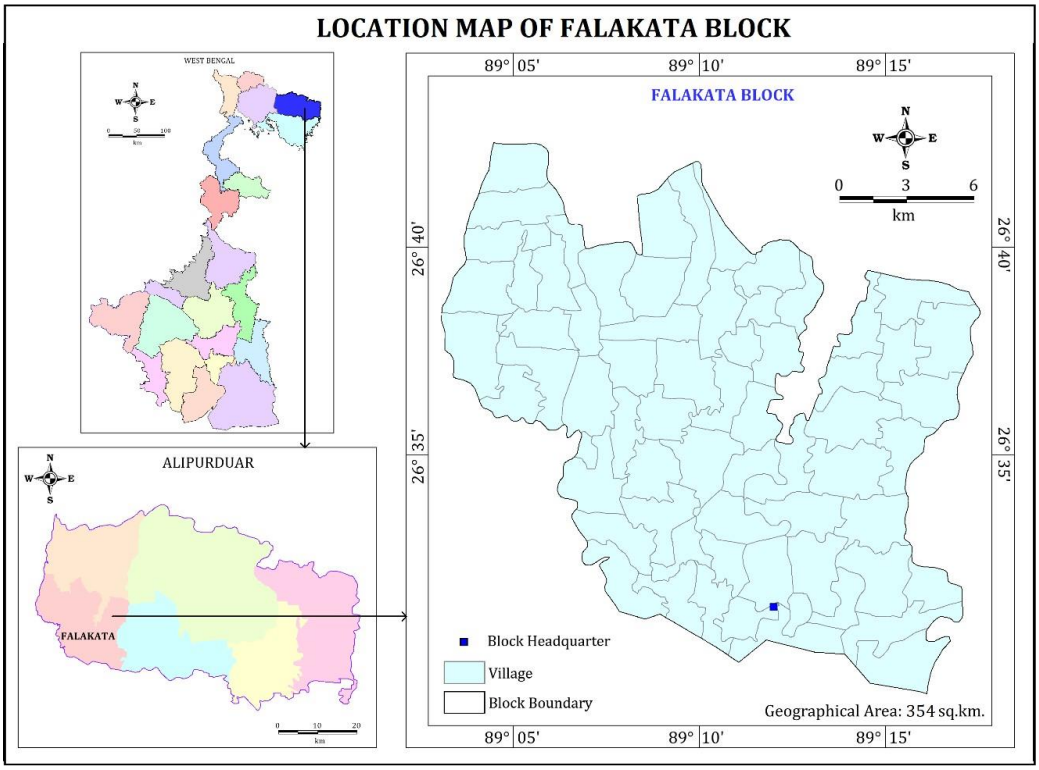


Figure-3.1: Location Map for Falakata block of Alipurduar district

Population (as on 2011):

Table-3.1: Details of population for Falakata block of Alipurduar district.

Rural	Urban	Total
244161	46561	290722

Rainfall: Average annual rainfall for the period 2017 -21 is 3688.85 (in mm).

Table-3.2: Details of Annual Rainfall for the last five years for Falakata block of Alipurduar district.

Block	District Normal	District Actual (Annual)				
		2017	2018	2019	2020	2021
Falakata	3320	3849.59	3537.5	3669.14	4354.15	3033.86

Agriculture& Irrigation (area in ha):

Table-3.3: Salient Land use features for Falakata block of Alipurduar district.

Name of the Block	Geographic Area	Cultivable area	Total CCA	Area to be brought under CCA	Forest Land
Falakata	35400	27050	4620	22430	3110

Ground Water Resource:

Table-3.4: Details of Ground Water Resource Availability and Utilization for Falakata block of Alipurduar district.(As on 31.03.2013)

Dynamic Ground Water Resources	
Annual Replenishable Ground Water Resource (HaM)	28344.11
Annual Extractable Ground Water Resource (HaM)	25509.70
Gross Ground Water Abstraction for all uses (HaM)	1888.61
Net Ground Water Availability for future use (HaM)	23464.22
Stage of Ground Water Development (%)	7.40
Category	Safe
Annual GW Allocation for Domestic and Industrial use as on 2025 (HaM)	612.58
In-storage Ground Water Resources	
In-storage Resource beneath Ground Water Fluctuation Zone upto a depth of 300 mbgl (HaM)	450659.5

Disposition of Aquifers:

The principal aquifer systems encountered in this Block is **Alluvium.** Major aquifer system is **Younger Alluvium (AL01).**

Table-3.5: Details of aquifer disposition for Falakata block of Alipurduar district.

Block	Geology	Depth range (mbgl)		Granular zones/Zones tapped	
		Aquifer-I	Aquifer-II	Aquifer-I	Aquifer-II
Falakata	Younger Alluvium	27.87 - 56.98	50 - 119.2	27.87 - 36.86, 40.04 - 56.98, 44 - 47	50 - 62, 65 - 68, 69.15 - 93.42, 74 - 80, 84.47 - 108.87, 86 - 92, 93 - 119.2

Table-3.6: Aquifer-wise parameters for Falakata block of Alipurduar district.

Block	Aquifer Type	Discharge (m^3/hr)	Drawdown (m)	SWL (m)	T (m^2/day)
Falakata	Aquifer-I	68.32	--	--	165-300
	Aquifer-II	60.56 - 177.16	≈7.87	5.08-39	10-2500

Table-3.7: Details of Aquifer Wise Water Level Ranges & seasonal long term water level trends For Falakata block of Alipurduar district.

Block	Aquifer	Pre-monsoon Trend			Post-monsoon Trend		
		WL Range (mbgl)	Rise (m/year)	Fall (m/year)	WL Range (mbgl)	Rise (m/year)	Fall (m/year)
Falakata	I	2.79-59	0.094	-	3.95-58.90	0.088	-
	II	--	--	--	--	--	--

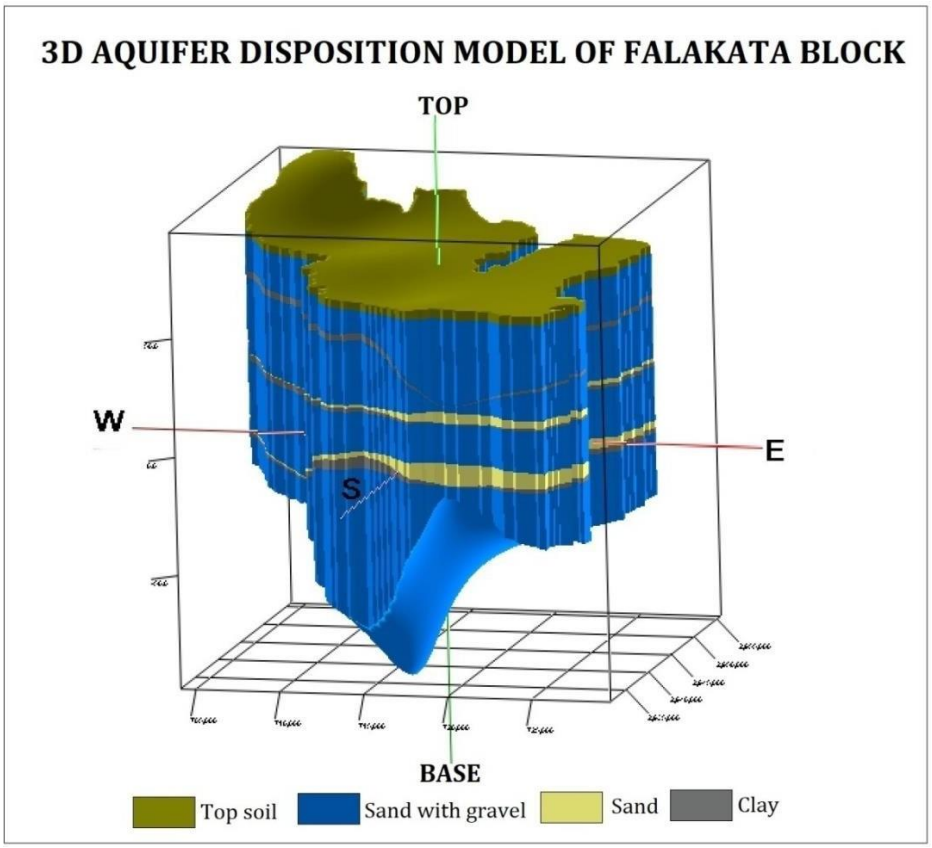


Figure-3.2: 3D disposition model diagram for the aquifers in Falakata block of Alipurduar district

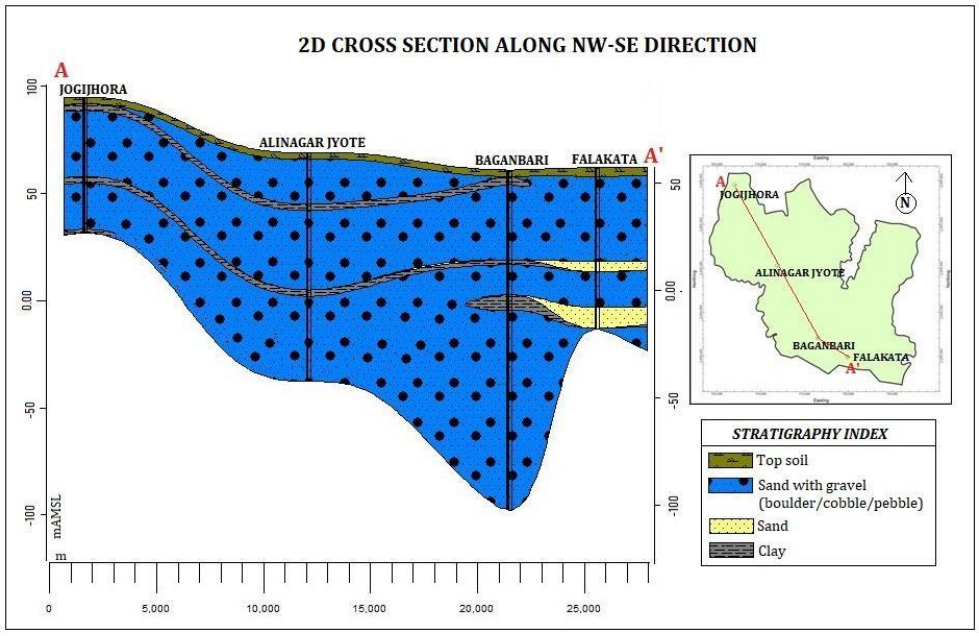


Figure-3.3: 2D Crossectional diagram for the Aquifers in Falakata block of Alipurduar district.

Ground water quality and issues:

The range of chemical parameter for the groundwater in Falakata block is given in the table below.

Table-3.8: Range of chemical parameters in groundwater for Falakata block in Alipurduar district.

Block	Aquifer Type	pH	EC (µS/cm)	Na (mg/l)	Cl (mg/l)	F (mg/l)	NO_3 (mg/l)	SO_4	Fe (mg/l)	Measured Hardness (mg/l)	Ur (ppb)
Falakata	Aquifer-I	7.46 - 7.82	202-584	5.98-36.76	14.18-67.35	--	0-3.5	0-15.6	0.6-8.5	95-205	2-5
	Aquifer-II	7.81	412	1.47	10.63	--	--	--	--	235	2.9

Aquifer Management Plan:

Issue-1: Very high iron content in groundwater is reported from some isolated pockets in Aquifer-I in the block.

Issue-2: Very deep water level is recorded from the upper northern region of the block.

Management strategy:

- Iron removal plants should be installed at places where high iron content is reported in order to make the water potable. The water should be filtered properly before distribution through public supply.
- Dug wells can be used for both domestic and drinking purposes after proper filtration. Water from dug wells is usually free from iron hence, their revival and maintenance is very highly recommended.
- Rain water harvesting methods should be adopted and conservation methods should be taken for optimum utilization of water in the block.
- In Terai zones dug wells, medium duty and heavy duty irrigational tube-wells are recommended. The water level in this zone is shallow; yield from the aquifers is high and therefore gives substantial amount of water to wells.
- Use of sprinkler and drip irrigation especially in the tea gardens is recommended in order to minimize the load on use of groundwater, particularly during the lean periods.
- Conjunctive use of both groundwater and surface water for irrigation should be encouraged.

Rain water harvesting and water conservation:

According to the Artificial Recharge Master Plan prepared by CGWB, no such area in Falakata block has been identified for artificial recharge at present. However, water conservation by open area rainwater harvesting in rural areas and rooftop rainwater harvesting in municipality area can be practiced.

The normal monsoon rainfall is relatively high in this part of the state and conservation of rainwater can be done through roof tops and also from the lands. The water from the roof tops can be conserved in PVC/cemented tanks and can later be used for drinking purpose after proper filtering. This water can also be utilized for other non-drinking purpose which consumes maximum water in domestic sector.

The population in the area should follow strict conservation measures. The traditional water sources can be renovated. The abandoned dug wells can be cleaned and used as recharge points. Planting trees in those non-cultivable wastelands can be done to increase the forest cover. Municipal bodies should create awareness on conservation of water. The rainwater stored should be used effectively and run-offs from surface should be managed properly. The irrigation over the area should be done in a planned manner. Contour farming and contour ploughing, contour furrows, retention ditches and planting pits can be made for effective use of soil water reserve.

4. KALCHINI

SALIENT INFORMATION

Block Name : Kalchini

Geographical area (sq. km) : 712

Mappable area (sq. km) : 361

District : Alipurduar

State : West Bengal

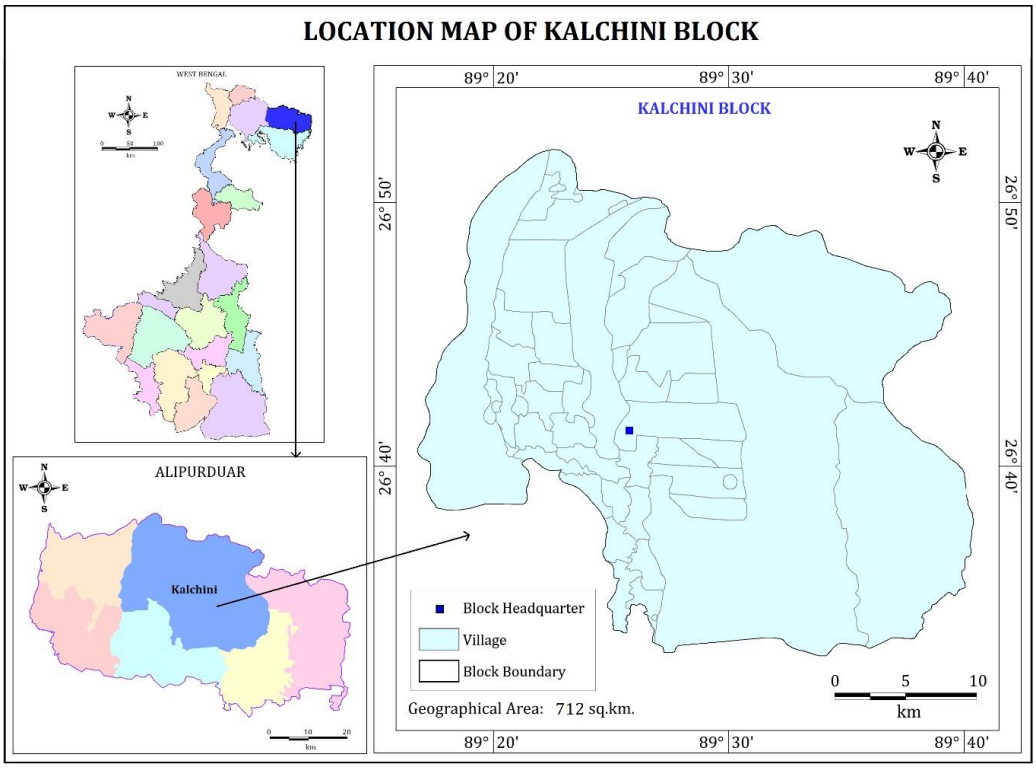


Figure-4.1: Location Map for Kalchini block of Alipurduar district.

Population (as on 2011):

Table-4.1: Details of population in Kalchini block of Alipurduar district.

Rural	Urban	Total
211808	86650	298458

Rainfall: Average annual rainfall for the period 2017 -21 is 3688.85 (in mm).

Table-4.2: Details of Annual Rainfall for the last five years in Kalchini block of Alipurduar district.

Block	District Normal	District Actual (Annual)				
		2017	2018	2019	2020	2021
Kalchini	3320	3849.59	3537.5	3669.14	4354.15	3033.86

Agriculture& Irrigation (area in ha):

Table-4.3: Salient Land use features for Kalchini block of Alipurduar district.

Name of the Block	Geographic Area	Cultivable area	Total CCA	Area to be brought under CCA	Forest Land
Kalchini	71200	22922	1612	21310	63254

Ground Water Resource:

Kalchini block falls under hilly area category. According to GEC-2013, areas with slope >20% are not considered for resource calculation. Hence no estimation of ground water resource has been initiated for the block.

Disposition of Aquifers:

There are two principal aquifer systems in Kalchini Block; Alluvium& Hard rocks.Four major aquifers are present in the block as such; Younger Alluvium, Older Alluvium, Pre-Cambrian crystallines and the Gondwanas.

Table-4.5: Details of aquifer disposition for Kalchini block of Alipurduar district.

Block	Geology	Depth range (mbgl)		Granular zones/Zones tapped	
		Aquifer-I	Aquifer-II	Aquifer-I	Aquifer-II
Kalchini	Younger Alluvium/ Older Alluvium/Sandstone/ Limestone/Dolomite/ Shale	46.88 - 53.03	55.05 - 100.8	46.88 - 53.03	55.05 - 85.05, 56.38 - 71. 82, 61 - 67, 64 - 79, 66 - 74, 73 - 85, 76.8 - 100.8, 80 - 96, 82 - 91

Table-4.6: Aquifer-wise parameters for Kalchini block of Alipurduar district.

Block	Aquifer Type	Discharge (m^3/hr)	Drawdown (m)	SWL (m)	T
Kalchini	Aquifer-I	19.14 - 25	--	--	165-300
	Aquifer-II	38.80 - 68.13	--	9.1-35	10-2500

Table-4.7: Details of Aquifer Wise Water Level Ranges & seasonal long term water level trends for Kalchini block of Alipurduar district.

Block	Aquifer	Pre-monsoon Trend			Post-monsoon Trend		
		WL Range (mbgl)	Rise (m/year)	Fall (m/year)	WL Range (mbgl)	Rise (m/year)	Fall (m/year)
Kalchini	I	1.58-8.59	0.231	--	1.14-5.70	-	0.082
	II	--	--	--	--	--	--

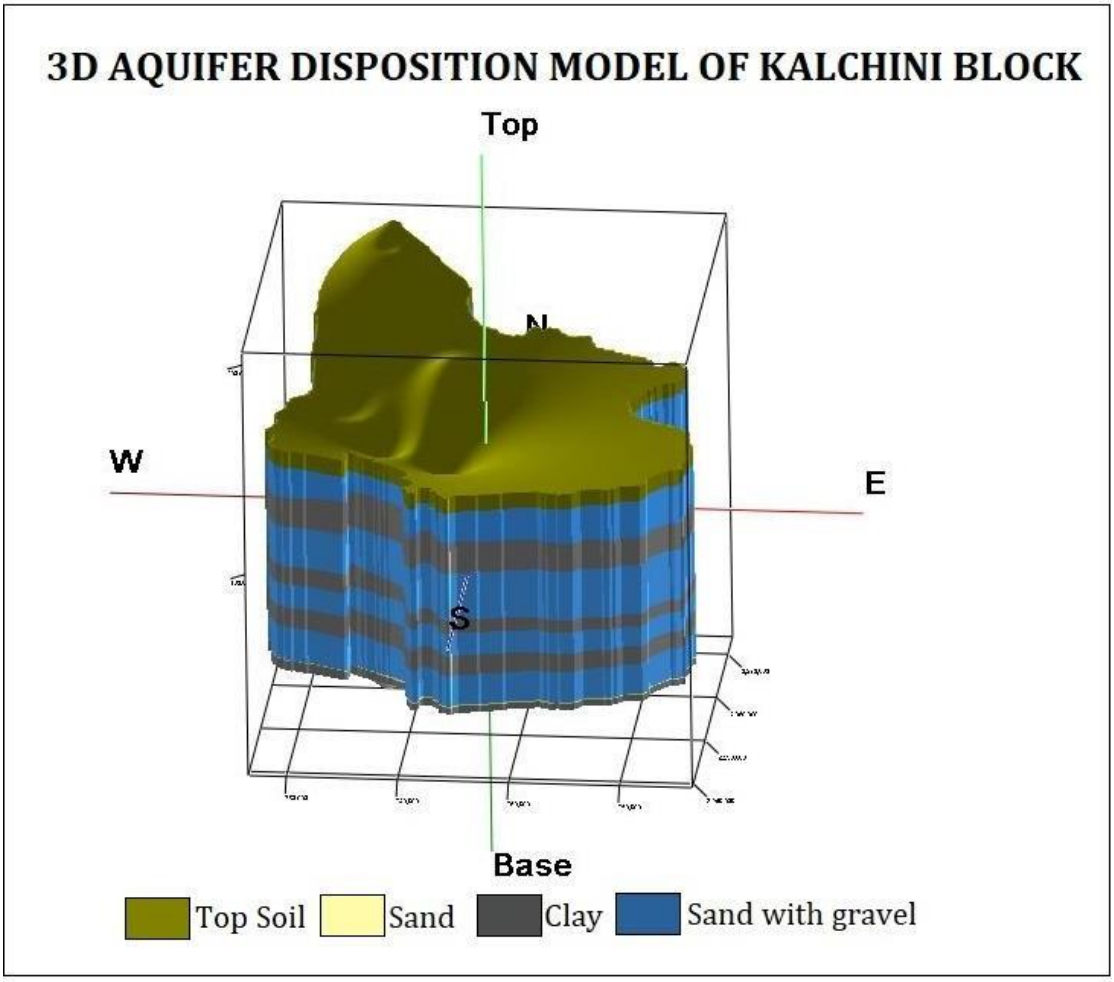


Figure-4.2: 3D disposition model diagram for the aquifers in Kalchini block of Alipurduar district

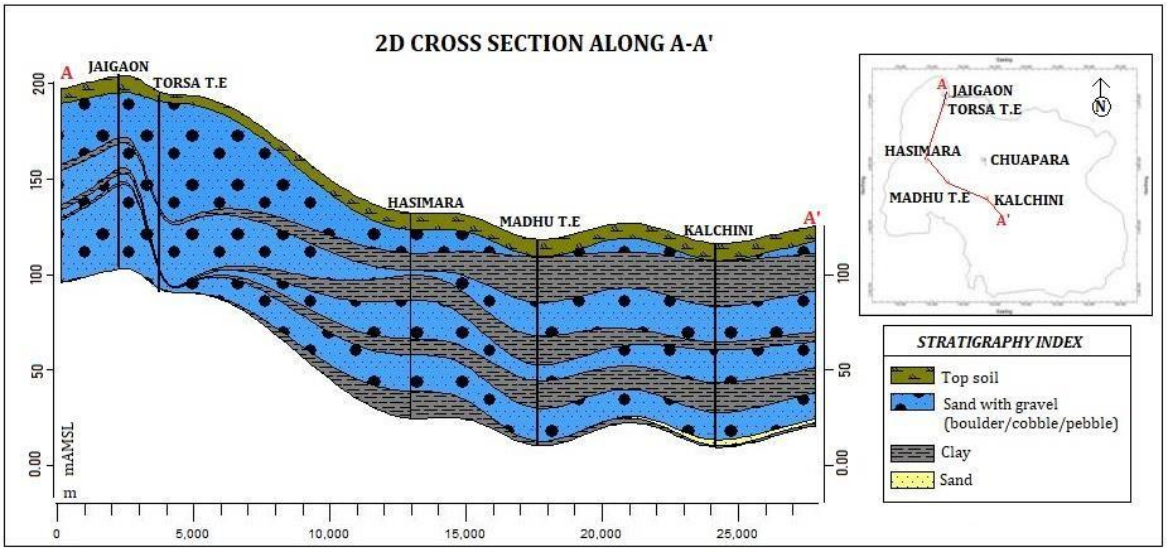


Figure-4.3: 2D Crossectional diagram for the Aquifers in Kalchini block of Alipurduar district.

Ground water quality and issues:

The range of chemical parameter for groundwater in Kalchini block is given in the table below.

Table-4.8: Range of chemical parameters in groundwater in Kalchini block of Alipurduar district.

Block	Aquifer Type	pH	EC (µS/cm)	Na (mg/l)	Cl (mg/l)	F (mg/l)	NO_3 (mg/l)	SO_4	Fe (mg/l)	Measured Hardness (mg/l)	Ur (ppb)
Kalchini	Aquifer-I	7.7-7.94	163-554	2.82-26.8	10.65-17.72	--	0-2.5	0-10.2	11.2	105-240	0.2-0.8
	Aquifer-II	7.65-7.97	161-349	2.95	10.63-17.72	--	--	--	--	75-190	0.54-0.28

Aquifer Management Plan:

Issue-1: Very high iron content in groundwater is reported from some isolated pockets in Aquifer-I in the block.

Issue-2: Very deep water level is recorded from the upper Bhabar region of the block.

Management strategy:

- Iron removal plants should be installed at places where high iron content is reported in order to make the water potable. The water should be filtered properly before distribution through public supply.
- Dug wells can be used for both domestic and drinking purposes after proper filtration. Water from dug wells is usually free from iron hence, their revival and maintenance is very highly recommended.
- Rain water harvesting methods should be adopted and conservation methods should be taken for optimum utilization of water in the block.
- In Terai zones dug wells, medium duty and heavy duty irrigational tube-wells are recommended. The water level in this zone is shallow; yield from the aquifers is high and therefore gives substantial amount of water to wells.
- Use of sprinkler and drip irrigation especially in the tea gardens is recommended in order to minimize the load on use of groundwater, particularly during the lean periods.
- Conjunctive use of both groundwater and surface water for irrigation should be encouraged.

Water Conservation, Rainwater Harvesting & Artificial Recharge

Based on component wise distribution of non-committed surface runoff, a number of different structures have been proposed in the study area. The status for the same along with their cost of construction and area identified for recharge is given in **Table-4.9**. The area feasible for artificial recharge is shown in **Figure-4.4.**

Table-4.9: Area suitable for recharge, Structures proposed and cost of construction in Kalchini block of Alipurduar district.

Block	Area feasible for AR (Sq.km)	Utilizable surface non committed monsoon run off (MCM)	Allocation of Utilizable Recource(MCM)			Number of Recharge Structures feasible			Cost of Recharge structures (Rs. In lakhs)		
			Percolation Tanks	REET with RS	Injection Well	Percolation Tanks	REET with RS	Injection Well	Percolation Tanks	REET with RS	Injection Well
Kalchini	342.50	274.82	137.41	54.96	82.45	275	550	275	2200	2200	825

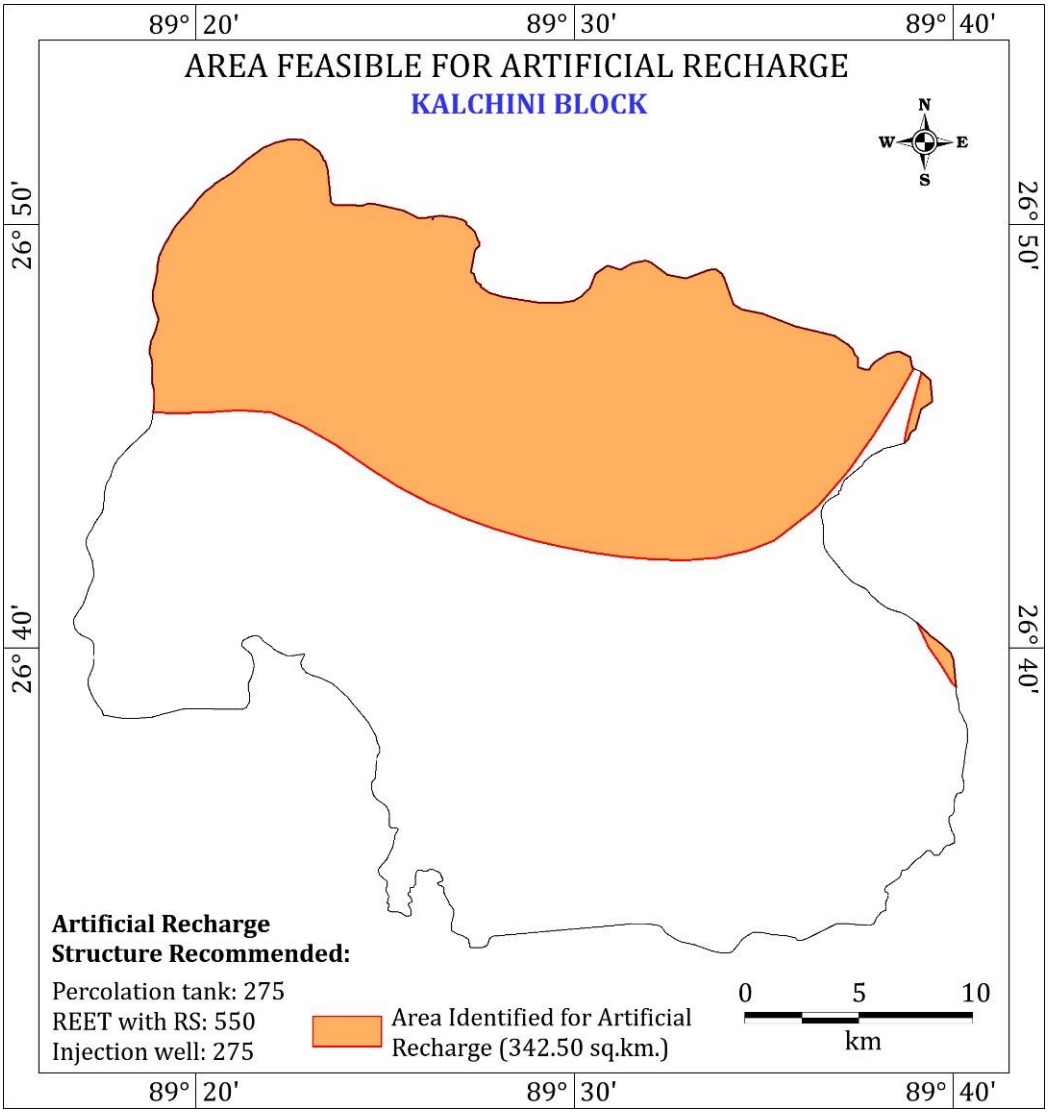


Figure-4.4: Artificial recharge map for Kalchini block of Alipurduar district.

5. KUMARGRAM

SALIENT INFORMATION

Block Name : Kumargram

Geographical area (sq. km) : 518

Mappable area (sq. km) : 226

District : Alipurduar

State : West Bengal

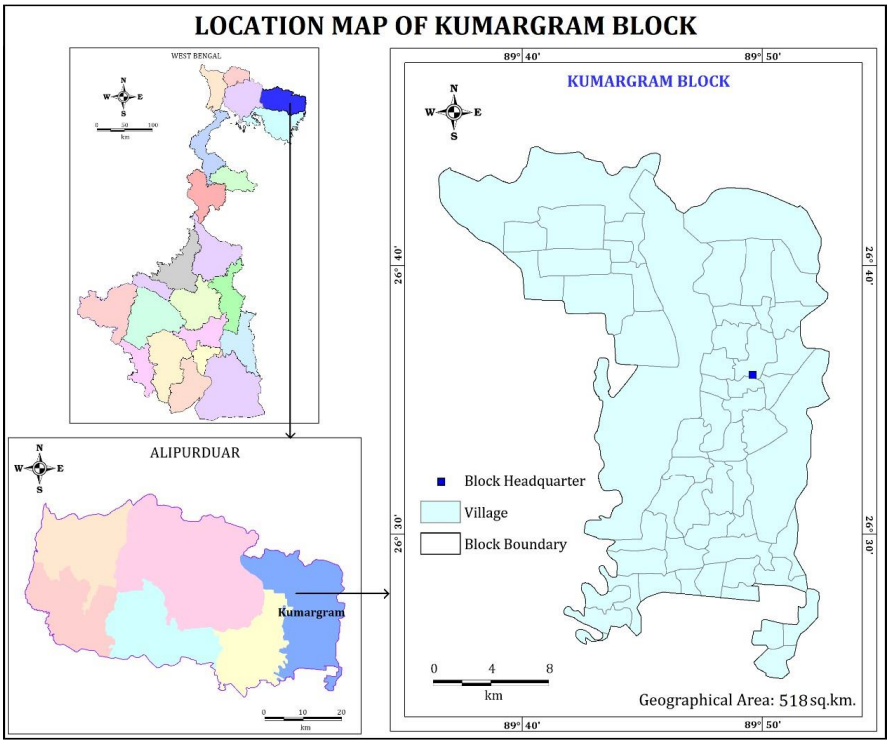


Figure-5.1: Location Map of Kumargram block of Alipurduar district.

Population (as on 2011):

Table-5.1: Details of population in Kumargram block of Alipurduar district.

Rural	Urban	Total
174058	25551	199609

Rainfall: Average annual rainfall for the period 2017 -21 is 3688.85 (in mm).

Table-5.2: Details of Annual Rainfall for the last five years in Kumargram block of Alipurduar district.

Block	District Normal	District Actual (Annual)				
		2017	2018	2019	2020	2021
Kumargram	3320	3849.59	3537.5	3669.14	4354.15	3033.86

Agriculture& Irrigation (area in ha):

Table-5.3: Salient Land use features in Kumargram block of Alipurduar district

Name of the Block	Geographic Area	Cultivable area	Total CCA	Area to be brought under CCA	Forest Land
Kumargram	51800	21461	5435.50	16025.5	23893

Ground Water Resource:

Table -5.4: Details of Ground Water Resource Availability and Utilization in Kumargram block. (As on 31.03.2013)

Dynamic Ground Water Resources	
Annual Replenishable Ground Water Resource (HaM)	40517.03
Annual Extractable Ground Water Resource (HaM)	36465.33
Gross Ground Water Abstraction for all uses (HaM)	696.20
Net Ground Water Availability for future use (HaM)	35659.29
Stage of Ground Water Development (%)	1.72
Category	Safe
Annual GW Allocation for Domestic and Industrial use as on 2025 (HaM)	428.94
In-storage Ground Water Resources	
In-storage Resource beneath Ground Water Fluctuation Zone upto a depth of 300 mbgl (HaM)	463654.04

Disposition of Aquifers:

There are two principal aquifer systems in Kalchini Block; Alluvium & Hard rocks**.** Four major aquifers are present in the block as such; Younger Alluvium, Older Alluvium, Pre-Cambrian crystallines and the Gondwanas.

Table-5.5: Details of aquifer disposition in Kumargram block of Alipurduar district.

Block	Geology	Depth range (mbgl)		Granular zones/Zones tapped	
		Aquifer-I	Aquifer-II	Aquifer-I	Aquifer-II
Kumargram	Younger Alluvium/ Sandstones	45.44 - 67.44	56.65 - 91	45.44 - 67.44	56.65 - 78, 67.1- 91

Table-5.6: Aquifer-wise parameters in Kumargram block of Alipurduar district.

Block	Aquifer Type	Discharge (m^3/hr)	Drawdown (m)	SWL (m)	T (m^2/day)
Kumargram	Aquifer-I	113.5	--	≈6	165-300
	Aquifer-II	66.48 - 73.13	3-5	≈10	10-2500

Table-5.7: Details of Aquifer Wise Water Level Ranges & seasonal long term water level trends for Kumargram block of Alipurduar district.

Block	Aquifer	Pre-monsoon Trend			Post-monsoon Trend		
		WL Range (mbgl)	Rise (m/year)	Fall (m/year)	WL Range (mbgl)	Rise (m/year)	Fall (m/year)
Kumargram	I	0.76-46.62	0.236	-	1.62-46.22	-	0.974
	II	--	--	--	--	--	--

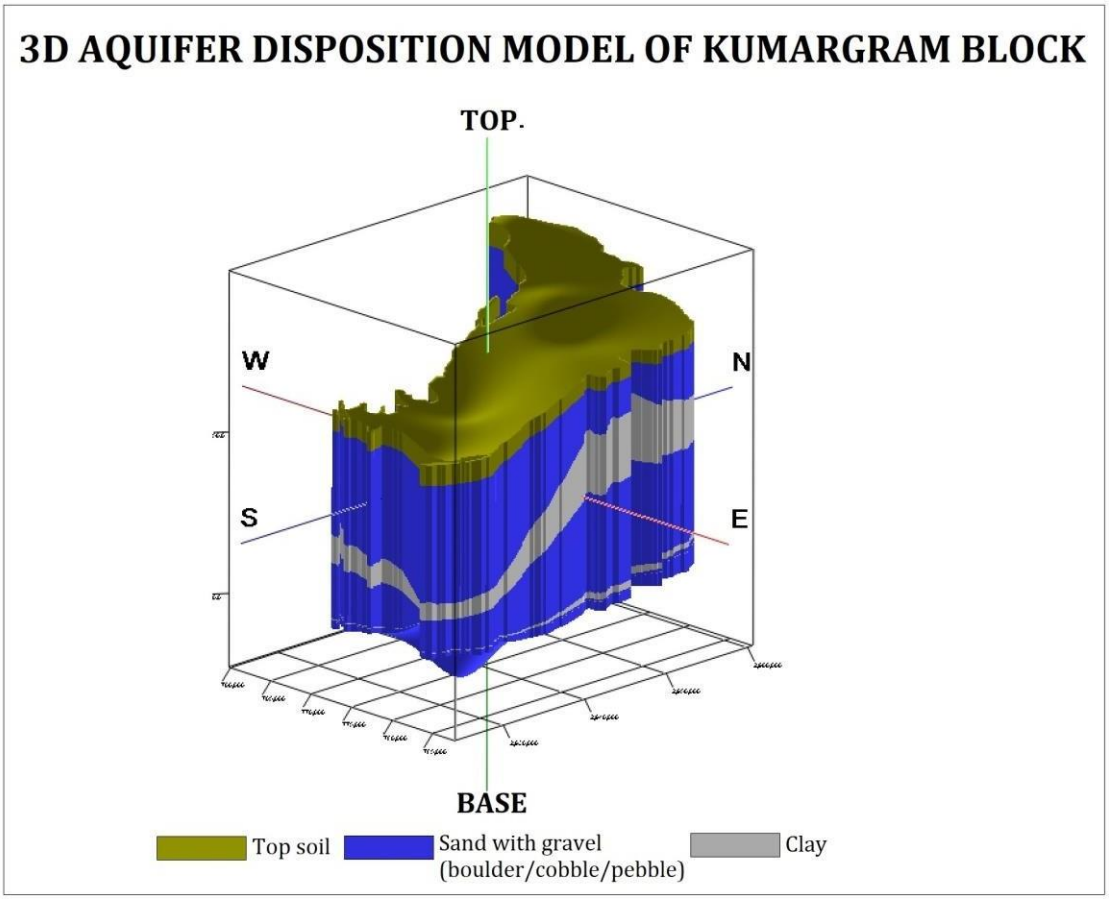


Figure-5.2: 3D disposition model diagram for the aquifers in Kumargram block of Alipurduar district.

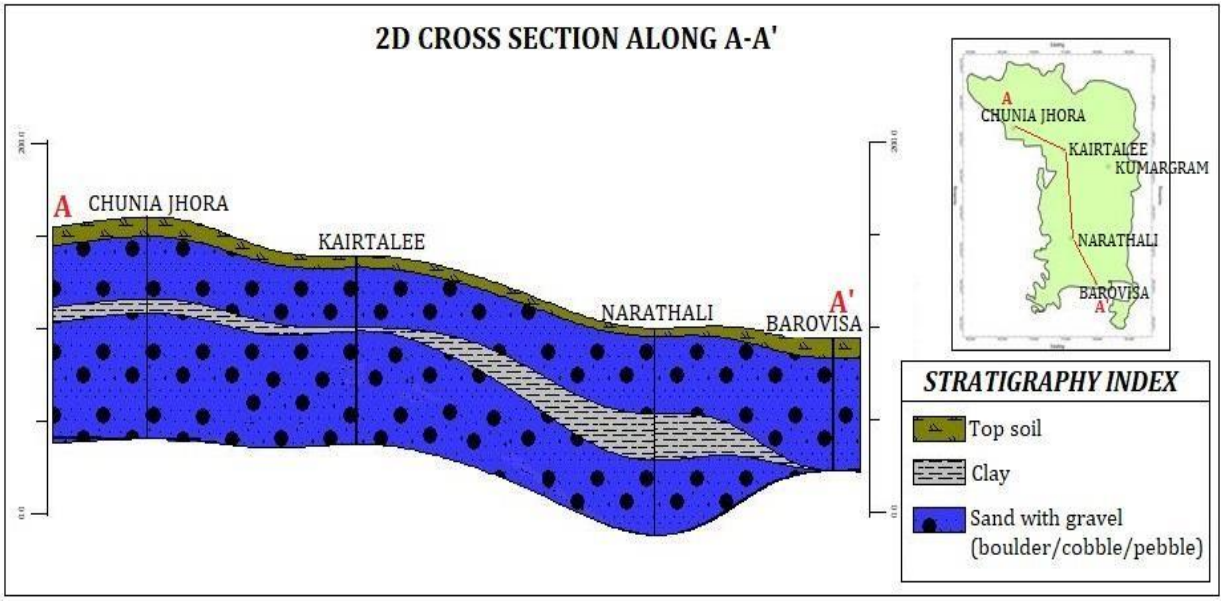


Figure-5.3: 2D Crossectional diagram for the Aquifers in Kumargram block of Alipurduar district.

Ground water quality and issues:

The range of chemical parameter in groundwater for Kumargram block is given in the table below.

Table-5.8: Range of chemical parameters in groundwater for Kumargram block of Alipurduar district.

Block	Aquifer Type	pH	EC (µS/cm)	Na (mg/l)	Cl (mg/l)	F (mg/l)	NO_3 (mg/l)	SO_4	Fe (mg/l)	Measured Hardness (mg/l)	Ur (ppb)
Kumargram	Aquifer-I	7.16-7.87	110-537	1.73-28	7.09-56.72	--	0-2.5	0-12	0.02-2.55	55-295	0.09-12.27
	Aquifer-II	7.42-7.83	125-455	0.98-19.8	7.09-42.54	0-0.11	--	--	1.29-9.5	60-260	0.24-10.01

Aquifer Management Plan:

Issue-1: Very high iron content in groundwater is reported from some isolated pockets in Aquifer-I in the block.

Issue-2: Very deep water level is recorded from the upper Bhabar region of the block.

Management strategy:

- Iron removal plants should be installed at places where high iron content is reported in order to make the water potable. The water should be filtered properly before distribution through public supply.
- Dug wells can be used for both domestic and drinking purposes after proper filtration. Water from dug wells is usually free from iron hence, their revival and maintenance is very highly recommended.
- Rain water harvesting methods should be adopted and conservation methods should be taken for optimum utilization of water in the block.
- In Terai zones dug wells, medium duty and heavy duty irrigational tube-wells are recommended. The water level in this zone is shallow; yield from the aquifers is high and therefore gives substantial amount of water to wells.
- Use of sprinkler and drip irrigation especially in the tea gardens is recommended in order to minimize the load on use of groundwater, particularly during the lean periods.
- Conjunctive use of both groundwater and surface water for irrigation should be encouraged.

Water Conservation, Rainwater Harvesting & Artificial Recharge

Based on component wise distribution of non-committed surface runoff, a number of different structures have been recommended. The status for the same along with their cost of construction and area identified for recharge is tabulated in **Table 5.9**. The area feasible for artificial recharge is shown in **Figure 5.4.**

Table-5.9: Area suitable for recharge, Structures proposed and cost of construction in Kumargram block of Alipurduar district.

Block	Area feasible for AR (Sq.km)	Utilizable surface non committed monsoon run off (MCM)	Allocation of Utilizable Recource(MCM)			Number of Recharge Structures feasible			Cost of Recharge structures (Rs. In lakhs)		
			Percolation Tanks	REET with RS	Injection Well	Percolation Tanks	REET with RS	Injection Well	Percolation Tanks	REET with RS	Injection Well
Kumargram	288.77	231.704	115.85	46.34	69.51	232	463	232	1856	1852	696

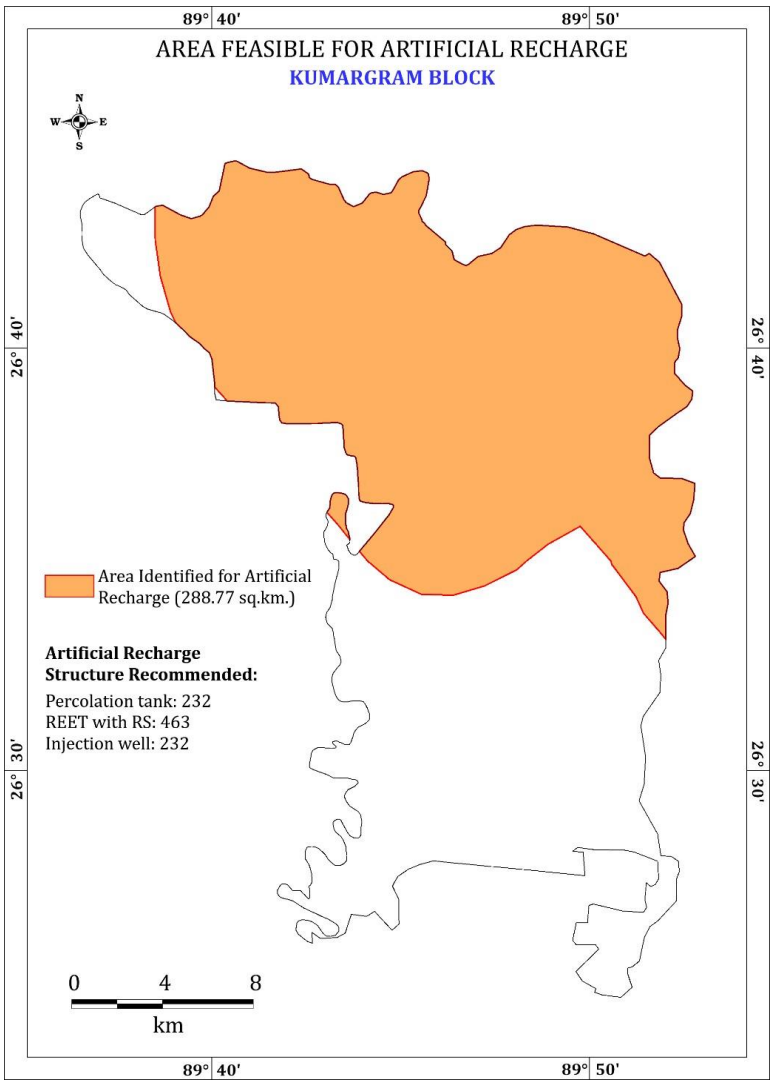


Figure-5.4: Artificial recharge map for Kumargram block of Alipurduar district

6. MADARIHAT

SALIENT INFORMATION

Block Name : Madarihat

Geographical area (sq. km): 377

Mappable area (sq. km) : 172

District : Alipurduar

State : West Bengal

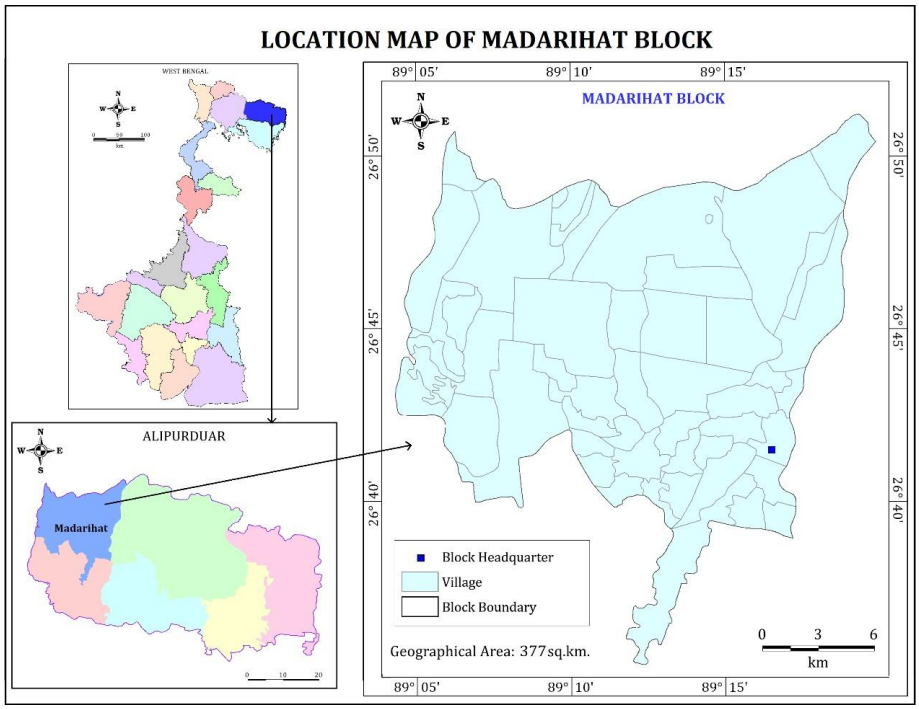


Figure-6.1: Location Map of Madarihat block of Alipurduar district

Population (as on 2011):

Table-6.1: Details of population in Madarihat block of Alipurduar district.

Rural	Urban	Total
188265	13761	202026

Rainfall: Average annual rainfall for the period 2017 -21 is 3688.85 (in mm).

Table-6.2: Details of Annual Rainfall for the last five years in Madarihat block of Alipuduar district.

Block	District Normal	District Actual (Annual)				
		2017	2018	2019	2020	2021
Madarihat	3320	3849.59	3537.5	3669.14	4354.15	3033.86

Agriculture& Irrigation (area in ha):

Table-6.3: Salient Land use features for Madarihat block of Alipurduar district.

Name of the Block	Geographic Area	Cultivable area	Total CCA	Area to be brought under CCA	Forest Land
Madarihat	37700	26662	5928.13	20733.87	8774

Ground Water Resource:

Madarihat block falls under hilly area category. According to GEC-2013, areas with slope >20% are not considered for resource calculation. Hence no estimation of ground water resource has been initiated for the block.

Disposition of Aquifers:

There are two principal aquifer systems in Madarihat block; Alluvium & Hard rocks**.** Three major aquifers are present in the block as such; Younger Alluvium, Older Alluvium and the Gondwana.

Table-6.4: Details of aquifer disposition in Madarihat block of Alipurduar district.

Block	Geology	Depth range (mbgl)		Granular zones/Zones tapped	
		Aquifer-I	Aquifer-II	Aquifer-I	Aquifer-II
Madarihat	Younger Alluvium/ Older Alluvium/ Sandstone/Limestone/Dolomite/Shale	49.7 - 67.7	53.4 - 167.48	49.7 - 67.7	53.4 - 77.4, 79 - 88, 114 - 123, 131 - 134, 132 - 156, 133.8 - 160.8, 137 - 164, 158 - 167.48

Table-6.5: Aquifer-wise depth range and parameters in Madarihat block of Alipurduar district.

Block	Aquifer Type	Discharge (m^3/hr)	Drawdown (m)	SWL (m)	T (m^2/day)
Madarihat	Aquifer-I	63.59	--	--	165-300
	Aquifer-II	3.22 - 75.6	≈5	10-39	10-2500

Table-6.6: Details of Aquifer Wise Water Level Ranges & seasonal long term water level trends for Madarihat block of Alipurduar district.

Block	Aquifer	Pre-monsoon Trend			Post-monsoon Trend		
		WL Range (mbgl)	Rise (m/year)	Fall (m/year)	WL Range (mbgl)	Rise (m/year)	Fall (m/year)
Madarihat	I	0.85-3.20	-	0.012	0.79-2.48	0.003	-
	II	--	--	--	--	--	--

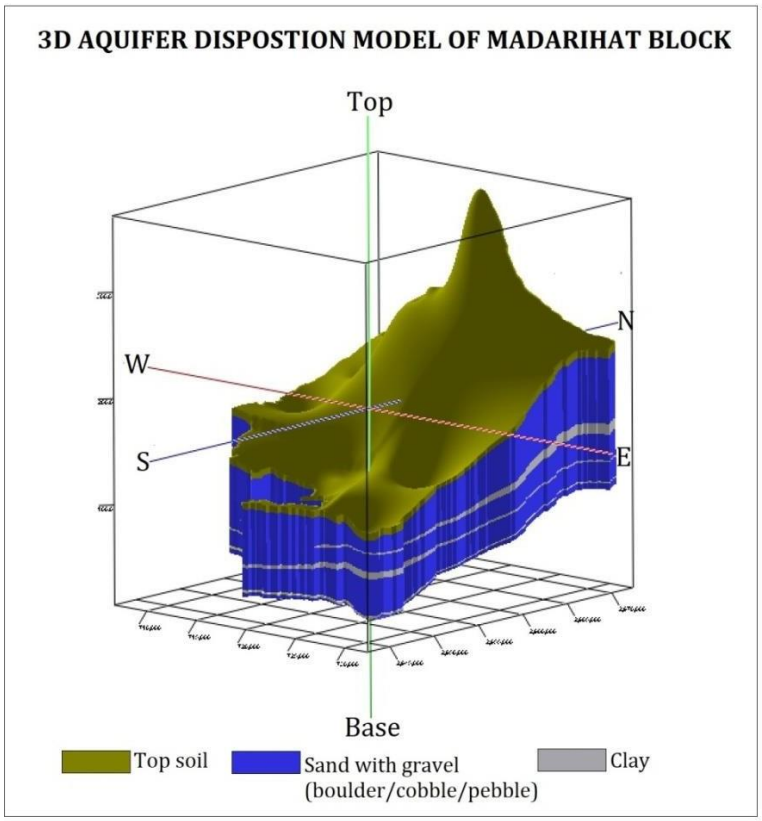


Figure-6.2: 3D disposition model diagram for the aquifers in Madarihat block of Alipurduar district.

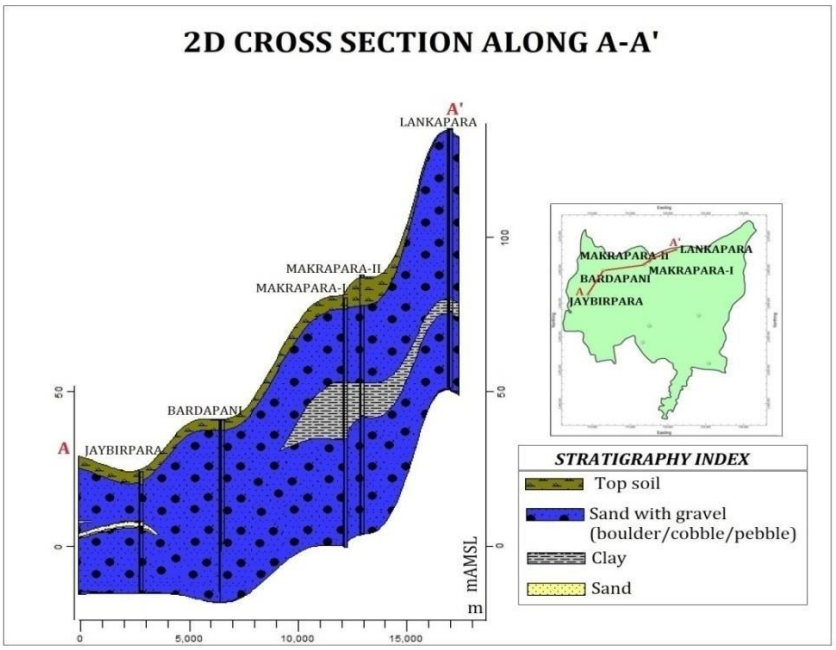


Figure-6.3: 2D Crossectional diagram for the Aquifers in Madarihat block of Alipurduar district.

Ground water quality and issues:

The range of chemical parameter for groundwater in Madarihat block is given in the table below.

Table-6.7: Range of chemical parameters in Madarihat block of Alipurduar district.

Block	Aquifer Type	pH	EC (µS/cm)	Na (mg/l)	Cl (mg/l)	F (mg/l)	NO_3 (mg/l)	SO_4	Fe (mg/l)	Measured Hardness (mg/l)	Ur (ppb)
Madarihat	Aquifer-I	8.02-8.43	111-359	1.85-7.72	7.09	--	--	--	0.13-0.18	80-180	0.61-0.22
	Aquifer-II	7.62-7.87	414-614	1.42-76.5	10.63-102.8	0.6	5.6	19.4	2.37	110-230	0.06-3.15

Aquifer management Plan:

Issue-1: Groundwater contamination by iron is reported from many sample points, basically from Aquifer-II in the block. (Fe: 11.57 mg/l, Chengmari area).

Issue-2: Very deep water level is recorded from the upper Bhabar region of the block.

Management strategy:

- Iron removal plants should be installed at places where high iron content is reported in order to make the water potable. The water should be filtered properly before distribution through public supply.
- Dug wells can be used for both domestic and drinking purposes after proper filtration. Water from dug wells is usually free from iron hence, their revival and maintenance is very highly recommended.
- Rain water harvesting methods should be adopted and conservation methods should be taken for optimum utilization of water in the block.
- In Terai zones dug wells, medium duty and heavy duty irrigational tube-wells are recommended. The water level in this zone is shallow; yield from the aquifers is high and therefore gives substantial amount of water to wells.
- Use of sprinkler and drip irrigation especially in the tea gardens is recommended in order to minimize the load on use of groundwater, particularly during the lean periods.
- Conjunctive use of both groundwater and surface water for irrigation should be encouraged.

Water Conservation, Rainwater Harvesting & Artificial Recharge

Based on component wise distribution of non-committed surface runoff, a number of different structures have been proposed for the study area. The status for the same along with their cost of construction and area identified for recharge is provided in **Table-6.9**. The area feasible for artificial recharge is shown in **Figure-6.4.**

Table-6.8: Area suitable for recharge, Structures proposed and cost of construction in Madarihat block of Alipurduar district

Block	Area feasible for AR (Sq.km)	Utilizable surface non committed monsoon run off (MCM)	Allocation of Utilizable Resource(MCM)			Number of Recharge Structures feasible			Cost of Recharge structures (Rs. In lakhs)		
			Percolation Tanks	REET with RS	Injection Well	Percolation Tanks	REET with RS	Injection Well	Percolation Tanks	REET with RS	Injection Well
Madarihat	66.58	53.42	26.71	10.68	16.03	53	107	53	424	428	159

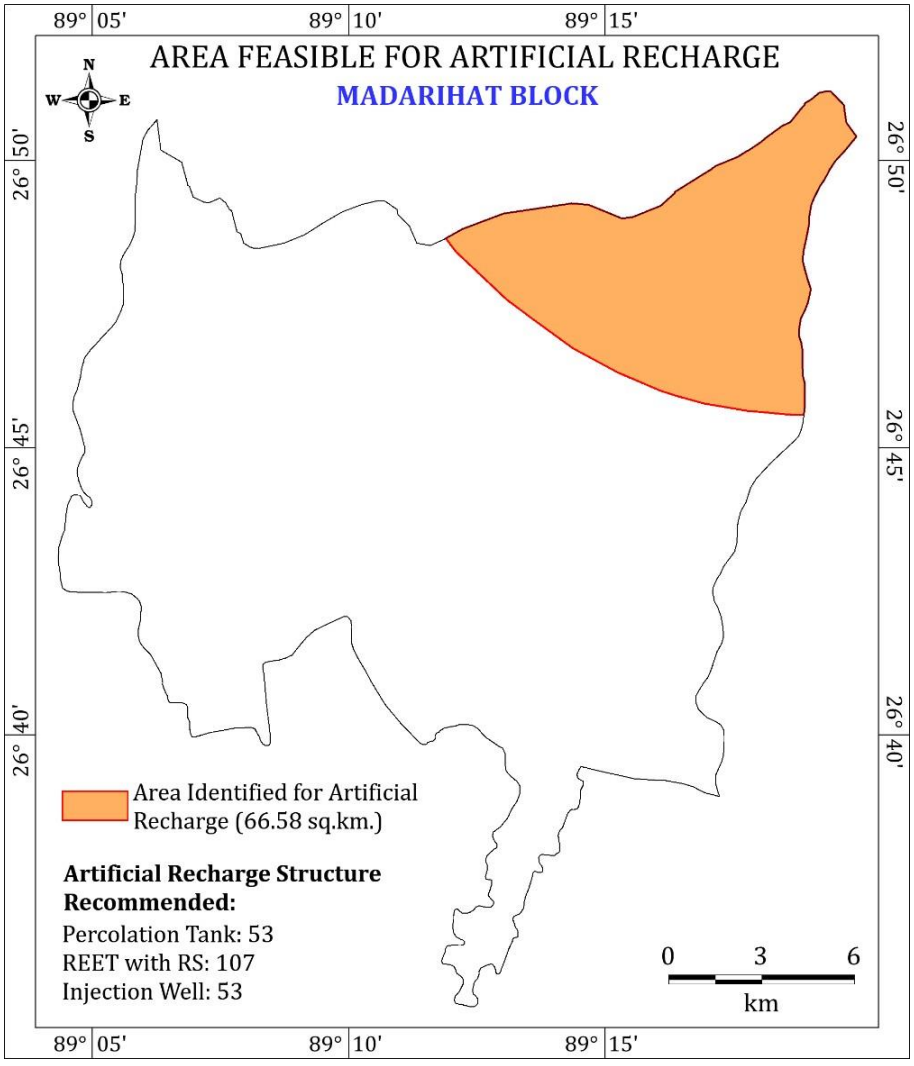


Figure-6.4: Artificial recharge map for Madarihat block of Alipurduar district.

PART-III

DATA GAP ANALYSIS FOR ALIPURDUAR DISTRICT OF WEST BENGAL

1. DATA GAP ANALYSIS FOR ALIPUDRUAR DISTRICT OF WEST BENGAL

(AAP 2021-2022)

Introduction

The present study area includes six blocks of Alipurduar district comprising a total geographical area of 2667 sq. km. and of mappable area of 1636 sq. km. It is bounded by the north latitudes of 26˚23'34" & 26˚52'22" and east longitudes of 89˚02'20" & 89˚53'13" in Survey of India, Toposheet no. 78F/1, 78F/2, 78F/5, 78F/6, 78F/7, 78F/9, 78F/10, 78F/11, 78F/14, 78F/15. Data Gap in terms of exploratory wells (EW), Key wells, water level monitoring stations (NHS wells), Geophysical studies viz. Vertical Electrical Sounding (VES) and water quality monitoring stations to study the aquifers in the area has been tabulated quadrant wise in different toposheets.

Data Availability

The available CGWB in-house Exploration data and existing NHS wells for monitoring water level in different blocks along with the toposheet no.s within the study area have been compiled, tabulated and plotted. The data insufficiency within the study area is thereby identified and given for recommendations.

Data gap analysis for Exploratory Wells

Each toposheet is considered at spatial scale of 5' x 5' grids, in which wells of 300 m depth is to be constructed in four corner quadrants and one well field in the central quadrant. Observation wells may be considered at well field or as per the requirement. The purpose is to determine the aquifer geometry and the aquifer parameters. As per the NAQUIM norms, for two aquifer system, 8 wells including EW and OW are required in each toposheet. Accordingly, the existing exploratory well data of CGWB has been plotted in the respective toposheets along with the block map. It is observed that no prior exploratory drilling has been carried out in Alipurduar-II and Kumargram blocks. A significant data gap exists in Falakata, Kalchini, Madarihat and Alipurduar-I blocks as well. As such, 33 additional wells (includes 20 nos. EW and 13 nos. OW) wells of 300 meters depth have been recommended. This will rationally reduce the gap in exploration data.

The map of existing exploratory wells and their details is furnished in **Figure-1.1** and **Table-1.1**. The map of the proposed wells and the list including the location and coordinate details is furnished in **Figure-1.2** and **Table-1.2**.

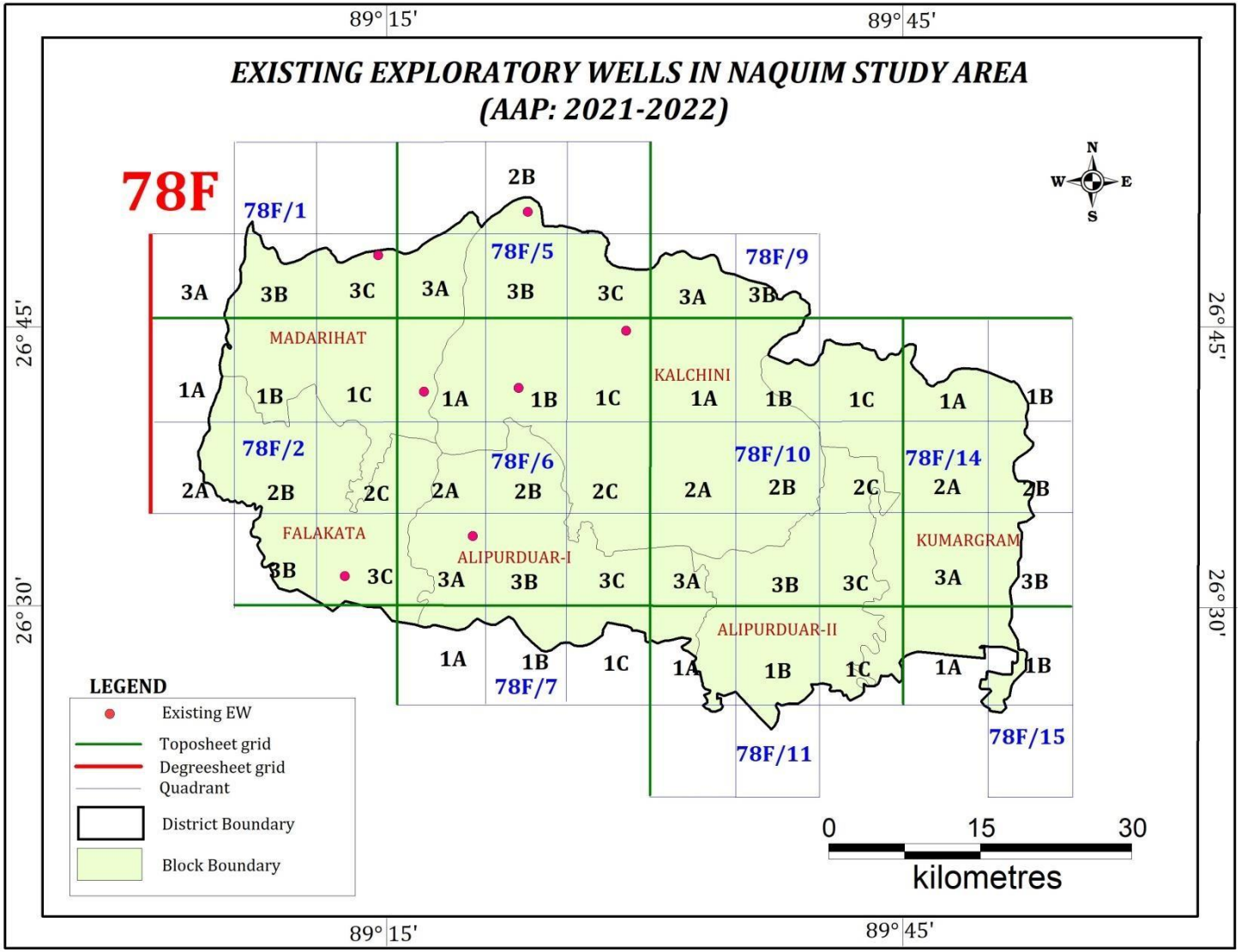


Figure-1.1: Map for existing exploratory wells in Alipurduar district of West Bengal.

Table- 1.1: Details of existing exploratory wells (In-house) for Alipurduar district of West Bengal.

Sl. No.	Block	Location	Latitude	Longitude	Depth of Well Constructed (mbgl)	Zone tapped (mbgl)	S.W.L. (mbgl)	Discharge (lpm)	Drawdown (m)	T (m2/day)
1	Madarihat	Madarihat	26.6945	89.2746	72	--	--	--	--	--
2	Kalchini	Jaigaon	26.8541	89.3778	93	64.00-79.00,82.00-91.00	--	720	--	--
3	Kalchini	Hasimara A/F	26.6851	89.3374	100	66-74, 80-96	4.37	900	--	--
4	Kalchini	Kalchini	26.6892	89.4296	109	61-67, 73-85	11.55	1060.8	2.45	--
5	Madarihat	Lankapara	26.8156	89.2294	159	79.00-88.00,132.00-156.00	90	1260	--	--
6	Alipurduar-I	Baganbari	26.5315	89.1964	128	45.00-51.00, 67.00-90.00,94.00-100.00, 119.00-125.00	3.11	2544	3.59	379.33
7	Falakata	Falakata SSB 23rd Battalion	26.5672	89.3231	71	44.00-47.00,50.00-62.00, 65.00-68.00	5.08	1138.8	7.87	2000

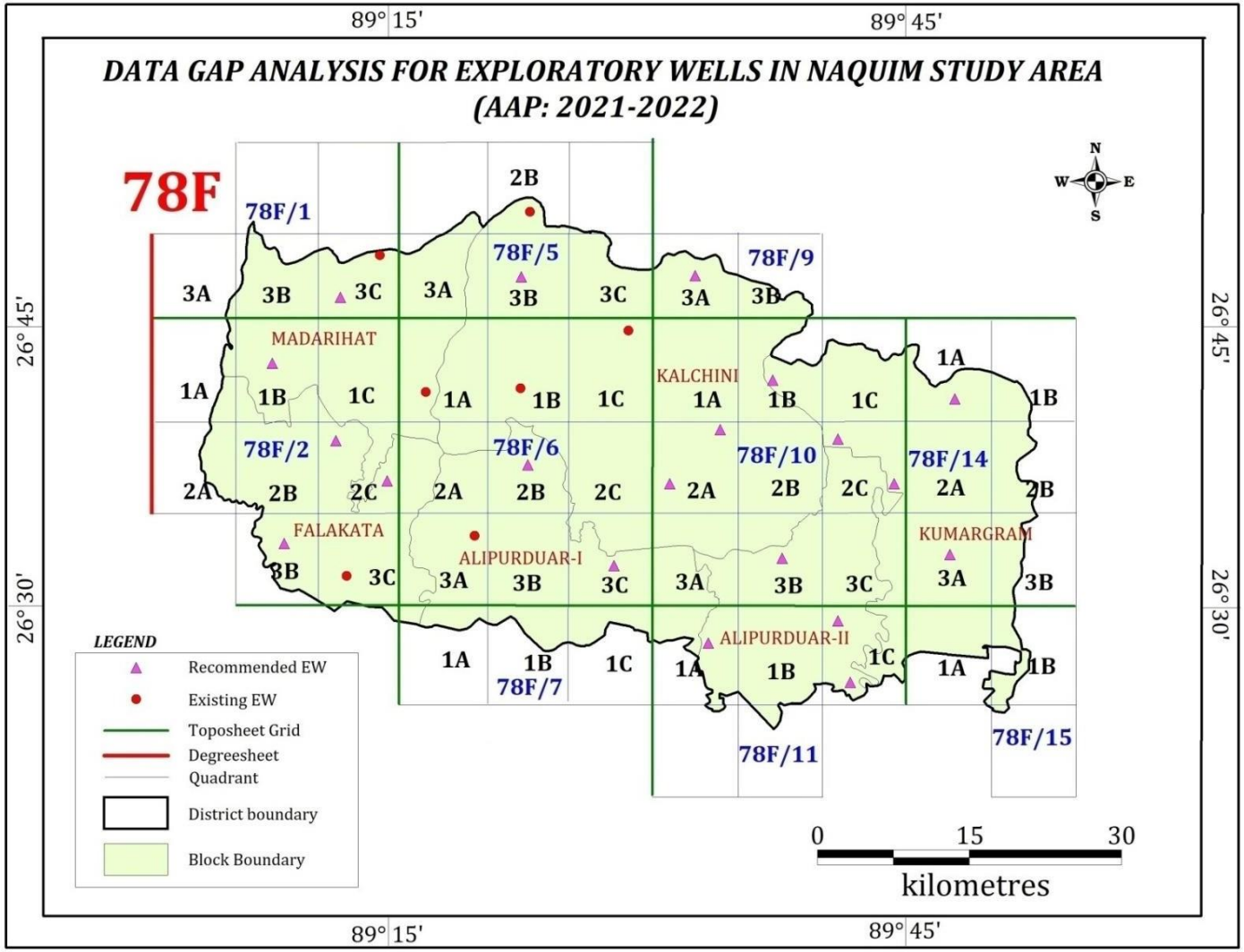


Figure-1.2: Map for proposed exploratory wells in Alipurduar district of West Bengal.

Table-1.2: Details of proposed exploratory wells in Alipurduar district of West Bengal.

Sl.No.	Block	Toposheet	Quadrant	Type of well	Latitude	Longitude	Depth of well
1	Kumargram	78F/14	1A	EW	26.68834	89.79812	300 m
2	Kumargram	78F/14	3A	EW	26.55044	89.7935	300 m
3	Kumargram	78F/10	2C	EW	26.65283	89.68265	300 m
4	Kumargram	78F/11	2C	OW	26.65283	89.68265	300 m
5	Kumargram	78F/10	2C	EW	26.61319	89.73807	300 m
6	Kumargram	78F/11	2C	OW	26.61319	89.73807	300 m
7	Kumargram	78F/10	1B	EW	26.70485	89.61798	300 m
8	Alipurduar-II	78F/10	3B	EW	26.54713	89.62722	300 m
9	Kalchini	78F/10	2A	EW	26.66109	89.56625	300 m
10	Kalchini	78F/10	2A	OW	26.66109	89.56625	300 m
11	Kalchini	78F/10	2A	EW	26.61319	89.51637	300 m
12	Kalchini	78F/10	2A	OW	26.61319	89.51637	300 m
13	Kalchini	78F/9	3A	EW	26.47199	89.55424	300 m
14	Kalchini	78F/9	3A	OW	26.47199	89.55424	300 m
15	Alipurduar-II	78F/11	1A	EW	26.79651	89.36949	300 m
16	Alipurduar-II	78F/11	1A	OW	26.79651	89.36949	300 m
17	Kalchini	78F/5	3B	EW	26.62971	89.37596	300 m
18	Kalchini	78F/5	3B	OW	26.62971	89.37596	300 m
19	Alipurduar-I	78F/6	2B	EW	26.71806	89.20783	300 m
20	Alipurduar-I	78F/6	2B	OW	26.71806	89.20783	300 m
21	Falakata	78F/2	2C	EW	26.61567	89.23647	300 m
22	Falakata	78F/2	2C	OW	26.61567	89.23647	300 m
23	Falakata	78F/2	2C	EW	26.71972	89.12285	300 m
24	Falakata	78F/2	2C	OW	26.71972	89.12285	300 m
25	Madarihat	78F/2	1B	EW	26.56034	89.13486	300 m
26	Falakata	78F/2	3B	EW	26.54053	89.46094	300 m
27	Alipurduar-I	78F/6	3C	EW	26.49181	89.68265	300 m
28	Alipurduar-II	78F/11	1C	EW	26.43728	89.69466	300 m
29	Alipurduar-II	78F/11	1C	OW	26.43728	89.69466	300 m
30	Alipurduar-II	78F/11	1C	EW	26.77837	89.19028	300 m
31	Alipurduar-II	78F/11	1C	OW	26.77837	89.19028	300 m
32	Madarihat	78F/1	3C	EW	26.77837	89.19028	300 m
33	Madarihat	78F/1	3C	OW	26.77837	89.19028	300 m

Ground Water Monitoring Data:

Considering each toposheets at spatial scale at 5' x 5' grids, for shallow phreatic aquifer two observation wells are required in each quadrant as per NAQUIM norms. For 2nd aquifer the well-constructed in the Well field and Special Purpose wells may be used as piezometers for GW monitoring. Primarily, after plotting the existing NHS wells it is observed that almost all the blocks have inadequate monitoring wells for both Aquifer-I

and Aquifer-II. Hence, additional key-wells were established for both the aquifers. Plate 3 shows the distribution of NHS wells in the study area. A total of 37 wells tapping Aquifer-I and 23 wells tapping Aquifer-II have been established which fulfilled the prior data adequacy. These key-wells may be converted to NHS wells if required in the future. **Figure-1.4** and **Figure-1.5** depicts the aquifer-wise key-wells considered in different blocks of study area. The details of NHS wells and key-wells are presented in **Table-1.3** and **Table-1.4**.

A combined map for all the wells considered for the present study is shown in **Figure-1.3**

Table-1.3: List of Existing NHS wells in Alipurduar district of West Bengal.

Well ID	Block	Site	Well Type	Latitude	Longitude	RL	Well Depth
WBJL26C	Alipurduar I	Alipurduar	Dug Well	26.4973	89.5240	52.7	8
WBJL38	Alipurduar I	Ghargharia	Dug Well	26.4667	89.4295	55.9	7.5
WBJL24	Alipurduar II	Bhatibari	Dug Well	26.4437	89.6381	47.6	5.77
WBJL39	Alipurduar II	Salsalabari	Dug Well	26.4877	89.5903	53.1	6.5
WBJL04	Alipurduar	Falakata	Dug Well	26.5148	89.1996	64.7	5.3
WBJL56	Falakata	Bengkandi	Dug Well	26.6339	89.1457	79.4	7.46
WBJL02B	Kalchini	Hasimara	Dug Well	26.7248	89.3497	120.7	--
WBJL03	Kalchini	Madarihat	Dug Well	26.6944	89.2618	101.8	5.39
WBJL13A	Kalchini	Jaigaon	Dug Well	26.8396	89.3810	204.8	21.78
WBJL49	Kalchini	Dabri	Dug Well	26.6883	89.4052	109.3	18
WBJL58	Kalchini	Milpara Pampu Basti	Dug Well	26.6094	89.5292	72.4	10.24
WBJL76	Kalchini	Raja Bhat Khawa	Dugwell	26.6147	89.5303	77.4	9
WBJL01	Kumargram	Kumargram	Dug Well	26.6156	89.8279	81.2	3.4
WBJL25	Kumargram	Barovisa More	Dug Well	26.4730	89.7982	52.9	5.56
WBJL47	Kumargram	Kamekshaguri (Shantinagar	Dug Well	26.4612	89.7201	50.4	21
WBJL48	Kumargram	Hemaguri	Dug Well	26.5603	89.8237	67.4	4.7
WBJL55	Kumargram	Bara Daldali	Dug Well	26.5374	89.8082	69.2	--
WBJL73	Kumargram	Madhya Kameksha	Dugwell	26.4531	89.7188	49	8
WBJL74	Kumargram	Telipara	Dugwell	26.4758	89.7672	52	7
WBJL87	Kumargram	Ghoramara	Dug Well	26.5484	89.8210	69.3	--
WBJL88	Kumargram	Ghoksapara	Dug Well	26.5343	89.8202	65.1	--
WBJL37A	Madarihat	Uttar Shishubari	Dug Well	26.6885	89.1706	96	--
WBJL78	Madarihat	Madhya Ragali Bajna	Dugwell	26.6859	89.1925	91	8
WBJL93	Madarihat	Madhya Ragali Bajna	Dug Well	26.6841	89.2157	90.6	--

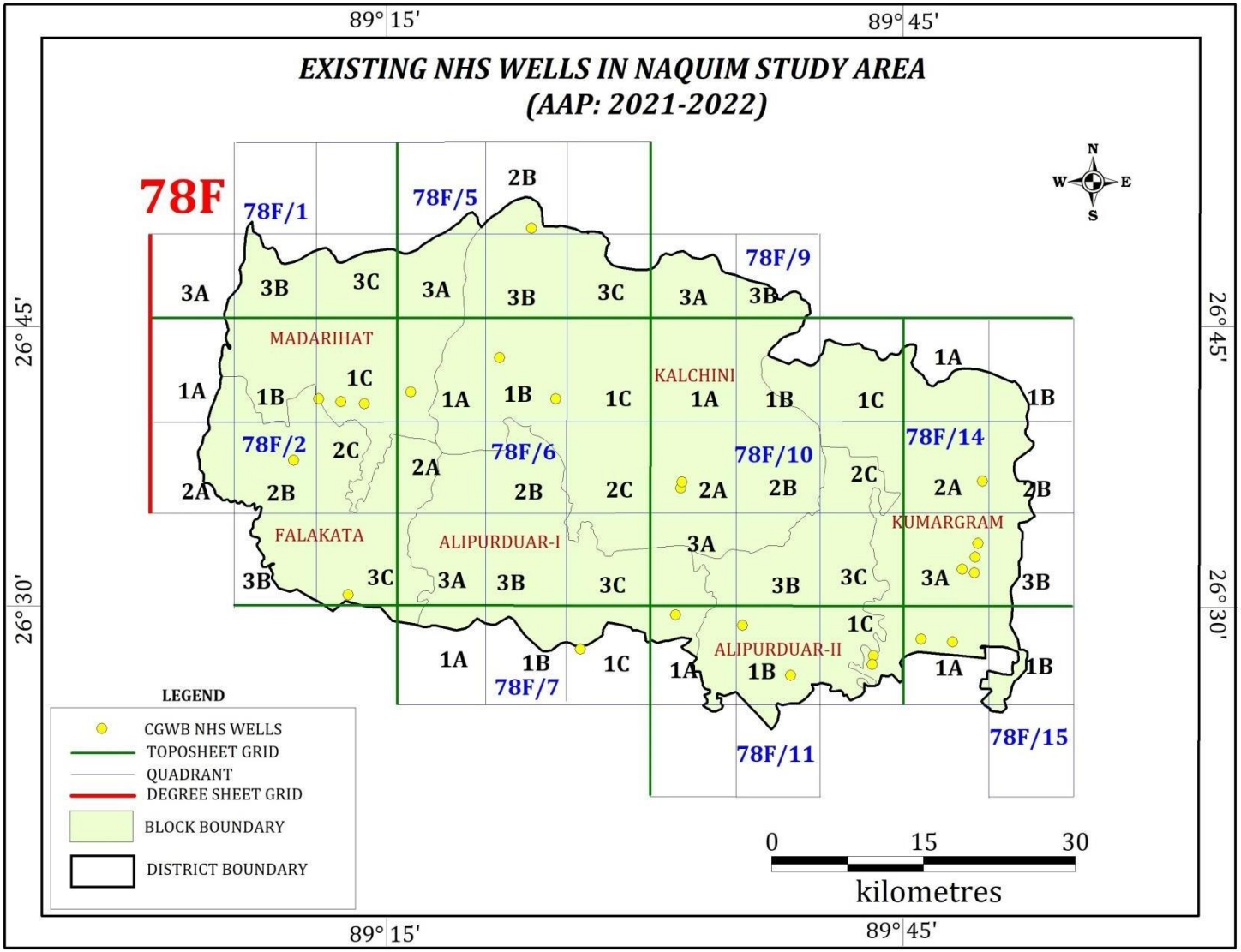


Figure1. 3: Map for existing NHS wells in Alipurduar district of West Bengal.

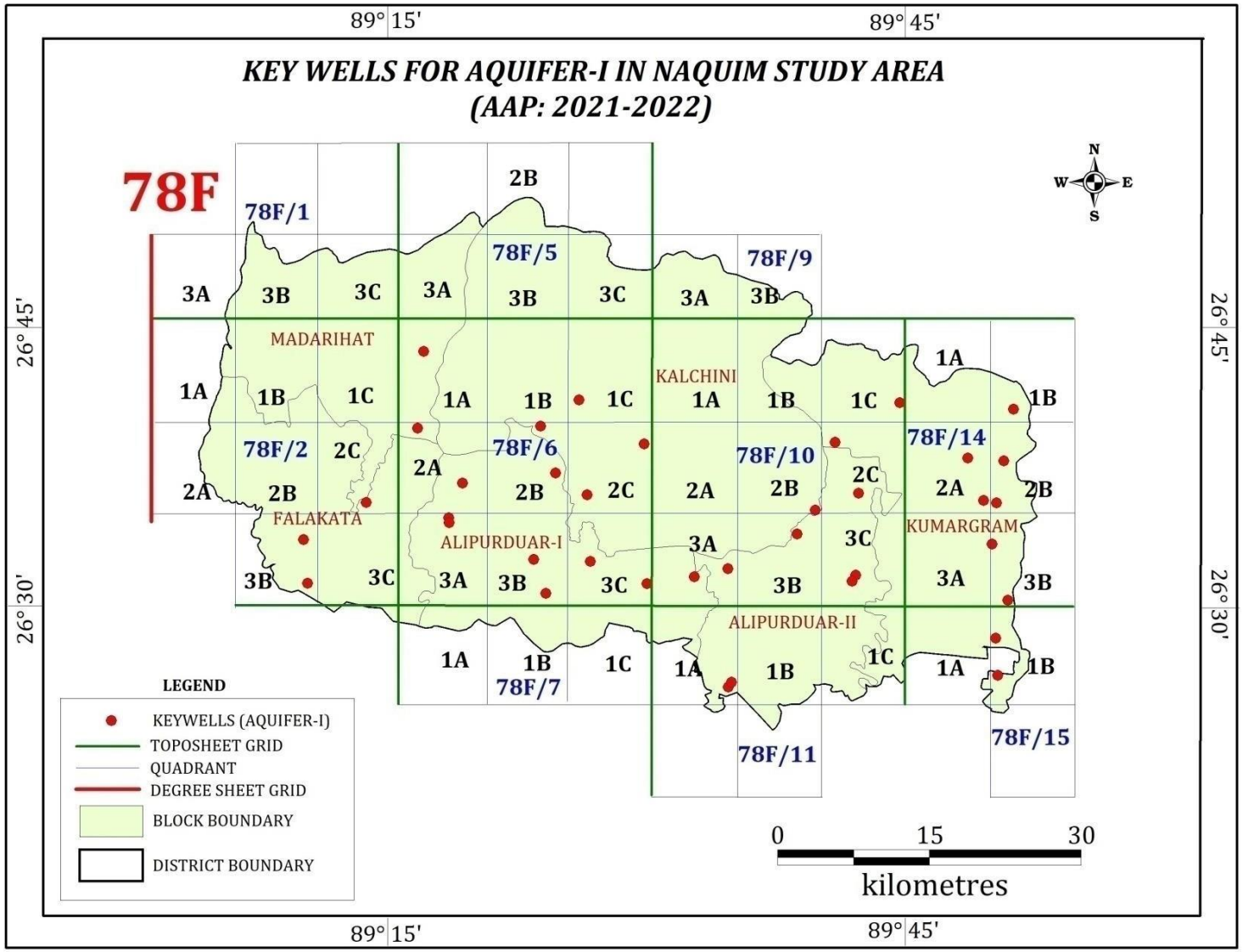


Figure1.4: Map of newly established key-wells for Aquifer-I in Alipurduar district of West Bengal.

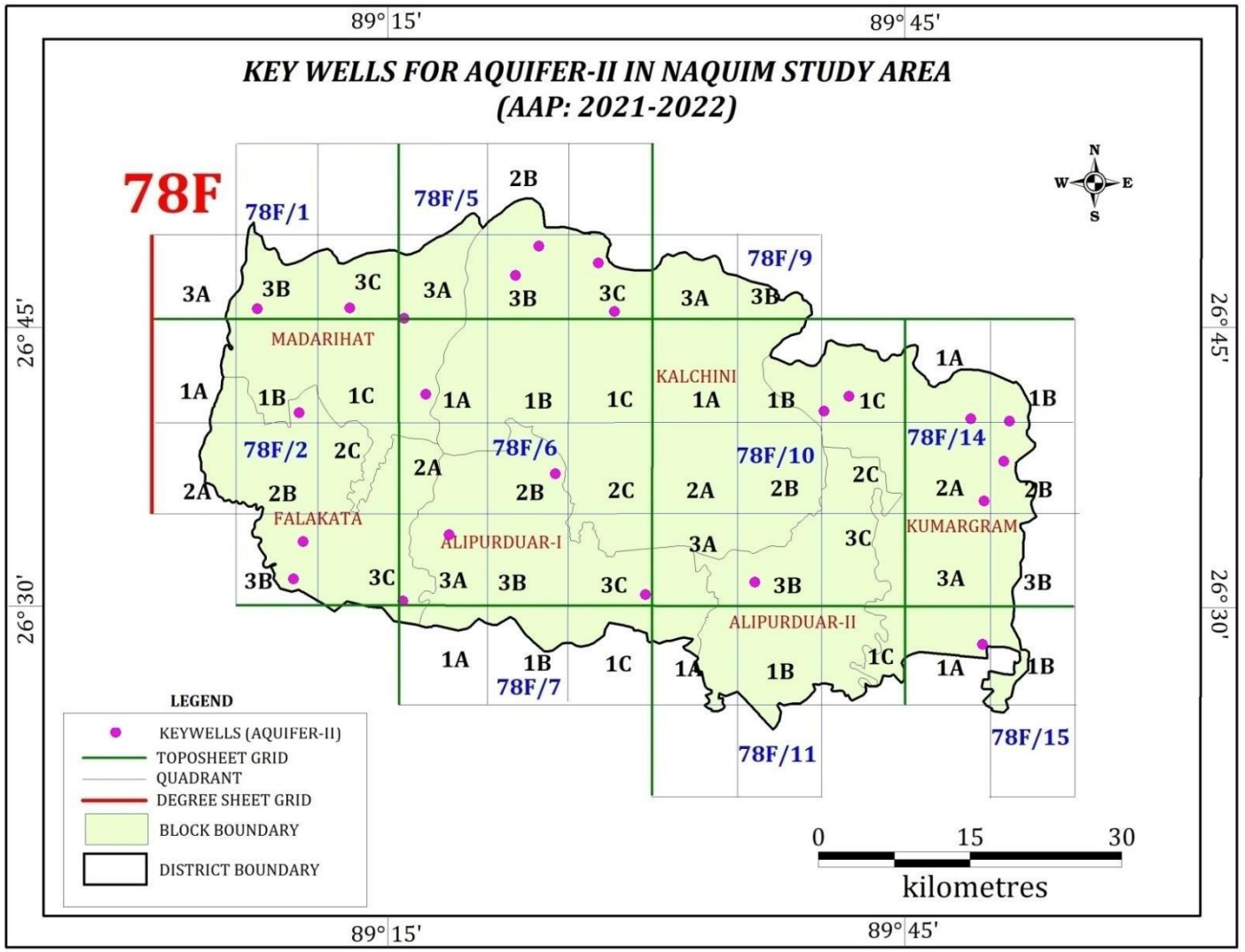


Figure-1.5: Map of newly established key-wells for Aquifer-II in Alipurduar district of West Bengal.

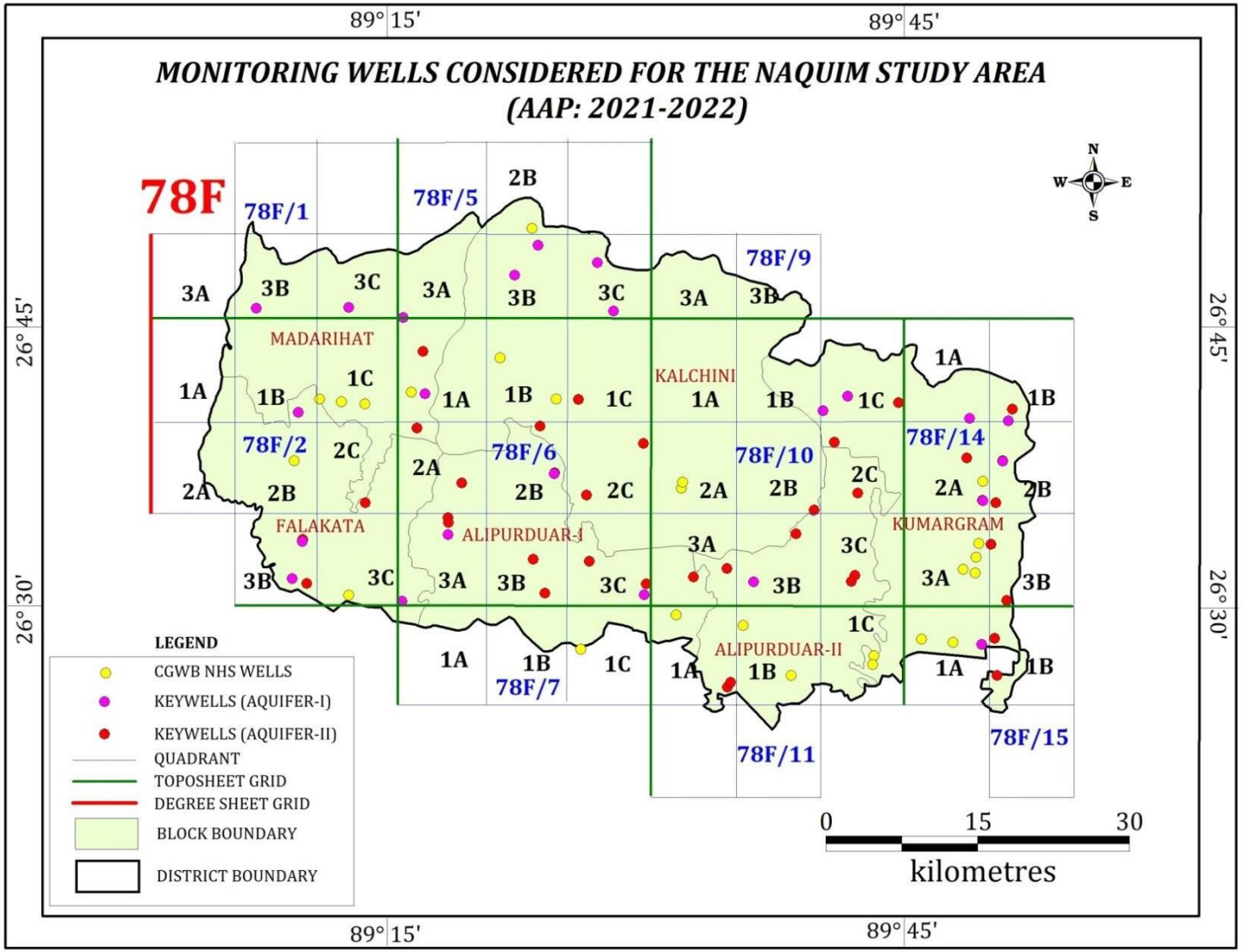


Figure-1.6: Map of total monitoring wells (NHS & Key-wells) considered for study in Alipurduar district of West Bengal.

Table-1.4: Details of all key wells considered for study in Alipurduar district of West Bengal.

Sl. No.	Location	Block	Lat	Long	RL	Type of well	Toposheet	Quadrant	Type of Aquifer	Depth (mbgl)	Location Details
1	Satbaki	Alipurduar-II	26.4331	89.5748	42	Mark-II	78F/11	1A	Aquifer-I	45.72	Satbaki Primary School.
2	Purba Barachouki	Alipurduar-II	26.4374	89.5779	42	Dug Well	78F/11	1A	Aquifer-I	3.92	On the left side of the road at Dulal Barman's residence.
3	Baruipara	Kumargram	26.4435	89.8418	47	Dug Well	78F/15	1B	Aquifer-I	5.18	Beside a road, infront of the house of Sushil Mondal.
4	Volka	Kumargram	26.4764	89.8396	53	Dug Well	78F/15	1B	Aquifer-I	6.1	At Volka High School.
5	Barobisha	Kumargram	26.4713	89.8266	8.88	Sub-TW	78F/15	1A	Aquifer-II	60.96	At Barobisha pump House.
6	Purba Salbari	Kumargram	26.5100	89.8515	7.43	Dug Well	78F/14	3B	Aquifer-I	4.82	Near Purba Salbari Primary school, at the residence of Ramesh Chandra Das.
7	Sankos	Kumargram	26.6795	89.8572	97	Dug Well	78F/14	1B	Aquifer-I	12.2	Near Sankos Believer's church, at the house of Gautam Chetri
8	Sankos	Kumargram	26.6691	89.8530	94	Mark-II	78F/14	1B	Aquifer-II	51	On the way to Sankos at Community Hall.
9	Dhumpara	Kumargram	26.6712	89.8148	50.65	Mark-II	78F/14	1A	Aquifer-II	51	Opposite/infront of Bishnu Munda house
10	Amarpur	Kumargram	26.6363	89.8120	84	Dug Well	78F/14	2A	Aquifer-I	4.96	On the way to Amarpur town, On RHS of the road, infront of a shed near the house of Ashim Kumar Machari.
11	Uttar Haldibari	Kumargram	26.6337	89.8477	81	Dug Well	78F/14	2B	Aquifer-I	4.85	At Uttar Haldibari B.I.P school, adjacent to the school toilet.
12	Uttar Haldibari	Kumargram	26.6334	89.8476	82	Mark-II	78F/14	2B	Aquifer-II	60.96	At Uttar Haldibari B.I.P school, on RHS of the road, near mid-day meal.
13	Kumargram	Kumargram	26.5987	89.8276	35	Dug Well	78F/14	2A	Aquifer-I	4.7	Opposite Kumargram BDO office, at the residence of Bapa Rai's residence.
14	Dakshin Haldibari	Kumargram	26.5966	89.8406	7.63	Dug Well	78F/14	2B	Aquifer-I	3.53	Pukharigaon, On RHS of the village road, at the residence of Prashanath Suthrothor.
15	Kumargram	Kumargram	26.5982	89.8280	24.15	Deep-TW	78F/14	2A	Aquifer-II	60.96	Inside Kumargram Block seed farm.

Sl. No.	Location	Block	Lat	Long	RL	Type of well	Toposheet	Quadrant	Type of Aquifer	Depth (mbgl)	Location Details
16	Baghmara	Kumargram	26.5599	89.8359	56	Dug Well	78F/14	3B	Aquifer-I	3.9	At the residence of Charia Oraon.
17	Dakshin Mahakalguri	Alipurduar-II	26.5323	89.7009	2.78	Dug Well	78F/10	3C	Aquifer-I	5.26	At the residence of Sujit Kispotta.
18	Jayanti Tea Garden	Kumargram	26.6911	89.6941	99.24	Mark-II	78F/14	1C	Aquifer-II	76.2	At 12 no. Nepal school.
19	Chunia Jhora	Kumargram	26.6504	89.6807	47.13	Dug Well	78F/10	2C	Aquifer-I	17.08	On RHS of the village road, near the house of Clement Oraon
20	Chunia Jhora	Kumargram	26.6781	89.6696	89.51	TW	78F/10	1C	Aquifer-II	54.86	On the way while coming back from Chunia Jhora.
21	Turturi Khanda	Kumargram	26.6852	89.7445	70.41	Sub-TW	78F/10	1C	Aquifer-I	49	At the residence of Kedar Chetri, on LHS of the road.
22	Lokenathpur	Alipurduar-II	26.6052	89.7040	20.99	Dug Well	78F/10	2C	Aquifer-I	4.1	At Lokenathpur Higher Secondary School, well located at the corner of the school ground, infront of the mandir.
23	Kohinoor	Alipurduar-II	26.5270	89.6976	14.04	Mark-II	78F/10	3C	Aquifer-I	36.58	By the side of the road junction, opposite to Sunny mandir
24	Dangi	Kalchini	26.5901	89.6608	40.4	Dug Well	78F/10	2B	Aquifer-I	6.28	At the residence of Soumai Oraon.
25	Uttar Shibkata	Alipurduar-II	26.5690	89.6429	14.67	Dug Well	78F/10	3B	Aquifer-I	4.52	At a turning point along the side of the main road.
26	Bhasadabri	Alipurduar-II	26.5263	89.6009	41	Deep-TW	78F/10	3B	Aquifer-II	167.64	Bhasadabri PHED Pump House.
27	Toorsa Tea Garden	Kalchini	26.8246	89.3871	157.49	Sub-TW	78F/5	3B	Aquifer-II	73.15	On RHS of the road while going to Jagaon, at the residence of Amit kujur. Few distance walk from the main road.
28	Dalsingpara Tea Estate	Kalchini	26.7984	89.3640	126.36	Deep-TW	78F/5	3B	Aquifer-II	91.44	On LHS of the road to Jagaon, PHED pump house
29	Hasimara	Kalchini	26.8094	89.4458	191.68	Deep-TW	78F/5	3C	Aquifer-II	97.54	Central Duars Tea Estate, at the residence of Sanjay Lama.
30	Nayabasti	Kalchini	26.7666	89.4619	166.6	Deep-TW	78F/5	3C	Aquifer-II	121.92	PHED pump house, on RHS of the road(Radharani Tea Garden)
31	Hamiltonganj	Kalchini	26.6880	89.4271	61.52	Sub-TW	78F/6	1C	Aquifer-I	42.67	At the backside of Hamiltonganj primary school

Sl. No.	Location	Block	Lat	Long	RL	Type of well	Toposheet	Quadrant	Type of Aquifer	Depth (mbgl)	Location Details
32	Adiabari	Kalchini	26.6490	89.4914	62.95	Dug Well	78F/6	2C	Aquifer-I	10.1	Well located in a corner at Adiabari market.
33	Pinialguri	Alipurduar-II	26.5383	89.5744	6.18	Mark-II	78F/10	3A	Aquifer-I	48.77	At Pinialguri PHC compound.
34	Chechakhata	Alipurduar-II	26.5309	89.5410	47	Mark-II	78F/10	3A	Aquifer-I	30.48	At Chechakhata Railway Hindi S.P. Primary school, on RHS of the road, well located on the side of the school compound.
35	Banchukamari	Alipurduar-I	26.5151	89.4925	39	Deep-TW	78F/6	3C	Aquifer-II	80.77	Banchkamari PHED pump house.
36	Banchukamari	Alipurduar-I	26.5248	89.4942	4.71	Dug Well	78F/6	3C	Aquifer-I	4.92	Infront of Prasentjit's Das residence
37	Patkapara	Alipurduar-I	26.5447	89.4381	38.88	Mark-II	78F/6	3C	Aquifer-I	28	Infront of Patkapara hospital on RHS of the road, near Kali mandir.
38	Nimti Domohani	Kalchini	26.6035	89.4352	31.42	Dug Well	78F/6	2C	Aquifer-I	4.85	At the residence of Mana Gharia, on RHS of the road.
39	Uttar Madarbari	Alipurduar-I	26.6232	89.4036	30.71	Dug Well	78F/6	2B	Aquifer-I	5.5	On RHS of the road at the residence of Matiakar Kereketta(dakshin Barajhar)
40	Uttar Madarbari	Alipurduar-I	26.6225	89.4032	34.13	Sub-TW	78F/6	2B	Aquifer-II	60.96	On RHS of the road, infront of the church at Uttar Madarbari
41	Dakshin Satali	Kalchini	26.6644	89.3891	48.7	Mark-II	78F/6	2B	Aquifer-I	47	At Dakshin Satali Post Office
42	Chilapata	Alipurduar-I	26.5464	89.3823	11.33	Dug Well	78F/6	3B	Aquifer-I	5.18	Inside the residence of of Bharat Chandra Bose, near Forest Range Office
43	Mathura	Alipurduar-I	26.5164	89.3941	61	Dug Well	78F/6	3B	Aquifer-I	6.48	At the residence of Minal das, near Mathura bazar.
44	Bhutnigirighat	Falakata	26.5293	89.1438	18.11	Deep-TW	78F/2	3B	Aquifer-II	146.3	Bhutnigirighat PHED Pump House.
45	Bhutnigirighat	Falakata	26.5251	89.1580	14.78	Dug Well	78F/2	3B	Aquifer-I	5.84	At the residence of Anil Rai.
46	Natunpara	Alipurduar-I	26.6142	89.3116	24.65	Dug Well	78F/6	2A	Aquifer-I	4.62	At the residence of Nazuruddin Miya.
47	Munshipara Salkumarhat	Alipurduar-I	26.5832	89.2981	35.1	Dug Well	78F/6	3A	Aquifer-I	6.42	At the residence of Ranjan Kumar Rai, on RHS of the road.

Sl. No.	Location	Block	Lat	Long	RL	Type of well	Toposheet	Quadrant	Type of Aquifer	Depth (mbgl)	Location Details
48	Munshipara Salkumarhat	Alipurduar-I	26.5790	89.2984	21.31	Sub-TW	78F/6	3A	Aquifer-I	48.77	At Salkumarhat High School compound.
49	Munshipara Salkumarhat	Alipurduar-I	26.5683	89.2980	10.69	Deep-TW	78F/6	3A	Aquifer-II	109.73	Salkumarhat PHED pump house.
50	Falakata	Falakata	26.5094	89.2523	12.11	Deep-TW	78F/6	3A	Aquifer-II	85.34	Inside the copound of North Bengal Development Department.
51	Dekhlapara	Madarihat	26.7688	89.1080	103.27	Mark-II	78F/1	3B	Aquifer-II	67.06	At the residence of Ramjit Datti, on LHS of the road
52	Ramjhora	Madarihat	26.7697	89.1996	187.04	Sub-TW	78F/1	3C	Aquifer-II	146.3	Inside the campus of Ramjhora Hindi High School
53	Hantupara	Madarihat	26.7605	89.2535	160.97	Deep-TW	78F/5	3A	Aquifer-II	109.73	Hantupara middle line pump house.
54	Uttar Khairbari	Madarihat	26.7308	89.2731	70.26	Mark-II	78F/6	1A	Aquifer-I	42.67	Within the compound of Shanti ITDP Prathamik Vidyalaya.
55	Madarihat	Madarihat	26.6929	89.2750	41.77	EW	78F/6	1A	Aquifer-II	73	Inside the campus of madarihat hospital, CGWB-EW
56	Purba Madarihat	Madarihat	26.6629	89.2672	39.45	Mark-II	78F/6	2A	Aquifer-I	42.67	On Madarihat road, infront of the gate of Vivekananda Vidyabhaban High School
57	Talukertary	Falakata	26.5967	89.2161	23.69	Mark-II	78F/2	2C	Aquifer-I	40.23	At Talukertary Primary school.
58	Dalimpur	Falakata	26.5624	89.1536	15.17	Deep-TW	78F/2	3B	Aquifer-II	112.78	Dalimpur PHED Pump House
59	Dalimpur	Falakata	26.5641	89.1542	4.13	Mark-II	78F/2	3B	Aquifer-I	42.67	At Himantamayee S. C. Primary School.
60	Dalgaon	Falakata	26.6767	89.1496	42.2	Mark-II	78F/2	1B	Aquifer-II	64.01	Dalgaon Tea garden, on RHS of the road before reaching Dalgaon bridge.

Groundwater quality data:

The norms for data required for groundwater quality is similar to that of Ground Water Monitoring. Water samples were collected for every NHS as well as key-wells for quality analysis.

Geophysical data:

2 or 3 Profiling/VES/TEM having 300 meter interpretation depth or as per the feasible spread in the field should be carried out in each of the nine quadrants. No prior Geophysical work has been carried out in the study area. A total of 106 VES is recommended to carry out in the study area. The recommendation for VES is presented in **Table-1.5**.

Table-1.5: List of recommended VES in in Alipurduar district of West Bengal.

Sl.No.	Toposheet No.	Quadrant	No. of VES	Aquifer Type
1	78F/14	2B	2	Aquifer-I, Aquifer-II
2	78F/14	3B	1	Aquifer-I, Aquifer-II
3	78F/14	1A	2	Aquifer-I, Aquifer-II
4	78F/14	2A	3	Aquifer-I, Aquifer-II
5	78F/14	3A	3	Aquifer-I, Aquifer-II
6	78F/15	1A	1	Aquifer-I, Aquifer-II
7	78F/9	3A	2	Aquifer-I, Aquifer-II
8	78F/10	1A	3	Aquifer-I, Aquifer-II
9	78F/10	1B	3	Aquifer-I, Aquifer-II
10	78F/10	1C	2	Aquifer-I, Aquifer-II
11	78F/10	2A	3	Aquifer-I, Aquifer-II
12	78F/10	2B	3	Aquifer-I, Aquifer-II
13	78F/10	2C	3	Aquifer-I, Aquifer-II
14	78F/10	3A	3	Aquifer-I, Aquifer-II
15	78F/10	3B	3	Aquifer-I, Aquifer-II
16	78F/10	3C	3	Aquifer-I, Aquifer-II
17	78F/11	1A	2	Aquifer-I, Aquifer-II
18	78F/11	1B	3	Aquifer-I, Aquifer-II
19	78F/11	1C	3	Aquifer-I, Aquifer-II
20	78F/5	3A	3	Aquifer-I, Aquifer-II
21	78F/5	3B	3	Aquifer-I, Aquifer-II
22	78F/5	3C	3	Aquifer-I, Aquifer-II
23	78F/6	1A	3	Aquifer-I, Aquifer-II
24	78F/6	1B	3	Aquifer-I, Aquifer-II
25	78F/6	1C	2	Aquifer-I, Aquifer-II
26	78F/6	2A	3	Aquifer-I, Aquifer-II
27	78F/6	2B	3	Aquifer-I, Aquifer-II
28	78F/6	2C	3	Aquifer-I, Aquifer-II
29	78F/6	3A	3	Aquifer-I, Aquifer-II
30	78F/6	3B	3	Aquifer-I, Aquifer-II
31	78F/6	3C	3	Aquifer-I, Aquifer-II
32	78F/1	3B	3	Aquifer-I, Aquifer-II
33	78F/1	3C	3	Aquifer-I, Aquifer-II
34	78F/2	1B	3	Aquifer-I, Aquifer-II
35	78F/2	1C	3	Aquifer-I, Aquifer-II
36	78F/2	2B	3	Aquifer-I, Aquifer-II

37	78F/2	2C	3	Aquifer-I, Aquifer-II
38	78F/2	3B	2	Aquifer-I, Aquifer-II
39	78F/2	3C	3	Aquifer-I, Aquifer-II

BIBLIOGRAPHY

1. Chaudhuri B., 2019, Health hazards and use of drinking water in Kumargram block, Alipurduar district, West Bengal: An empirical analysis, Journal of Emerging Technologies and Innovative Research (JETIR), Volume 6, Issue 4, ISSN-2349-5162.

2. Pathak D., 2016, Water Availability and Hydrogeological Condition in the Siwalik Foothill of east Nepal, Nepal Journal of Science and Technology , 17(1), pp. 31-38.

3. Government of West Bengal, 2021, District Survey Report of Alipurduar District, Work order No. MDTC/PM-5/160/66.

4. Hossain S.M., 2010, Groundwater Management study in parts of Jalpaiguri and Cooch Behar districts, West Bengal, CGWB, Eastern Region, Kolkata, Technical Report; series-D, No.226.

5. Majumdar N., 2008, Groundwater Management study in parts of Darjeeling and Jalpaiguri districts, West Bengal, CGWB, Eastern Region, Kolkata, Technical Report; series-D, No.208.

6. Bose S.K., Hydrogeology and Ground water Potential of Jalpaiguri district, West Bengal, CGWB, Eastern Region, Kolkata, Technical Report; series-D, No.23.

7. Bose S.K., Report on systematic Hydrogeological Survey in parts of Tista-Torsa River basin, Jalpaiguri district, West Bengal, CGWB, Eastern Region, Kolkata, Technical Report; series-A, No.42.