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

COOCHBEHAR DISTRICT
WEST BENGAL

पूर्वी क्षेत्र, कोलकाता

Eastern Region, Kolkata

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Report

On

AQUIFER MAPPING & MANAGEMENT PLAN

of

Coochbehar district, West Bengal

By:

Rajesh Kumar Sahoo
(Assistant Hydrogeologist)
Central Ground Water Board

Eastern Region, Kolkata

July 2022

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NATIONAL AQUIFER MAPPING AND MANAGEMENT PLAN

Coochbehar District, West Bengal

पूर्वी क्षेत्र, कोलकाता

Eastern Region, Kolkata

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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 Cooch Behar 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 of 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. Hydrogeological 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 the outcome of the efforts given by ***Shree. Rajesh Kumar Sahoo, Assistant Hydrogeologist*** under the supervision of ***Mrs. Sandhya Yadav, Scientist- 'E' & Dr. Indranil Roy, Scientist-'D' & Supervisory Officer, NAQUIM.*** The data in the section pertaining to Hydrochemistry has been prepared by ***Eastern Region's Chemical Section*** and their effort is thankfully acknowledged.

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 public to make them aware of local groundwater issues and its sustainable management.

(Dr Anadi Gayen)

Scientist-E/HOO, ER, Kolkata

EXECUTIVE SUMMARY

The study area comprises 12 blocks of Cooch Behar districts in West Bengal. The present study area covers a total of 3387 sq. km. geographical area. It is bounded by the north latitudes 25°57'47" and 26°36'20" & east longitudes of 88°47'44 & 89°54'35" in Survey of India Toposheet no. 78B/11, 78B/12, 78B/14, 78B/15, 78B/16, 78F/02, 78F/03, 78F/04, 78F/07, 78F/08, 78F/11, 78F/12, 78F/15, 78G/05, and 78G/09. The district with its headquarters at Cooch Behar is divided into five sub-divisions and 12 blocks. The district has six municipal towns. Population is of the district is 326,558. The normal rainfall of the district is 3213 mm annually, which is comparatively very high to the state's normal rainfall which is 1739 mm annually.

The study area broadly divided in to four geomorphological units and those are (i) Valley Bottom (ii) Active Flood Plain Area (iii) Alluvial Plain Upper (iv) Meander Flood Plain. Principal agricultural production of the district includes Paddy, Jute, Potato, different types of cucurbits (Melons, Watermelons, Musk Melons, Squash etc.). Major rivers flowing through the study area are Teesta, Jaldakha, Torsha, Kalijani, Raidak and Gadadhar. Five types of loamy classes are (i) Coarse Loamy (ii) Coarse Loamy to Fine Loamy (iii) Fine to Coarse Loamy (iv) Fine Loamy (v) Fine Loamy to Coarse Loamy. The pH range of the soil is in between 4.2 to 6.2. The district is entirely underlain by Quaternary alluvium. This Quaternary alluvium is divided in to two groups i.e (i) Older alluvium (ii) Younger alluvium. The major geological units present in the district of Cooch Behar are (i) Baikunthpur formation, (ii) Jalpaiguri formation (iii) Shaugaon formation (iv) Present day flood plain deposits.

Prime lithology encountered in the district of Cooch Behar are Gravel, Sand, Silt, Clay and Calcareous concretions. These deposits are capable of transmitting ground water at large and are replenished easily by downward percolation of rainwater during monsoon. The groundwater occurs under water table and semi to confined condition within the explored depth of 307.00mbgl. The area has been explored with 3 types of aquifers. The discharge varying from 430 – 2750 lpm. The Static water levels vary from 0.63mbgl to 4.65 mbgl with drawdown vary from 2.38 m to 10.31 m. The transmissivity varies from 195 – 1398 m^2/day.

Shallow aquifers generally occur under water table and semi-confined conditions. They are essentially restricted to a depth of 30-50 mbgl. However, in some parts the shallow aquifer depth varies from as shallow a 10 mbgl to as deep as 70 mbgl and in some cases extends beyond 100 m bgl. Ground water in deeper aquifers occurs confined condition. In deeper aquifer system there are two aquifer system Aquifer-2 and Aquifer-3. The Aquifer -2 is largely explored and found that there are three aquifer zones (Aquifer -2a, 2b, & 2c). The depth range of Aquifer-2 system vary from 70-140 mbgl, however the depth range vary from as shallow as 40 mbgl to as deep as 160 mbgl place to place depending upon local geology. The Aquifer-3 system is very less explored and as per the explored data the depth range vary from 180 mbgl to 220 mbgl. The general direction of ground water flow in near surface aquifer as well as the deeper aquifer is from north-west to south-east.

As per the computation (GEC, 2013) the net groundwater availability for recharge is estimated at 353275.05 Ham, while the total extraction for all uses is estimated at 131824.1 Ham. The total in-storage for the district is 794944.6562 MCM. The stage of groundwater development in the district stands at 41.46% and categorized as “safe”.

According to BIS (2012) iron’s drinking water permissible limit is 1 mg/l, but it is found that many areas of Cooch Behar district both Aquifer-I and Aquifer-II have iron concentration beyond permissible limit up to 9.6 mg/l which is a very alarming situation. Major Iron affected blocks are Haldibari, Mekhliganj, Mathabhanga-I, Cooch Behar-I, Cooch Behar-II, Dinhata-II and Sitalkuchi. Parts of Cooch Behar-I block are contaminated by arsenic (mainly shallow aquifers) reported by state government. Waterlogging is another prominent issue of the Cooch Behar district.

The stage of ground water development in Coohbehar district is 41.46 %, under safe category. However, further development should be done in planned manner to harness the additional available resource for more sustainable development. 137654.9 hectares more of land can be irrigated. Water applied for irrigation should not be wasted. Crops with low water requirement should be preferred. Heavy duty/medium duty tube wells can be constructed by Govt. agencies as they may help for irrigation in large perspective.

Water level is deeper than 3 mbgl in Cooch Behar-I, Cooch Behar-II and Mathabhanga-II, Tufanganj-I, Tufanganj-ii blocks in post monsoon period. As a whole the water level is not alarming condition, except these blocks of the district, where conservation of rainwater by different structures like percolation tank, roof top rainwater harvesting for conservation may be adopted.

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PART – I

AQUIFER MAPPING & MANAGEMENT PLAN OF COOCH BEHAR DISTRICT

CHAPTER-1

INTRODUCTION

Groundwater is one of the prime sources of fresh water contributing significantly for the survival of mankind. However, overexploitation, surface runoff and subsurface groundwater discharge have 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 CGWB under XIIth Plan. As per the annual action plan, groundwater management studies in 12 blocks of Cooch Behar have been 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 12 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) 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 collection, and wherever required procurement, of all maps from concerned 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 including arsenic. Additional data

pertaining to sub-surface lithology and aquifer parameters were obtained through in-situ 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 12 blocks of Cooch Behar districts in West Bengal. The present study area covers a total of 3387 sq. km. geographical area. It is bounded by the north latitudes 25°57'47" and 26°36'20" & east longitudes of 88°47'44 & 89°54'35" in Survey of India Toposheet no. 78B/11, 78B/12, 78B/14, 78B/15, 78B/16, 78F/02, 78F/03, 78F/04, 78F/07, 78F/08, 78F/11, 78F/12, 78F/15, 78G/05, and 78G/09.

The district is flanked by the international border with Bangladesh on the South-West, South and South-East and is bounded by Alipuduar district in the North, Jalpaiguri district in North-West and state of Assam in the east (bounded by the districts of Kokrajhar & Dhubri in Assam).

The district physiography is dominated by flat terrain. Being a riverine county, construction of Railways and structured Road-Networks require building many Bridges and flyovers across the water bodies, inducing larger expenditure. Thus,till date not all Sub-Divisional Head Quarters are well connected through Railway network from the district Head Quarter and the State Capital. New Cooch Behar Railway station near Cooch Behar (M) town is the most important station in the district. The nearest functioning airport is Bagdogra Airport near Siliguri located about 160 km from Cooch Behar. Cooch Behar is very well connected by road with neighboring areas and other cities of West Bengal and rest of the country. Cooch Behar is a major roadway junction after Siliguri towards Northeast India and Bangladesh. National Highway 31 and State Highway 12A passes through the district.

1.5 ADMINISTRATIVE DIVISION AND POPULATION

The district with its headquarters at Cooch Behar is divided into five sub-divisions namely Mekhliganj, Mathabhanga, Sadar, Tufanganj, Dinhata. Each sub-division has been divided into blocks as Mekhliganj with 2 blocks (Mekhliganj & Haldibari), Mathabhanga sub division with 3 blocks (Mathabhanga-I, Mathabhanga-II, Sitalkuchi). Sadar sub division with 2 blocks (Cooch Behar - I, Cooch Behar - II). Dinhata sub division with 3

blocks (Dinhata - I, Dinhata – II, Sitai). The district has six municipal towns at Cooch Behar, Mathabhanga, Dinhata, Tufanganj, Mekhliganj and Haldibari. The administrative detail of the district is presented in table 1.1(a) and table 1.1(b).

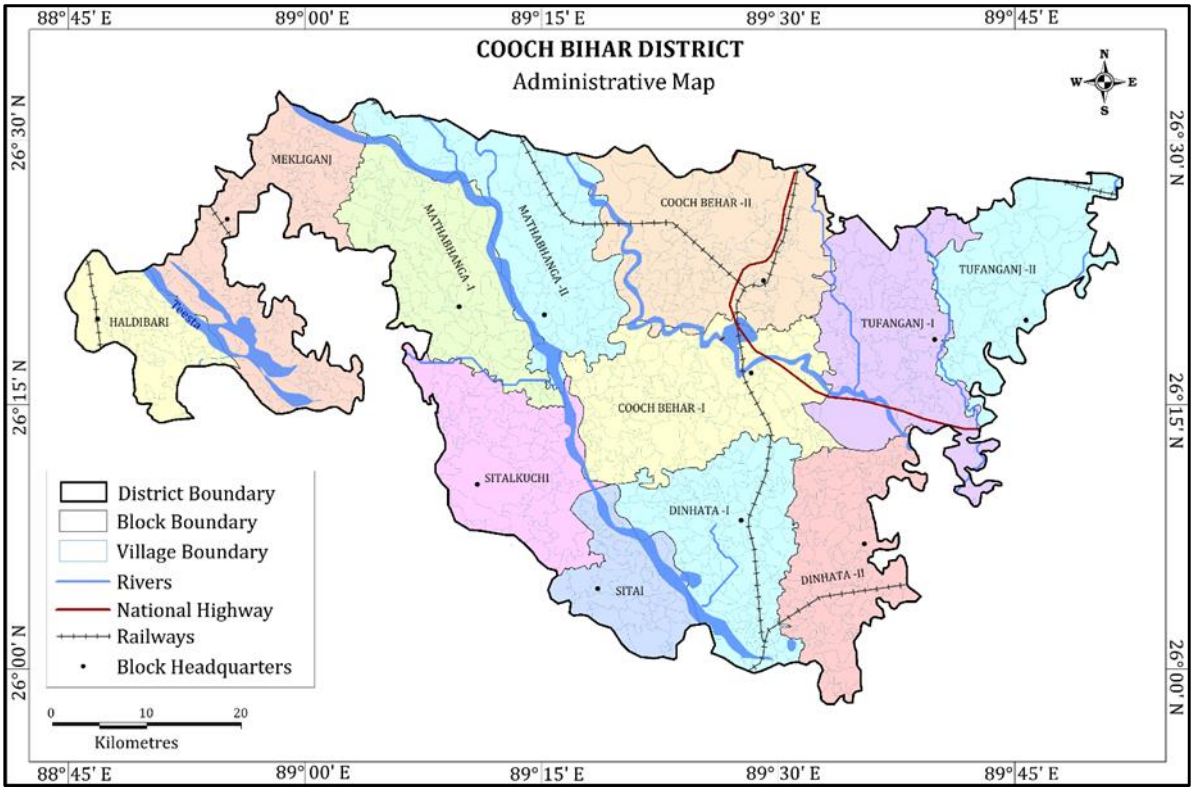

Fig. 1.4.1: Administrative map of the study area

Table 1.1(a): Major administrative division

DISTRICTS	SUBDIVISION	BLOCK
Cooch Behar	Mekhliganj	Mekhliganj
		Haldibari
	Mathabhanga	Mathabhanga-I
		Mathabhanga -II
		Sitalkuchi
	Cooch Behar Sadar	Cooch Behar -I
		Cooch Behar -II
	Tufanganj	Tufanganj - I
		Tufanganj - II
	Dinhata	Dinhata - I
		Dinhata -II
		Sitai

The study area covers a total of 12 panchayat samity, 128-gram panchayat, 1966 gram sansad, 1202 mouzas, 1132 inhibited village, 665720 house-holds, 6 municipalities, 79

wards and 12 census towns. Distribution of population of the study area is presented in Table 1.2.

Table 1.1(b): Major administrative division

Block	Panchayat			Mouzas	Inhabited Villages	House-holds	Town		
	Samity	Gram	Gram Sansad				Municipality		Census Town
							No.	Ward	
Mekhliganj	1	8	112	187	137	37142	-	-	1
Mekhliganj(M)	-	-	-	-	-	2249	1	9	-
Haldibari	1	6	73	62	57	24238	-	-	-
Haldibari(M)	-	-	-	-	-	3405	1	11	-
Mathabhanga-I	1	10	154	102	101	49786	-	-	-
Mathabhanga(M)	-	-	-	-	-	5792	1	12	-
Mathabhanga-II	1	10	168	93	92	50902	-	-	-
Sitalkuchi	1	8	143	70	67	42587	-	-	-
Cooch Behar-I	1	15	240	144	142	76550	-	-	3
Cooch Behar(M)	-	-	-	-	-	18431	1	20	-
Cooch Behar-II	1	13	257	115	111	80438	-	-	5
Tufanganj -I	1	14	192	73	72	60433	-	-	1
Tufanganj(M)	-	-	-	-	-	5171	1	12	-
Tufanganj -II	1	11	141	54	53	44727	-	-	1
Dinhata -I	1	16	220	130	128	67587	-	-	1
Dinhata (M)	-	-	-	-	-	8739	1	15	-
Dinhata-II	1	12	185	119	119	60896	-	-	-
Sitai	1	5	81	53	53	26647	-	-	-

(Source- District Statistical Handbook, 2013)

Table 1.2: Distribution of population in administrative units of the study area

Block/ Muncipality	Rural Population			Urban Population			Total Population		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Mekhliganj	77801	72966	150767	2251	2232	4483	80052	75198	155250
Mekhliganj(M)	-	-	-	4664	4463	9127	4664	4463	9127
Haldibari	52851	51118	103969	-	-	-	52851	51118	103969
Haldibari(M)	-	-	-	7306	7098	14404	7306	7098	14404
Mathabhanga-I	112497	105694	218191	-	-	-	112497	105694	218191
Mathabhanga(M)	-	-	-	12059	11831	23890	12059	11831	23890
Mathabhanga-II	117100	110297	227397	-	-	-	117100	110297	227397
Sitalkuchi	94277	91076	185353	-	-	-	94277	91076	185353
Cooch Behar-I	151337	141930	293267	16848	16443	33291	168185	158373	326558
Cooch Behar(M)	-	-	-	39014	38921	77935	39014	38921	77935
Cooch Behar-II	151946	137971	289917	27645	26339	53984	179591	164310	343901
Tufanganj-I	125672	117584	243256	2743	2596	5339	128415	120180	248595
Tufanganj(M)	-	-	-	10684	10314	20998	10684	10314	20998
Tufanganj-II	93431	87815	181246	2791	2689	5480	96222	90504	186726
Dinhata-I	145325	136565	281890	2277	2102	4379	147602	138667	286269
Dinhata(M)	-	-	-	18344	17780	36124	18344	17780	36124
Dinhata-II	126663	117403	244066	-	-	-	126663	117403	244066
Sitai	56016	54317	110333	-	-	-	56016	54317	110333

(Source- District Statistical Handbook, 2013.)

Table 1.3: Geographical area and Mappable area for the given study area

District	Block_Name	Geographical Area	Mappable Area
Cooch Behar	Mekhliganj	316	283
	Haldibari	197	176
	Mathabhanga-I	296	265
	Mathabhanga -II	313	281
	Sitalkuchi	264	236
	Cooch Behar -I	355	318
	Cooch Behar -II	388	347
	Tufanganj - I	322	288
	Tufanganj - II	254	227
	Dinhata - I	281	252
	Dinhata -II	250	224
	Sitai	151	136
Total Area		**3387**	**3033**

(Source- District Statistical Handbook, 2013.)

1.6 LAND-USE, CROPPING PATTERN AND IRRIGATION:

Land-Use

Data from West Bengal Land Use Land Cover Department shows that most area of Cooch Behar district is used for agriculture. As per the record the physical extent of land on which crops are sown and harvested is 77% of the reporting area (256131 hectares) in 2016-17. The total forest land is 4256 hectares which is about 1% of the reporting area. The existence of forest is very limited in district Cooch Behar and except the areas near Rasikbil and Patlakhawa, large vegetation is no more available in the district. Most of these forests are concentrated in the northern half of the district. Tufanganj-II block has the maximum area under forests while the blocks of Cooch Behar-I, Tufanganj-I, Haldibari, Sitai and Dinhata II have no forests at all. Other than Rasikbil and Patlakhawa forests, remaining are mostly located in small patches on the bank of rivers. Apart from agricultural land and forest land, other major land use pattern of Cooch Behar district are “Area under Non-Agricultural use”, “Land under misc. tree crops”, with 20%, 2% respectively. The details of the land-use are presented in table 1.6.1 and Fig.1.61 below.

Table 1.6.1: Block-wise details of Land-use pattern (in hectares)

Block	Reporting Area	Forest Area	Area under Non-Agricultural use	Barren and Un-cultura ble land	Land under misc tree crops	Cultur able waste s	Fallo wland Other than curre nt fallow	Current fallow	Net area sown
Mekhliganj	29320	101	5255	-	510	-	-	62	23392
Haldibari	14405	0	3663	0	773	-	-	102	9862
Mathabhanga-I	31475	146	8688	-	459	-	-	90	22092
Mathabhanga -II	30218	288	3945	-	351	-	-	19	25615
Sitalkuchi	26459	87	3087	-	987	-	-	75	22223
Cooch Behar -I	34663	0	7562	-	406	-	-	85	26610
Cooch Behar -II	38198	1427	6668	-	470	178	-	85	29370
Tufanganj – I	31618	0	8378	-	698	-	-	35	22507
Tufanganj – II	26020	2092	4200	-	449	-	-	25	19254
Dinhata – I	28259	115	6214	-	340	-	-	75	21515
Dinhata -II	25240	0	3332	-	310	-	-	65	21533
Sitai	15690	0	3150	-	300	-	-	82	12158
Total area	331565	4256	64142	0	6053	178	0	800	256131

*(*Source- Agriculture Department West Bengal)*

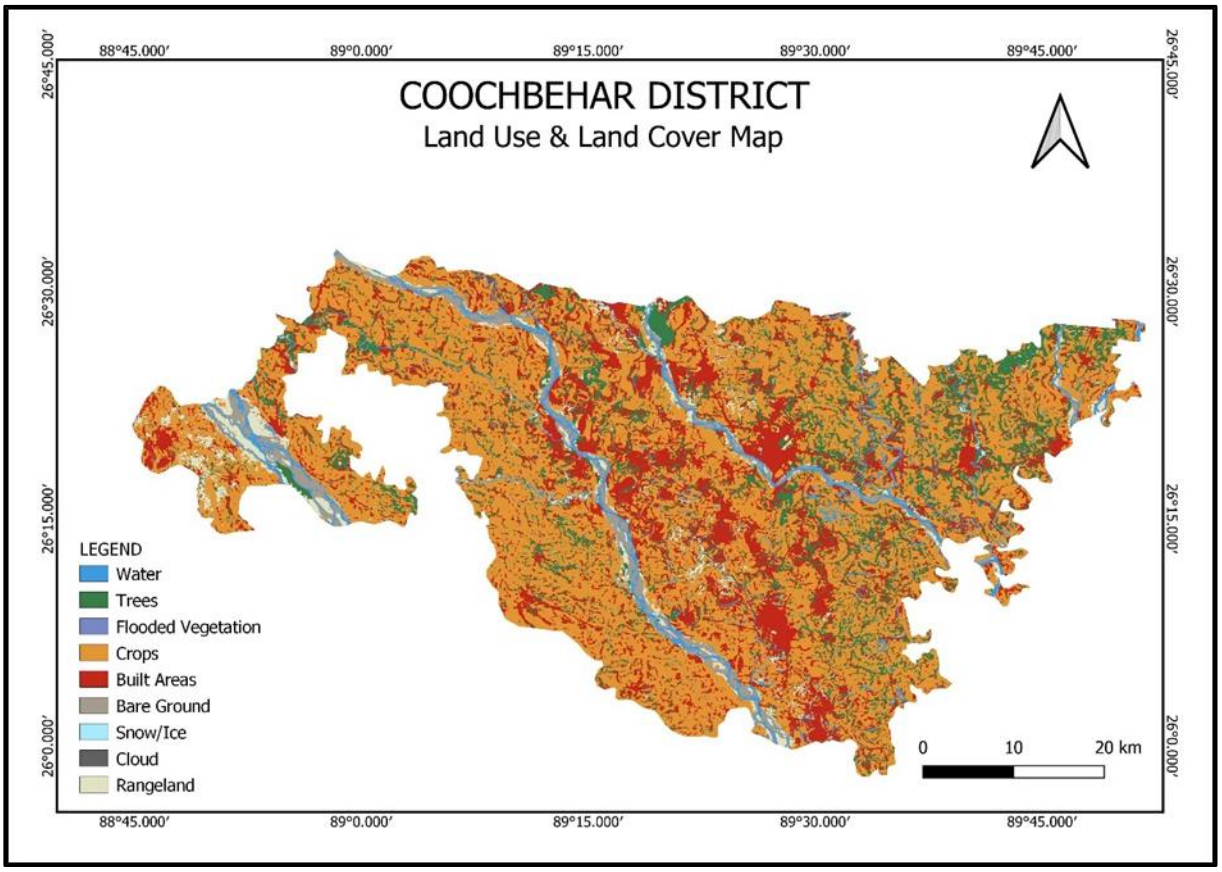

Fig. 1.6.1: Land Use and Land Cover Map of Cooch Behar District.

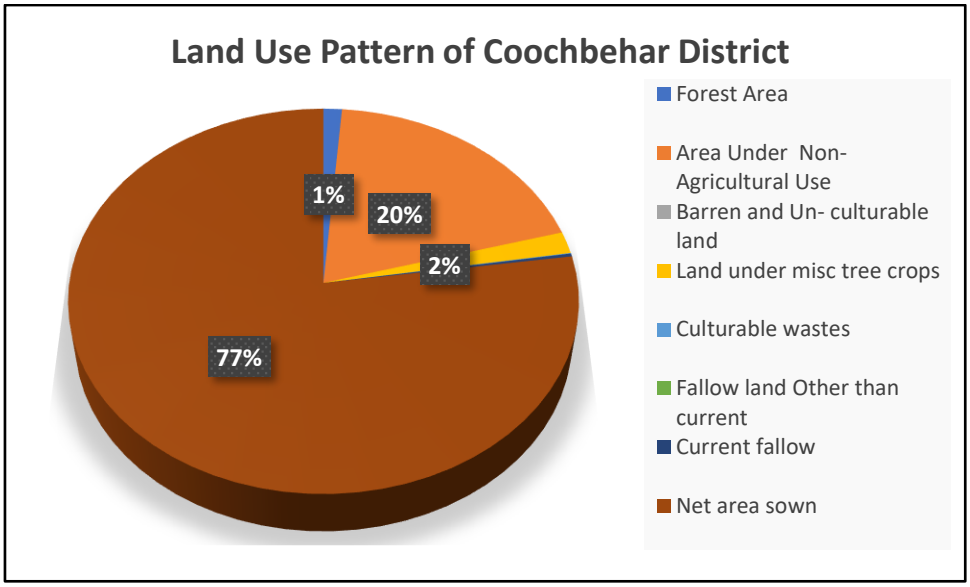

Fig. 1.6.2: Land Use Pattern of Cooch Behar District.

Cropping pattern:

Cooch Behar is primarily an agricultural district with an economy mainly deriving from agricultural activity. Principal agricultural production of the district includes Rice (Paddy), Jute, Potato, different types of cucurbits (Melons, Watermelons, Musk Melons, Squash etc.), Tomato, Cabbage, Cauliflower etc. Paddy being the main cereal crop sowing in the district, has two traditional cropping season Aus and Aman in addition to Boro paddy which is a relatively new introduction and non-traditional. Among the different cropping season of rice, Aman is the highest produced cropping season followed by Boro. Cultivation of Aus rice is very limited.

Jute is cropped in low lands, especially in the riverine areas. Due to presence of sand in the soil, different types of Melons are produced in the district; Watermelon and Musk Melon are the two highest producing varieties. The usual cropping sequence of the district is Jute-Aman-Potato or Jute-Aman-Vegetable from the month of March to December. Sometimes Aman and Boro rice is also cultivated sequentially in the field, Aman from May to July and Boro from November to December (Source: District census handbook 2011).

Two principal commercial crops are tobacco and jute with the former being concentrated mostly in Dinhata-I, Sitai, Sitalkuchi and Mathabhanga I & II. Tobacco has the advantage of being cultivable on sandy land of poorest quality and Cooch Behar alone supplies about 72% of the total tobacco output of West Bengal.

Table-1.6.2: Area, Production & Yield Rates of Major Crops in the Blocks of Cooch Behar District for the year 2011-2012.

Name of Blocks	Aus			Aman			Boro			Wheat			Maize			Jute			Masur		
	Area	Prodⁿ	Yield	Area	Prodⁿ	Yield	Area	Prodⁿ	Yield	Area	Prodⁿ	Yield	Area	Prodⁿ	Yield	Area	Prodⁿ*	Yield**	Area	Prodⁿ	Yield
Cooch Behar - I	-	-	-	19106	35.526	1859	4895	12.739	2603	3497	8.233	2354	72	0.163	2267	10258	171.309	16.70	10	0.006	580
Cooch Behar - II	319	0.826	2590	24699	52.660	2132	3993	11.986	3002	227	0.673	2964	136	0.308	2267	11557	148.970	12.89	21	0.015	704
Dinhata - I	1075	1.889	1757	20101	40.168	1998	9809	32.318	3295	111	0.250	2248	-	-	-	8170	92.893	11.37	7	0.004	539
Dinhata - II	-	-	-	18463	32.845	1779	6615	17.616	2663	632	1.273	2015	-	-	-	10094	131.929	13.07	53	0.015	289
Haldibari	-	-	-	10749	23.597	2195	115	0.302	2629	138	0.408	2956	2	0.005	2267	2677	28.457	10.63	-	-	-
Mathabhanga - I	-	-	-	19649	59.211	3013	2875	8.754	3045	124	0.358	2889	63	0.143	2267	6667	64.070	9.61	-	-	-
Mathabhanga - II	-	-	-	23992	43.583	1817	2887	8.367	2898	147	0.377	2563	-	-	-	6722	70.245	10.45	51	0.029	573
Mekhliganj	3	0.007	2266	15791	36.453	2308	452	1.345	2975	1235	2.668	2160	12	0.027	2267	2506	29.796	11.89	-	-	-
Sitai	1546	2.001	1295	10581	19.985	1889	2636	7.750	2940	62	0.133	2146	-	-	-	2835	28.775	10.15	-	-	-
Sitalkuchi	-	-	-	21223	41.488	1955	5285	16.578	3137	3	0.010	3178	-	-	-	10589	178.001	16.81	-	-	-
Tufanganj - I	1275	2.199	1725	18740	33.005	1761	5524	14.152	2562	2870	5.429	1892	371	0.841	2267	4477	49.247	11.00	59	0.025	429
Tufanganj - II	-	-	-	16633	33.532	2016	4244	9.804	2310	1606	3.771	2348	-	-	-	2804	35.134	12.53	-	-	-

*- in 1000 bales of 180 Kgs each

**- in bales per hectare

Area in hectare, Production in '000 MT and Yield Rate in Kg per hectare

Sources:

1) Directorate of Agriculture, Govt. of WestBengal

2) B.A.E.& S., Govt. of West Bengal

Continuation of Area, Production & Yield Rates of Major Crops in the Blocks of Cooch Behar District for the year 2011-2012.

Name of Blocks	Maskalai			Khesari			Gram			Mustard			Til			Potato			Sugarcane		
	Area	Prodn	Yield	Area	Prodn	Yield	Area	Prodn	Yield	Area	Prodn	Yield	Area	Prodn	Yield	Area	Prodn	Yield	Area	Prodn	Yield
Cooch Behar - I	98	0.046	468	23	0.030	1299	-	-	-	1271	0.399	314	19	0.010	551	3242	61.685	19027	11	1.280	116395
Cooch Behar - II	39	0.028	728	70	0.092	1315	-	-	-	281	0.204	934	13	0.007	551	3097	77.320	24966	-	-	-
Dinhata - I	74	0.027	361	2	0.002	984	-	-	-	1013	0.567	560	5	0.003	551	2265	60.977	26921	-	-	-
Dinhata - II	20	0.010	482	115	0.113	984	-	-	-	1346	0.493	366	6	0.003	551	2109	60.799	28828	-	-	-
Haldibari	-	-	-	-	-	-	-	-	-	281	0.024	934	-	-	-	707	16.447	23264	-	-	-
Mathabhanga - I	64	0.017	266	-	-	-	-	-	-	617	0.305	494	2	0.001	551	2370	83.018	35029	-	-	-
Mathabhanga - II	58	0.027	461	35	0.025	712	-	-	-	2464	1.263	513	11	0.006	551	4504	109.763	24370	-	-	-
Mekhliganj	2	0.001	549	-	-	-	-	-	-	1271	0.399	314	53	0.029	551	1470	31.607	21501	-	-	-
Sitai	6	0.004	646	-	-	-	-	-	-	290	0.150	517	7	0.004	551	626	9.732	15547	-	-	-
Sitalkuchi	31	0.015	475	-	-	-	-	-	-	145	0.058	398	7	0.004	551	1089	33.452	30718	-	-	-
Tufanganj - I	1500	0.787	525	16	0.016	973	-	-	-	1259	0.400	317	13	0.007	551	1508	42.010	27858	745	86.714	116395
Tufanganj - II	-	-	-	-	-	-	-	-	-	1808	0.810	448	11	0.006	551	724	18.016	24884	-	-	-

Note: Area in hectare, Production in '000 MT and Yield Rate in Kg per hectare

Sources: 1) Directorate of Agriculture, Govt. of West Bengal

2) B.A.E.& S., Govt. of West Bengal

Table-1.6.3: Culturable command area created by surface water and ground water

Block Name	Dugwell		Sallow Tubewell		Medium Tubewell		Deep Tubewell		Surface Flow		Sarface 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	
COOCH BEHAR-I	19.00	16.06	3625.00	6918.82	23.00	41.61	16.00	264.50	0.00	0.00	49.00	1254.30	7240.99	1254.30	8495.29
COOCH BEHAR-II	6.00	9.14	3097.00	5790.90	120.00	402.94	33.00	280.87	2.00	7.32	68.00	1990.64	6483.85	1997.96	8481.81
DINHATA-1	30.00	123.99	2600.00	5044.24	191.00	949.30	10.00	400.00	1.00	8.00	48.00	1519.20	6517.53	1527.20	8044.73
DINHATA-II	5.00	6.60	2510.00	5117.58	10.00	60.66	12.00	245.13	0.00	0.00	35.00	1663.00	5429.97	1663.00	7092.97
HALDIBARI	4.00	10.06	1004.00	2011.67	0.00	0.00	0.00	0.00	0.00	0.00	25.00	315.19	2021.73	315.19	2336.92
MATHABHANGA-I	19.00	40.02	2108.00	4368.92	91.00	272.91	33.00	110.51	0.00	0.00	55.00	926.98	4792.36	926.98	5719.34
MATHABHANGA-II	5.00	10.26	4788.00	10900.51	12.00	42.49	11.00	22.34	1.00	4.00	108.00	1489.01	10975.60	1493.01	12468.61
MEKHLIGANJ	1.00	1.00	1781.00	4186.41	79.00	173.04	9.00	16.72	22.00	94.85	205.00	1468.82	4377.17	1563.67	5940.84
SITAI	4.00	5.56	1679.00	4158.59	0.00	0.00	5.00	84.66	0.00	0.00	18.00	626.25	4248.81	626.25	4875.06
SITALKUCHI	0.00	0.00	2338.00	4607.62	10.00	21.62	2.00	80.00	0.00	0.00	18.00	780.00	4709.24	780.00	5489.24
TUFANGANJ-I	2.00	3.44	3568.00	9569.10	60.00	164.54	11.00	144.75	0.00	0.00	40.00	1270.00	9881.83	1270.00	11151.83
TUFANGANJ-II	83.00	128.03	2648.00	4544.84	10.00	23.83	4.00	121.62	0.00	0.00	23.00	851.80	4818.32	851.80	5670.12
TOTAL	178.00	354.16	31746.00	67219.20	606.00	2152.94	146.00	1771.10	26.00	114.17	692.00	14155.19	71497.40	14269.36	85766.76

CHAPTER-2

CLIMATE

2.1 INTRODUCTION

From meteorological perspective the state of West Bengal is divided in to two subdivision such as (i) Gangetic West Bengal (ii) Sub Himalayan West Bengal. Our study area Cooch Behar District falls under the Sub Himalayan West Bengal. Based on Koppen-Geiger Classification Cooch Behar is classified as "Humid Subtropical Climate". This humid subtropical climate is mainly characterized by hot and humid summer, mild to cool winter, and ample amount of rain during monsoon.

The study area under the influence of South-West Monsoon experiences mainly four seasons. Winter commences from the middle of November and ends in February. Winter is followed by summer from March to May. Monsoon begins from June and shows its effect till September. The period of post-monsoon or autumn is from September to middle of November, sporadic rainfall from retreating South-West monsoon occurs in isolated locations. Being nearer to the Himalayas, climate of this district is affected by the hill-weather and is less warm than the Southern or South-Western districts of West Bengal. There is a general breeze blowing all through the year and foggy mornings are typical during winters. Winter months in the district are generally dry and scattered to heavy and very-heavy rainfall is spread over rest of the nine months.

2.2 RAINFALL

The normal rainfall of the district is 3213 mm annually, which is comparatively very high to the state's normal rainfall which is 1739 mm annually. Fig. 2.1(a) shows the yearly Normal and Actual rainfall trend for 11 years that is from 2011 to 2021. It can be seen that in the year of 2020 the Actual rainfall is significantly higher (about 1400 mm) than the Normal rainfall. In the year of 2011, 2013, 2018 and 2021 the Actual rainfall is about 400 mm to 500mm lesser than Normal rainfall. Fig 2.1(b) represents the monthly distribution of rainfall data which shows, rainfall sharply increases in the month of April and May then peaked in the month of June and July followed by a gradual decline through the month of August, September and October. November onwards the rainfall is very light and this scenario prevails till February.

The South-West monsoon causes heavy to very heavy rainfall in the district which often crosses the mark of 2500 mm per annum. The highest rainfall usually occurs in the months of June and July, ranging from around 600 mm to more than 800 mm in a single month. Pre-monsoon rain starts from end of April.

Table 2.1(a) and Table 2.1(b) shows the data of Normal rainfall and Actual rainfall from 2011 to 2021 for Cooch Behar District.

Table 2.1(a): Annual Normal Rainfall for Cooch Behar District from 2011 to 2021

District	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Cooch Behar	12.5	13	34.6	127	390	708.2	717.8	553.4	470	172.3	11.4	2.8

*(*Source WRIS)*

*Table 2.1(b): Annual Actual Rainfall for Cooch Behar District from 2011 to 2021 (*Source WRIS)*

District	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Cooch Behar	2011	1.66	9.6	125.64	193.89	247.89	376.25	874.94	442.75	356.48	28.01	7.35	2.11
	2012	2.64	9.99	4.91	172.44	271.64	1285.71	883.16	364.47	511.31	176.45	0	0.05
	2013	0.02	14.07	6.11	141.6	306.42	436.65	832.62	364.45	462.91	168.12	3.47	0.02
	2014	0.24	37.97	10.54	33.95	517.6	760.07	298.79	736.25	456.08	27.59	2.54	0.54
	2015	19.8	6.84	42.2	125.59	455.88	959.54	387.94	936.61	356.7	46.55	15.93	1.83
	2016	8.25	0.88	121.22	153.14	318.51	957.34	782.72	153.85	507.4	176.86	0	0.14
	2017	0.45	0.08	73.14	198.15	299.67	472.17	379.63	1041.15	494.22	251.99	0.75	0
	2018	0	3.26	34.35	252.83	319.29	460.16	545.67	383.01	586.97	39.94	0.71	3.94
	2019	0.34	32.19	72.74	176.76	381.6	568.99	1303.08	230.71	622.66	112.57	19.56	0.18
	2020	0.84	14.34	51.05	204.7	475.11	1080.69	923.61	583.38	1210.72	129.21	3.14	0.28
	2021	9.27	1.36	30.35	119.47	218.12	530.97	493.55	783.31	292.84	309.18	3.94	1.32

*(*Source WRIS)*

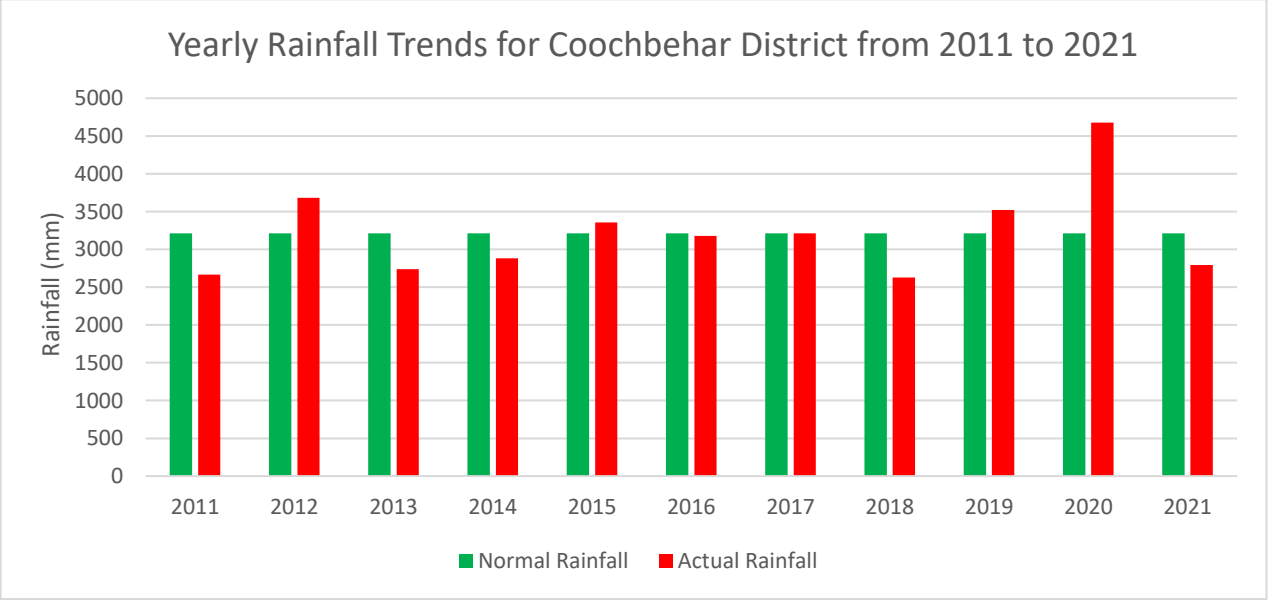

Fig. 2.1(a) Yearly rainfall trends for Cooch Behar from 2011 to 2021,

*(*Source WRIS)*

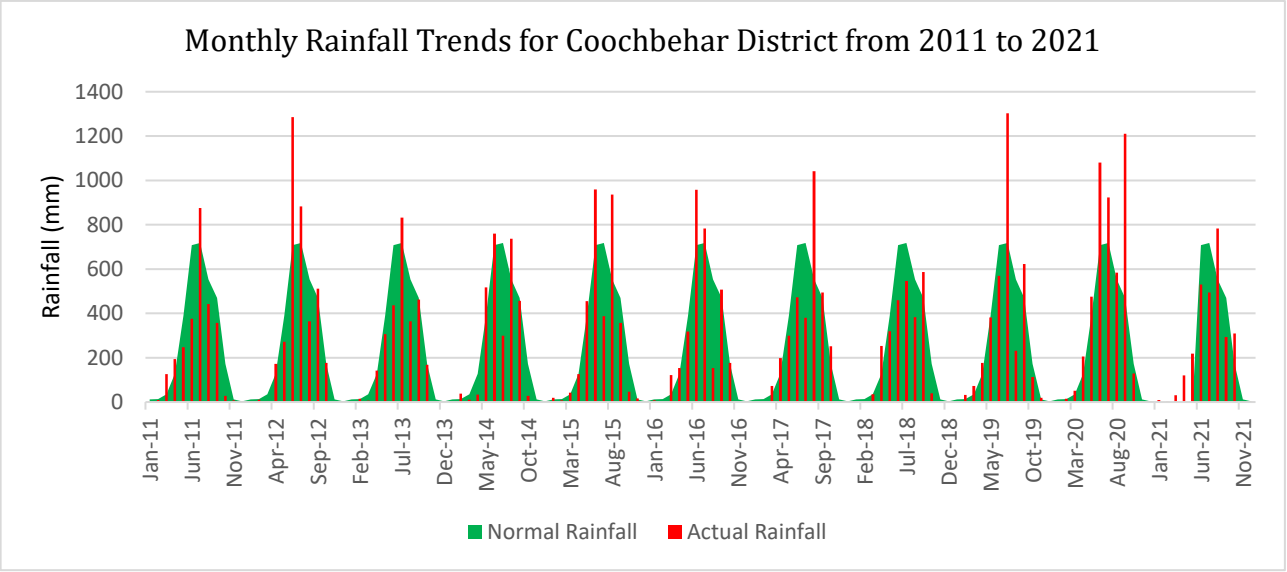

Fig. 2.1(b) Monthly rainfall trends for Cooch Behar from Jan-2011 to Dec-2021,

*(*Source WRIS)*

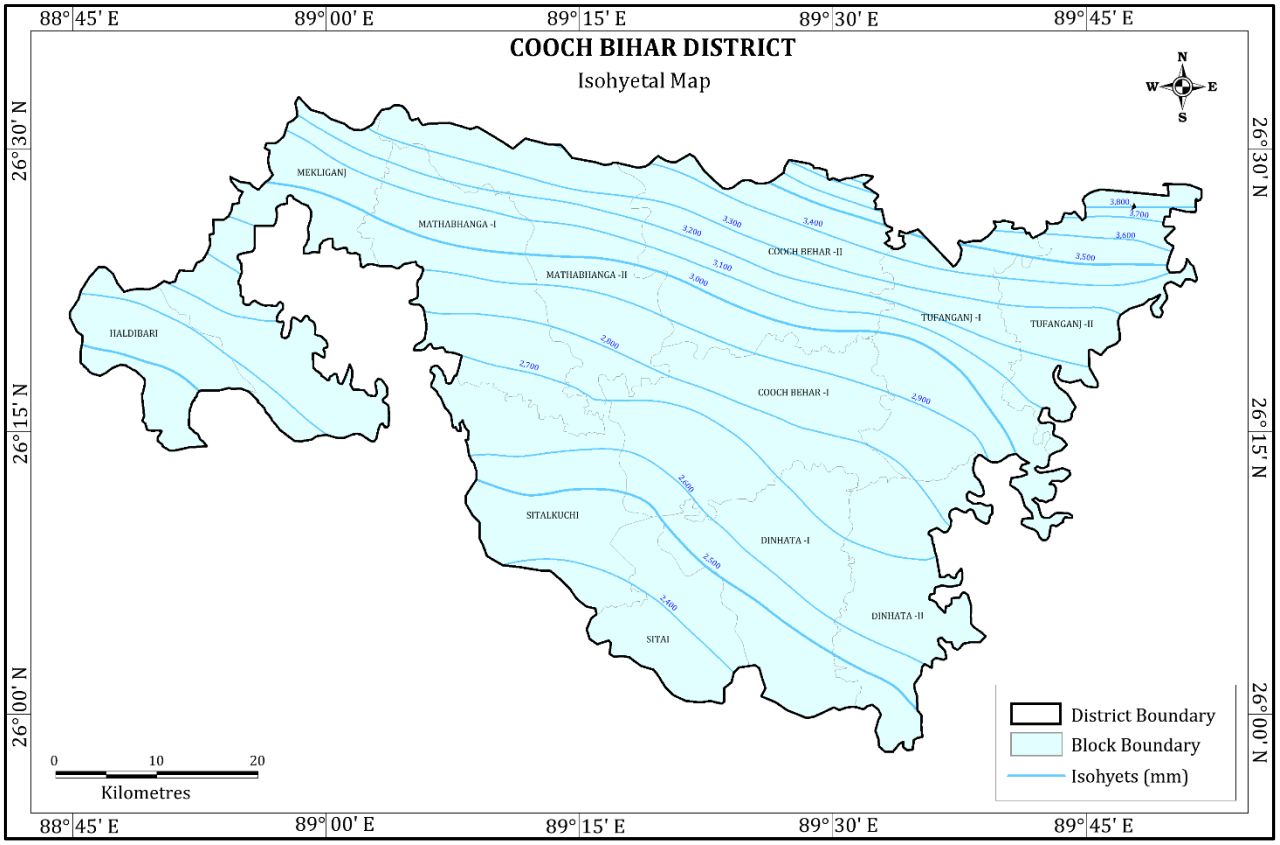

Fig. 2.1(c): Isohyetal Map of Cooch Behar District.

2.3 TEMPERATURE

The temperature in the Cooch Behar district varies from 8°C in January to 37°C in August. During summer, the maximum temperature usually touches 36 to 37°C but the month of occurrence varies from March to August. The lowest temperature is generally reached in January or February touching 7°C, although occasionally the minimum temperature goes below 7°C.

2.4 HUMIDITY

The climate in Cooch Behar district is highly humid throughout the year except February to May when relative humidity is as less as 50 to 70%. Average daily morning (07:00 hrs of LMT) noon (14:00 hrs of LMT) relative humidity of the district is 96% in July & 39% in March respectively. Sky remains heavily overcast during the monsoon. Fog or mist is very common from June to September but rare in December.

2.5 WIND

In Cooch Behar, wind direction is mainly controlled by two principal seasonal pressure patterns of this subcontinent. In Cooch Behar, the direction of monsoonal wind is not from south western direction. It is generally diverted towards Myanmar due to topographical arrangement of southern portion of Gangetic West Bengal. Due to its location in the interior of West Bengal, Cooch Behar experiences low wind velocity of 3.9 km/hr. The wind speed of the district shows that the highest velocity of 6.9km/hr is recorded in April while the lowest velocity of 1.8 km/hr is recorded in the month of December. Wind velocity shows increasing trend in winter season, remains more or less variable in summer, declining in monsoon & post monsoon periods.

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CHAPTER-3

GEOMORPHOLOGY

3.1 INTRODUCTION

Cooch Behar district is dominated by flat topography which is part of the North Bengal Plain. North Bengal Plain extends from south of the foot hill zone (Terai Plain) up to the left bank of the Ganges. This vast flat alluvial plain with huge thickness of quaternary sediments has been formed mainly by the sediments carried out by mountainous rivers (e.g. the Teesta, Jaldhaka, Torsha, Raidak, Sankosh *etc.*) from the hilly terrain of the Himalayas. Landform of the study area is largely influenced by the fluvial processes. As topographically the area is gently to moderately flat, rivers flowing through this area shows depositional landforms like Oxbow lakes, Point-bars, Mid-Channel bars, Natural levees. A large number of Palaeo-channels are observed in the study area because of the changes in the course of rivers due to migration and avulsion in the past. There are no mountain peaks or hills within the district and no-significant forest tract, Oxbow lakes are acting as reservoir during heavy rainfall in the district and are of economic importance as they serve for fisheries besides providing water to the cultivators for the steeping of the jute. The maximum elevation in the study area is found to be around 80 meters whereas the minimum elevation is around 20 meters. Most of the high elevation areas fall in the north-western part (apart from a tiny portion in the extreme north-east) and then elevation gradually decreases towards south-east. So, there is a very gentle slope from north-west to south-east that's why most of the rivers flowing through Cooch Behar following that slope direction. The elevation details are given in the Fig.3.1.

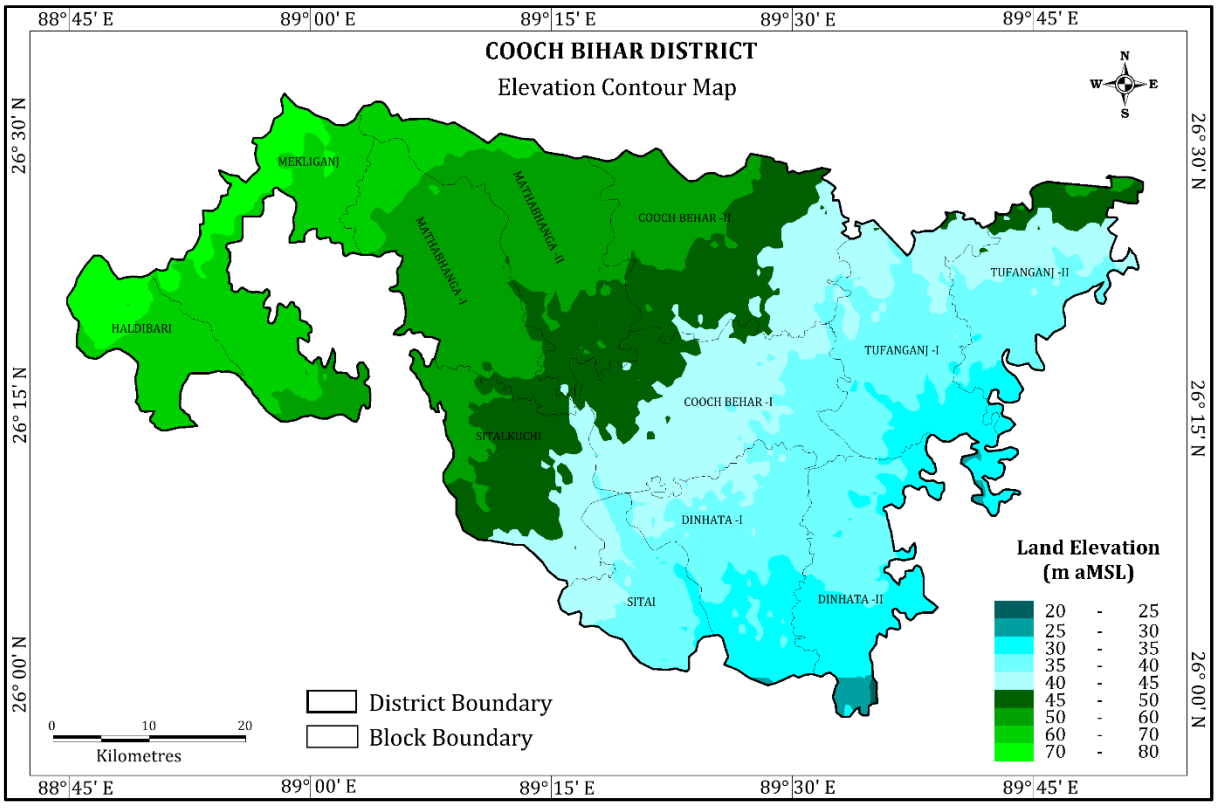

Fig. 3.1. Elevation Contour map of the study area.

3.2 GEOMORPHOLOGICAL UNITS

The study area broadly divided in to four geomorphological units and those are (i) Valley Bottom (ii) Active Flood Plain Area (iii) Alluvial Plain Upper (iv) Meander Flood Plain.

Valley bottom is restricted to a tiny portion of the study area along the Teesta river valley in the extreme west (mainly present in Haldibari & Mekhliganj block).

Active flood plain areas are present mainly along and either side of the rivers which are periodically flooded. In Cooch Behar district, active flood plain areas are located mainly along Teesta, Jaldhaka, and Raidak river (mainly present in Haldibari, Mekhliganj, Mathabhanga-I, Mathabhanga-II, Sitalkuchi & Siti block). Eastern part of the district is devoid of active flood plain area.

Meander flood plains are formed due to erosion of outer bank of rivers and deposition of point bar on the inner bank by meandering action of rivers. Meander flood plains mainly occurs along the south-east flank and south-east region of the study area (mainly present in Cooch Behar-I, Dinhata-I, Tufanganj-I & Sitalkuchi block).

Alluvial plain covers the major portion of the study area which has a thick pile of sediments transported from the highlands by the rivers. Alluvial plains are mainly present on the north-eastern part. Narrow elongated areas of central, west and north-west Cooch Behar is also covered by alluvial plains (mainly present in Cooch Behar-II, Tufanganj -II, Tufanganj-I. Above discussed geomorphological units are shown by Fig. 3.2.

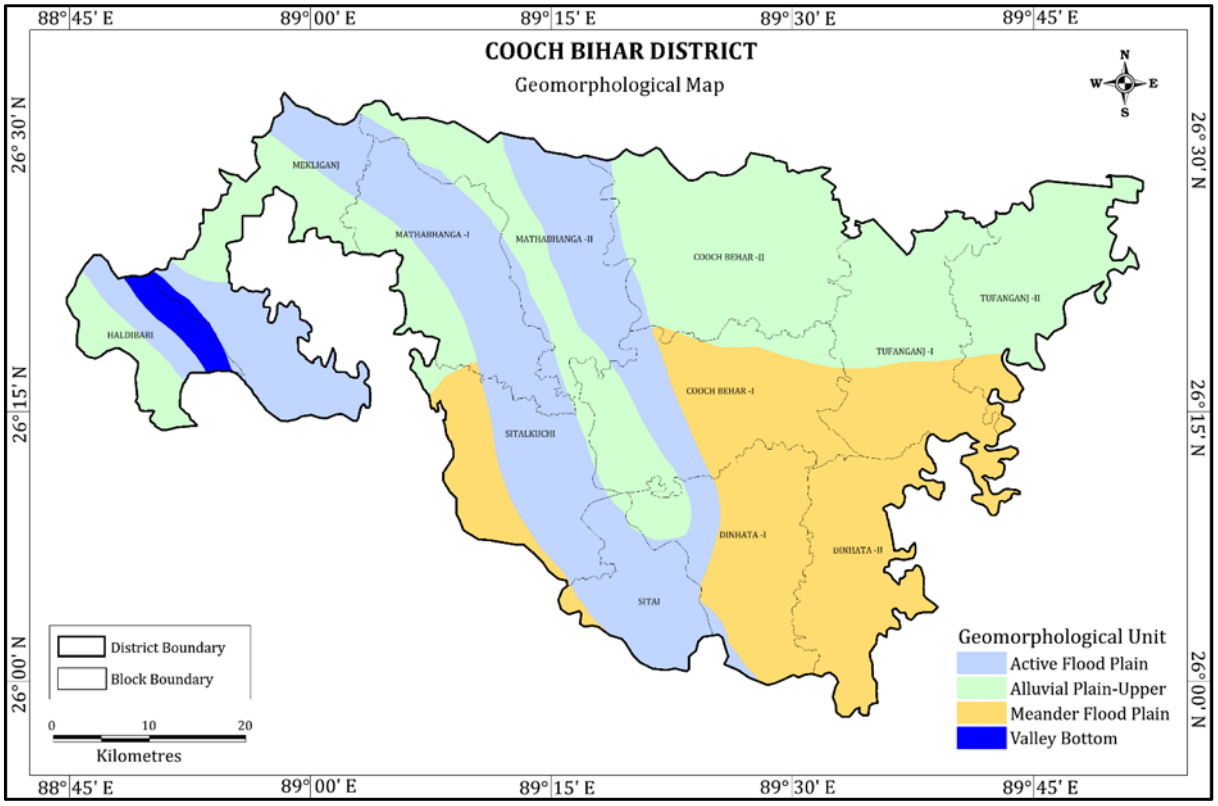

Fig. 3.2. Geomorphological map of the study area.

3.3 DRAINAGE

Drainage system of the district is controlled by following river courses:

River Teesta:

Teesta River is one of the largest rivers in North Bengal. Inside Cooch Behar- it flows in South-East ward direction through the Western most portion of the district. It enters the district at the Mekhliganj C.D. Block and exitsthe district near Kuchlibari. It is a trans-boundary international river. One flow of river Teesta is originated from Cholamoo (Tso Lhamo) lake in Tibet and the other flow is originated from Teesta Khangse in Sikkim. The combined flow, known as Teesta (or Tista), flows through Sikkim, districts Darjeeling and Jalpaiguri before entering Cooch Behar in several small flows and shallow wet-lands between villages Daripattani, Dakshin Nijtaraf and Bakshiganj. Although, no large river flows meet Teesta inside Cooch Behar, small streams known as Suti Nadi and Shaniajan meets the river in the Mekhliganj C. D. Block. Upon exit to the district; Teesta enters Bangladesh and ultimately meets Brahmaputra as its one of the most important tributaries.

River Jaldhaka:

Jaldhaka and its connected river-streams form the largest catchment area in the district Cooch Behar. Some portions of the river are also known as Manshai or Singimari in colloquial terms. At present, there is a very small independent stream named Singimari which is a tributary of river Jaldhaka. Similarly, a small stream named Manshai meets Jaldhaka, giving the combined flow its name. Like Teesta, Jaldhaka is also a trans-boundary international river. It is originated from the sacred Kupup Lake (also known as Bitan Cho) in Eastern Sikkim. It enters Cooch Behar from North-East corner of Mekliganj C.D. Block near villages Hat Sadikha and soulmari. The river then flows in a South-East direction after entering Cooch Behar and is met with river Dudya or Duduya (also known as Rehti-Dudya) from left side. Beyond that, at Khaterbari near Mathabhanga town, the river meets with a stream. There are also many smaller streams enrich Jaldhaka in its route throughout the district ultimately to meet mighty Brahmaputra in Bangladesh as one important tributary.

River Torsha:

The River generated from the Himalayas and flowing through Tibet, Bhutan, India and Bangladesh. It is known as 'Amo Chu' in Tibet and Bhutan and Torsa in India and Bangladesh. Torsa flows through the steep mountainous gorges in its hill path inside Tibet and Western Bhutan in a large and swift stream. It then enters the plain of Himalayan foothills of Dooars and flows through districts Jalpaiguri and Cooch Behar, where its course widens. Torsa enters Cooch Behar from North near Latabari at C. D. Block Mathabhanga-I.It ultimately meets Brahmaputra as tributary inside Bangladesh.

River Kaljani:

The Kaljani is formed in the western Doors by the combination of the Alaikuri and Dima in Alipurduar and enters Cooch Behar by the north of taluk Khulta. It receives the stream, Gidari, Gadadhar and Katajani. The river Kaljani joins the river Torsa in Panisala in Cooch Behar sadar.

River Raidak:

The River Raidak enters the district in between the taluks Dorko and Chentimari. There are two rivers of the same name: Raidak – I and Raidak – II. The stream bifurcates in taluk Naratali of Jalpaiguri district presently Alipurduar district and the western branch enters Cooch Behar at Dorko, while the eastern stream enters by the west of taluk khagrabari. The eastern branch falls into the Gadadhar in taluk Jaldhoa. The western branch, Raidak – I, flows by Andaran Fulbari, Chamta, Dipar–par and Rajarkuti taluks. The sub- Divisional town of Tufanganj is on the right bank of this river.

River Gadadhar:

The Gadadhar is called the Sankosh in its upper course and Gadadhar in lower course. It flows 60kms within the district and passes the district by the south of chat Baralaukuti. It enters Cooch Behar from the east in taluk Garbhanga. It receives streams like Takulla, Jorai, and Raidak – II.

River Dharla:

This is one of the most important rivers of district Cooch Behar and is also as Dharala or Dhalla. Presently the river flows gently through the district with heavy flow of water during months of monsoon. The main course of the river emerges from the Himalayas in Bhutan and is known as 'Chel' or 'Chil' in the upper course. This river stream meets with the other course near Chengmari andthe mixed flow is known as Dharla. Similar to other rivers of the district, Dharla River is also very prone to flooding. Dharla enters Cooch Behar from district Jalpaiguri near at Panisala near Mekliganj. It goes out of the district and the country as well near Patgram and re-enters the district (and India) near Dinhata. In its course through the district, it receives small streams called Neda, Chenakata etc. River Dharla ultimately meets Jaldhaka as a tributary near Kodaldhoa. Fig.3.3. represents the Drainage map of the study area.

3.3 SOIL CHARCTERISTICS:

The district of Cooch Behar more or less has homogeneous soil characteristics as the major soil class present in the district is Gangetic Alluvial. As soil found in the district of Cooch Behar is transported by rivers due to weathering and erosion of the highland areas, it inherits the physical and chemical properties of its parent rocks though modified during the process of transportation. Texturally, soil of Cooch Behar falls under the Loamy class which has balance proportion of sand and silt with lesser clay. Loamy soil has more capacity to hold moisture, humous and nutrients than sandy soil and at the same time better drainage compared to silty and clayey soil, so the study area has a fertile soil which is good enough for agriculture.

The loamy soil of the district is mainly classified in to five sub-types based upon variation of clay percentage. Five types of loamy classes are (i) Coarse Loamy (ii) Coarse Loamy to Fine Loamy (iii) Fine to Coarse Loamy (iv) Fine Loamy (v) Fine Loamy to Coarse Loamy. The term Coarse Loamy generally represents Loamy soil with 0 to 18 % of clay whereas Fine Loamy has 18 to 35 % clay.

The pH range of the soil is in between 4.2 to 6.2. Due to heavy rainfall in the study area, the H^+ ion released by the ionisation of carbonic acid replaces the Ca^{+2} ion held by the soil particles

and combines with bicarbonate ion to form Calcium bicarbonate and leached out from the soil as it is soluble. As the concentration of H^+ ions increase the soil becomes acidic.

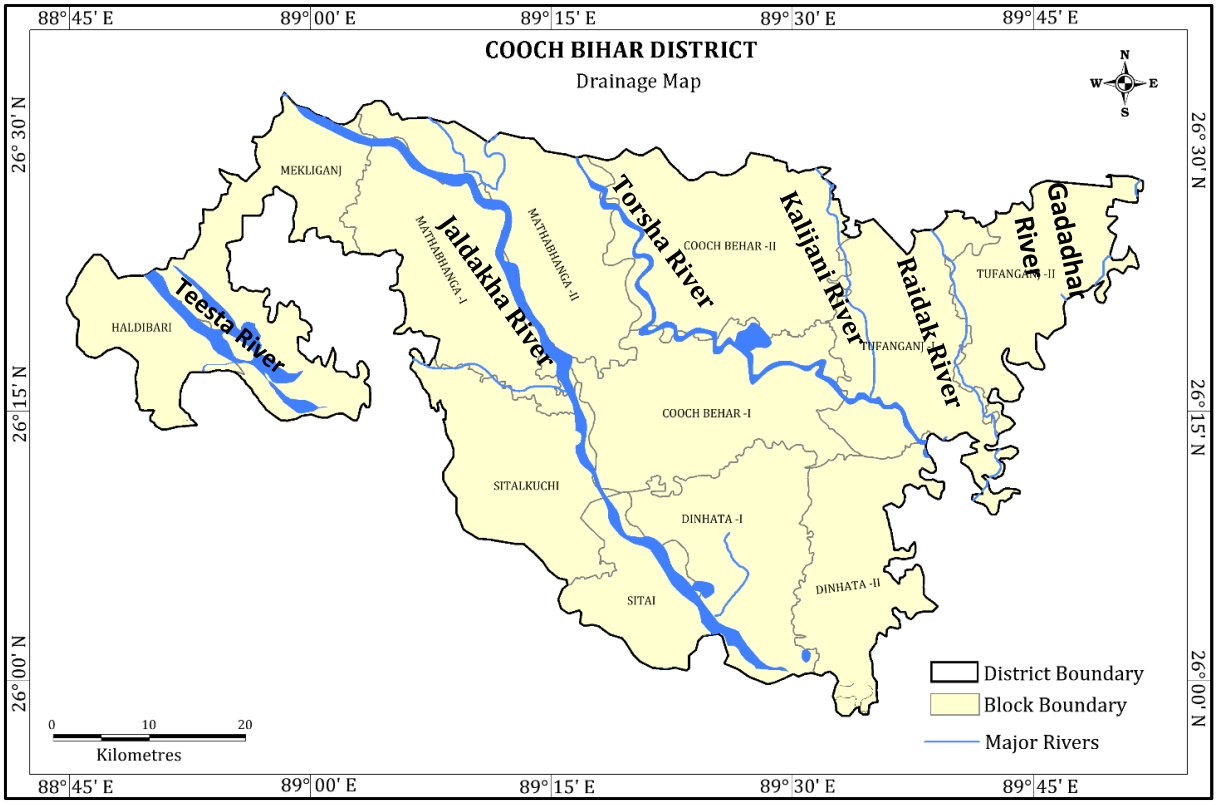

Fig. 3.3. Drainage map of the study area

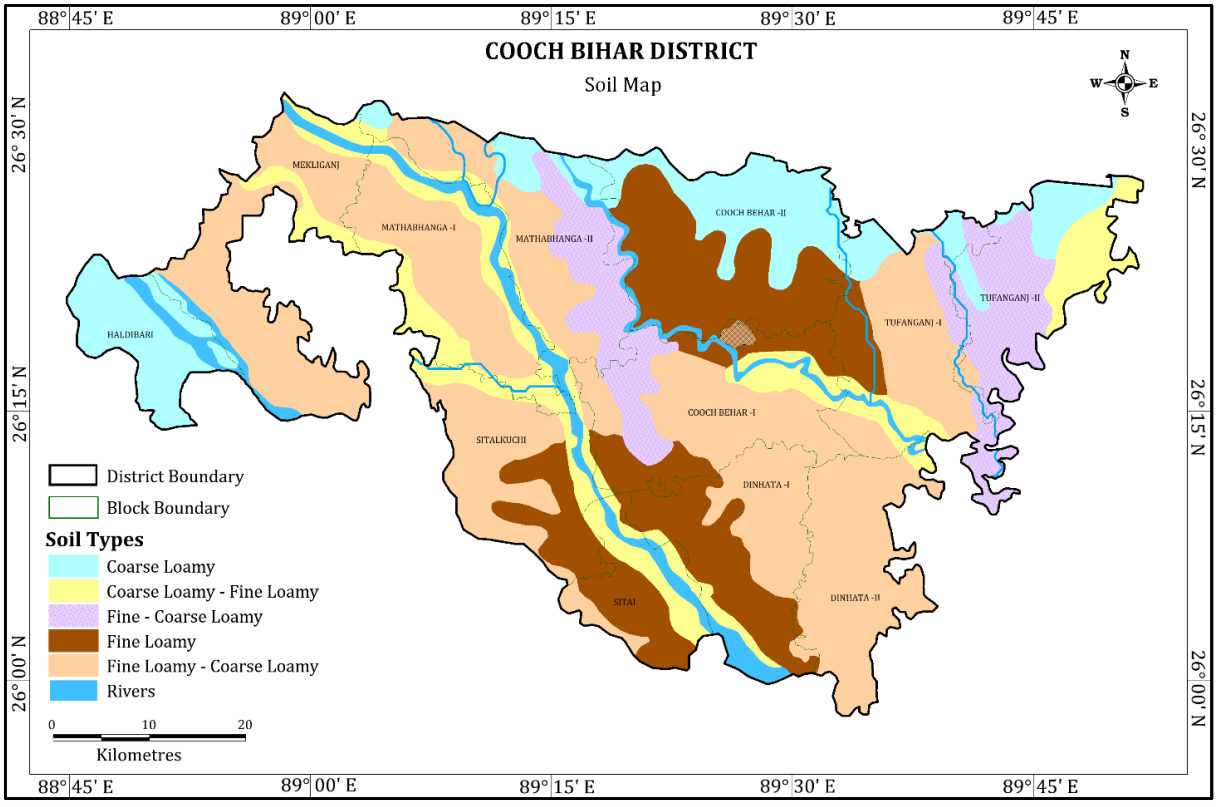

Fig. 3.4. Soil map of the study area

CHAPTER- 4

GEOLOGY

4.1 GENERAL GEOLOGY

The district is entirely underlain by Quaternary alluvium laid down by the South-flowing mountainous streams and rivers. This Quaternary alluvium is divided in to two groups i.e (i) Older alluvium (ii) Younger alluvium. The age of Older alluvium and Younger alluvium are Pleistocene and Holocene respectively. Most area of the district is covered by Younger alluvium whereas Older alluvium is restricted to a very small portion in the North-West area of the district.

4.2 STRATIGRAPHY

The major geological units present in the district of Cooch Behar are (i) Baikunthpur formation, (ii) Jalpaiguri formation (iii) Shaugaon formation (iv) Present day flood plain deposits. Baikunthpur formation is the oldest among the four geological units and belongs to Lower-Holocene to Upper-Pleistocene. Jalpaiguri formation, Shaugaon formation and Present-day flood plains belong to Holocene epoch and are part of an older to younger sequence.

Table 4.1: Stratigraphy of Cooch Behar District

Formation	Lithology	Age
Baikunthpur formation	Sand, Silt and Clay with Calcareous concretions.	Lower-Holocene to Upper-Pleistocene
Jalpaiguri formation	Feebly Oxidized Sand, Silt and Clay.	Holocene
Shaugaon formation	Sand, Silt and Clay.	Holocene
Present day flood plain deposits	Sand, Silt and Clay.	Holocene (Meghalayan)

4.3 LITHOLOGY

Prime lithology encountered in the district of Cooch Behar are Gravel, Sand, Silt, Clay and Calcareous concretions. Baikunthpur formation which is the only formation that contains sediments of Older alluvium has unconsolidated Sand, Silt and Clay with Calcareous concretions. Jalpaiguri formation younger to Baikunthpur formation has Feebly Oxidized Sand, Silt and Clay. Shaugaon formation has a cyclic and alternate layer of Sand, Silt and Clay. The sediments are essentially un-oxidised and unconsolidated except the clay horizons that are relatively compact. Present day flood plain deposits are the sediments deposited by the current river and stream systems present across the whole district of Cooch Behar. The major portion of Present-day flood plain deposits occurs along the active flood plain of Teesta,

Jaldhaka, Torsha, Kalijani and Raidak rivers and consist of Sand, Silt and Clay. These loose sediments show well developed bedforms like lamination, cross bedding and ripple marks. The channel bars are often composed of layers of pebble, coarse to fine grained sand and silt.

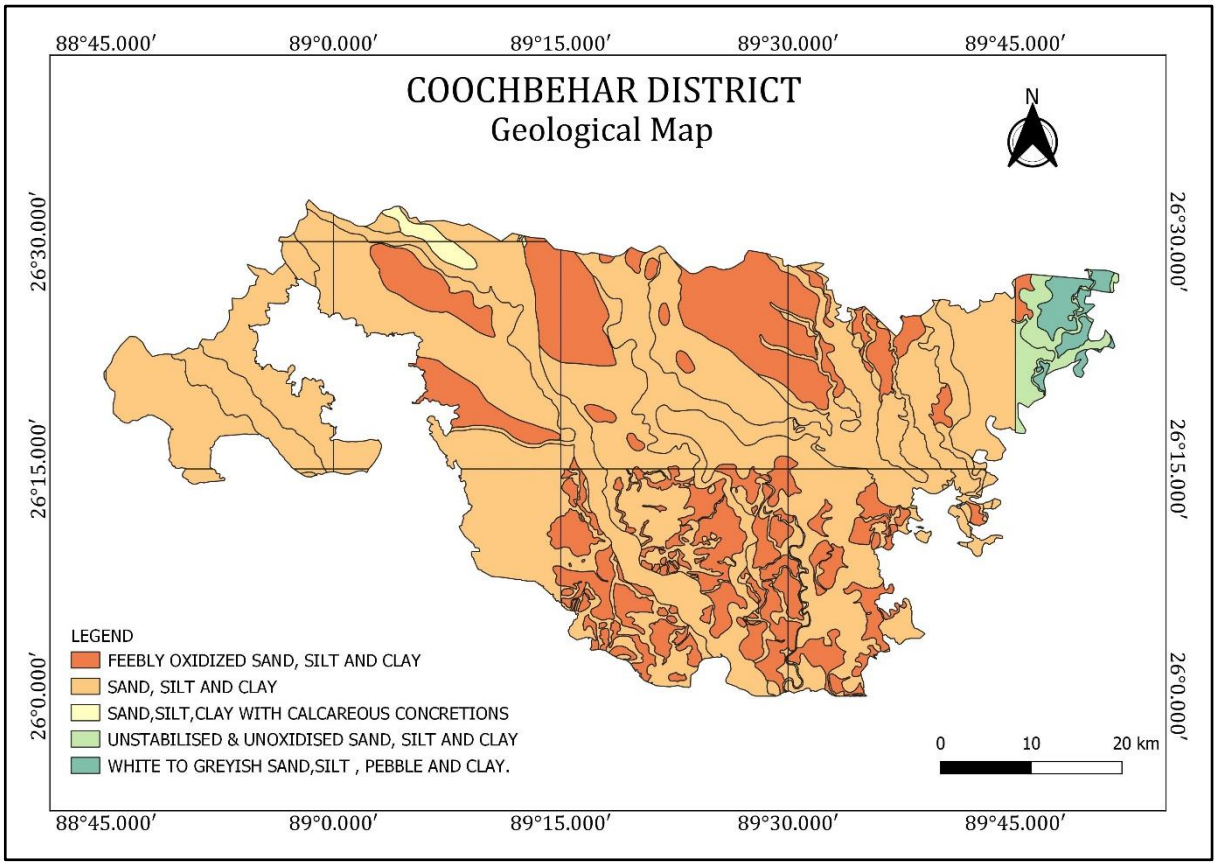

Fig. 4.1: Geological map of the study area

CHAPTER-5

HYDROGEOLOGY

5.1 OCCURRENCE, MOVEMENT, YIELD AND AQUIFER PROPERTIES:

Cooch Behar is basically an alluvial terrain which constitutes its principal aquifer system. There is only one major aquifer in the area, that is Younger Alluvium which covers the whole district. Younger alluviums are quaternary sediments deposited by the Himalayan rivers flowing through the basin.

Younger Alluvium comprising of coarse to fine sand (gravel deposits at few areas) constitutes the main repository of ground water in the area. These deposits are capable of transmitting ground water at large and are replenished easily by downward percolation of rain water during monsoon. The groundwater occurs under water table and semi to confined condition within the explored depth of 307.00mbgl. The area has been explored with 3 types of aquifers. The discharge varying from 430 – 2750 lpm. The Static water levels vary from 0.63mbgl to 4.65 mbgl with drawdown vary from 2.38 m to 10.31 m. The transmissivity varies from 195 – 1398 m2/day.

The aquifers in the study area can be broadly categorized into two;

a). Shallow aquifers: These aquifers generally occur under water table and semi-confined conditions. They are essentially restricted to a depth of 30-50 mbgl. However, in some parts the shallow aquifer depth varies from as shallow a 10 mbgl to as deep as 70 mbgl and in some cases extends beyond 100 m bgl.

b). Deeper aquifers: Ground water in deeper aquifers occur confined condition. Exploration up to 307 mbgl has been achieved at Phalimari in Dinhata block. Apart from this, more than 200 m bgl has been explored at Dharambanikuti , Ammunition Depot, of Cooch Behar – I block and at Batrigacch of Dinhata-I Block. In deeper aquifer system there are two aquifer system Aquifer-2 and Aquifer-3. The Aquifer -2 is largely explored and found that there are three aquifer zones (Aquifer -2a, 2b, & 2c). The depth ranage of Aquifer-2 system vary from 70-140 mbgl, however the depth range vary from as shallow as 40 mbgl to as deep as 160 mbgl place to place depending upon local geology.
The Aquifer-3 system is very less explored and as per the explored data the depth range vary from 180 mbgl to 220 mbgl.

The general direction of ground water flow in near surface aquifer as well as the deeper aquifer is from north-west to south-east.

Table 5.1: Water bearing zone/zones tapped for the Aquifers in Cooch Behar District

Block	Location	No. of Aquifers	Water bearing zones (Zones Tapped)	Discharge (m^3/hr)	SWL (mbgl)	Draw down	T (m^2/day)	S
Haldibari	Anguldekha		90-102, 116-128, 140-146	1020	1.1	**2.79**	-	-
Dinhata-I	Batrigachh		135-165	1500	3.65	2.38	-	-
	Phalimari		30.34 –42.77, 79.27 – 85.47, 94.82 – 100.96, 140.00 -169.11	2749.8	4.38	3.8	1397.6	-
Mekhliganj	Jamaldaha		98-104, 150-175	631.8	3.13	4.47	666.2	4.45x10-4
Cooch Behar-I	Harisabha		145-163	483.6	4.65	4.61	195	-
	Ammunition Depot, MES		15-27, 116-128,140-162	438	1.91	10.31	491.16	1.867x10-3
	Dharambanikuti		32.77 –50.80,79.16 – 91.54,106.58 – 118.65,134.02 –152.41	2033.4	0.63	6	1299.68	-
Cooch Behar-II	Dewanhat		57.93 – 66.89, 102.14 –109.76,121.95 – 130.61,133.66 –145.67	1638.6	1.1	9.97	955.9	-

Table-5.2: Long term trends for Aquifer-I & II during Pre-monsoon and post-monsoon season in the last 10 years (2011-2020)

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)
Cooch Behar-I	I		0.33025	--		0.04375	
Cooch Behar-II	I		0.295	--		0.074	
Dinhata-1	I		0.3764	-	-	0.1478	
Dinhata-II	I		0.572333333	--		0.231666667	
Haldibari	I		0.187	--		0.021	
Mathabhanga-I	I		0.405	--		0.034714286	
Mathabhanga-II	I		0.185	--		0.025	
Mekhliganj	I		0.165666667	--		0.042666667	
Sitai	I		0.2715	--			0.0755
Sitalkuchi	I		0.2225	--			0.02175
Tufanganj-I	I		0.340333333	--		--	0.006333333
Tufanganj-II	I		--	0.201666667		--	0.007333333

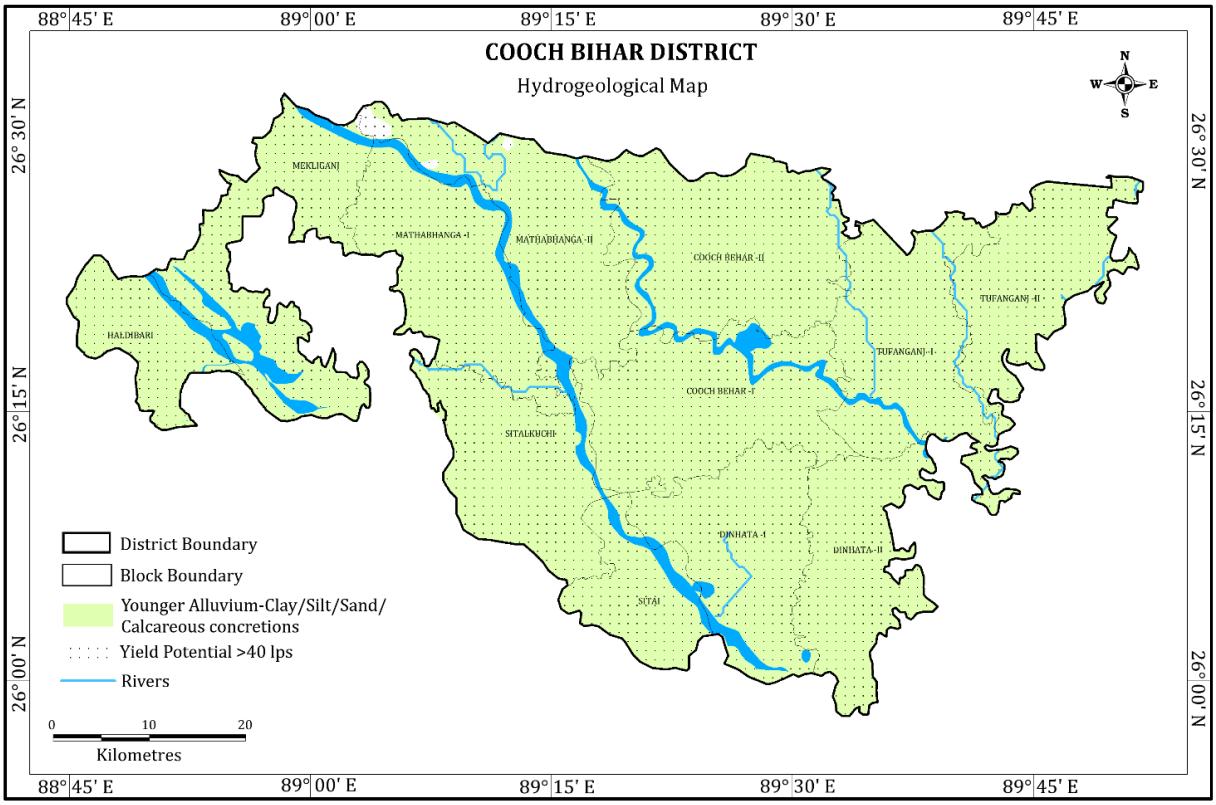

Fig. 5.1: Hydrogeological Map for Cooch Behar District of West Bengal

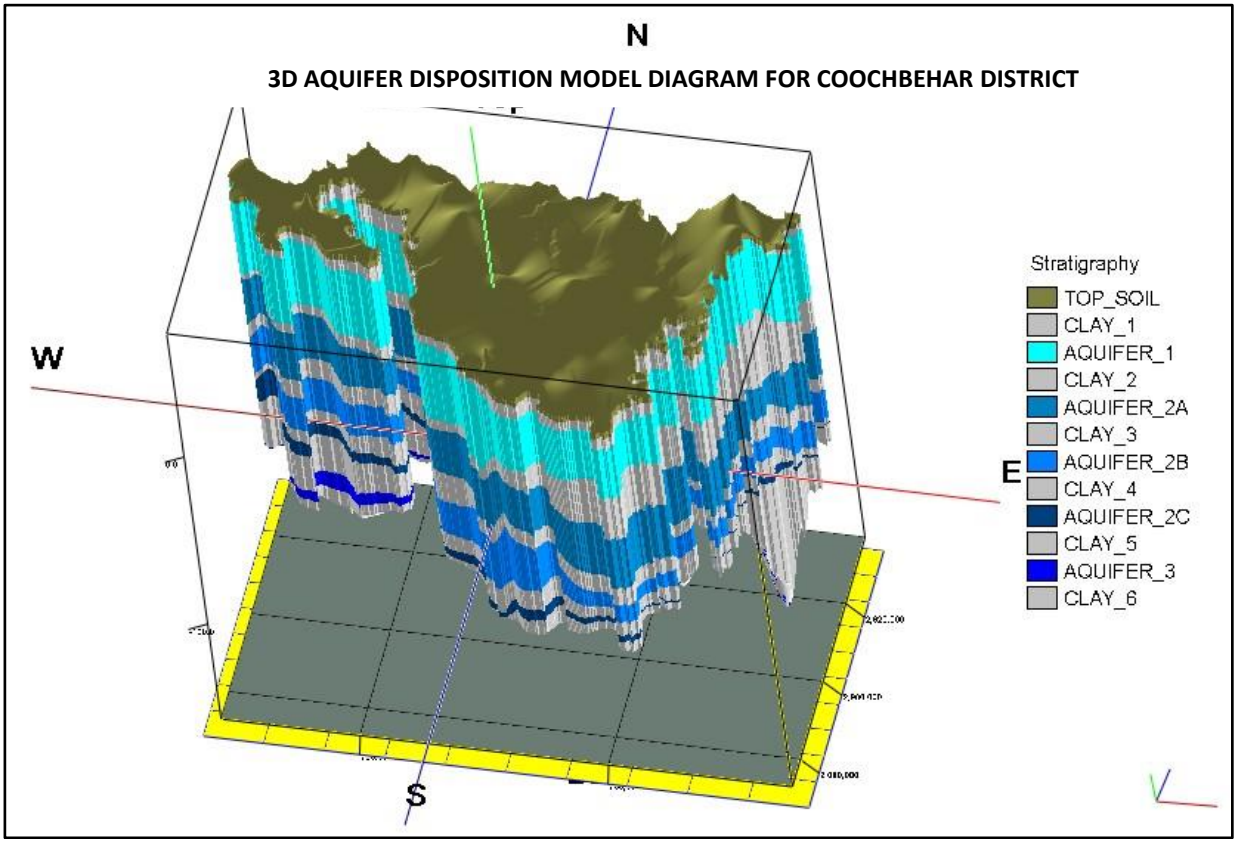

Fig. 5.2: 3D Model diagram for the disposition of Aquifers in Cooch Behar District

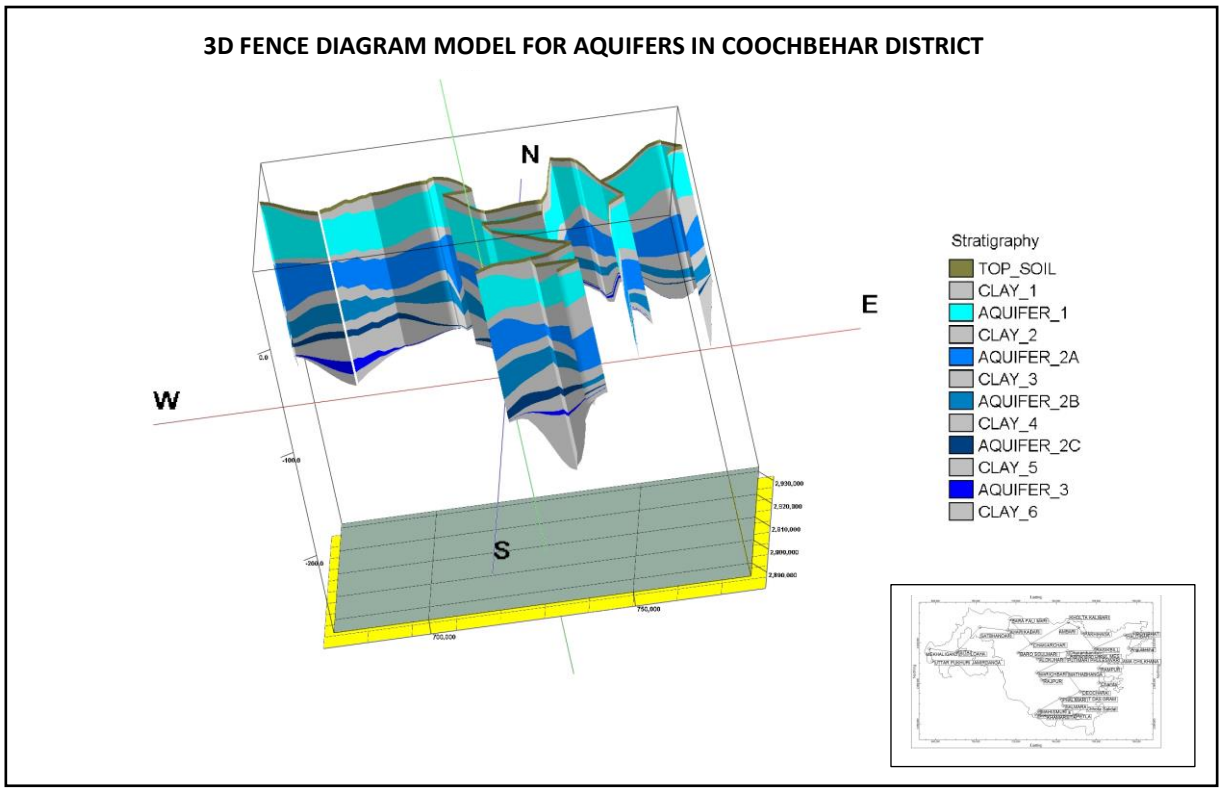

Fig. 5.3: Fence diagram for the disposition of Aquifers in Cooch Behar District

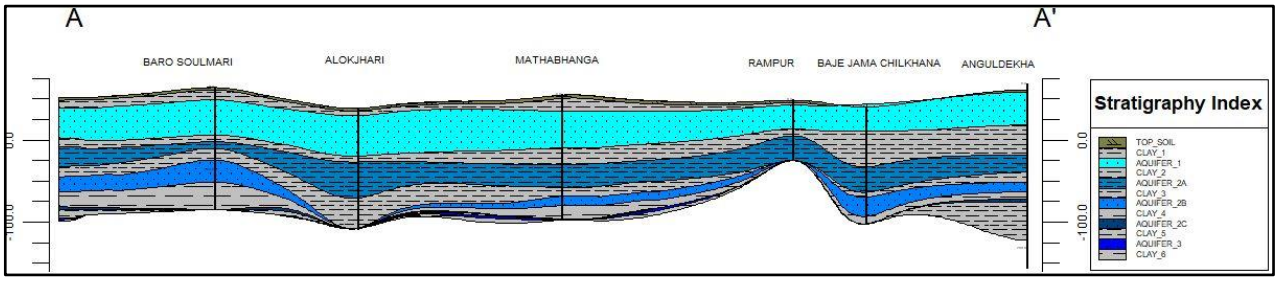

Fig. 5.4: 2D Cross-section diagram for the disposition of Aquifers along E-W in Cooch Behar District

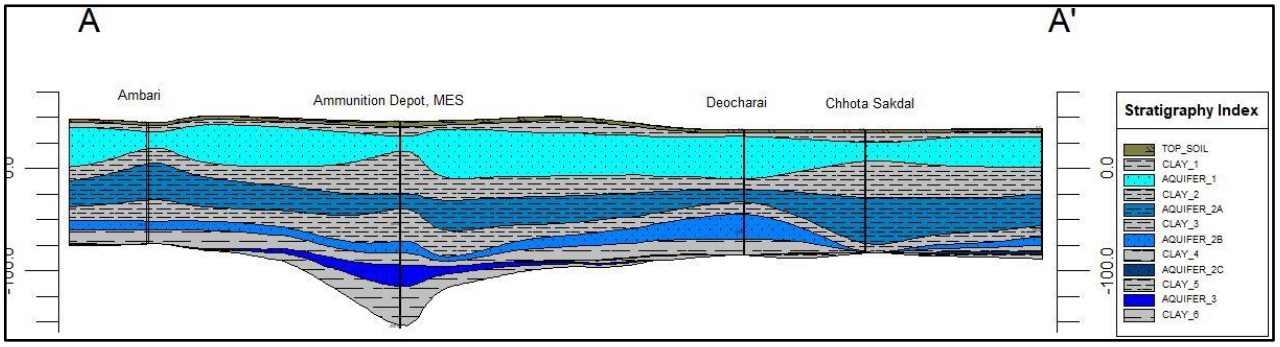

Fig. 5.5: 2D Cross-section diagram for the disposition of Aquifers along N-S Cooch Behar District

The water level contour maps, water table contour maps for shallow and potentiometric surface contour map for deeper aquifers are shown in the following pages.

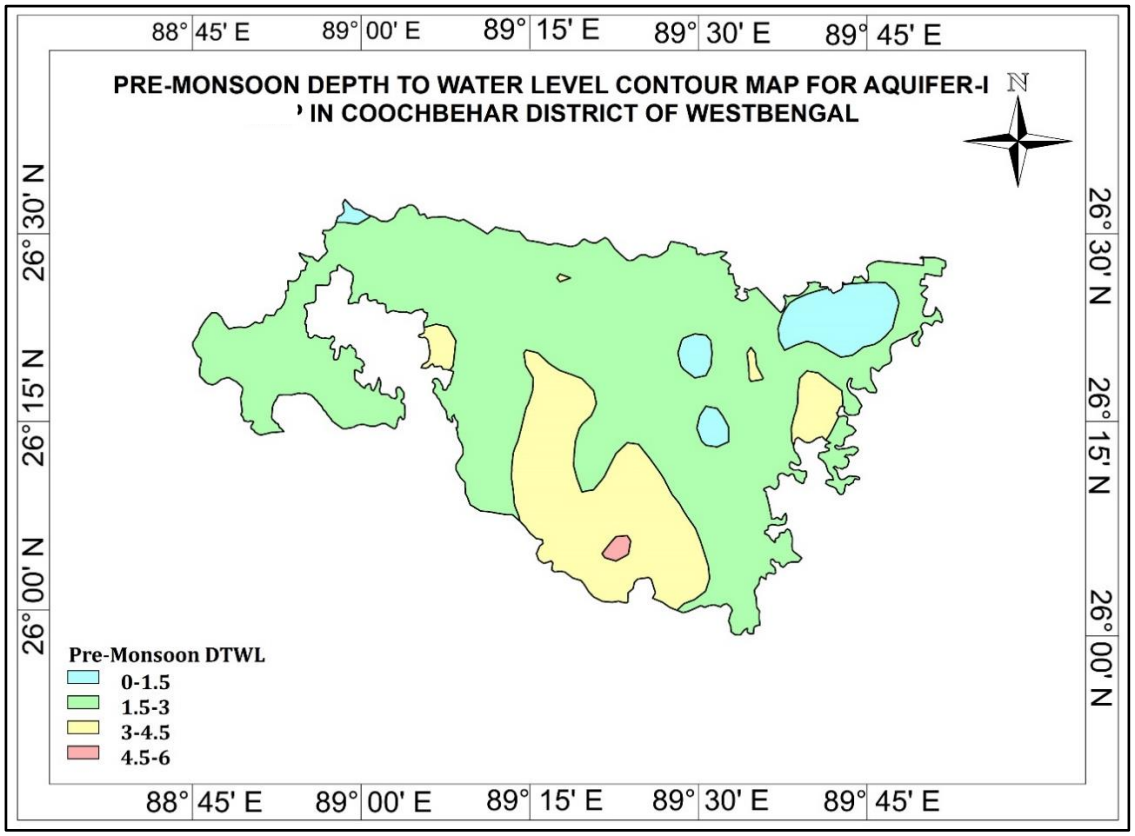

Fig. 5.6: Pre-Monsoon DTWL Contour map for Aquifer-I in Cooch Behar District

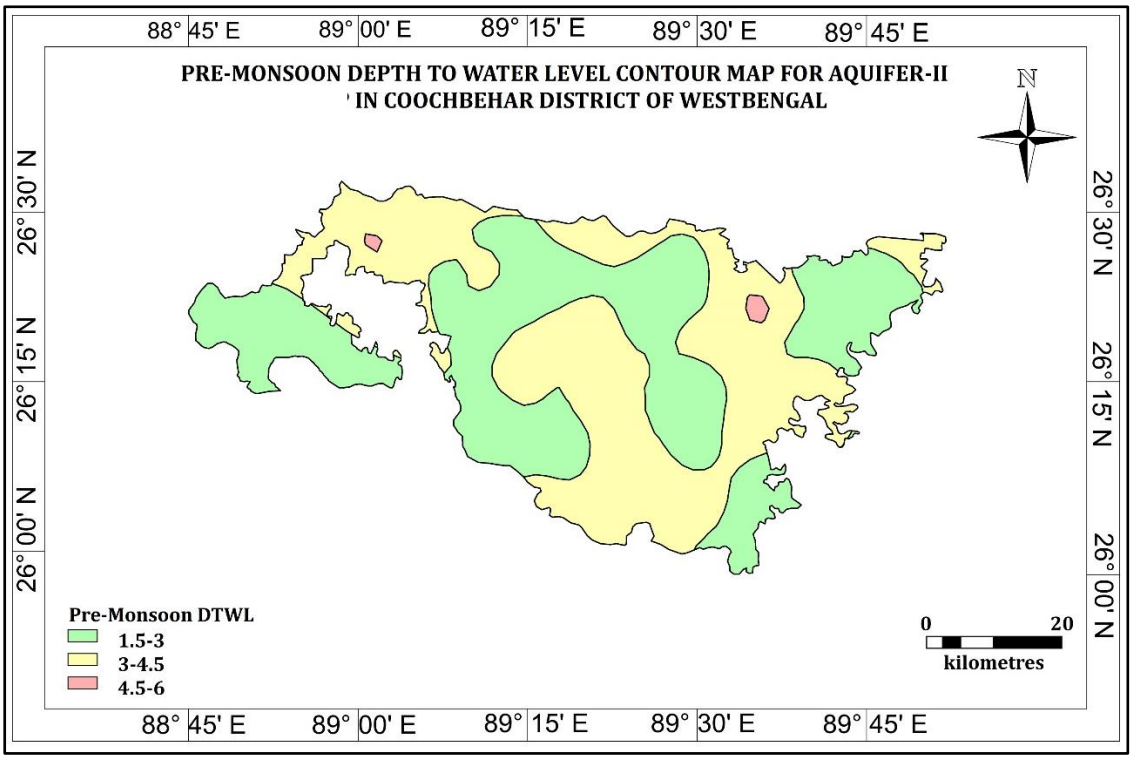

Fig. 5.7: Pre-Monsoon DTWL Contour map for Aquifer-II in Cooch Behar District

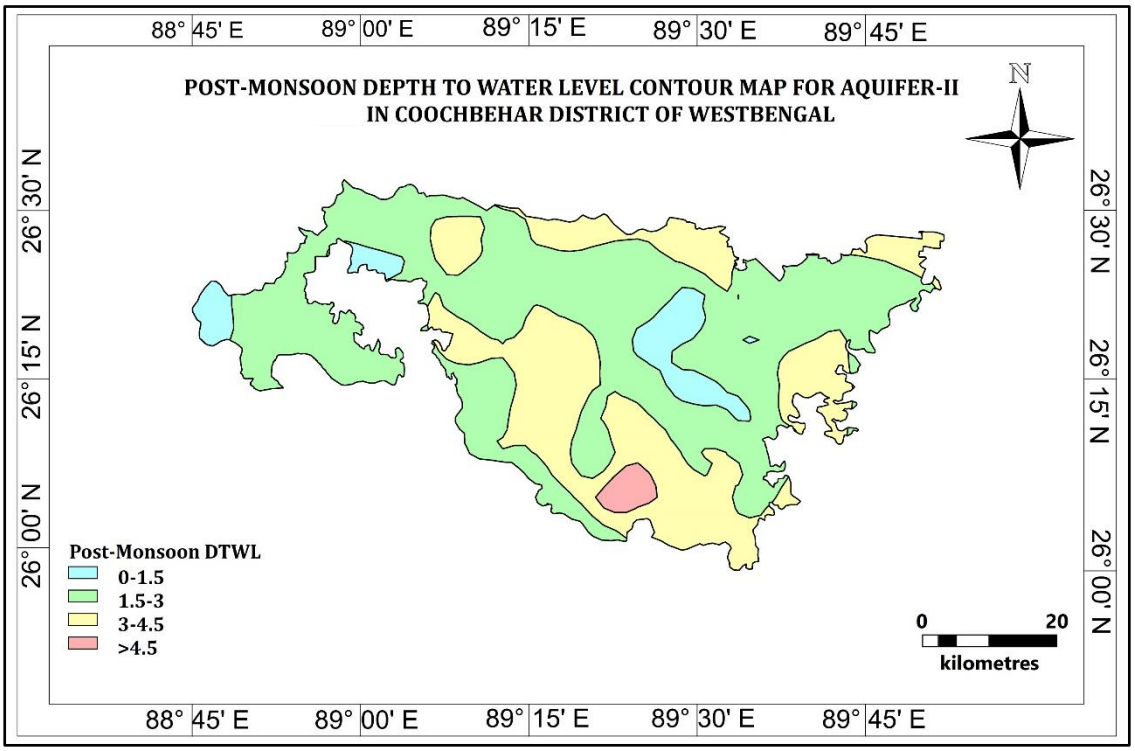

Fig. 5.8: Post-Monsoon DTWL Contour map for Aquifer-I in Cooch Behar District

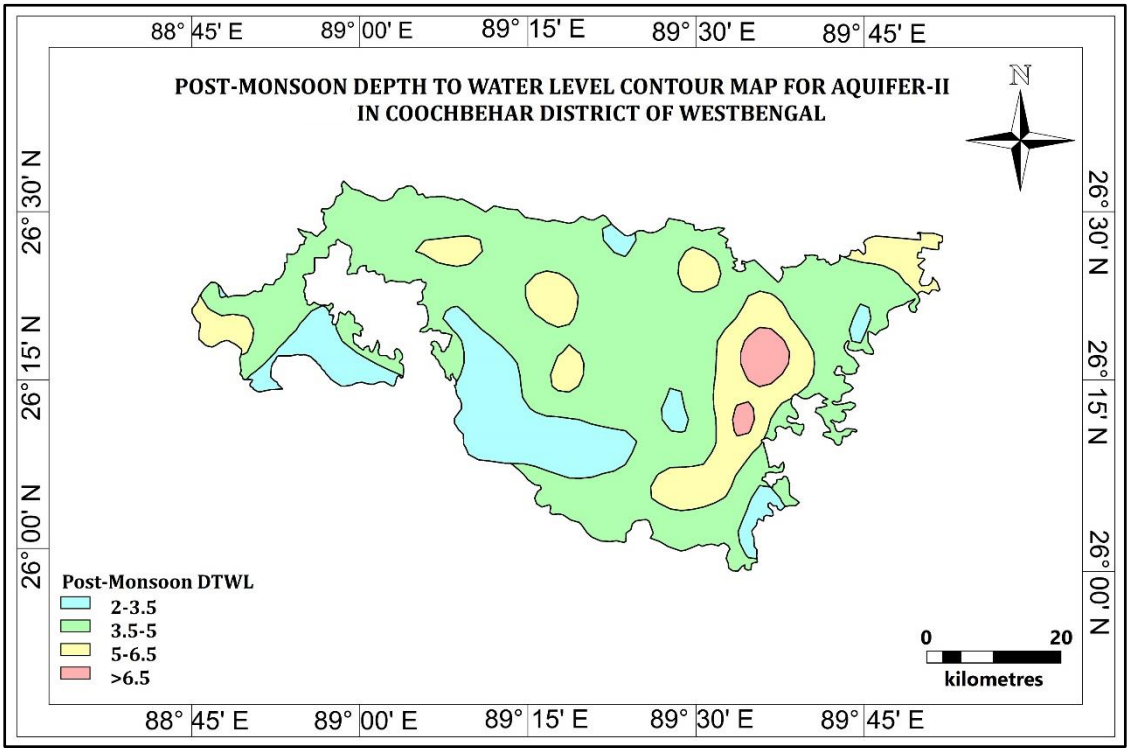

Fig. 5.9: Post-Monsoon DTWL Contour map for Aquifer-II in Cooch Behar District

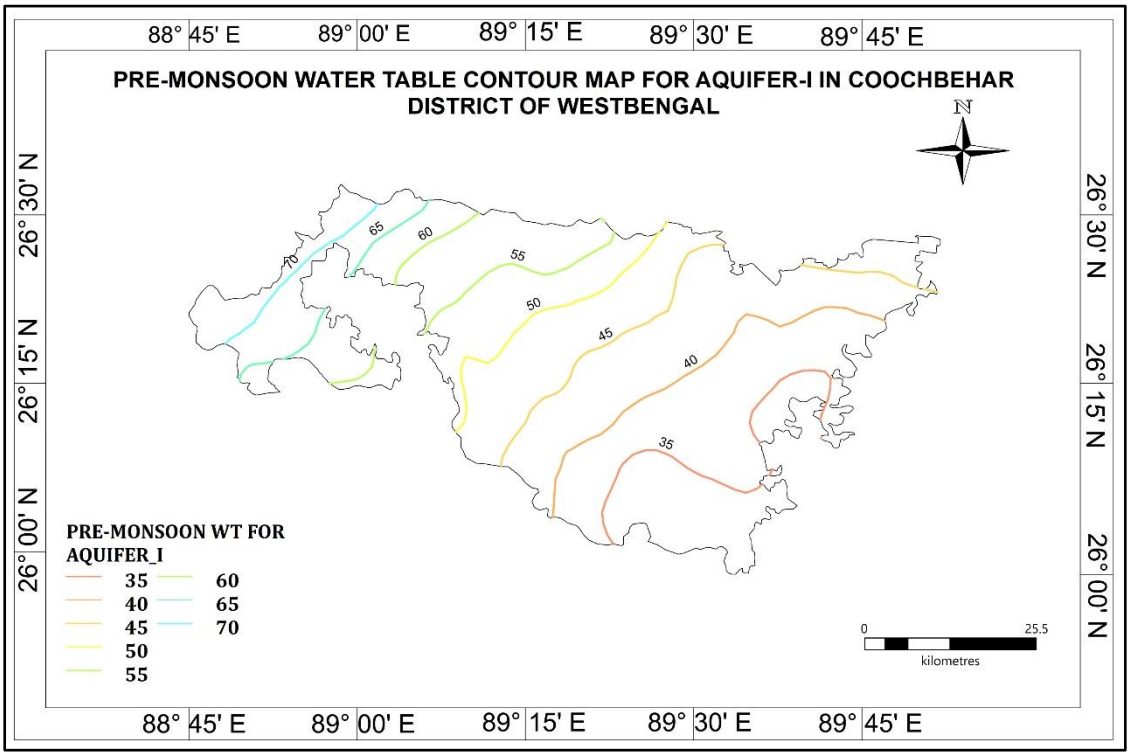

Fig. 5.10: Pre-Monsoon Water Table Contour map for Aquifer-I in Cooch Behar District

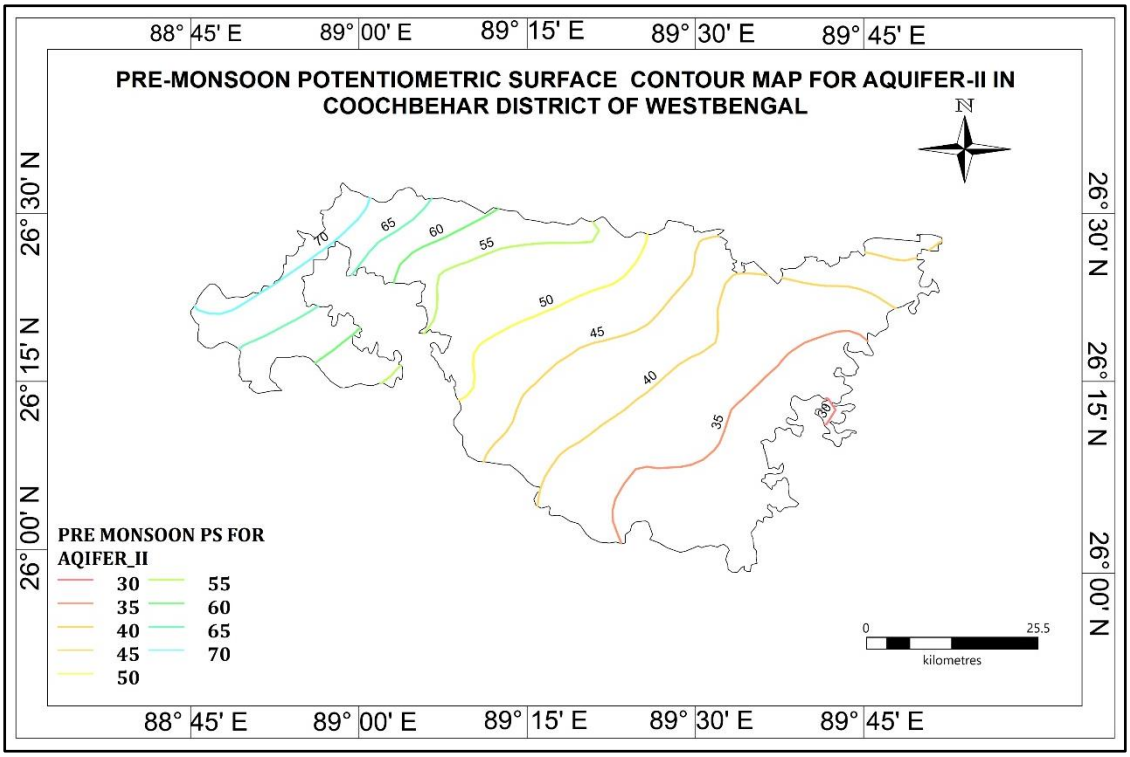

Fig. 5.11: Pre-Monsoon Potentiometric Surface Contour map for Aquifer-I in Cooch Behar District

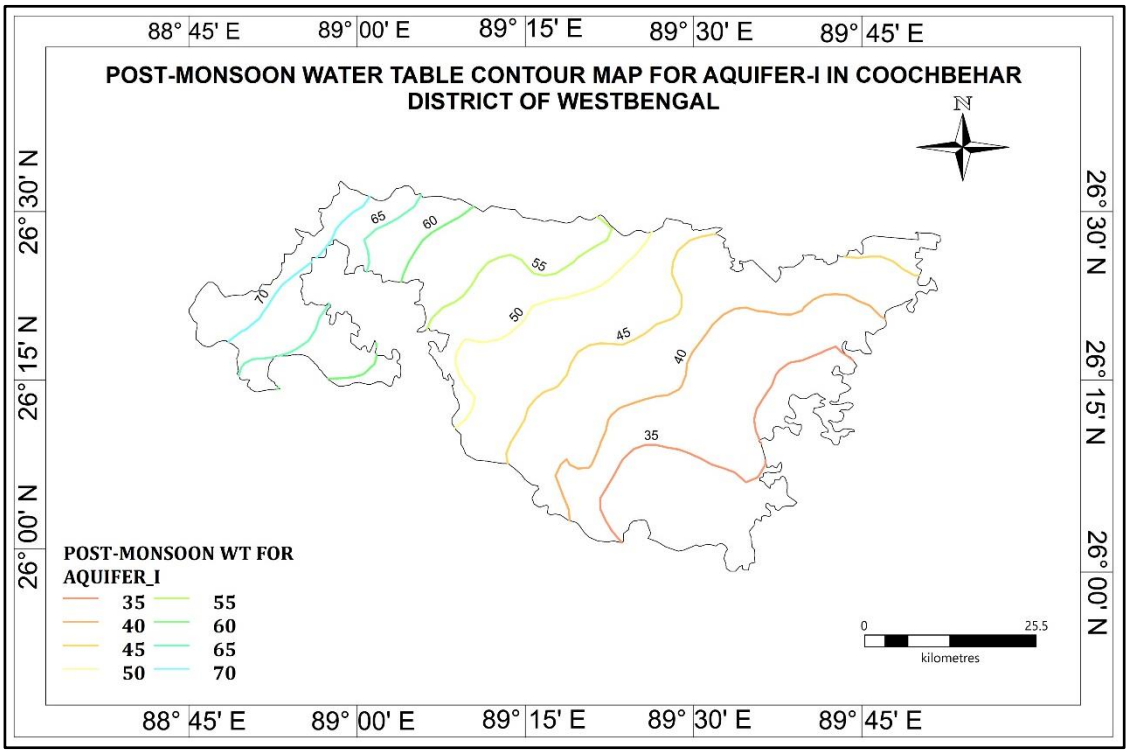

Fig. 5.12: Post-Monsoon Water Table Contour map for Aquifer-I in Cooch Behar District

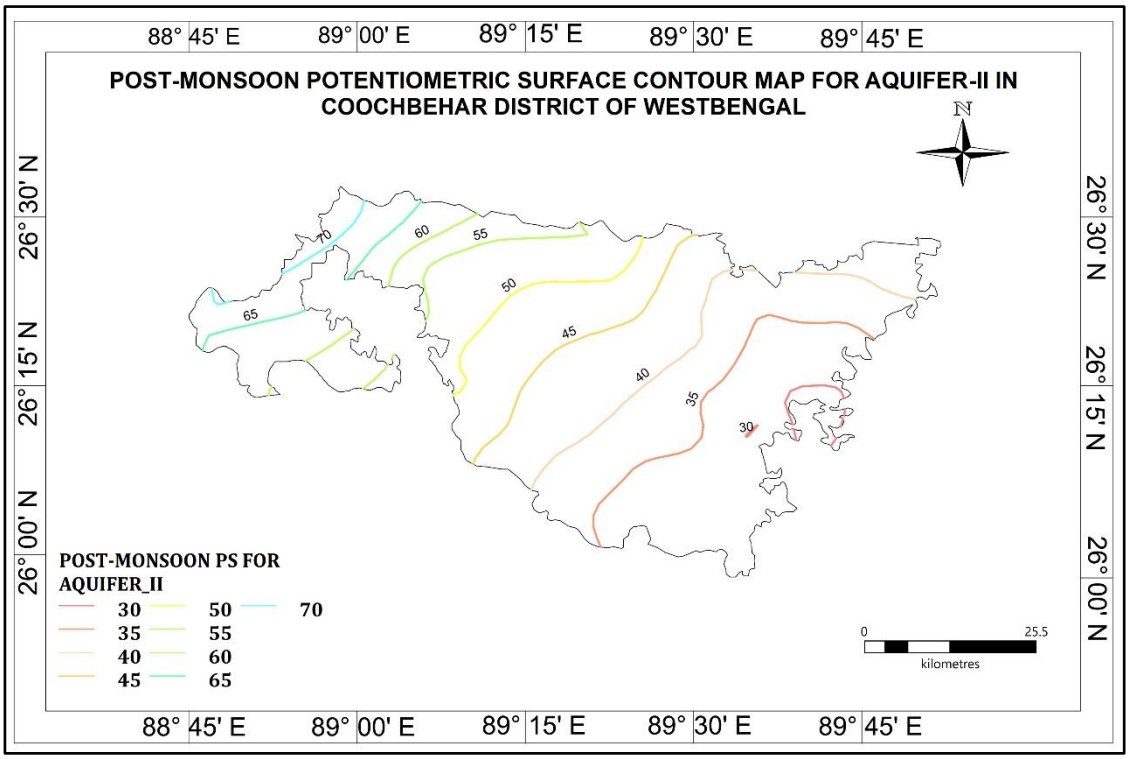

Fig. 5.13: Post-Monsoon Potentiometric Surface Contour map for Aquifer-II in Cooch Behar District

CHAPTER- 6

GROUND WATER RESOURCE ESTIMATION

6.1 DYNAMIC WATER RESOURCE

The present chapter deals with the resources available in the study area. The Dynamic Resource of the area for 2017 has been calculated jointly by CGWB and SWID (State Water Investigation Directorate) using GEC-2015 methodology. The irrigation data available to the 5th 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 considered 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.

As per the computation, the net ground water availability for recharge for Cooch Behar district is estimated at 353275.05 Ham, while the total extraction for all uses is estimated at 131824.1 Ham. The categorization of the blocks has been done based on their Stage of Development and long-term water level trend.

6.2 GROUND WATER RECHARGE AND RESOURCE

Recharge from ground water irrigation through a system of abstraction structures like deep tube wells, shallow tube wells and dug wells, surface water irrigation by surface liftand flow modes and rainfall has been separately calculated for both monsoon and non- monsoon periods. The annual recharge for this district is relatively high and the maximum recharge is from monsoon rainfall during monsoon while during the non-monsoon season the maximum recharge is from other sources. Ground water 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 projectingthe population and the number of ground water abstraction structures. The total extraction for the blocks as a whole is 131824.1 Ham.

6.3 STAGE OF DEVELOPMENT AND CATEGORY

The unit of assessment is categorized for groundwater development based on two criteria; Stage of ground water development and long-term water level trends. The level of ground water development in Cooch Behar district (41.46 %) is nearly equal to the state average of 42%. All the blocks in the district are under 'Safe' category as theirstage of groundwater development is < 70% and there is steady water level over the years. The following table gives an account of the groundwater recharge, their draft, andallocation of resource for future use, stage of development and categorization of the blocks in Dakshin Dinajpur district.

Table-6.1: Ground water Recharge, Resource and Stage of Development

BLOCK NAME	Total Annual Ground Water Recharge (Ham)	Total Natural Discharges (Ham)	Annual Extractable Ground Water Recharge (Ham)	Total Extraction	Annual GW Allocation for Domestic and Industrial Use as on 2042	Net Ground Water Availability for future irrigation use	Stage of Ground Water Extraction (%)	Categorization
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
COOCH BEHAR-I	41617.91	4161.79	37456.12	16804.12	651.28	20609	44.86	Safe
COOCH BEHAR-II	35160.28	3516.03	31644.25	14834.17	695.23	16755.43	46.88	Safe
DINHATA-I	32038.45	3203.85	28834.6	14795.75	590.89	13981.19	51.31	Safe
DINHATA-II	27128.12	2712.81	24415.31	11252.13	490.26	13127.54	46.09	Safe
HALDIBARI	13513.25	1351.33	12161.92	4122.89	194.54	8038.15	33.90	Safe
MATHABHANGA-I	31957.84	3195.78	28762.06	10381.93	442.08	18344.47	36.10	Safe
MATHABHANGA-II	32518.8	3251.88	29266.92	14604.06	461.69	14624.74	49.90	Safe
MEKHLIGANJ	30327.65	3032.76	27294.89	6093.67	316.93	21173.47	22.33	Safe
SITAI	21844.84	2184.48	19660.36	4835.48	226.66	14803.74	24.60	Safe
SITALKUCHI	26840.45	2684.05	24156.4	9168.09	370.22	14963.35	37.95	Safe
TUFANGANJ-I	33701.32	3370.13	30331.19	14597.19	513.9	15683.16	48.13	Safe
TUFANGANJ-II	26626.14	2662.61	23963.53	10334.62	382.83	13593.89	43.13	Safe
	353275.05	**35327.5**	**317947.55**	**131824.1**	**5336.51**	**185698.13**	**41.46**	

6.4 IRRIGATION POTENTIAL CREATED AND UTILIZED

The net ground water availability for future irrigation use in the district is estimated at 185698.13 Ham. This available balance resource could be utilized efficiently as per feasibility of the area. Presently, irrigation in the district is practiced maximum through shallow tube wells (Table 1.6.3). Since these blocks falls under 'Safe' category, there is further scope for expansion of ground water irrigation through additional irrigation potential with available resource. The

irrigation potential created and the net irrigated area through means of various abstraction structures are given in Table 6.2. Apart from common abstraction structures like dug wells, shallow tube wells and deep tube wells, there are number of surface water bodies in use for irrigation in this district. As per 5th MI Census record, there are a total of 6450 water bodies in the district out of which 5955 are for non-irrigation purpose, 288 water bodies are in use for irrigation and 207 are defunct. Out of 125 defunct water bodies, 17 are found to have the possibility of being revived.

Table-6.2: Irrigation potential created and actual area irrigated with groundwater in the study area (Source: 5th MI census)

DIST.	BLOCK	IRRIGATION POTENTIAL CREATED	ACTUAL/NET AREA IRRIGATED	ACHIEVEMENT (%)
Cooch Behar	COOCH BEHAR-I	8159.10	4234.59	52
	COOCH BEHAR-II	9919.92	3398.69	34
	DINHATA-1	9386.95	5355.89	57
	DINHATA-II	7794.61	2673.43	34
	HALDIBARI	2733.13	854.14	31
	MATHABHANGA-I	6868.66	3371.48	49
	MATHABHANGA-II	11873.38	4625.9	39
	MEKHLIGANJ	6844.87	3272.36	48
	SITAI	5772.06	2830.88	49
	SITALKUCHI	6631.22	2737.32	41
	TUFANGANJ-I	13023.46	6390.15	49
	TUFANGANJ-II	6539.30	2430.28	
Total		139891.37	42175.11	42175.11

6.5 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 -6.3: In-storage of groundwater for the study area (Cooch Behar)

Sl. No.	District	Assessment Unit/ District	Total Fresh In-Storage Ground Water Resources (2009)
1	Cooch Behar	COOCH BEHAR-I	526717
2		COOCH BEHAR-II	520349
3		DINHATA-I	353150
4		DINHATA-II	145963
5		HALDIBARI	210064
6		MATHABHANGA-I	446922
7		MATHABHANGA-II	443644
8		MEKHLIGANJ	408053
9		SITAI	213081
10		SITALKUCHI	144558
11		TUFANGANJ-I	273615
12		TUFANGANJ-II	361095
	Total		**794944**

CHAPTER- 7

GROUNDWATER QUALITY

Groundwater samples have been analyzed for Basic Parameters, Iron and other specific constituents collected from 12(twelve) blocks of Cooch Behar District. In next few paragraphs we discussed our findings.

pH: pH varies from 6.27 to 7.79 with an average of 7.13. Result indicates that **groundwater** as almost neutral to slightly alkaline in nature. All the samples are found within the permissible limit of 6.5 - 8.5 as per BIS 2012 except 3 samples (Fulkar Dabri, Uttar Bartar, Bromattar Kashal Danga) which are vary from 6.27 to 6.46 13 Fulkar Dabri, Uttar Bartar, Bromattar Kashal Danga.

EC &TDS: The wide range of Electrical Conductivity (EC) as well as Total Dissolve Solids (TDS) values indicates little variation in dissolved constituents in groundwater. The minimum conductivity value of Aquifer I is 81 µS cm^{-1} (at 25°C) whereas, maximum conductivity value of 819 µS cm^{-1} (at 25°C) has been observed. Similarly, in Aquifer II the minimum conductivity value is 103 µS cm^{-1} (at 25°C) whereas, maximum conductivity value of 384 µS cm^{-1} (at 25°C) has been observed.One sample of Aquifer I from Mekhliganj block (Alokjhari) showed TDS values higher than the Desirable Limit of 500 mg l^{-1}but no sample has TDS value higher than the permissible limit of 2000 mg l^{-1}.

Total Hardness as CaCO3: In general, the quality of groundwater in terms of Total Hardness as CaCO3 has been found in the range 30 – 275 mg l^{-1} for Aquifer I (the water class vary from soft to hard) and in the range 35 – 165 mg l^{-1} (the water class vary from soft to moderately hard except 2 samples).

Carbonate & Bi-Carbonate: All the samples are characterized by the presence of bi-carbonate and absence of carbonate. The value of Bi-carbonate alkalinity in study area ranged from 31 mg l^{-1} to 360 mg l^{-1}.

Chloride, Nitrate & Sulphate: Chloride content of groundwater varies from 7 mg l^{-1} to 99 mg l^{-1}**.** All the analyzed samples show Chloride concentration lower than the acceptable limit of 250 mg l^{-1} and below the permissible limits of 1,000 mg l^{-1} as per BIS (2012). Nitrate concentration of the analyzed samples ranged from traces to 99 mg l^{-1} NO3 concentration in samples lie within the permissible limit of 45 mg l^{-1} (BIS: 2012) except three dug-well samples which may be due to long term effect of unused condition and decomposition of organic waste. Concentration of Sulphate ion ranges from traces to 60 mg l^{-1}. None of the samples showed sulphate concentration higher than the acceptable limit of 200 mg l^{-1} (BIS: 2012).

Fluoride: Fluoride ion concentration varies from 0.22 mg l-1 to 0.71 mg l^{-1}, None the analysed samples detected having Fluoride concentration higher than the permissible limit of 1.5 mg l^{-1} (BIS: 2012). Bengal.

Iron (Fe): As per BIS (2012), the Permissible Limit for Iron in drinking water is 1.0 mg l^{-1}. The Fe content from the samples in the study range between Traces to 9.3 mg l^{-1} in Aquifer I and range between Traces to 7.73 mg l^{-1} in Aquifer II. Almost all the blocks of the Cooch Behar district have Iron issue except Sitai block. The maximum Concentration was observed from Aquifer I is 9.63 mg/l in Cooch Behar II block and 7.73 mg/l from Aquifer II in Mathabhanga I block.

Uranium (U): The range of Uranium varies from traces to 3.36 (µg/l). The highest concentration is observed at Dhanmatia, Tufanganj II block. All of the analyzed groundwater samples were found safe (U<0.03 mg L^{-1}, WHO provisional guideline) asper observed Uranium concentration.

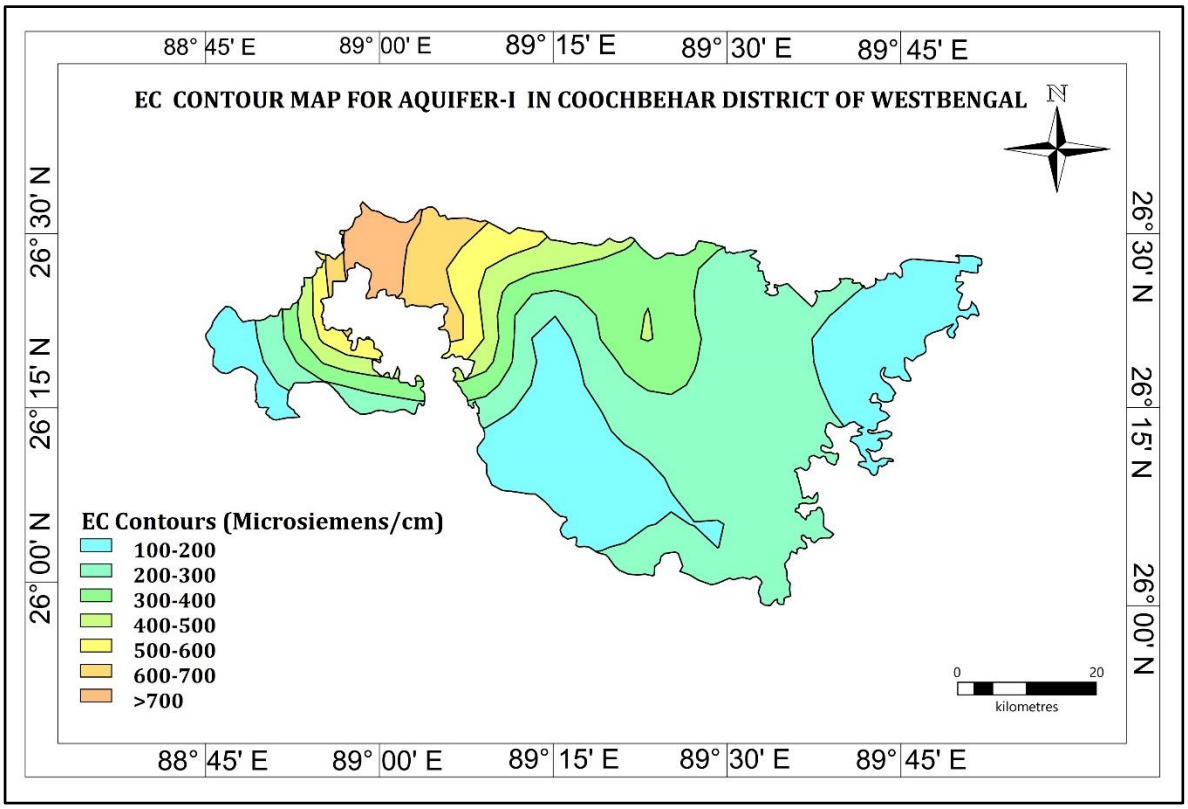

Fig. 7.1: EC Contour Map of Aquifer-I for Cooch Behar District

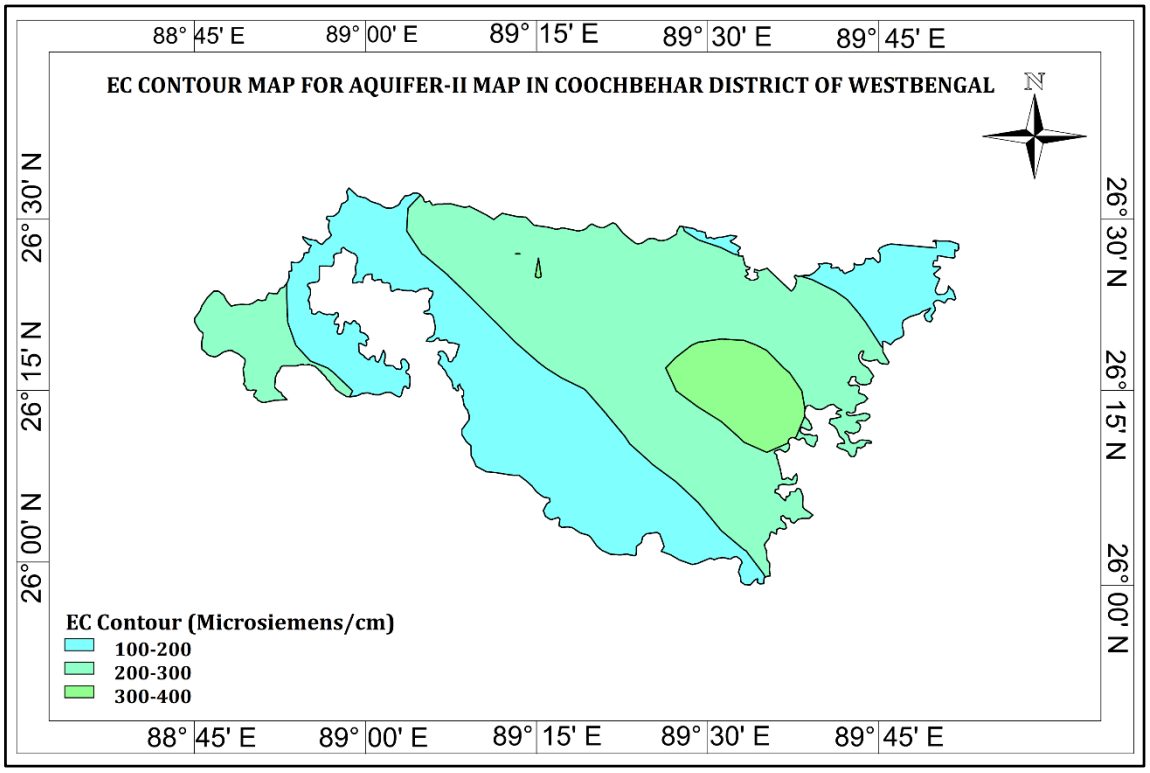

Fig. 7.2: EC Contour Map of Aquifer-II for Cooch Behar District

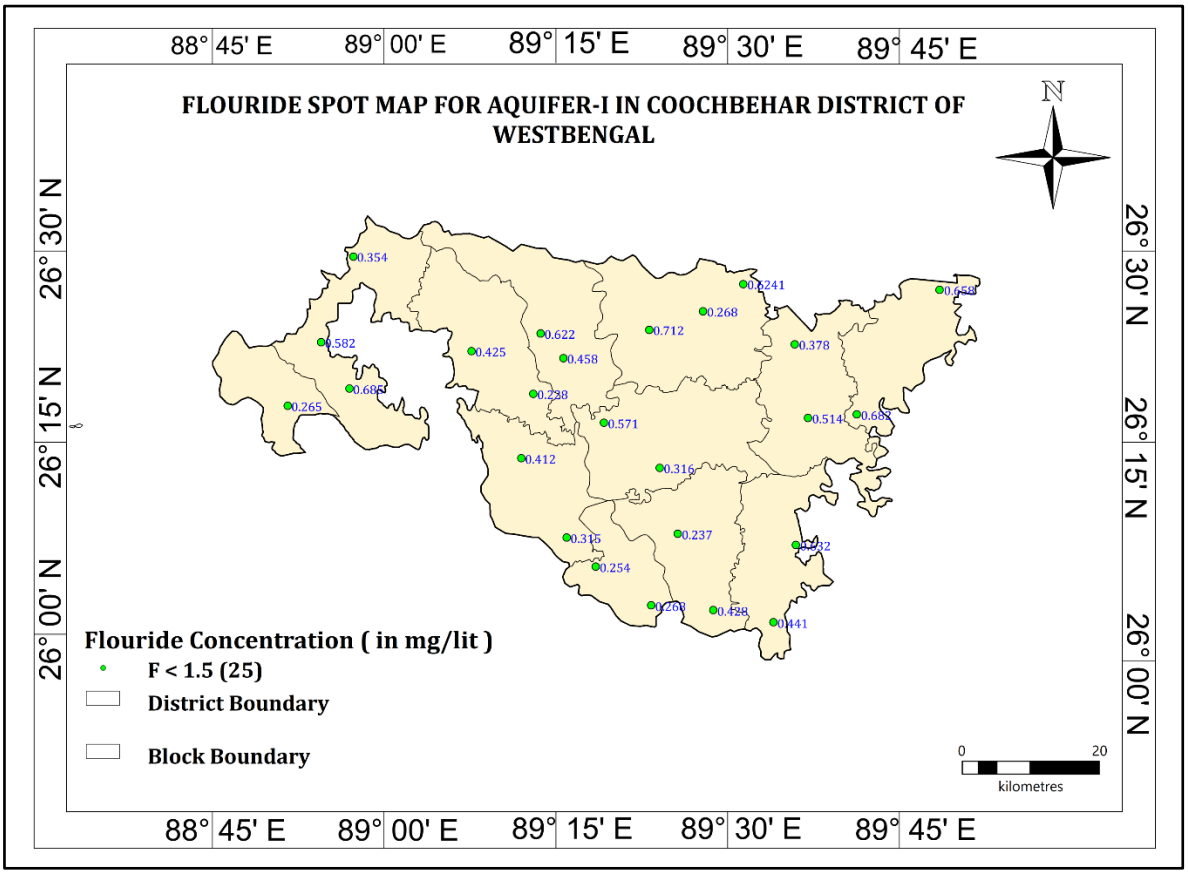

Fig.7.3: Fluoride Spot Map of Aquifer-I for Cooch Behar District

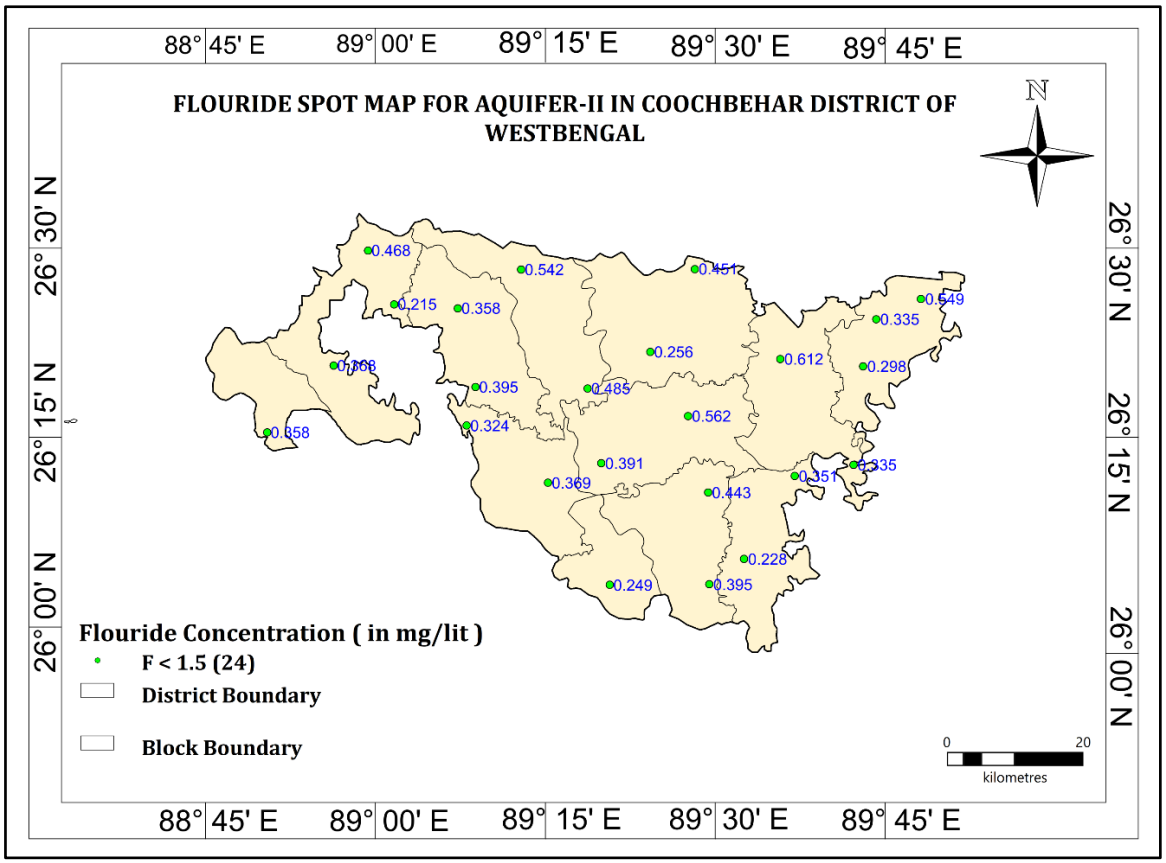

Fig.7.4: Fluoride Spot Map of Aquifer-II for Cooch Behar District

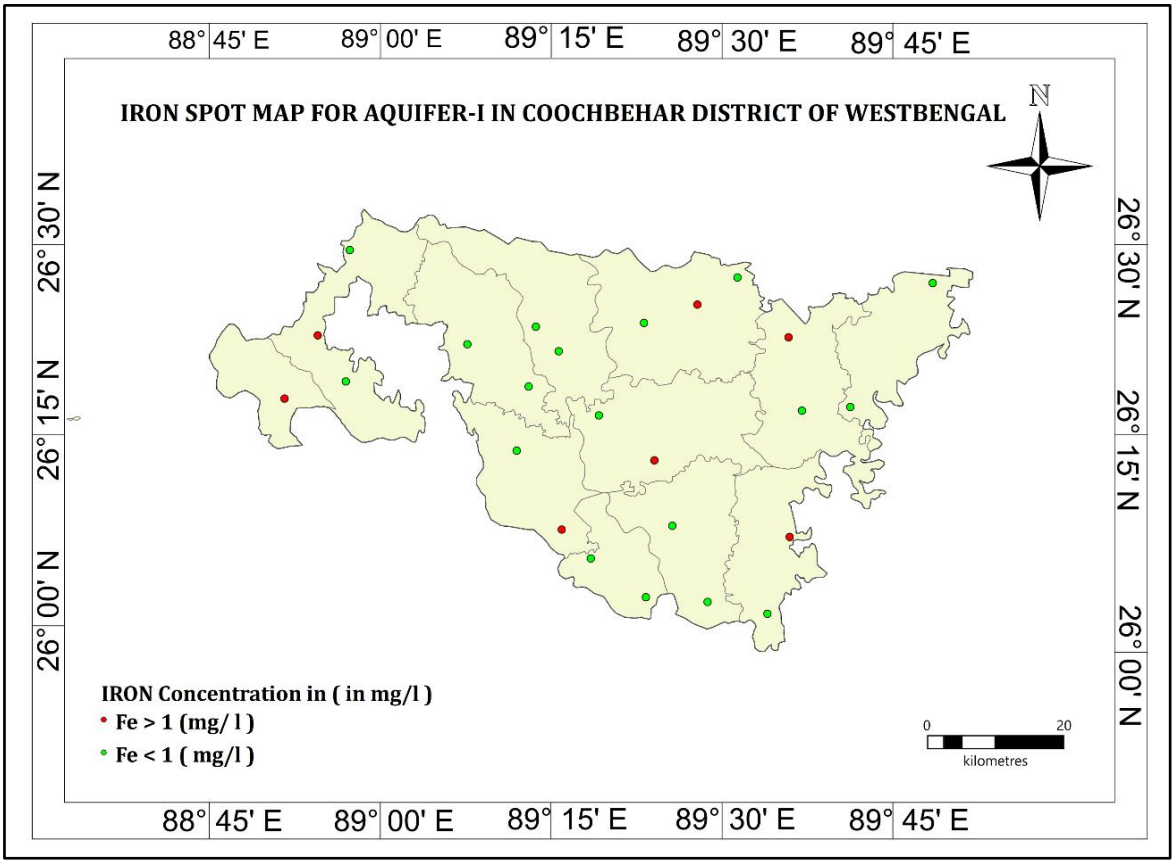

Fig.7.5: Iron Spot Map of Aquifer-I for Cooch Behar District

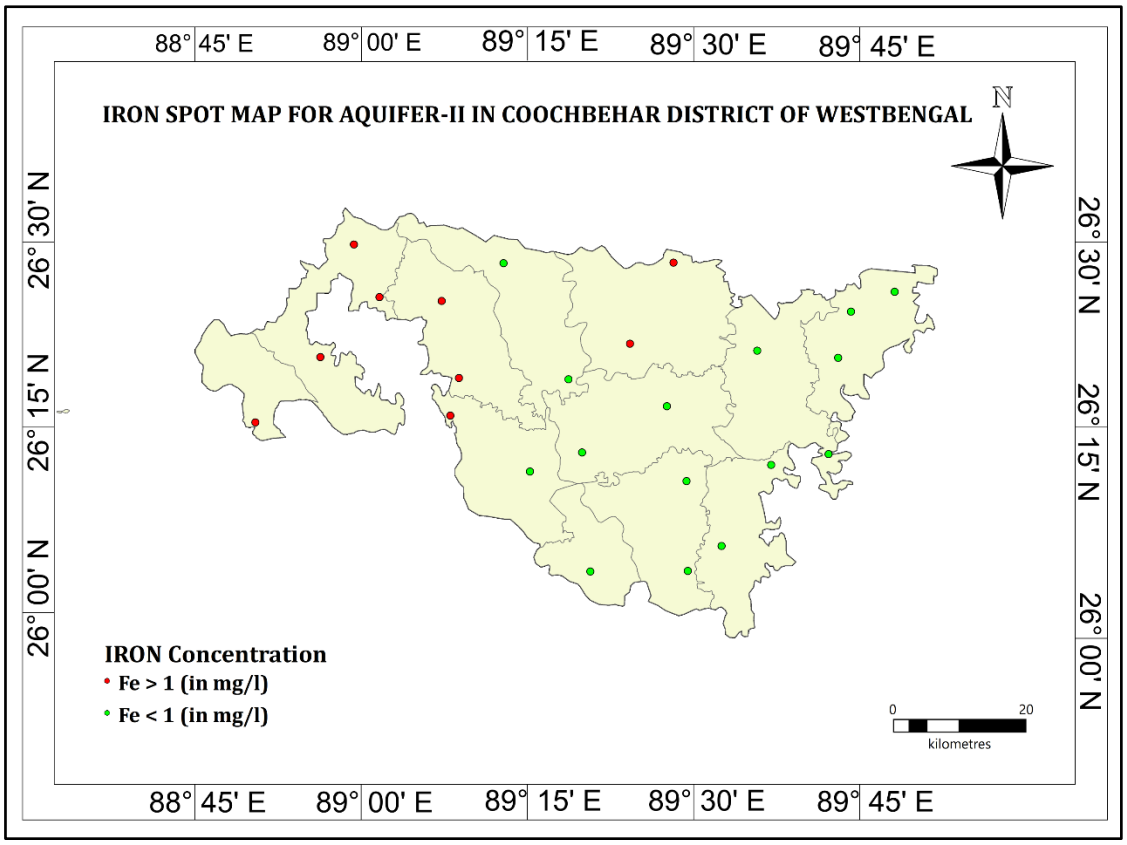

Fig.7.6: Iron Spot Map of Aquifer-II for Cooch Behar District

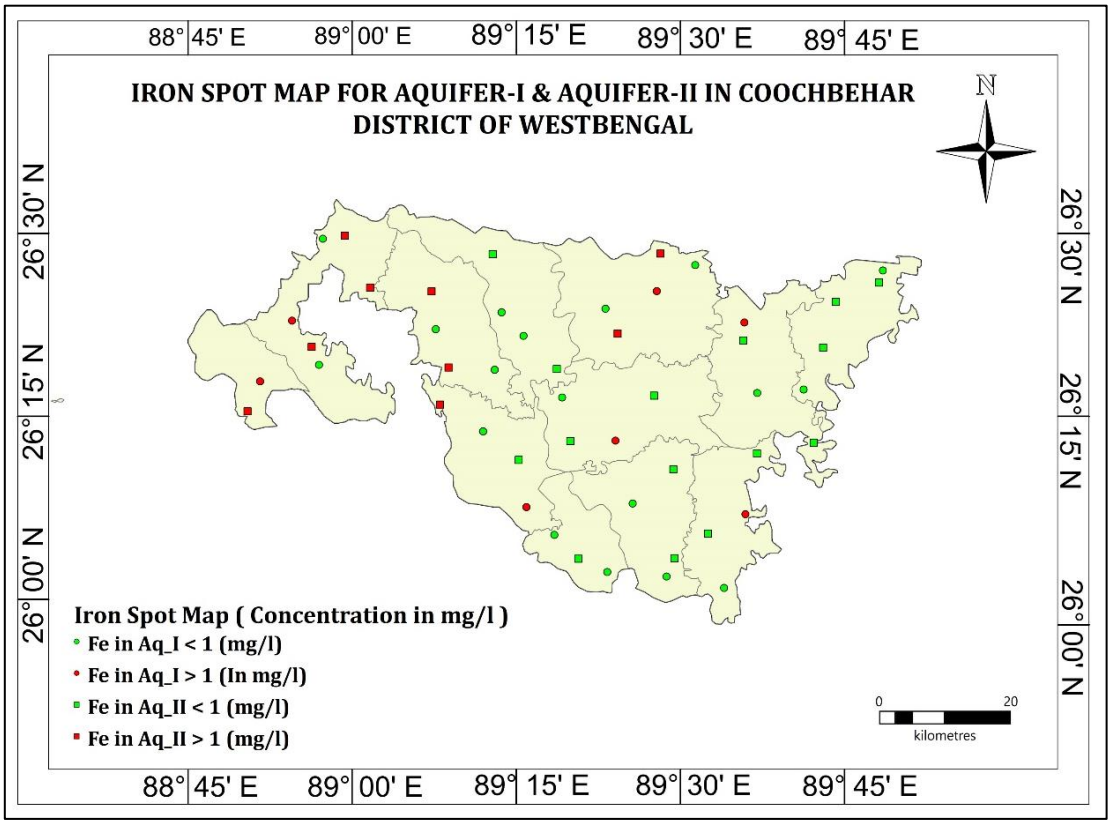

Fig.7.7: Iron Spot Map of Aquifer-II for Cooch Behar District

Table 7.1 Groundwater Physicochemical Constituents for Aquifer-I

Block	Location	Source	Lat	Long	pH	EC	TH	Ca	Mg	Na	K	CO3	HCO3	Total Alk as CaCO3	Cl	NO3	SO4	F	TDS	Fe	U (µg/l)
Haldibari	Deewanganj	Mark ii shallow	26.2984	88.8568	6.81	164	50	16	2	13	3	0	73	60	14	BDL	BDL	0.27	93	8.72	0.02
Mekhliganj	13 fulkar dabri	Dug well	26.3208	88.9465	6.27	521	145	40	11	24	31	0	122	100	50	98	BDL	0.69	328	BDL	0.08
Mekhliganj	147 vot bari	Dug well	26.3813	88.9055	7.22	673	140	50	4	61	49	0	238	195	92	8	BDL	0.58	409	1.24	0.31
Mathabhanga -I	Ashokbari-1	Dug well	26.3696	89.1243	7.22	776	160	34	18	55	75	0	195	160	99	67	BDL	0.43	468	BDL	0.06
Mathabhanga -I	Baishguri(pachagarh)	Shallow tubewell	26.3140	89.2142	6.52	150	45	14	2	13	3	0	61	50	18	5	BDL	0.23	93	0.08	BDL
Mathabhanga -II	Taurikata	Dug well	26.3605	89.2580	6.91	174	60	20	2	12	4	0	73	60	21	BDL	BDL	0.46	104	0.30	0.02
Mathabhanga -II	Angarkata parodubbi	Shallow tubewell	26.3928	89.2247	6.79	81	30	8	2	4	2	0	37	30	7	BDL	BDL	0.62	47	BDL	BDL
Sitai	Uttar bartar	Dug well	26.0378	89.3858	6.33	294	75	24	4	25	11	0	85	70	50	BDL	BDL	0.27	165	0.11	BDL
Sitai	Kuna chatra	Shallow tubewell	26.0885	89.3050	6.58	94	35	10	2	5	2	0	37	30	11	BDL	BDL	0.25	53	0.16	BDL
Sitalkuchi	Chaat lalbazzar	Shallow tubewell	26.1264	89.2626	6.65	130	50	16	2	6	3	0	31	25	14	24	BDL	0.32	85	1.92	BDL
Sitalkuchi	Barapinjar jhar	Shallow tubewell	26.2298	89.1966	7.10	126	35	12	1	11	3	0	31	25	18	12	BDL	0.41	75	0.95	0.01
Dinhata-II	Shaebganj	Dug well	26.1167	89.5962	7.45	306	140	48	5	7	4	0	177	145	14	BDL	BDL	0.63	187	2.25	0.04
Dinhata-I	Gitaldaha	Shallow tubewell	26.0316	89.4759	6.76	94	30	8	2	6	2	0	37	30	11	1	BDL	0.43	54	0.00	BDL
Dinhata-II	Chanderkuthi	Shallow tubewell	26.0158	89.5636	6.92	209	65	12	9	16	8	0	73	60	32	BDL	BDL	0.44	121	0.63	BDL
Cooch Behar-I	Bromattar kashal danga	Shallow tubewell	26.2762	89.3168	6.46	214	95	20	11	7	4	0	73	60	21	10	12	0.57	131	BDL	BDL
Dinhata-I	Chotobwol mari	Shallow tubewell	26.1313	89.4244	6.89	190	75	18	7	9	3	0	98	80	14	BDL	BDL	0.24	112	BDL	BDL
Cooch Behar-I	Pathsara	Shallow tubewell	26.2174	89.3982	7.10	274	120	26	13	13	2	0	140	115	18	1	BDL	0.32	159	7.35	BDL
Cooch Behar-II	Dakhin kalaraikuti	Shallow tubewell	26.3976	89.3828	7.64	587	275	46	39	6	6	0	360	295	11	1	BDL	0.71	328	0.06	0.14
Cooch Behar-II	Kholta kalibari	Shallow tubewell	26.4573	89.5196	6.78	265	105	18	15	12	2	0	104	85	35	1	BDL	0.62	148	BDL	BDL
Cooch Behar-II	Gopalpur	Shallow tubewell	26.4217	89.4611	6.83	179	65	12	9	12	4	0	67	55	25	2	BDL	0.27	104	9.63	BDL
Tufanganj-I	Deocharai	Shallow tubewell	26.2825	89.6140	7.29	231	100	22	11	10	1	0	116	95	14	BDL	1	0.51	131	0.29	0.05
Tufanganj-I	Charnaljari	Shallow tubewell	26.3787	89.5946	6.95	204	90	12	15	7	6	0	67	55	11	2	32	0.38	125	1.13	BDL
Tufanganj-II	Dhanmatia	Dug well	26.2871	89.6849	7.09	141	60	20	2	5	3	0	61	50	11	4	BDL	0.68	83	BDL	3.36
Tufanganj-II	Jorai	Dug well	26.4498	89.8054	6.52	180	50	12	5	13	3	0	49	40	14	24	BDL	0.66	102	BDL	0.03
Mekhliganj	Alokjhari(Mekhliganj)	Dug well	26.4932	88.9523	6.88	819	240	46	30	70	20	0	195	160	89	99	60	0.35	533	BDL	0.16

Table 7.2 Groundwater Physicochemical Constituents for Aquifer-II

Block	Location	Source	Lat	Long	pH	EC	TH	Ca	Mg	Na	K	CO3	HCO3	Total Alk as CaCO3	Cl	NO3	SO4	F	TDS	Fe	U(µg/l)
Haldibari	Dakhin hemkumaribaje jama	Phed DTW	26.2572	88.8377	7.05	220	80	26	4	14	3	0	128	105	7	BDL	BDL	0.36	132	3.74	0.35
Mekhliganj	Choto fulkar dabri bajejama	Phed DTW	26.3453	88.9354	7.13	176	65	18	5	12	3	0	98	80	7	BDL	BDL	0.37	104	4.96	0.04
Mekhliganj	Jamaldaha	Phed DTW	26.4263	89.0244	7.25	170	50	14	4	15	3	0	85	70	7	8	BDL	0.22	103	4.86	0.27
Mathabhanga-I	Mahischaru	Mark-II Deep	26.3171	89.1440	7.24	130	40	14	1	13	2	0	55	45	14	5	BDL	0.40	83	7.73	0.64
Sitalkuchi	Mahismuri	Phed DTW	26.2663	89.1311	7.20	208	75	22	5	14	2	0	122	100	7	BDL	BDL	0.32	125	1.24	0.01
Mathabhanga-II	Ramthenga	Phed DTW	26.4722	89.2112	7.74	357	165	22	27	9	2	0	226	185	7	BDL	BDL	0.54	206	BDL	0.74
Sitalkuchi	Bara gadaikhora	Phed DTW	26.1908	89.2509	7.23	103	35	12	1	7	2	0	49	40	11	BDL	BDL	0.37	63	0.07	BDL
Sitai	Satbhandari	Phed DTW	26.0558	89.3416	7.14	126	40	12	2	9	2	0	67	55	7	BDL	BDL	0.25	74	0.01	BDL
Mathabhanga-II	Nishiganj	Phed DTW	26.3152	89.3090	7.48	288	120	32	10	9	2	0	159	130	11	BDL	BDL	0.49	161	0.07	0.05
Cooch Behar-I	Ghugumari	Phed DTW	26.2788	89.4570	7.55	352	60	12	7	52	2	0	214	175	7	BDL	BDL	0.56	212	BDL	0.05
Dinhata-I	Bara fali mari	Phed DTW	26.0566	89.4883	7.48	176	75	12	11	8	1	0	92	75	11	BDL	BDL	0.40	100	0.03	BDL
Dinhata-II	Kishmat das gram	Phed DTW	26.0901	89.5393	7.62	269	100	30	6	17	1	0	128	105	11	20	BDL	0.23	164	BDL	0.08
Dinhata-II	Salmara	Phed DTW	26.1997	89.6138	7.41	384	160	24	24	19	1	0	232	190	14	BDL	BDL	0.35	225	BDL	0.18
Dinhata-I	Kushni part 2	Phed DTW	26.1779	89.4865	7.51	243	100	18	13	11	1	0	85	70	39	1	BDL	0.44	136	0.00	BDL
Cooch Behar-I	Putimari phuleswari	Phed DTW	26.2165	89.3293	7.35	169	65	18	5	9	1	0	67	55	21	BDL	BDL	0.39	96	BDL	BDL
Cooch Behar-II	Matikata	Phed DTW	26.3635	89.4014	7.45	213	75	22	5	15	2	0	128	105	7	1	BDL	0.26	130	2.34	BDL
Cooch Behar-II	Marichbari	Phed DTW	26.4728	89.4669	7.52	188	70	16	7	13	1	0	98	80	11	1	BDL	0.45	109	4.65	BDL
Tufanganj-I	Bajejama chilakhana	Phed DTW	26.3541	89.5928	7.79	286	110	28	10	20	2	0	171	140	11	BDL	BDL	0.61	175	0.00	0.18
Tufanganj-I	Balabhut	Phed DTW	26.2144	89.7004	7.49	247	105	32	6	12	1	0	104	85	28	1	4	0.34	148	0.36	0.88
Tufanganj-II	Harirhat	Phed DTW	26.3444	89.7146	7.63	211	90	30	4	8	1	0	110	90	14	1	BDL	0.30	125	0.97	0.60
Tufanganj-II	Rasikbil	Phed DTW	26.4067	89.7339	7.33	176	70	20	5	10	1	0	85	70	11	2	9	0.34	110	BDL	0.02
TUFANGANJ-II	RAMPUR, SINGIMARI	Phed DTW	26.4334	89.7997	7.38	134	45	10	5	11	1	0	61	50	7	3	6	0.55	81	0.05	0.07
MEKHLIGANJ	CHARCHARABARI	Phed DTW	26.4974	88.9861	7.33	157	55	14	5	12	3	0	55	45	11	11	10	0.47	98	5.86	0.44
MATHABHANGA-I	NAYARHAT	Phed DTW	26.4211	89.1181	7.52	162	50	16	2	12	3	0	79	65	7	7	BDL	0.36	96	1.78	0.61

CHAPTER- 8

GROUNDWATER REALATED ISSUES & PROBLEMS

The following groundwater problems have been observed in the study area.

8.1 IRON CONTAMINATION:

According to BIS (2012) iron's drinking water permissible limit is 1 mg/l, but it is found that many areas of Cooch Behar district both Aquifer-I and Aquifer-II have iron concentration beyond permissible limit up to 9.6 mg/l which is a very alarming situation. Major Iron affected blocks are Haldibari, Mekhliganj, Mathabhanga-I, Cooch Behar-I, Cooch Behar-II, Dinhata-II and Sitalkuchi. Iron creates an unpleasant odour, colour and taste in water. Iron causes rusting and blockage of screens, pumps and pipes of the tube wells.

Fig. 8.1: (A), (B), (C), (D) Photographs from study area showing effect of high concentration of iron. The last one (D) showing the dental problem (Blackening of teeth) due to consumption of iron rich water.

8.2 ARSENIC CONTAMINATION:

Public Health Engineering Directorate, West Bengal has declared that groundwater in some parts Cooch Behar-I is arsenic affected.

8.3 WATER LOGGING:

Water logging situation can be observed in many parts with the commence of pre-monsoon rainfall and continue to exist throughout the monsoon. The main crops grown in the study area is paddy which requires a huge amount of water. The unscientific management of water in agricultural fields along with excess water during monsoon season leads to water logging in these areas. Water logging causes land degradation thereby making the land unproductive. Excess water changes the physical, chemical and microbiological properties of water-logged soils.

Figure 8.2.: (A), (B) Showing water logging condition during premonsoon time in the Rasikbill area of the Tufanganj-II block.

CHAPTER- 9

GROUNDWATER DEVELOPMENT AND MANAGEMENT

Groundwater development and management involves the planning implementation, and operation necessary to provide safe and reliable ground water. For assessing development potentialities of and aquifer, the following information is required; (i)geometry of the reservoir defining dimensions and boundaries (ii) condition at the boundaries in particular the source of recharge; (iii) lithology and aquifer characteristics; (iv) hydrodynamic condition- whether phreatic, confined or semi- confined; (v) order of magnitude of the reservoirs, (vi) average natural recharge and discharge and (vii) quality of water.

9.1 URBAN AND RURAL WATER SUPPLY SCHEMES:

Urban and rural water supply scheme for drinking and domestic purpose is mainly looked after by PHED, local municipality and Gram Panchayats of Cooch Behar. The water supply to both urban and rural areas is achieved through construction of various ground water structures depending upon the requirement and feasibility. Deep tube wells, shallow tube wells commonly used for water supply. Though piped water supply is the most popular source of drinking water in the district only about 45% - 47% of the population of this district have access to piped water supply. The major source of drinking water in the district are presently the shallow hand tube well.

9.2 MANAGEMENT PLAN FOR IRRIGATION:

The stage of ground water development in Cooch Behar district is 41.46 %, under safe category. However, further development should be done in planned manner to harness the additional available resource for more sustainable development. Additionally 137654.9 hectares of land can be irrigated. Water applied for irrigation should not be wasted. An effective water management technique should be considered through modern agricultural management maintaining minimum pumping hours and selecting most appropriate cropping pattern. The application of modern techniques like sprinkler and drip irrigation will help increase crop yield and consequently conserve ground water.

Crops with low water requirement should be preferred. Heavy duty/medium duty tube wells can be constructed by Govt. agencies as they may help for irrigation in large perspective. Installation and maintenance cost of heavy-duty tube well is high and it will be difficult for individual or small farmers to maintain. Therefore, heavy-duty tube wells can be constructed by local government agencies and after installation of pumps it can be handed over to the local co-operative based farmers for its operation and maintenance.

Dug wells, light duty tube wells fitted with submersible pump, medium duty tube wells are feasible for irrigation purposes. But the capacity of the pump should be decided in such a way so that drawdown may be minimized. In view of sufficient rainfall in the area, excavation of tanks with large catchment areas can help in augmentation of irrigation facilities.

Table 9.1: Ground-water scenario for irrigation in Cooch Behar District

Sl. No.	Block	Geographical Area in Ha	Net Area Sown in Ha	Net Area Irrigated in Ha	Area to be Irrigated in Ha	SOD in %
1	COOCH BEHAR-I	131756	22155	4234.59	17920.41	44.86
2	COOCH BEHAR-II	55366	20154	3398.69	16755.31	46.88
3	DINHATA-1	38165	10180	5355.89	4824.11	51.31
4	DINHATA-II	99910	16060	2673.43	13386.57	46.09
5	HALDIBARI	11675	6407	854.14	5552.86	33.9
6	MATHABHANGA-I	43241	18483	3371.48	15111.52	36.1
7	MATHABHANGA-II	49087	19328	4625.9	14702.1	49.9
8	MEKHLIGANJ	70116	20553	3272.36	17280.64	22.33
9	SITAI	18967	8876	2830.88	6045.12	24.6
10	SITALKUCHI	54923	14647	2737.32	11909.68	37.95
11	TUFANGANJ-I	30842	9900	6390.15	3509.85	48.13
12	TUFANGANJ-II	29947	13087	2430.28	10656.72	43.13
Total:		633995	179830	42175.11	137654.9	41.46

9.3 RAINWATER HARVESTING AND ARTIFICIAL RECHARGE

The area receives plenty of rainfall but due to lack of proper rainwater harvesting structures and un-distributed rainfall causes huge amount of rainwater to drain into thesea. On the other hand, the area being predominantly underlain by clay, direct rainfall infiltration is very less, resulting high volume of runoff. The non-committed runoff, thus produced, may be diverted for water harvesting either for conservation or for artificial recharge to the depleted aquifer in the area.

No structure has been constructed by CGWB till date. Generally, water conservation and artificial recharge is feasible is such area where water level is more than 3 mbgl in post monsoon period. Water level is deeper than 3 mbgl in Cooch Behar-I, Cooch Behar-II and Mathabhanga-II, Tufanganj-I, Tufanganj-ii blocks in post monsoon period. As a whole the water level is not alarming condition, except these blocks of the district, where conservation of rainwater by different structures like percolation tank, roof top rainwater harvesting for conservation may be adopted.

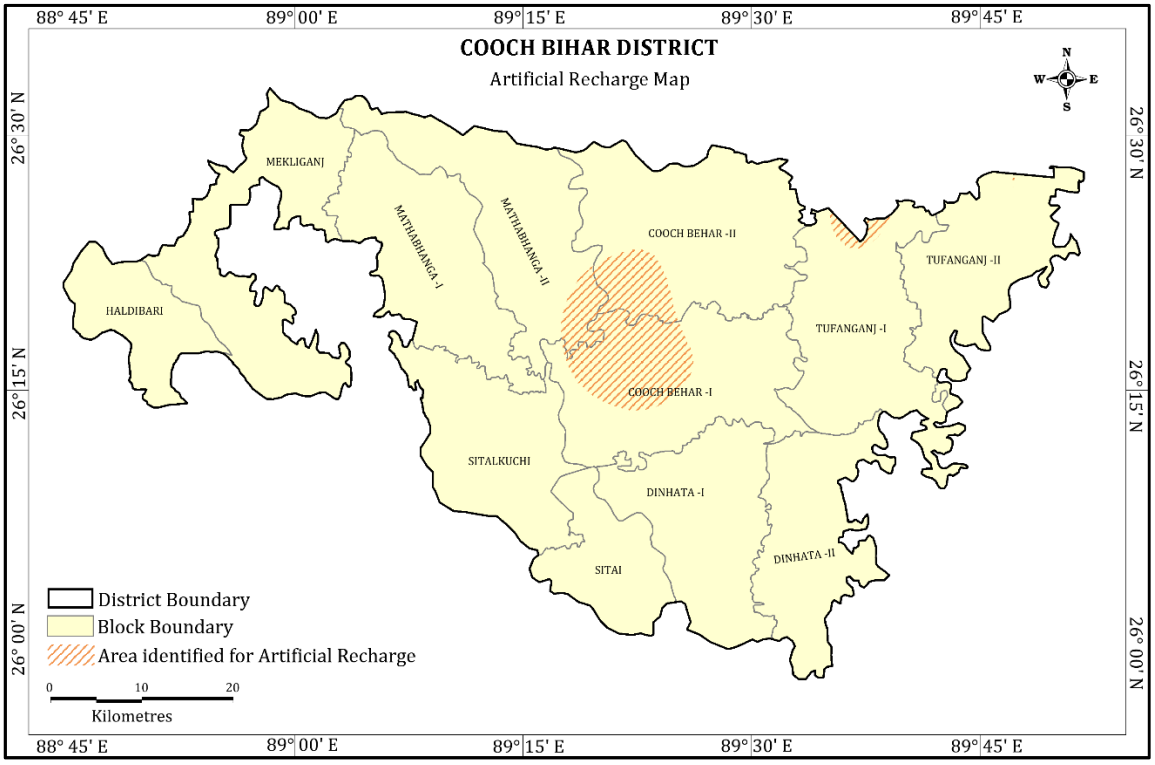

Fig.9.1: Area Feasible for Artificial Recharge of groundwater of Cooch Behar District.

Table-9.2: Artificial recharge priority area-structures feasible and their cost of construction for the study area

Block	Utilizable Surface runoff	Allocation of Utilizable Resource (MCM)			Structures Feasible (No.s)			Cost of structures (in lakhs)			Total cost (in lakhs)
		Percolation tank	REET withRS	Injection Well	Percolation tank	REET with RS	Injection Well	Percolation tank	REET with RS	Injection Well	
Cooch Behar-I	48.714	24.357	9.743	14.614	49	97	49	392.00	388.	147.0	927.0
Cooch Behar-II	23.085	11.543	4.617	6.926	23	46	23	184.00	184	69.0	437.0
Mathabhanga-II	12.847	6.423	2.569	3.854	13	26	13	104.00	104	39.0	247.0
Tufanganj-I	5.144	2.572	1.029	1.543	5	10	5	40.00	40	15.0	95.0
Tufanganj-II	0.080	0.04	0.016	0.024	0	0	0	0.00	0.00	0.0	0.0

Table-9.3: Ground Water Management Strategy

STATUS OF GROUND WATER DEVELOPMENT IN COOCH BEHAR DISTRICT (BLOCK WISE)				
Block	**Occurrence of aquifers & its potentiality**	**Feasibility of GW Abstraction Structures**	**Ground Water Resource Available & Status of GW Development (as on March)**	**Remarks**
Cooch Behar I	Multiple aquifer system occurs between the depth span of 4-165 mbgl. Transmissivity value is 3100 m^2/day.	Low duty (30-40 m^3/hr) and heavy duty (125-150 m^3/hr) tubewells are feasible.	Net GW availability 26959.27 ham. Net GW availability for future irrigation development 21626.07 ham. No. of irrigation wells (as per MI census 2006): Dug wells: 7, STW : 4871,DTW: 15.	Ground water development may be done in planned manner. Safe Category.
Cooch Behar II	Multiple aquifer system occurs between the depth span of 6-120 mbgl. Transmissivity value is 2000 m^2/day.	Low duty (30-40 m^3/hr) and heavy duty (100-175 m^3/hr) tubewells are feasible.	Net GW availability 28172.54 ham. Net GW availability for future irrigation development 23169.69 ham. No. of irrigation wells (as per MI census 2006): Dug wells: 2, STW : 4729, DTW: 7.	Safe Category. Iron present in shallow aquifer.
Dinhata I	Multiple aquifer system occurs between the depth span of 4-120 mbgl. Transmissivity value is 3400 m^2/day.	Low duty (30-40 m^3/hr) and heavy duty (100-150 m^3/hr) tubewells are feasible.	Net GW availability 21105.82 ham. Net GW availability for future irrigation development 16208.49 ham. No. of irrigation wells (as per MI census 2006): Dug wells: 8, STW : 4532, DTW: 21.	Ground water development may be done in planned manner. Safe Category.
Dinhata II	Multiple aquifer system occurs between the depth span of 3.5-130, 160-190 mbgl. Transmissivity value is 3500 m^2/day.	Low duty (30-40 m^3/hr) and heavy duty (125-150 m^3/hr) tubewells are feasible.	Net GW availability 18294.86 ham. Net GW availability for future irrigation development 13727.17 ham. No. of irrigation wells (as per MI census 2006): Dug wells: 21, STW : 3359, DTW: 9.	Ground water development may be done in planned manner. Safe Category. Iron present in shallow aquifer.
Haldibari	Multiple aquifer system occurs between the depth span of 6-80, 110-196 mbgl. Transmissivity value is 2800 m^2/day.	Low duty (30-40 m^3/hr) and heavy duty (100-175 m^3/hr) tubewells are feasible.	Net GW availability 10933.57 ham. Net GW availability for future irrigation development 9578.36 ham. No. of irrigation wells (as per MI census 2006): Dug wells: 5, STW : 1211, DTW: 2.	Ground water development may be done in planned manner. Safe Category. High potential aquifer exists within 90-165 mbgl depth.

Mathabhanga I	Multiple aquifer system occurs between the depth span of 4-150 mbgl. Transmissivity value is 3400 m^2/day.	Low duty (30-40 m^3/hr) and heavy duty (100-150 m^3/hr) tubewells are feasible.	Net GW availability 23202.79 ham. Net GW availability for future irrigation development 19851.08 ham. No. of irrigation wells (as per MI census 2006): Dug wells: 8, STW : 3166, DTW: 2.	Ground water development may be done in planned manner. Safe Category.
Mathabhanga II	Multiple aquifer system occurs between the depth span of 10-165 mbgl. Transmissivity value is 660-3100 m^2/day.	Low duty (30-40 m^3/hr) and heavy duty (125-150 m^3/hr) tubewells are feasible.	Net GW availability 22815.73ham. Net GW availability for future irrigation development 17891.96 ham. No. of irrigation wells (as per MI census 2006): Dug wells: 7, STW : 4955.	Ground water development may be done in planned manner. Safe Category.
Mekhliganj	Multiple aquifer system occurs between the depth span of 6-50, 98-104, 151-175 mbgl. Transmissivity value is 666 m^2/day. S= 4.45 X 10^{-4}.	Low duty (30-40 m^3/hr) and heavy duty (100-150 m^3/hr) tubewells are feasible.	Net GW availability 22372.98 ham. Net GW availability for future irrigation development 20629.18 ham. No. of irrigation wells (as per MI census 2006): Dug wells: 653, STW : 1474, DTW: 2.	Safe Category. Iron present in shallow aquifer.
Sitai	Multiple aquifer system occurs between the depth span of 10-120 mbgl. Transmissivity value is 3400 m^2/day.	Low duty (30-40 m^3/hr) and heavy duty (100-150 m^3/hr) tubewells are feasible.	Net GW availability 11547.78 ham. Net GW availability for future irrigation development 9886.14 ham. No. of irrigation wells (as per MI census 2006): Dug wells: 8, STW : 1579, DTW: 2.	Ground water development may be done in planned manner. Safe Category.

PART – II
BLOCK WISE MANAGEMENT PLANS

1. Cooch Behar-I

Salient Information

Block Name: Cooch Behar-I

Geographical area (in sq. km): 355

Mapable area (in sq. km): 318

District: Cooch Behar

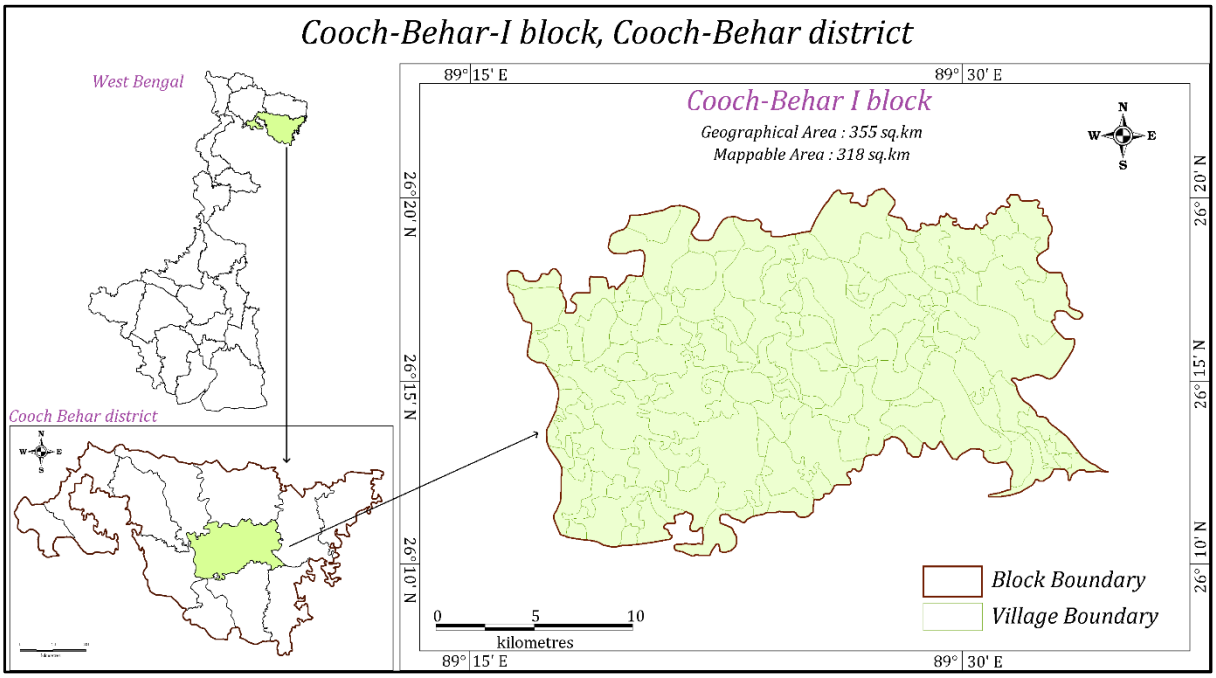

Fig.1.1. Location map for Cooch Behar-I block

Population (as on 2011):

Table 1.1: Distribution of population in administrative units of the study area

Block/ Muncipality	Rural Population			Urban Population			Total Population		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Cooch Behar-I	151337	141930	293267	16848	16443	33291	168185	158373	326558

Rainfall:

*Table 1.2: Annual Actual Rainfall for Cooch Behar District from 2011 to 2021 (*Source WRIS)*

Block Name	Normal Rainfall	Rain Fall										
Cooch Behar_I	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2011
	3213	2666.57	3682.77	2736.46	2882.16	3355.41	3180.31	3211.4	2630.13	3521.38	4677.07	2793.68

Landuse, Agriculture & Irrigation (area in ha):

Table 1.3.1: Cooch Behar-I Block details of Land-use pattern (in hectares)

Block	Reporting Area	Forest Area	Area under Non-Agricultural use	Barren and Un-culturable land	Land under misc tree crops	Culturable wastes	Fallow land Other than current fallow	Current fallow	Net area sown
Cooch Behar -I	34663	0	7562	-	406	-	-	85	26610

Table 1.3.2: Command area(ha) of Cooch Behar-I block

Sl. No.	Block Name	Dugwell		Sallow Tubewell		Medium Tubewell		Deep Tubewell		Surface Flow		Sarface 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	
1	COOCH BEHAR-I	19	16.06	3625	6918.82	23	41.61	16	264.50	0	0.00	49	1254.30	7240.99	1254.30	8495.29

Ground Water Resources:

Table 1.4 Details of Ground Water Resource Availability and Utilization in Cooch Behar-I Block. (As on 31.03.2013)

BLOCK NAME		COOCH BEHAR-I
Total Annual Ground Water Recharg e (Ham)		41617.91
Total Natural Discharg es (Ham)		4161.79
Annual Extractab le Ground Water Recharge (Ham)		37456.12
Total Extraction		16804.12
Annual GW	Allocation for Domestic and Industrial Use as on 2042	651.28
Net Ground Water Availabili ty for future irrigation use		20609
Stage of Ground Water Extraction (%)		44.86
Categorization		Safe
Instorage		526717

Geology:

Cooch Behar-I block is mainly covered with quaternary newer alluvium sediments. The major lithology encountered in this block are sand, sand with pebbles & gravels and clay. A lithological model is prepared based on the lithologs of exploratory wells of CGWB and PHED of Govt. of West Bengal.

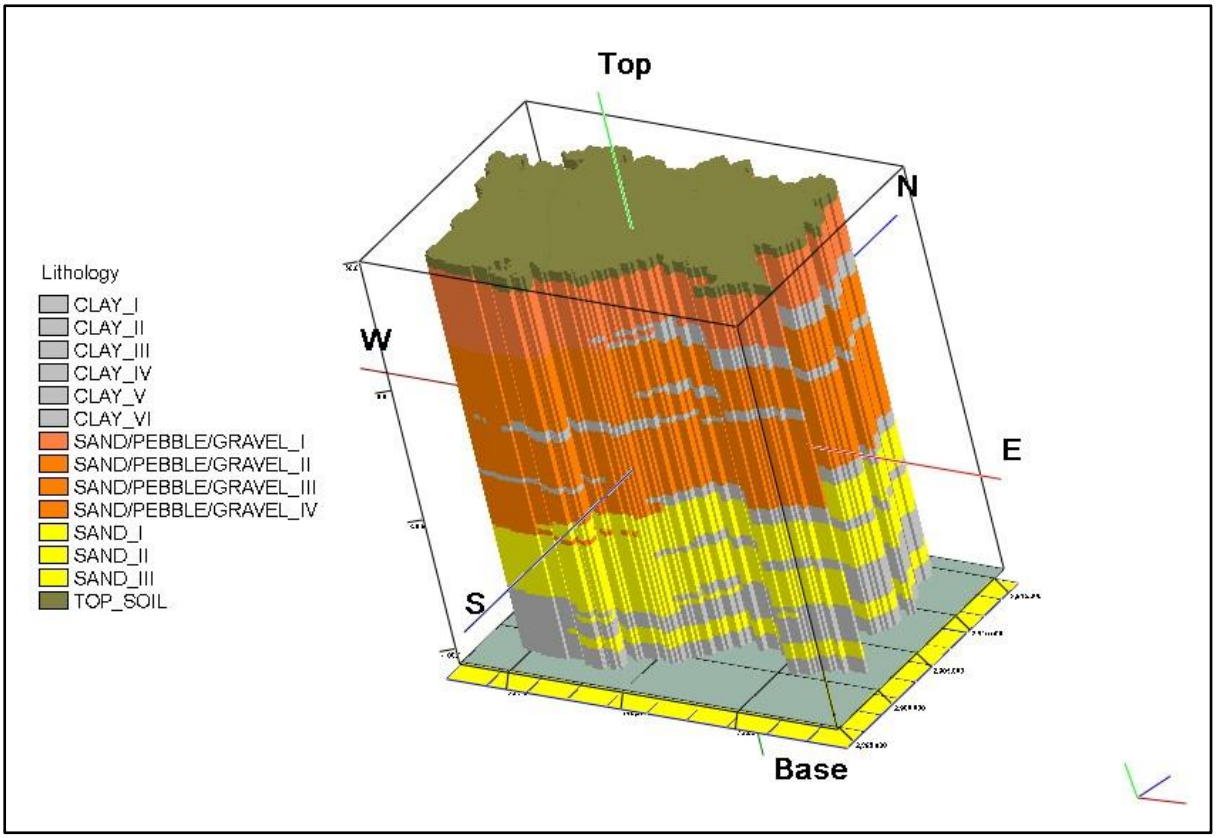

Fig. 1.2 Lithological model of Cooch Behar-I block.

Disposition of Aquifers:

In Cooch Behar-I there are two aquifer systems. One is shallow which extends from 5-meter bgl to 104-meter bgl and another is deep which extends from 108-meter bgl to beyond 150-meter bgl. Aquifer_I is unconfined to semi-confined whereas Aquifer_II is confined.

Aquifer_I again classified as Aquifer_I_A, Aquifer_I_B, Aquifer_I_C and Aquifer_I_D depends upon the clay layers present in between. Similarly, Aquifer_II again classified as Aquifer_II_A, Aquifer_II_B and Aquifer_II_C

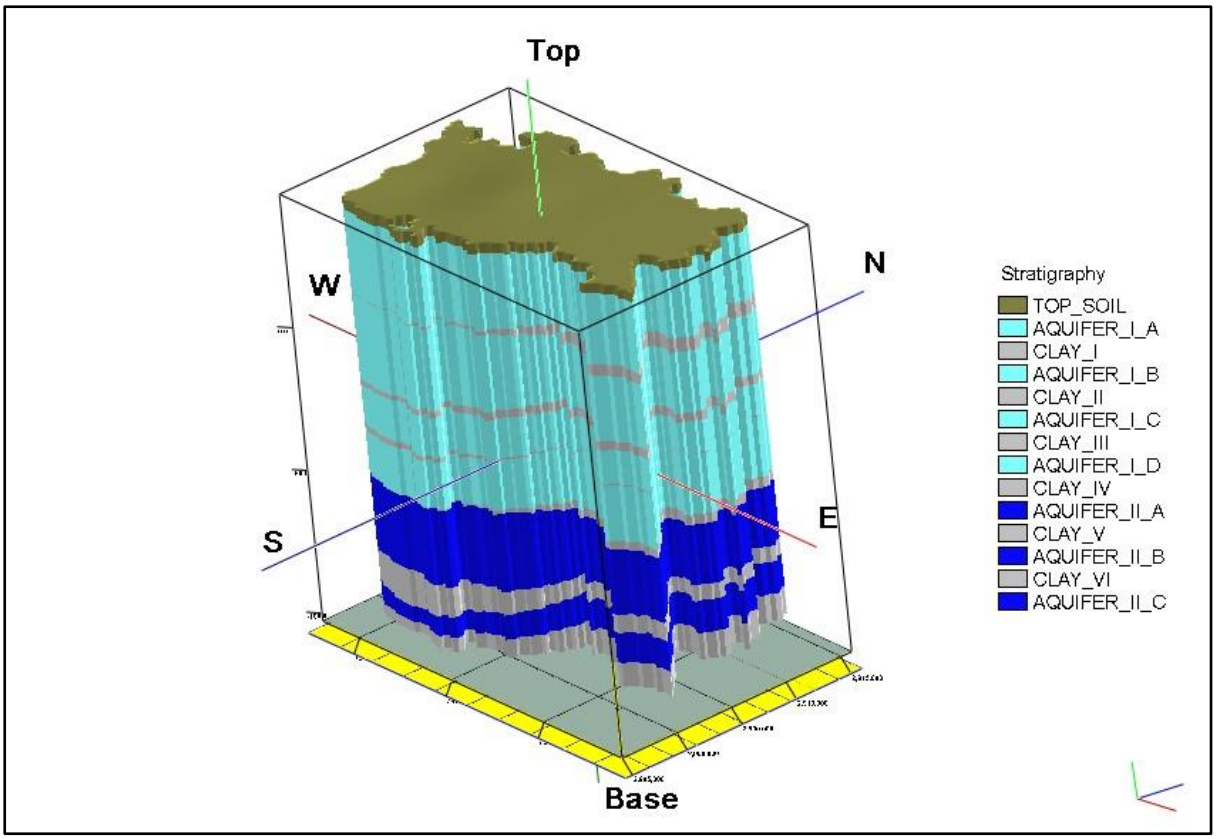

Fig.1.3 Aquifer disposition model of Cooch Behar_I block.

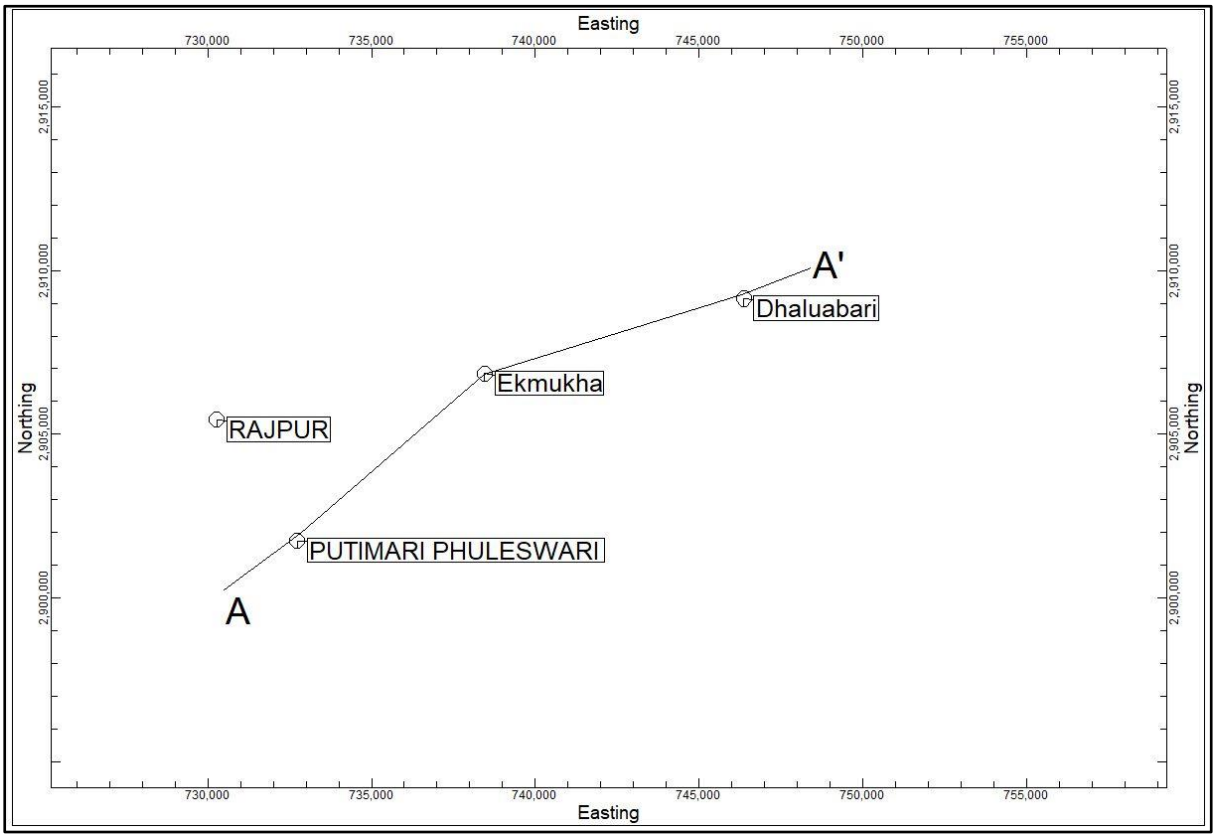

Fig.1.4 Borehole location map for Cross-Section of Cooch Behar-I block.

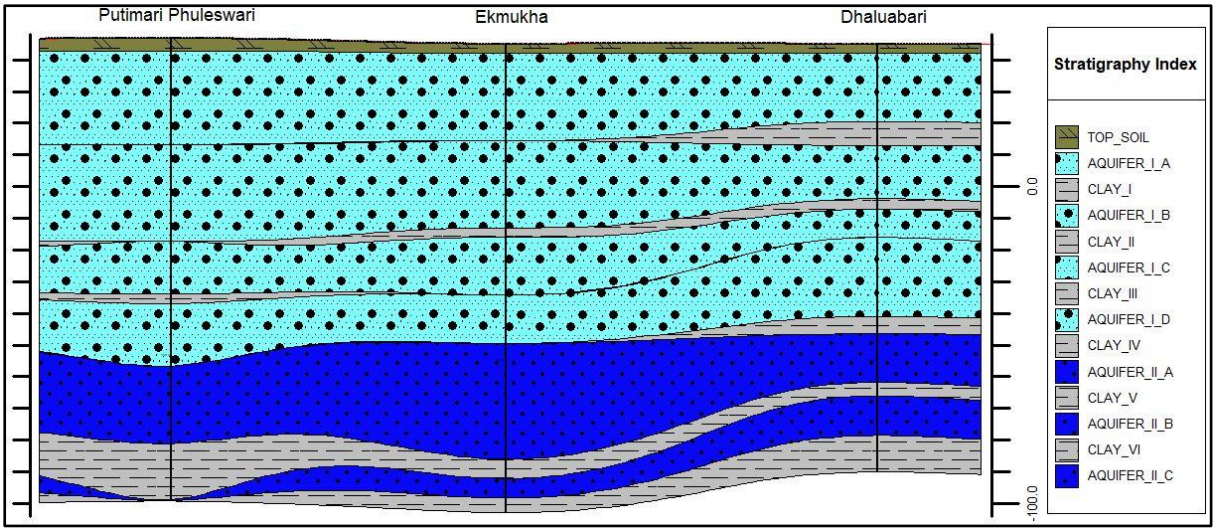

Fig.1.5 Cross-Sectional map of Cooch Behar-I block.

Table 1.5: Details of aquifer disposition in Cooch Behar-I Block

Block	Location	No. of Aquifers	Water bearing zones (Zones Tapped)	Discharge (m^3/hr)	SWL (mbgl)	Drawdown	T (m^2/day)	S
Cooch Behar-I	Harisabha	2	145-163	483.6	4.65	4.61	195	-
	Ammunition Depot, MES	2	15-27, 116-128,140-162	438	1.91	10.31	491.16	1.867x10-3
	Dharambanikuti	2	32.77 –50.80,79.16 – 91.54,106.58 – 118.65,134.02 – 152.41	2033.4	0.63	6	1299.68	-

Table 1.6: Details of aquifer wise water level ranges and seasonal long-term water level trend (2011-2020) in Cooch Behar-I Block

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)
Cooch Behar-I	I		0.33025	--		0.04375	
	II	-	-	-	-	-	-

Ground Water Quality and Issues:

Based on NHS and Keywells data, the range of chemical parameters for the block is given below.

Table 1.7: Average concentration of chemical parameters in Cooch Behar-I Block

Block	Aquifer Type	pH	EC	TH	Ca	Mg	Na	K	CO3	HCO3	Total Alk as CaCO3	Cl	NO3	SO4	F	TDS	Fe	U (µg/l)
COOCH BEHAR-I	Aquifer-I	6.46-7.10	214-274	95-120	20-26	11-13	7-13	2-4	0	73-140	60-115	18-21	1-10	BDL-12	0.32-0.57	131-159	BDL-7.35	BDL
	Aquifer-II	7.35-7.55	169-352	60-65	12-18	5-7	9-52	1-2	0	67-214	55-175	7-21	BDL	BDL	0.39-0.56	96-212	BDL	BDL-0.05

Groundwater Resource Enhancement and Management Plan:

Ground Water Management Plan for Drinking Purpose:

There are twenty (20) ground water based public water supply schemes are commissioned till July 2022 by PHED which are the main sources of drinking water in the block. Till July 2022 about 18.48 % of the Functional Household Tap Connection is achieved since inception. Cooch Behar-I block receives ample amount of rain during monsoon. Though the stage of development is only 44.86 % it will be good if we practice conservation through rain water harvesting and used it as an alternative for drinking water because with time ground water abstraction will increase and to maintain the categorization as safe we have to look supplement sources for drinking purposes.

For monitoring of change in ground water regime in the area in future, cost of construction of observation well should be included.

Management plan for Irrigation:

Table 1.8: Ground-water scenario for irrigation in Cooch Behar-I block

Block	Geographical Area in Ha	Net Area Sown in Ha	Net Area Irrigated in Ha	Area to be Irrigated in Ha	SOD in %
COOCH BEHAR-I	131756	22155	4234.59	17920.41	44.86

The stage of ground water development in the block is 44.86 %, under safe category. However, further development should be done in planned manner to harness the additional available resource for more sustainable development.

17920.41 hectares more of land can be irrigated. Water applied for irrigation should not be wasted. An effective water management technique should be considered through modern agricultural management maintaining minimum pumping hours and selecting most appropriate cropping pattern. The application of modern techniques like sprinkler and drip irrigation will help increase crop yield and consequently conserve ground water.

Crops with low water requirement should be preferred. Heavy duty/medium duty tube wells can be constructed by Govt. agencies as they may help for irrigation in large perspective. Installation and maintenance cost of heavy-duty tube well is high and it will be difficult for individual or small farmers to maintain. Therefore, heavy-duty tube wells can be constructed by local government agencies and after installation of pumps it can be handed over to the local co-operative based farmers for its operation and maintenance.

Dug wells, light duty tube wells fitted with submersible pump, medium duty tube wells are feasible for irrigation purposes. But the capacity of the pump should be decided in such a way so that drawdown may be minimized.

In view of sufficient rainfall in the area, excavation of tanks with large catchment areas can help in augmention of irrigation facilities.

Management Intervention Through Rain Water Harvesting (Roof Top and Surface Runoff) And Artifitial Recharge:

The area receives plenty of rainfall but due to lack of proper rainwater harvesting structures and un-distributed rainfall causes huge amount of rainwater to drain into the sea. The runoff, thus produced, may be diverted for water harvesting either for conservation or for artificial recharge to the depleted aquifer in the area. No structure has been constructed by CGWB till date. Generally, water conservation and artificial recharge is feasible is such area where water level is more than 3 mbgl in post monsoon period. As a whole the water level is not in alarming condition in this block.

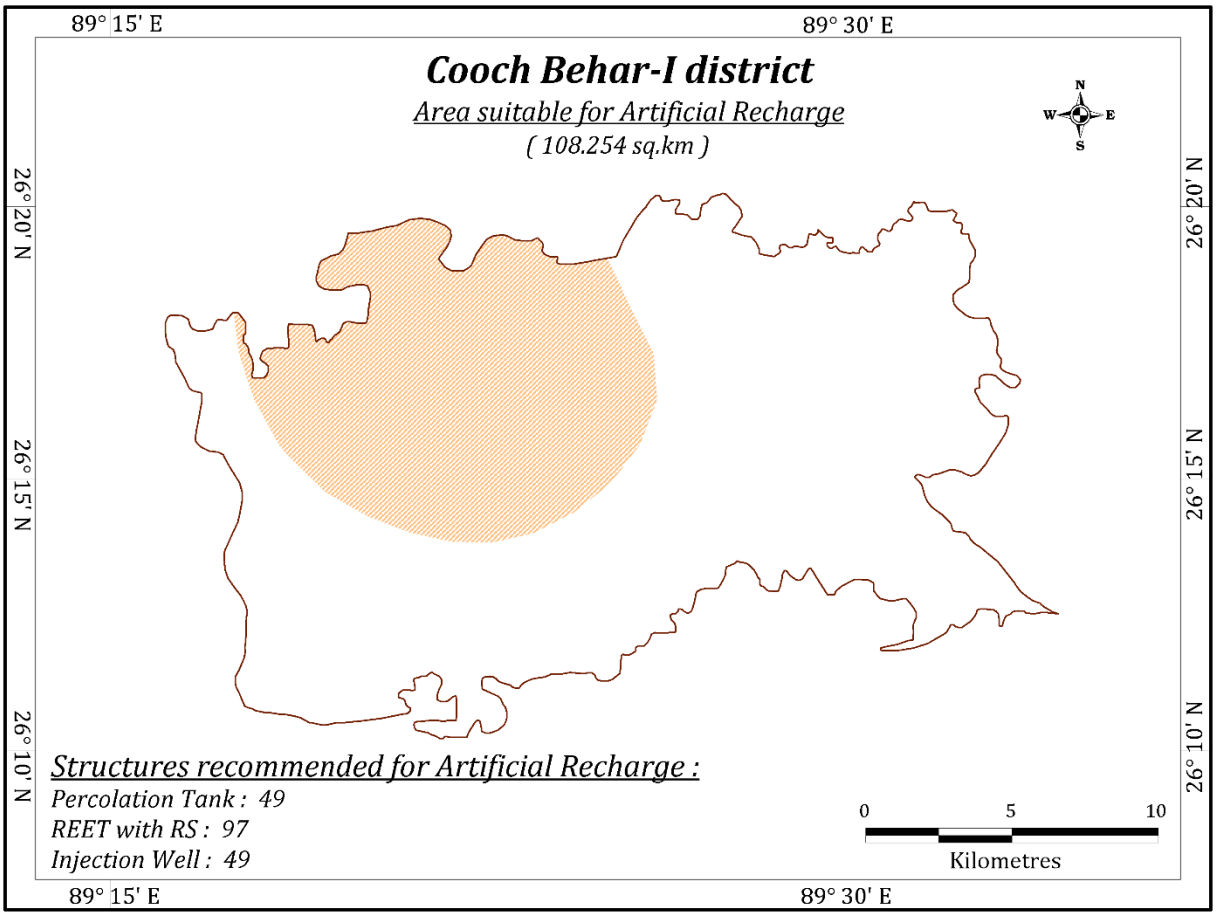

Fig.1.6: Area Feasible for Artificial Recharge of groundwater of Cooch Behar-I block.

Water conservation of rainwater by different structures like percolation tank,Injection well, roof top rainwater harvesting can be considered for the block in future. It has been estimated that the utilizable surface runoff produced in the block is 48.714 MCM. This surface runoff is proposed to be utilized to recharge the depleted aquifers in the block. As per the available storage space, 14.614 MCM water is required to fill the deeper aquifers in block. Therefore, 49 injection wells with roof top rain water harvesting structures are recommended in the block. The remaining surface runoff, 34.1 MCM is recommended to be utilized in storage tanks for generation of irrigation potential and thus, 146 storage tanks have been proposed. The roof top rain water harvesting structures with suitably design injection wells may be proposed to construct in the census towns areas in primary phases and subsequently may be extended to the rural areas.

Table 1.9: Area suitable for recharge in Cooch Behar-I block

District	Block Name	Block Area (in Ha)	Area (in Ha) suitable for recharge (having DTW 3 m and more in Postmonsoon)
Cooch Behar	Cooch Behar-I	35500	10825.4

Table 1.10: Artificial recharge priority area-structures feasible and their cost of construction for Cooch Behar-I block

Block	Utilizable Surface runoff	Allocation of Utilizable Resource (MCM)			Structures Feasible (No.s)			Cost of structures (in lakhs)			Total cost (in lakhs)
		Percolation tank	REET withRS	Injection Well	Percolation tank	REET with RS	Injection Well	Percolation tank	REET with RS	Injection Well	
Cooch Behar-I	48.714	24.357	9.743	14.614	49	97	49	392.00	388.00	147.00	927.00

2. Cooch Behar-II

Salient Information

Block Name: Cooch Behar-II

Geographical area (in sq. km): 388

Mapable area (in sq. km): 347

District: Cooch Behar

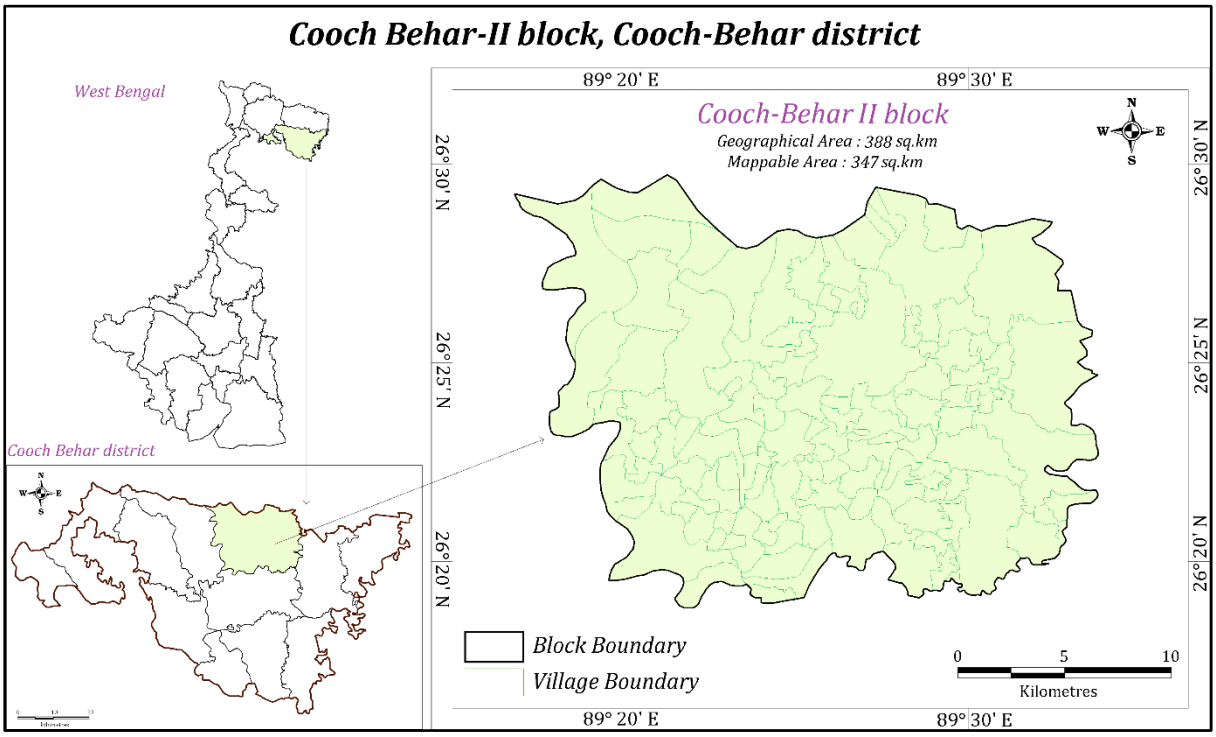

Fig.2.1. Location map for Cooch Behar-II block

Population (as on 2011):

Table 2.1: Distribution of population in administrative units of the study area

Block/ Muncipality	Rural Population			Urban Population			Total Population		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Cooch Behar-II	151946	137971	289917	27645	26339	53984	179591	164310	343901

Rainfall:

*Table 2.2: Annual Actual Rainfall for Cooch Behar District from 2011 to 2021 (*Source WRIS)*

Block Name	Normal Rainfall	Rain Fall										
Cooch Behar_II	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2011
	3213	2666.57	3682.77	2736.46	2882.16	3355.41	3180.31	3211.4	2630.13	3521.38	4677.07	2793.68

Landuse, Agriculture & Irrigation (area in ha):

Table 2.3.1: Cooch Behar-II Block details of Land-use pattern (in hectares)

Block	Reporting Area	Forest Area	Area under Non-Agricultural use	Barren and Un-culturable land	Land under misc tree crops	Culturable wastes	Fallow land Other than current fallow	Current fallow	Net area sown
Cooch Behar -II	38198	1427	6668	-	470	178	-	85	29370

Table 1.3.2: Command area(ha) of Cooch Behar-II block

Block Name	Dugwell		Sallow Tubewell		Medium Tubewell		Deep Tubewell		Surface Flow		Sarface 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	
Cooch Behar -II	6	9.14	3097.00	5790.90	120	402.94	33	280.87	2	7.32	68	1990.64	6483.85	1997.96	8481.81

Ground Water Resources:

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

BLOCK NAME		COOCH BEHAR-II
Total Annual Ground Water Recharg e (Ham)		35160.28
Total Natural Discharg es (Ham)		3516.03
Annual Extractab le Ground Water Recharge (Ham)		31644.25
Total Extraction		14834.17
Annual GW	Allocation for Domestic and Industrial Use as on 2042	695.23
Net Ground Water Availabili ty for future irrigation use		16755.43
Stage of Ground Water Extracti on (%)		46.88
Categorization		Safe
Instorage		520349

Table 2.5: Details of aquifer disposition in Cooch Behar-II Block

Block	Location	No. of Aquifers	Water bearing zones (Zones Tapped)	Discharge (m^3/hr)	SWL (mbgl)	Draw down	T (m^2/day)	S
Cooch Behar-II	Dewanhat		57.93 – 66.89, 102.14 –109.76,121.95 – 130.61,133.66 –145.67	1638.6	1.1	9.97	955.9	-

Geology:

Cooch Behar-II block is mainly covered with quaternary newer alluvium sediments. The major lithology encountered in this block are sand with pebbles & gravels, sand and clay. A lithological model is prepared based on the lithologs of exploratory wells of CGWB and PHED of Govt. of West Bengal.

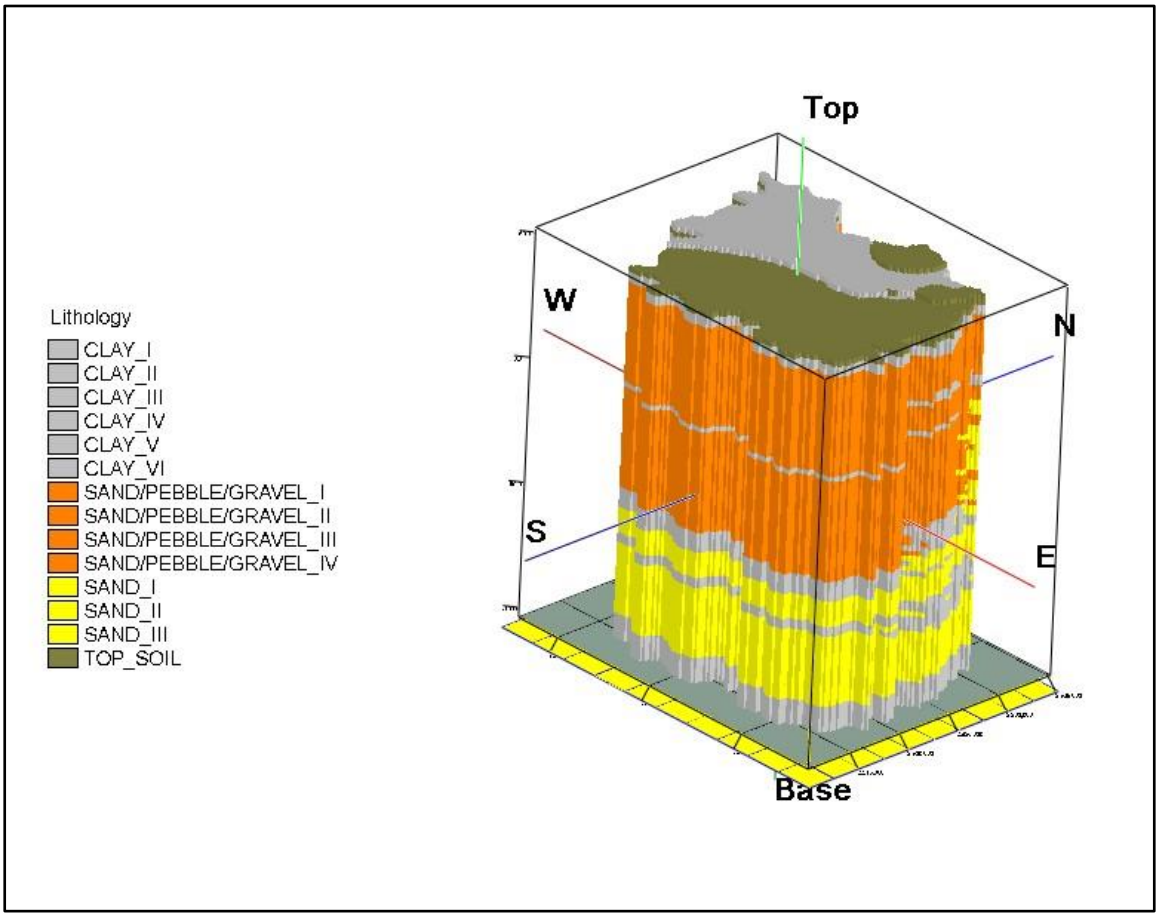

Fig. 2.2 Lithological model of Cooch Behar-II block.

Disposition of Aquifers:

In Cooch Behar-II there are two aquifer systems. One is shallow which extends from 4-meter bgl to 88 -meter bgl and another is deep which extends from 44-meter bgl to beyond 150-meter bgl. Aquifer_I is unconfined to semi-confined whereas Aquifer_II is confined.

Aquifer_I again classified as Aquifer_I_A, Aquifer_I_B, Aquifer_I_C and Aquifer_I_D depends upon the clay layers present in between. Similarly, Aquifer_II again classified as Aquifer_II_A, and Aquifer_II_B

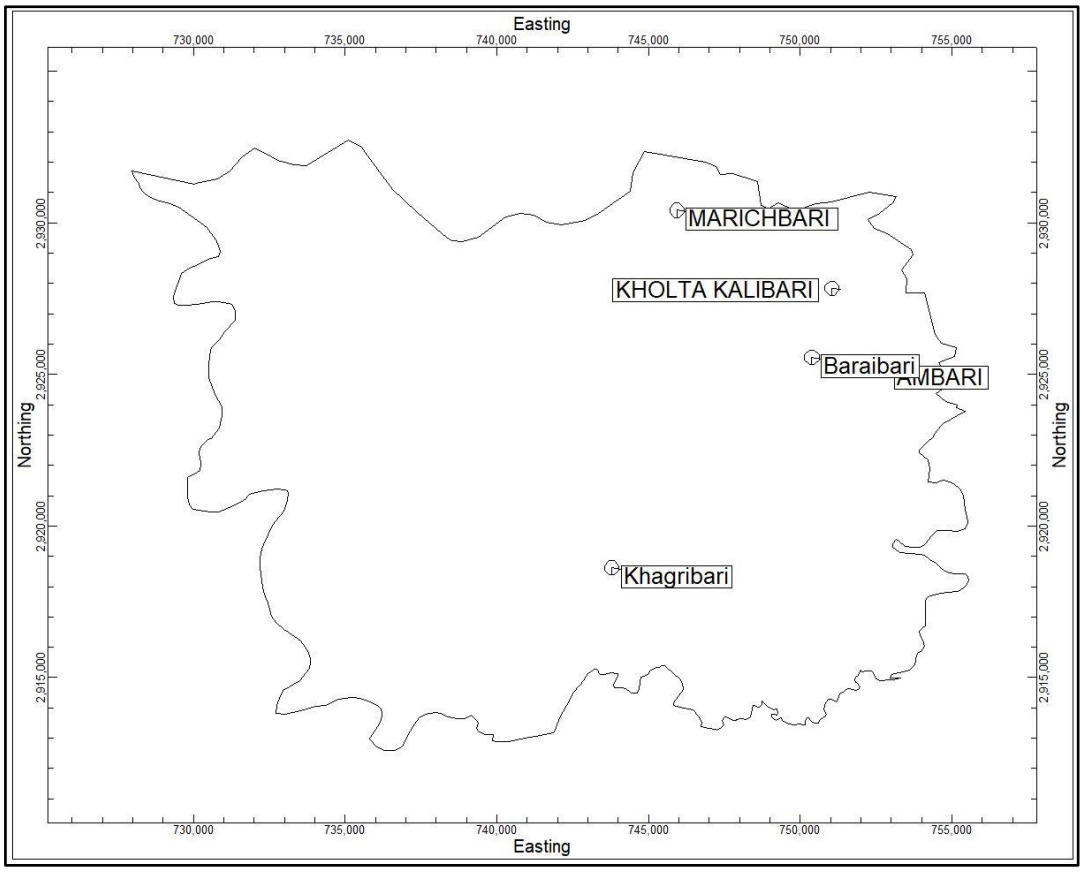

Fig. 2.3 Borehole location map of Cooch Behar-II block.

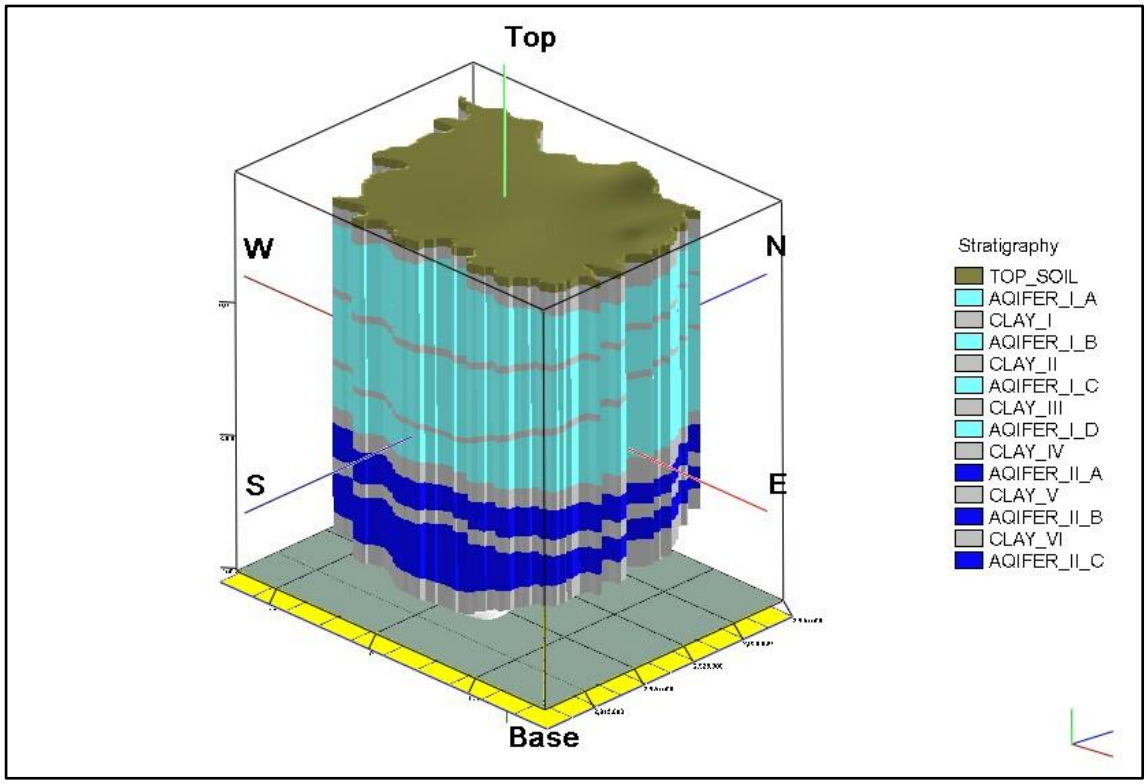

Fig.2.4 Aquifer disposition model of Cooch Behar-II block.

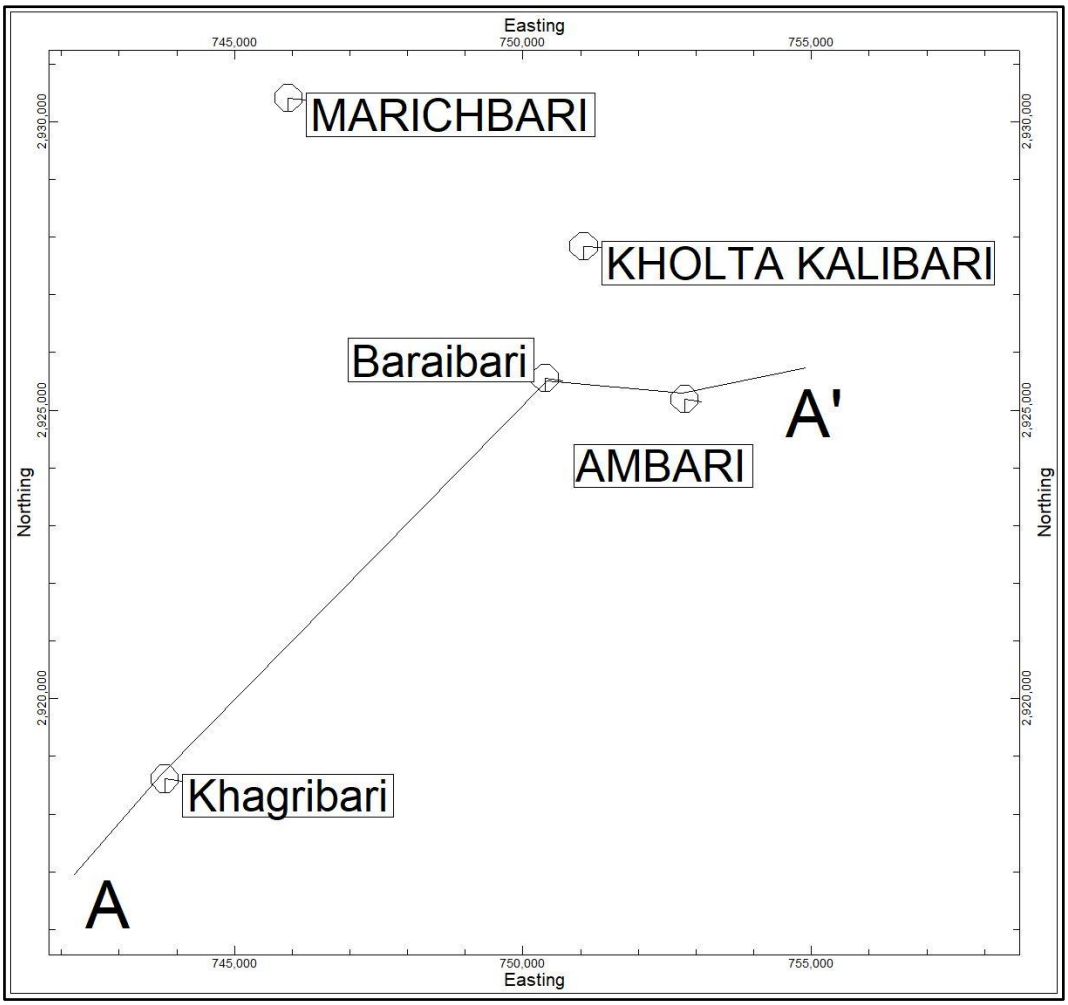

Fig. 2.5 Borehole location map for cross-section of Cooch Behar-II block.

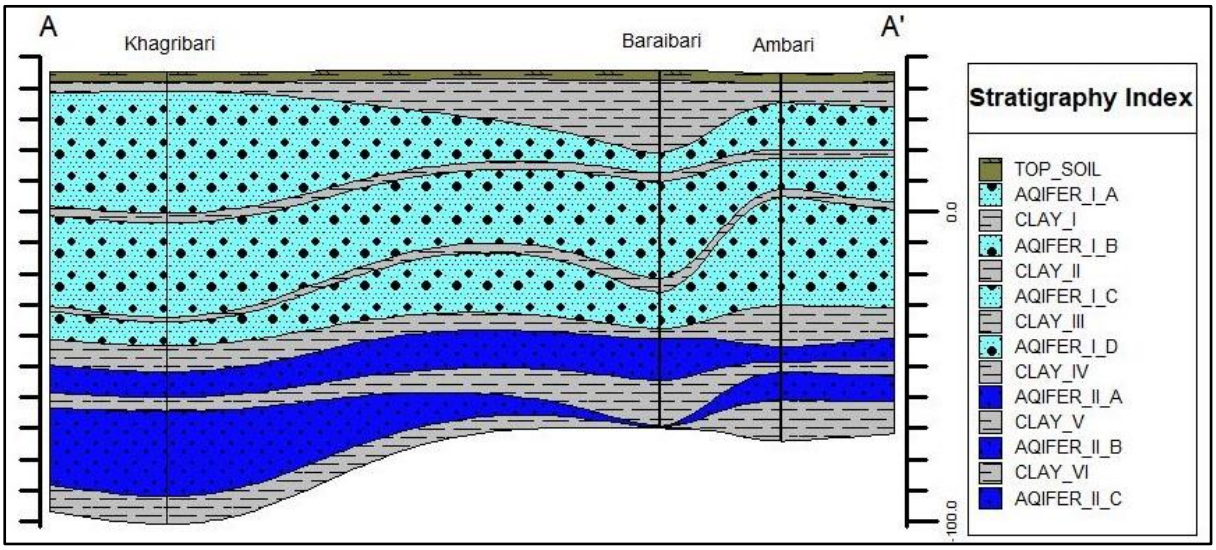

Fig.2.6 Cross-Sectional Map of Cooch Behar-II block.

Table 2.6: Details of aquifer wise water level ranges and seasonal long-term water level trend (2011-2020) in Cooch Behar-II Block

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)
Cooch Behar-II	I		0.295	--		0.074	
	II	-	-	-	-	-	-

Ground Water Quality and Issues:

Based on NHS and Keywells data, the range of chemical parameters for the block is given below.

Table 2.7: Average concentration of chemical parameters in Cooch Behar-II Block

Block	Aquifer Type	pH	EC	TH	Ca	Mg	Na	K	CO3	HCO3	Total Alk as CaCO3	Cl	NO3	SO4	F	TDS	Fe	U (µg/l)
COOCH BEHAR-II	Aquifer-I	6.78-7.64	179-587	65-275	12-46	9-39	6-12	2-6	0	67-360	55-295	11-35	1-10	BDL-12	0.27-0.71	104-328	BDL-9.63	BDL-0.14
	Aquifer-II	7.45-7.52	188-213	70-75	16-22	5-7	13-15	1-2	0	98-128	80-105	7-11	1	BDL	0.26-0.45	109-130	2.34-4.65	BDL

Groundwater Resource Enhancement and Management Plan:

Ground Water Management Plan for Drinking Purpose:

There are nineteen (19) ground water based public water supply schemes are commissioned till July 2022 by PHED which are the main sources of drinking water in the block. Till July 2022 about 19.44 % of the Functional Household Tap Connection is achieved since inception. Cooch Behar-II block receives ample amount of rain during monsoon. Though the stage of development is only 46.88 %, it will be good if we practice conservation through rain water harvesting and used it as an alternative for drinking water because with time ground water abstraction will increase and to maintain the categorization as safe we have to look supplement sources for drinking purposes.

For monitoring of change in ground water regime in the area in future, cost of construction of observation well should be included.

Management plan for Irrigation:

Table 2.8: Ground-water scenario for irrigation in Cooch Behar-II block

Block	Geographical Area in Ha	Net Area Sown in Ha	Net Area Irrigated in Ha	Area to be Irrigated in Ha	SOD in %
COOCH BEHAR-II	55366	20154	3398.69	16755.31	46.88

The stage of ground water development in the block is 44.86 %, under safe category. However, further development should be done in planned manner to harness the additional available resource for more sustainable development.

16755.31 hectares more of land can be irrigated. Water applied for irrigation should not be wasted. An effective water management technique should be considered through modern agricultural management maintaining minimum pumping hours and selecting most appropriate cropping pattern. The application of modern techniques like sprinkler and drip irrigation will help increase crop yield and consequently conserve ground water.

Crops with low water requirement should be preferred. Heavy duty/medium duty tube wells can be constructed by Govt. agencies as they may help for irrigation in large perspective. Installation and maintenance cost of heavy-duty tube well is high and it will be difficult for individual or small farmers to maintain. Therefore, heavy-duty tube wells can be constructed by local government agencies and after installation of pumps it can be handed over to the local co-operative based farmers for its operation and maintenance.

Dug wells, light duty tube wells fitted with submersible pump, medium duty tube wells are feasible for irrigation purposes. But the capacity of the pump should be decided in such a way so that drawdown may be minimized. In view of sufficient rainfall in the area, excavation of tanks with large catchment areas can help in augmentation of irrigation facilities.

Management Intervention Through Rain Water Harvesting (Roof Top and Surface Runoff) And Artifitial Recharge:

The area receives plenty of rainfall but due to lack of proper rainwater harvesting structures and un-distributed rainfall causes huge amount of rainwater to drain into the sea. On the other hand,the area being predominantly underlain by clay, direct rainfall infiltration is very less, resulting high volume of runoff. The runoff, thus produced, may be diverted for water harvesting either for conservation or for artificial recharge to the depleted aquifer in the area. No structure has been constructed by CGWB till date. Generally, water conservation and artificial recharge is feasible is such area where water level is more than 3 mbgl in post monsoon period. As a whole the water level is not in alarming condition in this block.

Water conservation of rainwater by different structures like percolation tank,Injection well, roof top rainwater harvesting can be considered for the block in future. It has been estimated that the utilizable surface runoff produced in the block is 23.085 MCM. This surface runoff is proposed to be utilized to recharge the depleted aquifers in the block. As per the available storage space, 6.926 MCM water is required to fill the deeper aquifers in block. Therefore, 23 injection wells with roof top rain water harvesting structures are recommended in the block. The remaining surface runoff, 16.16 MCM is recommended to be utilized in storage tanks for generation of irrigation potential and thus, 69 storage tanks have been proposed. The roof top rain water harvesting structures with suitably design injection wells may be proposed to construct in the census towns areas in primary phases and subsequently may be extended to the rural areas.

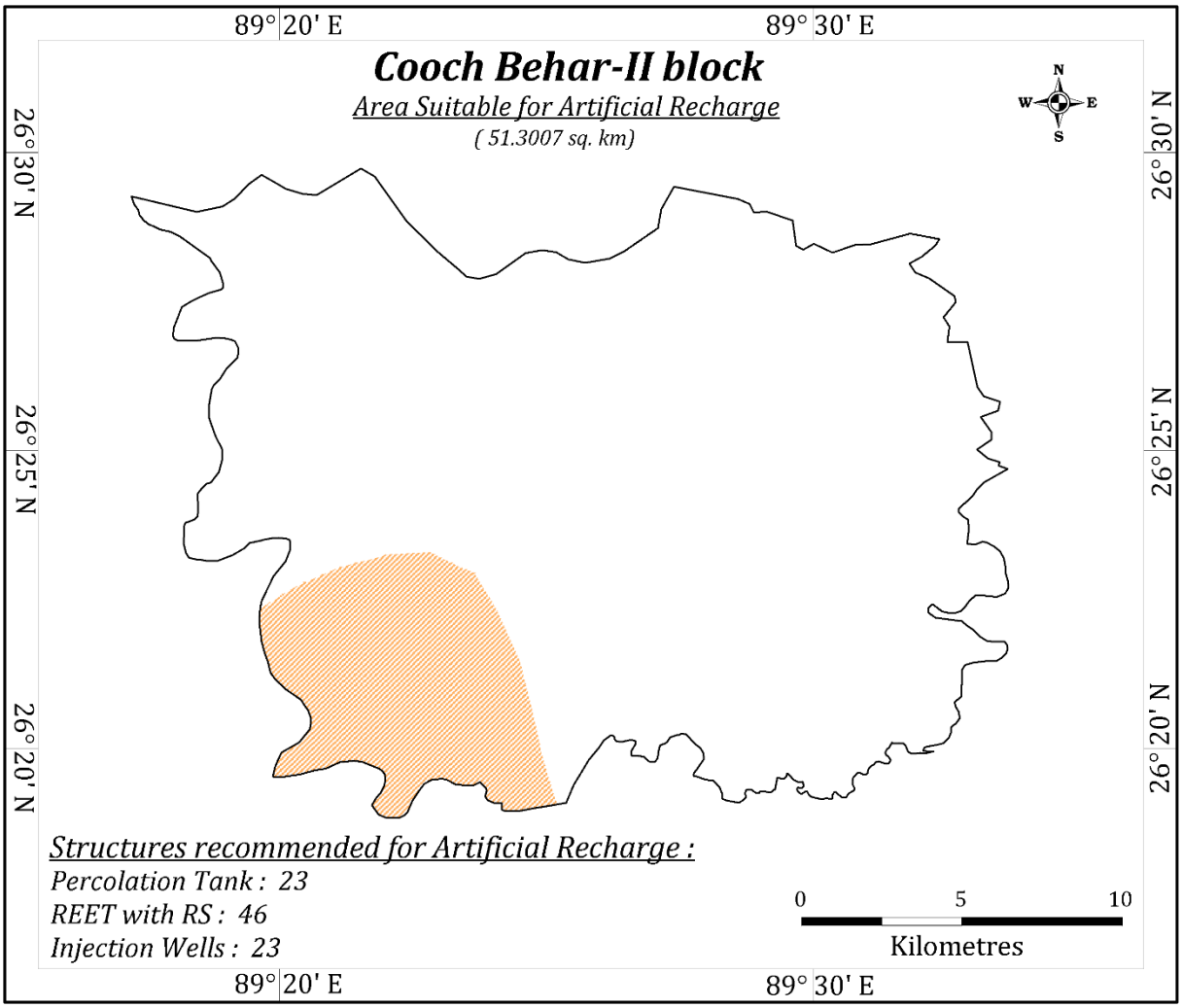

Fig.2.7: Area Feasible for Artificial Recharge of groundwater of Cooch Behar-II block.

Table 2.9: Area suitable for recharge in Cooch Behar-II block

District	Block Name	Block Area (in Ha)	Area (in Ha) suitable for recharge (having DTW 3 m and more in Postmonsoon)
Cooch Behar	Cooch Behar-II	38800	5130.070

Table 2.10: Artificial recharge priority area-structures feasible and their cost of construction for Cooch Behar-II block

Block	Utilizable Surface runoff	Allocation of Utilizable Resource (MCM)			Structures Feasible (No.s)			Cost of structures (in lakhs)			Total cost (in lakhs)
		Percolation tank	REET withRS	Injection Well	Percolation tank	REET with RS	Injection Well	Percolation tank	REET with RS	Injection Well	
Cooch Behar-II	23.085	11.543	4.617	6.926	23	46	23	184.00	184.00	69.00	437.00

3. Dinhata-I

Salient Information

Block Name: Dinhata-I

Geographical area (in sq. km): 281

Mapable area (in sq. km): 252

District: Cooch Behar

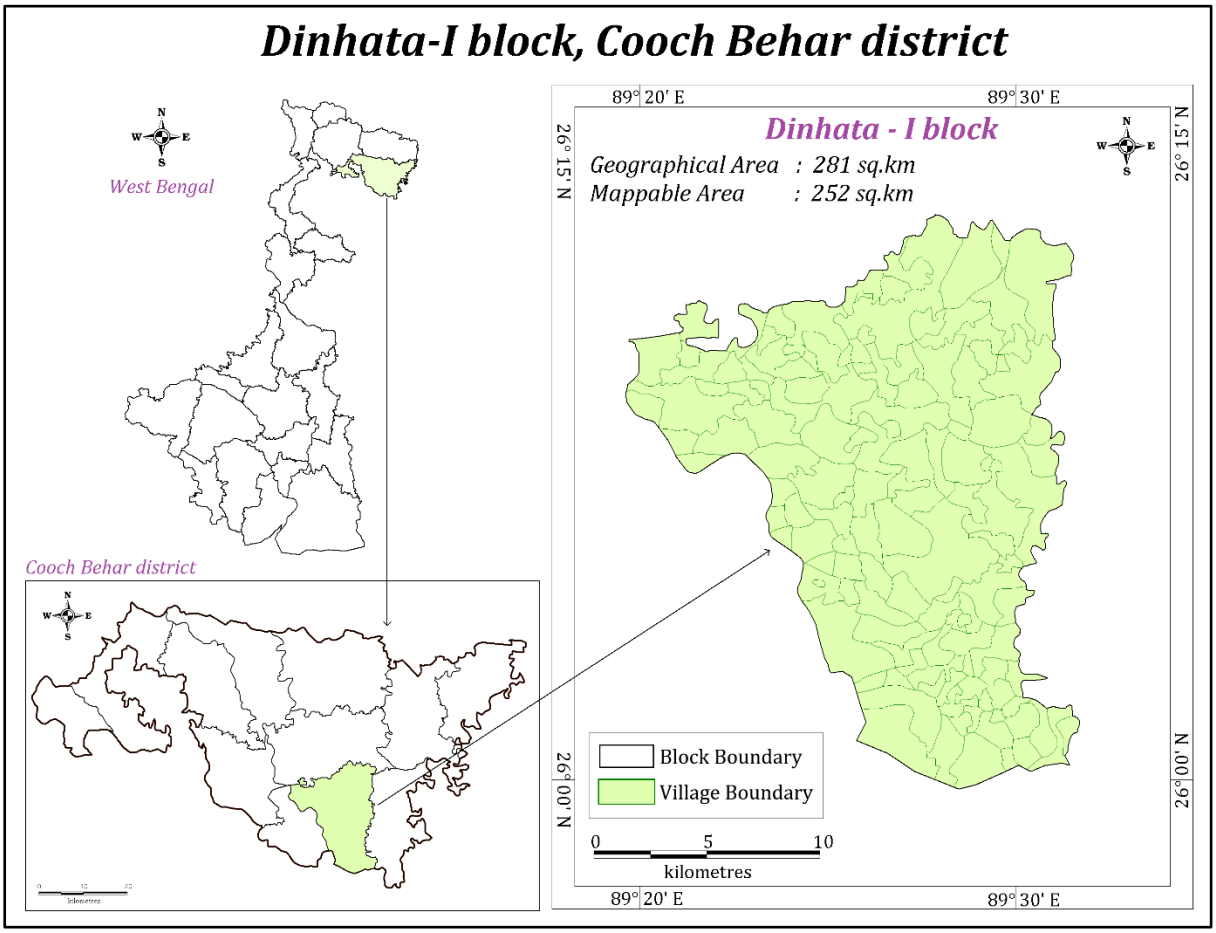

Fig.3.1. Location map for Dinhata-I block

Population (as on 2011):

Table 3.1: Distribution of population in administrative units of the study area

Block/ Muncipality	Rural Population			Urban Population			Total Population		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Dinhata-I	145325	136565	281890	2277	2102	4379	147602	138667	286269

Rainfall:

*Table 3.2: Annual Actual Rainfall for Cooch Behar District from 2011 to 2021 (*Source WRIS)*

Block Name	Normal Rainfall	Rain Fall										
Dinhata -I	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2011
	3213	2666.57	3682.77	2736.46	2882.16	3355.41	3180.31	3211.4	2630.13	3521.38	4677.07	2793.68

Landuse, Agriculture & Irrigation (area in ha):

Table 3.3.1: Dinhata-I Block details of Land-use pattern (in hectares)

Block	Reporting Area	Forest Area	Area under Non-Agricultural use	Barren and Un-culturable land	Land under misc tree crops	Cultur able wastes	Fallow land Other than current fallow	Current fallow	Net area sown
Dinhata - I	28259	115	6214	-	340	-	-	75	21515

Table 3.3.2: Command area(ha) of Dinhata-I block

Block Name	Dugwell		Sallow Tubewell		Medium Tubewell		Deep Tubewell		Surface Flow		Sarface 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	
Dinhata-I	30	123.99	2600	5044.24	191	949.30	10	400.00	1	8	48.00	1519.20	6517.53	1527.20	8044.73

Ground Water Resources:

Table 3.4 Details of Ground Water Resource Availability and Utilization in Dinhata-I Block. (As on 31.03.2013)

BLOCK NAME		DINHATA-I
Total Annual Ground Water Recharg e (Ham)		32038.45
Total Natural Discharg es (Ham)		3203.85
Annual Extractab le Ground Water Recharge (Ham)		28834.6
Total Extraction		14795.75
Annual GW	Allocation for Domestic and Industrial Use as on 2042	590.89
Net Ground Water Availabili ty for future irrigation use		13981.19
Stage of Ground Water Extracti on (%)		51.31
Categorization		Safe
Instorage		353150

Table 3.5: Details of aquifer disposition in Dinhata-I Block

Block	Location	No. of Aquifers	Water bearing zones (Zones Tapped)	Discharge (m^3/hr)	SWL (mbgl)	Draw down	T (m^2/day)	S
Dinhata-I	Batrigachh		135-165	1500	3.65	2.38	-	-
	Phalimari		30.34 –42.77, 79.27 – 85.47, 94.82 – 100.96, 140.00 -169.11	2749.8	4.38	3.8	1397.6	-

Geology:

Dinhata-I block is mainly covered with quaternary newer alluvium sediments. The major lithology encountered in this block are sand with pebbles & gravels, sand and clay. A lithological model is prepared based on the lithologs of exploratory wells of CGWB and PHED of Govt. of West Bengal.

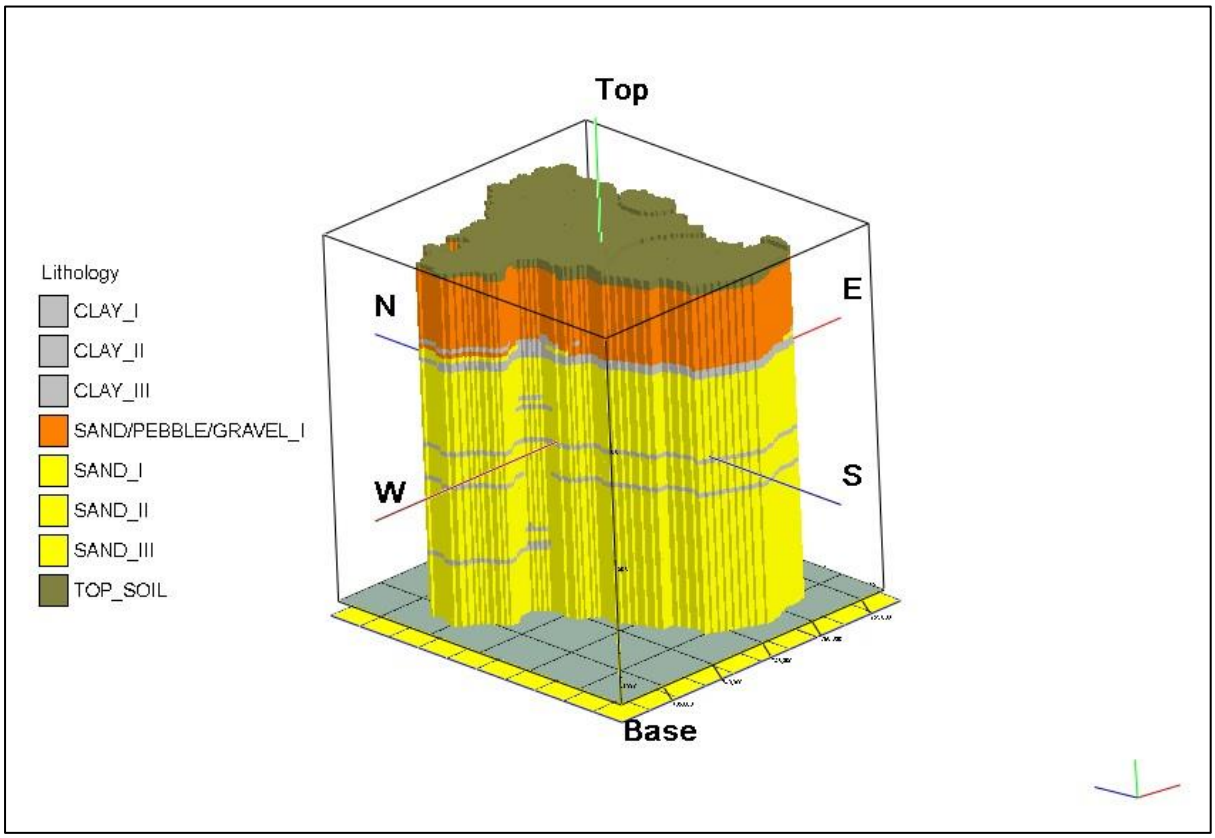

Fig. 3.2 Lithological model of Dinhata-I block.

Disposition of Aquifers:

In Dinhata-I there are two aquifer systems. One is shallow which extends from 3-meter bgl to 73-meter bgl and another is deep which extends from 64-meter bgl to beyond 150-meter bgl. Aquifer_I is unconfined to semi-confined whereas Aquifer_II is confined.

Aquifer_I again classified as Aquifer_I_A, and Aquifer_I_B depends upon the clay layers present in between. Similarly, Aquifer_II again classified as Aquifer_II_A, and Aquifer_II_B.

Fig. 3.3 Borehole location map of Dinhata-I block.

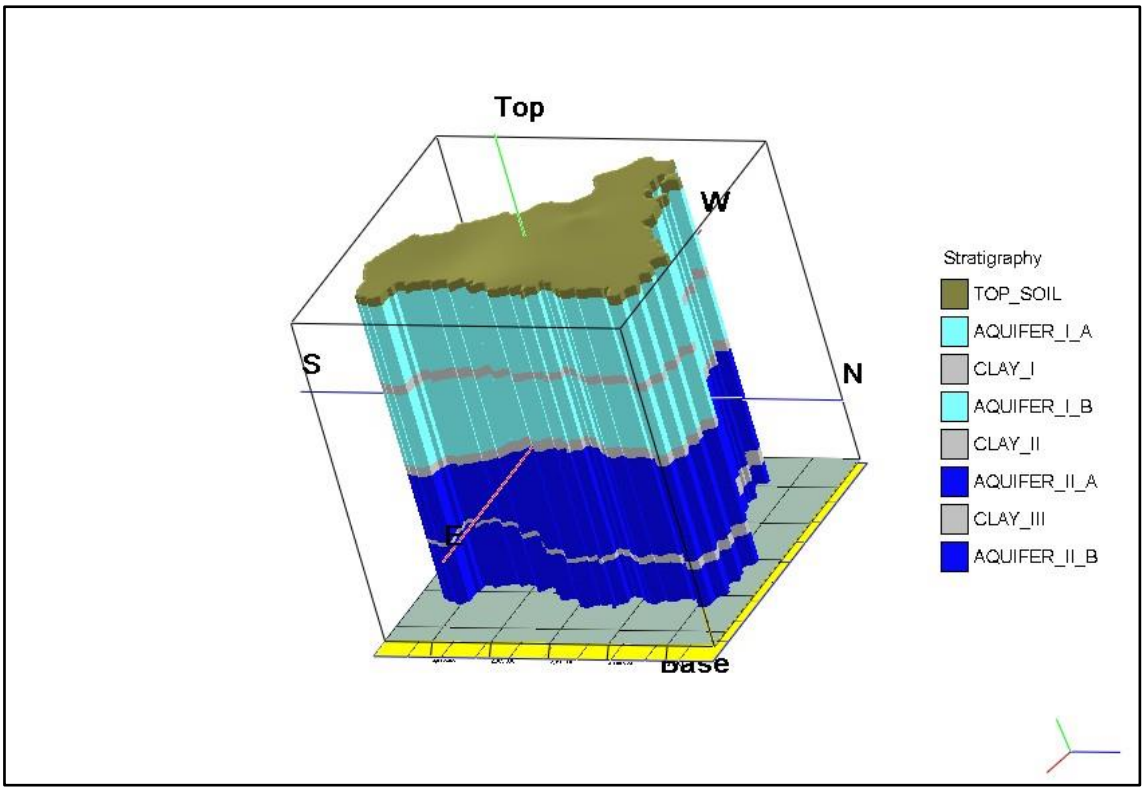

Fig.3.4 Aquifer disposition model of Dinhata-I block.

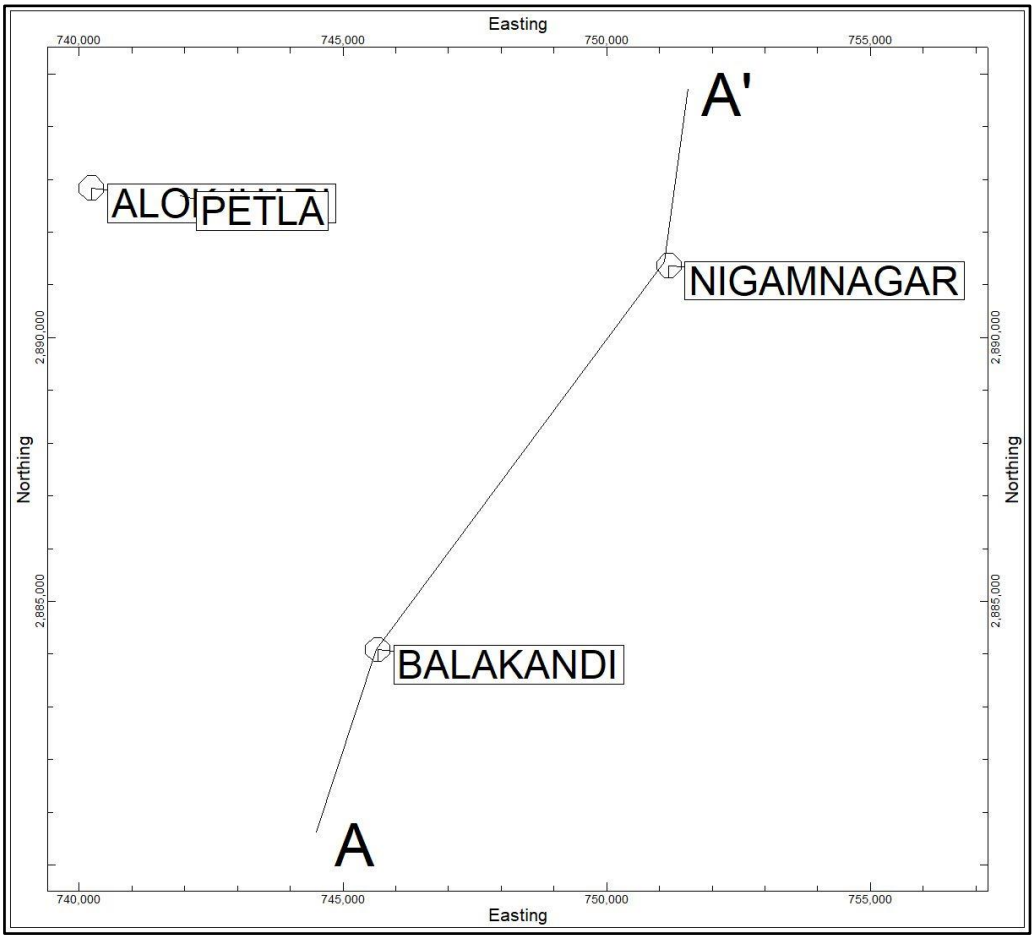

Fig. 3.5 Borehole location map for cross-section of Dinhata-I block.

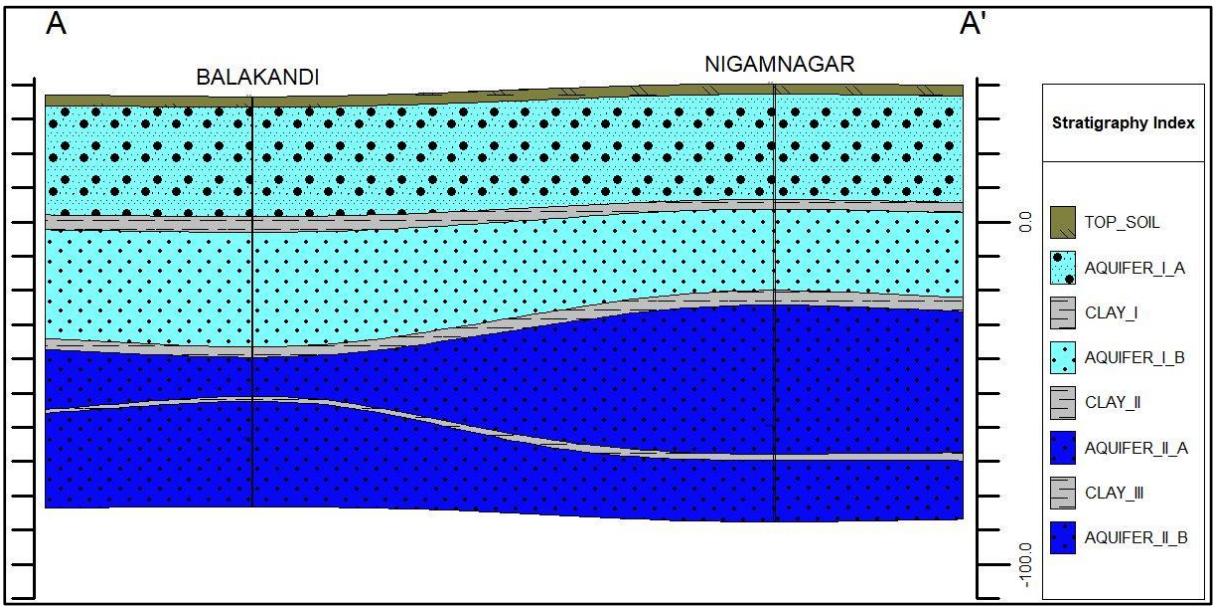

Fig.3.6 Cross-Sectional Map of Dinhata-I block.

Table 3.6: Details of aquifer wise water level ranges and seasonal long-term water level trend (2011-2020) in Dinhata-I Block

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)
DINHATA-1	I		0.3764	-	-	0.1478	
	II	-	-	-	-	-	-

Ground Water Quality and Issues:

Based on NHS and Keywells data, the range of chemical parameters for the block is given below.

Table 3.7: Average concentration of chemical parameters in Dinhata-I Block

Block	Aquifer Type	pH	EC	TH	Ca	Mg	Na	K	CO3	HCO3	Total Alk as CaCO3	Cl	NO3	SO4	F	TDS	Fe	U (µg/l)
Dinhata_I	Aquifer-I	6.76-6.89	94-190	30-75	8-18	2-7	6-9	2-3	0	37-98	30-80	11-14	BDL-1	BDL	0.24-0.43	54-112	BDL	BDL
	Aquifer-II	7.48-7.51	176-243	75-100	12-18	11-13	8-11	1	0	85-92	79-75	11-39	BDL-1	BDL	0.40-0.44	109-136	0.03-0.00	BDL

Groundwater Resource Enhancement and Management Plan:

Ground Water Management Plan for Drinking Purpose:

There are eleven (11) ground water based public water supply schemes are commissioned till July 2022 by PHED which are the main sources of drinking water in the block. Till July 2022 about 10.38 % of the Functional Household Tap Connection is achieved since inception. Dinhata-I block receives ample amount of rain during monsoon. Though the stage of development is only 51.31 % it will be good if we practice conservation through rain water harvesting and used it as an alternative for drinking water because with time ground water abstraction will increase and to maintain the categorization as safe we have to look supplement sources for drinking purposes.

For monitoring of change in ground water regime in the area in future, cost of construction of observation well should be included.

Management plan for Irrigation:

Table 3.8: Ground-water scenario for irrigation in Dinhata-I block

Block	Geographical Area in Ha	Net Area Sown in Ha	Net Area Irrigated in Ha	Area to be Irrigated in Ha	SOD in %
DINHATA-1	38165	10180	5355.89	4824.11	51.31

The stage of ground water development in the block is 51.31 %, under safe category. However, further development should be done in planned manner to harness the additional available resource for more sustainable development.

4824.11 hectares more of land can be irrigated. Water applied for irrigation should not be wasted. An effective water management technique should be considered through modern agricultural management maintaining minimum pumping hours and selecting most appropriate cropping pattern. The application of modern techniques like sprinkler and drip irrigation will help increase crop yield and consequently conserve ground water.

Crops with low water requirement should be preferred. Heavy duty/medium duty tube wells can be constructed by Govt. agencies as they may help for irrigation in large perspective. Installation and maintenance cost of heavy-duty tube well is high and it will be difficult for individual or small farmers to maintain. Therefore, heavy-duty tube wells can be constructed by local government agencies and after installation of pumps it can be handed over to the local co-operative based farmers for its operation and maintenance.

Dug wells, light duty tube wells fitted with submersible pump, medium duty tube wells are feasible for irrigation purposes. But the capacity of the pump should be decided in such a way so that drawdown may be minimized.

In view of sufficient rainfall in the area, excavation of tanks with large catchment areas can help in augmention of irrigation facilities.

Management Intervention Through Rain Water Harvesting (Roof Top and Surface Runoff) And Artifitial Recharge:

The area receives plenty of rainfall but due to lack of proper rainwater harvesting structures and un-distributed rainfall causes huge amount of rainwater to drain into the sea. The runoff, thus produced, may be diverted for water harvesting either for conservation or for artificial recharge to the depleted aquifer in the area. No structure has been constructed by CGWB till date.

Generally, water conservation and artificial recharge is feasible is such area where water level is more than 3 mbgl in post monsoon period. As a whole the water level is not in alarming condition in this block. Water conservation of rainwater by different structures like percolation tank, roof top rainwater harvesting can be considered for the block in future.

This block is not considered under artificial recharge and no Artificial Recharge Structures has thus been proposed at present.

4. Dinhata-II

Salient Information

Block Name: Dinhata-II

Geographical area (in sq. km): 250

Mapable area (in sq. km): 224

District: Cooch Behar

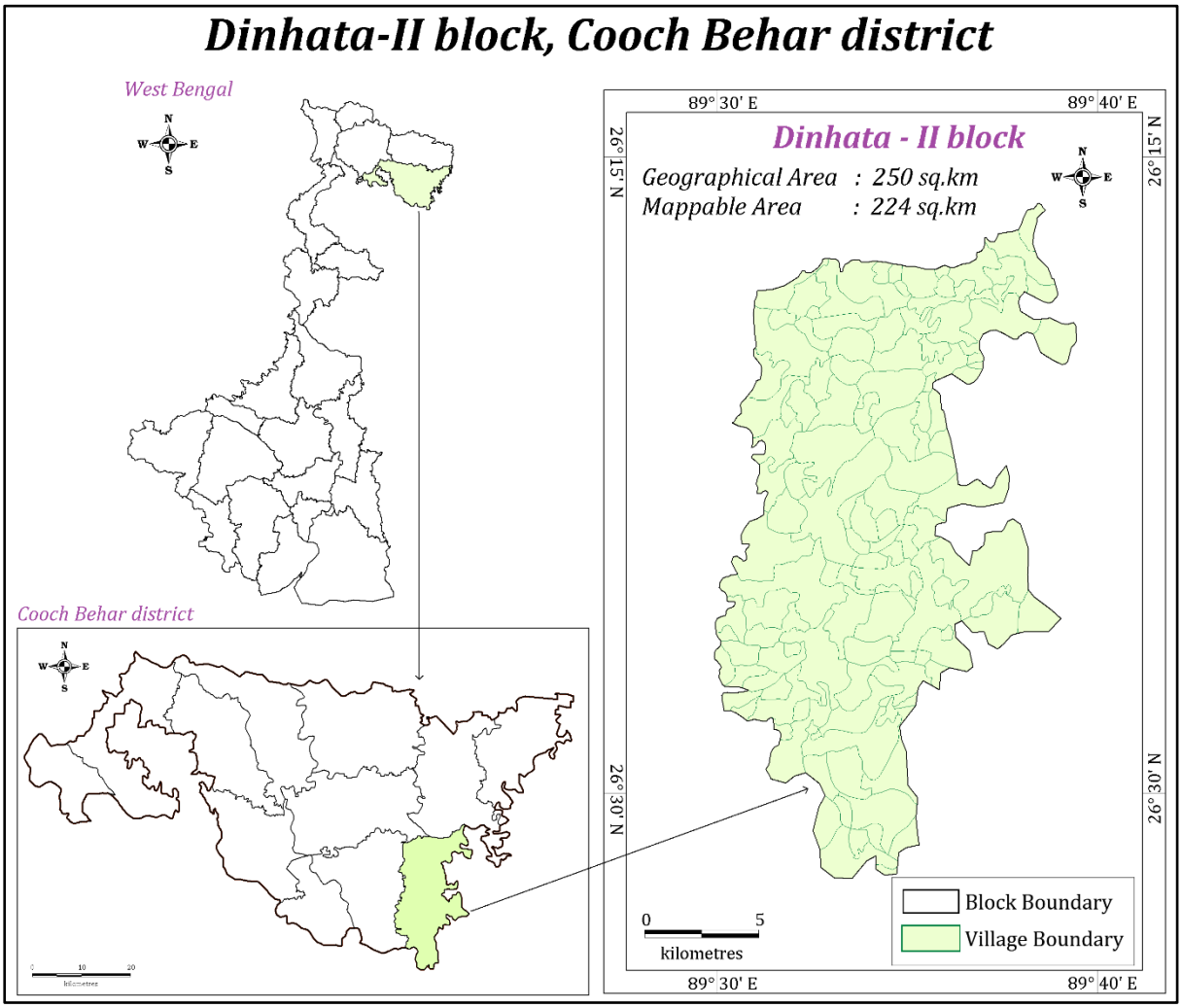

Fig.4.1. Location map for Dinhata-II block

Population (as on 2011):

Table 4.1: Distribution of population in administrative units of the study area

Block/ Muncipality	Rural Population			Urban Population			Total Population		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Dinhata-II	126663	117403	244066	-	-	-	126663	117403	244066

Rainfall:

*Table 4.2: Annual Actual Rainfall for Cooch Behar District from 2011 to 2021 (*Source WRIS)*

Block Name	Normal Rainfall	Rain Fall										
Dinhata-II	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2011
	3213	2666.57	3682.77	2736.46	2882.16	3355.41	3180.31	3211.4	2630.13	3521.38	4677.07	2793.68

Landuse, Agriculture & Irrigation (area in ha):

Table 4.3.1: Dinhata-II Block details of Land-use pattern (in hectares)

Block	Reporting Area	Forest Area	Area under Non-Agricultural use	Barren and Un-culturable land	Land under misc tree crops	Culturable wastes	Fallow land Other than current fallow	Current fallow	Net area sown
Dinhata -II	25240	0	3332	-	310	-	-	65	21533

Table 4.3.2: Command area(ha) of Dinhata-II block

Block Name	Dugwell		Sallow Tubewell		Medium Tubewell		Deep Tubewell		Surface Flow		Sarface 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	
Dinhata -II	5	6.60	2510.00	5117.58	10	60.66	12	245.13	0	0.00	35	1663.00	5429.97	1663.00	7092.97

Ground Water Resources:

Table 4.4 Details of Ground Water Resource Availability and Utilization in Dinhata-II Block. (As on 31.03.2013)

BLOCK NAME		DINHATA-II
Total Annual Ground Water Recharg e (Ham)		27128.12
Total Natural Discharg es (Ham)		2712.81
Annual Extractab le Ground Water Recharge (Ham)		24415.31
Total Extraction		11252.13
Annual GW	Allocation for Domestic and Industrial Use as on 2042	490.26
Net Ground Water Availabili ty for future irrigation use		13127.54
Stage of Ground Water Extracti on (%)		46.09
Categorization		Safe
Instorage		145963

Geology:

Dinhat-II block is mainly covered with quaternary newer alluvium sediments. The major lithology encountered in this block are sand, sand with pebbles & gravels and clay. A lithological model is prepared based on the lithologs of exploratory wells of CGWB and PHED of Govt. of West Bengal.

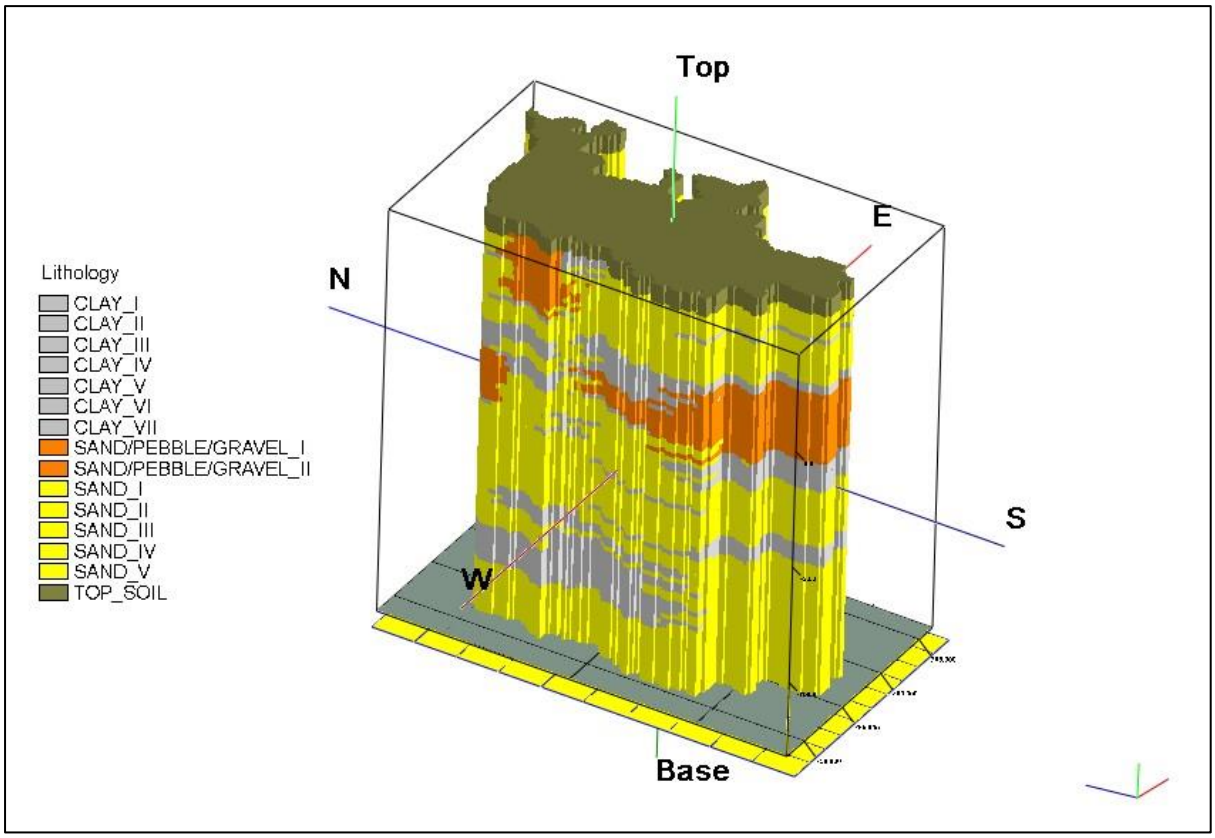

Fig. 4.2 Lithological model of Dinhata-II block.

Disposition of Aquifers:

In Dinhata-II there are two aquifer systems. One is shallow which extends from 3-meter bgl to 88-meter bgl and another is deep which extends from 88-meter bgl to beyond 150-meter bgl. Aquifer_I am unconfined to semi-confined whereas Aquifer_II is confined.

In some areas like Rakhalmari and Chotosakdal Aquifer_I extend from 3-meter bgl to 33-meter bgl, and Aquifer_II present as shallow as 33-meter bgl.

Aquifer_I again classified as Aquifer_I_A, Aquifer_I_B, Aquifer_I_C and Aquifer_I_D depends upon the clay layers present in between. Similarly, Aquifer_II again classified as Aquifer_II_A, Aquifer_II_B and Aquifer_II_C.

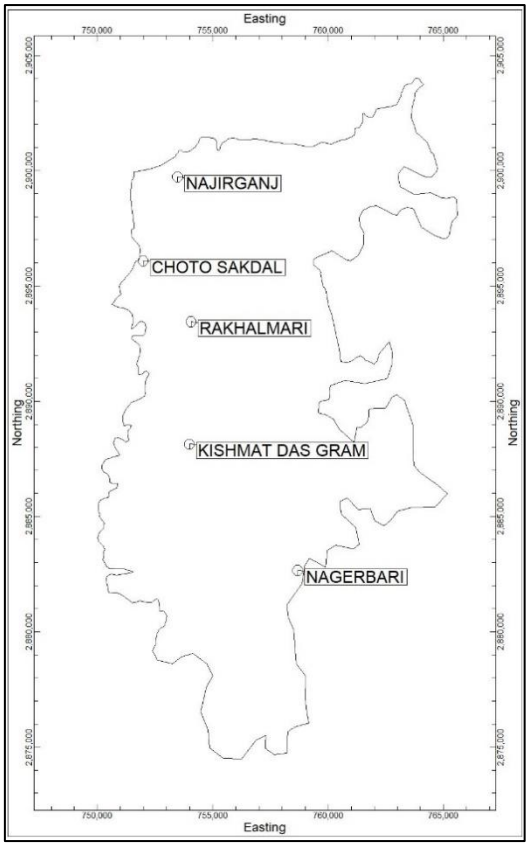

Fig.4.3 Borehole Location map of Dinhata-II block.

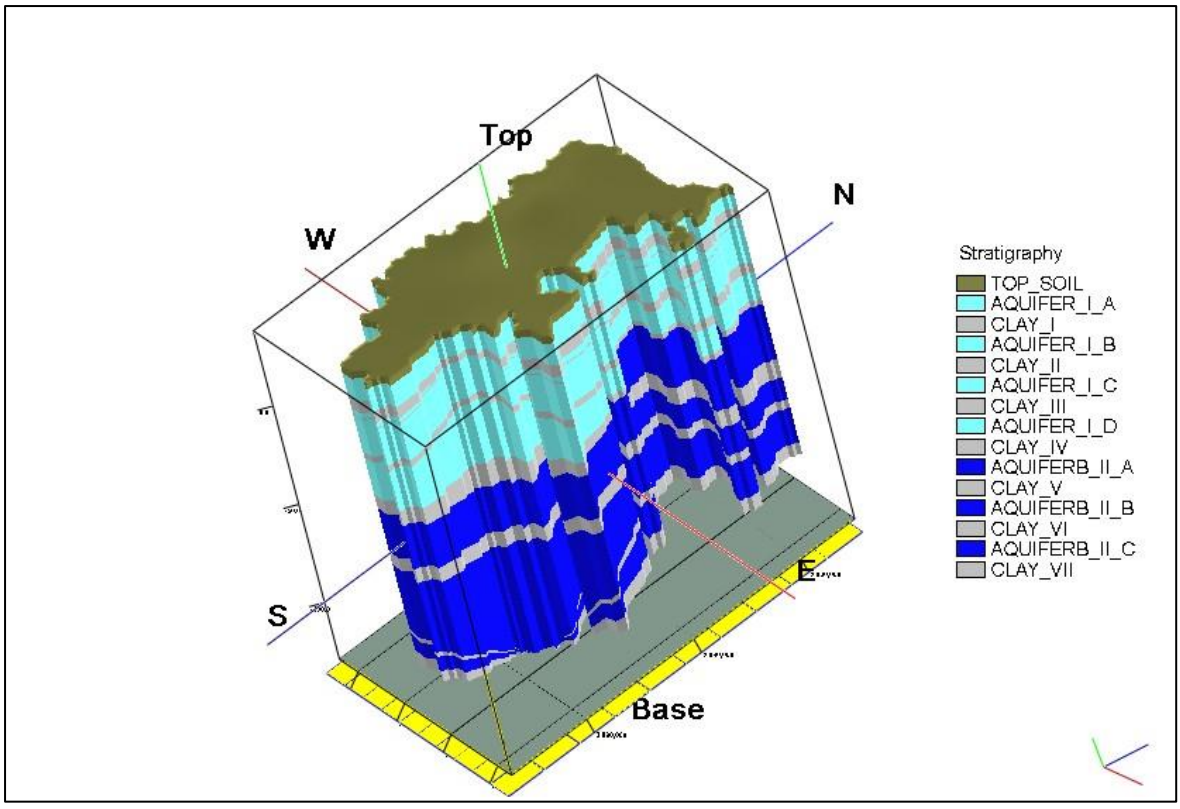

Fig.4.4 Aquifer disposition model of Dinhata-II block.

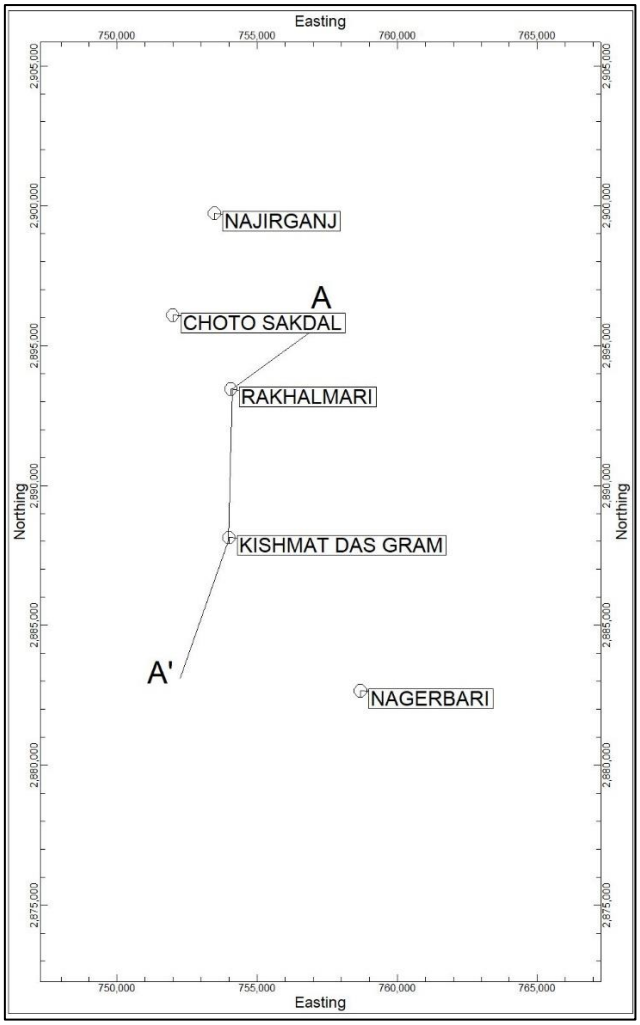

Fig.4.5 Borehole Location map for cross-section of Dinhata-II block.

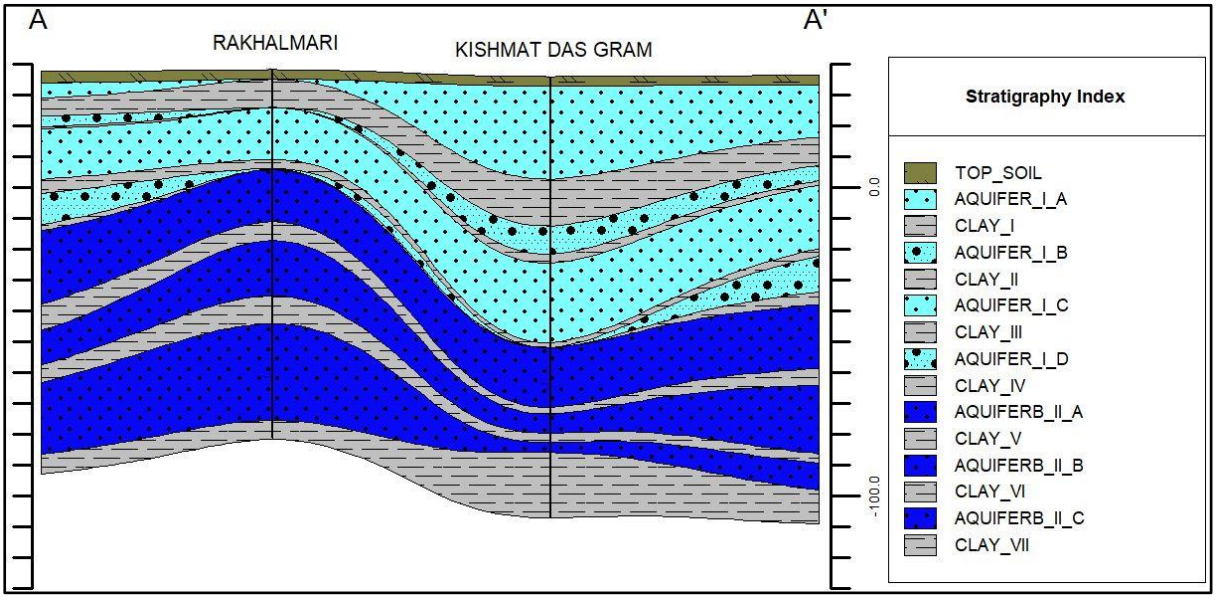

Fig.4.6 Cross-Sectional Map of Dinhata-II block.

Table 4.5: Details of aquifer wise water level ranges and seasonal long-term water level trend (2011-2020) in Dinhata-II Block

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)
DINHATA-II	I		0.572333333	--		0.231666667	
	II	-	-	-	-	-	-

Ground Water Quality and Issues:

Based on NHS and Keywells data, the range of chemical parameters for the block is given below.

Table 4.6: Average concentration of chemical parameters in Dinhata-II Block

Block	Aquifer Type	pH	EC	TH	Ca	Mg	Na	K	CO3	HCO3	Total Alk as CaCO3	Cl	NO3	SO4	F	TDS	Fe	U (µg/l)
Dinhata_II	Aquifer-I	6.92-7.45	209-306	65-140	12-48	5-9	7-16	4-8	0	73-177	60-145	14-32	BDL	BDL	0.44-0.63	121-187	0.63-2.25	BDL-0.04
	Aquifer-II	7.41-7.62	269-384	100-160	24-30	6-24	17-19	1	0	128-232	105-190	11-14	BDL-20	BDL	0.23-0.35	164-225	BDL	0.08-0.18

Groundwater Resource Enhancement and Management Plan:

Ground Water Management Plan for Drinking Purpose:

There are seven (14) ground water based public water supply schemes are commissioned till July 2022 by PHED which are the main sources of drinking water in the block. Till July 2022 about 16.12 % of the Functional Household Tap Connection is achieved since inception. Dinhata-II block receives ample amount of rain during monsoon. Though the stage of development is only 46.09% it will be good if we practice conservation through rain water harvesting and used it as an alternative for drinking water because with time ground water abstraction will increase and to maintain the categorization as safe we have to look supplement sources for drinking purposes.

For monitoring of change in ground water regime in the area in future, cost of construction of observation well should be included.

Management plan for Irrigation:

Table 4.7: Ground-water scenario for irrigation in Dinhata-II block

Block	Geographical Area in Ha	Net Area Sown in Ha	Net Area Irrigated in Ha	Area to be Irrigated in Ha	SOD in %
DINHATA-II	99910	16060	2673.43	13386.57	46.09

The stage of ground water development in the block is 46.09 %, under safe category. However, further development should be done in planned manner to harness the additional available resource for more sustainable development.

13386.57 hectares more of land can be irrigated. Water applied for irrigation should not be wasted. An effective water management technique should be considered through modern agricultural management maintaining minimum pumping hours and selecting most appropriate cropping pattern. The application of modern techniques like sprinkler and drip irrigation will help increase crop yield and consequently conserve ground water.

Crops with low water requirement should be preferred. Heavy duty/medium duty tube wells can be constructed by Govt. agencies as they may help for irrigation in large perspective. Installation and maintenance cost of heavy-duty tube well is high and it will be difficult for individual or small farmers to maintain. Therefore, heavy-duty tube wells can be constructed by local government agencies and after installation of pumps it can be handed over to the local co-operative based farmers for its operation and maintenance.

Dug wells, light duty tube wells fitted with submersible pump, medium duty tube wells are feasible for irrigation purposes. But the capacity of the pump should be decided in such a way so that drawdown may be minimized.

In view of sufficient rainfall in the area, excavation of tanks with large catchment areas can help in augmentation of irrigation facilities.

Management Intervention Through Rain Water Harvesting (Roof Top and Surface Runoff) And Artificial Recharge:

The area receives plenty of rainfall but due to lack of proper rainwater harvesting structures and un-distributed rainfall causes huge amount of rainwater to drain into the sea. The runoff, thus produced, may be diverted for water harvesting either for conservation or for artificial recharge to the depleted aquifer in the area. No structure has been constructed by CGWB till date.

Generally, water conservation and artificial recharge is feasible is such area where water level is more than 3 mbgl in post monsoon period. As a whole the water level is not in alarming condition in this block. Water conservation of rainwater by different structures like percolation tank, roof top rainwater harvesting can be considered for the block in future.

This block is not considered under artificial recharge and no Artificial Recharge Structures has thus been proposed at present.

5. Haldibari

Salient Information

Block Name: Haldibari

Geographical area (in sq. km): 197

Mapable area (in sq. km): 176

District: Cooch Behar

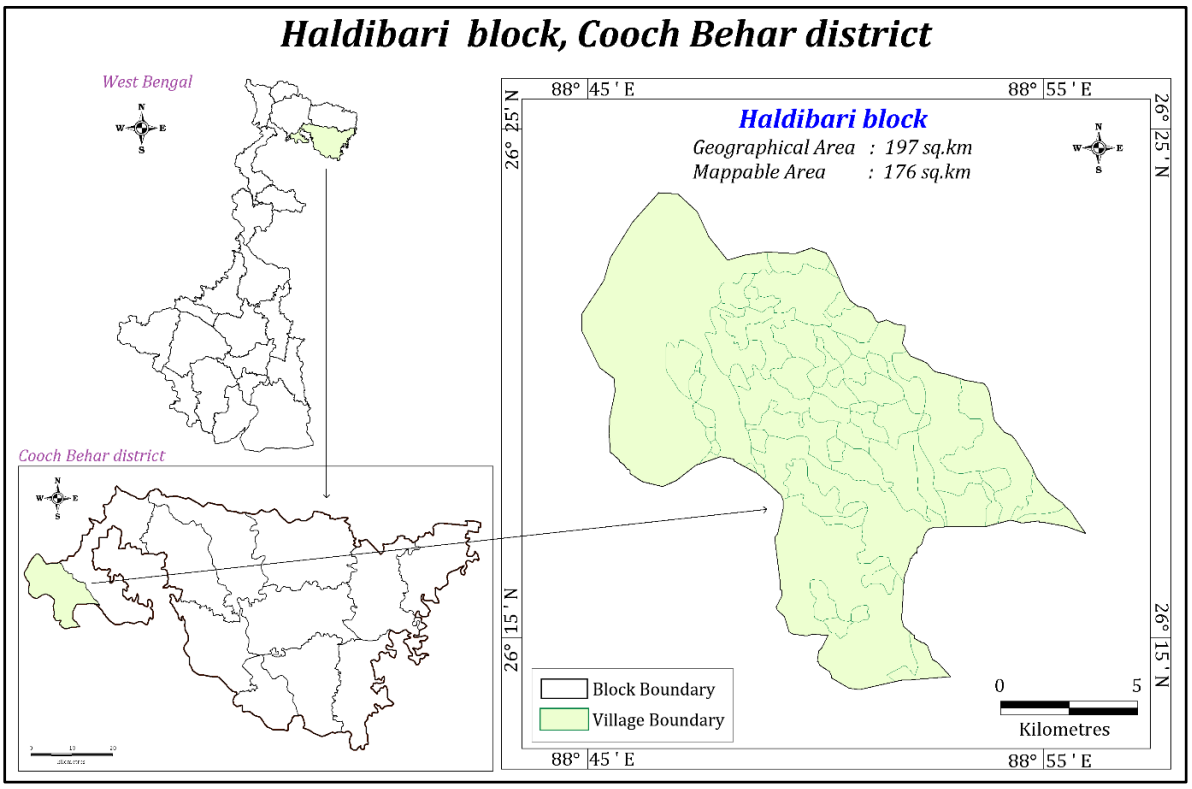

Fig.5.1. Location map for Haldibari block

Population (as on 2011):

Table 5.1: Distribution of population in administrative units of the study area

Block/ Muncipality	Rural Population			Urban Population			Total Population		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Haldibari(M)	-	-	-	7306	7098	14404	7306	7098	14404

Rainfall:

*Table 5.2: Annual Actual Rainfall for Cooch Behar District from 2011 to 2021 (*Source WRIS)*

Block Name	Normal Rainfall	Rain Fall										
Haldibari	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2011
	3213	2666.57	3682.77	2736.46	2882.16	3355.41	3180.31	3211.4	2630.13	3521.38	4677.07	2793.68

Landuse, Agriculture & Irrigation (area in ha):

Table 5.3.1: Haldibari Block details of Land-use pattern (in hectares)

Block	Reporting Area	Forest Area	Area under Non-Agricultural use	Barren and Un-culturable land	Land under misc tree crops	Culturable wastes	Fallow land Other than current fallow	Current fallow	Net area sown
Haldibari	14405	0	3663	0	773	-	-	102	9862

Table 5.3.2: Command area(ha) of Haldibari block

Block Name	Dugwell		Sallow Tubewell		Medium Tubewell		Deep Tubewell		Surface Flow		Sarface 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	
Haldibari	4	10.06	1004.00	2011.67	0	0.00	0	0.00	0	0.00	25	315.19	2021.73	315.19	2336.92

Ground Water Resources:

Table 5.4 Details of Ground Water Resource Availability and Utilization in Haldibari Block. (As on 31.03.2013)

BLOCK NAME		HALDIBARI
Total Annual Ground Water Recharg e (Ham)		13513.25
Total Natural Discharg es (Ham)		1351.33
Annual Extractab le Ground Water Recharge (Ham)		12161.92
Total Extraction		4122.89
Annual GW	Allocation for Domestic and Industrial Use as on 2042	194.54
Net Ground Water Availabili ty for future irrigation use		8038.15
Stage of Ground Water Extracti on (%)		33.9
Categorization		Safe
Instorage		210064

Geology:

Haldibari block is mainly covered with quaternary newer alluvium sediments. The major lithology encountered in this block are sand, and clay. A lithological model is prepared based on the lithologs of exploratory wells of CGWB and PHED of Govt. of West Bengal.

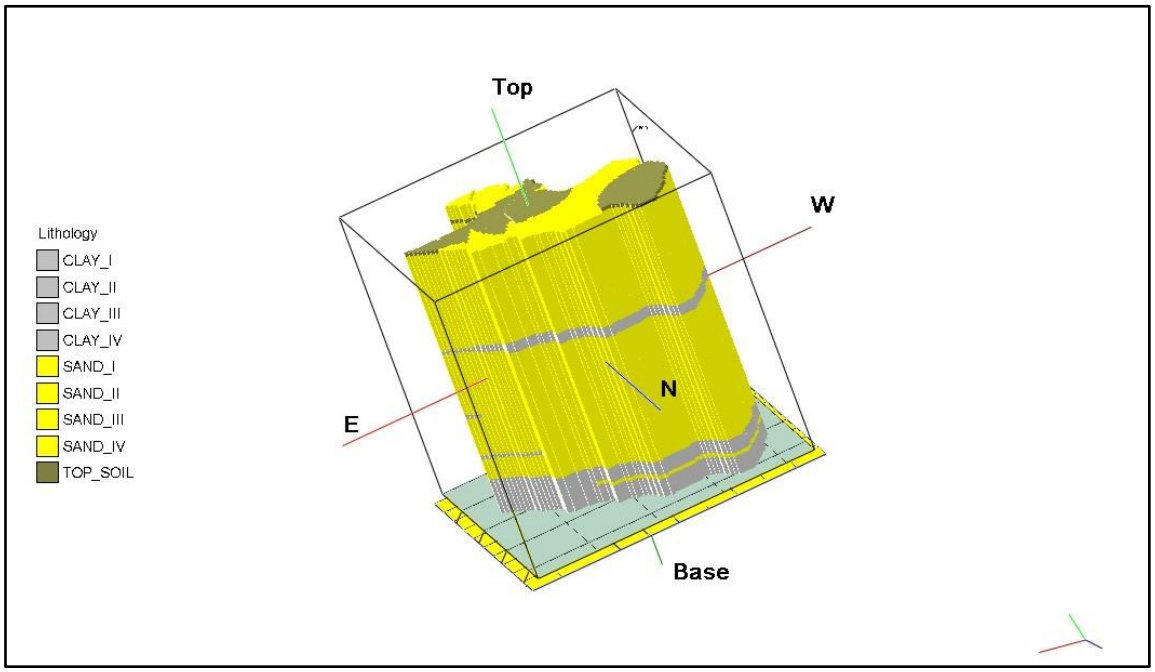

Fig. 5.2 Lithological model of Haldibari block.

Disposition of Aquifers:

In Haldibari there are two aquifer systems. One is shallow which extends from 5-meter bgl to 61-meter bgl and another is deep which extends from 67-meter bgl to beyond 150-meter bgl. Aquifer_I is unconfined to semi-confined whereas Aquifer_II is confined.

Aquifer_II again classified as Aquifer_I_A, Aquifer_I_B, and Aquifer_I_C depends upon the clay layers present in between. Similarly.

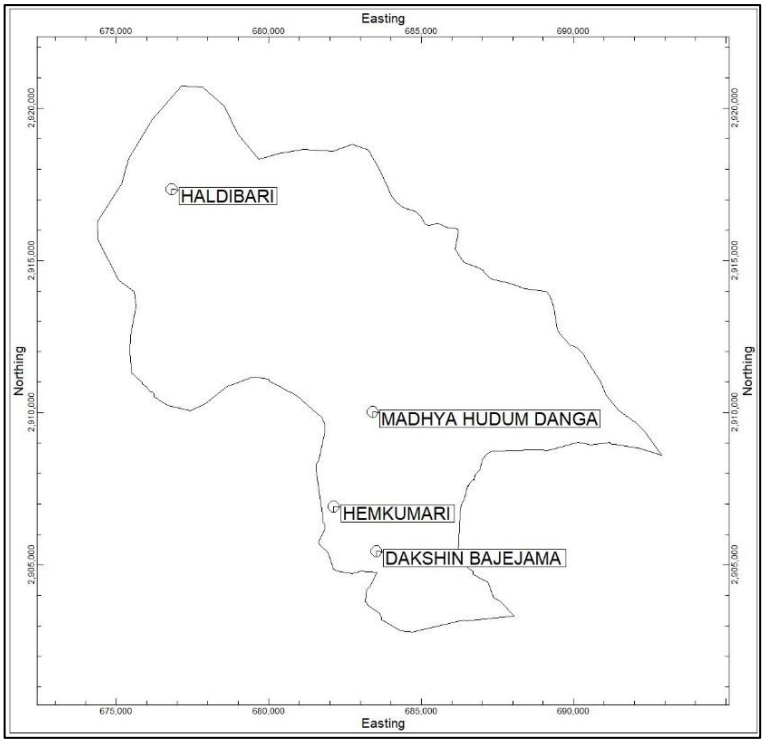

Fig. 5.3 Borehole Location map of Haldibari block.

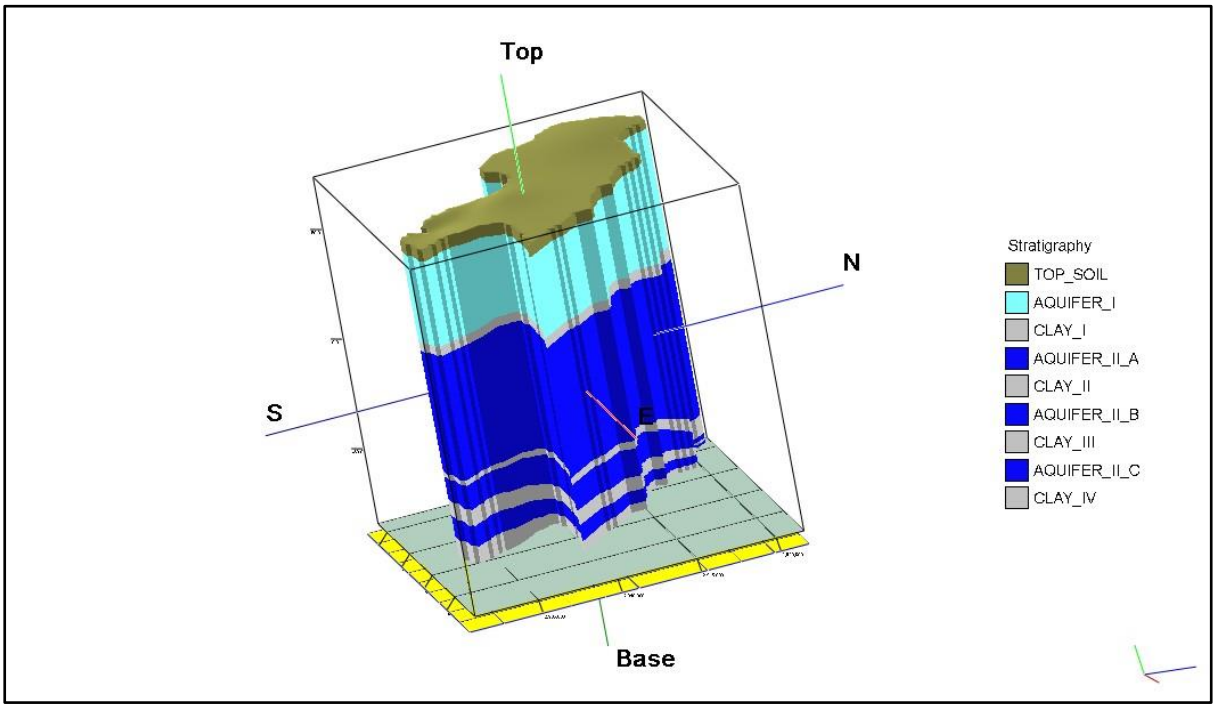

Fig.5.4 Aquifer disposition model of Haldibari block.

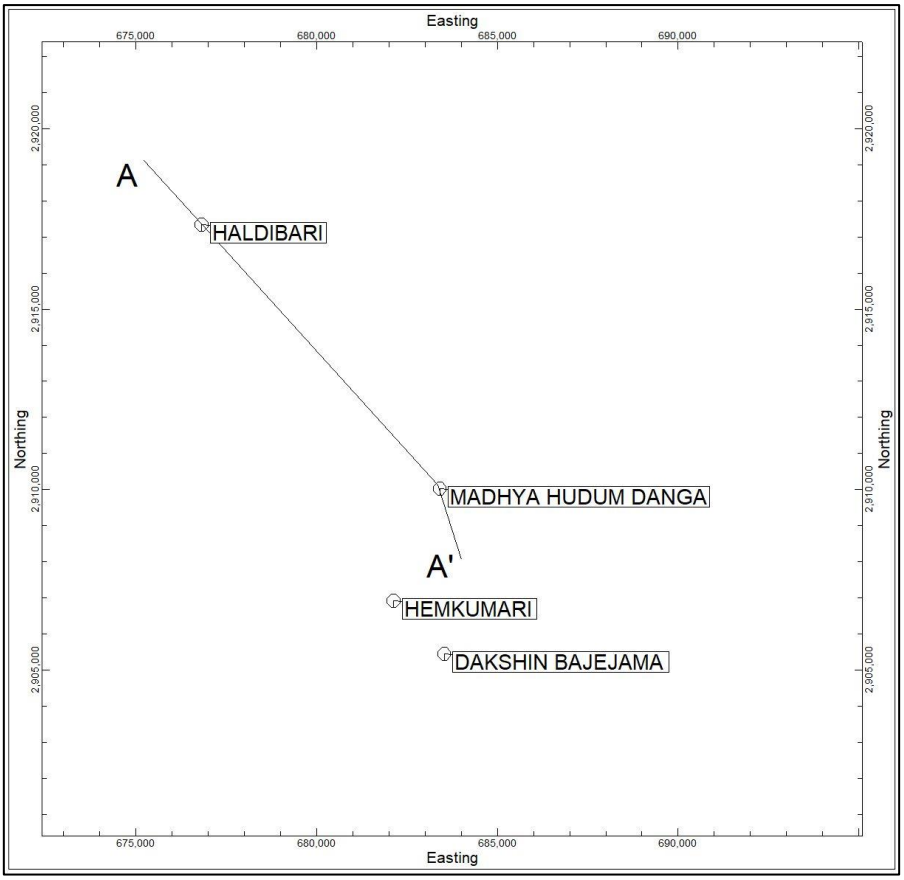

Fig. 5.5 Borehole Location map for cross-section of Haldibari block.

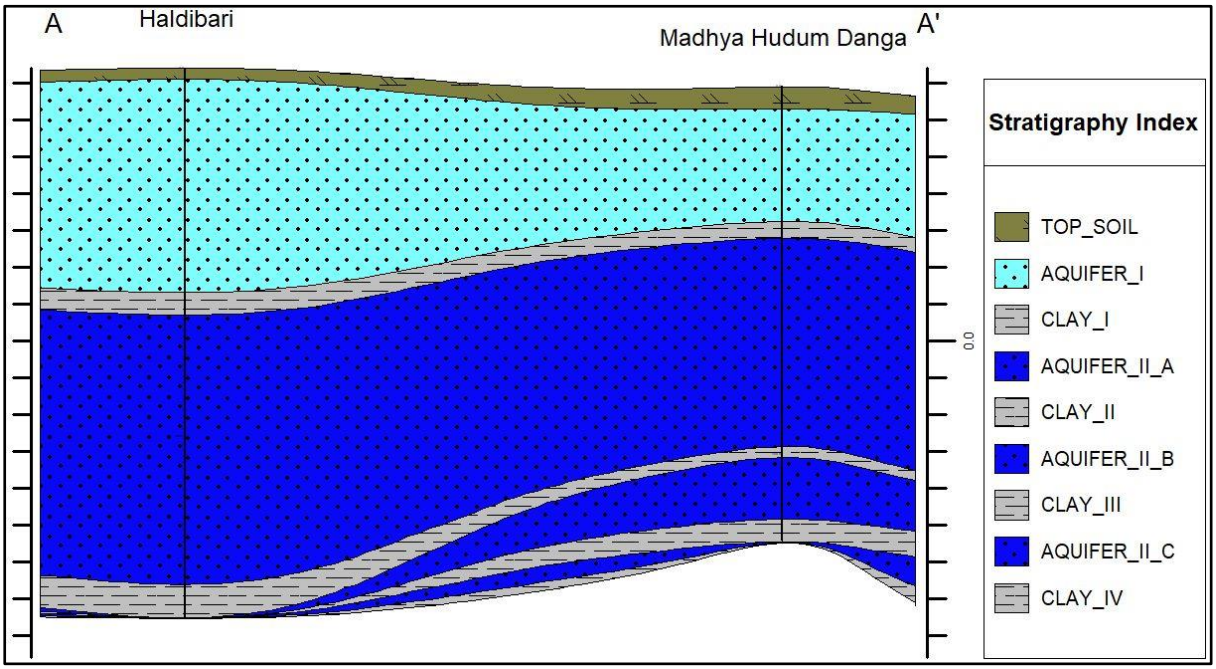

Fig.5.6 Cross-Sectional Map of Haldibari block.

Table 5.5: Details of aquifer disposition in Haldibari Block

Block	Location	No. of Aquifers	Water bearing zones (Zones Tapped)	Discharge (m^3/hr)	SWL (mbgl)	Draw down	T (m^2/day)	S
Haldibari	Anguldekha	**2**	90-102, 116-128, 140-146	1020	1.1	**2.79**	-	-

Table 5.6: Details of aquifer wise water level ranges and seasonal long-term water level trend (2011-2020) in Haldibari Block

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)
Haldibari	I		0.187	--		0.021	
	II	-	-	-	-	-	-

Ground Water Quality and Issues:

Based on NHS and Keywells data, the range of chemical parameters for the block is given below.

Table 5.7: Average concentration of chemical parameters in Haldibari Block

Block	Aquifer Type	pH	EC	TH	Ca	Mg	Na	K	CO3	HCO3	Total Alk as CaCO3	Cl	NO3	SO4	F	TDS	Fe	U (µg/l)
Haldibari	Aquifer-I	6.81	164	50	16	2	13	3	0	73	60	14	BDL	BDL	0.27	93	8.72	0.02
	Aquifer-II	7.05	220	80	26	4	14	3	0	128	105	7	BDL	BDL	0.36	132	3.74	0.35

Groundwater Resource Enhancement and Management Plan:

Ground Water Management Plan for Drinking Purpose:

There are five (5) ground water based public water supply schemes are commissioned till July 2022 by PHED which are the main sources of drinking water in the block. Till July 2022 about 23.58 % of the Functional Household Tap Connection is achieved since inception. Haldibari block receives ample amount of rain during monsoon. Though the stage of development is only 33.9 % it will be good if we practice conservation through rain water harvesting and used it as an alternative for drinking water because with time ground water abstraction will increase and to maintain the categorization as safe we have to look supplement sources for drinking purposes.

For monitoring of change in ground water regime in the area in future, cost of construction of observation well should be included.

Management plan for Irrigation:

Table 5.8: Ground-water scenario for irrigation in Haldibari block

Block	Geographical Area in Ha	Net Area Sown in Ha	Net Area Irrigated in Ha	Area to be Irrigated in Ha	SOD in %
HALDIBARI	11675	6407	854.14	5552.86	33.9

The stage of ground water development in the block is 33.9 %, under safe category. However, further development should be done in planned manner to harness the additional available resource for more sustainable development.

5552.86 hectares more of land can be irrigated. Water applied for irrigation should not be wasted. An effective water management technique should be considered through modern agricultural management maintaining minimum pumping hours and selecting most appropriate cropping pattern. The application of modern techniques like sprinkler and drip irrigation will help increase crop yield and consequently conserve ground water.

Crops with low water requirement should be preferred. Heavy duty/medium duty tube wells can be constructed by Govt. agencies as they may help for irrigation in large perspective. Installation and maintenance cost of heavy-duty tube well is high and it will be difficult for individual or small farmers to maintain. Therefore, heavy-duty tube wells can be constructed by local government agencies and after installation of pumps it can be handed over to the local co-operative based farmers for its operation and maintenance.

Dug wells, light duty tube wells fitted with submersible pump, medium duty tube wells are feasible for irrigation purposes. But the capacity of the pump should be decided in such a way so that drawdown may be minimized.

In view of sufficient rainfall in the area, excavation of tanks with large catchment areas can help in augmentation of irrigation facilities.

Management Intervention Through Rain Water Harvesting (Roof Top and Surface Runoff) And Artificial Recharge:

The area receives plenty of rainfall but due to lack of proper rainwater harvesting structures and un-distributed rainfall causes huge amount of rainwater to drain into the sea. The runoff, thus produced, may be diverted for water harvesting either for conservation or for artificial recharge to the depleted aquifer in the area. No structure has been constructed by CGWB till date.

Generally, water conservation and artificial recharge is feasible is such area where water level is more than 3 mbgl in post monsoon period. As a whole the water level is not in alarming condition in this block. Water conservation of rainwater by different structures like percolation tank, roof top rainwater harvesting can be considered for the block in future.

This block is not considered under artificial recharge and no Artificial Recharge Structures has thus been proposed at present.

6. Mathabhanga-I

Salient Information

Block Name: Mathabhanga-I

Geographical area (in sq. km): 296

Mapable area (in sq. km): 265

District: Cooch Behar

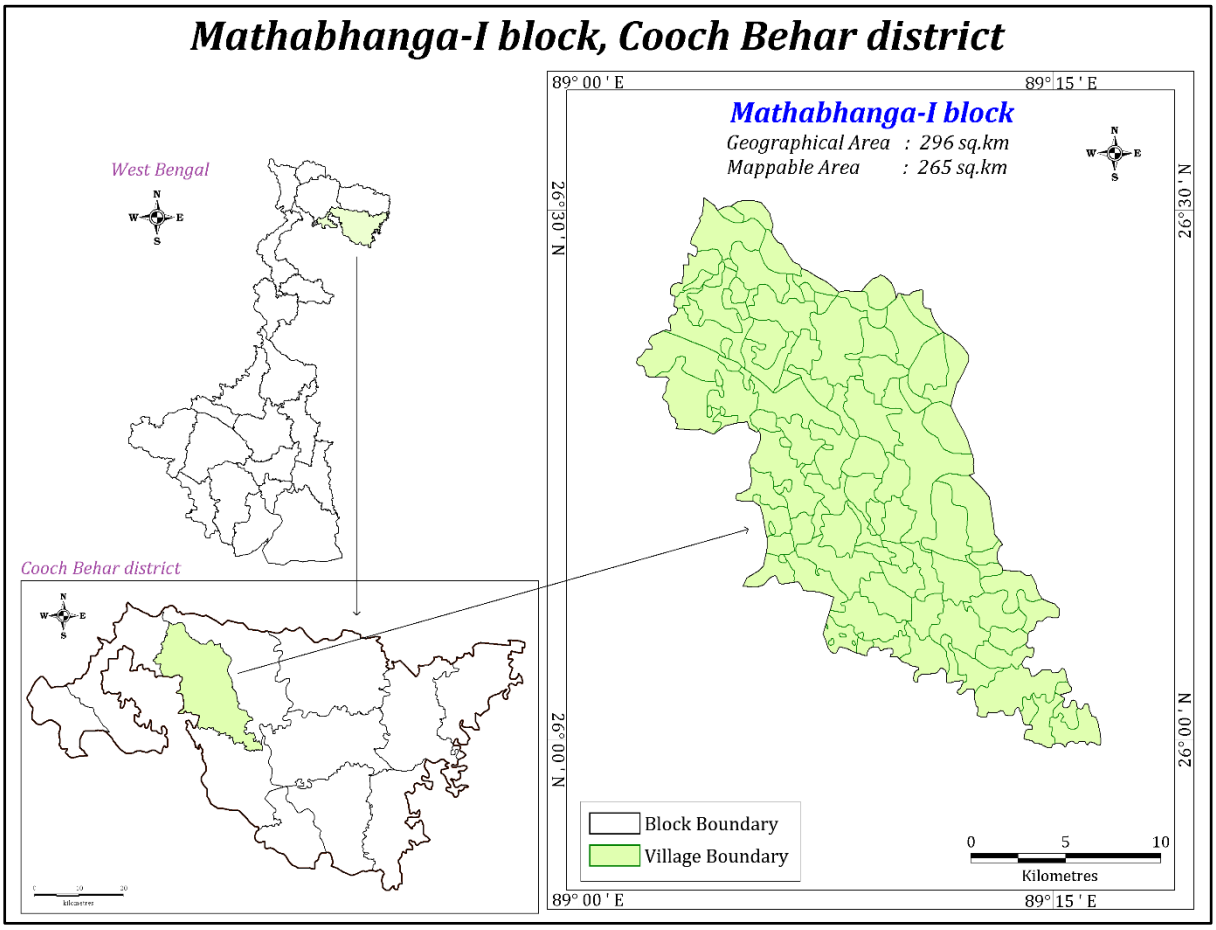

Fig.6.1. Location map for Mathabhanga-I block

Population (as on 2011):

Table 6.1: Distribution of population in administrative units of the study area

Block/ Muncipality	Rural Population			Urban Population			Total Population		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Mathabhanga-I	112497	105694	218191	-	-	-	112497	105694	218191

Rainfall:

*Table 6.2: Annual Actual Rainfall for Cooch Behar District from 2011 to 2021 (*Source WRIS)*

Block Name	Normal Rainfall	Rain Fall										
Mathabhanga-I	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2011
	3213	2666.57	3682.77	2736.46	2882.16	3355.41	3180.31	3211.4	2630.13	3521.38	4677.07	2793.68

Landuse, Agriculture & Irrigation (area in ha):

Table 6.3.1: Mathabhanga-I Block details of Land-use pattern (in hectares)

Block	Reporting Area	Forest Area	Area under Non-Agricultural use	Barren and Un-culturable land	Land under misc tree crops	Culturable wastes	Fallow land Other than current fallow	Current fallow	Net area sown
Mathabhanga-I	31475	146	8688	-	459	-	-	90	22092

Table 6.3.2: Command area(ha) of Mathabhanga-I block

Block Name	Dugwell		Sallow Tubewell		Medium Tubewell		Deep Tubewell		Surface Flow		Sarface 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	
Mathabhanga-I	19	40.02	2108	4368.92	91	272.91	33	110.51	0	0.00	55	926.98	4792.36	926.98	5719.34

Ground Water Resources:

Table 6.4 Details of Ground Water Resource Availability and Utilization in Mathabhanga-I Block. (As on 31.03.2013)

BLOCK NAME		MATHABHANGA-I
Total Annual Ground Water Recharg e (Ham)		31957.84
Total Natural Discharg es (Ham)		3195.78
Annual Extractab le Ground Water Recharge (Ham)		28762.06
Total Extraction		10381.93
Annual GW	Allocation for Domestic and Industrial Use as on 2042	442.08
Net Ground Water Availabili ty for future irrigation use		18344.47
Stage of Ground Water Extracti on (%)		36.1
Categorization		Safe
Instorage		446922

Geology:

Mathabhanga-I block is mainly covered with quaternary newer alluvium sediments. The major lithology encountered in this block are sand, sand with pebbles & gravels and clay. A lithological model is prepared based on the lithologs of exploratory wells of CGWB and PHED of Govt. of West Bengal.

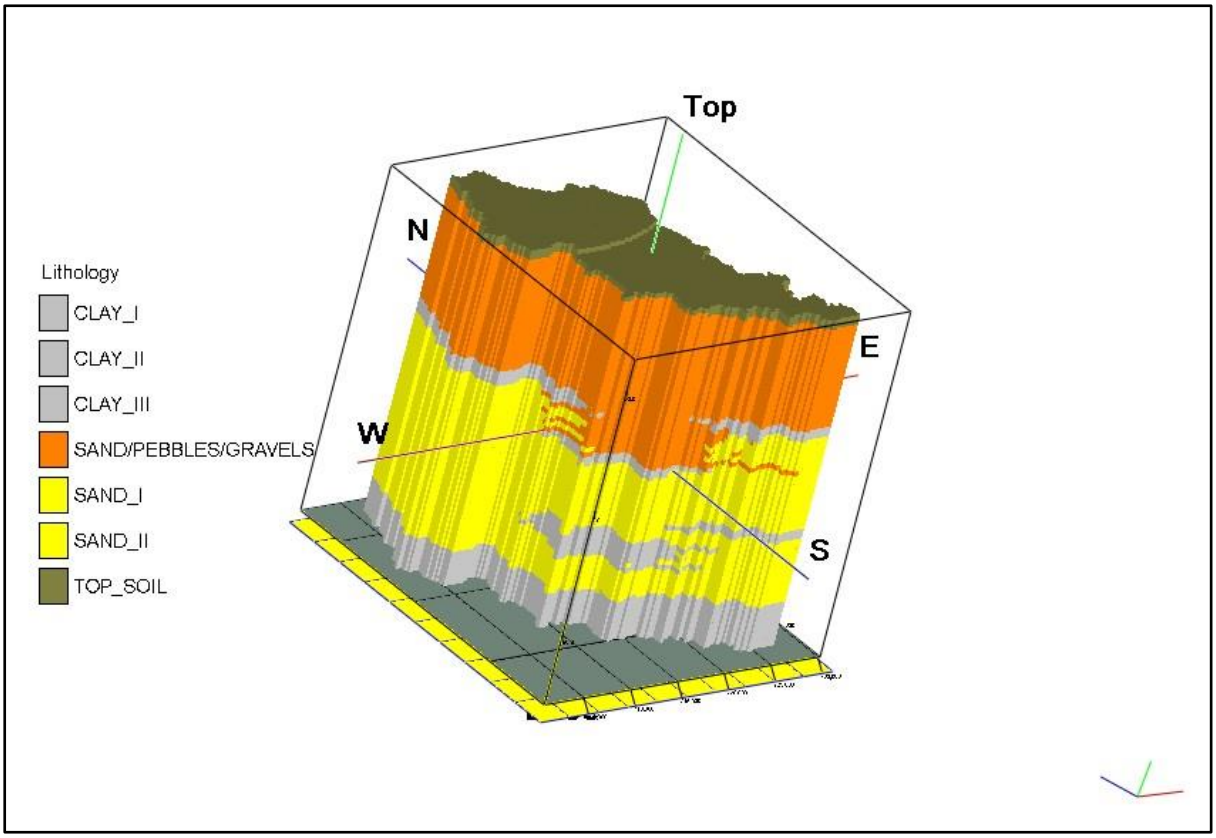

Fig. 6.2 Lithological model of Mathabhanga-I block.

Disposition of Aquifers:

In Mathabhanga-I there are two aquifer systems. One is shallow which extends from 3-meter bgl to 66-meter bgl and another is deep which extends from 48-meter bgl to beyond 150-meter bgl. Aquifer_I is unconfined whereas Aquifer_II is confined.

Aquifer_II again classified as Aquifer_II_A, and Aquifer_II_B depends upon the clay layers present in between.

Fig. 6.3 Borehole location map of Mathabhanga-I block.

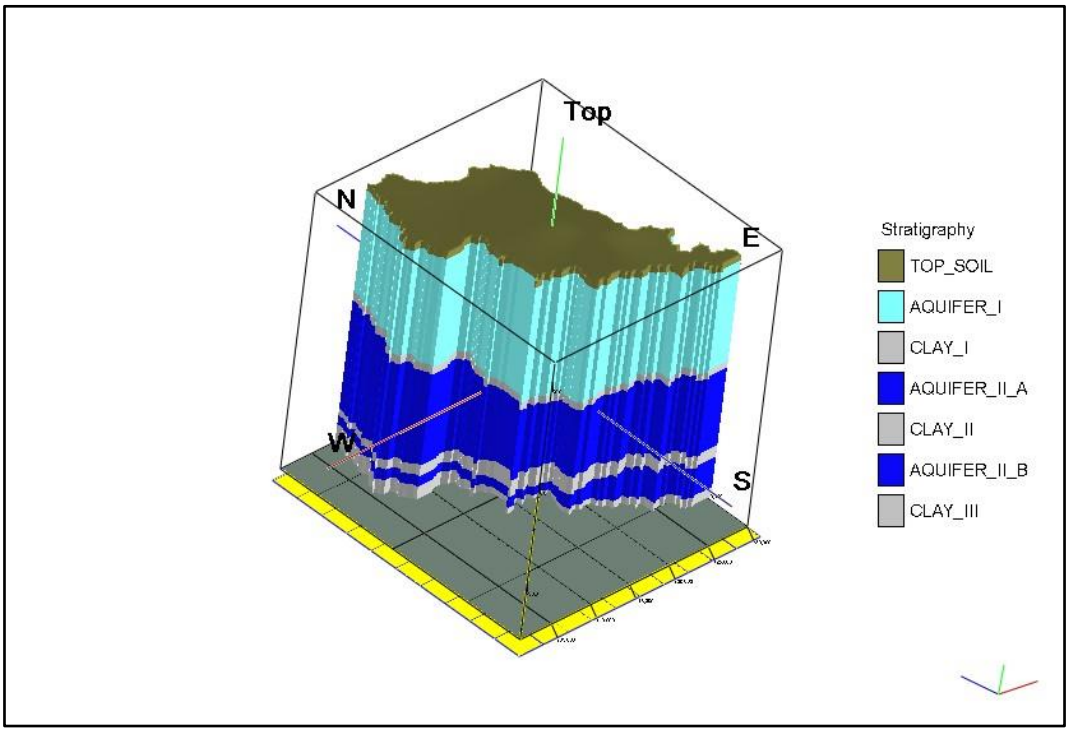

Fig.6.4 Aquifer disposition model of Mathabhanga-I block.

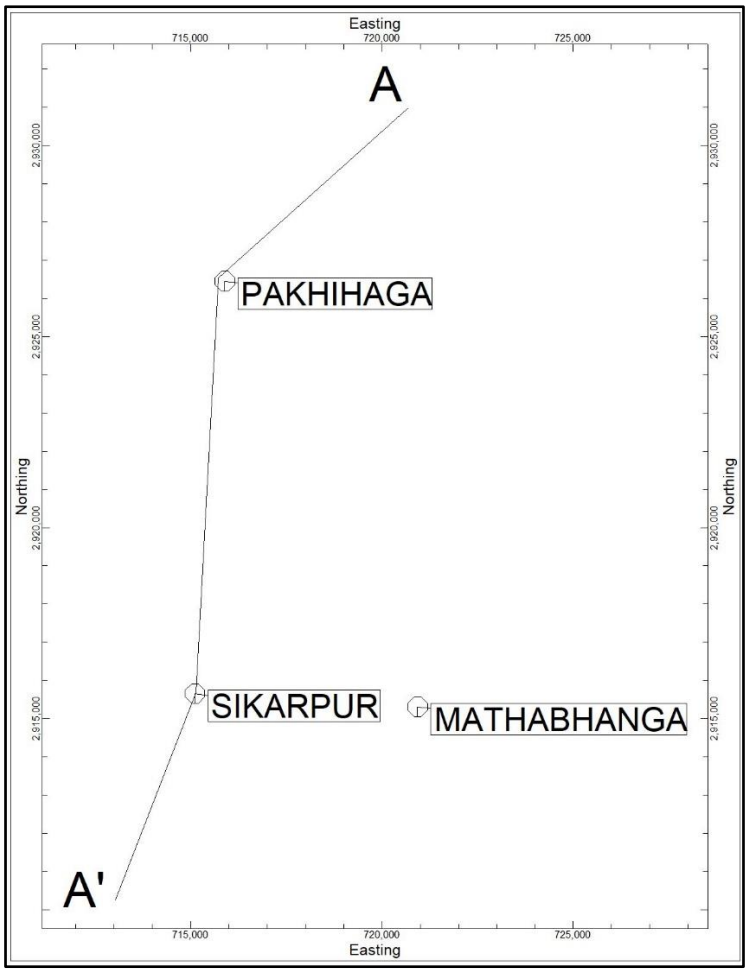

Fig. 6.5 Borehole location map for cross-section of Mathabhanga-I block.

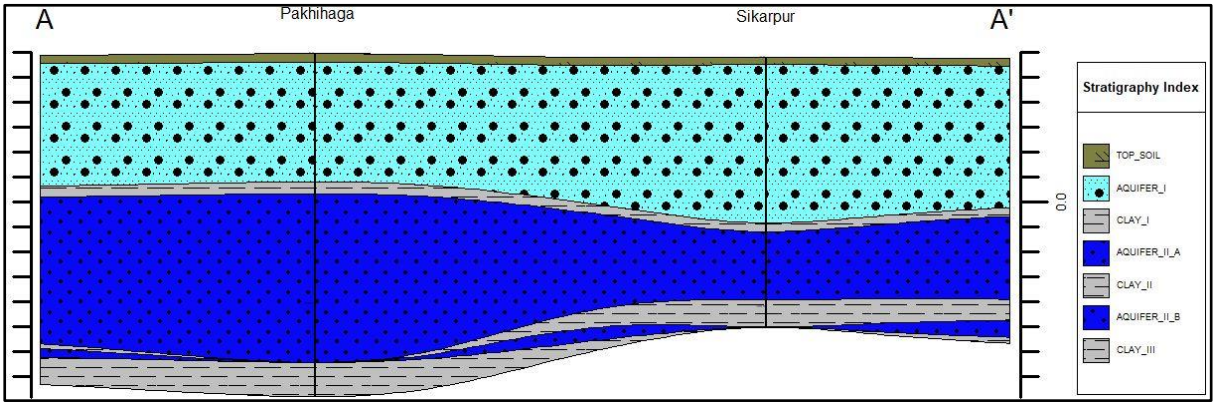

Fig.6.6 Cross-Sectional Map of Mathabhanga-I block.

Table 6.5: Details of aquifer wise water level ranges and seasonal long-term water level trend (2011-2020) in Mathabhanga-I Block

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)
MATHABHANGA-I	I		0.405	--		0.034714286	
	II	-	-	-	-	-	-

Ground Water Quality and Issues:

Based on NHS and Keywells data, the range of chemical parameters for the block is given below.

Table 6.6: Average concentration of chemical parameters in Mathabhanga-I Block

Block	Aquifer Type	pH	EC	TH	Ca	Mg	Na	K	CO3	HCO3	Total Alk as CaCO3	Cl	NO3	SO4	F	TDS	Fe	U (µg/l)
Mathabhanga-I	Aquifer-I	6.52-7.22	150-776	45-160	14-34	2-18	13-55	3-75	0	61-195	50-160	18-99	5-67	BDL	0.23-0.43	93-468	BDL-0.08	BDL-0.06
	Aquifer-II	7.24-7.52	130-162	40-50	14-16	1-2	12-13	2-3	0	55-79	45-65	7-14	5-7	BDL	0.36-0.40	83-96	1.787.73	0.61-0.64

Groundwater Resource Enhancement and Management Plan:

Ground Water Management Plan for Drinking Purpose:

There are seven (7) ground water based public water supply schemes are commissioned till July 2022 by PHED which are the main sources of drinking water in the block. Till July 2022 about 15.26 % of the Functional Household Tap Connection is achieved since inception. Mathabhanga-I block receives ample amount of rain during monsoon. Though the stage of development is only 36.1 % it will be good if we practice conservation through rain water harvesting and used it as an alternative for drinking water because with time ground water abstraction will increase and to maintain the categorization as safe we have to look supplement sources for drinking purposes.

For monitoring of change in ground water regime in the area in future, cost of construction of observation well should be included.

Management plan for Irrigation:

Table 6.7: Ground-water scenario for irrigation in Mathabhanga-I block

Block	Geographical Area in Ha	Net Area Sown in Ha	Net Area Irrigated in Ha	Area to be Irrigated in Ha	SOD in %
MATHABHANGA-I	43241	18483	3371.48	15111.52	36.1

The stage of ground water development in the block is 36.1 %, under safe category. However, further development should be done in planned manner to harness the additional available resource for more sustainable development.

15111.52 hectares more of land can be irrigated. Water applied for irrigation should not be wasted. An effective water management technique should be considered through modern agricultural management maintaining minimum pumping hours and selecting most appropriate cropping pattern. The application of modern techniques like sprinkler and drip irrigation will help increase crop yield and consequently conserve ground water.

Crops with low water requirement should be preferred. Heavy duty/medium duty tube wells can be constructed by Govt. agencies as they may help for irrigation in large perspective. Installation and maintenance cost of heavy-duty tube well is high and it will be difficult for individual or small farmers to maintain. Therefore, heavy-duty tube wells can be constructed by local government agencies and after installation of pumps it can be handed over to the local co-operative based farmers for its operation and maintenance.

Dug wells, light duty tube wells fitted with submersible pump, medium duty tube wells are feasible for irrigation purposes. But the capacity of the pump should be decided in such a way so that drawdown may be minimized.

In view of sufficient rainfall in the area, excavation of tanks with large catchment areas can help in augmention of irrigation facilities.

Management Intervention Through Rain Water Harvesting (Roof Top and Surface Runoff) And Artifitial Recharge:

The area receives plenty of rainfall but due to lack of proper rainwater harvesting structures and un-distributed rainfall causes huge amount of rainwater to drain into the sea. The runoff, thus produced, may be diverted for water harvesting either for conservation or for artificial recharge to the depleted aquifer in the area. No structure has been constructed by CGWB till date.

Generally, water conservation and artificial recharge is feasible is such area where water level is more than 3 mbgl in post monsoon period. As a whole the water level is not in alarming condition in this block. Water conservation of rainwater by different structures like percolation tank, roof top rainwater harvesting can be considered for the block in future.

7. Mathabhanga-II

Salient Information

Block Name: Mathabhanga-II

Geographical area (in sq. km): 313

Mapable area (in sq. km): 281

District: Cooch Behar

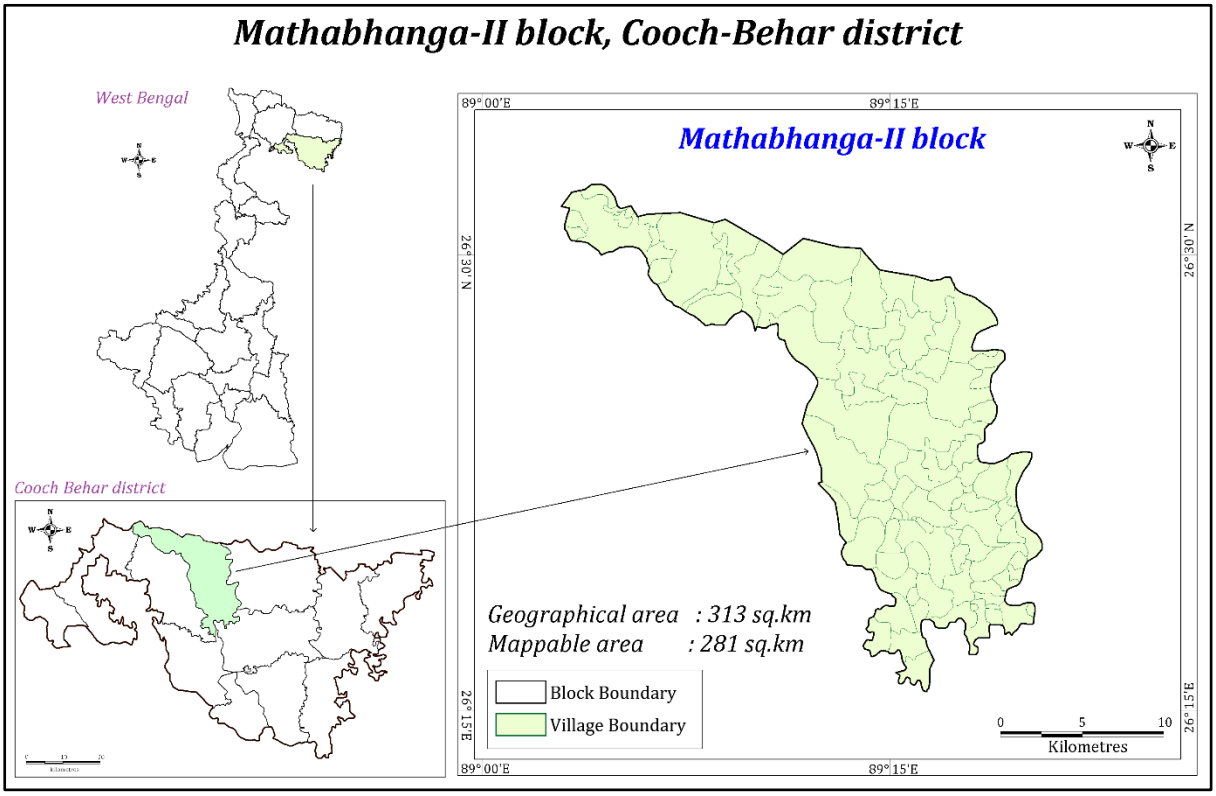

Fig.7.1. Location map for Mathabhanga-II block

Population (as on 2011):

Table 7.1: Distribution of population in administrative units of the study area

Block/ Muncipality	Rural Population			Urban Population			Total Population		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Mathabhanga-II	117100	110297	227397	-	-	-	117100	110297	227397

Rainfall:

*Table 7.2: Annual Actual Rainfall for Cooch Behar District from 2011 to 2021 (*Source WRIS)*

Block Name	Normal Rainfall	Rain Fall										
Mathabhanga-II	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2011
	3213	2666.57	3682.77	2736.46	2882.16	3355.41	3180.31	3211.4	2630.13	3521.38	4677.07	2793.68

Landuse, Agriculture & Irrigation (area in ha):

Table 7.3.1: Mathabhanga-II Block details of Land-use pattern (in hectares)

Block	Reporting Area	Forest Area	Area under Non-Agricultural use	Barren and Un-culturable land	Land under misc tree crops	Culturable wastes	Fallow land Other than current fallow	Current fallow	Net area sown
Mathabhanga -II	30218	288	3945	-	351	-	-	19	25615

Table 7.3.2: Command area(ha) of Mathabhanga-II block

Block Name	Dugwell		Sallow Tubewell		Medium Tubewell		Deep Tubewell		Surface Flow		Sarface 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	
MATHABHANGA-II	5	10.26	4788	10900.51	12	42.49	11	22.34	1	4.00	108	1489.01	10975.60	1493.01	12468.61

Ground Water Resources:

Table 7.4 Details of Ground Water Resource Availability and Utilization in Mathabhanga-II Block. (As on 31.03.2013)

BLOCK NAME		COOCH BEHAR-I
Total Annual Ground Water Recharg e (Ham)		MATHABHANGA-II
Total Natural Discharg es (Ham)		32518.8
Annual Extractable Ground Water Recharge (Ham)		3251.88
Total Extraction		29266.92
Annual GW	Allocation for Domestic and Industrial Use as on 2042	461.69
Net Ground Water Availabili ty for future irrigation use		14624.74
Stage of Ground Water Extracti on (%)		49.9
Categorization		Safe
Instorage		443644

Geology:

Mathabhanga-II block is mainly covered with quaternary newer alluvium sediments along with older alluvium sediments in the northern part of the block which belongs to Baikunthapur formation. The major lithology encountered in this block are sand, sand with pebbles & gravels and clay. A lithological model is prepared based on the lithologs of exploratory wells of CGWB and PHED of Govt. of West Bengal.

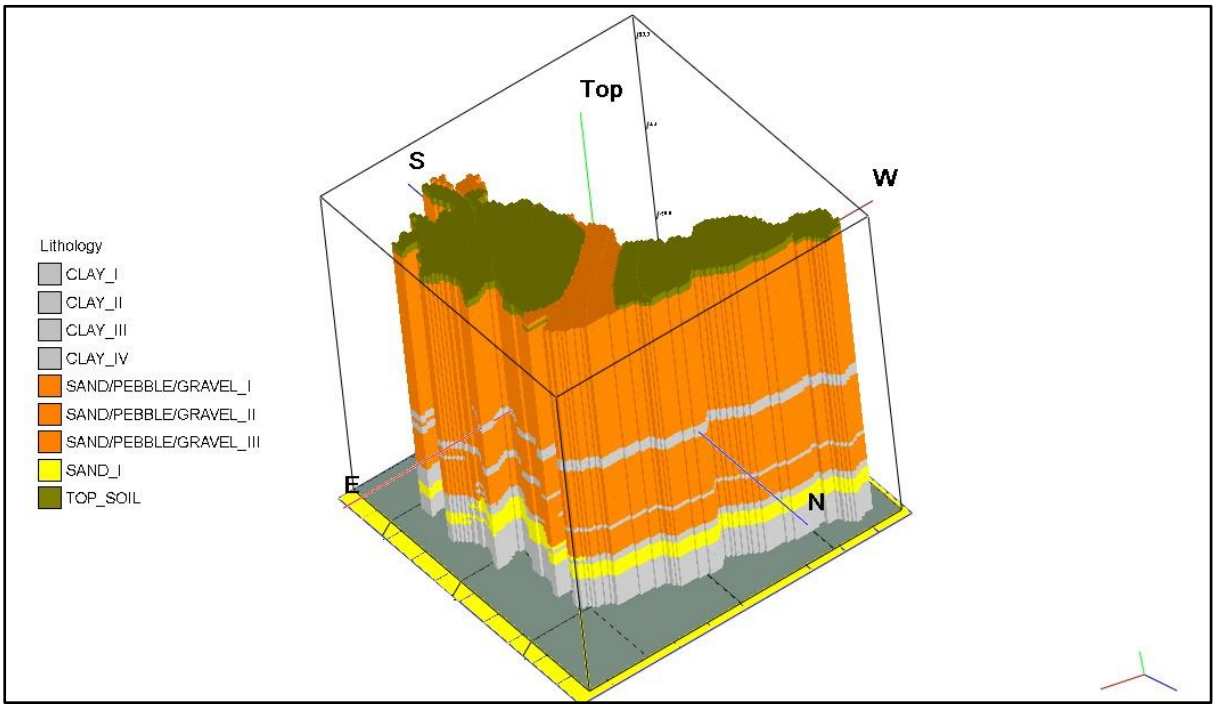

Fig. 7.2 Lithological model of Mathabhanga-II block.

Disposition of Aquifers:

In Mathabhanga-II there are two aquifer systems. One is shallow which extends from 5-meter bgl to 79-meter bgl and another is deep which extends from 76-meter bgl to beyond 150-meter bgl. Aquifer_I is unconfined whereas Aquifer_II is confined.

Aquifer_II again classified as Aquifer_I_A, Aquifer_I_B,and Aquifer_I_C depends upon the clay layers present in between.

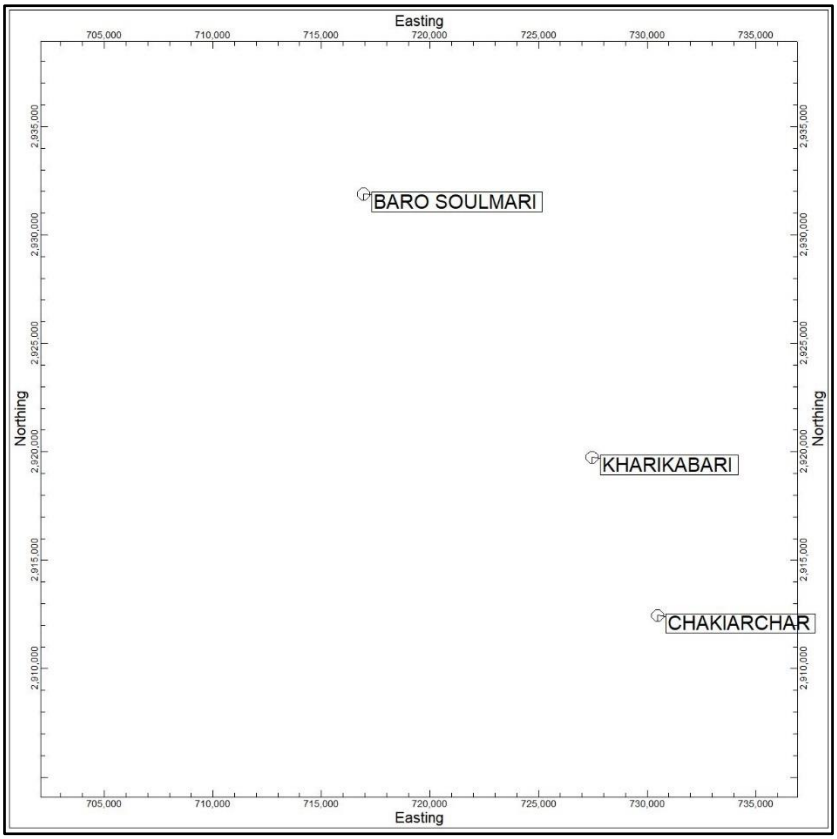

Fig. 7.3 Borehole Location Map of Mathabhanga-II block.

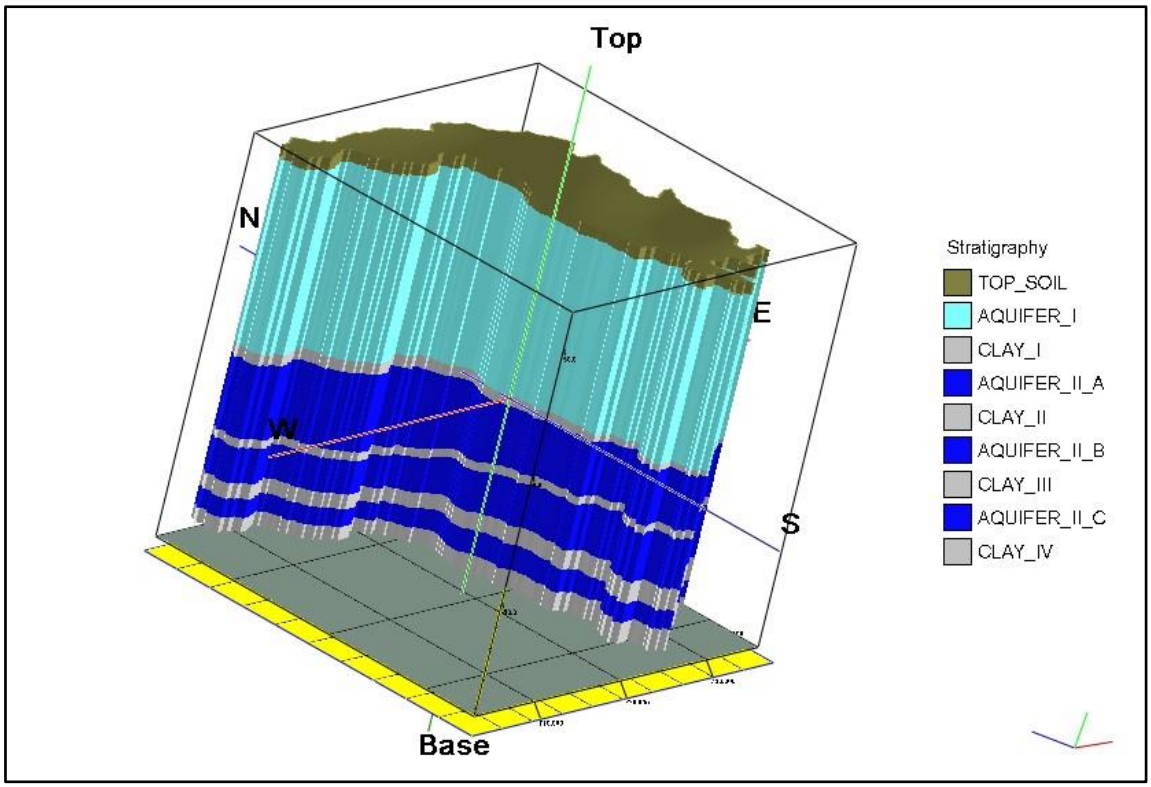

Fig.7.4 Aquifer disposition model of Mathabhanga-II block.

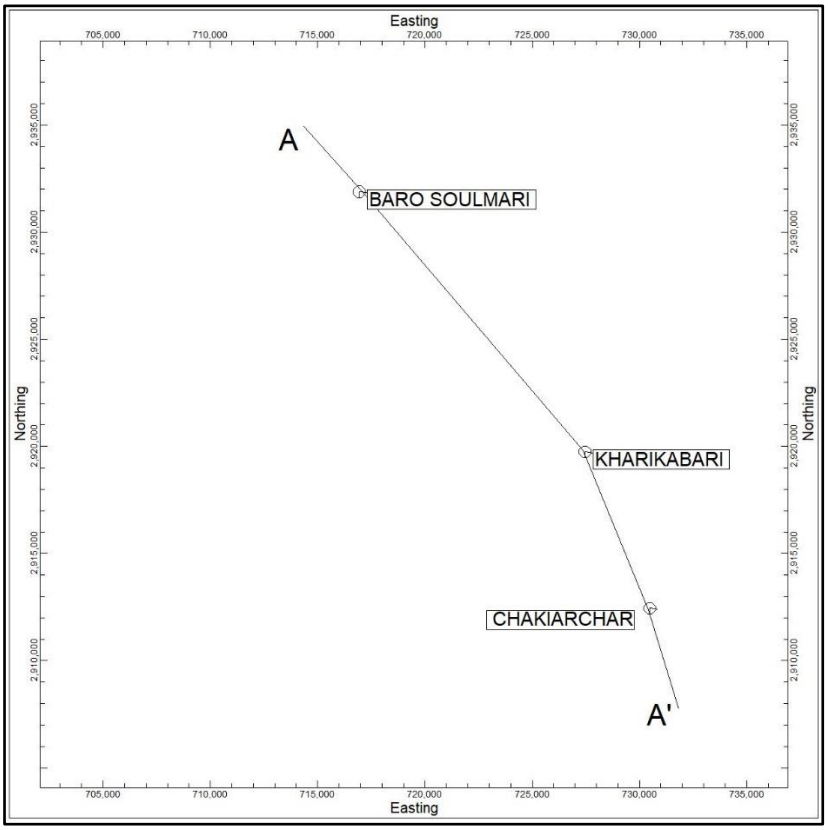

Fig. 7.5 Borehole Location Map for Cross-Section of Mathabhanga-II block.

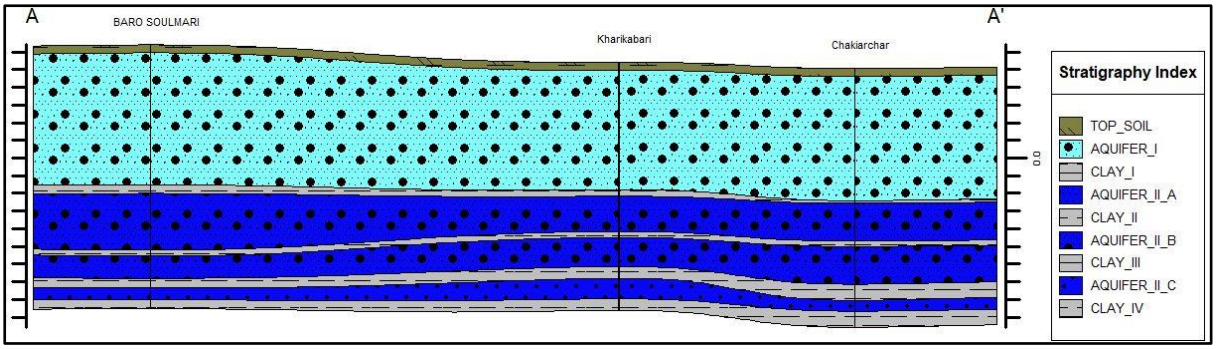

Fig.7.6 Cross-Sectional Map of Mathabhanga-II block.

Table 7.5: Details of aquifer wise water level ranges and seasonal long-term water level trend (2011-2020) in Mathabhanga-II Block

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)
Mathabhanga-II	I		0.185	--		0.025	
	II	-	-	-	-	-	-

Ground Water Quality and Issues:

Based on NHS and Keywells data, the range of chemical parameters for the block is given below.

Table 7.6: Average concentration of chemical parameters in Mathabhanga-II Block

Block	Aquifer Type	pH	EC	TH	Ca	Mg	Na	K	CO3	HCO3	Total Alk as CaCO3	Cl	NO3	SO4	F	TDS	Fe	U (µg/l)
Mathabhanga-II	Aquifer-I	6.79-6.91	81-174	30-60	8-20	2	4-12	2-4	0	37-73	30-60	7-21	BDL	BDL	0.46-0.62	47-104	BDL-0.30	BDL-0.02
	Aquifer-II	7.48-7.74	288-357	120-165	22-32	10-27	9	2	0	159-226	130-185	7-11	BDL	BDL	0.49-0.54	161-206	BDL-0.07	0.05-.74

Groundwater Resource Enhancement and Management Plan:

Ground Water Management Plan for Drinking Purpose:

There are nine (9) ground water based public water supply schemes are commissioned till July 2022 by PHED which are the main sources of drinking water in the block. Till July 2022 about 14.22 % of the Functional Household Tap Connection is achieved since inception. Mathabhanga-II block receives ample amount of rain during monsoon. Though the stage of development is only 49.9 % it will be good if we practice conservation through rain water harvesting and used it as an alternative for drinking water because

with time ground water abstraction will increase and to maintain the categorization as safe we have to look supplement sources for drinking purposes.

For monitoring of change in ground water regime in the area in future, cost of construction of observation well should be included.

Management plan for Irrigation:

Table 7.7: Ground-water scenario for irrigation in Mathabhanga-II block

Block	Geographical Area in Ha	Net Area Sown in Ha	Net Area Irrigated in Ha	Area to be Irrigated in Ha	SOD in %
MATHABHANGA-II	49087	19328	4625.9	14702.1	49.9

The stage of ground water development in the block is 49.9 %, under safe category. However, further development should be done in planned manner to harness the additional available resource for more sustainable development.

14702.1 hectares more of land can be irrigated. Water applied for irrigation should not be wasted. An effective water management technique should be considered through modern agricultural management maintaining minimum pumping hours and selecting most appropriate cropping pattern. The application of modern techniques like sprinkler and drip irrigation will help increase crop yield and consequently conserve ground water.

Crops with low water requirement should be preferred. Heavy duty/medium duty tube wells can be constructed by Govt. agencies as they may help for irrigation in large perspective. Installation and maintenance cost of heavy-duty tube well is high and it will be difficult for individual or small farmers to maintain. Therefore, heavy-duty tube wells can be constructed by local government agencies and after installation of pumps it can be handed over to the local co-operative based farmers for its operation and maintenance.

Dug wells, light duty tube wells fitted with submersible pump, medium duty tube wells are feasible for irrigation purposes. But the capacity of the pump should be decided in such a way so that drawdown may be minimized.

In view of sufficient rainfall in the area, excavation of tanks with large catchment areas can help in augmentation of irrigation facilities.

Management Intervention Through Rain Water Harvesting (Roof Top and Surface Runoff) And Artificial Recharge:

The area receives plenty of rainfall but due to lack of proper rainwater harvesting structures and un-distributed rainfall causes huge amount of rainwater to drain into the sea. The runoff, thus produced, may be diverted for water harvesting either for conservation or for artificial recharge to the depleted aquifer in the area. No structure has

been constructed by CGWB till date. Generally, water conservation and artificial recharge is feasible is such area where water level is more than 3 mbgl in post monsoon period. As a whole the water level is not in alarming condition in this block.

Water conservation of rainwater by different structures like percolation tank, Injection well, roof top rainwater harvesting can be considered for the block in future. It has been estimated that the utilizable surface runoff produced in the block is 12.847 MCM. This surface runoff is proposed to be utilized to recharge the depleted aquifers in the block. As per the available storage space, 3.854 MCM water is required to fill the deeper aquifers in block. Therefore, 13 injection wells with roof top rain water harvesting structures are recommended in the block. The remaining surface runoff, 8.992 MCM is recommended to be utilized in storage tanks for generation of irrigation potential and thus, 39 storage tanks have been proposed. The roof top rain water harvesting structures with suitably design injection wells may be proposed to construct in the census towns areas in primary phases and subsequently may be extended to the rural areas.

Table 7.8: Area suitable for recharge in Mathabhanga-II block

District	Block Name	Block Area (in Ha)	Area (in Ha) suitable for recharge (having DTW 3 m and more in Postmonsoon)
Cooch Behar	Mathabhanga-II	31300	2854.800

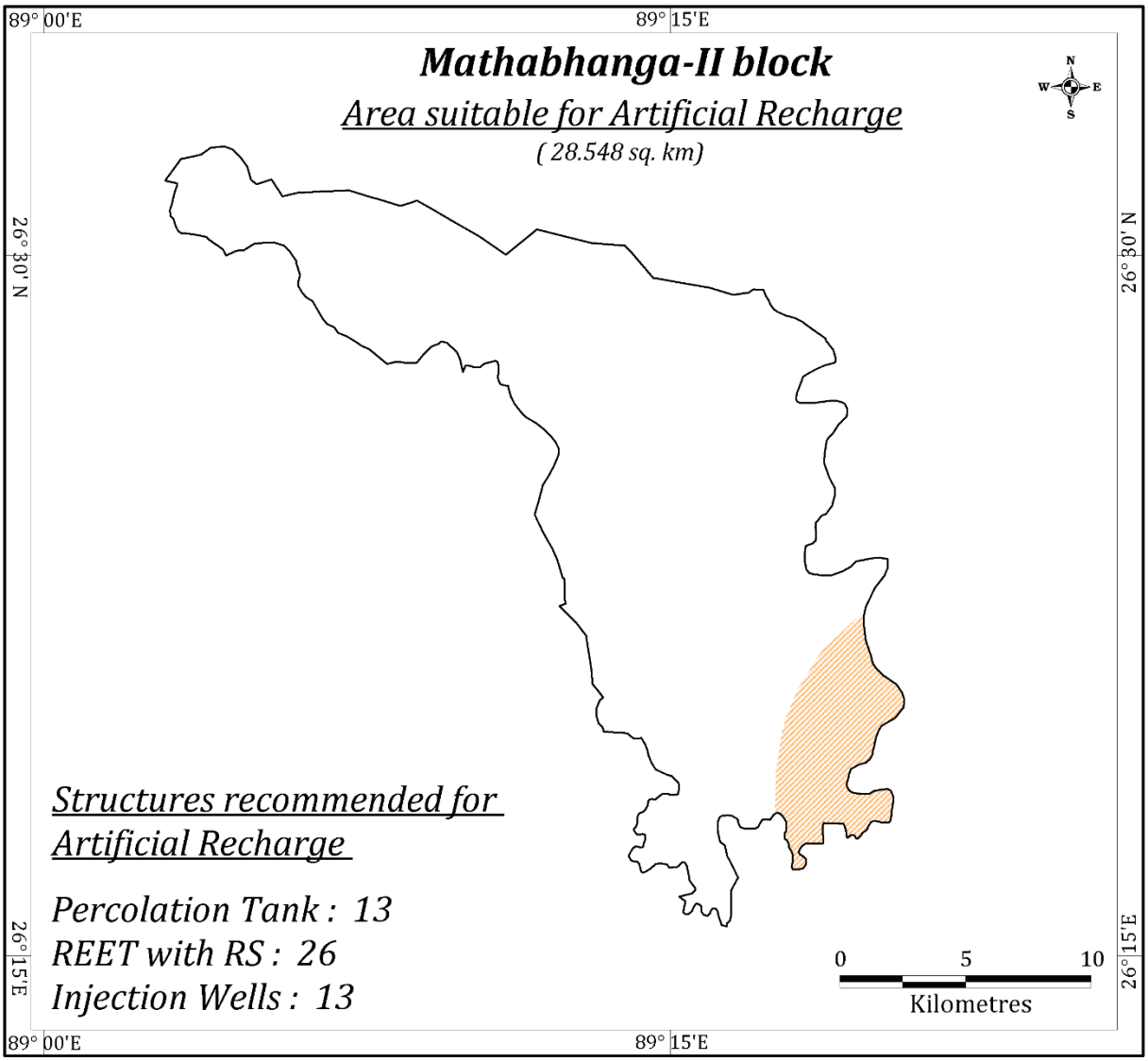

Fig.7.7: Area Feasible for Artificial Recharge of groundwater of Mathabhanga-II block.

Table 7.9: Artificial recharge priority area-structures feasible and their cost of construction for Mathabhanga-II block

Block	Utilizable Surface runoff	Allocation of Utilizable Resource (MCM)			Structures Feasible (No.s)			Cost of structures (in lakhs)			Total cost (in lakhs)
		Percolation tank	REET withRS	Injection Well	Percolation tank	REET with RS	Injection Well	Percolation tank	REET with RS	Injection Well	
Mathabhanga-II	12.847	6.423	2.569	3.854	13	26	13	104.00	104.00	39.00	247.00

8. Mekhliganj

Salient Information

Block Name: Mekhliganj

Geographical area (in sq. km): 316

Mapable area (in sq. km): 283

District: Cooch Behar

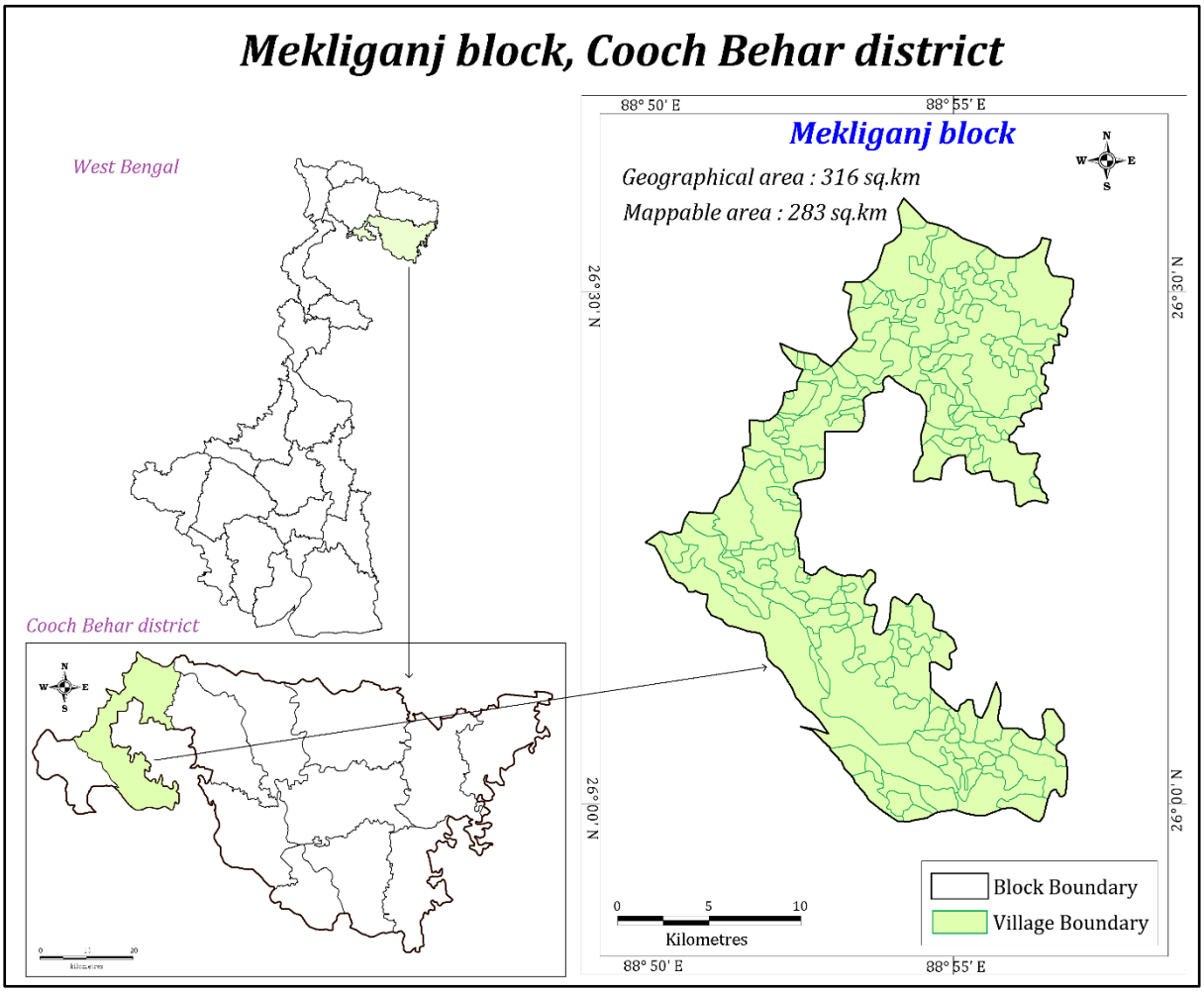

Fig.8.1. Location map for Mekhliganj block

Population (as on 2011):

Table 8.1: Distribution of population in administrative units of the study area

Block/ Muncipality	Rural Population			Urban Population			Total Population		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Mekhliganj	77801	72966	150767	2251	2232	4483	80052	75198	155250

Rainfall:

*Table 8.2: Annual Actual Rainfall for Cooch Behar District from 2011 to 2021 (*Source WRIS)*

Block Name	Normal Rainfall	Rain Fall										
Mekhliganj	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2011
	3213	2666.57	3682.77	2736.46	2882.16	3355.41	3180.31	3211.4	2630.13	3521.38	4677.07	2793.68

Landuse, Agriculture & Irrigation (area in ha):

Table 8.3.1: Mekhliganj Block details of Land-use pattern (in hectares)

Block	Reporting Area	Forest Area	Area under Non-Agricultural use	Barren and Un-culturable land	Land under misc tree crops	Cultur able wastes	Fallow land Other than current fallow	Current fallow	Net area sown
Mekhliganj	29320	101	5255	-	510	-	-	62	23392

Table 8.3.2: Command area(ha) of Mekhliganj block

Block Name	Dugwell		Sallow Tubewell		Medium Tubewell		Deep Tubewell		Surface Flow		Sarface 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	
Mekhliganj	1	1.00	1781	4186.41	79	173.04	9	16.72	22	94.85	205	1468.82	4377.17	1563.67	5940.84

Ground Water Resources:

Table 8.4 Details of Ground Water Resource Availability and Utilization in Mekhliganj Block. (As on 31.03.2013)

BLOCK NAME		MEKHLIGANJ
Total Annual Ground Water Recharg e (Ham)		30327.65
Total Natural Discharg es (Ham)		3032.76
Annual Extractab le Ground Water Recharge (Ham)		27294.89
Total Extraction		6093.67
Annual GW	Allocation for Domestic and Industrial Use as on 2042	316.93
Net Ground Water Availabili ty for future irrigation use		21173.47
Stage of Ground Water Extracti on (%)		22.33
Categorization		Safe
Instorage		408053

Table 8.5: Details of aquifer disposition in Mekhliganj Block

Block	Location	No. of Aquifers	Water bearing zones (Zones Tapped)	Discharge (m^3/hr)	SWL (mbgl)	Draw down	T (m^2/day)	S
Mekhliganj	Jamaldaha		98-104, 150-175	631.8	3.13	4.47	666.2	4.45x10-4

Geology:

Mekhliganj block is mainly covered with quaternary newer alluvium sediments. The major lithology encountered in this block are sand with pebbles & gravels, sand and clay. A lithological model is prepared based on the lithologs of exploratory wells of CGWB and PHED of Govt. of West Bengal.

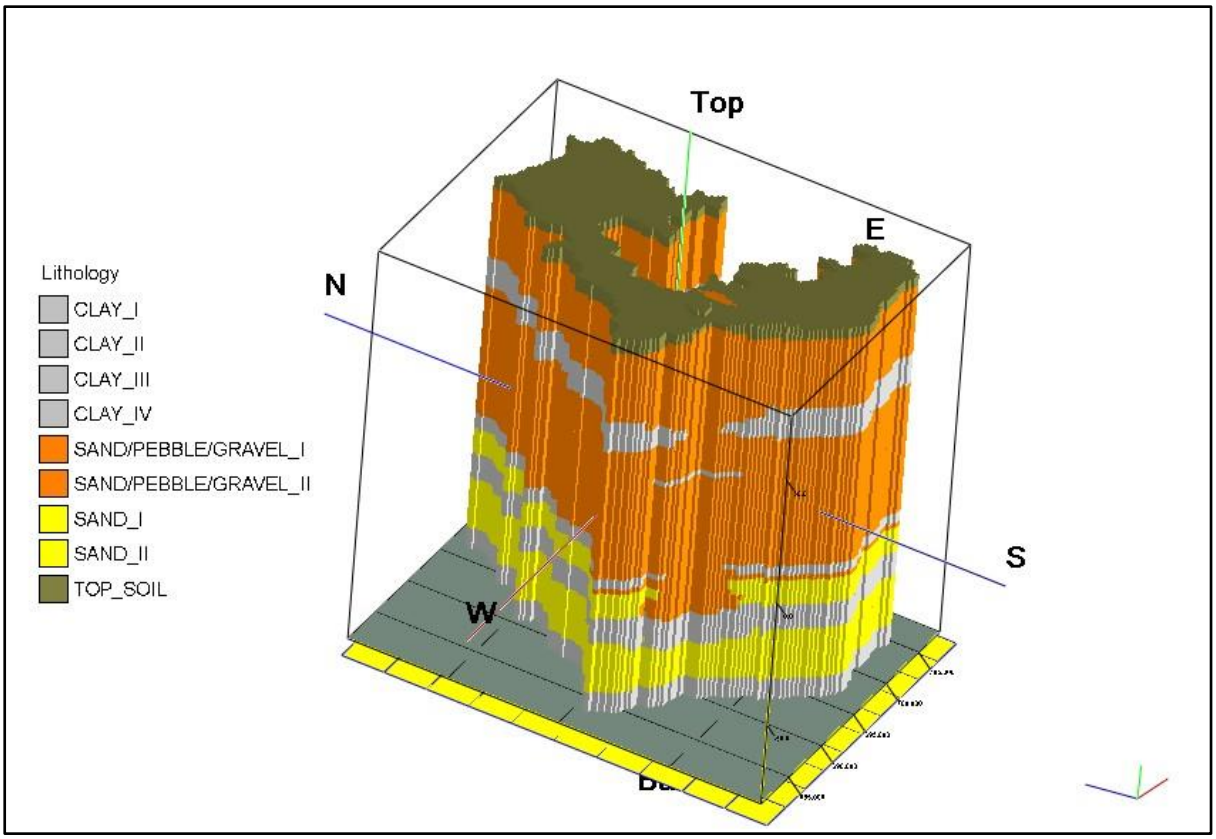

Fig. 8.2 Lithological model of Mekhliganj block.

Disposition of Aquifers:

In Mekhliganj there are two aquifer systems. One is shallow which extends from 3-meter bgl to 61-meter bgl and another is deep which extends from 45-meter bgl to beyond 150-meter bgl. Aquifer_I is unconfined whereas Aquifer_II is confined.

Aquifer_II again classified as Aquifer_II_A, Aquifer_II_B and Aquifer_II_C depends upon the clay layers present in between.

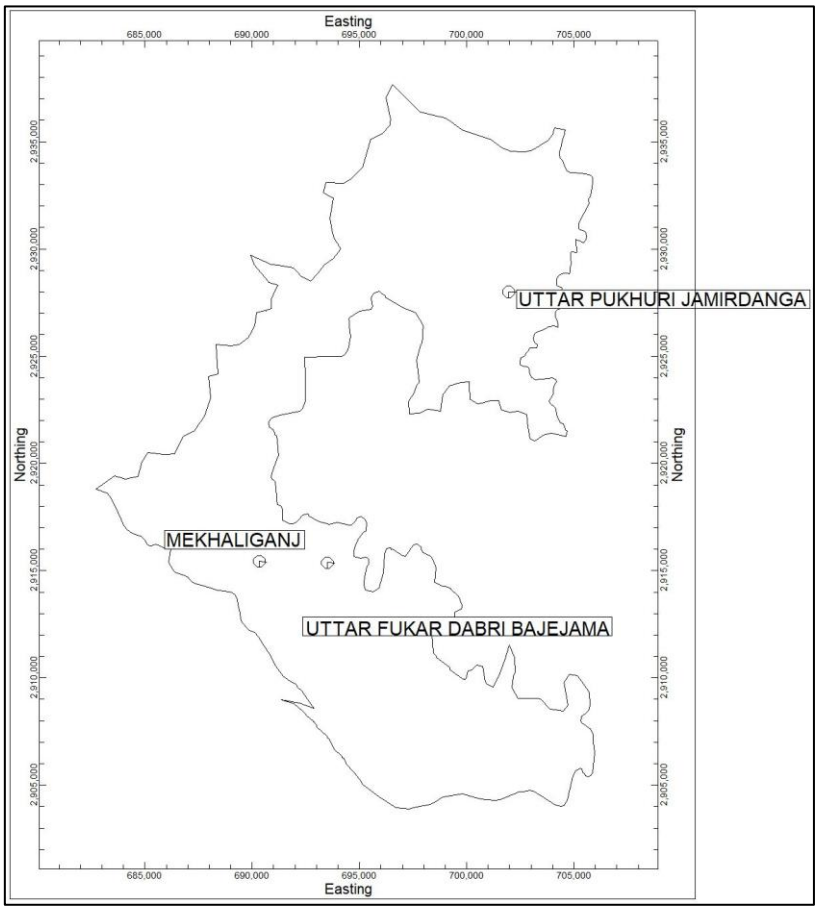

Fig.8.3 Borehole location map of Mekhliganj block.

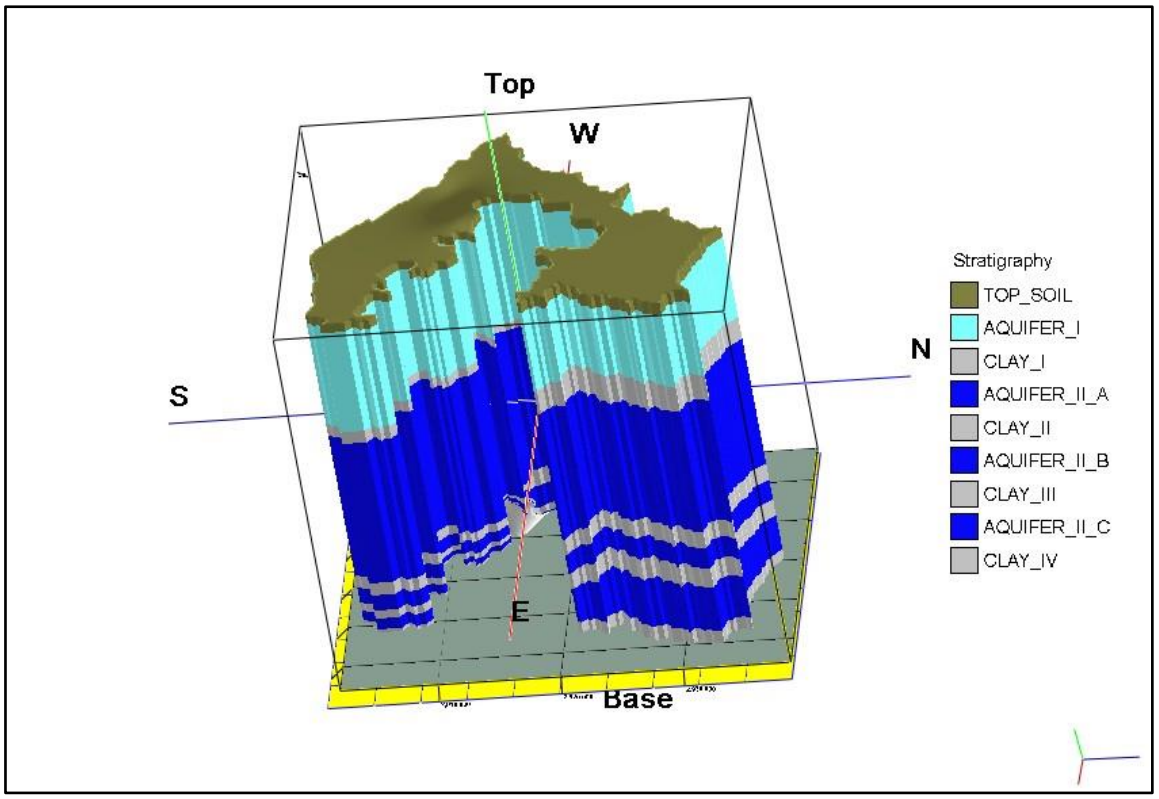

Fig.8.4 Aquifer disposition model of Mekhliganj block

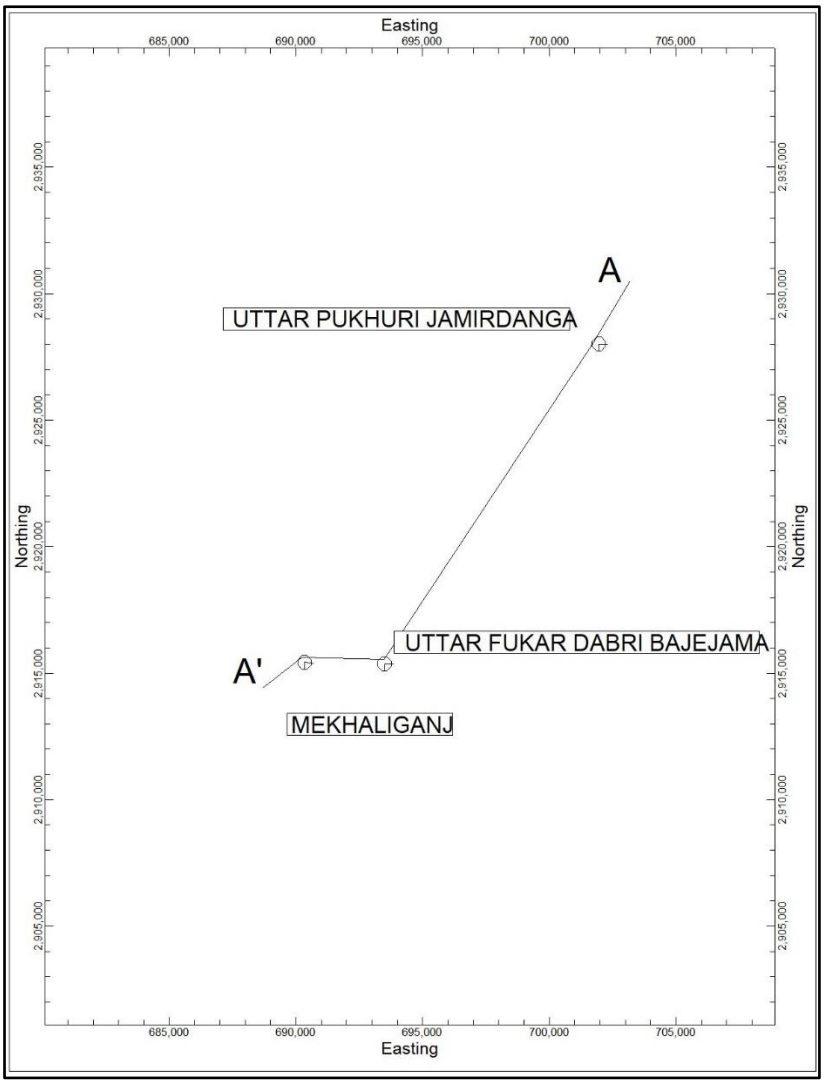

Fig.8.5 Borehole location map for cross-section of Mekhliganj block.

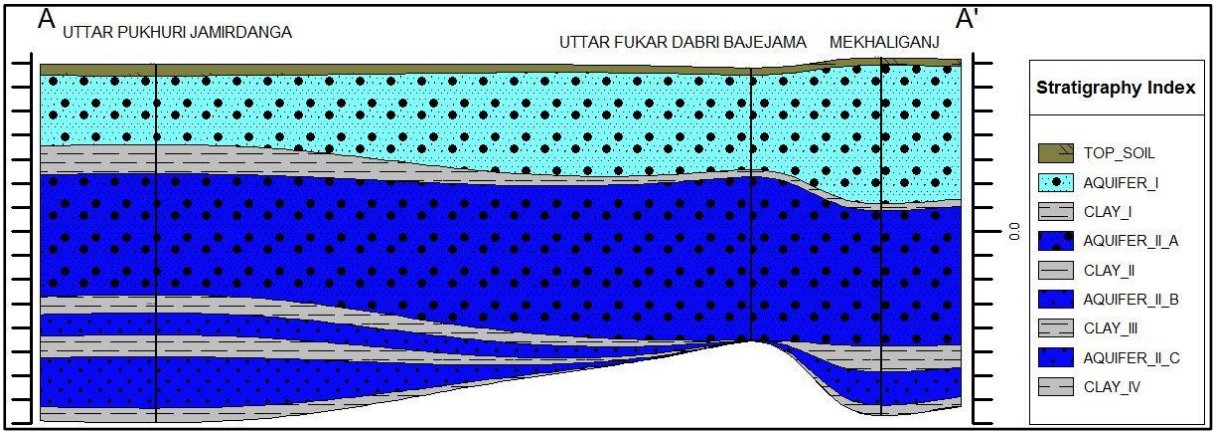

Fig.8.6 Cross-Sectional Map of Mekhliganj block

Table 8.6: Details of aquifer wise water level ranges and seasonal long-term water level trend (2011-2020) in Mekhliganj Block

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)
Mekhliganj	I		0.165666667	--		0.042666667	
	II	-	-	-	-	-	-

Ground Water Quality and Issues:

Based on NHS and Keywells data, the range of chemical parameters for the block is given below.

Table 8.7: Average concentration of chemical parameters in Mekhliganj Block

Block	Aquifer Type	pH	EC	TH	Ca	Mg	Na	K	CO3	HCO3	Total Alk as CaCO3	Cl	NO3	SO4	F	TDS	Fe	U (µg/l)
Mekhliganj	Aquifer-I	6.27-7.22	521-819	140-240	40-50	4-30	24-70	20-49	0	122-238	100-195	50-92	8-99	BDL-60	0.35-0.69	328-533	BDL-1.24	0.08-0.31
	Aquifer-II	7.13-7.73	157-176	50-65	14-18	4-5	12-15	3	0	55-98	45-80	7-11	8-11	BDL-10	0.22-0.47	98-104	4.86-4.96	0.04-0.44

Groundwater Resource Enhancement and Management Plan:

Ground Water Management Plan for Drinking Purpose:

There are eleven (11) ground water based public water supply schemes are commissioned till July 2022 by PHED which are the main sources of drinking water in the block. Till July 2022 about 14 % of the Functional Household Tap Connection is achieved since inception. Mekhliganj block receives ample amount of rain during monsoon. Though the stage of development is only 22.3% it will be good if we practice conservation through rain water harvesting and used it as an alternative for drinking water because with time ground water abstraction will increase and to maintain the categorization as safe we have to look supplement sources for drinking purposes.

For monitoring of change in ground water regime in the area in future, cost of construction of observation well should be included.

Management plan for Irrigation:

Table 8.8: Ground-water scenario for irrigation in Mekhliganj block

Block	Geographical Area in Ha	Net Area Sown in Ha	Net Area Irrigated in Ha	Area to be Irrigated in Ha	SOD in %
MEKHLIGANJ	70116	20553	3272.36	17280.64	22.33

The stage of ground water development in the block is 22.3 %, under safe category. However, further development should be done in planned manner to harness the additional available resource for more sustainable development.

17280.64 hectares more of land can be irrigated. Water applied for irrigation should not be wasted. An effective water management technique should be considered through modern agricultural management maintaining minimum pumping hours and selecting most appropriate cropping pattern. The application of modern techniques like sprinkler and drip irrigation will help increase crop yield and consequently conserve ground water.

Crops with low water requirement should be preferred. Heavy duty/medium duty tube wells can be constructed by Govt. agencies as they may help for irrigation in large perspective. Installation and maintenance cost of heavy-duty tube well is high and it will be difficult for individual or small farmers to maintain. Therefore, heavy-duty tube wells can be constructed by local government agencies and after installation of pumps it can be handed over to the local co-operative based farmers for its operation and maintenance.

Dug wells, light duty tube wells fitted with submersible pump, medium duty tube wells are feasible for irrigation purposes. But the capacity of the pump should be decided in such a way so that drawdown may be minimized.

In view of sufficient rainfall in the area, excavation of tanks with large catchment areas can help in augmentation of irrigation facilities.

Management Intervention Through Rain Water Harvesting (Roof Top and Surface Runoff) And Artificial Recharge:

The area receives plenty of rainfall but due to lack of proper rainwater harvesting structures and un-distributed rainfall causes huge amount of rainwater to drain into the sea. The runoff, thus produced, may be diverted for water harvesting either for conservation or for artificial recharge to the depleted aquifer in the area. No structure has been constructed by CGWB till date.

Generally, water conservation and artificial recharge is feasible is such area where water level is more than 3 mbgl in post monsoon period. As a whole the water level is not in alarming condition in this block. Water conservation of rainwater by different structures like percolation tank, roof top rainwater harvesting can be considered for the block in future.

This block is not considered under artificial recharge and no Artificial Recharge Structures has thus been proposed at present.

9. Sitai

Salient Information

Block Name: Sitai

Geographical area (in sq. km): 151

Mapable area (in sq. km): 136

District: Cooch Behar

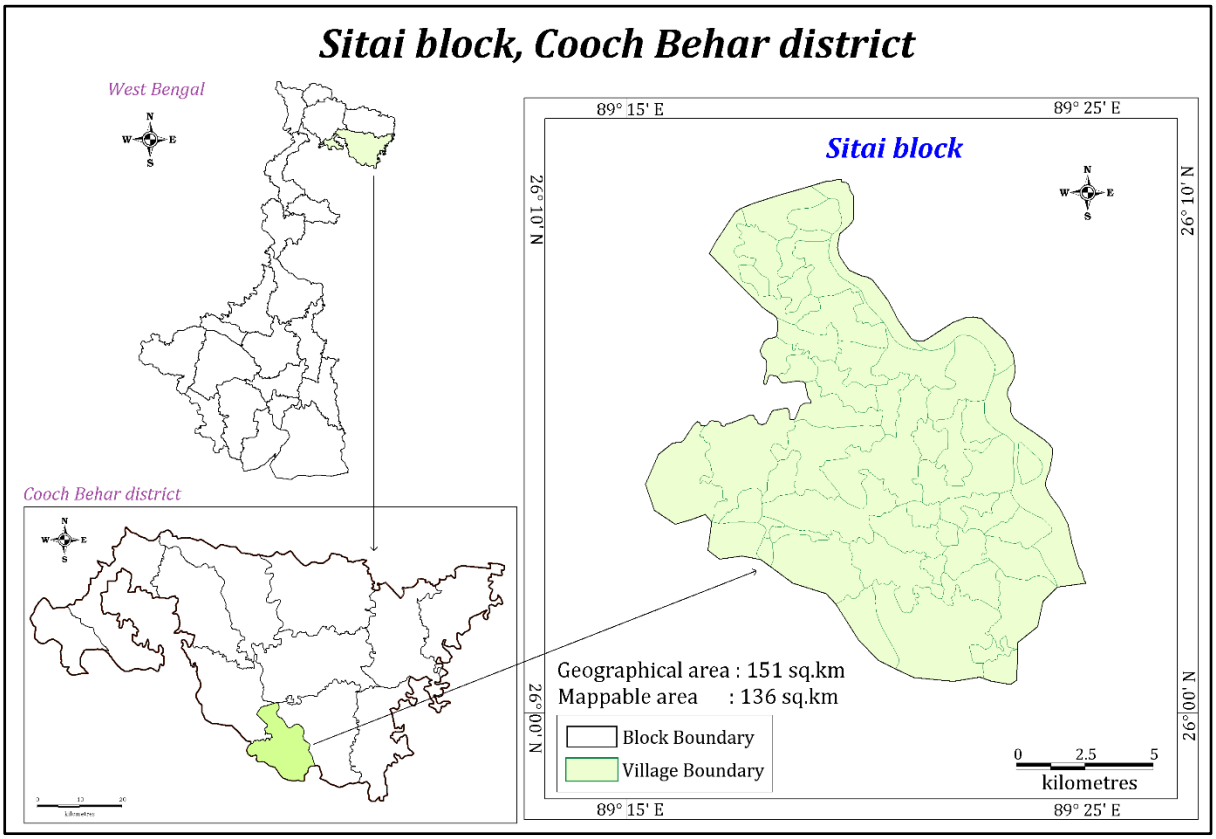

Fig.9.1. Location map for Sitai block

Population (as on 2011):

Table 9.1: Distribution of population in administrative units of the study area

Block/ Muncipality	Rural Population			Urban Population			Total Population		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Sitai	56016	54317	110333	-	-	-	56016	54317	110333

Rainfall:

*Table 9.2: Annual Actual Rainfall for Cooch Behar District from 2011 to 2021 (*Source WRIS)*

Block Name	Normal Rainfall	Rain Fall										
Sitai	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2011
	3213	2666.57	3682.77	2736.46	2882.16	3355.41	3180.31	3211.4	2630.13	3521.38	4677.07	2793.68

Landuse, Agriculture & Irrigation (area in ha):

Table 9.3.1: Sitai Block details of Land-use pattern (in hectares)

Block	Reporting Area	Forest Area	Area under Non-Agricultural use	Barren and Un-culturable land	Land under misc tree crops	Cultur able wastes	Fallow land Other than current fallow	Current fallow	Net area sown
Sitai	15690	0	3150	-	300	-	-	82	12158

Table 9.3.2: Command area(ha) of Sitai block

Block Name	Dugwell		Sallow Tubewell		Medium Tubewell		Deep Tubewell		Surface Flow		Sarface 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	
Sitai	4	5.56	1679	4158.59	0	0.00	5	84.66	0	0.00	18	626.25	4248.81	626.25	4875.06

Ground Water Resources:

Table 9.4 Details of Ground Water Resource Availability and Utilization in Sitai Block. (As on 31.03.2013)

BLOCK NAME		SITAI
Total Annual Ground Water Recharg e (Ham)		21844.84
Total Natural Discharg es (Ham)		2184.48
Annual Extractab le Ground Water Recharge (Ham)		19660.36
Total Extraction		4835.48
Annual GW	Allocation for Domestic and Industrial Use as on 2042	226.66
Net Ground Water Availabili ty for future irrigation use		14803.74
Stage of Ground Water Extracti on (%)		24.6
Categorization Instorage213081		Safe
Instorage		213081

Geology:

Sitai block is mainly covered with quaternary newer alluvium sediments. The major lithology encountered in this block are sand, sand with pebbles & gravels and clay. A lithological model is prepared based on the lithologs of exploratory wells of CGWB and PHED of Govt. of West Bengal.

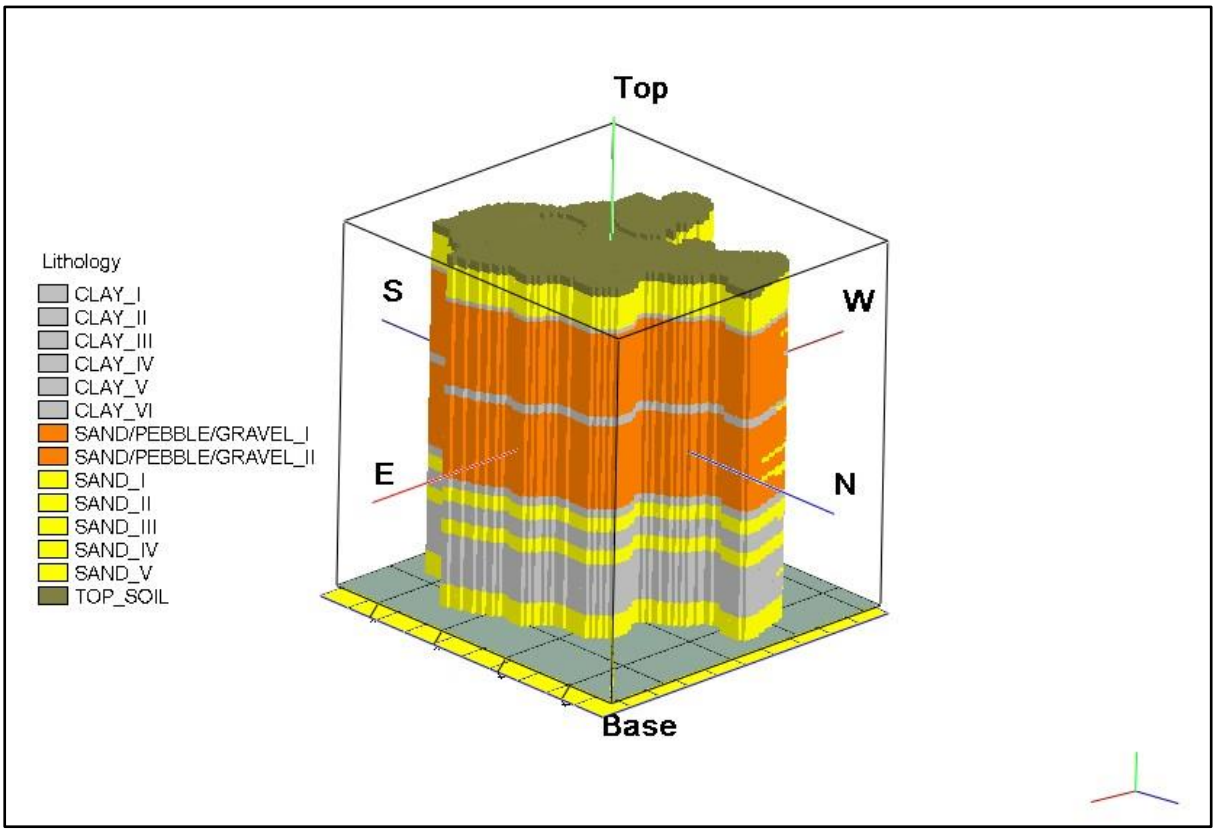

Fig. 9.2 Lithological model of Sitai block.

Disposition of Aquifers:

In Sitai there are two aquifer systems. One is shallow which extends from 3-meter bgl to 54-meter bgl and another is deep which extends from 40-meter bgl to beyond 150-meter bgl. Aquifer_I is unconfined to semi-confined whereas Aquifer_II is confined.

Aquifer_I again classified as Aquifer_I_A, Aquifer_I_B. Aquifer_I_B is mainly found in and adjascent area of sathbhandari area. depends upon the clay layers present in between. Similarly, Aquifer_II again classified as Aquifer_II_A, Aquifer_II_B, Aquifer_II_C, Aquifer_II_D and Aquifer_II_E.

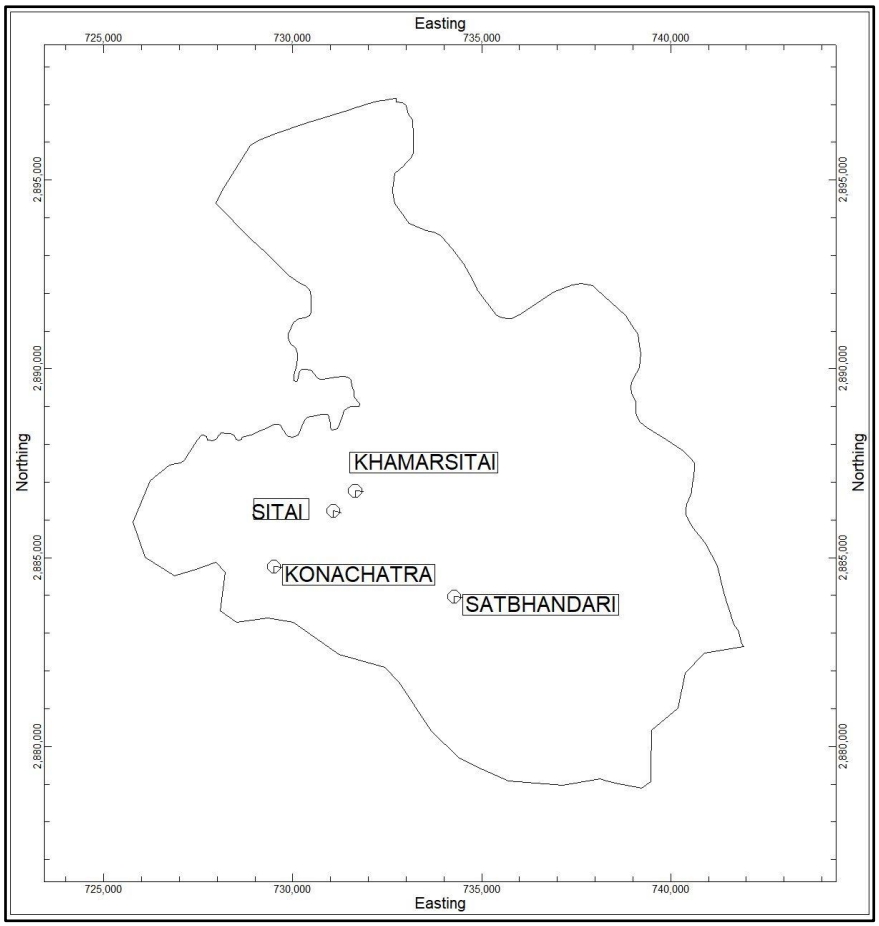

Fig. 9.3 Borehole location map of Sitai block.

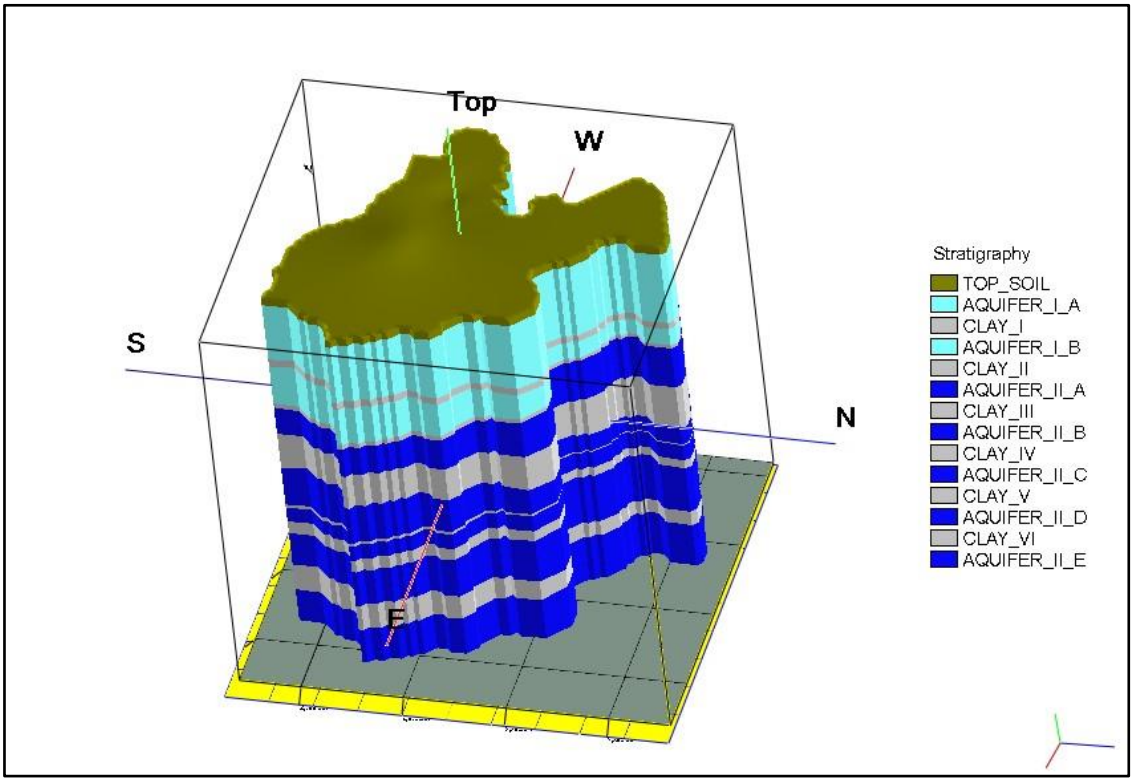

Fig. 9.4 Aquifer disposition model of Sitai block.

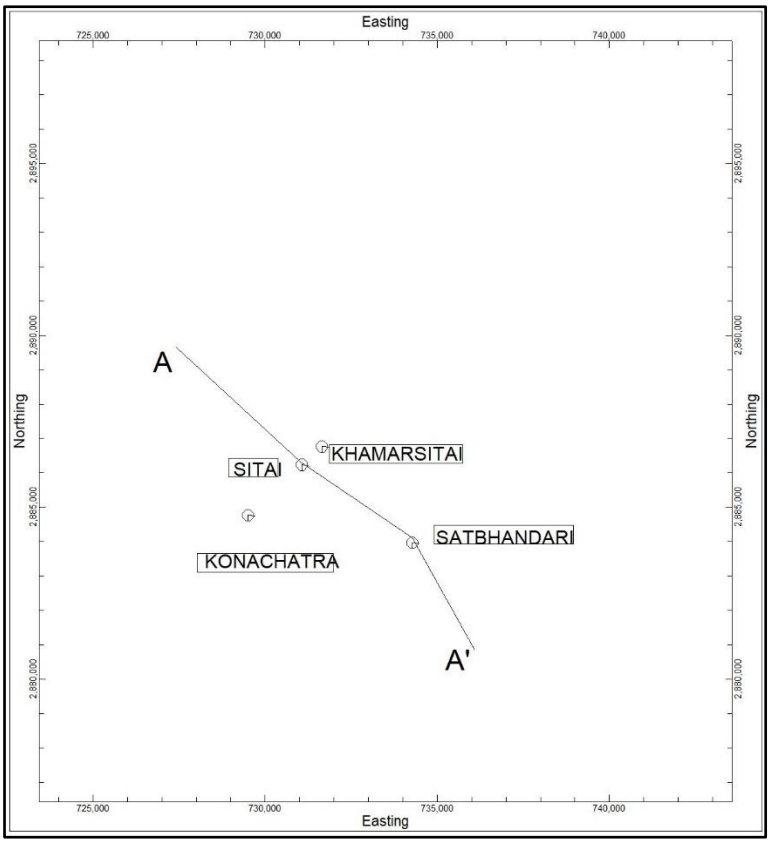

Fig. 9.5 Borehole location map for cross-section of Sitai block.

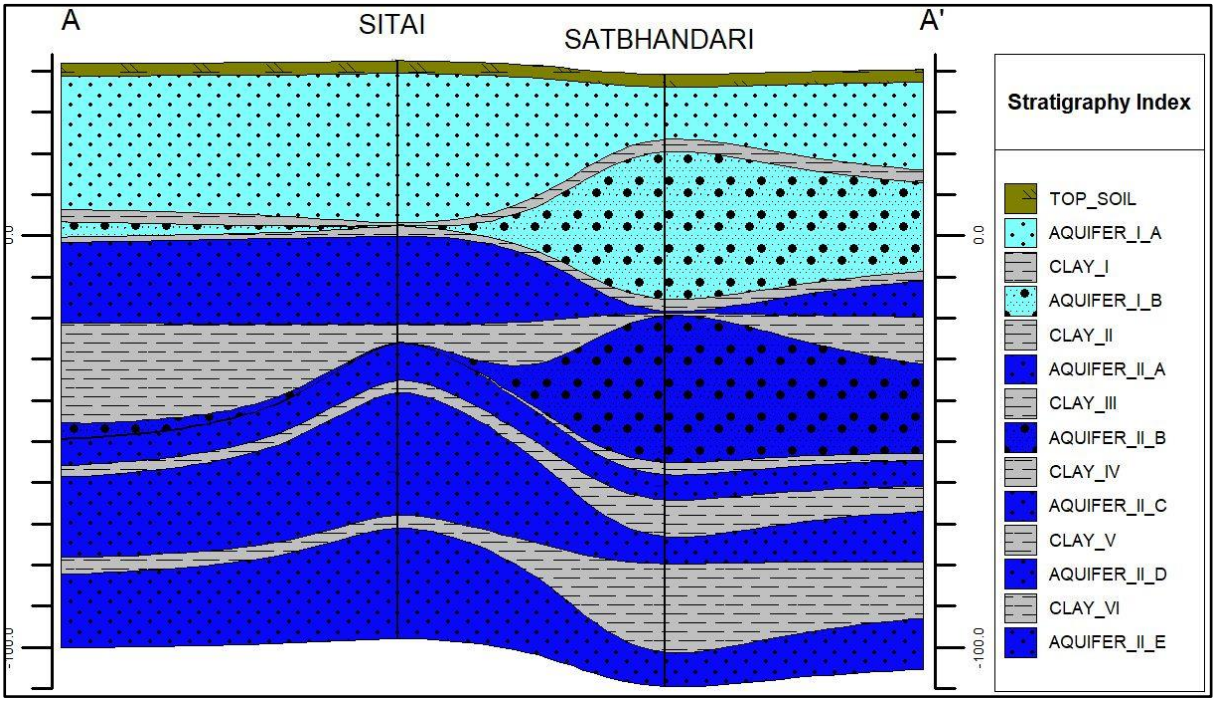

Fig. 9.6 Cross-Sectional Map of Sitai block.

Table 9.5: Details of aquifer wise water level ranges and seasonal long-term water level trend (2011-2020) in Sitai Block

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)
Sitai	I		0.2715	--			0.0755
	II	-	-	-	-	-	-

Ground Water Quality and Issues:

Based on NHS and Keywells data, the range of chemical parameters for the block is given below.

Table 9.6: Average concentration of chemical parameters in Sitai Block

Block	Aquifer Type	pH	EC	TH	Ca	Mg	Na	K	CO3	HCO3	Total Alk as CaCO3	Cl	NO3	SO4	F	TDS	Fe	U (µg/l)
Sitai	Aquifer-I	6.33-6.58	94-294	35-75	10-24	2-4	5-25	2-11	0	37-85	30-70	11-50	BDL	BDL	0.25-0.27	53-165	0.11-0.16	BDL
	Aquifer-II	7.14	126	40	12	2	9	2	0	67	55	7	BDL	BDL	0.25	74	0.01	BDL

Groundwater Resource Enhancement and Management Plan:

Ground Water Management Plan for Drinking Purpose:

There are four (4) ground water based public water supply schemes are commissioned till July 2022 by PHED which are the main sources of drinking water in the block. Till July 2022 about 15.66 % of the Functional Household Tap Connection is achieved since inception. Sitai block receives ample amount of rain during monsoon. Though the stage of development is only 24.6 % it will be good if we practice conservation through rain water harvesting and used it as an alternative for drinking water because with time ground water abstraction will increase and to maintain the categorization as safe we have to look supplement sources for drinking purposes.

For monitoring of change in ground water regime in the area in future, cost of construction of observation well should be included.

Management plan for Irrigation:

Table 9.7: Ground-water scenario for irrigation in Sitai block

Block	Geographical Area in Ha	Net Area Sown in Ha	Net Area Irrigated in Ha	Area to be Irrigated in Ha	SOD in %
SITAI	18967	8876	2830.88	6045.12	24.6

The stage of ground water development in the block is 36.1 %, under safe category. However, further development should be done in planned manner to harness the additional available resource for more sustainable development.

6045.12 hectares more of land can be irrigated. Water applied for irrigation should not be wasted. An effective water management technique should be considered through modern agricultural management maintaining minimum pumping hours and selecting most appropriate cropping pattern. The application of modern techniques like sprinkler and drip irrigation will help increase crop yield and consequently conserve ground water.

Crops with low water requirement should be preferred. Heavy duty/medium duty tube wells can be constructed by Govt. agencies as they may help for irrigation in large perspective. Installation and maintenance cost of heavy-duty tube well is high and it will be difficult for individual or small farmers to maintain. Therefore, heavy-duty tube wells can be constructed by local government agencies and after installation of pumps it can be handed over to the local co-operative based farmers for its operation and maintenance.

Dug wells, light duty tube wells fitted with submersible pump, medium duty tube wells are feasible for irrigation purposes. But the capacity of the pump should be decided in such a way so that drawdown may be minimized.

In view of sufficient rainfall in the area, excavation of tanks with large catchment areas can help in augmentation of irrigation facilities.

Management Intervention Through Rain Water Harvesting (Roof Top and Surface Runoff) And Artificial Recharge:

The area receives plenty of rainfall but due to lack of proper rainwater harvesting structures and un-distributed rainfall causes huge amount of rainwater to drain into the sea. The runoff, thus produced, may be diverted for water harvesting either for conservation or for artificial recharge to the depleted aquifer in the area. No structure has been constructed by CGWB till date.

Generally, water conservation and artificial recharge is feasible is such area where water level is more than 3 mbgl in post monsoon period. As a whole the water level is not in alarming condition in this block. Water conservation of rainwater by different structures like percolation tank, roof top rainwater harvesting can be considered for the block in future.

This block is not considered under artificial recharge and no Artificial Recharge Structures has thus been proposed at present.

10. Sitalkuchi

Salient Information

Block Name: Sitalkuchi

Geographical area (in sq. km): 264

Mapable area (in sq. km): 236

District: Cooch Behar

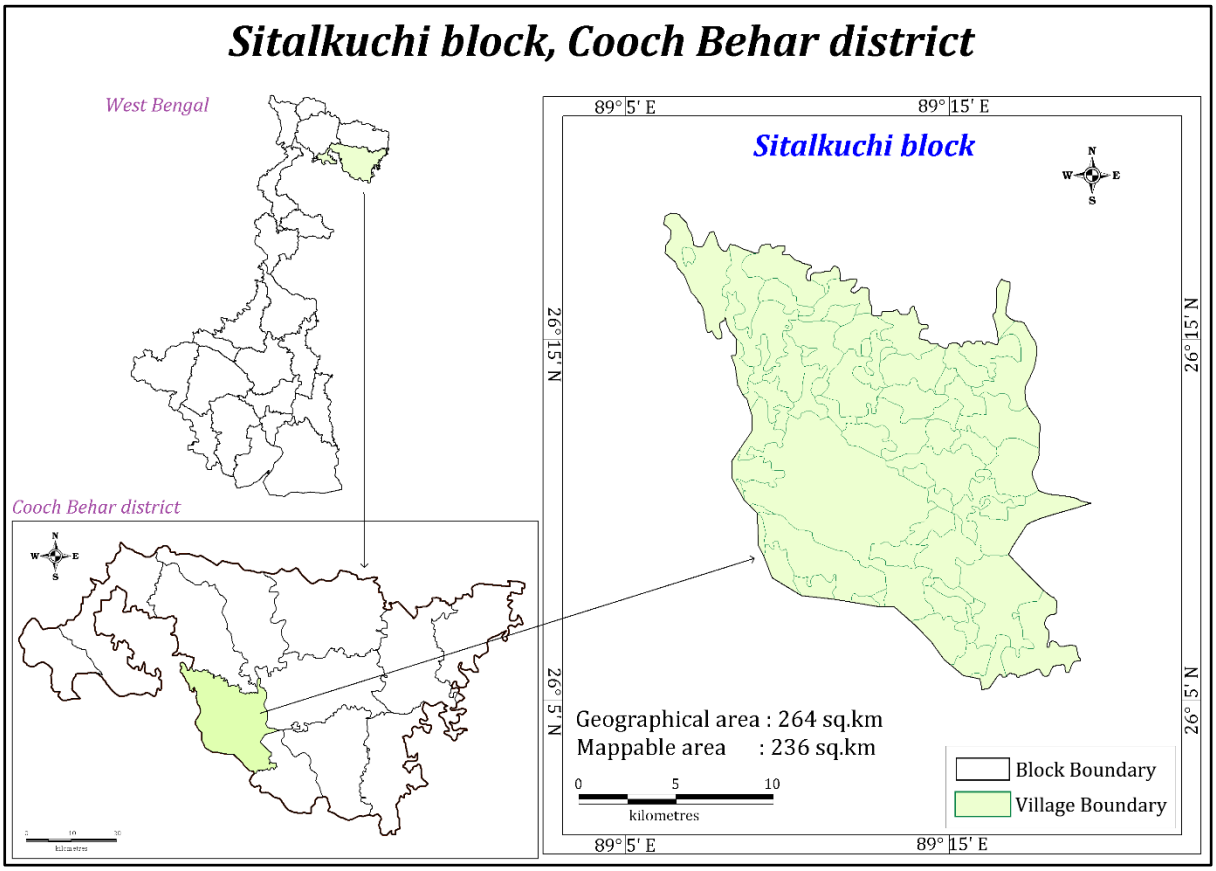

Fig.10.1. Location map for Sitalkuchi block

Population (as on 2011):

Table 10.1: Distribution of population in administrative units of the study area

Block/ Muncipality	Rural Population			Urban Population			Total Population		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Sitalkuchi	94277	91076	185353	-	-	-	94277	91076	185353

Rainfall:

*Table 10.2: Annual Actual Rainfall for Cooch Behar District from 2011 to 2021 (*Source WRIS)*

Block Name	Normal Rainfall	Rain Fall										
Sitalkuchi	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2011
	3213	2666.57	3682.77	2736.46	2882.16	3355.41	3180.31	3211.4	2630.13	3521.38	4677.07	2793.68

Landuse, Agriculture & Irrigation (area in ha):

Table 10.3.1: Sitalkuchi Block details of Land-use pattern (in hectares)

Block	Reporting Area	Forest Area	Area under Non-Agricultural use	Barren and Un-culturable land	Land under misc tree crops	Culturable wastes	Fallow land Other than current fallow	Current fallow	Net area sown
Sitalkuchi	26459	87	3087	-	987	-	-	75	22223

Table 10.3.2: Command area(ha) of Sitalkuchi block

Block Name	Dugwell		Sallow Tubewell		Medium Tubewell		Deep Tubewell		Surface Flow		Sarface 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	
Sitalkuchi	0	0.00	2338	4607.62	10	21.62	2	80.00	0	0.00	18	780.00	4709.24	780.00	5489.24

Ground Water Resources:

Table 10.4 Details of Ground Water Resource Availability and Utilization in Sitalkuchi Block. (As on 31.03.2013)

BLOCK NAME		SITALKUCHI
Total Annual Ground Water Recharg e (Ham)		26840.45
Total Natural Discharg es (Ham)		2684.05
Annual Extractab le Ground Water Recharge (Ham)		24156.4
Total Extraction		9168.09
Annual GW	Allocation for Domestic and Industrial Use as on 2042	370.22
Net Ground Water Availabili ty for future irrigation use		14963.35
Stage of Ground Water Extracti on (%)		37.95
Categorization		Safe
Instorage		144558

Geology:

Sitalkuchi block is mainly covered with quaternary newer alluvium sediments. The major lithology encountered in this block are sand and clay. A lithological model is prepared based on the lithologs of exploratory wells of CGWB and PHED of Govt. of West Bengal.

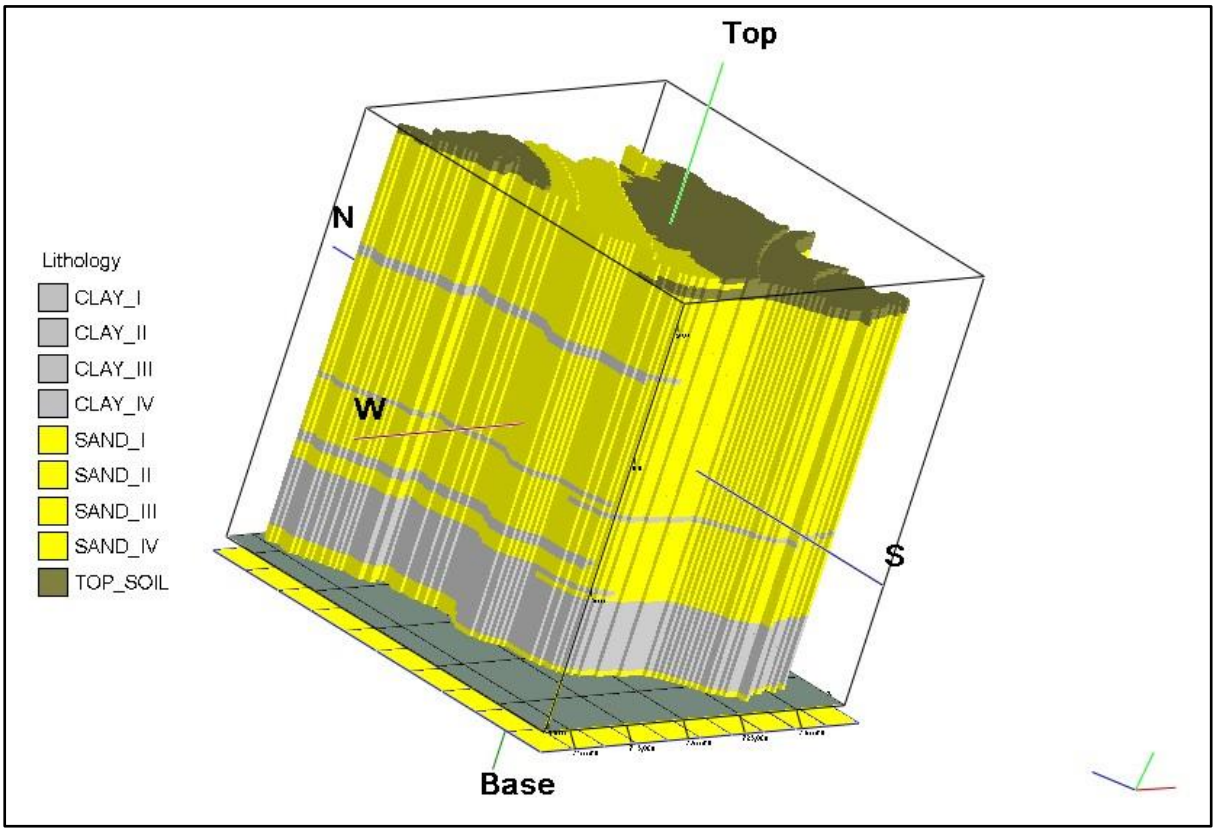

Fig. 10.2 Lithological model of Sitalkuchi block

Disposition of Aquifers:

In Sitalkuchi there are two aquifer systems. One is shallow which extends from 3-meter bgl to 80-meter bgl and another is deep which extends from 49-meter bgl to beyond 150-meter bgl. Aquifer_I is unconfined whereas Aquifer_II is confined.

Aquifer_II again classified as Aquifer_I_A, Aquifer_I_B and Aquifer_I_D depends upon the clay layers present in between.

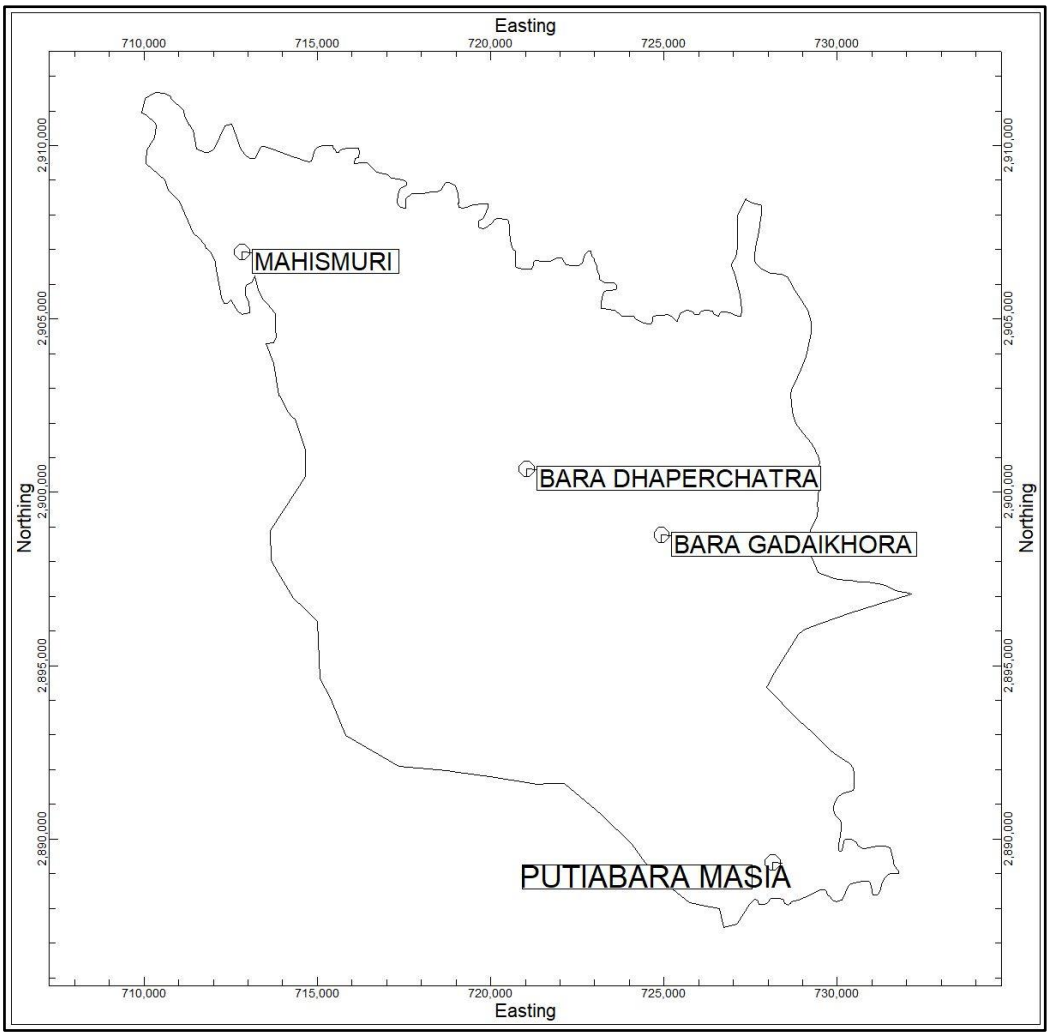

Fig. 10.3 Borehole location map of Sitalkuchi block.

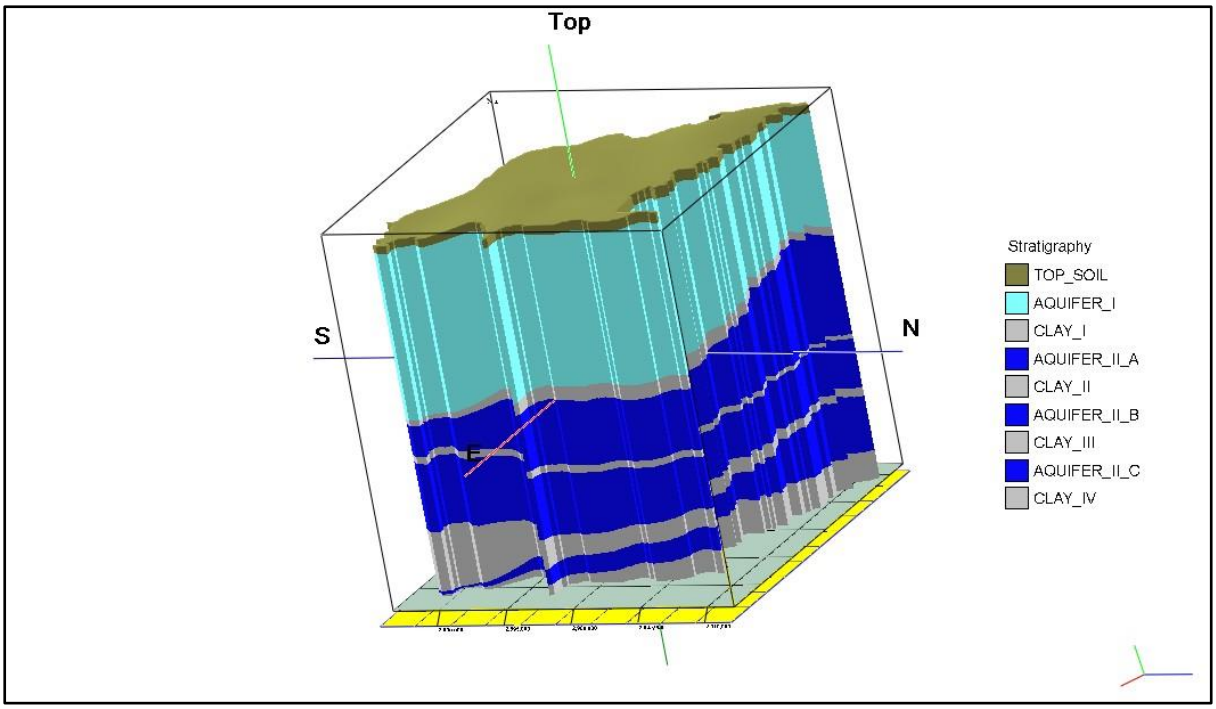

Fig.10.4 Aquifer disposition model of Sitalkuchi block.

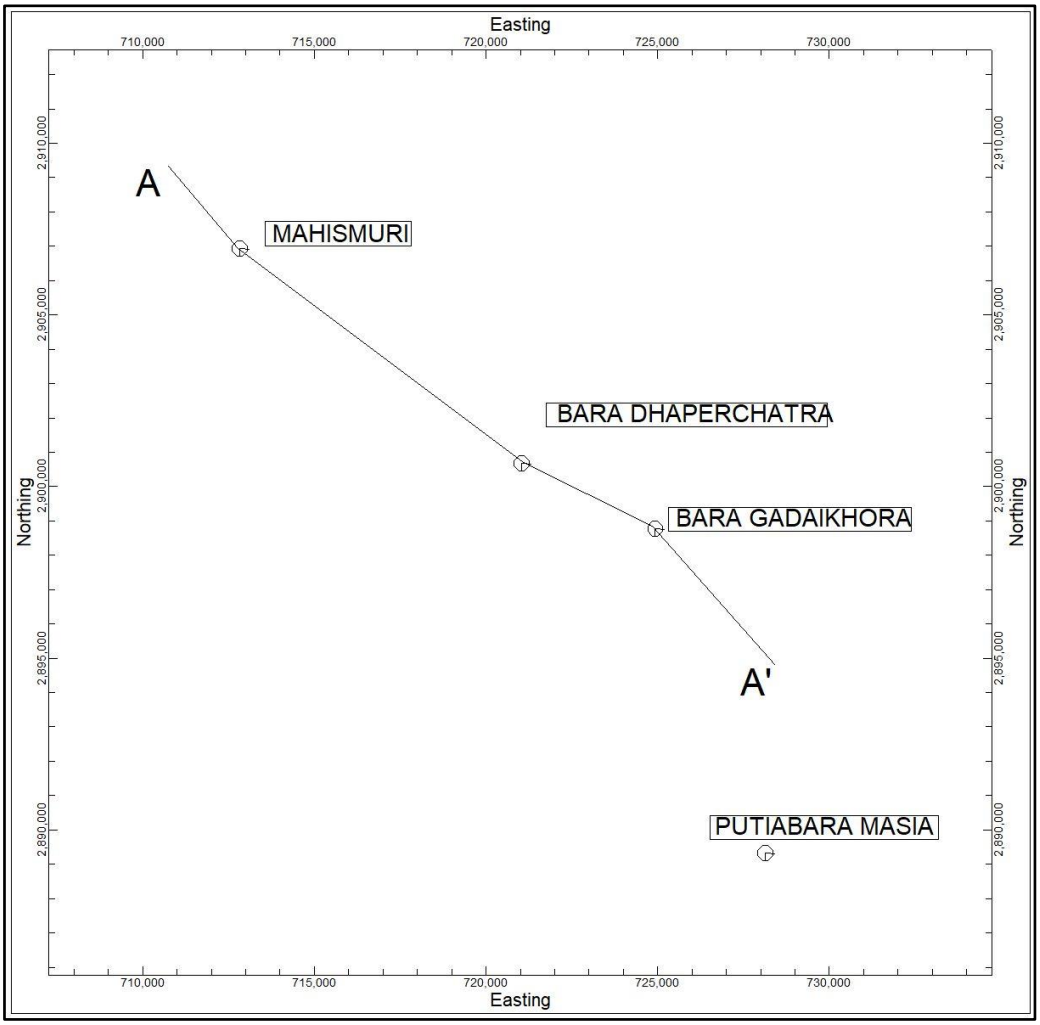

Fig. 10.5 Borehole location map for cross-section of Sitalkuchi block.

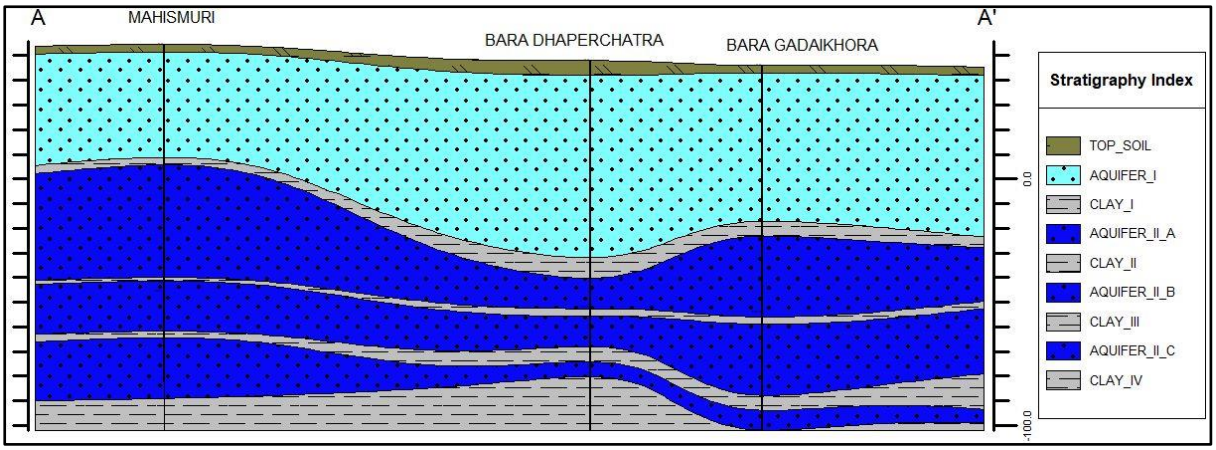

Fig.10.6 Cross-Sectional Map of Sitalkuchi block.

Table 10.5: Details of aquifer wise water level ranges and seasonal long-term water level trend (2011-2020) in Sitalkuchi block

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)**
Sitalkuchi	I		0.2225	--			0.02175
	II	-	-	-	-	-	-

Ground Water Quality and Issues:

Based on NHS and Keywells data, the range of chemical parameters for the block is given below.

Table 10.6: Average concentration of chemical parameters in Sitalkuchi block

Block	Aquifer Type	pH	EC	TH	Ca	Mg	Na	K	CO3	HCO3	Total Alk as CaCO3	Cl	NO3	SO4	F	TDS	Fe	U (µg/l)
Sitalkuchi	Aquifer-I	6.65-7.10	126-130	35-50	12-16	1-2	6-11	2	0	31	25	14-18	12-24	BDL	0.32-0.41	75-85	0.95-1.92	BDL
	Aquifer-II	7.20-7.23	103-208	35-75	12-22	1-5	7-14	2	0	49-122	40-100	7-11	BDL	BDL	0.32-0.37	63-125	0.07-1.24	BDL-0.01

Groundwater Resource Enhancement and Management Plan:

Ground Water Management Plan for Drinking Purpose:

There are nine (9) ground water based public water supply schemes are commissioned till July 2022 by PHED which are the main sources of drinking water in the block. Till July 2022 about 12.49 % of the Functional Household Tap Connection is achieved since inception. Sitalkuchi block receives ample amount of rain during monsoon. Though the stage of development is only 36.1 % it will be good if we practice conservation through rain water harvesting and used it as an alternative for drinking water because with time

ground water abstraction will increase and to maintain the categorization as safe we have to look supplement sources for drinking purposes.

For monitoring of change in ground water regime in the area in future, cost of construction of observation well should be included.

Management plan for Irrigation:

Table 10.7: Ground-water scenario for irrigation in Sitalkuchi block

Block	Geographical Area in Ha	Net Area Sown in Ha	Net Area Irrigated in Ha	Area to be Irrigated in Ha	SOD in %
SITALKUCHI	54923	14647	2737.32	11909.68	37.95

The stage of ground water development in the block is 37.95 %, under safe category. However, further development should be done in planned manner to harness the additional available resource for more sustainable development.

11909.68 hectares more of land can be irrigated. Water applied for irrigation should not be wasted. An effective water management technique should be considered through modern agricultural management maintaining minimum pumping hours and selecting most appropriate cropping pattern. The application of modern techniques like sprinkler and drip irrigation will help increase crop yield and consequently conserve ground water.

Crops with low water requirement should be preferred. Heavy duty/medium duty tube wells can be constructed by Govt. agencies as they may help for irrigation in large perspective. Installation and maintenance cost of heavy-duty tube well is high and it will be difficult for individual or small farmers to maintain. Therefore, heavy-duty tube wells can be constructed by local government agencies and after installation of pumps it can be handed over to the local co-operative based farmers for its operation and maintenance.

Dug wells, light duty tube wells fitted with submersible pump, medium duty tube wells are feasible for irrigation purposes. But the capacity of the pump should be decided in such a way so that drawdown may be minimized.

In view of sufficient rainfall in the area, excavation of tanks with large catchment areas can help in augmentation of irrigation facilities.

Management Intervention Through Rain Water Harvesting (Roof Top and Surface Runoff) And Artificial Recharge:

The area receives plenty of rainfall but due to lack of proper rainwater harvesting structures and un-distributed rainfall causes huge amount of rainwater to drain into the sea. The runoff, thus produced, may be diverted for water harvesting either for conservation or for artificial recharge to the depleted aquifer in the area. No structure has been constructed by CGWB till date.Generally, water conservation and artificial recharge is feasible is such area where water level is more than 3 mbgl in post monsoon period. As

a whole the water level is not in alarming condition in this block. Water conservation of rainwater by different structures like percolation tank, roof top rainwater harvesting can be considered for the block in future.

This block is not considered under artificial recharge and no Artificial Recharge Structures has thus been proposed at present.

11. Tufanganj-I

Salient Information

Block Name: Tufanganj-I

Geographical area (in sq. km): 322

Mapable area (in sq. km): 288

District: Cooch Behar

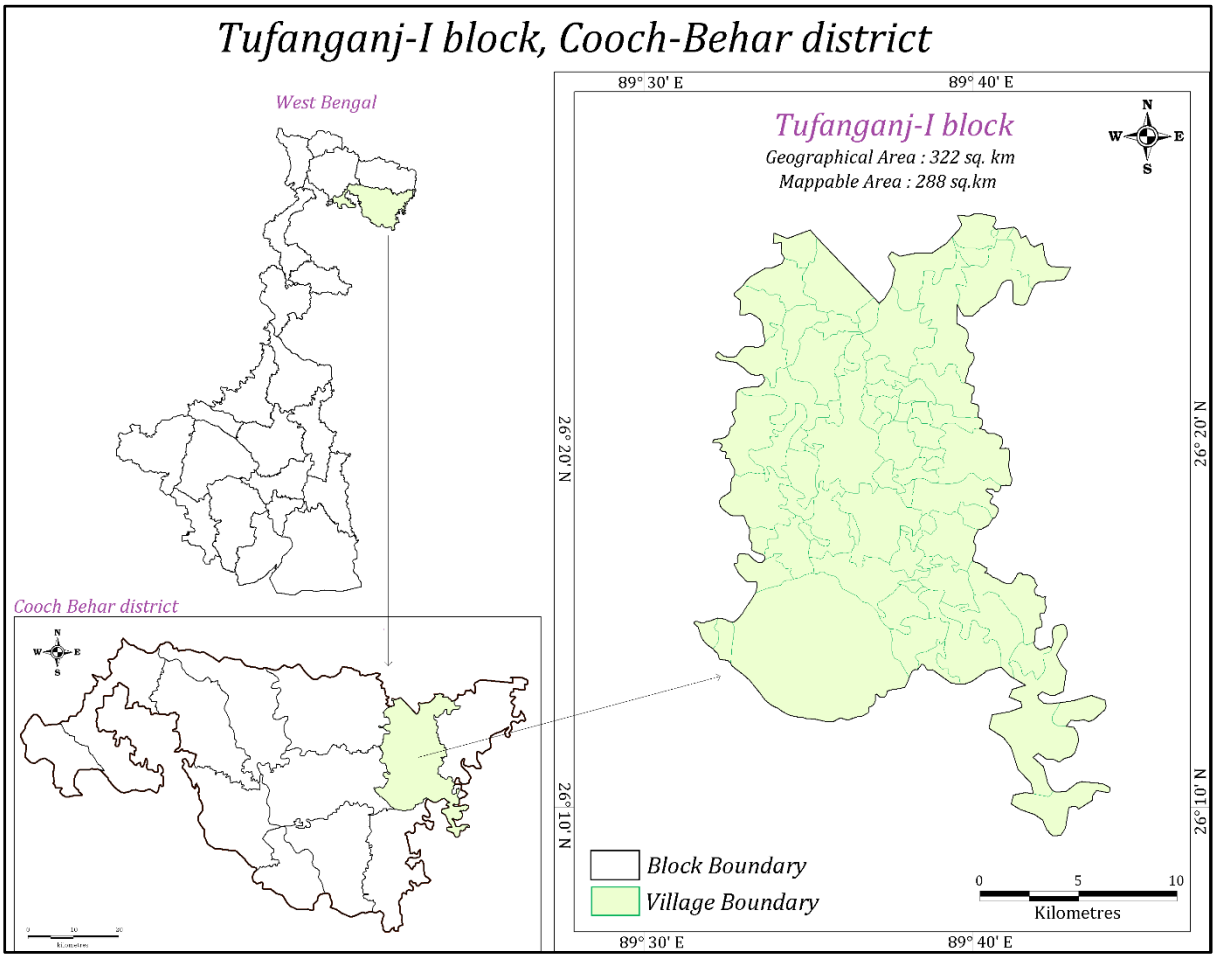

Fig.11.1. Location map for Tufanganj-I block

Population (as on 2011):

Table 11.1: Distribution of population in administrative units of the study area

Block/ Muncipality	Rural Population			Urban Population			Total Population		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Tufanganj-I	125672	117584	243256	2743	2596	5339	128415	120180	248595

Rainfall:

*Table 11.2: Annual Actual Rainfall for Cooch Behar District from 2011 to 2021 (*Source WRIS)*

Block Name	Normal Rainfall	Rain Fall										
Tufanganj-I	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2011
	3213	2666.57	3682.77	2736.46	2882.16	3355.41	3180.31	3211.4	2630.13	3521.38	4677.07	2793.68

Landuse, Agriculture & Irrigation (area in ha):

Table 11.3.1: Tufanganj-I Block details of Land-use pattern (in hectares)

Block	Reporting Area	Forest Area	Area under Non-Agricultural use	Barren and Un-culturable land	Land under misc tree crops	Culturable wastes	Fallow land Other than current fallow	Current fallow	Net area sown
Tufanganj - I	31618	0	8378	-	698	-	-	35	22507

Table 11.3.2: Command area(ha) of Tufanganj-I block

Block Name	Dugwell		Sallow Tubewell		Medium Tubewell		Deep Tubewell		Surface Flow		Sarface 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	
Tufanganj - I	2	3.44	3568	9569.10	60	164.54	11	144.75	0	0.00	40	1270.00	9881.83	1270.00	11151.83

Ground Water Resources:

Table 11.4 Details of Ground Water Resource Availability and Utilization in Tufanganj-I Block. (As on 31.03.2013)

BLOCK NAME		TUFANGANJ-I
Total Annual Ground Water Recharg e (Ham)		33701.32
Total Natural Discharg es (Ham)		3370.13
Annual Extractab le Ground Water Recharge (Ham)		30331.19
Total Extraction		14597.19
Annual GW	Allocation for Domestic and Industrial Use as on 2042	513.9
Net Ground Water Availabili ty for future irrigation use		15683.16
Stage of Ground Water Extracti on (%)		48.13
Categorization		Safe
Instorage		273615

Geology:

Tufanganj-I block is mainly covered with quaternary newer alluvium sediments. The major lithology encountered in this block are sand with pebbles & gravels, sand and clay. A lithological model is prepared based on the lithologs of exploratory wells of CGWB and PHED of Govt. of West Bengal.

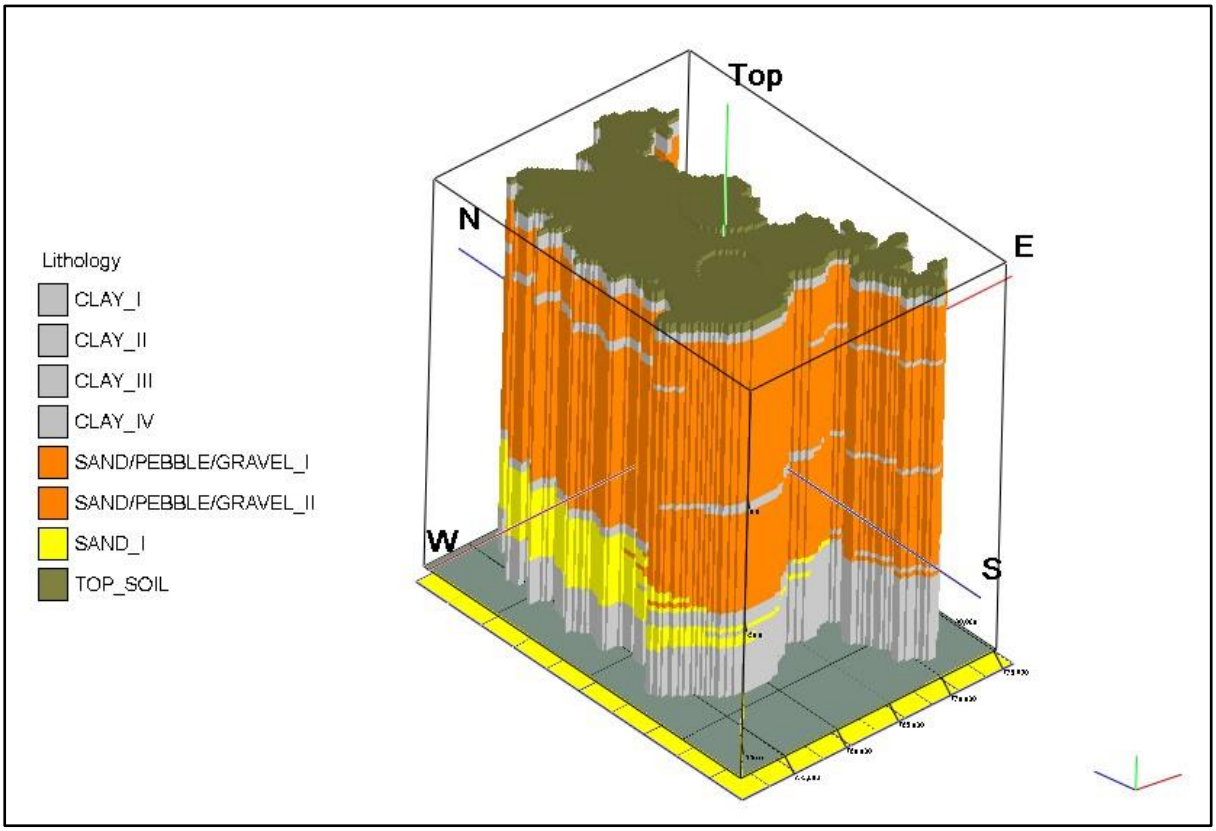

Fig. 11.2 Lithological model of Tufanganj-I block.

Disposition of Aquifers:

In Tufanganj-I there are two aquifer systems. One is shallow which extends from 7-meter bgl to 72-meter bgl and another is deep which extends from 31-meter bgl to beyond 150-meter bgl. Aquifer_I is unconfined to semi-confined whereas Aquifer_II is confined.

Aquifer_II is again classified as Aquifer_II_A & Aquifer_II_B depends upon the clay layers present in between.

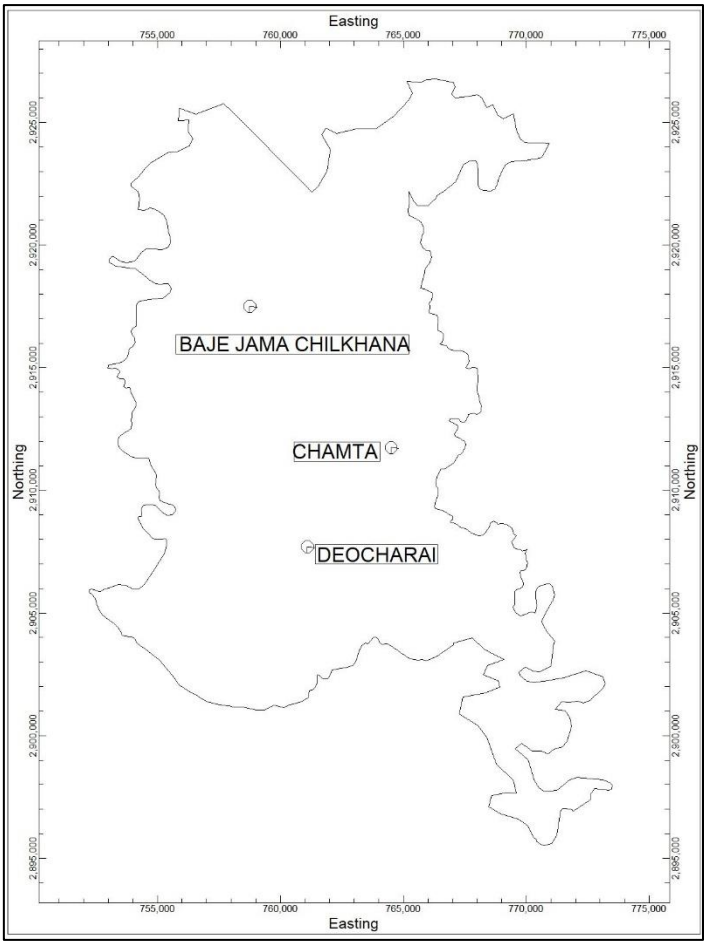

Fig. 11.3 Borehole location map of Tufanganj-I block.

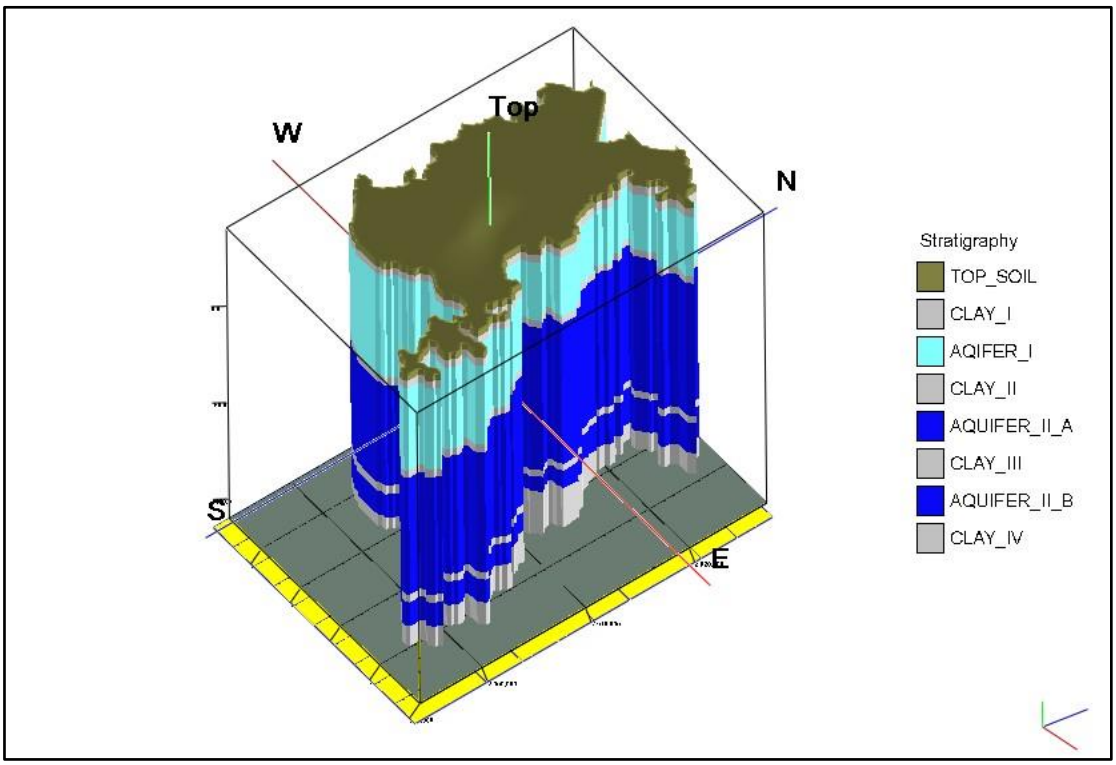

Fig.11.4 Aquifer disposition model of Tufanganj-I block.

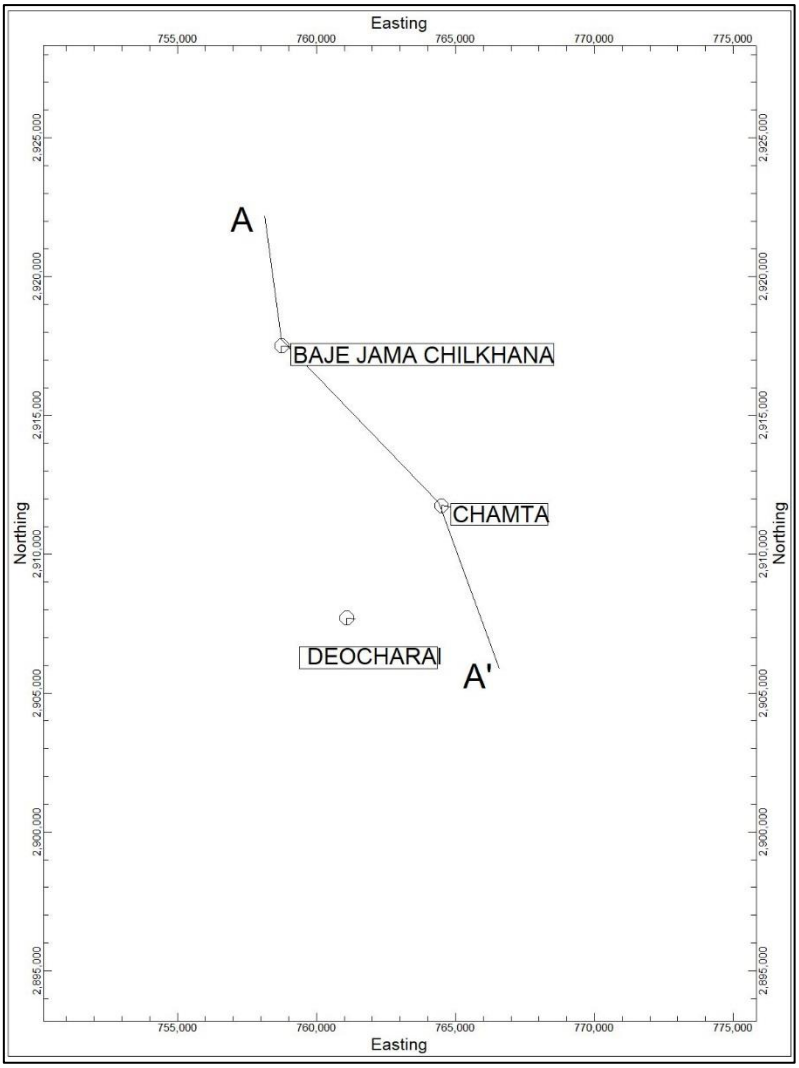

Fig. 11.5 Borehole location map for cross-section of Tufanganj-I block.

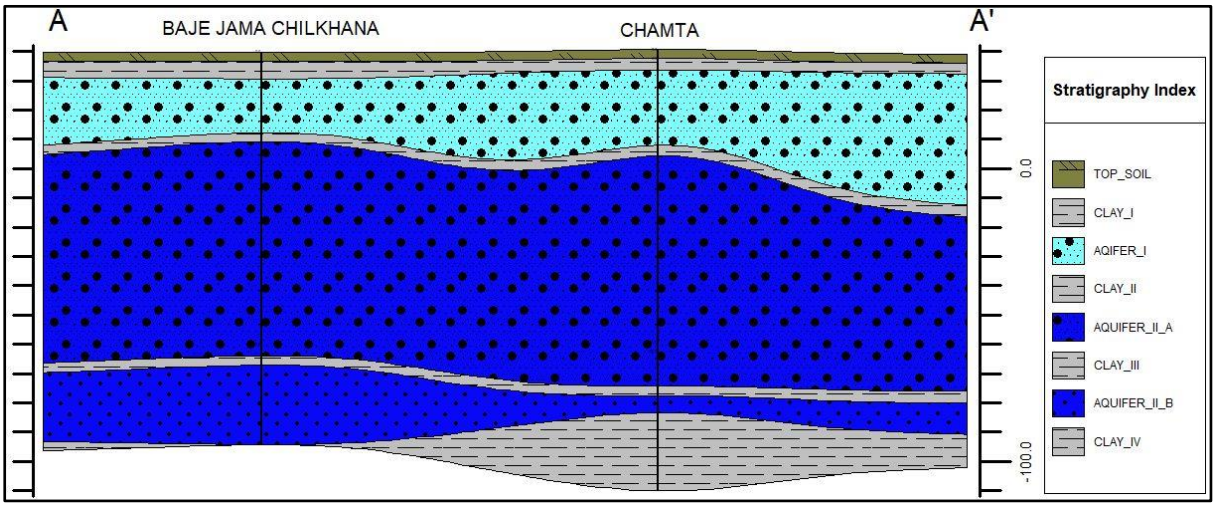

Fig.11.6 Cross-Sectional Map of Tufanganj-I block.

Table 11.5: Details of aquifer wise water level ranges and seasonal long-term water level trend (2011-2020) in Tufanganj-I Block

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)
Tufanganj-I	I		0.340333333	--		--	0.006333333
	II	-	-	-	-	-	-

Ground Water Quality and Issues:

Based on NHS and Keywells data, the range of chemical parameters for the block is given below.

Table 11.6: Average concentration of chemical parameters in Tufanganj-I Block

Block	Aquifer Type	pH	EC	TH	Ca	Mg	Na	K	CO3	HCO3	Total Alk as CaCO3	Cl	NO3	SO4	F	TDS	Fe	U (µg/l)
Tufanganj-I	Aquifer-I	6.95-7.29	204-231	90-100	12-22	11-15	7-10	1-6	0	67-116	55-95	11-14	BDL-2	1-32	0.38-0.51	125-131	0.29-1.13	BDL-0.05
	Aquifer-II	7.49-7.79	247-286	105-110	28-32	6-10	12-20	1-2	0	104-171	85-140	11-28	BDL-1	BDL-4	0.34-0.61	148-175	0-0.36	0.18-88

Groundwater Resource Enhancement and Management Plan:

Ground Water Management Plan for Drinking Purpose:

There are sixteen (16) ground water based public water supply schemes are commissioned till July 2022 by PHED which are the main sources of drinking water in the block. Till July 2022 about 31.36 % of the Functional Household Tap Connection is achieved since inception. Tufanganj-I block receives ample amount of rain during monsoon. Though the stage of development is only 48.13 % it will be good if we practice conservation through rain water harvesting and used it as an alternative for drinking water because with time ground water abstraction will increase and to maintain the categorization as safe we have to look supplement sources for drinking purposes.

For monitoring of change in ground water regime in the area in future, cost of construction of observation well should be included.

Management plan for Irrigation:

Table 11.7: Ground-water scenario for irrigation in Tufanganj-I block

Block	Geographical Area in Ha	Net Area Sown in Ha	Net Area Irrigated in Ha	Area to be Irrigated in Ha	SOD in %
Tufanganj-I	30842	9900	6390.15	3509.85	48.13

The stage of ground water development in the block is 48.13 %, under safe category. However, further development should be done in planned manner to harness the additional available resource for more sustainable development.

3509.85 hectares more of land can be irrigated. Water applied for irrigation should not be wasted. An effective water management technique should be considered through modern agricultural management maintaining minimum pumping hours and selecting most appropriate cropping pattern. The application of modern techniques like sprinkler and drip irrigation will help increase crop yield and consequently conserve ground water.

Crops with low water requirement should be preferred. Heavy duty/medium duty tube wells can be constructed by Govt. agencies as they may help for irrigation in large perspective. Installation and maintenance cost of heavy-duty tube well is high and it will be difficult for individual or small farmers to maintain. Therefore, heavy-duty tube wells can be constructed by local government agencies and after installation of pumps it can be handed over to the local co-operative based farmers for its operation and maintenance.

Dug wells, light duty tube wells fitted with submersible pump, medium duty tube wells are feasible for irrigation purposes. But the capacity of the pump should be decided in such a way so that drawdown may be minimized.

In view of sufficient rainfall in the area, excavation of tanks with large catchment areas can help in augmentation of irrigation facilities.

Management Intervention Through Rain Water Harvesting (Roof Top and Surface Runoff) And Artificial Recharge:

The area receives plenty of rainfall but due to lack of proper rainwater harvesting structures and un-distributed rainfall causes huge amount of rainwater to drain into the sea. The runoff, thus produced, may be diverted for water harvesting either for conservation or for artificial recharge to the depleted aquifer in the area. No structure has been constructed by CGWB till date. Generally, water conservation and artificial recharge is feasible is such area where water level is more than 3 mbgl in post monsoon period. As a whole the water level is not in alarming condition in this block.

Water conservation of rainwater by different structures like percolation tank, Injection well, roof top rainwater harvesting can be considered for the block in future. It has been estimated that the utilizable surface runoff produced in the block is 5.144 MCM. This surface runoff is proposed to be utilized to recharge the depleted aquifers in the block. As per the available storage space, 1.543 MCM water is required to fill the deeper aquifers in block. Therefore, 5 injection wells with roof top rain water harvesting structures are recommended in the block. The remaining surface runoff, 3.601 MCM is recommended to be utilized in storage tanks for generation of irrigation potential and thus, 15 storage tanks have been proposed. The roof top rain water harvesting structures with suitably design injection wells may be proposed to construct in the census towns areas in primary phases and subsequently may be extended to the rural areas.

Table 11.8: Area suitable for recharge in Tufanganj-I block

District	Block Name	Block Area (in Ha)	Area (in Ha) suitable for recharge (having DTW 3 m and more in Postmonsoon)
Cooch Behar	Tufanganj-I	32200	11.43120

Table 11.9: Artificial recharge priority area-structures feasible and their cost of construction for Tufanganj-I block

Block	Utilizable Surface runoff	Allocation of Utilizable Resource (MCM)			Structures Feasible (No.s)			Cost of structures (in lakhs)			Total cost (in lakhs)
		Percolation tank	REET withRS	Injection Well	Percolation tank	REET with RS	Injection Well	Percolation tank	REET with RS	Injection Well	
Tufanganj-I	5.144	2.572	1.029	1.543	5	10	5	40.00	40.00	15.00	95.00

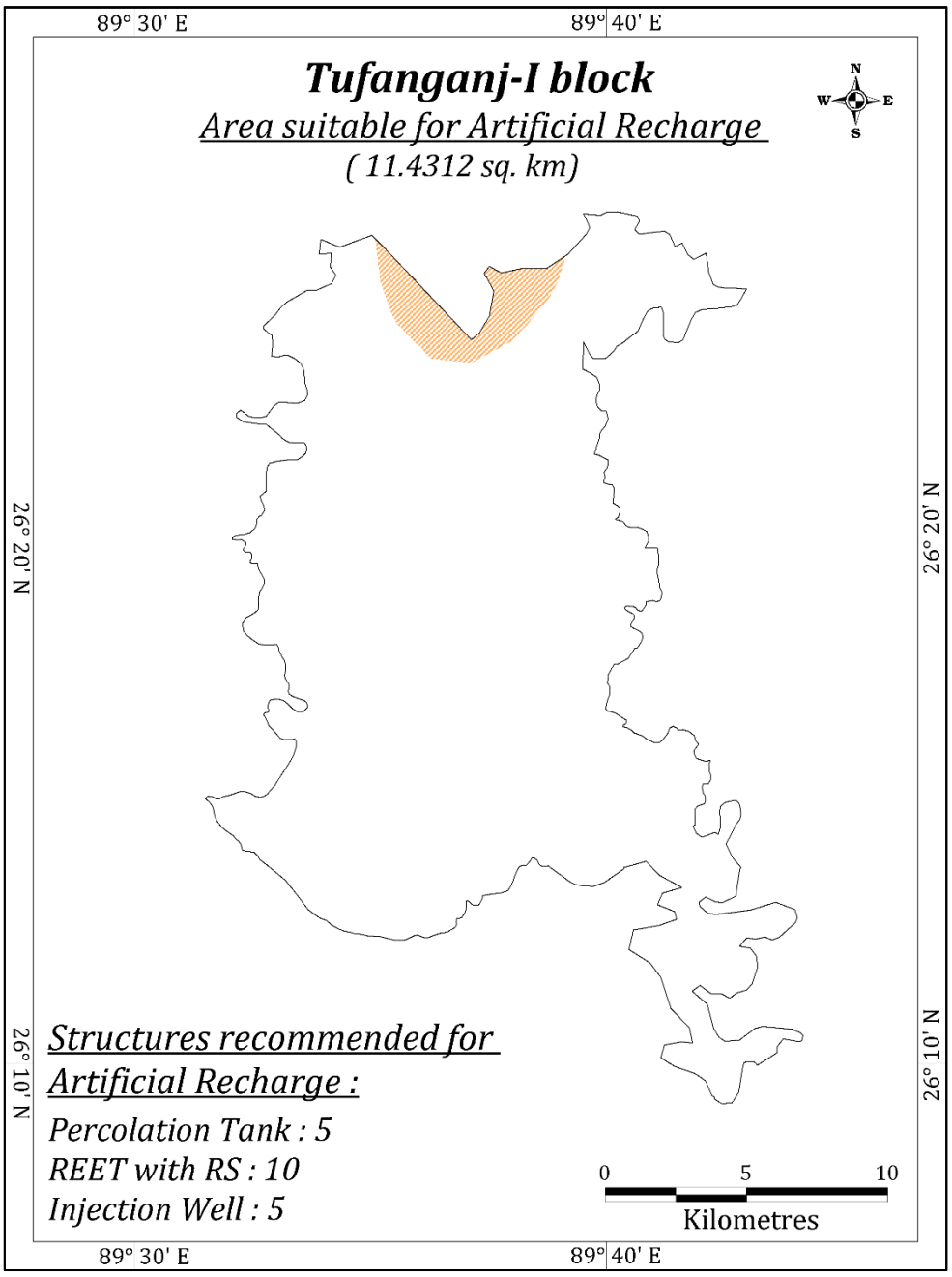

Fig.11.7: Area Feasible for Artificial Recharge of groundwater of Tufanganj-I block.

12. Tufanganj-II

Salient Information

Block Name: Tufanganj-II

Geographical area (in sq. km): 254

Mapable area (in sq. km): 227

District: Cooch Behar

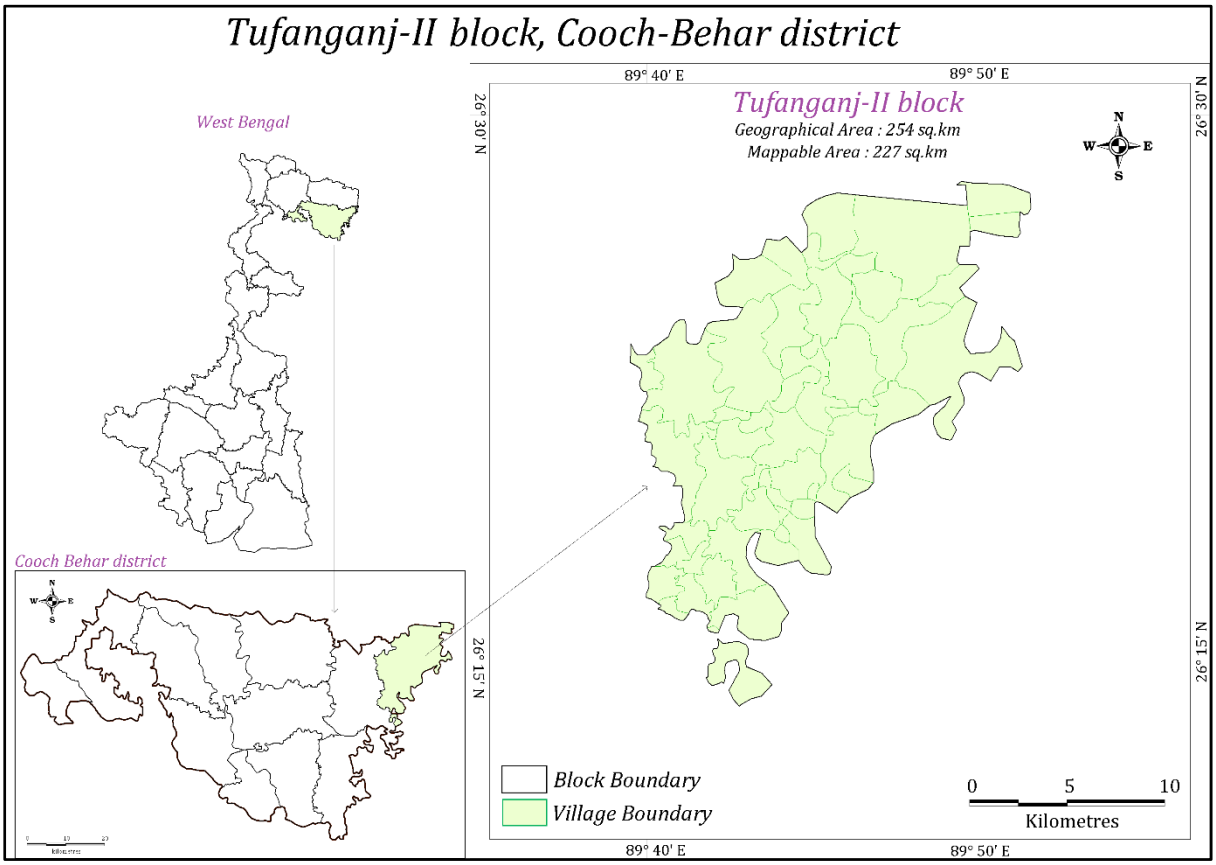

Fig.12.1. Location map for Tufanganj-II block

Population (as on 2011):

Table 12.1: Distribution of population in administrative units of the study area

Block/ Muncipality	Rural Population			Urban Population			Total Population		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Tufanganj-II	93431	87815	181246	2791	2689	5480	96222	90504	186726

Rainfall:

*Table 12.2: Annual Actual Rainfall for Cooch Behar District from 2011 to 2021 (*Source WRIS)*

Block Name	Normal Rainfall	Rain Fall										
Tufanganj-II	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2011
	3213	2666.57	3682.77	2736.46	2882.16	3355.41	3180.31	3211.4	2630.13	3521.38	4677.07	2793.68

Landuse, Agriculture & Irrigation (area in ha):

Table 12.3.1: Tufanganj-II Block details of Land-use pattern (in hectares)

Block	Reporting Area	Forest Area	Area under Non- Agricultural use	Barren and Un-culturable land	Land under misc tree crops	Cultur able wastes	Fallow land Other than current fallow	Current fallow	Net area sown
Tufanganj - II	26020	2092	4200	-	449	-	-	25	19254

Table 12.3.2: Command area(ha) of Tufanganj-II block

Block Name	Dugwell		Sallow Tubewell		Medium Tubewell		Deep Tubewell		Surface Flow		Sarface 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	
Tufanganj-II	83	128.03	2648	4544.84	10	23.83	4	121.62	0	0.00	23	851.80	4818.32	851.80	5670.12

Ground Water Resources:

Table 12.4 Details of Ground Water Resource Availability and Utilization in Tufanganj-II Block. (As on 31.03.2013)

BLOCK NAME	TUFANGANJ-II
Total Annual Ground Water Recharg e (Ham)	26626.14
Total Natural Discharg es (Ham)	2662.61
Annual Extractab le Ground Water Recharge (Ham)	23963.53
Total Extraction	10334.62
Annual GW	382.83
Net Ground Water Availabili ty for future irrigation use	13593.89
Stage of Ground Water Extraction (%)	43.13
Categorization	Safe
Instorage	361095

Geology:

Tufanganj-II block is mainly covered with quaternary newer alluvium sediments. The major lithology encountered in this block are sand with pebbles & gravels, sand and clay. A lithological model is prepared based on the lithologs of exploratory wells of CGWB and PHED of Govt. of West Bengal.

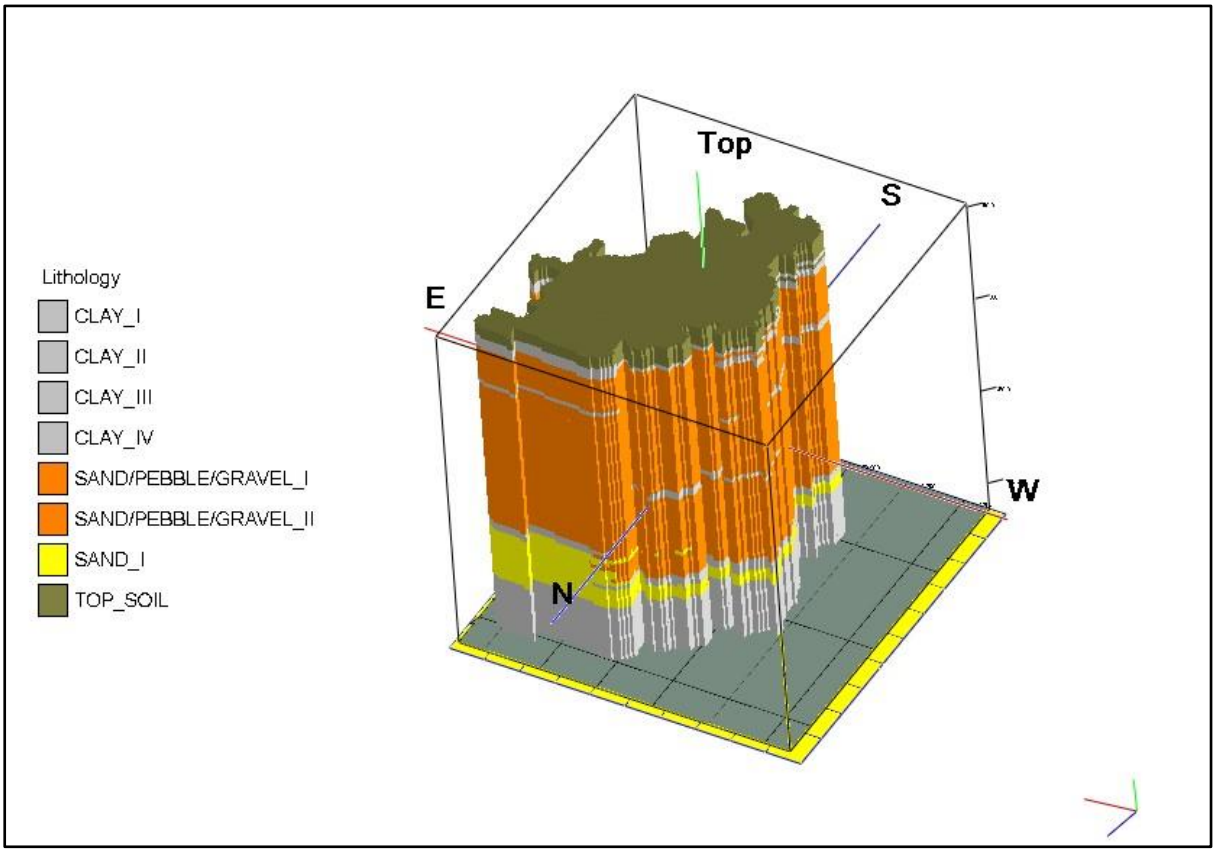

Fig. 12.2 Lithological model of Tufanganj-II block.

Disposition of Aquifers:

In Tufanganj-I there are two aquifer systems. One is shallow which extends from 7-meter bgl to 72-meter bgl and another is deep which extends from 31-meter bgl to beyond 150-meter bgl. Aquifer_I is semi-confined to confined whereas Aquifer_II is confined.

Aquifer_II is again classified as Aquifer_II_A & Aquifer_II_B depends upon the clay layers present in between.

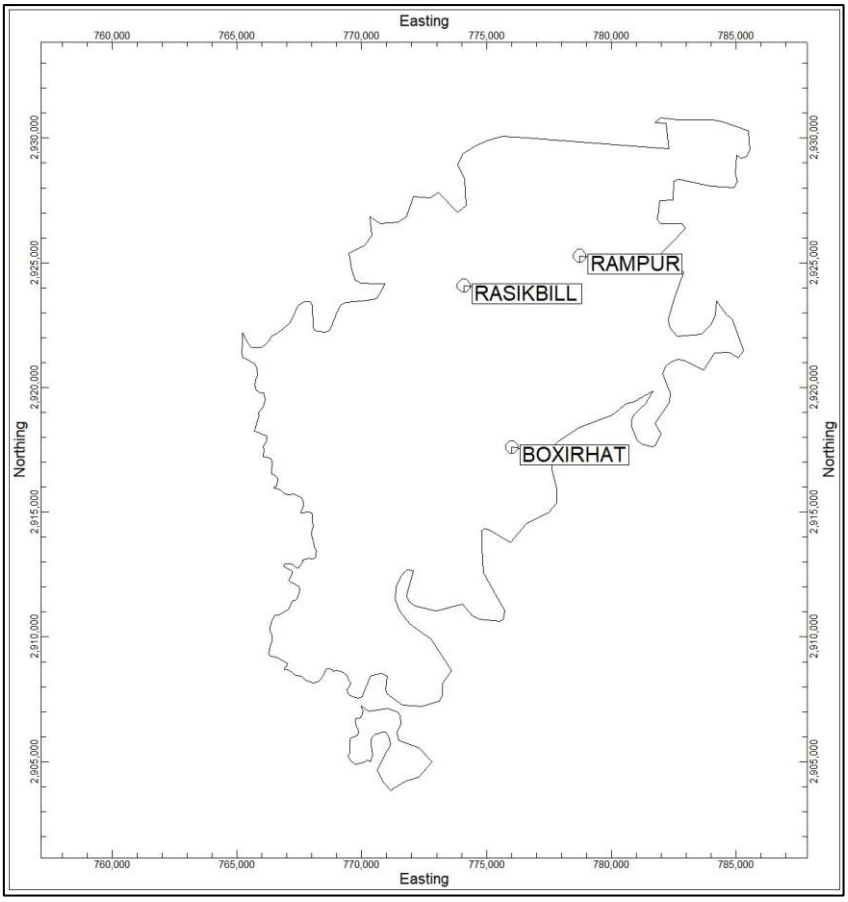

Fig. 12.3 Borehole map location of Tufanganj-II block.

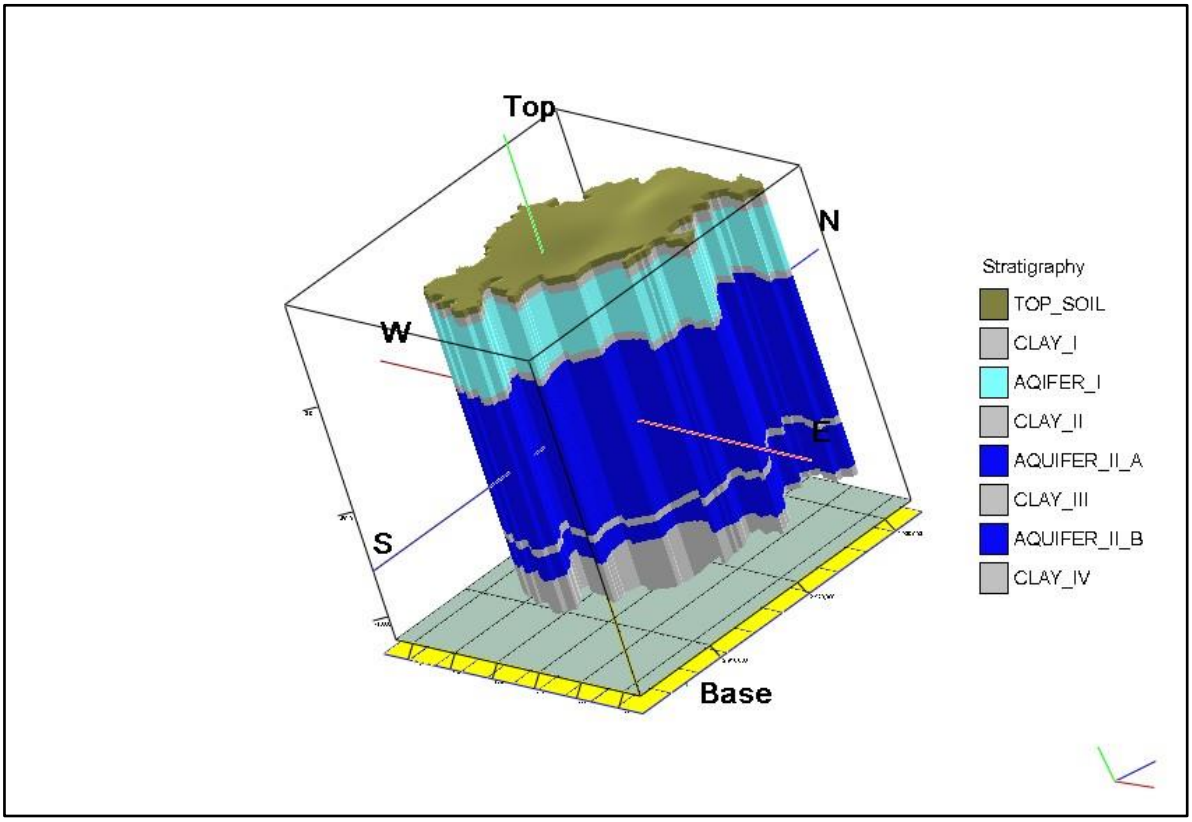

Fig.12.4 Aquifer disposition model of Tufanganj-II block.

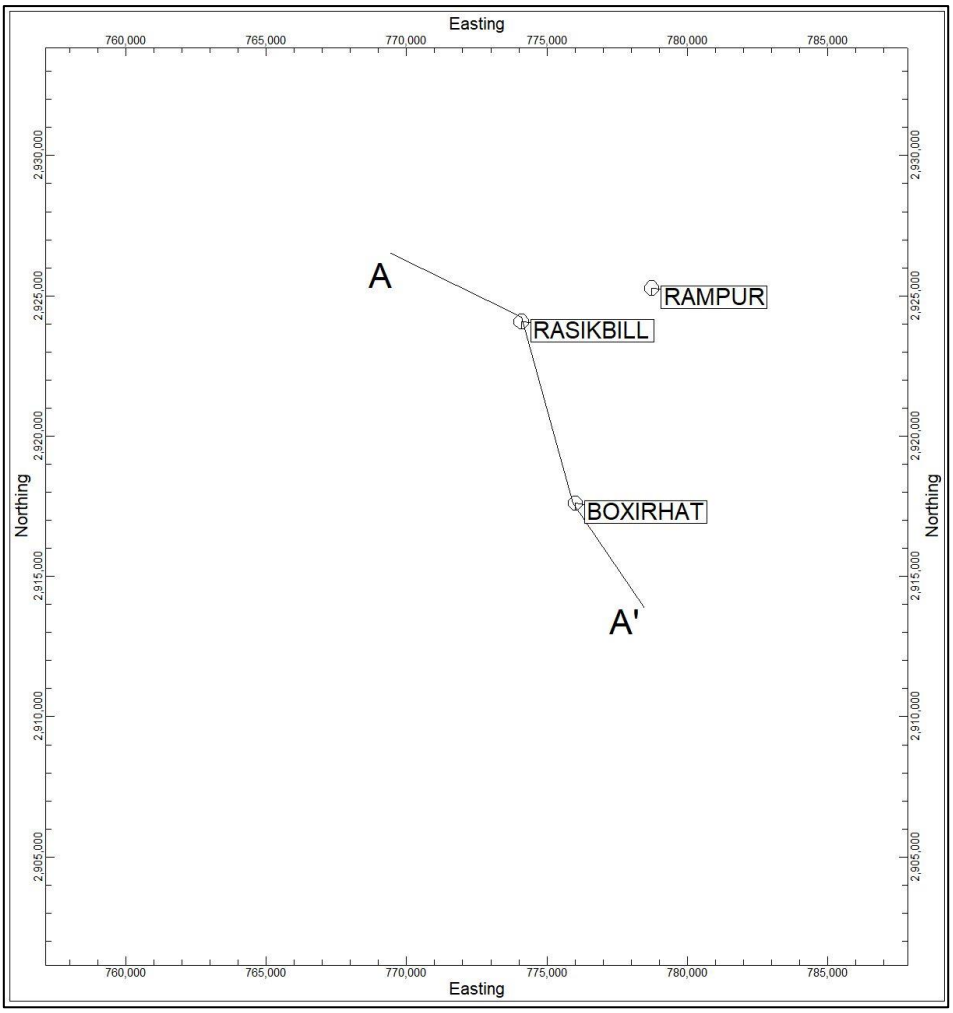

Fig. 12.5 Borehole map location of Tufanganj-II block.

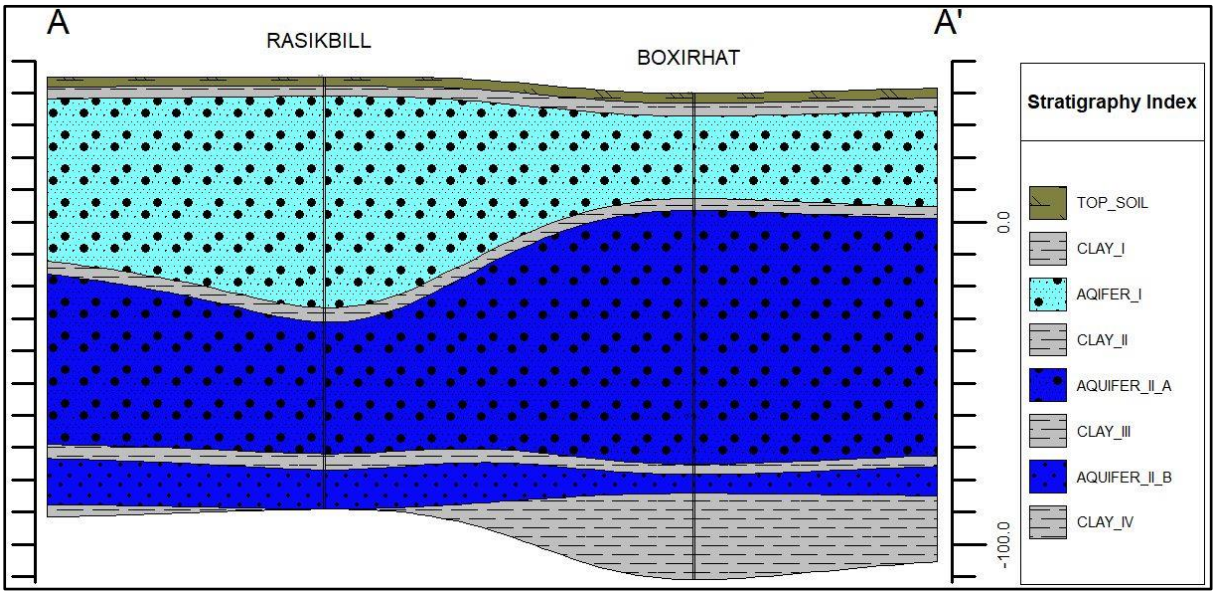

Fig.12.6 Cross-Sectional Map of Tufanganj-II block.

Table 12.5: Details of aquifer wise water level ranges and seasonal long-term water level trend (2011-2020) in Tufanganj-II Block

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)
Tufanganj-II	I		--	0.201666667		--	0.007333333
	II	-	-	-	-	-	-

Ground Water Quality and Issues:

Based on NHS and Keywells data, the range of chemical parameters for the block is given below.

Table 12.6: Average concentration of chemical parameters in Tufanganj-II Block

Block	Aquifer Type	pH	EC	TH	Ca	Mg	Na	K	CO3	HCO3	Total Alk as CaCO3	Cl	NO3	SO4	F	TDS	Fe	U (µg/l)
Tufanganj-II	Aquifer-I	6.52-7.09	141-180	50-60	12-20	2-5	5-13	3	0	49-61	40-50	11-14	4-24	BDL	0.66-0.68	83-102	BDL	0.03-3.36
	Aquifer-II	7.33-7.63	134-211	45-90	10-30	4-5	8-11	1	0	61-110	50-90	7-14	1-3	BDL-9	0.30-0.55	81-125	BDL-0.97	0.02-0.60

Groundwater Resource Enhancement and Management Plan:

Ground Water Management Plan for Drinking Purpose:

There are twelve (12) ground water based public water supply schemes are commissioned till July 2022 by PHED which are the main sources of drinking water in the block. Till July 2022 about 26.14% of the Functional Household Tap Connection is achieved since inception. Tufanganj-II block receives ample amount of rain during monsoon. Though the stage of development is only 43.13 % it will be good if we practice conservation through rain water harvesting and used it as an alternative for drinking water because with time ground water abstraction will increase and to maintain the categorization as safe we have to look supplement sources for drinking purposes.

For monitoring of change in ground water regime in the area in future, cost of construction of observation well should be included.

Management plan for Irrigation:

Table 12.7: Ground-water scenario for irrigation in Tufanganj-II block

Block	Geographical Area in Ha	Net Area Sown in Ha	Net Area Irrigated in Ha	Area to be Irrigated in Ha	SOD in %
TUFANGANJ-II	29947	13087	2430.28	10656.72	43.13

The stage of ground water development in the block is 43.13 %, under safe category. However, further development should be done in planned manner to harness the additional available resource for more sustainable development.

10656.72 hectares more of land can be irrigated. Water applied for irrigation should not be wasted. An effective water management technique should be considered through modern agricultural management maintaining minimum pumping hours and selecting most appropriate cropping pattern. The application of modern techniques like sprinkler and drip irrigation will help increase crop yield and consequently conserve ground water.

Crops with low water requirement should be preferred. Heavy duty/medium duty tube wells can be constructed by Govt. agencies as they may help for irrigation in large perspective. Installation and maintenance cost of heavy-duty tube well is high and it will be difficult for individual or small farmers to maintain. Therefore, heavy-duty tube wells can be constructed by local government agencies and after installation of pumps it can be handed over to the local co-operative based farmers for its operation and maintenance.

Dug wells, light duty tube wells fitted with submersible pump, medium duty tube wells are feasible for irrigation purposes. But the capacity of the pump should be decided in such a way so that drawdown may be minimized.

In view of sufficient rainfall in the area, excavation of tanks with large catchment areas can help in augmentation of irrigation facilities.

Management Intervention Through Rain Water Harvesting (Roof Top and Surface Runoff) And Artificial Recharge:

The area receives plenty of rainfall but due to lack of proper rainwater harvesting structures and un-distributed rainfall causes huge amount of rainwater to drain into the sea. The runoff, thus produced, may be diverted for water harvesting either for conservation or for artificial recharge to the depleted aquifer in the area. No structure has been constructed by CGWB till date. Generally, water conservation and artificial recharge is feasible is such area where water level is more than 3 mbgl in post monsoon period. As a whole the water level is not in alarming condition in this block.

Water conservation of rainwater by different structures like percolation tank, Injection well, roof top rainwater harvesting can be considered for the block in future. It has been estimated that the utilizable surface runoff produced in the block is 0.080 MCM. This surface runoff is proposed to be utilized to recharge the depleted aquifers in the block. As per the available storage space, 0.024 MCM water is required to fill the deeper aquifers in block. The remaining surface runoff, 0.04 MCM is recommended to be utilized in storage tanks for generation of irrigation potential and thus, The roof top rain water harvesting structures with suitably design injection wells may be proposed to construct in the census towns areas in primary phases and subsequently may be extended to the rural areas.

Table 12.8: Area suitable for recharge in Tufanganj-II block

District	Block Name	Block Area (in Ha)	Area (in Ha) suitable for recharge (having DTW 3 m and more in Postmonsoon)
Cooch Behar	Tufanganj-II	25400	0.17765

Table 12.9: Artificial recharge priority area-structures feasible and their cost of construction for Tufanganj-II block

Block	Utilizable Surface runoff	Allocation of Utilizable Resource (MCM)			Structures Feasible (No.s)			Cost of structures (in lakhs)			Total cost (in lakhs)
		Percolation tank	REET withRS	Injection Well	Percolation tank	REET with RS	Injection Well	Percolation tank	REET with RS	Injection Well	
Tufanganj-II	0.080	0.04	0.016	0.024	0	0	0	0.00	0.00	0.00	0.00

PART – III
DATA GAP ANALYSIS

INTRODUCTION:

The study area comprises 12 blocks of Cooch Behar districts in West Bengal. The present study area covers a total of 3387 sq. km. geographical area. It is bounded by the north latitudes 25°57'47" and 26°36'20" & east longitudes of 88°47'44 & 89°54'35" in Survey of India Toposheet no. 78B/11, 78B/12, 78B/14, 78B/15, 78B/16, 78F/02, 78F/03, 78F/04, 78F/07, 78F/08, 78F/11, 78F/12, 78F/15, 78G/05, and 78G/09. Data Gap in terms of exploratory wells (EW), water level monitoring stations (key wells), geophysical studies viz. Vertical Electrical Sounding (VES), additional water quality monitoring stations etc. to study the aquifers in the area has been tabulated quadrant wise in different toposheets.

Data Gap for Exploratory Wells

Exploratory wells constructed by CGWB, ER, Kolkata has been considered for the study. After plotting the existing exploratory wells and following the guidelines it is seen that a total of 29 Exploratory wells (EW), 10 Observation wells (OW) and 5 Well Fields are required in the study area.

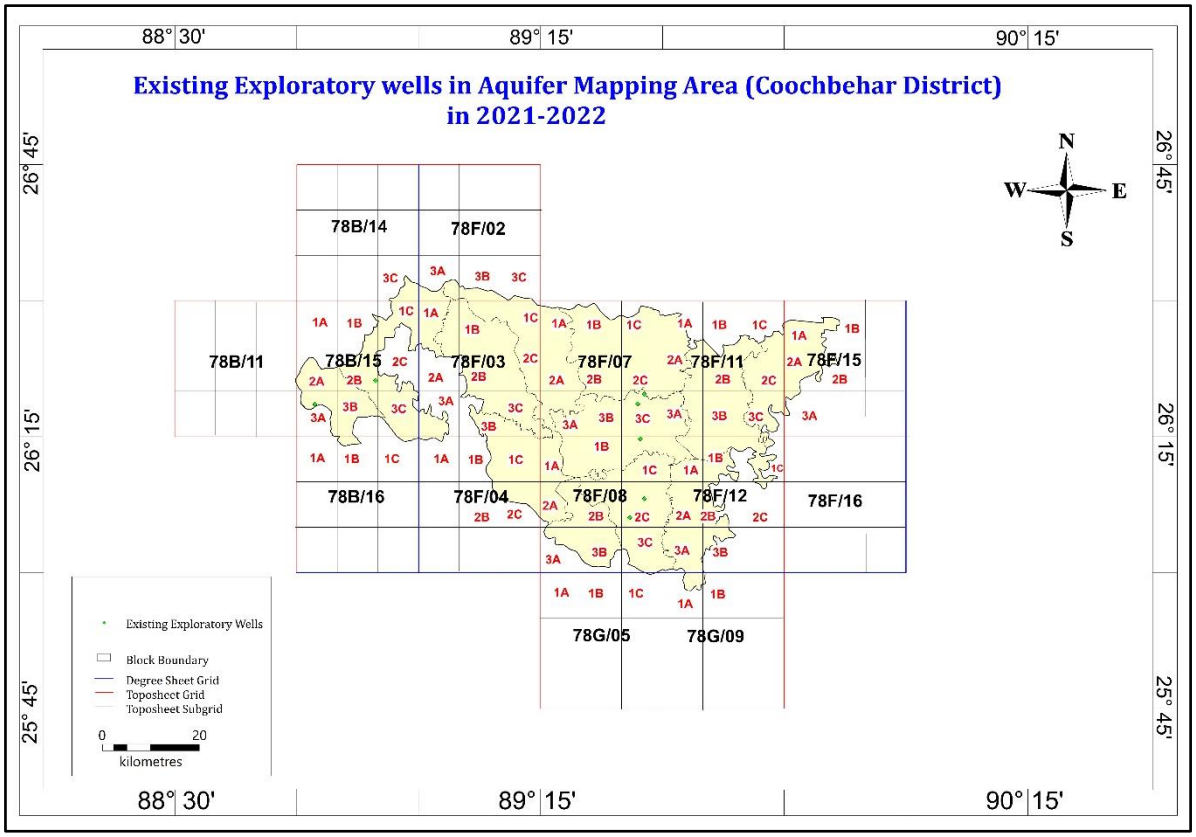

Fig.1: Map of existing exploratory wells in the study area.

Table 1: Table suggesting extra Exploratory wells and their depths for the study area

Toposheet No.	Quadrant	No. of Additional EW/OW required	Depth of Drilling (Meters)
78B/11	1A	0	
	1B	0	
	1C	0	
	2A	0	
	2B	0	
	2C	0	
	3A	0	
	3B	0	
	3C	0	
78B/12	1A	0	
	1B	0	
	1C	0	
	2A	0	
	2B	0	
	2C	0	
	3A	0	
	3B	0	
	3C	0	
78B/14	1A	0	
	1B	0	
	1C	0	
	2A	0	
	2B	0	
	2C	0	
	3A	0	
	3B	0	
	3C	0	
78B/15	1A	0	
	1B	0	
	1C	1	300
	2A		
	2B	2 EW, 2 OW (1 Well Field)	300
	2C	0	
	3A	0	
	3B	0	
	3C	1	300
78B/16	1A	0	
	1B	0	
	1C	0	
	2A	0	
	2B	0	
	2C	0	
	3A	0	
	3B	0	
	3C	0	
78F/02	1A	0	

	1B	0	
	1C	0	
	2A	0	
	2B	0	
	2C	0	
	3A	0	
	3B	0	
	3C	0	
78F/03	1A	0	
	1B	1	300
	1C	0	
	2A	0	
	2B	2 EW, 2 OW (1 Well Field)	300
	2C	1	300
	3A	0	
	3B	1	
	3C	0	
78F/04	1A	0	
	1B	0	
	1C	1	300
	2A	0	
	2B	0	
	2C	0	
	3A	0	
	3B	0	
	3C	0	
78F/07	1A	1	300
	1B	0	
	1C	1	300
	2A	0	
	2B	2 EW, 2 OW (1 Well Field)	300
	2C	0	
	3A	1	
	3B	0	
	3C	0	
78F/08	1A	0	
	1B	1	300
	1C	0	
	2A	1	300
	2B	2 EW, 2 OW (1 Well Field)	300
	2C	0	
	3A	0	
	3B	1	300
	3C	0	
78F/11	1A	0	
	1B	0	
	1C	0	
	2A	1	300
	2B	2 EW, 2 OW (1 Well Field)	300

	2C	1	300
	3A	0	
	3B	1	300
	3C	0	
78F/12	1A	1	300
	1B	0	
	1C	1	300
	2A	0	
	2B	0	
	2C	0	
	3A	1	
	3B	0	
	3C	0	
78F/15	1A	1	300
	1B	0	
	1C	0	
	2A	0	
	2B	0	
	2C	0	
	3A	0	
	3B	0	
	3C	0	
78G/05	1A	0	
	1B	0	
	1C	0	
	2A	0	
	2B	0	
	2C	0	
	3A	0	
	3B	0	
	3C	0	
78G/09	1A	0	
	1B	0	
	1C	0	
	2A	0	
	2B	0	
	2C	0	
	3A	0	
	3B	0	
	3C	0	

Data Gap for Monitoring stations (Key wells)

Monitoring wells in terms of key wells were plotted for data gap analysis. The NHS monitoring wells of CGWB. It has been found that an extra of 68 wells tapping Aquifer- I, 24 wells tapping Aquifer-II.

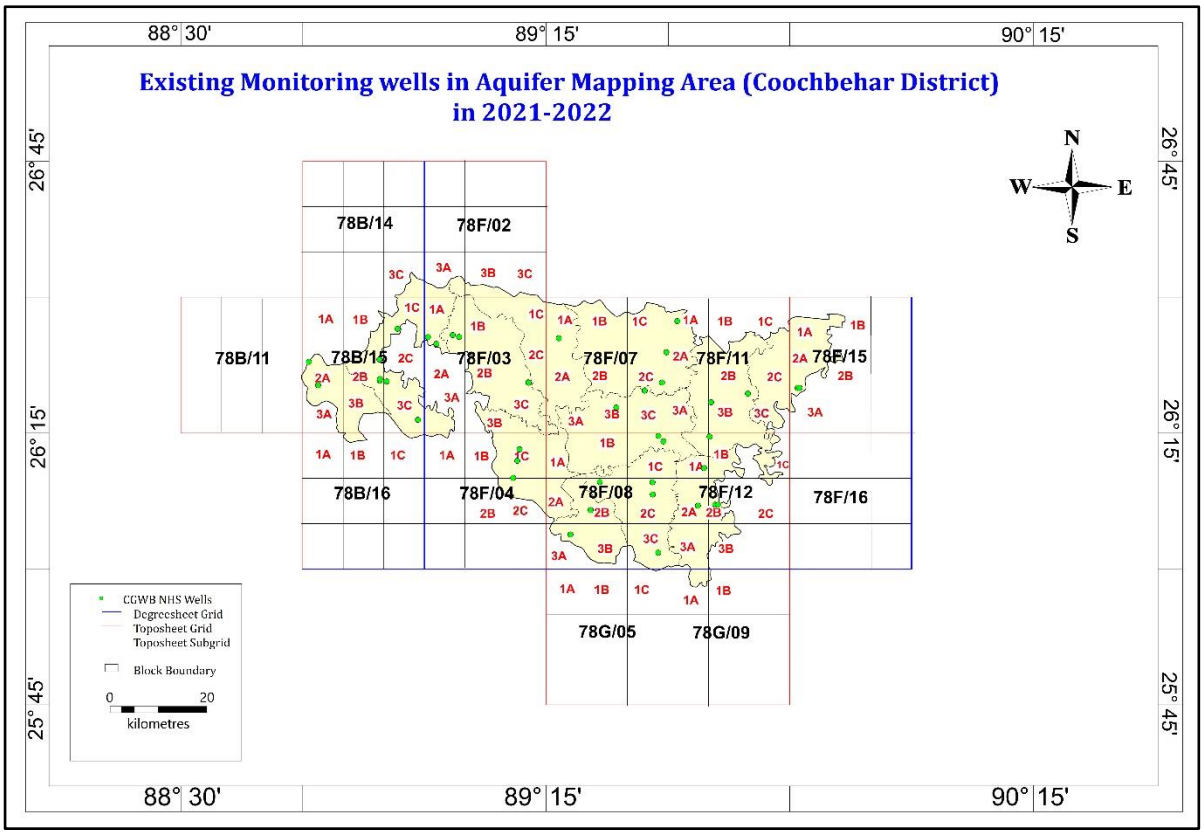

Fig. 2: Map of existing NHS Wells in the study area.

Table-2: Table suggesting aquifer wise extra key-wells for the study area

Toposheet No.	Quadrant	No. of Additional Key Wells required Aquifer wise
78B/11	1A	Aquifer I: 0, Aquifer II: 0
	1B	Aquifer I: 0, Aquifer II: 0
	1C	Aquifer I: 0, Aquifer II: 0
	2A	Aquifer I: 0, Aquifer II: 0
	2B	Aquifer I: 0, Aquifer II: 0
	2C	Aquifer I: 0, Aquifer II: 0
	3A	Aquifer I: 0, Aquifer II: 0
	3B	Aquifer I: 0, Aquifer II: 0
	3C	Aquifer I: 0, Aquifer II: 0
78B/12	1A	Aquifer I: 0, Aquifer II: 0
	1B	Aquifer I: 0, Aquifer II: 0
	1C	Aquifer I: 0, Aquifer II: 0
	2A	Aquifer I: 0, Aquifer II: 0
	2B	Aquifer I: 0, Aquifer II: 0
	2C	Aquifer I: 0, Aquifer II: 0
	3A	Aquifer I: 0, Aquifer II: 0
	3B	Aquifer I: 0, Aquifer II: 0
	3C	Aquifer I: 0, Aquifer II: 0
78B/14	1A	Aquifer I: 0, Aquifer II: 0
	1B	Aquifer I: 0, Aquifer II: 0
	1C	Aquifer I: 0, Aquifer II: 0

	2A	Aquifer I: 0, Aquifer II: 0
	2B	Aquifer I: 0, Aquifer II: 0
	2C	Aquifer I: 0, Aquifer II: 0
	3A	Aquifer I: 0, Aquifer II: 0
	3B	Aquifer I: 0, Aquifer II: 0
	3C	Aquifer I: 0, Aquifer II: 0
78B/15	1A	Aquifer I: 0, Aquifer II: 0
	1B	Aquifer I: 0, Aquifer II: 0
	1C	Aquifer I: 1, Aquifer II: 1
	2A	Aquifer I: 0, Aquifer II: 0
	2B	Aquifer I: 0, Aquifer II: 1
	2C	Aquifer I: 1, Aquifer II: 0
	3A	Aquifer I: 0, Aquifer II: 0
	3B	Aquifer I: 0, Aquifer II: 0
	3C	Aquifer I: 1, Aquifer II: 1
78B/16	1A	Aquifer I: 0, Aquifer II: 0
	1B	Aquifer I: 0, Aquifer II: 0
	1C	Aquifer I: 0, Aquifer II: 0
	2A	Aquifer I: 0, Aquifer II: 0
	2B	Aquifer I: 0, Aquifer II: 0
	2C	Aquifer I: 0, Aquifer II: 0
	3A	Aquifer I: 0, Aquifer II: 0
	3B	Aquifer I: 0, Aquifer II: 0
	3C	Aquifer I: 0, Aquifer II: 0
78F/02	1A	Aquifer I: 0, Aquifer II: 0
	1B	Aquifer I: 0, Aquifer II: 0
	1C	Aquifer I: 0, Aquifer II: 0
	2A	Aquifer I: 0, Aquifer II: 0
	2B	Aquifer I: 0, Aquifer II: 0
	2C	Aquifer I: 0, Aquifer II: 0
	3A	Aquifer I: 0, Aquifer II: 0
	3B	Aquifer I: 0, Aquifer II: 0
	3C	Aquifer I: 0, Aquifer II: 0
78F/03	1A	Aquifer I: 0, Aquifer II: 0
	1B	Aquifer I: 2, Aquifer II: 1
	1C	Aquifer I: 2, Aquifer II: 0
	2A	Aquifer I: 0, Aquifer II: 0
	2B	Aquifer I: 2, Aquifer II: 0
	2C	Aquifer I: 1, Aquifer II: 1
	3A	Aquifer I: 0, Aquifer II: 0
	3B	Aquifer I: 2, Aquifer II: 1
	3C	Aquifer I: 2, Aquifer II: 0
78F/04	1A	Aquifer I: 0, Aquifer II: 0
	1B	Aquifer I: 0, Aquifer II: 0
	1C	Aquifer I: 0, Aquifer II: 1
	2A	Aquifer I: 0, Aquifer II: 0
	2B	Aquifer I: 0, Aquifer II: 0
	2C	Aquifer I: 2, Aquifer II: 0
	3A	Aquifer I: 0, Aquifer II: 0

	3B	Aquifer I: 0, Aquifer II: 0
	3C	Aquifer I: 0, Aquifer II: 0
78F/07	1A	Aquifer I: 1, Aquifer II: 1
	1B	Aquifer I: 2, Aquifer II: 0
	1C	Aquifer I: 2, Aquifer II: 1
	2A	Aquifer I: 2, Aquifer II: 0
	2B	Aquifer I: 2, Aquifer II: 1
	2C	Aquifer I: 1, Aquifer II: 0
	3A	Aquifer I: 2, Aquifer II: 1
	3B	Aquifer I: 1, Aquifer II: 0
	3C	Aquifer I: 1, Aquifer II: 1
78F/08	1A	Aquifer I: 2, Aquifer II: 0
	1B	Aquifer I: 2, Aquifer II: 1
	1C	Aquifer I: 1, Aquifer II: 0
	2A	Aquifer I: 2, Aquifer II: 1
	2B	Aquifer I: 0, Aquifer II: 0
	2C	Aquifer I: 1, Aquifer II: 1
	3A	Aquifer I: 0, Aquifer II: 0
	3B	Aquifer I: 2, Aquifer II: 1
	3C	Aquifer I: 1, Aquifer II: 0
78F/11	1A	Aquifer I: 1, Aquifer II: 0
	1B	Aquifer I: 0, Aquifer II: 0
	1C	Aquifer I: 0, Aquifer II: 0
	2A	Aquifer I: 2, Aquifer II: 1
	2B	Aquifer I: 2, Aquifer II: 0
	2C	Aquifer I: 2, Aquifer II: 1
	3A	Aquifer I: 2, Aquifer II: 0
	3B	Aquifer I: 1, Aquifer II: 1
	3C	Aquifer I: 1, Aquifer II: 0
78F/12	1A	Aquifer I: 2, Aquifer II: 1
	1B	Aquifer I: 1, Aquifer II: 0
	1C	Aquifer I: 2, Aquifer II: 1
	2A	Aquifer I: 2, Aquifer II: 0
	2B	Aquifer I: 0, Aquifer II: 1
	2C	Aquifer I: 0, Aquifer II: 0
	3A	Aquifer I: 2, Aquifer II: 1
	3B	Aquifer I: 0, Aquifer II: 0
	3C	Aquifer I: 0, Aquifer II: 0
78F/15	1A	Aquifer I: 2, Aquifer II: 1
	1B	Aquifer I: 0, Aquifer II: 0
	1C	Aquifer I: 0, Aquifer II: 0
	2A	Aquifer I: 2, Aquifer II: 0
	2B	Aquifer I: 0, Aquifer II: 0
	2C	Aquifer I: 0, Aquifer II: 0
	3A	Aquifer I: 0, Aquifer II: 0
	3B	Aquifer I: 0, Aquifer II: 0
	3C	Aquifer I: 0, Aquifer II: 0
78G/05	1A	Aquifer I: 0, Aquifer II: 0
	1B	Aquifer I: 0, Aquifer II: 0

	1C	Aquifer I: 0, Aquifer II: 0
	2A	Aquifer I: 0, Aquifer II: 0
	2B	Aquifer I: 0, Aquifer II: 0
	2C	Aquifer I: 0, Aquifer II: 0
	3A	Aquifer I: 0, Aquifer II: 0
	3B	Aquifer I: 0, Aquifer II: 0
	3C	Aquifer I: 0, Aquifer II: 0
78G/09	1A	Aquifer I: 0, Aquifer II: 0
	1B	Aquifer I: 0, Aquifer II: 0
	1C	Aquifer I: 0, Aquifer II: 0
	2A	Aquifer I: 0, Aquifer II: 0
	2B	Aquifer I: 0, Aquifer II: 0
	2C	Aquifer I: 0, Aquifer II: 0
	3A	Aquifer I: 0, Aquifer II: 0
	3B	Aquifer I: 0, Aquifer II: 0
	3C	Aquifer I: 0, Aquifer II: 0

Data Gap for Ground Water Quality Monitoring stations

Water quality monitoring stations are required to study the chemical property of groundwater viz. pH, EC, TDS, Total Hardness, F, Na, K, As, Fe, Cl etc. It has been found that an extra of 68 wells tapping Aquifer- I, 24 wells tapping Aquifer-II are required for future monitoring.

Table 3: Table suggesting Aquifer wise extra water quality monitoring stations for the study area

Toposheet No.	Quadrant	No. of Additional Water Quality stations required Aquifer wise
78B/11	1A	Aquifer I: 0, Aquifer II: 0
	1B	Aquifer I: 0, Aquifer II: 0
	1C	Aquifer I: 0, Aquifer II: 0
	2A	Aquifer I: 0, Aquifer II: 0
	2B	Aquifer I: 0, Aquifer II: 0
	2C	Aquifer I: 0, Aquifer II: 0
	3A	Aquifer I: 0, Aquifer II: 0
	3B	Aquifer I: 0, Aquifer II: 0
	3C	Aquifer I: 0, Aquifer II: 0
78B/12	1A	Aquifer I: 0, Aquifer II: 0
	1B	Aquifer I: 0, Aquifer II: 0
	1C	Aquifer I: 0, Aquifer II: 0
	2A	Aquifer I: 0, Aquifer II: 0
	2B	Aquifer I: 0, Aquifer II: 0
	2C	Aquifer I: 0, Aquifer II: 0
	3A	Aquifer I: 0, Aquifer II: 0
	3B	Aquifer I: 0, Aquifer II: 0
	3C	Aquifer I: 0, Aquifer II: 0
78B/14	1A	Aquifer I: 0, Aquifer II: 0
	1B	Aquifer I: 0, Aquifer II: 0
	1C	Aquifer I: 0, Aquifer II: 0

	2A	Aquifer I: 0, Aquifer II: 0
	2B	Aquifer I: 0, Aquifer II: 0
	2C	Aquifer I: 0, Aquifer II: 0
	3A	Aquifer I: 0, Aquifer II: 0
	3B	Aquifer I: 0, Aquifer II: 0
	3C	Aquifer I: 0, Aquifer II: 0
78B/15	1A	Aquifer I: 0, Aquifer II: 0
	1B	Aquifer I: 0, Aquifer II: 0
	1C	Aquifer I: 1, Aquifer II: 1
	2A	Aquifer I: 0, Aquifer II: 0
	2B	Aquifer I: 0, Aquifer II: 1
	2C	Aquifer I: 1, Aquifer II: 0
	3A	Aquifer I: 0, Aquifer II: 0
	3B	Aquifer I: 0, Aquifer II: 0
	3C	Aquifer I: 1, Aquifer II: 1
78B/16	1A	Aquifer I: 0, Aquifer II: 0
	1B	Aquifer I: 0, Aquifer II: 0
	1C	Aquifer I: 0, Aquifer II: 0
	2A	Aquifer I: 0, Aquifer II: 0
	2B	Aquifer I: 0, Aquifer II: 0
	2C	Aquifer I: 0, Aquifer II: 0
	3A	Aquifer I: 0, Aquifer II: 0
	3B	Aquifer I: 0, Aquifer II: 0
	3C	Aquifer I: 0, Aquifer II: 0
78F/02	1A	Aquifer I: 0, Aquifer II: 0
	1B	Aquifer I: 0, Aquifer II: 0
	1C	Aquifer I: 0, Aquifer II: 0
	2A	Aquifer I: 0, Aquifer II: 0
	2B	Aquifer I: 0, Aquifer II: 0
	2C	Aquifer I: 0, Aquifer II: 0
	3A	Aquifer I: 0, Aquifer II: 0
	3B	Aquifer I: 0, Aquifer II: 0
	3C	Aquifer I: 0, Aquifer II: 0
78F/03	1A	Aquifer I: 0, Aquifer II: 0
	1B	Aquifer I: 2, Aquifer II: 1
	1C	Aquifer I: 2, Aquifer II: 0
	2A	Aquifer I: 0, Aquifer II: 0
	2B	Aquifer I: 2, Aquifer II: 0
	2C	Aquifer I: 1, Aquifer II: 1
	3A	Aquifer I: 0, Aquifer II: 0
	3B	Aquifer I: 2, Aquifer II: 1
	3C	Aquifer I: 2, Aquifer II: 0
78F/04	1A	Aquifer I: 0, Aquifer II: 0
	1B	Aquifer I: 0, Aquifer II: 0
	1C	Aquifer I: 0, Aquifer II: 1
	2A	Aquifer I: 0, Aquifer II: 0
	2B	Aquifer I: 0, Aquifer II: 0
	2C	Aquifer I: 2, Aquifer II: 0
	3A	Aquifer I: 0, Aquifer II: 0

	3B	Aquifer I: 0, Aquifer II: 0
	3C	Aquifer I: 0, Aquifer II: 0
78F/07	1A	Aquifer I: 1, Aquifer II: 1
	1B	Aquifer I: 2, Aquifer II: 0
	1C	Aquifer I: 2, Aquifer II: 1
	2A	Aquifer I: 2, Aquifer II: 0
	2B	Aquifer I: 2, Aquifer II: 1
	2C	Aquifer I: 1, Aquifer II: 0
	3A	Aquifer I: 2, Aquifer II: 1
	3B	Aquifer I: 1, Aquifer II: 0
	3C	Aquifer I: 1, Aquifer II: 1
78F/08	1A	Aquifer I: 2, Aquifer II: 0
	1B	Aquifer I: 2, Aquifer II: 1
	1C	Aquifer I: 1, Aquifer II: 0
	2A	Aquifer I: 2, Aquifer II: 1
	2B	Aquifer I: 0, Aquifer II: 0
	2C	Aquifer I: 1, Aquifer II: 1
	3A	Aquifer I: 0, Aquifer II: 0
	3B	Aquifer I: 2, Aquifer II: 1
	3C	Aquifer I: 1, Aquifer II: 0
78F/11	1A	Aquifer I: 1, Aquifer II: 0
	1B	Aquifer I: 0, Aquifer II: 0
	1C	Aquifer I: 0, Aquifer II: 0
	2A	Aquifer I: 2, Aquifer II: 1
	2B	Aquifer I: 2, Aquifer II: 0
	2C	Aquifer I: 2, Aquifer II: 1
	3A	Aquifer I: 2, Aquifer II: 0
	3B	Aquifer I: 1, Aquifer II: 1
	3C	Aquifer I: 1, Aquifer II: 0
78F/12	1A	Aquifer I: 2, Aquifer II: 1
	1B	Aquifer I: 1, Aquifer II: 0
	1C	Aquifer I: 2, Aquifer II: 1
	2A	Aquifer I: 2, Aquifer II: 0
	2B	Aquifer I: 0, Aquifer II: 1
	2C	Aquifer I: 0, Aquifer II: 0
	3A	Aquifer I: 2, Aquifer II: 1
	3B	Aquifer I: 0, Aquifer II: 0
	3C	Aquifer I: 0, Aquifer II: 0
78F/15	1A	Aquifer I: 2, Aquifer II: 1
	1B	Aquifer I: 0, Aquifer II: 0
	1C	Aquifer I: 0, Aquifer II: 0
	2A	Aquifer I: 2, Aquifer II: 0
	2B	Aquifer I: 0, Aquifer II: 0
	2C	Aquifer I: 0, Aquifer II: 0
	3A	Aquifer I: 0, Aquifer II: 0
	3B	Aquifer I: 0, Aquifer II: 0
	3C	Aquifer I: 0, Aquifer II: 0
78G/05	1A	Aquifer I: 0, Aquifer II: 0
	1B	Aquifer I: 0, Aquifer II: 0

	1C	Aquifer I: 0, Aquifer II: 0
	2A	Aquifer I: 0, Aquifer II: 0
	2B	Aquifer I: 0, Aquifer II: 0
	2C	Aquifer I: 0, Aquifer II: 0
	3A	Aquifer I: 0, Aquifer II: 0
	3B	Aquifer I: 0, Aquifer II: 0
	3C	Aquifer I: 0, Aquifer II: 0
78G/09	1A	Aquifer I: 0, Aquifer II: 0
	1B	Aquifer I: 0, Aquifer II: 0
	1C	Aquifer I: 0, Aquifer II: 0
	2A	Aquifer I: 0, Aquifer II: 0
	2B	Aquifer I: 0, Aquifer II: 0
	2C	Aquifer I: 0, Aquifer II: 0
	3A	Aquifer I: 0, Aquifer II: 0
	3B	Aquifer I: 0, Aquifer II: 0
	3C	Aquifer I: 0, Aquifer II: 0

Data Gap for Geophysical studies (VES)

CGWB has not carried out any Profiling/VES/TEM in the study area. A total of 126 Profiling/VES/TEM is suggested to carry out in the study area. The details of numbers of Profiling/VES/TEM required is explained quadrant wise in the following table.

Table- 4: Table suggesting no. of VES stations for the study area

Toposheet No.	Quadrant	No. of Profiling/VES/TEM required within the quadrant
78B/11	1A	0
	1B	0
	1C	0
	2A	0
	2B	0
	2C	0
	3A	0
	3B	0
	3C	0
78B/12	1A	0
	1B	0
	1C	0
	2A	0
	2B	0
	2C	0
	3A	0
	3B	0
	3C	0
78B/14	1A	0
	1B	0

	1C	0
	2A	0
	2B	0
	2C	0
	3A	0
	3B	0
	3C	0
78B/15	1A	0
	1B	0
	1C	3
	2A	0
	2B	3
	2C	3
	3A	0
	3B	0
	3C	3
78B/16	1A	0
	1B	0
	1C	0
	2A	0
	2B	0
	2C	0
	3A	0
	3B	0
	3C	0
78F/02	1A	0
	1B	0
	1C	0
	2A	0
	2B	0
	2C	0
	3A	0
	3B	0
	3C	0
78F/03	1A	0
	1B	3
	1C	3
	2A	0
	2B	3
	2C	3
	3A	0
	3B	3
	3C	3
78F/04	1A	0
	1B	0
	1C	3
	2A	0
	2B	0
	2C	3

	3A	0
	3B	0
	3C	0
78F/07	1A	3
	1B	3
	1C	3
	2A	3
	2B	3
	2C	3
	3A	3
	3B	3
	3C	3
78F/08	1A	3
	1B	3
	1C	3
	2A	3
	2B	0
	2C	3
	3A	0
	3B	3
	3C	3
78F/11	1A	3
	1B	0
	1C	0
	2A	3
	2B	3
	2C	3
	3A	3
	3B	3
	3C	3
78F/12	1A	3
	1B	3
	1C	3
	2A	3
	2B	3
	2C	0
	3A	3
	3B	0
	3C	0
78F/15	1A	3
	1B	0
	1C	0
	2A	3
	2B	0
	2C	0
	3A	0
	3B	0
	3C	0
78G/05	1A	0

	1B	0
	1C	0
	2A	0
	2B	0
	2C	0
	3A	0
	3B	0
	3C	0
78G/09	1A	0
	1B	0
	1C	0
	2A	0
	2B	0
	2C	0
	3A	0
	3B	0
	3C	0

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