केंद्रीय भूमि जल बोर्ड

जल संसाधन, नदी विकास और गंगा संरक्षण

विभाग, जल शक्ति मंत्रालय

भारत सरकार

Central Ground Water Board

Department of Water Resources, River Development and Ganga Rejuvenation,

Ministry of Jal Shakti

Government of India

AQUIFER MAPPING AND MANAGEMENT OF GROUND WATER RESOURCES

Bankura District West Bengal

पूर्वी क्षेत्र, कोलकाता

Eastern Region, Kolkata

Technical Report: Series 'A'

No. : 219
For Official use only

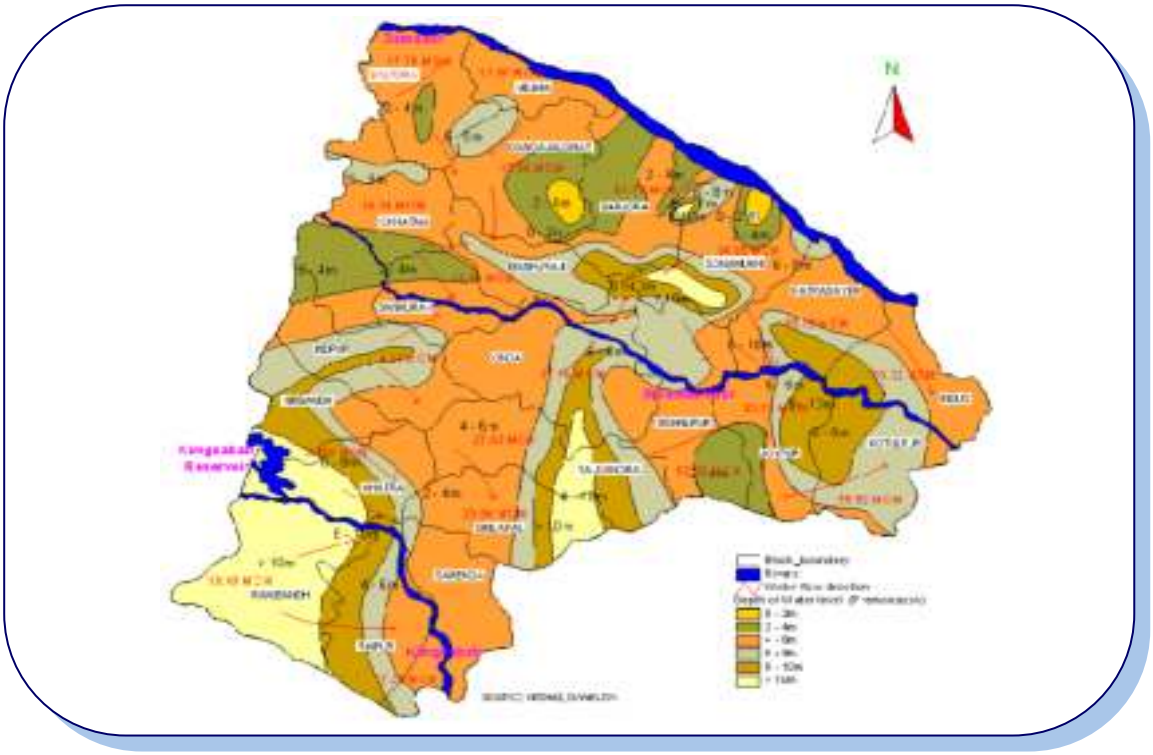
Government of India
MINISTRY OF JAL SHAKTI
Department of Water Resources, River Development & Ganga Rejuvenation

Report
On

NATIONAL AQUIFER MAPPING & MANAGEMENT PLAN

In

Bankura District, West Bengal



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September 2022

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FOREWORD

To understand the nature and occurrences of groundwater, aquifer geometry, aquifer disposition & 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 2020-2021, Aquifer Mapping studies & Management plan was taken up in Bankura District, West Bengal.

The study under the aegis of NAQUIM includes four major components namely; 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 includes Block wise Management Plans and Part-III comprises Data Gap Analysis done for the district. Relevant data in respect of the said subjects have been collected from different departments and their publications, viz. Public Health Engineering Dept., State Water Investigation Dept., Agri.-Irrigation Dept., Bureau of economics & Statistics, Land & Land Reforms Dept., Data of Indian Meteorological Dept., National Bureau of Soil Survey & Land Use Planning, etc. of Govt. of India have also been used. Hydro-geological data is sourced from the scientific studies of CGWB pertaining to groundwater explorations, hydrogeological surveys, chemical analysis and outsourcing explorations being taken up for data generation.

Compilation of this report, evaluation of data and preparation of relevant maps, 2D cross-sections & 3D models of aquifers and their reproduction in the form of present report is the outcome of effort given by Sh. Bibhuti Bhusan Sahu, Scientist- 'B' and Sh. Awadhesh Kumar, Senior Technical Assistant (Hydrogeology) under the supervision of Mrs Sandhya Yadav, Scientist- 'E' & Dr. Indranil Roy Scientist- 'D' (OIC NAQUIM). The section pertaining to Hydrochemistry and Geophysics has been contributed by Dr. Suparna Datta, Assistant Chemist and Dr. Ajay Kumar Sinha, Scientist- 'B' respectively. 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 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)
Regional Director (I/C)

EXECUTIVE SUMMARY

The total geographical area encompassed under the project is 6882 sq. km. The mappable area for the same is about 5864 sq. km. The study area comprises of 22 blocks. The study area can be located in Survey of India Toposheet No.- 73I/14, 73I/15, 73I/16, 73J/9, 73J/13, 73J/14, 73M/2, 73M/3, 73M/4, 73M/7, 73M/8, 73M/12,73N/1, 73N/5, 73N/9.

The district head quarter of Bankura District is at Bankura, with 3 Municipality. The total population of the study area is 3596674 as per 2011 Census with rural population accounting for almost 92% and the rest 08 % as urban population. The study area experiences moderate climatic condition with cold dry winter, hot humid summer and prolonged rainy season. The maximum highest temperature varies from 40°C to 44 °C in the month of May and June while minimum temperature varies from 8 °C to 9 °C during December and January. The normal rainfall of the study area is from 1386 mm. About 75% of rainfall occurs during monsoon and the rest 25% occurs during non-monsoon. The study area consists of three major physiographical divisions viz. the Hilly terrain in the west is covered by crystalline rocks of Archean age. The Eastern plain Land is the part of the block comprising Bishnupur, Kotulpur, Indus block is characterized by the flat plain land which constitute a vast arable land and the Marginal Undulating tract. This topography is witness in the central part of the district, where hilly terrain of the west gradually merges in to plain alluvium land interspersed with hillocks, mounds most area of in Paschim Bardhhaman and Alluvial plain. The river system in Bankura includes the Damodar & Kangsabati sub basin and is drained by number of major rivers with predominantly NW-NNW to SE-SSE flowing trend across the area. From North to South the Major Rivers are Damodar, Sali (tributary of Damodar) Gandheswari, Dwarkeswar, Sialbati and Kangsabati. The major soil types of this area are Entisols comprising mainly alluvium soil, Alfisols comprising older alluvium soil and red soil and Ultisols comprising mainly lateritic soil.

The principal crops grown in the district are paddy (Aus, Aman and Boro), wheat, various pulse, oilseeds(sunflower), mustard oil, jute, sugarcane as miscellaneous crops and other Rabi crops. some seasonal vegetables like potato, tomato, cabbage, cauliflower and pumpkin. The district has vast irrigation potential, which is yet to be fully utilized. The crops grown are mainly rain-fed. The Kharif, Rabi and Boro paddy and vegetables are grown mostly by ground water through DTW and STW. There are a total of21475 tanks, 473 RLI, 429 DTW, 6261 DW and 30005 STW as sources for irrigation in the district. There is a large-scale industrial infrastructure developed in Durgapur, Asansol, Raniganj industrial belt is the centre for small and medium scale industrial development. Mejia thermal power station (MTPS) of DVC is the heart of industrial development in the area. Barjora industrial belt is growing fast with numbers of sponge Iron Company, alloy industry, plastic industry has come up. Coal is the major mineral resource which is being mined economically in Mejia and Barjora block of the study area.

The most area of the Bankura district characterised by the various litho units of different geological age A. crystalline granite gneiss of Archean age, which exposed in the western & South western part of the district, B. Sedimentary sandstone and Shales of lower Gondwana age covering Northern & North western part of the district, both Archean and Gondwana have been cut across dolerite dykes equivalent to Rajmahals. C. Laterite and older alluvium deposits of Pleistocene age exposed in linear tract in the central Part of the district. D. The extreme alluvium deposit in the eastern part. Study of subsurface geology based on correlation of Litholog reveals that the study area western

sector comprising mainly of Crystalline rocks ground water occurs in the weathered mantle of varying thickness from 6 metre to 15 metre under water table conditions. In many parts of the area lateritic gravels lies on the weathered basement rock that attributes favourable condition for percolation of rain water. The block of Chatna, Bankura-I, Saltora, Gangajalghati, Ranibandh, Khattra, Hirbandh and Indpur falls under this sector. In the middle sector covered by laterite and older alluvium, groundwater occurs in the moderately thick to thin aquifer under unconfined to semi confined condition. Heterogeneous character of the water bearing formation with complex aquifer geometry prevails in the area and is feasible for open dug wells of 10 metre to 15 metre depth with 3 metres of diameters. The complete or parts of the blocks of Bankura II, Mejia, Taldangra, Simlapal, Raipur &Sarenga fall under this sector. Ground water occurs under confined condition below a blanket of clay whose thickness varies around 10 metres. In the eastern alluvial area of Indus, Kotulpur & Joypur blocks. The diverse geological set up of the district control the hydrogeological condition of the district. In areas underlain by hard crystalline and Gondwana rocks, ground water occurs under unconfined condition in the weathered residuum down to the depth of about 15 mbgl and under semi-confined to confined condition in the fracture zones in the depth span of 30-60 mbgl.

In the present study area, CGWB, ER has conducted surface geophysical survey. However, a total of 31 TEM (Transient Electromagnetic Exploration) done in study area. Based on interpretation of TEM data carried out in Saltora block of Bankura district reveals that northern part of the block close to Damodar River and eastern part of the block is occupied by the alluvium formation. The western and southern part of the block is covered by hard rock. The ground water occurrence confined to the sand formation in alluvium and fractured rock.

Groundwater in the district occurs both under water table condition and confined condition. In the western sector comprising mainly of Crystalline rocks ground water occurs in the weathered mantle of varying thickness. In this part ground water from the zone of secondary porosities is being developed through bore wells and yield to the tune of 45-150 lpm. Eastern part of the district is covered by alluvium, older alluvium and laterites occur in central-southern part of the district; ground water exploration carried out in the area indicates that the thickness of the alluvial sediments increases eastward from 36m in the marginal part to 150m in the eastern most part. The potential aquifers exist between 30-95 mbgl and the discharge of the wells varies from 20-124 m^3/hr with drawdown to the tune of 6-13 m depending upon the geometry of the aquifers. Depth to water level in the older alluvium varies from 6-15 mbgl during pre-monsoon period. The dug wells in the laterites usually dry up in summer, but those wells which have tapped both laterites and lithomarge below, are found to contain water during the summer months also.

A number of flowing tube wells exist along with the banks of the Dwarkeswar, Jaipanda and Silai rivers. These tube wells are of 30-75 m deep (38-50 mm dia.) and free flow discharge to the tune of 23-30 lpm along Dwarkeswar river, and both the banks of Jaipanda river in Taldangra block and Bishnupur block, the depth of existing auto flow tube well ranges between 45-75m and free flow discharge ranges between 126-252 lpm, the pressure head maximum recorded as 1.10 m bgl. These wells are used for small scale irrigation purpose.

Recent alluvium occupies in the eastern and north central parts of the district and extends down to the drilled depth of about 300 mbgl. The thickness of the alluvium increases eastward. Potential granular zones exist in the depth span of 30-270 m bgl,

yielding about 80-150 m^3/hr. with a drawdown between 6 to 10 m. In general, co-efficient of Transmissivity of deeper aquifer ranges from 272-806 m^2/day and Storativity ranges from 1.019 x 10-3 to 2.1 x 10^-4. The depth to water level range for Aquifer-I varies from 2.81-18.14 m and Aquifer-II range varies from 4.10-20.93m during the pre- monsoons. The post-monsoon variation for Aquifer-I is from 1-4.59 m and 2.15-7.40 m for Aquifer-II respectively

As per the computation, the net ground water availability for recharge for Bankura district is estimated at 258599.38 Ham, while the total extraction for all uses is estimated at 91228.9Ham. The total in-storage of consolidated formation for district is 102881 MCM and for soft rock is 1078918 MCM. The stage of ground water development in the district stands at 38.94%, deemed as 'Safe'. At present, all the 22 blocks in the study area are 'Safe' category.

From the chemical analysis of the samples collected from the study revealed that the ground water quality in the area is suitable for drinking purposes with a few locations having Hardness and alkalinity problems. 31.6% of the study area depicted the TDS concentration more than the Acceptable limit of 500 mgL-1 (as per BIS, 2012), Higher concentration of Fluoride exceeding the permissible limit of 1.5 mg/L was found in few pockets. In respect of suitability assessment for Irrigation water, the ground water of majority of the study area was in suitable category. Facies classification of the area indicates that maximum groundwater samples belong to Ca-Mg-HCO3and Ca-Mg-Cl type (as high as 70% locations), which indicates, water type with temporary hardness.

At present, all the 22 blocks in the study area are under 'Safe' category and there is large scope for ground water development in agricultural, domestic and industrial sectors through different structures considering optimum command area of the abstraction structures. However, effective water management technique is proposed for planning and management of resources in the district. Conservation through rainwater harvesting structures is suggested for all the blocks in view of better ground water sustainability in the study area. Recharge structures like Percolation tank, REET with RS and Injection Wells have been proposed in the recharge priority areas.

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AQUIFER MAPPING & MANAGEMENT PLAN OF BANKURA DISTRICT, WEST BENGAL

CHAPTER - I

INTRODUCTION

Bankura district, in the western part of West Bengal, is one of the drought prone districts of the state and is periodically affected by severe drought. The adverse geological and hydrogeological settings, water scarcity in western part of the district, poor infrastructure support altogether impede agricultural and economic advancement of the district. Lying between the alluvial plains of Hugli and Bardhhaman districts in the east and Chotanagpur plateau in the west, the district has geomorphological features common to both. However, the area adjacent to the Chotanagpur plateau, bordering Purulia district, where the lands are characterized by undulating uplands, ridges and valleys and underlain by hard crystalline rocks faces the real hardship of development in the agriculture, irrigation, industrial and drinking water sectors. The considerable portion of the geographical area is forest cover or barren land, and about 40% of total population consists of scheduled caste and tribes. Therefore, the hydro geomorphic as well as socioeconomic features of this part of Bankura district make it challenging choice to take up ground water development and management.

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 22 blocks of Bankura district 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 whole district have been covered.

1.1 Purpose and Scope:

The objective of the study was mainly to ascertain the ground water potentiality in water scarce hard rock terrain, to assess the changes in hydrogeological regime in terms of ground water quantity and quality and to take up subsequent managements and to suggest alternative sustainable methodologies/ solutions to combat the challenges posed by scarcity and contamination of ground water.

The hydrogeological studies were carried out with the following steps.

I. Study of previous literatures, reports, maps, toposheets of the targeted area.

II. Reconnoitory and detail field traverse which includes, well inventory and subsequently collection of pre and post monsoon ground water level from the

inventoried wells as well as from existing ground water monitoring wells (GWMW) in the study area.

III. Collection of water samples from ground water structures for complete and F^- analysis.

IV. Collection of agriculture, irrigation hydrogeological and water supply data from different State Govt., departments.

V. Hydrogeological studies through field investigation and regular interaction with the farmers, water users and with the local people.

VI. Taking up field photographs.

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.

1.2 Approach & Methodology:

An approach and methodology adopted 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.

1.3 Location, Extent & the Accessibility:

The study area comprises Twenty-Two (22) blocks of Bankura district were considered under study. The total geographical area encompassed under the project is 6882 sq. km. The mapable area for the same is about 5864 sq. km. It is bounded by the north latitudes 22°38'27" and 23°35'50" & east longitudes of 86°35'58" & 87°47'42" in Survey of India toposheet Nos 73I/14,15 & 16, 73J/9, 13 & 14, 73M/2, 3, 4, 7, 8 & 12, 73N/1, 5 & 9. It is bounded by Bardhhaman district on the north from which it is separated by natural barrier of the river Damodar. The entire southern and western boundaries of the study area lie with Paschim Medinipur and Purulia district respectively.

Figure 1.3.1 Administrative map of Bankura District.

The district headquarters; the Bankura town is very well connected by network of railways either from north via Adra junction through eastern railway or from the south via Kharagpur through South Eastern Railway. The abandoned BDR Railway is already upgraded to Broad gauge and is expected to function very soon. NH-60 which connects NH-2 and NH-6 passes through Bankura town. The entire study area has an

advantageous road communication with Durgapur, an important industrial city of the state. It has excellent road connectivity with Raniganj - Asansole industrial belt. More over the network of surfaced road is very good.

1.4 Administrative division and population:

The district with its headquarters at Bankura can be divided into three sub-divisions namely Bankura Sadar, Khatra and Bishnupur. Each sub-division has been divided into blocks as Bankura Sadar with 08 blocks (Bankura-I, Bankura-II, Chatna, Saltora, Mejhia, Gangajalghati, Barjora & Onda), Khatra sub division with 08 blocks (Indpur, Khatra, Hirabundh, Ranibundh, Taldangra, Simlapal, Raipur & Sarenga) and Bishnupur sub-division with 06 blocks (Bishnupur, Joypur, Kotulpur, Sonamukhi, Patrasayer& Indus). The district has three municipal towns at Bankura, Sonamukhi & Bishnupur. The administrative details of the district are presented in table **1.4.1(a) and table 1.4.1(b) & Table 1.4.2**

Table 1.4.1(a): Major administrative division

DISTRICT	SUBDIVISION	BLOCKS
BANKURA	SADAR	BANKURA-I
		BANKURA-II
		CHATNA
		SALTORA
		MEJHIA
		GANGAJALGHATI
		BARJORA
		ONDA
	KHATRA	INDPUR
		KHATRA
		HIRABUNDH
		RANIBUNDH
		TALDANGRA
		SIMLAPAL
		RAIPUR
		SARENGA
	BISHNUPUR	BISHNUPUR
		JOYPUR
		KOTULPUR
		SONAMUKHI
		PATRASAYER
		INDUS

**Source- District Statistical Handbook,2014*

The study area covers a total of 22 Panchayat samity, 190 Gram Panchayat, 2504 gram sansad, 3830 mouzas, 3585 inhibited village, 766902 households, 3 municipalities, 57 wards and 12 census towns. Distribution of population of the study area is presented in table 1.4.2

Table 1.4.1(b)-Major administrative division

C.D.Block/M	Panchayat			Mouzas	Inhabited Villages	House-holds	Town			Total
	Samity	Gram	Gram Sansad				Municipality		Census Town	
							No	Ward		
Bankura-I	1	6	82	150	137	21917	-	-	-	-
Bankura (M)	-	-	-	-	-	29807	1	23	-	1
Bankura-II	1	7	102	154	144	29502	-	-	-	-
Chhatna	1	13	147	288	277	40009	-	-	1	1
Saltora	1	8	103	157	145	28115	-	-	-	-
Mejia	1	5	65	75	72	17659	-	-	-	-
Gangajalghati	1	10	138	165	156	37878	-	-	-	-
Barjora	1	11	157	199	182	44421	-	-	3	3
Onda	1	15	185	291	271	53006	-	-	-	-
Indpur	1	7	112	222	198	31668	-	-	-	-
Khatra	1	7	86	155	146	25228	-	-	2	2
Hirbandh	1	5	59	121	116	17249	-	-	-	-
Ranibandh	1	8	90	186	169	25953	-	-	-	-
Taldangra	1	9	109	145	141	31312	-	-	-	-
Simplapal	1	7	105	203	191	29836	-	-	1	1
Raipur	1	10	131	206	197	37141	-	-	1	1
Sarenga	1	6	80	166	153	22020	-	-	-	-
Bishnupur	1	9	113	161	147	33793	-	-	-	-
Bishnupur(M)	-	-	-	-	-	15074	1	19	-	1
Joypur	1	9	116	139	137	34491	-	-	-	-
Kotulpur	1	8	141	170	165	41119	-	-	1	1
Sonamukhi	1	10	120	186	161	35022	-	-	-	-
Sonamukhi(M)	-	-	-	-	-	6379	1	15	-	1
Patrasayer	1	10	134	160	151	40653	-	-	-	-
Indus	1	10	129	131	129	37650	-	-	-	-
Total	**22**	**190**	**2504**	**3830**	**3585**	**766902**	**3**	**57**		**12**

**Source- District Statistical Handbook,2014*

Table 1.4.2: Distribution of population in administrative units of the study area

Sub-Division / C.D.Block / M	Rural Population			Urban Population			Total Population		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Bankura-I	55079	52606	107685	-	-	-	55079	52606	107685
Bankura(M)	-	-	-	69843	67543	137386	69843	67543	137386
Bankura-II	72302	68562	140864	-	-	-	72302	68562	140864
Chhatna	96797	92915	189712	2726	2600	5326	99523	95515	195038
Saltora	69732	66248	135980	-	-	-	69732	66248	135980
Mejia	44575	41613	86188	-	-	-	44575	41613	86188
Gangajalghati	93252	87722	180974	-	-	-	93252	87722	180974
Barjora	90624	85639	176263	13145	12641	25786	103769	98280	202049
Onda	129248	123736	252984	-	-	-	129248	123736	252984
Indpur	80556	75966	156522	-	-	-	80556	75966	156522
Khatra	53702	50890	104592	6356	6082	12438	60058	56972	117030
Hirbandh	42917	40917	83834	-	-	-	42917	40917	83834
Ranibandh	60290	58799	119089	-	-	-	60290	58799	119089
Taldangra	74999	72894	147893	-	-	-	74999	72894	147893
Simlapal	69315	66517	135832	3693	3513	7206	73008	70030	143038
Raipur	84107	80990	165097	3232	3048	6280	87339	84038	171377
Sarenga	54168	52640	106808	-	-	-	54168	52640	106808
Bishnupur	79941	76881	156822	-	-	-	79941	76881	156822
Bishnupur(M)	-	-	-	34055	33728	67783	34055	33728	67783
Joypur	80138	76782	156920	-	-	-	80138	76782	156920
Kotulpur	92114	88178	180292	4280	4203	8483	96394	92381	188775
Sonamukhi	81610	77087	158697	-	-	-	81610	77087	158697
Sonamukhi(M)	-	-	-	14988	14097	29085	14988	14097	29085
Patrasayer	93614	90456	184070	-	-	-	93614	90456	184070
Indus	86697	83086	169783	-	-	-	86697	83086	169783
District Total	1685777	1611124	3296901	152318	147455	299773	1838095	1758579	3596674

**Source- District Statistical Handbook, 2014*

Table 1.4.3: Geographical area and Mappable area for the given study area

DISTRICT	BLOCKS	GEOGRAPHICAL AREA	MAPPABLE AREA
BANKURA	Bankura-I	179	179
BANKURA	Bankura-II	219	219
BANKURA	Chhatna	457	357
BANKURA	Saltora	332	282
BANKURA	Mejhia	164	164
BANKURA	Gangajalghati	404	354
BANKURA	Barjora	423	373
BANKURA	Onda	510	410
BANKURA	Indpur	308	308
BANKURA	Khatra	230	130
BANKURA	Hirbandh	202	202
BANKURA	Ranibundh	428	260
BANKURA	Taldangra	338	238
BANKURA	Simlapal	316	216
BANKURA	Raipur	364	364
BANKURA	Sarenga	220	170
BANKURA	Vishnupur	371	371
BANKURA	Jaypur	204	154
BANKURA	Kotulpur	234	234
BANKURA	Sonamukhi	400	400
BANKURA	Patrasayer	329	329
BANKURA	Indus	250	250

**Source- Central Ground Water Board, Eastern Region, Kolkata*

Table 1.4.4: Distribution of Population over different Categories of Worker and Nonworkers*

Sub-Division / C.D.Block / M	Total Workers (TW)		Class of Total Workers								Main workers		Marginal workers		Non-workers		Total Population
	Number	P.C.	Cultivators		Agricultural Labourers		Household Ind. Workers		Other Workers		Number	P.C.	Number	P.C.	Number	P.C.	
			Number	PC to TW	Number	PC to TW	Number	PC to TW	Number	PC to TW							
Bankura-I	40327	37.45	7744	19.20	11751	29.14	2906	7.21	17926	44.45	29689	27.57	10638	9.88	67358	62.55	107685
Bankura(M)	49494	36.03	343	0.69	299	0.60	2463	4.98	46389	93.73	41358	30.10	8136	5.92	87892	63.97	137386
Bankura-II	52525	37.29	11288	21.49	13578	25.85	2718	5.17	24941	47.48	35590	25.27	16935	12.02	88339	62.71	140864
Chhatna	77212	39.59	14774	19.13	32500	42.09	2835	3.67	27103	35.10	40212	20.62	37000	18.97	117826	60.41	195038
Saltora	54335	39.96	13099	24.11	19252	35.43	1766	3.25	20218	37.21	32107	23.61	22228	16.35	81645	60.04	135980
Mejia	30439	35.32	5659	18.59	8127	26.70	690	2.27	15963	52.44	19985	23.19	10454	12.13	55749	64.68	86188
Gangajalghati	69291	38.29	16856	24.33	25301	36.51	2571	3.71	24563	35.45	37105	20.50	32186	17.78	111683	61.71	180974
Barjora	79107	39.15	15235	19.26	28677	36.25	3135	3.96	32060	40.53	52948	26.21	26159	12.95	122942	60.85	202049
Onda	99984	39.52	24522	24.53	46704	46.71	4616	4.62	24142	24.15	69540	27.49	30444	12.03	153000	60.48	252984
Indpur	63403	40.51	12834	20.24	33939	53.53	2100	3.31	14530	22.92	31324	20.01	32079	20.49	93119	59.49	156522
Khatra	45441	38.83	7575	16.67	24186	53.23	914	2.01	12766	28.09	25256	21.58	20185	17.25	71589	61.17	117030
Hirbandh	37470	44.70	5979	15.96	23479	62.66	1000	2.67	7012	18.71	15516	18.51	21954	26.19	46364	55.30	83834
Ranibandh	57473	48.26	13103	22.80	33602	58.47	2967	5.16	7801	13.57	27419	23.02	30054	25.24	61616	51.74	119089
Taldangra	62413	42.20	13661	21.89	35293	56.55	2234	3.58	11225	17.99	34088	23.05	28325	19.15	85480	57.80	147893
Simlapal	57948	40.51	12062	20.82	30773	53.10	2726	4.70	12387	21.38	30681	21.45	27267	19.06	85090	59.49	143038
Raipur	78233	45.65	18316	23.41	45944	58.73	2269	2.90	11704	14.96	37531	21.90	40702	23.75	93144	54.35	171377
Sarenga	45015	42.15	10061	22.35	25769	57.25	1443	3.21	7742	17.20	21760	20.37	23255	21.77	61793	57.85	106808
Bishnupur	67156	42.82	14261	21.24	29960	44.61	3876	5.77	19059	28.38	43762	27.91	23394	14.92	89666	57.18	156822
Bishnupur(M)	25335	37.38	377	1.49	323	1.27	2318	9.15	22317	88.09	22327	32.94	3008	4.44	42448	62.62	67783
Joypur	64114	40.86	16314	25.45	28805	44.93	3723	5.81	15272	23.82	44294	28.23	19820	12.63	92806	59.14	156920
Kotulpur	77559	41.09	23737	30.61	30249	39.00	3318	4.28	20255	26.12	57527	30.47	20032	10.61	111216	58.91	188775
Sonamukhi	72581	45.74	18332	25.26	38357	52.85	2737	3.77	13155	18.12	53414	33.66	19167	12.08	86116	54.26	158697
Sonamukhi(M)	11084	38.11	168	1.52	766	6.91	1195	10.78	8955	80.79	9877	33.96	1207	4.15	18001	61.89	29085
Patrasayer	79419	43.15	18441	23.22	42494	53.51	3391	4.27	15093	19.00	58244	31.64	21175	11.50	104651	56.85	184070
Indus	68862	40.56	14982	21.76	37246	54.09	1475	2.14	15159	22.01	44839	26.41	24023	14.15	100921	59.44	169783
District Total	**1466220**	**40.77**	**309723**	**21.12**	**647374**	**44.15**	**61386**	**4.19**	**447737**	**30.54**	**916393**	**25.48**	**549827**	**15.29**	**2130454**	**59.23**	**3596674**

**Source- District Statistical Handbook, 2014*

1.5 Land use, Irrigation and Cropping pattern:

An account of land use pattern of the study area has been given in Table 1.5 Net cultivable area varies between 51% to 80% of total geographical area. The maximum forest cover area falls in Bankura II, Gangajalghati and Borjora blocks.

The area under more than one crop varies between 2% to 18%. Saltora, Chatna, Gangajalghati blocks are principally mono-cropped (with negligible double cropped area of 2 to 4%). Mejia and Onda blocks, on the other hand have considerable area under multiple crops. District average cropping intensity which is the ratio of gross cropped area to net cultivable area is 143% whereas in the study area the cropping intensity is as low as 104 to 133 % only.

Land-use:
Bankura district is basically agrarian district of the state of West Bengal. Land use pattern of urban and rural areas mainly depends on Socio-economic and Socio-cultural factors.

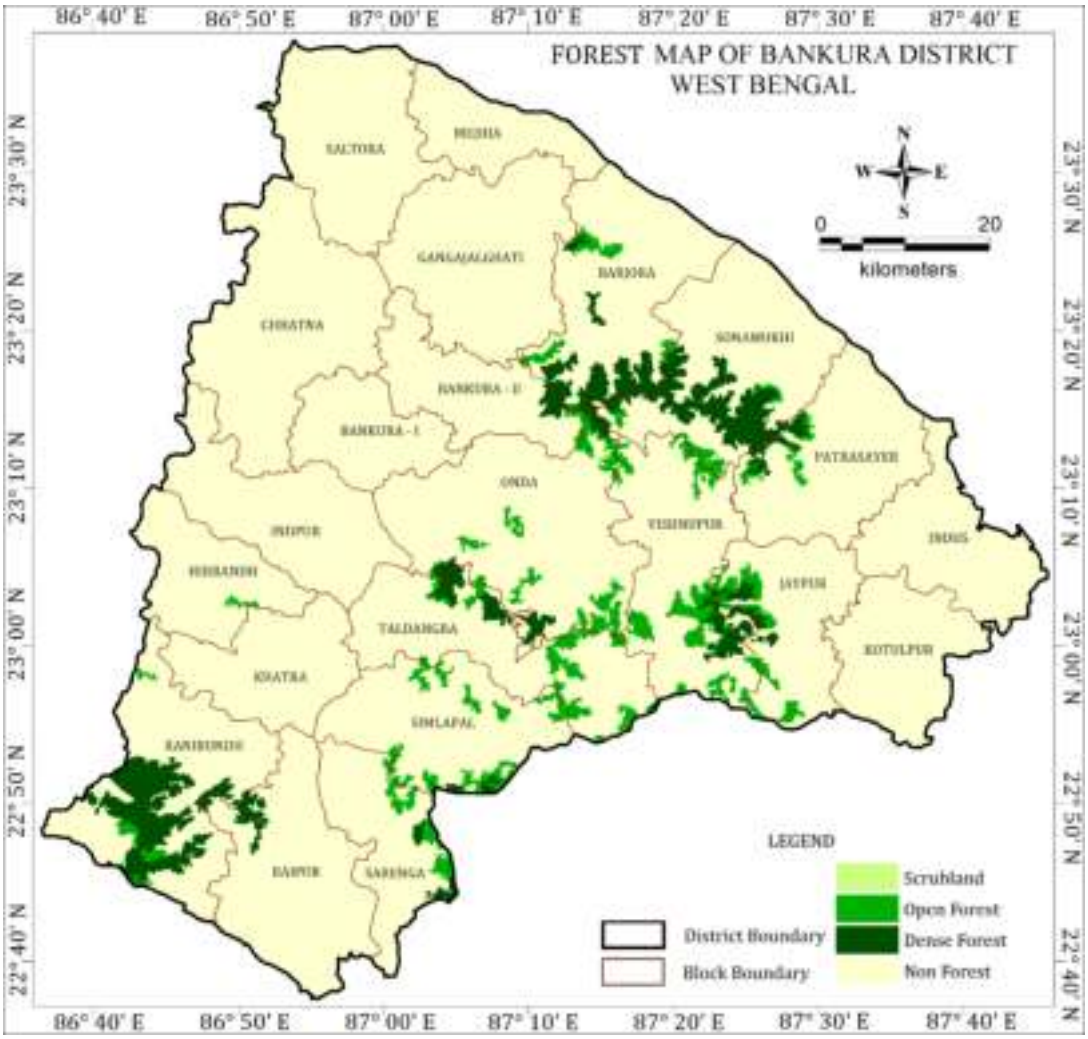


Figure 1.5.1 Forest cover map of Bankura District.

Forest:

Dense Forest like Khatra, Ranibandh, Bishnupur, Sonamukhi, Bojora, Gangajalghati occupies huge areas of the district, Bankura. Currently the land under forest department is approximately 21.5%. About 48% of the forest in this district is degraded type and alarmingly the forest/plant cover is depleting gradually. In addition to ecological utilities, the forests in this district also serve as the basis of livelihood of poor communities of the rural area and the tribes as well. Forests not only provide money but also are important for energy resources in form of fuel and forage for the disadvantaged folks.

Agriculture:

Agriculture in Bankura district is dominated by paddy cultivation in kharif season and mustard cultivation in rabi season. For the district as a whole, there is very little irrigation infrastructure i.e., tube wells, dug wells, surface flow irrigation schemes and surface lift structures (Mandal & Gupta, 2012). A large number of landraces of rice were cultivated by the tribal and rural community of farmers of Bankura district, so far 65 folk rice varieties are producd from Bankura District of West Bengal viz., Dharnagra, Suakalma, Vutmuri, Tulsibhog, Sitasal, Gobindabhog, Rupsal, Kalamkati, Neta, Nagrasal, Danarguri, Chandrakanta, Daharlagra, Badsahabhog, Raghusal, Bhurisal, Khajurchari, Gangajali, Basmati and Kataribhog (Sinha &Mishra, 2012). Crops like paddy, wheat, sugarcane, oilseeds etc., are cultivated in the study area. In most of the patches of forest area of this district are occupied by the cultivation of variety of seasonal vegetables such as potatoes, tomatoes, cabbage, cauliflower, pumpkins, and gourds are found. A variety of fruit crops such as jackfruits, banana, watermelon and sugarcane are also farmed in the farmers' pasture (Panja & Mistry, 2018). Although the district is prone towards drought, the farmers are engaged themselves to yield surplus food crop and/or other food resources every year during the time of good rainfall and rice is the main crop of the district. Besides rice, the major crops are potato, wheat, vegetables, mustard, summer til etc. The cultivators of the district produce potato & other vegetables as surplus. Pulse & oilseed production are still impoverished in this district and that is why government is trying to focus in production of same by introducing new varieties of pulse crops as arhar, lentil, gram, khesari, kalai, moong etc., and groundnut and sunflower as oilseeds. To meet up the gap between demand and production, the oilseed crops have been introduced in Rabi season. Broccoli and Capsicum are also cultivated by farmers of this district to meet up the demand of the local people.

Cropping pattern:

The principal crops of the district are paddy (*Aus, Aman* and *Boro*), potato, wheat, various pulses etc. as food grains; mustard and other oil seeds; jute and sugarcane as miscellaneous crops and other *Rabi* crops. Among the food grains paddy is the principal crop and among paddy, *Boro* and *Aman* are the main paddy crops in this district. The jute cultivation ranks next to paddy in the area. Apart from paddy, potato is also an important crop in this area. Among cash crops, mango ranks as principal fruit grown in the area.

Out of the three varieties of paddies, *Aman* (autumn paddy) is grown over a larger area of the district. The productivity is far away from the state average particularly in case of *Aus* paddy, potato, and barley but the same in case of other crops is more or less at per with the state average or even more in few cases like sugarcane, wheat and *Aman* paddy.

The details of the crops grown, the production and yield are presented in tabular form in table 1.5.2(a).

1.6 Urban area, Industries and Mining Activities:

Bankura Municipality area of 19.06 sq.km and parts of Borjora block constitute the urban area. Total population in Bankura Municipality area is 1,37,386and the urban cluster in smaller section of Borjora block include 2,02,049 persons.

Borjora and Mejia, located at the close proximity of Durgapur, Asansol, Raniganj industrial belt is the centre for small and medium scale industrial development. Good connectivity of road and rail, steady power situation, availability of land for industrial use, cheap labours of both skilled and unskilled groups offer ample scope for growth. Mejia Thermal Power Station (MTPS) of DVC is the heart of industrial development in the area. Borjora industrial belt is growing fast with numbers of sponge Iron Company, alloy industry, plastic industry has come up. Besides above, the area is also famous for unique traditional craft in Dokra work of Bikna in Bankura I block, stone crafts of Susunia in Chhatna block.

Coal is the major mineral resource which is being mined economically in Mejia and Borjora block of the study area. In Mejia coal is found in Raniganj formation whereas in Borjora it occurs in Barakar formation of Gondwana Super Group of rock.

In Mejia, the proved reserve of coal is 13.14 million tones and the indicated reserve being 197.37 million tonnes according to GSI. In Borjora area the proved reserve is 12 million tons (GSI).

Quite a good number of china clay deposit associated with Archeans and as well as with Tertiaries are reported from the study area. China clay is used for pottery industry, white ware including porcelain, bone china etc. Several occurrences of mica, feldspar, associated with pegmatite are also reported in the area. Basic and ultrabasic intrusives and quartzite provide additional resources for road metal and building stones. Stone crusher is also a prominent small-scale industry in the area particularly in Gangajalghati and Saltora block.

Table 1.5.1: Block-wise details of Land-use pattern *(hectares)

Block	Reporting Area	Forest Area	Area Under Non-Agricultural Waste	Barren and Un-culturable land	Permanent pastures and grazing lands	Land under misc tree crops	Culturable wastes	Fallow land Other than current fallow	Current fallow	Net area sown	Cultivable Area
Bankura-I	18764	1772	6605	36	2	5	71	19	200	10054	10349
Bankura-II	22093	4472	6498	214	8	130	184	35	956	9596	10901
Bishnupur	38844	13514	11346	95	-	129	-	-	7	13753	13889
Barjora	39390	10646	7546	101	-	103	378	112	601	19903	21097
Chhatna	44955	4471	8865	416	109	134	61	-	4400	26499	31094
Gangajalghati	37137	7774	8424	22	-	-	-	98	1250	19569	20917
Hirabandh	19367	3505	6057	-	-	-	-	-	1009	8796	9805
Indpur	30264	5836	5608	36	-	-	-	3	524	18257	18784
Indus	25498	0	8800	-	-	-	-	-	377	16321	16698
Joypur	26382	6182	4646	-	-	160	-	-	1463	13931	15554
Kotulpur	25038	257	5401	321	-	26	202	101	3008	15722	19059
Khatra	23273	5101	6316	-	-	-	143	78	1089	10546	11856
Mejia	16287	535	4189	-	-	10	-	30	422	11101	11563
Onda	50240	15370	7615	-	-	-	-	-	3936	23319	27255
Patrasayer	32260	5157	8725	-	-	154	-	-	1600	16624	18378
Raipur	36993	7165	9194	-	-	-	-	101	2565	17968	20634
Ranibandh	42750	14331	8093	7	-	-	-	-	1952	18367	20319
Saltora	31093	3818	5612	360	-	-	514	87	1603	19099	21303
Sarenga	22385	5868	8360	47	-	42	60	-	2123	5885	8110
Simlipal	31015	9709	5657	-	-	160	-	-	1180	14309	15649
Sonamukhi	39049	12147	10870	-	-	17	9	-	903	15103	16032
Taldangra	34921	11300	10017	-	-	-	-	-	-	13604	13604
Total	**687998**	**148930**	**164444**	**1655**	**119**	**1070**	**1622**	**664**	**31168**	**338326**	**372850**

** Source- West Bengal Land Use Land Cover Department.*

Table: 1.5.2 (a) Crops cultivated in the study area

Name of Block	Aus			Aman			Boro			Wheat			Maize		
	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield
Bankura-I	15	0.31	2054.19	9255	25.440	2749	4	0.012	2944	6	0.014	2335	-	-	-
Bankura-II	-	-	-	32270	95.513	2960	19	0.061	3202	72	0.185	2573	-	-	-
Chhatna	-	-	-	2756	6.976	2531	-	-	-				-	-	-
Saltora				2006	3.771	1880	-	-	-	10	0.025	2461	-	-	-
Mejia	-	-	-	1371	2.858	2084	-	-	-	6	0.012	2044	-	-	-
Gangajalghati	-	-	-	2109	5.781	2741	-	-	-	5	0.012	2418	-	-	-
Barjora	300	0.853	2844.55	16611	44.594	2685	122	0.414	3397	195	0.345	1772	-	-	-
Onda	2246	6.525	2905.25	19947	53.122	2663	5020	15.395	3067	327	0.969	2962	-	-	-
Indpur	-	-	-	1611	3.573	2218	-	-	-	128	0.284	2221	-	-	-
Khatra	-	-	-	9222	22.770	2469	973	2.552	2623	51	0.121	2367	-	-	-
Hirbandh	-	-	-	7829	19.285	2463	-	-	-	50	0.107	2147	-	-	
Ranibandh	74	0.11	1481.29	17982	46.199	2569	-	-	-	9	0.016	1734	112	0.206	1841
Taldangra	1921	4.424	2303.15	1922	4.429	2304	503	1.474	2930	329	0.549	1669	-	-	-
Simlapal	65	0.181	2781.13	34047	99.087	2910	1239	3.290	2655	105	0.237	2261	3	0.006	1841
Raipur	31	0.084	2708.07	16373	44.430	2714	363	0.840	2315	666	0.939	1410	2	0.004	1841
Sarenga	-	-	-	36541	102.823	2814	-	-	-	142	0.308	2171	-	-	-
Bishnupur	236	0.358	1514.99	37032	103.234	2788	561	1.707	3042	14	0.030	2138	-	-	-
Joypur	2699	7.016	2599.46	10990	29.897	2720	5569	14.715	2642	450	1.046	2324	-	-	-
Kotulpur	6424	16.917	2633.39	37750	108.046	2862	5147	18.746	3642	104	0.244	2349	-	-	-
Sonamukhi	662	1.466	2214.64	17209	45.542	2646	11216	32.128	2864	404	0.766	1896	-	-	-
Patrasayer	3191	7.964	2495.83	1405	3.390	2413	4851	16.859	3475	152	0.293	1927	-	-	-
Indus	1853	4.38	2363.6	1646	3.726	2264	4422	12.370	2797	235	0.452	1921	-	-	-

*__Area__ = hectare, * __Production__ = thousand million tones, **__Yield__= Kg/hect. ***Source- District Statistical Handbook, 2014*

Table: 1.5.2 (b) Crops cultivated in the study area

Name of Block	Mustard			Til			Potato			Musur			Gram		
	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield
Bankura-I	24	0.019	799	-	-	-	55	1524.000	27700	3	0.002	749	-	-	-
Bankura-II	344	0.192	574	48	0.032	663	3128	86596.000	27684	5	0.003	547	1	0.001	1024
Chhatna	25	0.020	805	-	-	-	-	-	-	-	-	-	-	-	-
Saltora	2	0.001	473	168	0.167	996	-	-	-	1	0.001	715	-	-	-
Mejia	27	0.017	639	-	-	-	-	-	-	9	0.005	577			
Gangajalghati	1500	1.376	918	-	-	-	1010	29539.000	29247	8	0.009	1091	1	-	471
Barjora	95	0.035	372	246	0.193	783	2135	69208.000	32416	5	0.002	470	1	0.001	804
Onda	1322	1.363	1031	2453	2.310	942	1984	44557.000	22458	6	0.006	1082	1	0.001	835
Indpur	228	0.102	446	98	0.055	557	7	182.000	26000	10	0.005	492	1	-	454
Khatra	316	0.208	659	53	0.046	873	25	694.000	27765	4	0.002	388	1	0.001	811
Hirbandh	322	0.272	845	144	0.086	601	53	1431.000	27000	2	0.001	534	1	0.001	796
Ranibandh	444	0.411	926	-	-	-	207	6052.000	29235	-	-	-	1	0.001	817
Taldangra	551	0.300	545	1415	0.862	609	879	11080.000	12605	5	0.003	553	1	0.001	817
Simlapal	588	0.414	704	971	0.846	871	2214	40671.000	18370	-	-	-	-	-	-
Raipur	115	0.056	491	2202	1.106	502	1883	39760.000	21115	10	0.003	282	1	0.001	1024
Sarenga	835	0.645	773	287	0.192	668	1310	22557.000	17219	5	0.007	1373	1	0.001	810
Bishnupur	744	0.531	713	19	0.014	751	2005	26873.000	13403	9	0.012	1360	1	0.001	899
Joypur	322	0.258	802	2636	2.091	793	2384	21585.000	9054	-	-	-	-	-	-
Kotulpur	575	0.448	779	4744	4.413	930	4633	28196.000	6086	7	0.009	1260	-	-	-
Sonamukhi	736	0.424	577	347	0.208	600	2843	29573.000	10402	1	0.001	1088	-	-	-
Patrasayer	893	0.613	687	1246	0.935	751	2030	12578.000	6196	9	0.007	767	-	-	-
Indus	1265	1.031	815	1165	0.912	782	940	6368.000	6774	12	0.017	1431	1	0.001	898

***Area** = hectare, * **Production** = thousand million tones, ****Yield**= Kg/hect. ***Source- District Statistical Handbook, 2014*

Table: 1.5.3 Irrigation of Crops cultivated in the study area

Name of Block	Canal Area	Tank		RLI		DTW		STW		ODW		Others		Total	
		No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area
Bankura-I	198	845	925	17	660	-	-	28	78	600	300	26	165	1516	2326
Bankura-II	-	650	1350	18	680	-	-	675	1300	490	200	37	72	1870	3602
Chhatna	-	970	1695	23	860	-	-	17	45	137	25	-	-	1147	2625
Saltora	-	2010	2400	14	560	-	-	-	-	170	90	320	250	2514	3300
Mejia	-	647	1556	16	720	-	-	215	327	260	100	7	150	1145	2853
Gangajalghati	443	2300	6095	13	480	-	-	**2**	**5**	625	245	-	-	2940	7268
Barjora	3043	1010	660	27	1320	21	224	1498	2089	314	112	125	799	2995	8247
Onda	9796	1455	900	27	1140	76	606	3541	6080	812	30	24	115	5935	18667
Indpur	3570	366	850	38	1800	-	-	-	-	250	40	3	30	657	6290
Khatra	5246	475	1500	17	600	-	-	-	-	525	370	6	280	1023	7996
Hirbandh	929	570	1050	26	940	-	-	-	-	580	70	5	220	1181	3209
Ranibandh	2890	535	260	20	800	-	-	-	-	250	95	-	-	805	4045
Taldangra	12262	260	1435	31	1300	20	232	578	1350	10	5	16	400	915	16984
Simlapal	11853	630	1790	28	1120	10	116	690	2400	250	45	538	1820	2146	19144
Raipur	14072	527	2030	32	1360	-	-	165	385	235	480	20	600	979	18927
Sarenga	9723	305	950	18	700	-	-	1315	2905	135	17	66	1075	1839	15370
Bishnupur	6760	475	350	24	820	71	1050	3810	11094	100	20	522	290	5002	20384
Joypur	14474	3835	2021	14	560	43	524	2569	2178	435	150	-	-	6896	19907
Kotulpur	13192	1515	1612	16	820	42	702	2562	3661	-	-	-	-	4135	19987
Sonamukhi	14900	35	250	19	580	70	866	4015	4825	13	12	15	242	4167	21675
Patrasayer	7727	60	225	26	980	34	438	4025	8432	70	55	6	10	4221	17867
Indus	13001	2000	200	9	420	42	538	4300	6644	-	-	-	-	6351	20803

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

**Source- District Statistical Handbook, 2014*

Table1.5.4: Culturable command area created by surface water and ground water.

Block Name	Dug well		Shallow Tube well		Medium Tube well		Deep Tube well		Surface Flow		Surface Lift		CCA (ha.)		Total CCA (ha.)
	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	Ground Water	Surface Water	
BANKURA-I	47	88.1	121	438.51	1	5	0	1000	37	217	587	3554.43	1531.61	3771.43	5303.04
BANKURA-II	3	7	317	1244.26	0	-	0	-	54	235	644	3584.49	1251.26	3819.49	5070.75
BISHNUPUR	3	10	1246	4252.4	160	914	25	-	48	261	132	779	5176.4	1040	6216.4
BORJORA	2	6	501	1558.9	47	338.8	3	86	214	1035	344	1386.9	1989.7	2421.9	4411.6
CHHATNA	10	43	130	440.2	0	-	0	-	44	274.42	813	3576.4	483.2	3850.82	4334.02
GANGAJAL GHATI	6	9.55	60	209.35	0	-	0	-	26	88	1098	5511.82	218.9	5599.82	5818.72
HIRBUNDH	7	7	62	198.83	0	-	0	-	69	379.3	403	2559.76	205.83	2939.06	3144.89
INDPUR	2	8	4	69	0	410	0	-	198	1703.73	568	3763.68	487	5467.41	5954.41
INDUS	5	25	1239	4824.05	58	834.75	21	245	31	196	331	1416.85	5928.8	1612.85	7541.65
JOYPUR	1	5	756	2545.62	142	-	53	241	63	330	182	797.96	2791.62	1127.96	3919.58
KATUL PUR	2	10	1175	4014.97	239	1262.37	81	609.35	52	287	119	318.7	5896.69	605.7	6502.39
KHATRA-I	0	-	2	2	0	-	1	5	84	491	360	1758.3	7	2249.3	2256.3
MEJIA	11	26	50	185.1	0	-	4	21	83	426.45	276	1467.32	232.1	1893.77	2125.87
ONDA	2	9	1761	5181.48	205	1131.24	195	620.99	169	833.1	451	1833.79	6942.71	2666.89	9609.6
PATRASAYER	2	8	1155	3641.09	97	707	62	546	19	254	78	651	4902.09	905	5807.09
RAIPUR	2	10	399	1301.93	47	210.7	63	224	164	811	280	1381	1746.63	2192	3938.63
RANIBUNDH	11	47.96	77	201.35	1	2	0	-	254	1244	316	1049.82	251.31	2293.82	2545.13
SALTORA	26	69.3	102	334.94	0	0	2	6	21	167.5	790	5676.91	410.24	5844.41	6254.65
SARENGA	1	1	495	1542.3	53	244.75	46	198	128	614	146	619.2	1986.05	1233.2	3219.25
SIMLAPAL	4	10	378	1292.01	46	249.63	8	180.43	107	479	308	1671.21	1732.07	2150.21	3882.28
SONAMUKHI	2	10	871	2908.96	161	961.65	163	1117.5	119	672	417	1643.4	4998.11	2315.4	7313.51
TALDANGRA	5	17	481	1770.09	17	157.5	137	568	83	436	186	1049.3	2512.59	1485.3	3997.89
TOTAL	154	426.91	11382	38157.34	1274	7429.39	864	5668.27	2067	11434.5	8829	46051.24	51681.91	57485.74	109167.65

**Source- District Statistical Handbook, 2014*

1.7 Previous work:

The area as a whole or part of it has been surveyed, under systematic hydrogeological survey and reappraisal survey items by the officer of Central Ground Water Board and Geological Survey of India. Ground Water Exploration has been carried out by Geological Survey of India and later by CGWB in the eastern part of the study area. A part of the area in south western part was studied in detail by a team of scientists under UNDP sponsored Kasai-Subarnarekha Project (1984-89). The district as a whole has also been studied under Technology Mission Programme for finding spot sources in identified problem villages.

In addition, short term water supply investigation and also electrical resistivity sounding and profiling had been undertaken time and again for pin point location of spot water sources.

Recently, Shri A. Ray (2001) compiled a report entitled 'Hydrogeology and Ground Water Resources of Bankura district, West Bengal. "Report on the Reappraisal Hydrogeological Survey in parts of Bankura district, WB" by R.K. Guha (2001) and the report entitled "Ground Water Development and Management Studies in parts of Water Scarce Hard Rock Terrain in Bankura district, West Bengal" by Shri S.M. Hossain (2004) give a detail account of hydrogeology, ground water development and management aspect in the study area. Special study carried out by Shri T.L Chakraborty et al (2001) under Central Sector Scheme for artificial recharge of ground water by construction of sub-surface dykes in Saltora block is an important document for development and management of water shed in water scarce hard rock terrain of the district.

CHAPTER-2

CLIMATE

2.1 Rainfall:

The district of Bankura like many other places of the North Indian Plain is characterized by humid tropical climate. The Normal annual rainfall in the district is to the tune of 1386 mm. The precipitation during the monsoon contributes about 75% of the total annual rainfall. The monsoon ensues in the month of May and maintains its spell till the first week of October. The bulk of the precipitation takes place during the months of July and August.

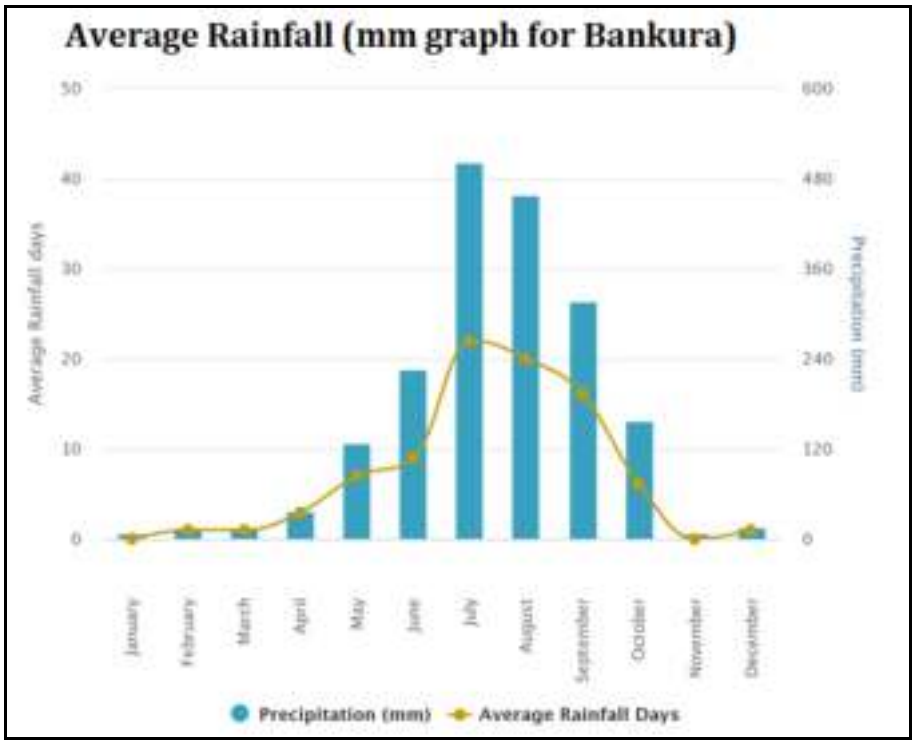


Figure2.1.1 Average rainfall for Bankura district

Table 2.1.1 Monthly Rainfall data for the districts of Bankura District (from 2014-2018)

District	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Bankura	2014	0.8	38.3	8	3.3	84.7	85.7	313.7	323.4	164.1	53.2	0	0.3
	2015	17.4	1.5	7.1	85.6	55.9	152.2	467.5	230.6	96.5	12.7	0	0.2
	2016	6.1	10.2	15.6	0.8	101.3	175.1	264.8	445.5	268.9	46.9	0.7	0
	2017	0	0	16.9	27.9	76.3	228.8	634.2	330.4	186.1	249.1	25.3	5.2
	2018	0	0.1	9.1	149.6	76.5	235	328.9	315.4	151	27.6	0.5	40.6

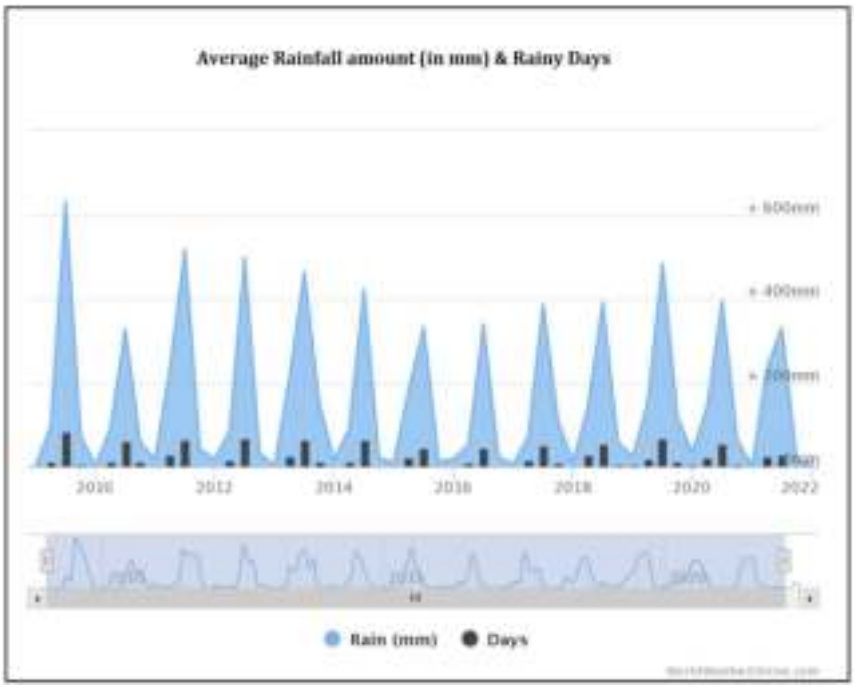


Figure2.1.2 Average rainfall amount & rainy days

2.2 Temperature:

Late December and early part of January are marked as the coolest period in the study area with minimum temperature hovering around 8°-9° C. May is the hottest month with temperature soaring as high as 44° C. Generally, the temperature rises from the beginning of March and the day temperature goes upto 40°C in the month of April and May.

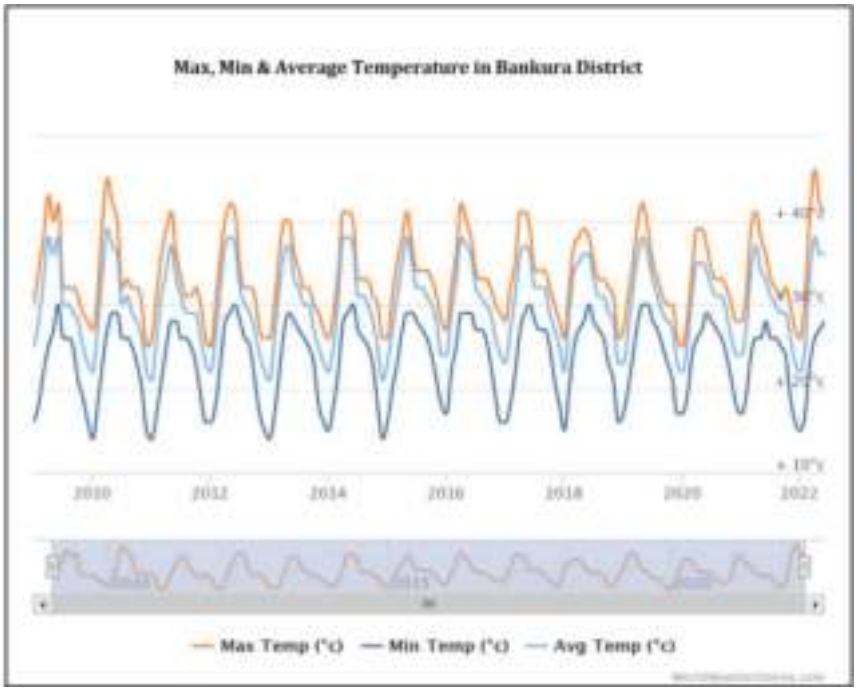


Figure 2.2.1 Maximum, Minimum and average temperature in Bankura District

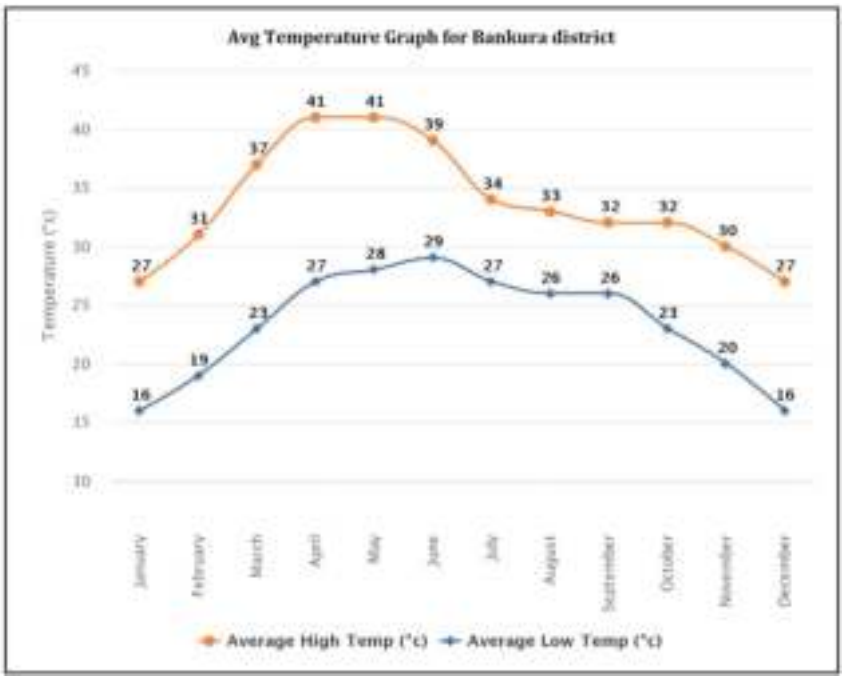


Figure2.2.2 Average temperature graph for Bankura District

2.3 Humidity:

The Area is humid to sub humid as far as data in regard to relative humidity is concerned. The relative humidity percentage at 7.00 LMT varies from 72.5 to 89.5% and the relative humidity percentage at 14.00 LMT varies from 27.9 to 86.4%. The relative humidity is maximum during August after monsoon and minimum during Feb-March.

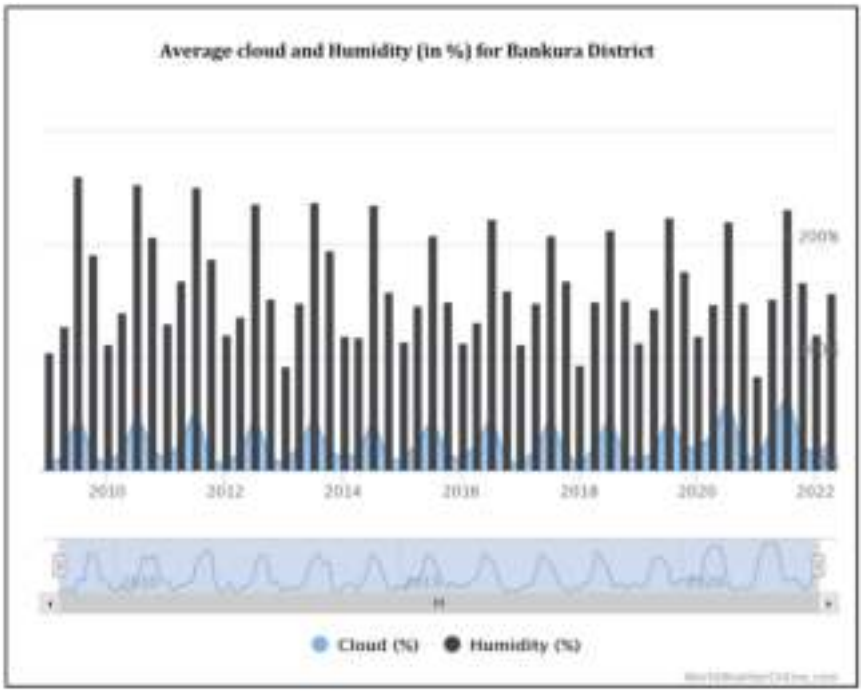


Figure 2.3.1 Average cloud and humidity percentage

2.4 Climatic factors:

Intensity of rainfall:

The intensity of rainfall due to depressions sometimes becomes very extensive and may cause enhanced soil erosion in the district. During winter, western disturbances generally cause light rainfall. This does not cause any major soil erosion problem. During summer of season i.e., March to May, rainfall is caused by the 'Nor'westers' or 'Kalbaisakhis'. Kalbaishakhis generally bring sudden rainfall with pronounced intensities. Besides, the season in which Kalbaishakhis occurs is characterized by the presence of bare soil mostly devoid of vegetation. Therefore, it causes considerable amount of soil erosion. Bankura district enjoys the tropical monsoon type of climate which is characterized by hot wet summer and cool dry winter. There is a relatively short wet period preceded by a period of comparatively dry spells of long duration.

Climate Zone:

Bankura district enjoys the tropical monsoon type of climate characterized by hot wet summer and cool dry winter. There is a relatively short wet period preceded by a period of comparatively dry spells of long duration.

Temperature variation:

The year in general is divided into four seasons. The cool weather commences in the later part of November and lasts until the middle of February. During these months the prevailing winds are from the north and north-east. This is followed by the hot and dry season which extends up to May. The weather becomes increasingly hot during the day, though the night remains fairly cool. The daily range of temperature is often tempered by Nor'westers which generally appears in the evening. The south west monsoon season sets in about the middle of June and continues up to the end of September. October and the first half of November constitute the post monsoon season.

CHAPTER-3

GEOMORPHOLOGY

3.1 Physiography:

Physiographically the district may be broadly divided into three distinct geomorphological units with characteristics morphological assemblages. They are:

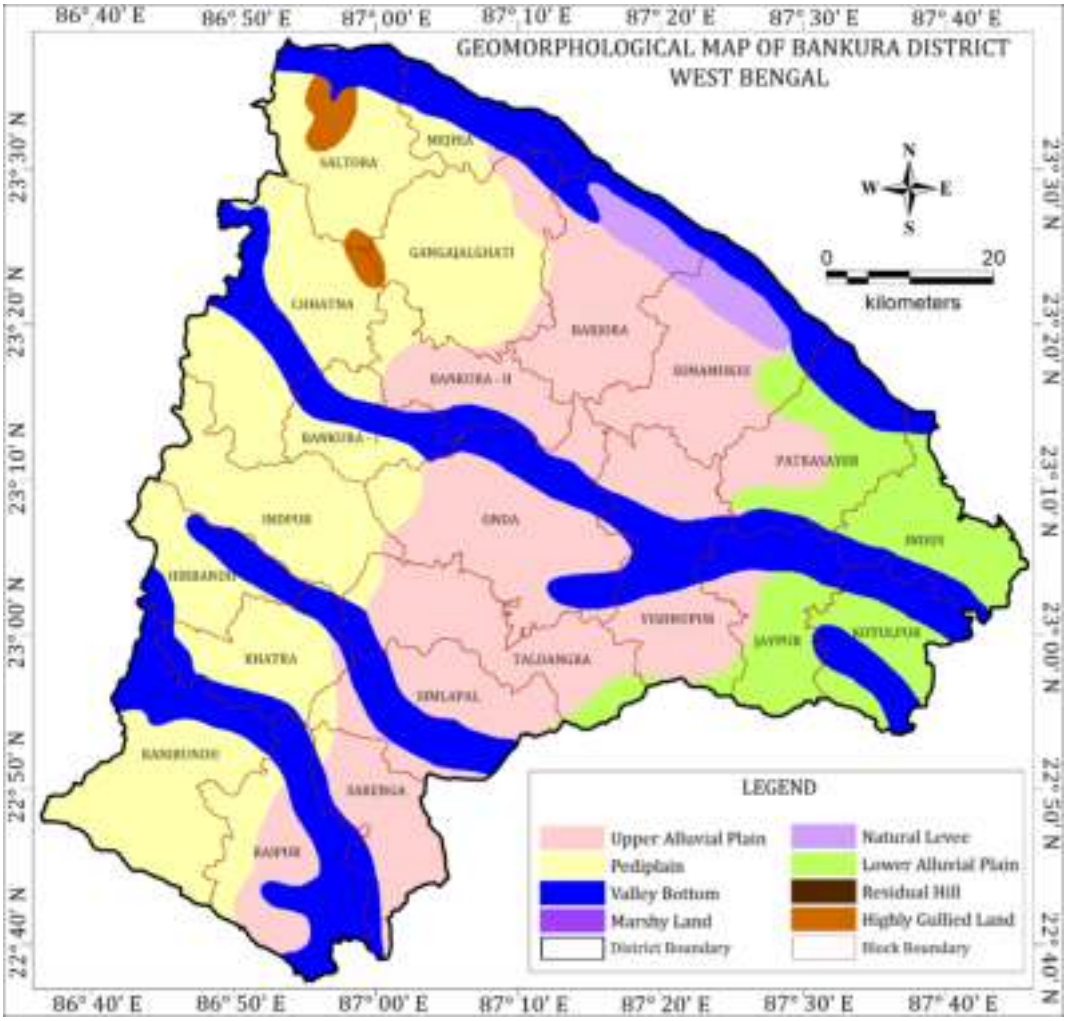


Figure 3.1.1Geomorphological map of Bankura District.

The Hilly Terrain:

The hilly terrain in the west is covered by crystalline rocks of archean age, Hillocks, lowridges and valleys. Susnia and Biharinath hills from the highest point in the units. The landslope of this unit varies between 10-20 m/km and the master slope of this towards south east. There are other small hills scattered in this district in the blocks of Mejhia, Gangajhalghati, Khatra, Ranibundh and Raipur. The average elevation of this unit ranges between 100-150m abobe mean sea level. The entire geomorphic unit is the south eastern extension of Chhotanagpur Plateau.

The Eastern Plain Land:

The eastern part of the block comprising Bishnupur, Kotulpur, Indus block is charatcterized by a flat plain land which constitutes a vast arable land. The surface elevation of this unit ranges between 10-50 m above mean sea level with a gentle slope of less than 10 m/km towards south east. The flat land is marked at places by dissected badlands (gullies) and is devoid of natural swamps or lakes.

The Marginal Undulating Tract:

This topography is witnessed in the central part of the district, where hilly terrain of the west gradually merges into plain alluvial land. This geomorphic unit has been suitable for the growth of forest in the district. The morphology of this unit presents highly dissected topography where the average surface elevation is to the tune of 10-20 m/km towards south east. Streams of the lower order predominates in this area.

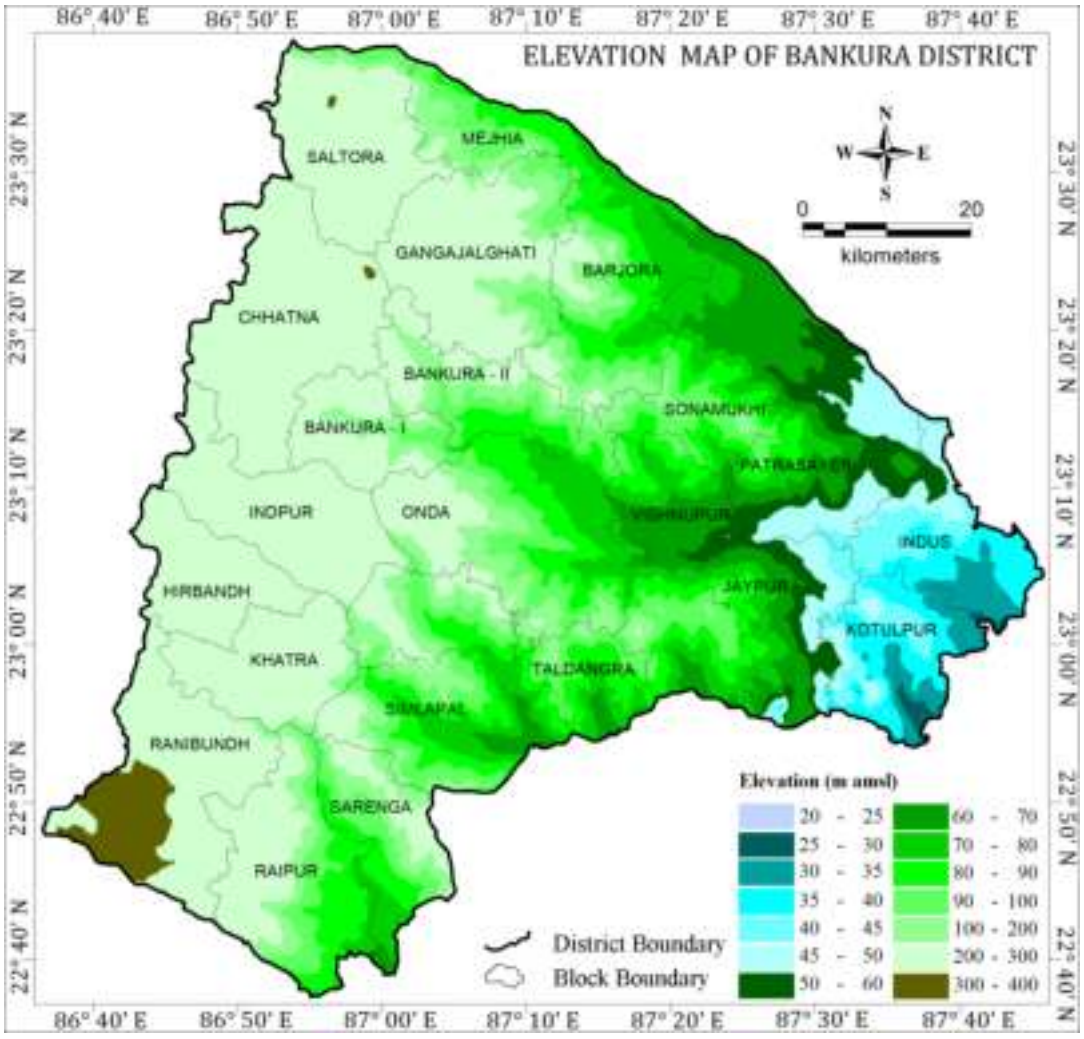


Figure 3.1.2 Elevation map of Bankura District.

3.2 Drainage:

The study area comprises parts of Damodar and Kangsabati sub basin and is drained by number of major rivers with predominantly NW-NNW to SE-SSE flowing trend across the area. From north to south the major rivers are Damodar, Sali (tributary of Damodar) Gandheswari, Dwarakeswar, Silabati and Kangsabati. (Figure 3.2.1)

Damodar: The most important river in the district and marks the northern boundary of the present study and as well as separates Bankura district from Barddhaman district. Damodar originates in hilly country of Chhotonagpur and before it touches upon the Bankura district, it receives the water of many smaller hill streams including those of Barakar, its principal tributary. Damodar enters Bankura district in Saltora block and then flows in a southeasterly direction through Mejia and Borjora block of study area and further east. The river drains only the northern most part of the district and most of the tributaries originating either in the district or in Purulia district. A barrage across the river Damodar has been constructed which connects Durgapur and Pratapur in Borjora block. The construction of barrage has reduced the frequency of devastating floods in rainy seasons and also created a considerable irrigation potential both in Bankura and Barddhaman district as well.

Sali: Sali, another tributary of Damodar rises from the western forested high lands of Gangajalghati block and passes through Gangajalghati and Borjora block of study area and ultimately merges to Damodar in Indus block of Bankura district. A dam is constructed at the upper reaches of the river course at Gangdua in Gangajalghati block, the 'Sali Reservoir Scheme',

Gandheswari: The Gandheswari river rises in the region N-W of Susunia Hills in Chhatna block and flowing the southeasterly course drains a large part of Chhatna and Bankura block before it joins the Dwarakeswar. The entire river course is in the study area.

Dwarakeswar: The Dwarakeswar is the second most important river in the district. It rises in the northern part of Hura in Purulia district and flowing in a south easterly course enters Bankura district in Chhatna. Thereafter, it takes a zigzag course through Bankura–I & II and Onda blocks in the study area and flows towards east. The river almost gets dried up in the dry season however, it is subjected to high torrents in the rains and sometimes subject to flood.

The other two important rivers the Silabati and the Kangsabati are flowing in a south easterly course through the southern part of the study area.

Besides these major drainages, there are numbers of small streams (perennial or ephemeral) originating at comparatively higher altitude area and are draining a particular watershed. The drainage of the study area is characterized by dendritic and parallel pattern while radial type of drainage pattern has been found at few places. The major and the minor lineaments (N-S/NE-SW) are the principal control over the drainage system of the area.

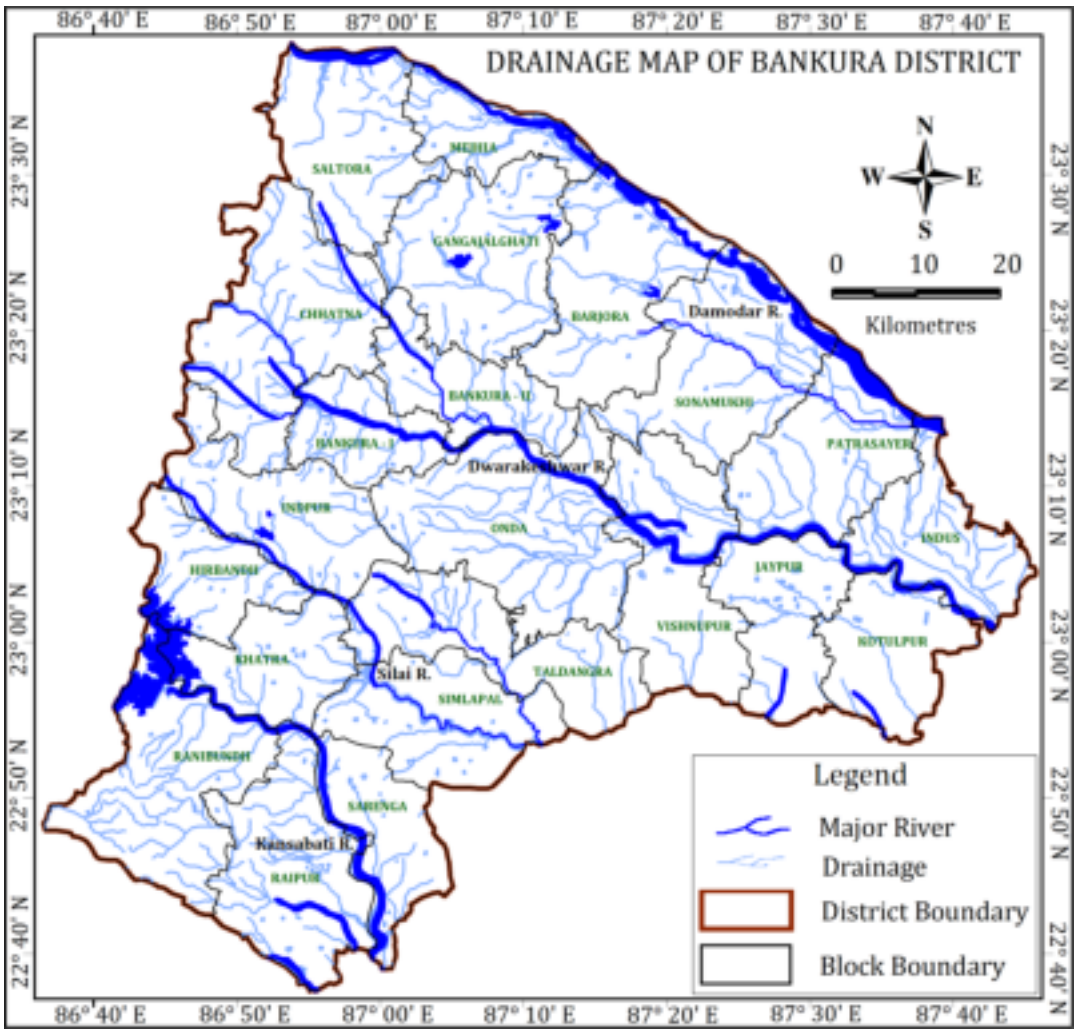


Figure 3.2.1 Drainage map of Bankura District.

3.3 Pedology:

Based on the parent lithological source the soil in the study area may be divided into following categories:

I. Soil originating in situ from parent materials like Gneisses, Anorthosite etc.

Soil at or near the ridge is lighter in texture, red to brown in colour, soil in between ridges and vicinity to ridges are light to medium texture and yellowish brown to brownish yellow colour whereas the soil at valley bottoms or its adjoining areas are mostly heavily textured and grey colour.

II. Laterite or Lateritic type of soils.

Laterisation is a predominant process of soil formation giving rise to red to brown laterite or lateritic soils as it falls under humid tropical area. Soils are lighter in texture and depth and width of laterite or lateritic soils varies widely.

The major part of Borjora block is covered by lateritic soil and a considerable area of Onda block is traversed by laterite soil. The laterite covered are is negligible in all other blocks of the study area.

III. Soil originated from Alluvial Parent Material.

This type of soil is developed in flat land due to deposition of transported materials brought by rivers. This soil is normally better in all respect in comparison to soils stated earlier and holds most of the cultivable and cultivated area. The texture of soils is loam, clay loam, silty loam, silty clay, clay and brown, grayish brown in colour.

Soils of Bankura district can broadly divided into three principal types of soils, which are as follows

Entisols: Comprising mainly younger alluvial soil. The younger alluvial soil in the district is confined to only extreme eastern part of the district in the blocks of Kotulpur and Indus. This type of soil gets enriched by silt deposition during floods. The area covered by younger alluvial soil is characterized by shallow water table, a heavy sub soil and occurrence of brown concretion at lower depths.

Alfisols: Comprising older alluvial soil and red soil. These red coloured sedimentary soils found mainly on laterites supporting vegetation. This type of soil is confined to south central and south western part of the district in and around Kotulpur and Raipur blocks. They are also found along margins of small hills bare of vegetations. This type of soil contains low calcium carbonate. Older alluvial soil is disposed in the blocks of Bishnupur, Joypur and Patrasayer. The colour of this soil varies from dark brown to greyish brown and its texture from loam to silty clay or clay.

Ultisols: Comprising mainly lateritic soil. These are lateritic soil which has distribution in the blocks of Bankura, Barjora, Taldangra and Onda. This type of soil is differentiated from the red soils by the occurrence of ferruginous concretions are distributed throughout the profile. This type of soil also contains calcium carbonate in the form of Kankar, Soil is lighter in texture, well drained and acidic.

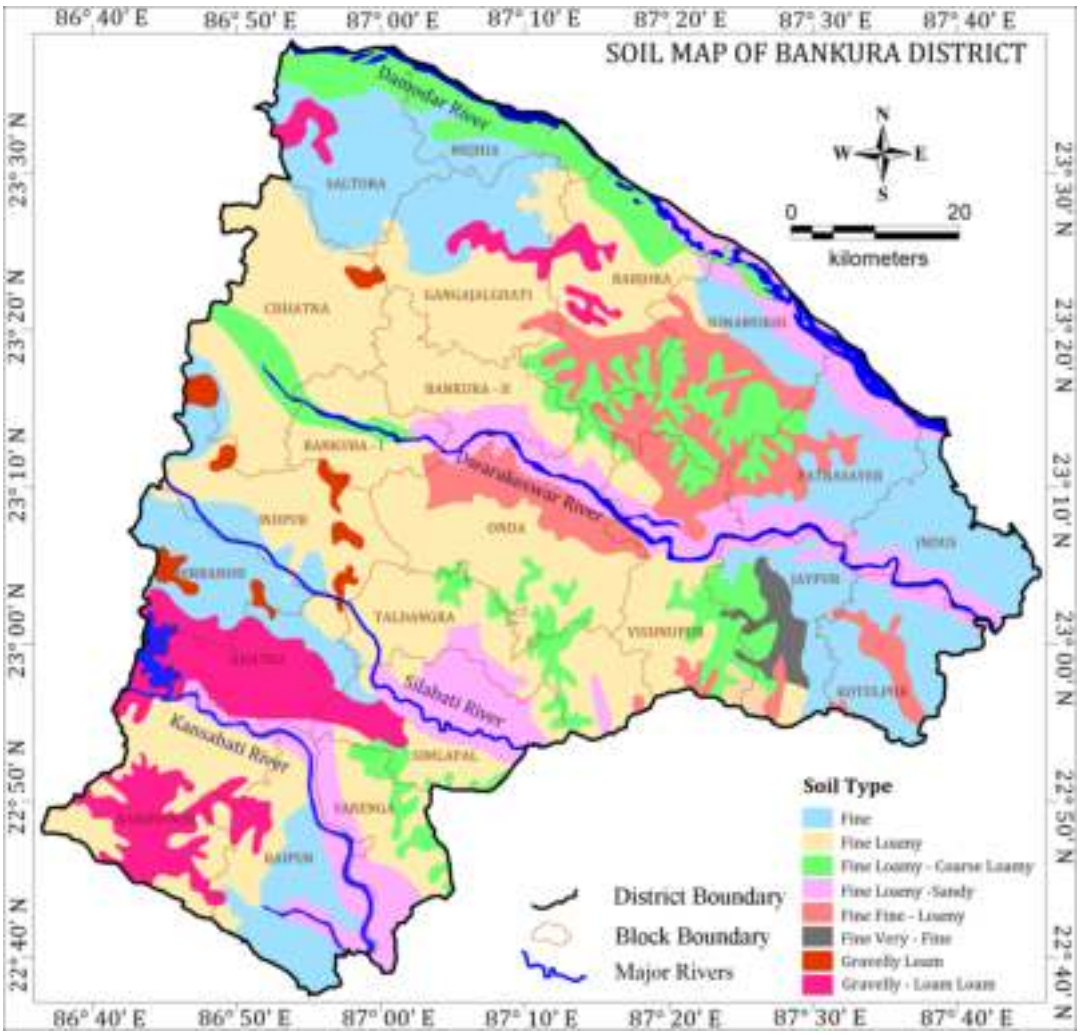


Figure 3.3.1 Soil Distribution map of Bankura District.

CHAPTER-4

GEOLOGY

4.1 General Geology

Bankura district is characterized by the various litho units of different geologic age. Broadly four litho units are exposed in the district. They are as follows;

I. Crystalline granite gneiss of Archean age, which are exposed in the western and south western part of the district.
II. Sedimentary sandstones and shales of Lower Gondwana age covering northern north western part of the district. Both Archeans and Gondwanas have been cut across dolerite dykes equivalent to Rajmahals.
III. Laterite and older alluvial deposits of Pleistocene age exposed in a linear tract in the central part of the district.
IV. The Recent alluvial deposit in the extreme eastern part.

The geology of Bankura district has been studied mainly by GSI and the State Directorate and others have carried out geological mapping in selected area. The tentative stratigraphic succession of the district has been suggested as follows.

Pre- Cambrian (Archean) Quartz veins, pegmatites, granite gneiss, hornblende schist, talc-hornblende schist, epidiorites, anorthosites, norites, sericite chlorite, carbon phyllites, chlorites, magnetite schists, dolomites, crystalline limestone, calc-granulite, quartzites and associated rocks.

The oldest rock types as exposed in the southern part of the district usually form ridges and hillocks in the district. These rocks are well foliated with a north-westerly trend with moderate to high easterly dips. They also exhibit well developed joint planes; three sets of joints have been identified. The relationship between these foliation planes and joint planes indicates that while one set of joints is parallel to the foliation plane, the second set is nearly perpendicular to the foliation plane and the third one trends NNE-SSW. Apart from these there are others sets of joints too, which are not well developed. The consolidated rocks belonging to the Archean groups covers Ranibundh, Indpur, Khatra, Chhatna, Saltora, parts of Mejhia, Gangajalghati and Raipur blocks.

Semi consolidated rocks belonging to to Gondwana group covers parts of Saltora, Mejia and Barjora blocks. Gondwana group in Bankura district comprises a succession of coarse-grained felspathic sandstones and grey micaceous shales.

Laterites which occur in the central blocks of Bishnupur and Joypur both as massive and nodules. Laterite along with older alluvium overlie the hard rocks of the Archean age in this part of the district.

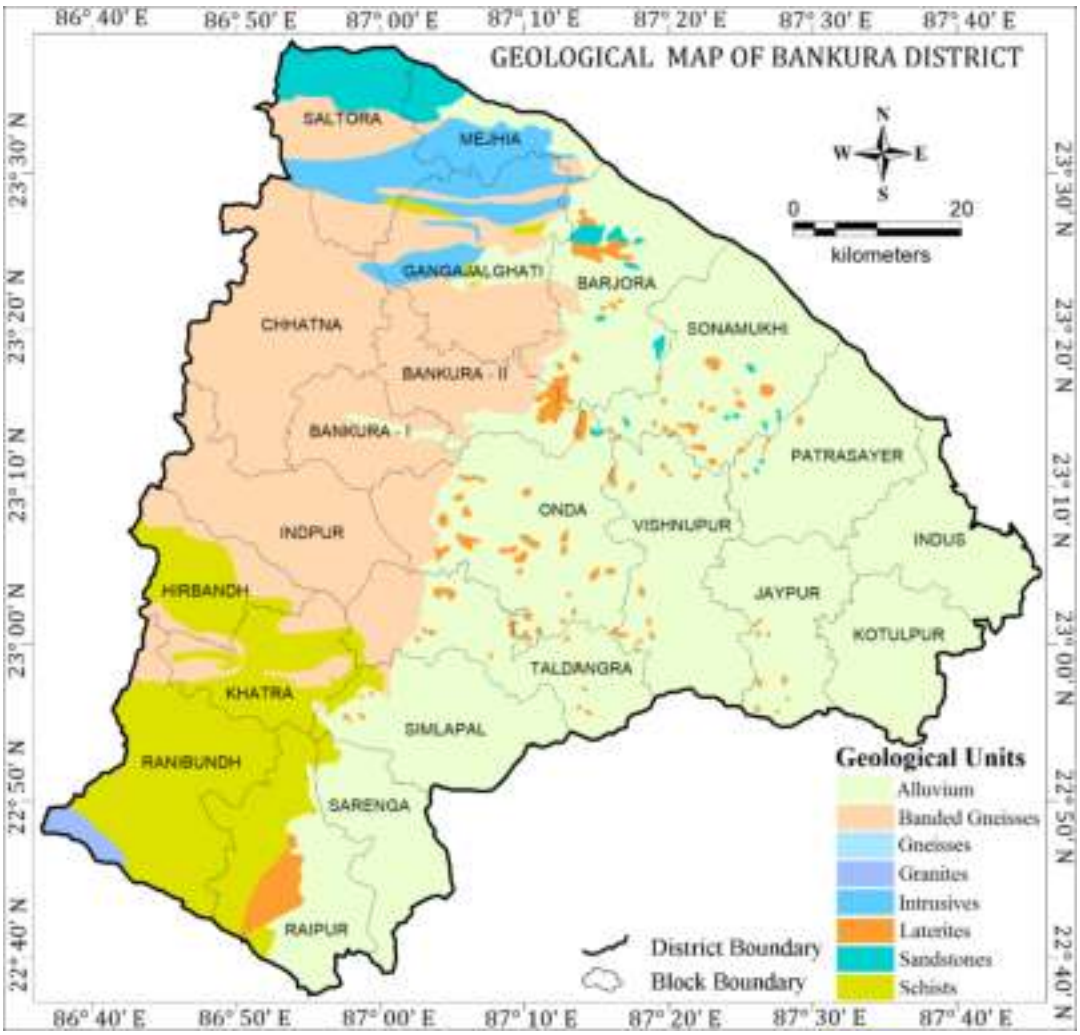


Figure 4.1.1 Geological Map of Bankura District

Alluvial Deposit of Recent age cover the eastern extreme part of the district in the blocks of Kotulpur, Indus and parts of Ptrasayer and Sonamukhi blocks.

The lithology of the area at and around the district is dominated by garnetiferous mica-schist &leuco-granite. This area is the easternmost extension of the East Indian Sheild& bounded by two mega lineaments: one has NNW-SSE trend. One lineament is separating laterite from Precambrian rocks. Another lineament trending east-west; probably is defined by 'Dalma Thrust'. The litho-units that encountered here are meta-sediments in nature. These are represented by altered mica-schist covered by thick alluvium and soil. Coarse grained melanocratic amphibolites are also noted here in the extreme north western part of the Puranpani village. Coarse granite outcrops also occur adjacent to JikhuNalah. At some places granites are gneissic in nature to some extent. Coarse Grained Granites are the host of the ore minerals. Near Saltora sandstone & shale are also noticed.

Table 4.1 Stratigraphic succession in Bankura District

Quaternary	Recent to Sub-recent Pleistocene	Alluvium and residual soil Laterities, Lateritic gravels
----------	Unconformity	----------
Tertiary	Mio-Pliocene	Gritty to medium grained ferruginous sandstones and gravels, coarse, yellowish feldspathic sandstones occasionally with clays.
----------	Unconformity	----------
Mesozoic	Triassic (Upper Gondwana)	Supra-Panchet Sandstones of Biharinath hills.
Paleozoic	Permo-Carboniferous (Lower Gondwana)	Sandstone and shale with coal seams both in the Raniganj formation and in the Barakar formation.
----------	Unconformity	----------
Riphean	Lower Palaeozoic to Purana	Quartzite of Susunia hill and the quartzite gritty sandstone near Beliator.
----------	Unconformity	----------
Archean		Dolerite, pegmatite, aplite and vein quartz. Granite, granite gneiss, norite, anorthosite, amphibolite, epidiorite, pyroxene-granulite. Para-gneisses and schist, Cale-silicates, calc-schist, quartz-schist, mica-schist, hornblende schist, gneisses, quartzite, Calc-granulite with dolomitic and crystalline limestone etc.

**Source: Geological Survey of India*

The Chhotanagpur granite gneiss complex which is occurring around Saltora is mainly Quartzo-feldspathic gneiss and within this anorthosite has been intruded. The outcrop of anorthosites exhibit heterogeneity of deformation & is probably due to the impact of shear regime related to the North Purulia Shear Zone (NPSZ). Susunia hills in Bankura district lies within Singbhum group of rocks. The Singbhum group of rocks and Chhotanagpur granite gneiss complex are linked by a narrow lineament, viz., Purulia-Bankura Shear Zone. A study of Sususnia Hill (top R.L. 442 metre) reveals its presence in the Chhotanagpur gneissic plateau of West Bengal. On the other hand, Mukutmanipur

of Bankura (Latitude: 22º57'47.87", Longitude: 86º47'0.04") is characterized by the presence of granite gneiss. Towards the western part of Kangsabati barrage, at the river base, highly fractured & jointed granite-gneiss is exposed (Latitude: 22º57'48.21", Longitude: 86º47'18.08"). The granite gneiss has distinct quartz-vein & reef quartz. Gabbro & anorthosite are present around Saltora. Granites are present at Thanpahar, Satnala &Cheradungri. Amphibolites occur near Bheduasol. In Bankura, anorthosite occurs at lower topography. Clay is seen below laterite and above anorthosite and granitic rocks as an altered product of the phenomenon of Kaolinisation.

4.2 Sub-Surface Geology:

The sub-surface lithological characteristics is explored from the existing drill holes records and lithological logs of the bore holes. The borehole data is rare in the central and the western parts of the study area being underlain by hard crystalline basement at shallower depth. However, in these cases, the Schlumberger Soundings (VES) is proved to be useful tool to decipher the sub-surface geological sections. The hard rock area is represented by soil cover, weathered and semi-weathered mantle; fractured/jointed formation successively underlain by dry, hard, massive rocks.

The central and eastern parts are covered by alluvium underlain by Tertiary formation. The western and the southwestern part of the district covered by the gneisses and schists of the Archaean age remain practically unexplored in terms of sub-surface geology.

Exploration carried out in the alluvial part of the district reveals that the depth to crystalline rocks increases towards east and southeastward, which implies that the thickness of alluvial sediments increases eastward.

CHAPTER-5

GEOPHYSICS

5.1 Geophysical Studies

TRANSIENT ELECTROMAGNETIC (TEM) SURVEY

Time-domain EM methods represent an alternative approach to detecting weak secondary magnetic fields. This works by simply switching the primary field off and observing the decay of the secondary magnetic fields. This method is often referred to as transient electromagnetic exploration (TEM) or time-domain electromagnetic (TDEM) exploration.

Electric current flows through the transmitter loop and generate a static primary magnetic field (HP). The transmitter current is then switched off and the primary magnetic field immediately falls to zero. This change in magnetic field induces a secondary electric current in the Earth. The secondary current acts to oppose the decrease in the primary magnetic field (Lenz's Law). The secondary electric current distribution can be approximated as a horizontal loop of current and generates a secondary magnetic field, HS (t). Over time the secondary electric currents spread out (diffuse) in a pattern that is similar to a smoke ring. The secondary current moves

deeper as time increases and thus gives information about progressively deeper structure. Initially the magnetic field is oriented downwards at the RX. As the current rings pass beneath the RX, the sign of HS change. Nabighian (1979) described the pattern of electric currents as being like smoke rings. This process can also be visualized as a contour plot of electric current density.

In a layered Earth, the ring of electric current will propagate downwards and outwards through the various layers. In a low resistivity layer the decay will be relatively slow. In a high resistivity layer, the decay will be relatively fast. Thus observation of the decay of HS with time can tell us how resistivity varies with depth. Time domain data can be converted into the equivalent of apparent resistivity.

These ground-based TDEM systems can use a flexible layout and the TX size can be adjusted from 1 x 1 m to 2000 x 2000 m. larger loops can be used to boost signal strength and give deeper signal penetration. Having the TX and RX stay in the same location for a period of time allows stacking i.e., record many on-off cycles of the TX and adds the responses together. This allows detection of weaker signals and the removal of incoherent noise. Time Domain Electromagnetic Survey has applications such as mapping the thickness of aquifers, clay layers and assessing water quality.

The choice of loop configuration depends primarily on the survey objective; it impacts on survey productivity, sensitivity, resolution, noise immunity, depth penetration, and ease of interpretation. The coincident loop configuration (**Figure-1**) is recommended for the majority of surveys. It combines high productivity (for linear traverses adopting station spacing equal to the loop diameter), low noise and good sensitivity for deep targets. Once established, productivity rates of 36 minutes per station can be achieved across clear terrain for loop sizes of 50 m or less. Loops should be offset by at least 1 m to avoid possible Super-paramagnetic (SPM) effects. Depth penetration of this configuration is typically 2-3 times the loop diameter.

Based on the detailed hydro-geological studies of the area, Transient Electromagnetic Survey (TEM) was carried out to find out the sub-surface formations in view of ground water occurrences in terms of quantity and quality. To delineate the sub-surface formations the total one hundred eight (108) number of Transient Electromagnetic (TEM) Survey were carried out in parts of six districts of West Bengal in Coincident Loop Configuration with loop area of 1600 square meter using terraTEM24.

Location of TEM survey is selected as per availability of open workable space to cover the entire area. The loop size controls the depth of investigation and the desired size facilitates to get the sub-surface information to the depths. The TEM curves are interpreted by using “IX1D” software. The ‘IX1D’ software is based on principal of

inversion which takes the geo-electrical parameters as input and the output is in the form of layer parameters in terms of resistivity and thickness. In this computer aided curve matching technique, an initial model is given for which the computer arrives at the theoretical curve and compares with the field data; then it takes difference between the recomputed and field curves and modifies old model parameters to start with a new model for reducing this difference (error). Again computes new theoretical curve and compares with the field curve, and sets another new model to reduce the differences. This process of iteration goes on till the error is minimized and finally displays the match between the field and theoretical curves giving the final model parameters. The final results were corroborated with the known hydro-geological conditions existing in the area. The final interpreted geo-electrical layer parameters of TEM's (layer resistivity and layer depths), inferred geology, block-wise location maps and few interpreted TEM curves are given in the running text.

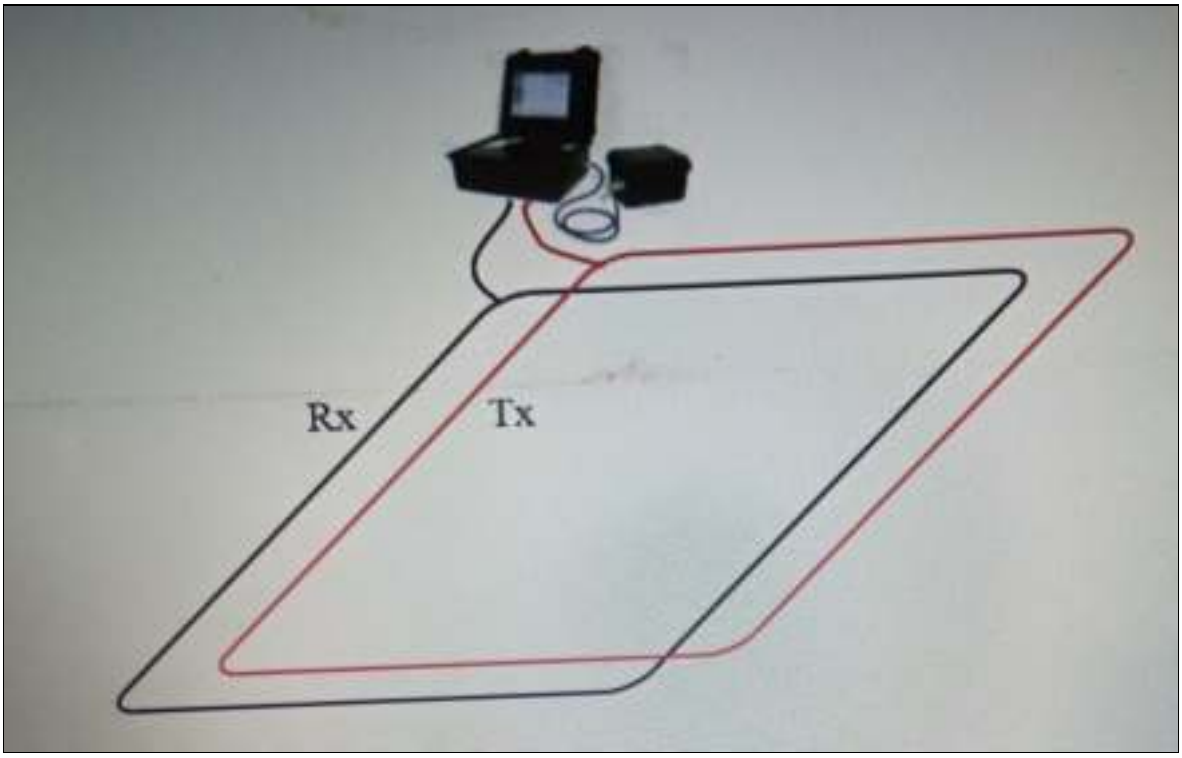


Figure 5.1.1: Coincident loop configuration.

5.2 RESULTS AND DISCUSSION

A total thirty-one (31) numbers of TEM surveys have been carried out in block Saltora, Purulia district, West Bengal at fifteen locations namely Haroka, Gogva, Kanari, Shyampur, Saltora, Sharbedia, Udaypur, Nabagram, Dighit, Tentultokuri, Dhapali, Piprabad, Pobra, Durlavpur and Majit. The location map is shown in **Figure-5.2.1**. The interpreted layer parameter is given in **Table-5.2.1** and inferred geology is given in **Table-5.2.2**.

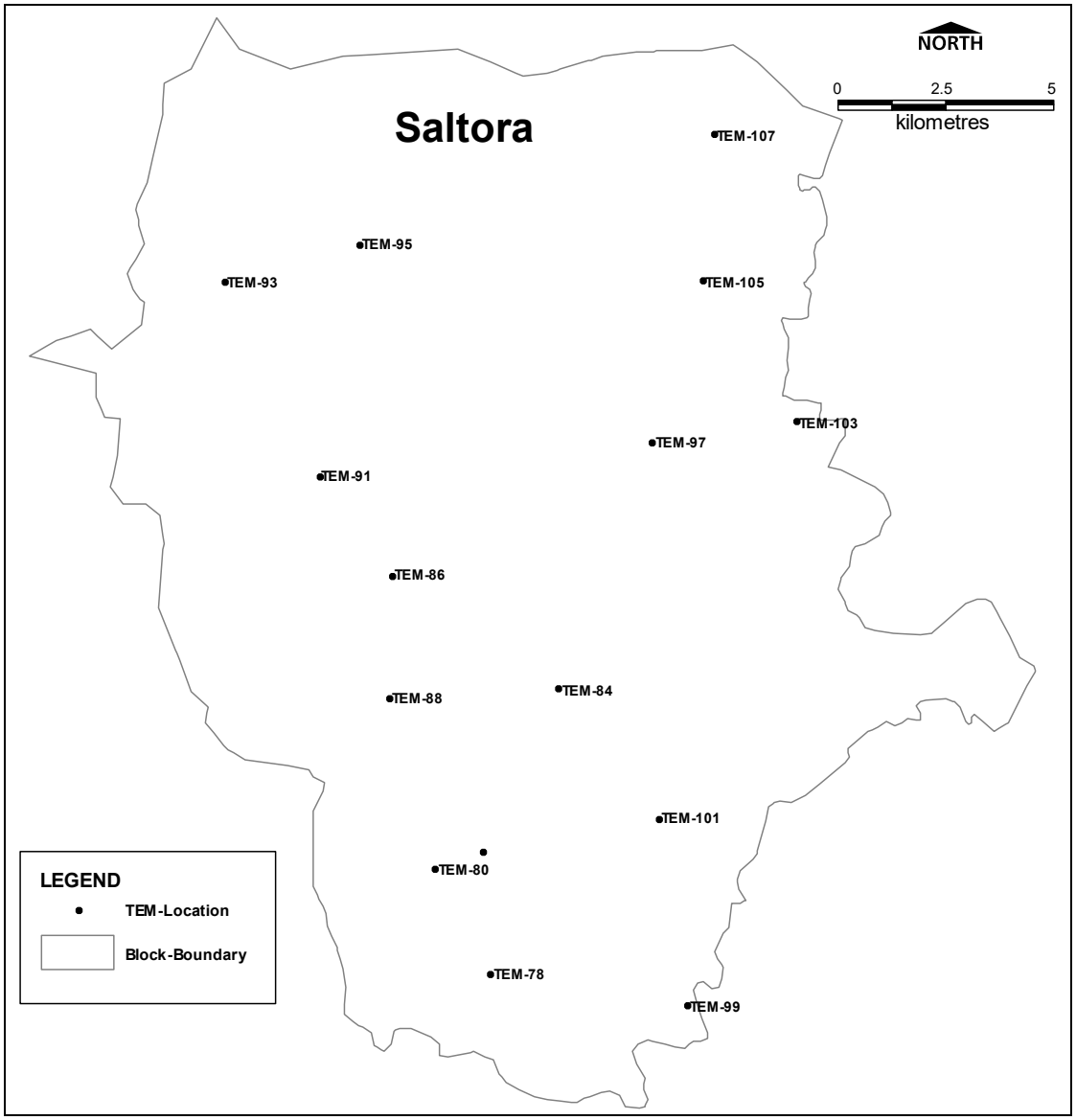


Figure-5.2.1: TEM location in Saltora block of Bankura district.

Table-5.2.1 Interpreted layer parameters of TEM curves carried out in Bankura district.

S.No.	TEM No.	District	Location	Respective layer Resistivity in (Ohm-m)				Respective layer Depth in (m)		
				ρ_1	ρ_2	ρ_3	ρ_4	D_1	D_2	D_3
1	TEM-78	Bankura	Haroka-1	36	18	700	1300	1	5.8	35
2	TEM-79	Bankura	Haroka-2	33	17	1150	2000	1	5.8	34
3	TEM-80	Bankura	Gogva-1	35	18	1650	3000	1	5.8	34
4	TEM-81	Bankura	Gogva-2	48	25	320	700	1	5.8	34
5	TEM-82	Bankura	Kanurai-1	124	1500	55	10000	1	5.8	34
6	TEM-83	Bankura	Kanurai-2	380	3000	67	1650	1	5.8	35
7	TEM-84	Bankura	Shyampur-1	100	250	63	2000	1	5.9	34

8	TEM-85	Bankura	Shyampur-2	40	17	9000	12000	1	5.7	33
9	TEM-86	Bankura	Saltora-1	30	21	1400	5000	1	5.9	33
10	TEM-87	Bankura	Saltora-2	35	16	2300	7000	1	5.8	34
11	TEM-88	Bankura	Shiarbedia-1	36	11	400	240	1	5.7	34
12	TEM-89	Bankura	Shiarbedia-2	38	14	220	127	1	5.8	34
13	TEM-90	Bankura	Shiarbedia-3	26	12	220	350	1	5.8	34
14	TEM-91	Bankura	Udaipur-1	30	15	900	52	1	5.7	33
15	TEM-92	Bankura	Udaipur-2	38	21	550	77	1	5.8	35
16	TEM-93	Bankura	Nabagram-1	38	7.5	87	30	1	6	33
17	TEM-94	Bankura	Nabagram-2	30	17	32	29	1	5.8	34
18	TEM-95	Bankura	Dighit-1	12	18	35	29	1	5.9	34
19	TEM-96	Bankura	Dighit-2	25	65	22	30	1	5.8	34
20	TEM-97	Bankura	Tentultokuri-1	29	11	300	1000	1	5.9	33
21	TEM-98	Bankura	Tentultokuri-2	24	14	650	3000	1	6	34
22	TEM-99	Bankura	Dhapali-1	31	11	1500	7000	1	5.8	34
23	TEM-100	Bankura	Dhapali-2	55	14	74	3000	1	5.8	34
24	TEM-101	Bankura	Pirrabad-1	32	12	285	2000	1	5.9	32
25	TEM-102	Bankura	Pirrabad-2	31	21	113	6000	1	5.8	34
26	TEM-103	Bankura	Pobra-1	31	475	8	18	1	5.8	34
27	TEM-104	Bankura	Pobra-2	86	475	8	16	1	5.8	34
28	TEM-105	Bankura	Durlavpur-1	5	17	50	17	1	5.7	34
29	TEM-106	Bankura	Durlavpur-2	8	20	32	22	1	5.9	35
30	TEM-107	Bankura	Majit-1	47	13	47	32	1	5.9	34
31	TEM-108	Bankura	Majit-2	30	55	26	35	1	5.8	34

Table-5.2.2 Stratigraphy of TEM curves carried out in Bankura district.

Location	Depth1	Depth2	Stratigraphy
Haroka-1	0	1	Top Soil
	1	5.8	Weathered Rock
	5.8	35	Fractured Rock
	35	100	Hard Rock
Haroka-2	0	1	Top Soil
	1	5.8	Weathered Rock
	5.8	34	Fractured Rock
	34	100	Hard Rock
Gogva-1	0	1	Top Soil
	1	5.8	Weathered Rock
	5.8	34	Fractured Rock
	34	100	Hard Rock
Gogva-2	0	1	Top Soil
	1	5.8	Weathered Rock
	5.8	34	Fractured Rock
	34	100	Hard Rock
Kanari-1	0	1	Top Soil

	1	5.8	Laterite
	5.8	34	Weathered Rock
	34	100	Hard Rock
Kanari-2	0	1	Top Soil
	1	5.8	Laterite
	5.8	35	Weathered Rock
	35	100	Hard Rock
Saltora-1	0	1	Top Soil
	1	5.9	Weathered Rock
	5.9	33	Fractured Rock
	33	100	Hard Rock
Saltora-2	0	1	Top Soil
	1	5.8	Weathered Rock
	5.8	34	Fractured Rock
	34	100	Hard Rock
Sharbedia-1	0	1	Top Soil
	1	5.7	Clay with Kankar
	5.7	34	Fractured Rock
	34	100	Weathered Rock
Sharbedia-2	0	1	Top Soil
	1	5.8	Clay with Kankar
	5.8	34	Fractured Rock
	34	100	Weathered Rock
Sharbedia-3	0	1	Top Soil
	1	5.8	Clay with Kankar
	5.8	34	Weathered Rock
	34	100	Fractured Rock
Udaypur-1	0	1	Top Soil
	1	5.7	Clay with Kankar
	5.7	33	Fractured Rock
	33	100	Weathered Rock
Udaypur-2	0	1	Top Soil
	1	5.8	Clay with Kankar
	5.8	35	Fractured Rock
	35	100	Weathered Rock
Nabagram-1	0	1	Top Soil
	1	6	Clay
	6	33	Fine to Medium Sand
	33	100	Fine Sand
Nabagram-2	0	1	Top Soil
	1	5.8	Fine Sand
	5.8	34	Fine to Medium Sand
	34	100	Fine Sand
Dighit-1	0	1	Top Soil
	1	5.9	Fine Sand
	5.9	34	Fine to Medium Sand
	34	100	Fine Sand
Dighit-2	0	1	Top Soil
	1	5.8	Fine to Medium Sand
	5.8	34	Fine Sand
	34	100	Fine to Medium Sand
Tentultokuri-1	0	1	Top Soil
	1	5.9	Clay with Kankar
	5.9	33	Fractured Rock
	33	100	Hard Rock
Tentultokuri-2	0	1	Top Soil
	1	6	Clay with Kankar

	6	34	Fractured Rock
	34	100	Hard Rock
Dhapali-1	0	1	Top Soil
	1	5.8	Clay with Kankar
	5.8	34	Fractured Rock
	34	100	Hard Rock
Dhapali-2	0	1	Top Soil
	1	5.8	Clay with Kankar
	5.8	34	Fractured Rock
	34	100	Hard Rock
Piprabad-1	0	1	Top Soil
	1	5.9	Clay with Kankar
	5.9	32	Fractured Rock
	32	100	Hard Rock
Piprabad-2	0	1	Top Soil
	1	5.8	Clay with Kankar
	5.8	34	Fractured Rock
	34	100	Hard Rock
Pobra-1	0	1	Top Soil
	1	5.8	Medium to Coarse Sand
	5.8	34	Clay
	34	100	Fine Sand
Pobra-2	0	1	Top Soil
	1	5.8	Medium to Coarse Sand
	5.8	34	Clay
	34	100	Fine Sand
Durlavpur-1	0	1	Top Soil
	1	5.7	Fine Sand
	5.7	34	Fine to Medium Sand
	34	100	Fine Sand
Durlavpur-2	0	1	Top Soil
	1	5.9	Fine Sand
	5.9	35	Fine to Medium Sand
	35	100	Fine Sand
Majit-1	0	1	Top Soil
	1	5.9	Sandy Clay
	5.9	34	Fine to Medium Sand
	34	100	Fine Sand
Majit-2	0	1	Top Soil
	1	5.8	Fine to Medium Sand
	5.8	34	Fine Sand
	34	100	Fine to Medium Sand

1. Haroka, Saltora, Bankura (TEM-78)

A total two (2) numbers of TEM (TEM-78 to TEM-79) has been carried out in Haroka village area of Saltora block in Bankura district, West Bengal at interval of 40 m. The interpretation of all the two TEM's are showing four layers earth model in the hard rock terrain. The interpretation of TEM-78 curve is shown in **Figure-5.2.2**. The first layer is having resistivity value 36 Ohm-m and thickness of 1 m is sandy formation as top soil. The second layer with resistivity value 180hm-m and depth upto5.8 m is indicative of weathered rock with clay. The third layer is having resistivity value 700 Ohm-m and depth upto 35m shows the formation as fractured rock. The fourth and last layer with

resistivity value 1300 Ohm-m is indicative of hard rock extended upto depth of investigation as 100 m.

This location is suitable for tapping fresh ground water upto depth of 35 m.

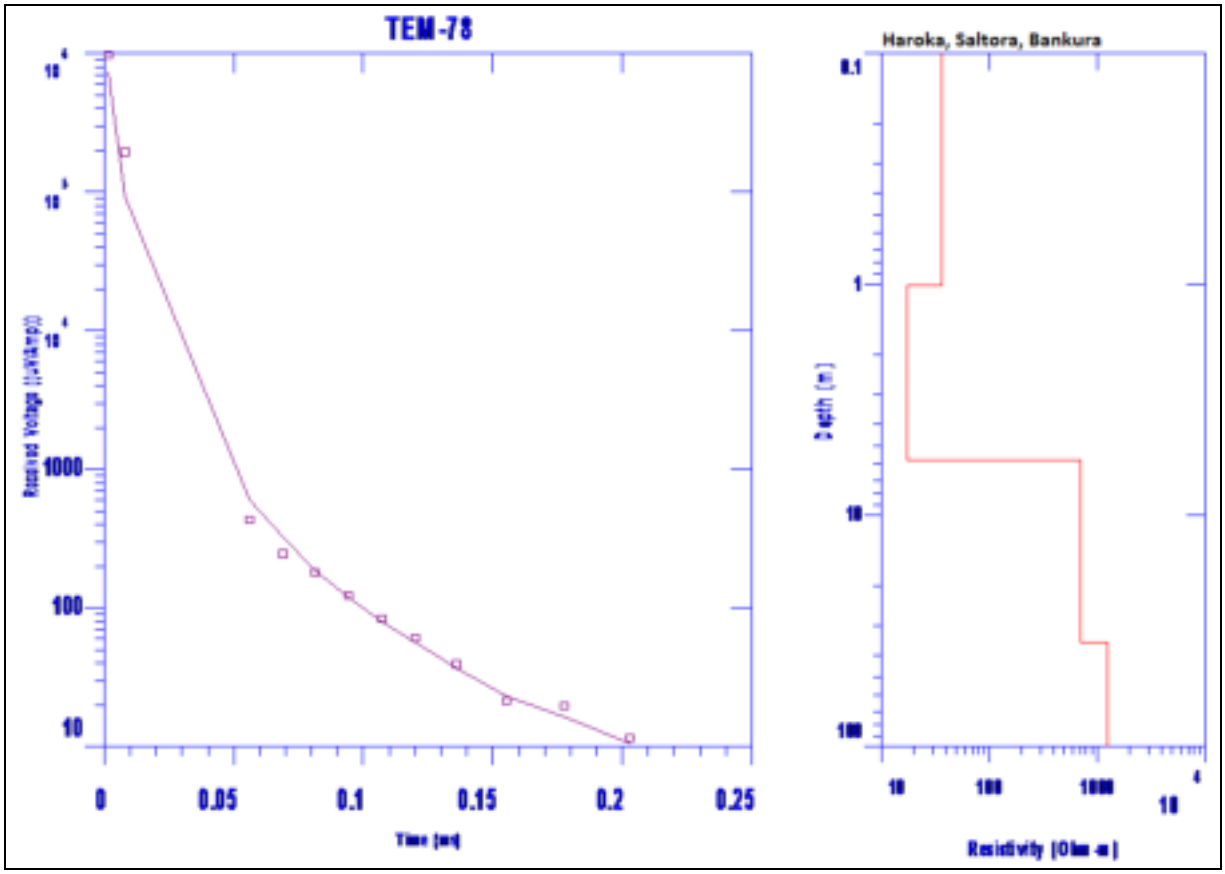


Figure-5.2.2: Interpretation of TEM-78 curve at Haroka, Saltora, Bankura.

2. Saltora, Saltora, Bankura (TEM-86)

A total two (2) numbers of TEM (TEM-86 to TEM-87) has been carried out in Saltora village area of Saltora block in Bankura district, West Bengal at interval of 40 m. The interpretation of all the two TEM's are showing four layers earth model in the hard rock terrain. The interpretation of TEM-86 curve is shown in **Figure-5.2.3**. The first layer is having resistivity value 30 Ohm-m and thickness of 1 m is sandy formation as top soil. The second layer with resistivity value 21 Ohm-m and depth upto 5.9 m is indicative of weathered rock with clay. The third layer is having resistivity value 1400 Ohm-m and depth upto 33 m shows the formation as fractured rock. The fourth and last layer with resistivity value 5000 Ohm-m is indicative of hard rock extended upto depth of investigation as 100 m.

This location is suitable for tapping fresh ground water upto depth of 33 m.

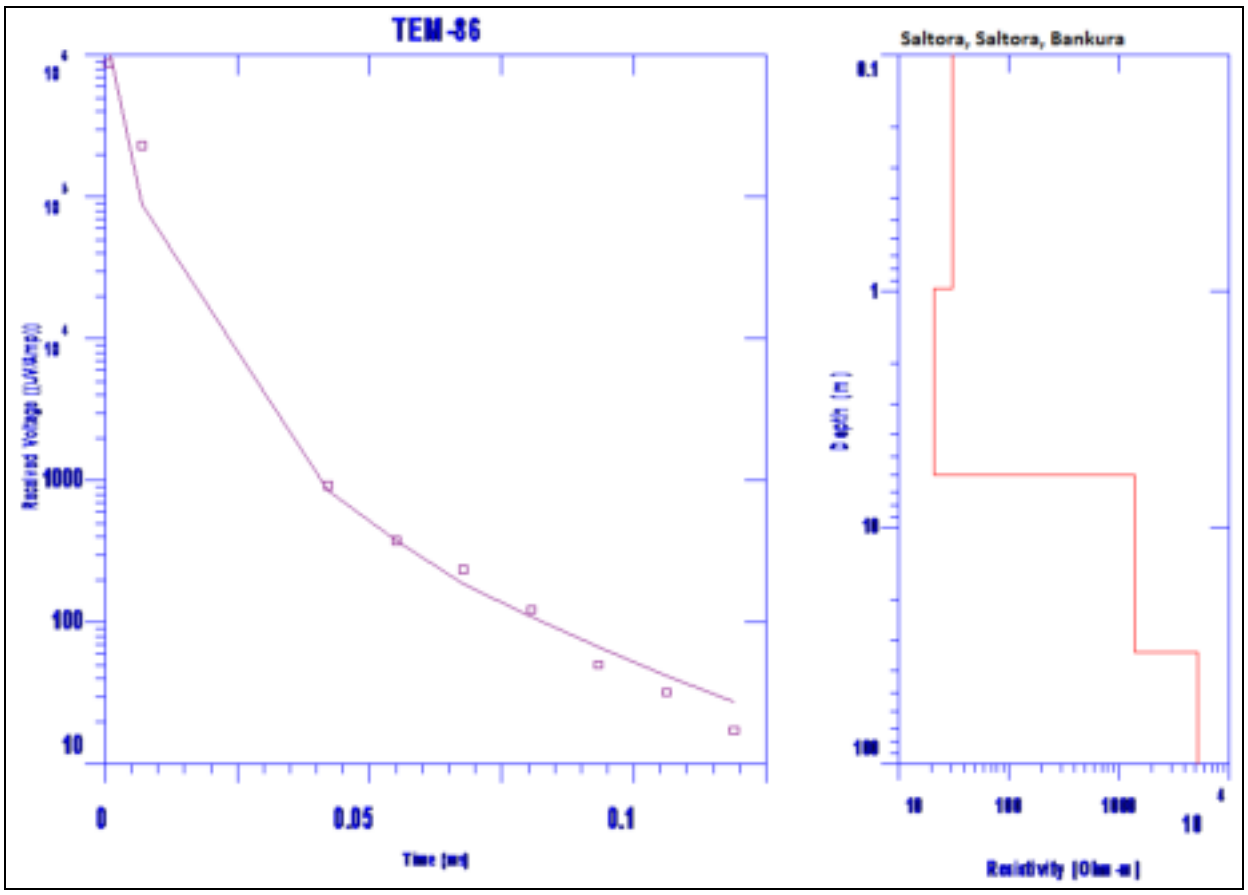


Figure-5.2.3: Interpretation of TEM-86 curve at Saltora, Saltora, Bankura.

3. Nabagram, Saltora, Bankura (TEM-93)

A total two (2) numbers of TEM (TEM-93 to TEM-94) has been carried out in Nabagram village area of Saltora block in Bankura district, West Bengal at interval of 40 m. The interpretation of all the two TEM's are showing four layers earth model in the hard rock terrain. The interpretation of TEM-93 curve is shown in **Figure-5.2.4**. The first layer is having resistivity value 38 Ohm-m and thickness of 1 m is sandy formation as top soil. The second layer with resistivity value 7.5Ohm-m and depth upto6 m is indicative of clay formation. The third layer is having resistivity value 87 Ohm-m and depth upto 33m shows the formation as fine to medium grained sand. The fourth and last layer with resistivity value 30 Ohm-m is indicative of fine sand formation extended upto depth of investigation as 100 m.

This location is suitable for tapping fresh ground water upto depth of 100 m.

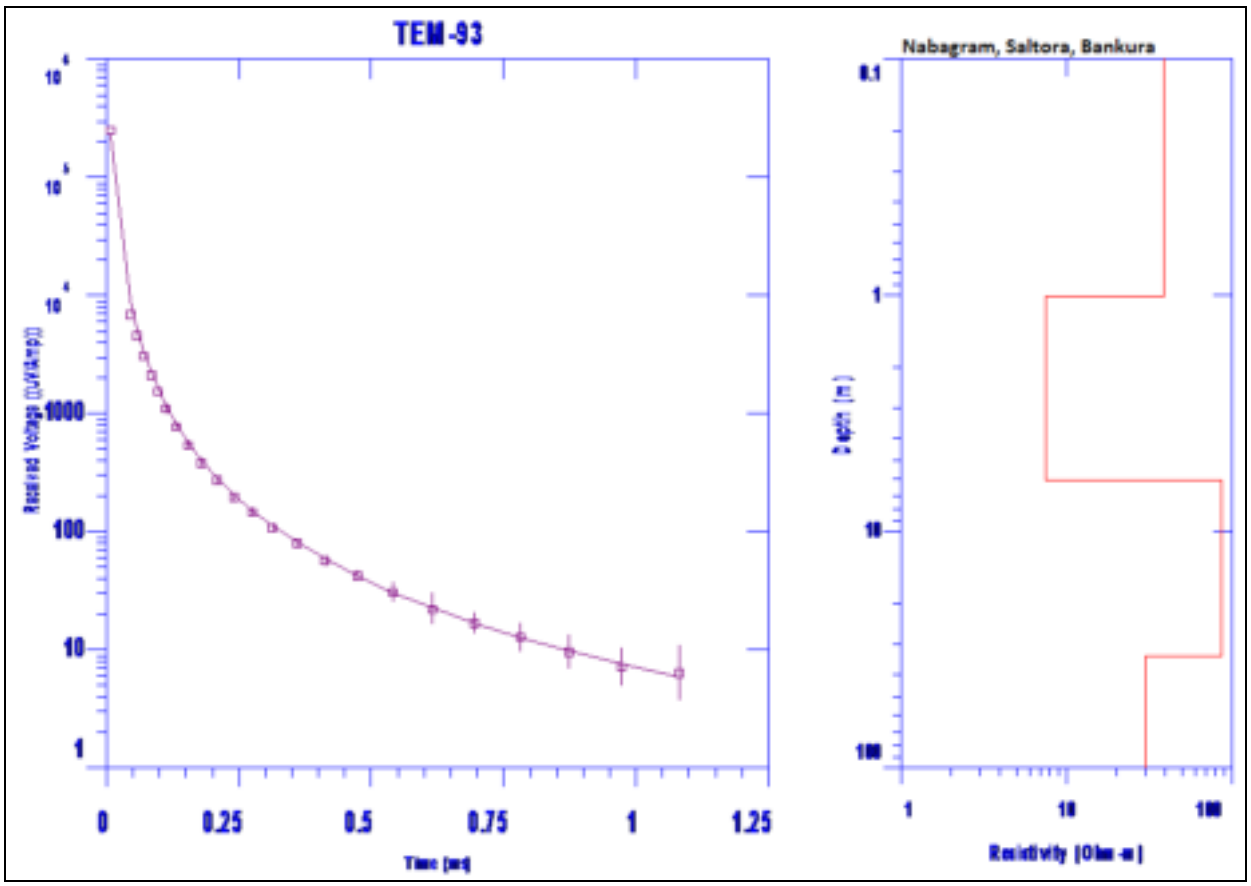


Figure-5.2.4: Interpretation of TEM-93 curve at Nabagram, Saltora, Bankura.

4. Pobra, Saltora, Bankura (TEM-103)

A total two (2) numbers of TEM (TEM-103 to TEM-104) has been carried out in Pobra village area of Saltora block in Bankura district, West Bengal at interval of 40 m. The interpretation of all the two TEM's are showing four layers earth model in the hard rock terrain. The interpretation of TEM-103 curve is shown in **Figure-5.2.5**. The first layer is having resistivity value 31 Ohm-m and thickness of 1 m is sandy formation as top soil. The second layer with resistivity value 475Ohm-m and depth upto 5.8 m is indicative of unsaturated coarse sand formation. The third layer is having resistivity value 8 Ohm-m and depth upto 34m shows the formation as clay. The fourth and last layer with resistivity value 18 Ohm-m is indicative of fine sand formation extended upto depth of investigation as 100 m.

This location is suitable for tapping fresh ground water upto depth of 100 m.

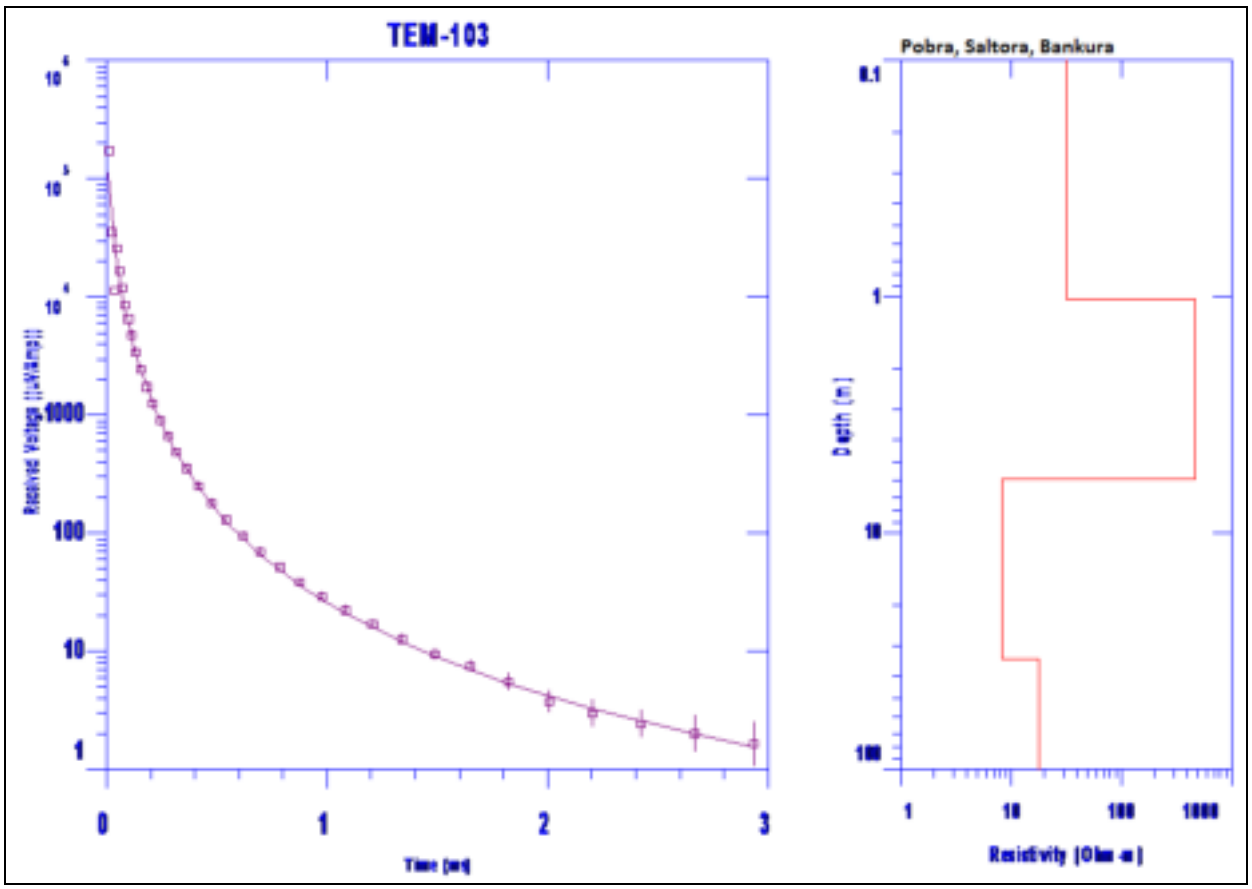


Figure-5.2.5: Interpretation of TEM-103 curve at Pobra, Saltora, Bankura.

5. Majit, Saltora, Bankura (TEM-107)

A total two (2) numbers of TEM (TEM-107 to TEM-108) has been carried out in Majit village area of Saltora block in Bankura district, West Bengal at interval of 40 m. The interpretation of all the two TEM's are showing four layers earth model in the hard rock terrain. The interpretation of TEM-78 curve is shown in **Figure-5.2.6**. The first layer is having resistivity value 47 Ohm-m and thickness of 1 m is sandy formation as top soil. The second layer with resistivity value 13Ohm-m and depth upto 5.9 m is indicative of sandy clay formation. The third layer is having resistivity value 47 Ohm-m and depth upto 34m shows the formation as fine to medium grained sand. The fourth and last layer with resistivity value 32 Ohm-m is indicative of fine-grained sand formation extended upto depth of investigation as 100 m.

This location is suitable for tapping fresh ground water upto depth of 100 m.

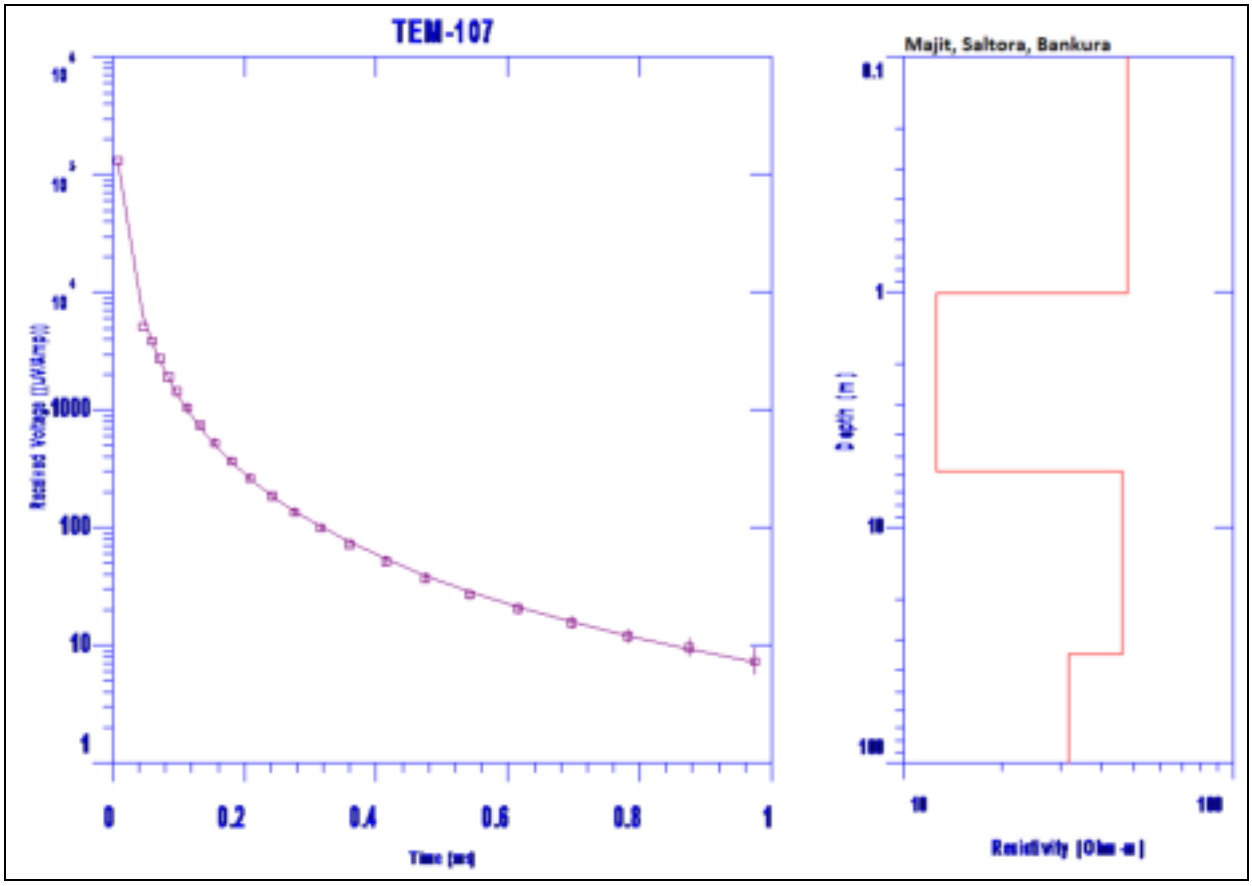


Figure-5.2.6: Interpretation of TEM-107 curve at Majit, Saltora, Bankura.

Table5.2.3: TEM locations in Bankura District

TEM No.	District	Block	Location	Longitude	Latitude
TEM-78	Bankura	Saltora	Harova-1	86.959722	23.440833
TEM-79	Bankura	Saltora	Harova-2	86.959732	23.440852
TEM-80	Bankura	Saltora	Gogva-1	86.946959	23.462784
TEM-81	Bankura	Saltora	Gogva-2	86.946973	23.462792
TEM-82	Bankura	Saltora	Kanurai-1	86.958056	23.466389
TEM-83	Bankura	Saltora	Kanurai-2	86.958064	23.466412
TEM-84	Bankura	Saltora	Shyampur-1	86.975278	23.500556
TEM-85	Bankura	Saltora	Shyampur-2	86.975302	23.500564
TEM-86	Bankura	Saltora	Saltora-1	86.937255	23.523862
TEM-87	Bankura	Saltora	Saltora-2	86.937265	23.523889
TEM-88	Bankura	Saltora	Shiarbedia-1	86.936944	23.498611
TEM-89	Bankura	Saltora	Shiarbedia-2	86.936978	23.498623
TEM-90	Bankura	Saltora	Shiarbedia-3	86.936997	23.498630
TEM-91	Bankura	Saltora	Udaipur-1	86.920833	23.544722
TEM-92	Bankura	Saltora	Udaipur-2	86.920842	23.544742
TEM-93	Bankura	Saltora	Nabagram-1	86.899167	23.585278
TEM-94	Bankura	Saltora	Nabagram-2	86.899176	23.585305
TEM-95	Bankura	Saltora	Dighit-1	86.930000	23.593056

TEM-96	Bankura	Saltora	Dighit-2	86.930007	23.593098
TEM-97	Bankura	Saltora	Tentultokuri-1	86.996667	23.551944
TEM-98	Bankura	Saltora	Tentultokuri-2	86.996678	23.551976
TEM-99	Bankura	Saltora	Dhapali-1	87.004722	23.434444
TEM-100	Bankura	Saltora	Dhapali-2	87.004746	23.434456
TEM-101	Bankura	Saltora	Pirrabad-1	86.998056	23.473056
TEM-102	Bankura	Saltora	Pirrabad-2	86.998065	23.473079
TEM-103	Bankura	Saltora	Pobra-1	87.036111	23.562500
TEM-104	Bankura	Saltora	Pobra-2	87.036119	23.562528
TEM-105	Bankura	Saltora	Durlavpur-1	87.008056	23.585556
TEM-106	Bankura	Saltora	Durlavpur-2	87.008072	23.585586
TEM-107	Bankura	Saltora	Majit-1	87.010833	23.616111
TEM-108	Bankura	Saltora	Majit-2	87.010839	23.616138

Conclusions:

Based on interpretation of TEM data carried out in Saltora block of Bankura district reveals that northern part of the block close to Damodar River and eastern part of the block is occupied by the alluvium formation. The western and southern part of the block is covered by hard rock. The ground water occurrence confined to the sand formation in alluvium and fractured rock.

CHAPTER-6

HYDROGEOLOGY

6.1 Water bearing Formation

Bankura district displays diversified hydrogeological characters that do not have resemblance with the planes. Based on geology and mode of occurrence of groundwater the underline area of the district has been divided into three sectors

I. Western sector covered by crystalline rocks of Archean age.
II. Middle sector covered by laterite and Older Alluvium formation of Pleistocene age and
III. Eastern sector covered by Recent Alluvium.

Groundwater in the district occurs both under water table condition and confined condition. The water table generally declines with the varying gradients from west, north-west to east and south-east directions and broadly confirms to the topographical slopes. In the western sector comprising mainly of Crystalline rocks ground water occurs in the weathered mantle of varying thickness from 6 metre to 15 metre under water table conditions. In many parts of the area lateritic gravels lies on the weathered basement rock that attributes favourable condition for percolation of rain water. The block of Chatna, Bankura-I, Saltora, Gangajalghati, Ranibandh, Khattra, Hirbandh and Indpur falls under this sector. In the middle sector covered by laterite and older alluvium, groundwater occurs in the moderately thick to thin aquifer under unconfined to semi confined condition. Heterogeneous character of the water bearing formation with complex aquifer geometry prevails in the area and is feasible for open dug wells of 10 metre to 15 metre depth with 3 metres of diameters. The complete or parts of the blocks of Bankura II, Mejia, Taldangra, Simlapal, Raipur &Sarenga fall under this sector. Ground water occurs under confined condition below a blanket of clay whose thickness varies around 10 metres. In the eastern alluvial area of Indus, Kotulpur & Joypur blocks. The diverse geological set up of the district control the hydrogeological condition of the district. In areas underlain by hard crystalline and Gondwana rocks, ground water occurs under unconfined condition in the weathered residuum down to the depth of about 15 mbgl and under semi-confined to confined condition in the fracture zones in the depth span of 30-60 mbgl.

Ground water from the zone of secondary porosities is being developed through bore wells and yield to the tune of 45-150 lpm. About 2/3rd of the district is covered by alluvium, older alluvium and laterites occur in central-southern part of the district; ground water exploration carried out in the area indicates that the thickness of the alluvial sediments increases eastward from 36m in the marginal part to 150m in the eastern most part. The potential aquifers exist between 30-95 mbgl and the discharge of the wells varies from 20-124 m^3/hr with drawdown to the tune of 6-13 m depending upon the geometry of the aquifers. Depth to water level in the older alluvium varies from 6-15 mbgl during pre-monsoon period. The dug wells in the laterites usually dry up in summer, but those wells which have tapped both laterites and lithomarge below, are found to contain water during the summer months also.

6.2 Occurrence, movement and distribution of ground

A number of flowing tube wells exist along with the banks of the Dwarkeswar, Jaipanda and Silai rivers. These tube wells are of 30-75 m deep (38-50 mm dia.) and free flow discharge to the tune of 23-30 lpm along Dwarkeswar river, and both the banks of Jaipanda river in Taldangra block and Bishnupur block, the depth of existing auto flow tube well ranges between 45-75m and free flow discharge ranges between 126-252 lpm, the pressure head maximum recorded as 1.10 m bgl. These wells are used for small scale irrigation purpose.

Recent alluvium occupies in the eastern and north central parts of the district and extends down to the drilled depth of about 300 mbgl. The thickness of the alluvium increases eastward. Potential granular zones exist in the depth span of 30-270 m bgl, yielding about 80-150 m^3/hr. with a drawdown between 6 to 10 m.

In general, co-efficient of Transmissivity of deeper aquifer ranges from 272-806 m^2/day and Storativity ranges from 1.019 x 10^{-3} to 2.1 x 10^{-4}.

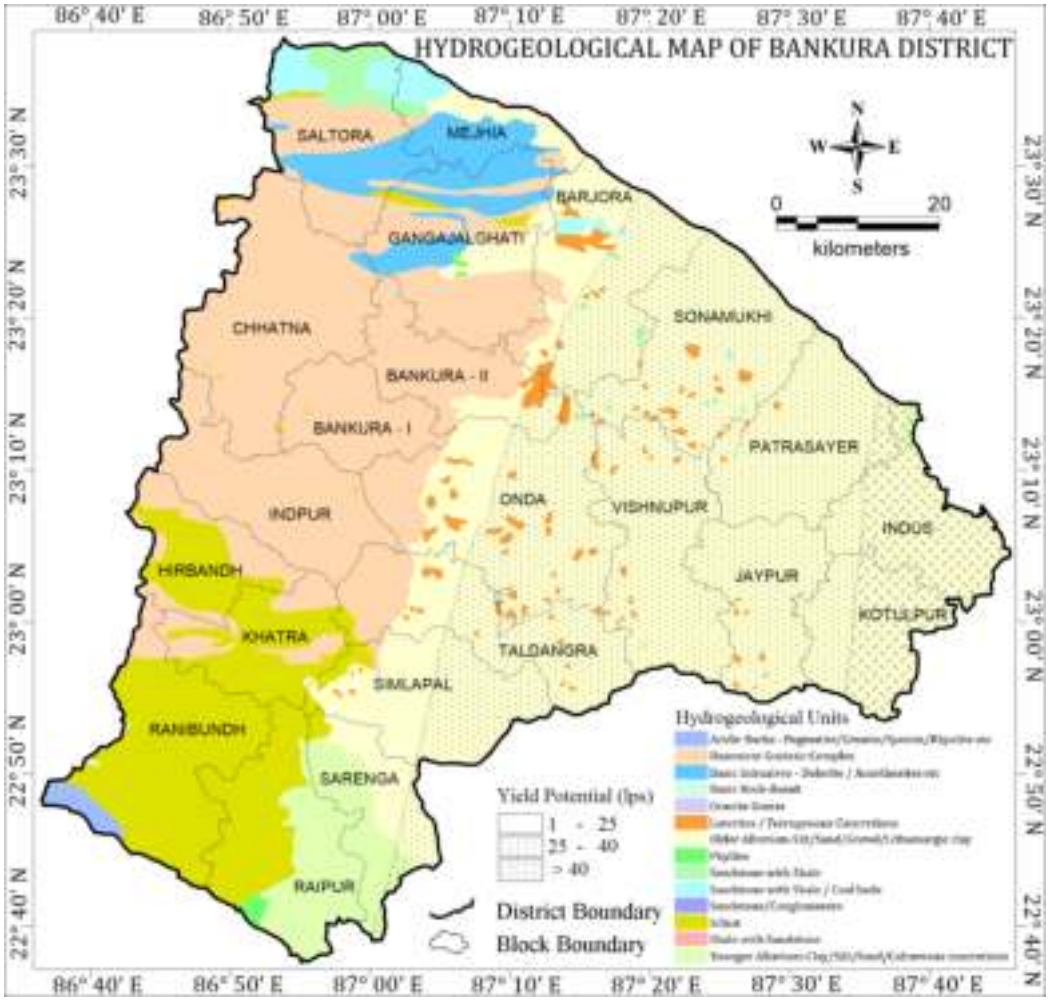


Figure 6.2.1 Hydrogeological map of Bankura District

Figure 6.2.2Borehole Location map in Bankura District

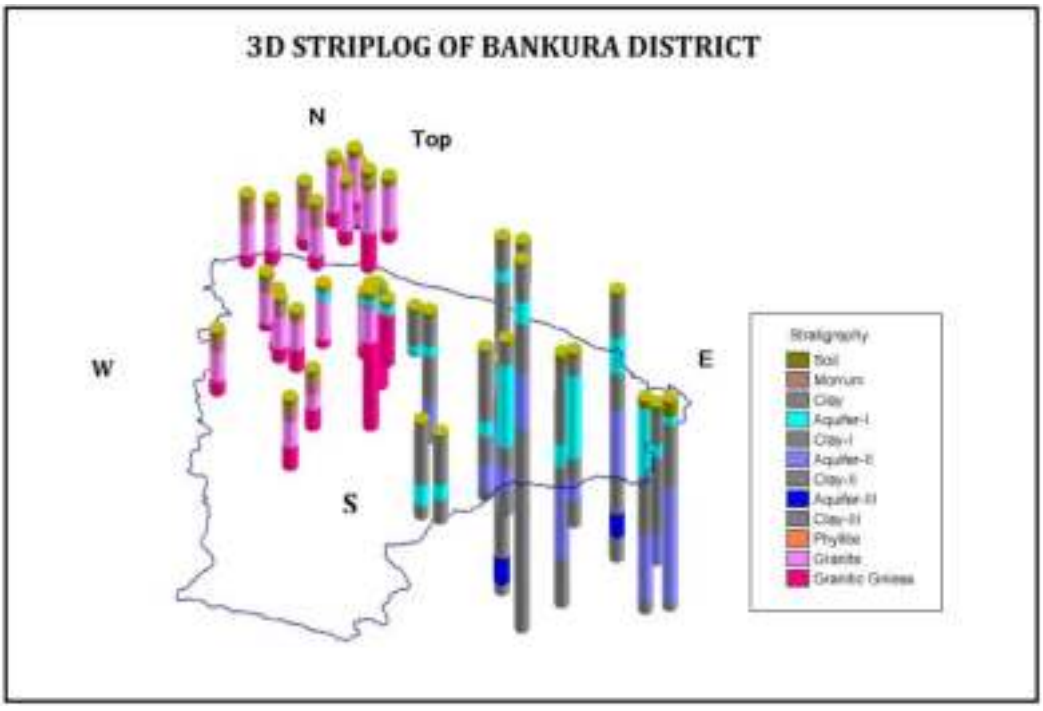


Figure 6.2.3 Striplog of different boreholes in Bankura District

Figure 6.2.4 3D Aquifer Disposition of Bankura District.

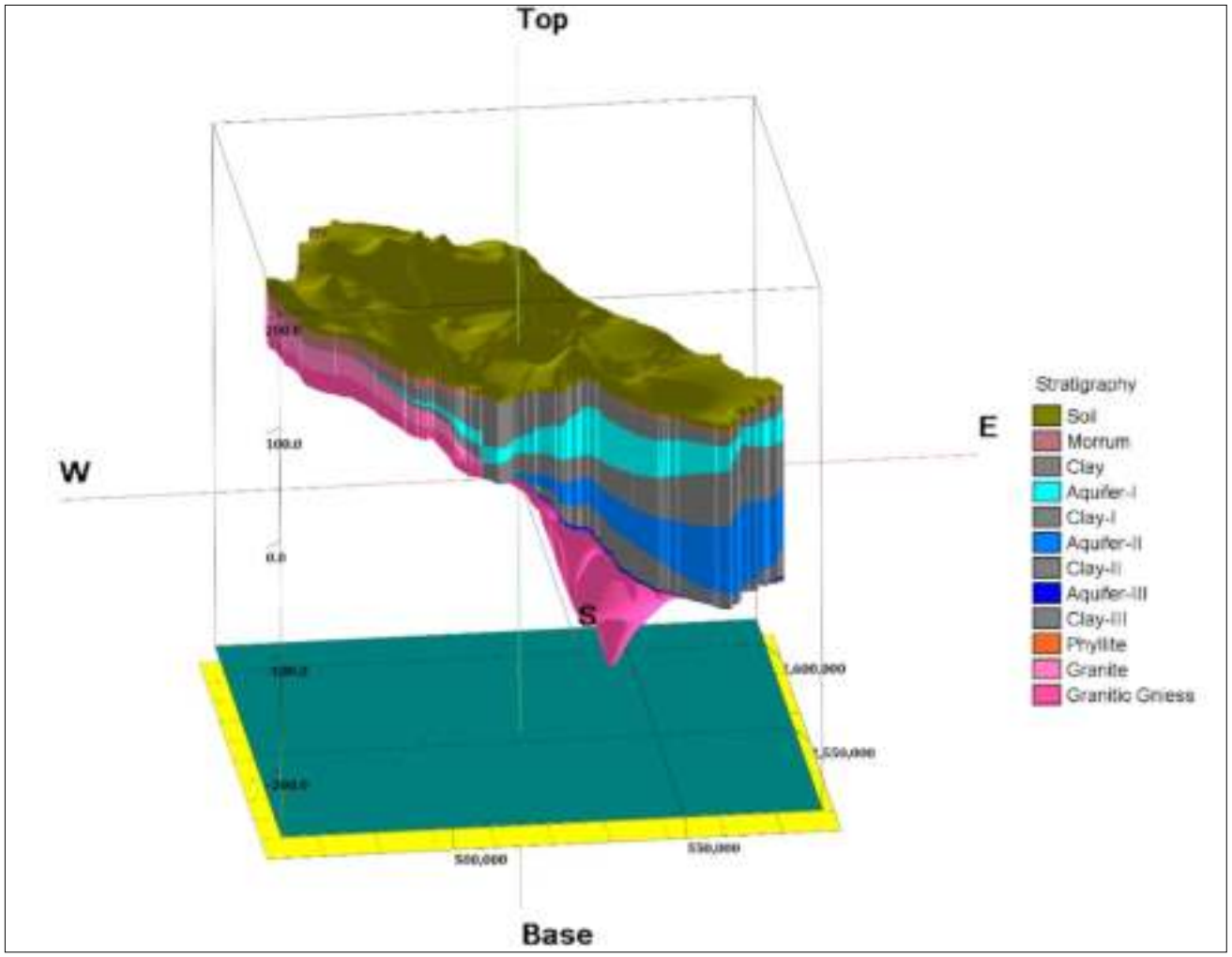


Figure 6.2.5 Section of Bankura District along NE- SW orientation.

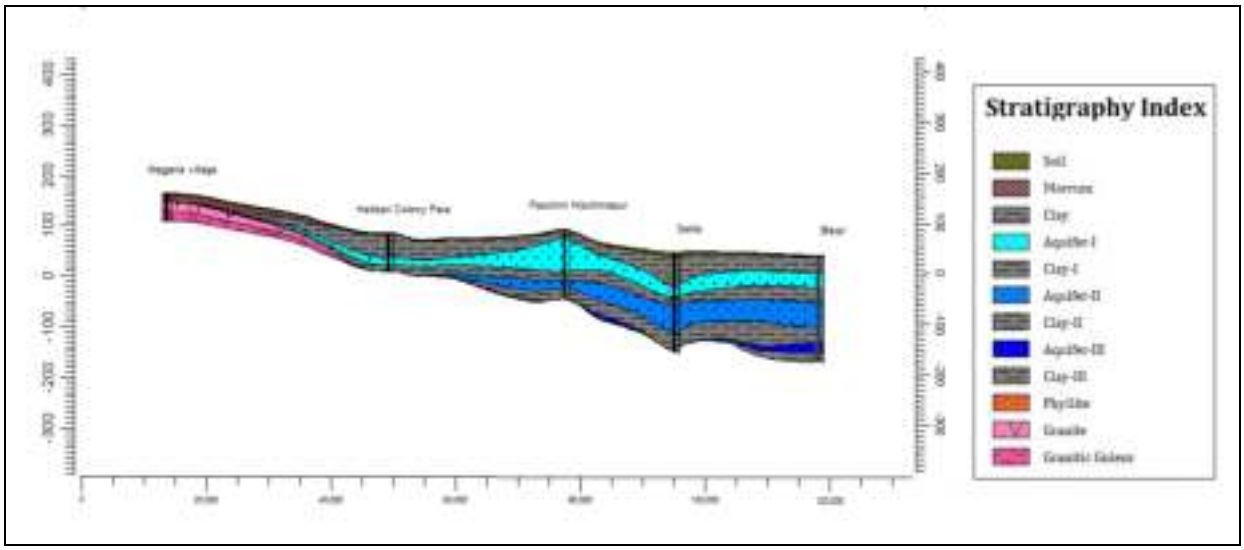


Figure 6.2.6 2D Aquifer Disposition of Bankura District (Section along NE- SW orientation).

Figure 6.2.7 Section of Bankura District along E-W orientation

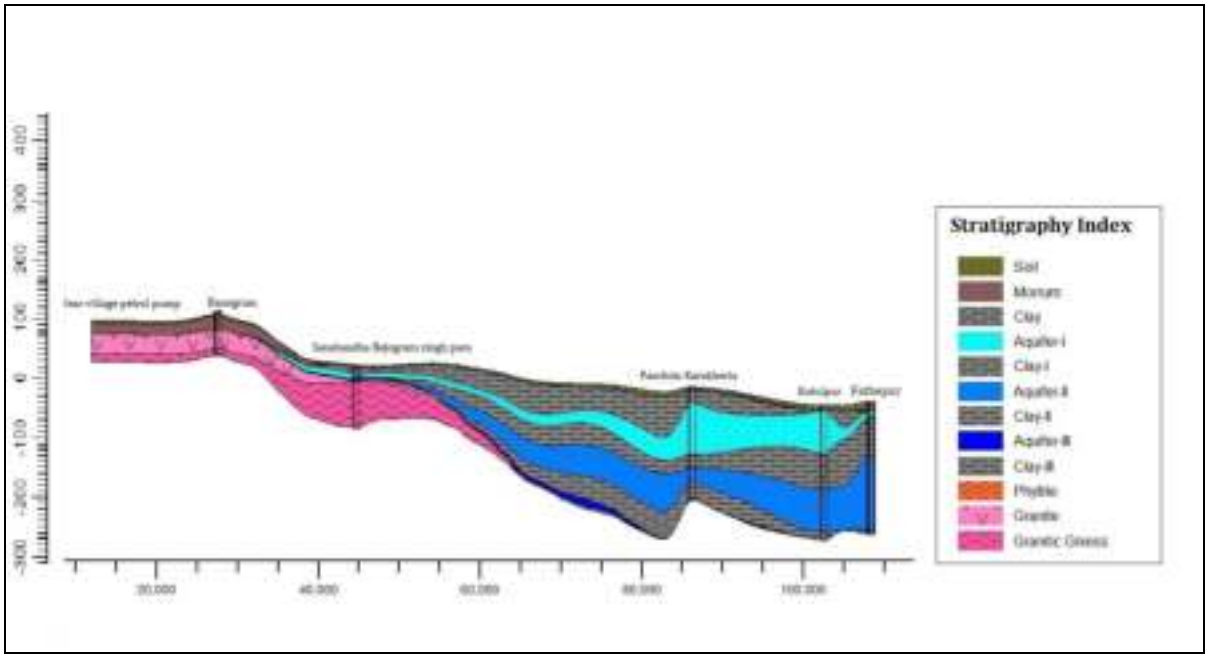


Figure 6.2.8 2D Aquifer Disposition of Bankura District (Section along E-W orientation).

Figure 6.2.9 Section of Bankura District along N-S orientation

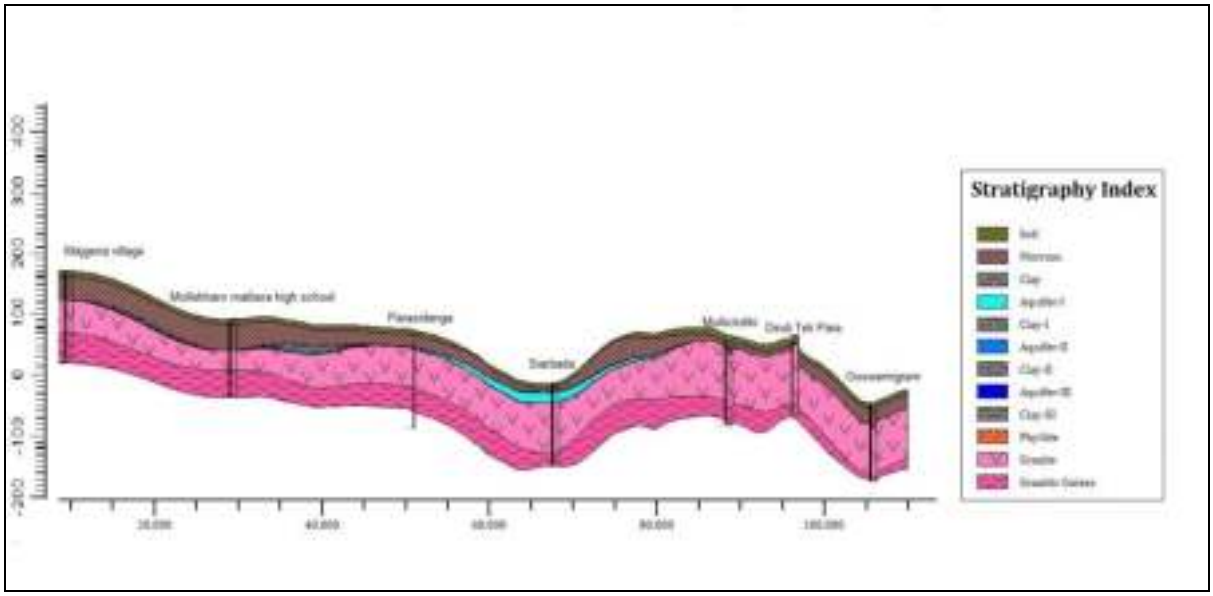


Figure 6.2.10 2D Aquifer Disposition of Bankura District (Section along N-S orientation).

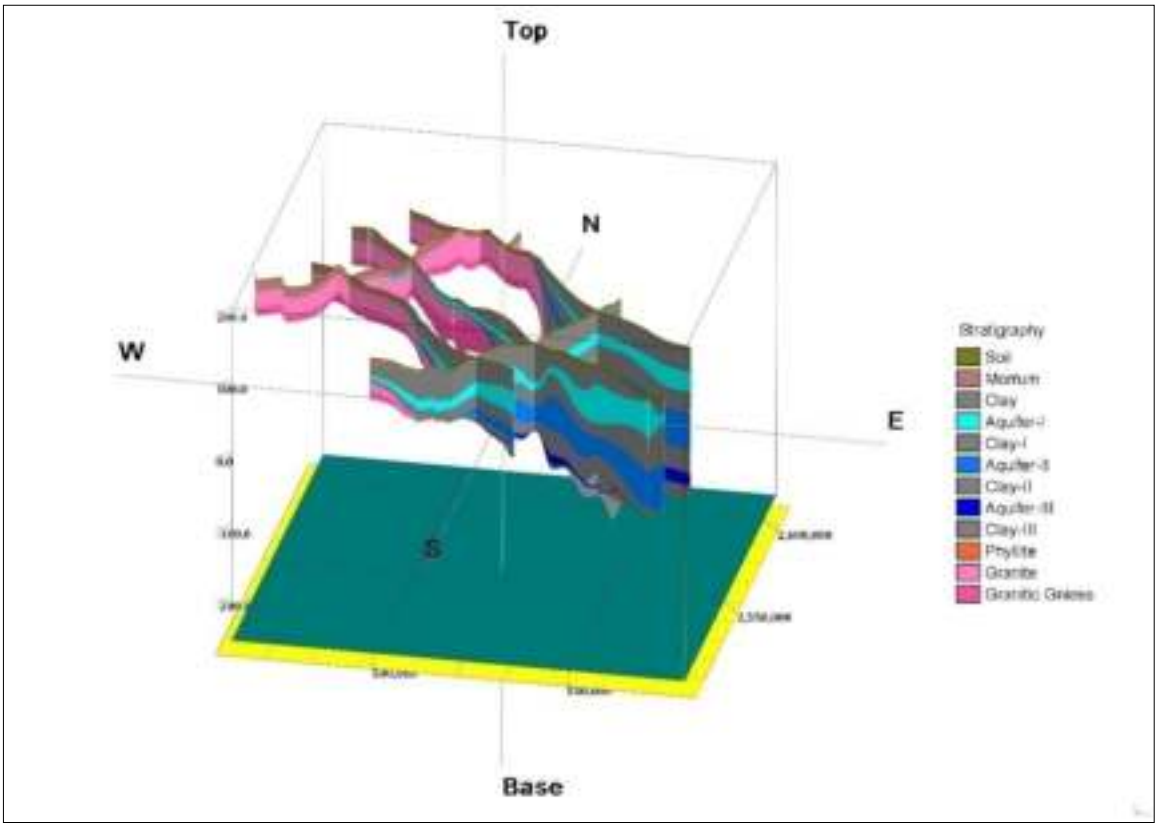


Figure 6.2.11 Fence Diagram of Bankura District

Table: 6.2.1 Block wise Aquifer disposition and Parameters

(Consolidated formation)

Blocks (dominant in hard rock)	No. of Aquifers	Water bearing zone	Casing depth	Aquifer Thickness (m)		Discharge (lpm)	T (m^2/day)	SWL (mbgl)	Drawdown (mbgl)	S
				Aquifer-I weathered Zone	Aquifer-II Fracture zone					
Bankura-I	2	4-11	(upto 24m)	7	26, 38, 45,	20	--	8.5	--	--
BANKURA-II	2	6-18	(upto 26m)	12	26, 70	15	--	7.3	--	--
Chhatna	2	3-18	(upto 20m)	15	38, 45	25	--	11	--	--
Saltora	2	4-15	(upto 18m)	11	31,42	25	--	7.5	--	--
Mejhia	2	3-12	(upto 14m)	9	28, 38	20	--	10.6	--	--
Gangajalghati	2	4-8	(upto 17m)	4	32, 45	20	--	11.3	--	--
Indpur	2	2-11	(upto 18m)	9	41	20	--	9.9	--	--
Khatra	2	4-17	(upto 17m)	13	30, 45	18	--	13.4	--	--
Hirabundh	2	4-12	(upto 15m)	8	36,45	15	--	9.2	--	--
Ranibundh	2	3-15	(upto 14m)	12	35, 42	18	--	14.3	--	--

Table: 6.2.2 Block wise Aquifer disposition and Parameters

(Unconsolidated formation)

Blocks (dominant in soft rock)	No. of Aquifers	Water bearing zone	Aquifer Thickness (m)			Discharge (lpm)	T (m^2/ day)	SWL (mbgl)	Draw down (mbgl)	S
			Aquifer-I (Within 50 mbgl)	Aquifer-II (above 50 mbgl)	Aquifer-III (above 150					
Barjora	3	25-48, 77-130, 241-248	23	53	7	1620	--	8.6	--	--
Onda	2	29-68, 70-114	39	48	--	1680	--	6.7	--	--
Taldangra	2	35-60, 90-109	25	19	--	1800	--	7.9	--	--
Simlapal	1	39-65,	26	--	--	1260	--	6.9	--	--
Raipur	3	12-34, 67-158, 163-178, 241-248	22	91	22	1080	--	6.3	--	--
Sarenga	3	33-60, 70-98, 133-156, 213-229	27	51	16	1560	--	8.5	--	--
Bishnupur	3	18-53, 62-112, 153-174	25	60	21	2220	--	12.5	--	--
Joypur	2	28-85, 113-148	57	35	--	2280	--	7.8	--	--
Kotulpur	2	23-55, 106-148	32	44	--	3300	--	10.6	--	--
Sonamukhi	3	31-48, 70-130, 213-248	17	60	35	1980	--	9.8	--	--
Patrasayer	3	35-64, 92-144, 174-193	29	52	19	2520	--	12.6	--	--
Indus	2	13-60, 67-156	47	89	--	3060	--	8.6	--	--

a. Ground water Regime, Depth to water level, Wells and Fluctuations

The district, Bankura displays diversified hydrogeological characters that do not have resemblance with the planes. Based on geology and mode of occurrence of groundwater the underline area of the district has been divided into three sectors (i) western sector covered by crystalline rocks of Archean age. (ii) Middle sector covered by laterite and Older Alluvium formation of Pleistocene age and (iii) Eastern sector covered by Recent Alluvium. Groundwater in the district occurs both under water table condition and confined condition. The water table generally declines with the varying gradients from west, north-west to east and south-east directions and broadly confirms to the topographical slopes. In the western sector comprising mainly of Crystalline rocks ground water occurs in the weathered mantle of varying thickness from 6 metre to 15 metre under water table conditions. In many parts of the area lateritic gravels lies on the weathered basement rock that attributes favourable condition for percolation of rain water. The block of Chatna, Bankura-I, Saltora, Gangajalghati, Ranibandh, Khattra, Hirbandh and Indpur falls under this sector. In the middle sector covered by laterite and older alluvium, groundwater occurs in the moderately thick to thin aquifer under unconfined to semi confined condition. Heterogeneous character of the water bearing formation with complex aquifer geometry prevails in the area and is feasible for open dug wells of 10 metre to 15 metre depth with 3 metres of diameters. The complete or

parts of the blocks of Bankura II, Mejia, Taldangra, Simlapal, Raipur & Sarenga fall under this sector. Ground water occurs under confined condition below a blanket of clay whose thickness varies around 10 metres. In the eastern alluvial area of Indus, Kotulpur & Joypur blocks.

For the year 2020-2021, 138 monitoring wells of CGWB and SWID have been considered for study. The depth to water level range for Aquifer-I varies from 2.81-18.14 m and Aquifer-II range varies from 4.10-20.93m during the pre-monsoons, shown in **figure 6.3.1 & 6.3.4.** The post-monsoon variation for Aquifer-I is from 1-4.59 m and 2.15-7.40 m for Aquifer-II respectively shown in **figure 6.3.2 & 6.3.5** Deep water level is recorded in Kotulpur block. A groundwater mound is observed in Onda block during the pre-monsoon. This is suggested to be a recharge zone for the aquifers in the nearby areas.
Seasonal fluctuation in water level between pre-monsoon and post-monsoon period has been compared and it has been found that there is a general rise in water level to the tune of 2-6 m except in restricted places where a fall has been recorded between 0-1 m. shown in **figure 6.3.3.**
Hydrographs of selected network stations in the district shows that there is a rising water level trend in Peripathar, Pairaguri, Naldanga, Rangamati, Hereparlat network stations. Falling trend is not observed in any of the block. However, no significant fall in the water level trend has been recorded in the district shown in **Figure 6.3.8-6.3.15.**
The ground water in the district is abstracted through dug wells, hand pumps, shallow tube wells and deep tube wells. The water from these sources is supplied through pipelines to the population in the area for drinking and domestic purpose. There is a network of piped water supply schemes by PHED. The depth of dug wells varies from 12.5 to 20.0 mbgl. The depth of the medium tube wells and shallow tube wells installed by PHED, ranges from 70 to 140 mbgl and 40 to 80 mbgl respectively. These wells tap aquifers with granular zones thickness of 6-9 metres.
The district of Bankura has well defined seasonal rainfall and the water table rise and fall in annual cycle. The rise corresponds to the rainfall period and the fall stage corresponds to the dry/lean period. The monitoring/network stations over the district reveals that the deepest water level occur during the month of April/May and most shallow during the month of October/November. Fluctuation for the given study area is considered by taking April month as the Pre-monsoon and November month as the post-monsoon. The magnitude of fluctuation of water level in a particular area is influenced by its climate, drainage, topography, relief and the existing hydrogeological conditions. The fluctuation tends to diminish from a higher to lower altitude corresponding to areas of recharge and discharge.
The water level range, fluctuation and trends for the blocks in the study area are given **Table6.3.1.**

Table 6.3.1: water level range, fluctuation and trends for the blocks in Bankura District

Block	Pre-monsoon Trend			Post-monsoon Trend		
	WL Range (mbgl)	Rise (m/year)	Fall (m/year)	WL Range (mbgl)	Rise (m/year)	Fall (m/year)
Bankura-I	2.65-5.32	--	0.083	1.5-4.38	0.083	--
Bankura-II	1.33-4.89	0.186	--	1.9-5.43	0.175	--
Chhatna	1.74-7.28	--	0.085	1.47-7.44	0.109	--
Saltora	1.75-5.22	0.091	--	2.58-5.43	--	0.038
Mejia	2.93-4.45	--	0.056	1.9-4.23	0.214	--
Gangajalghati	1.6-5.52	--	0.497	2.95-6.33	--	0.096
Barjora	2.05-7.09	--	0.303	1.45-5.98	--	0.120
Onda	0.9-4.2	--	0.036	1.36-4.44	0.008	--
Indpur	0.8-2.43	0.029	--	1.7-2.9	--	0.090
Khatra	1.05-2.38	0.135	--	1.3-3.41	--	0.034
Hirbandh	NA	NA	NA	NA	NA	NA
Ranibandh	1.88-7.56	--	0.174	0.35-5.84	--	0.079
Taldangra	0.74-6.53	--	0.433	1.83-6.16	0.022	--
Simlapal	1.57-4.98	0.996	--	1.26-5.32	--	0.078
Raipur	1.32-4.44	0.143	--	2.1-4.94	--	0.004
Sarenga	NA	NA	NA	NA	NA	NA
Bishnupur	0.88-10.28	--	0.360	0.9-8.53	0.510	--
Joypur	0.45-2.84	0.172	--	1.28-3.10	0.012	--
Kotulpur	5.49-12.86	0.164	--	4.73-13.12	0.320	--
Sonamukhi	0.37-6.74	--	0.355	0.9-7.85	1.224	--
Patrasayer	1.7-13.56	0.368	--	1.8-12.99	0.034	--
Indus	0.93-11.6	0.539	--	1.55-10.87	0.071	--

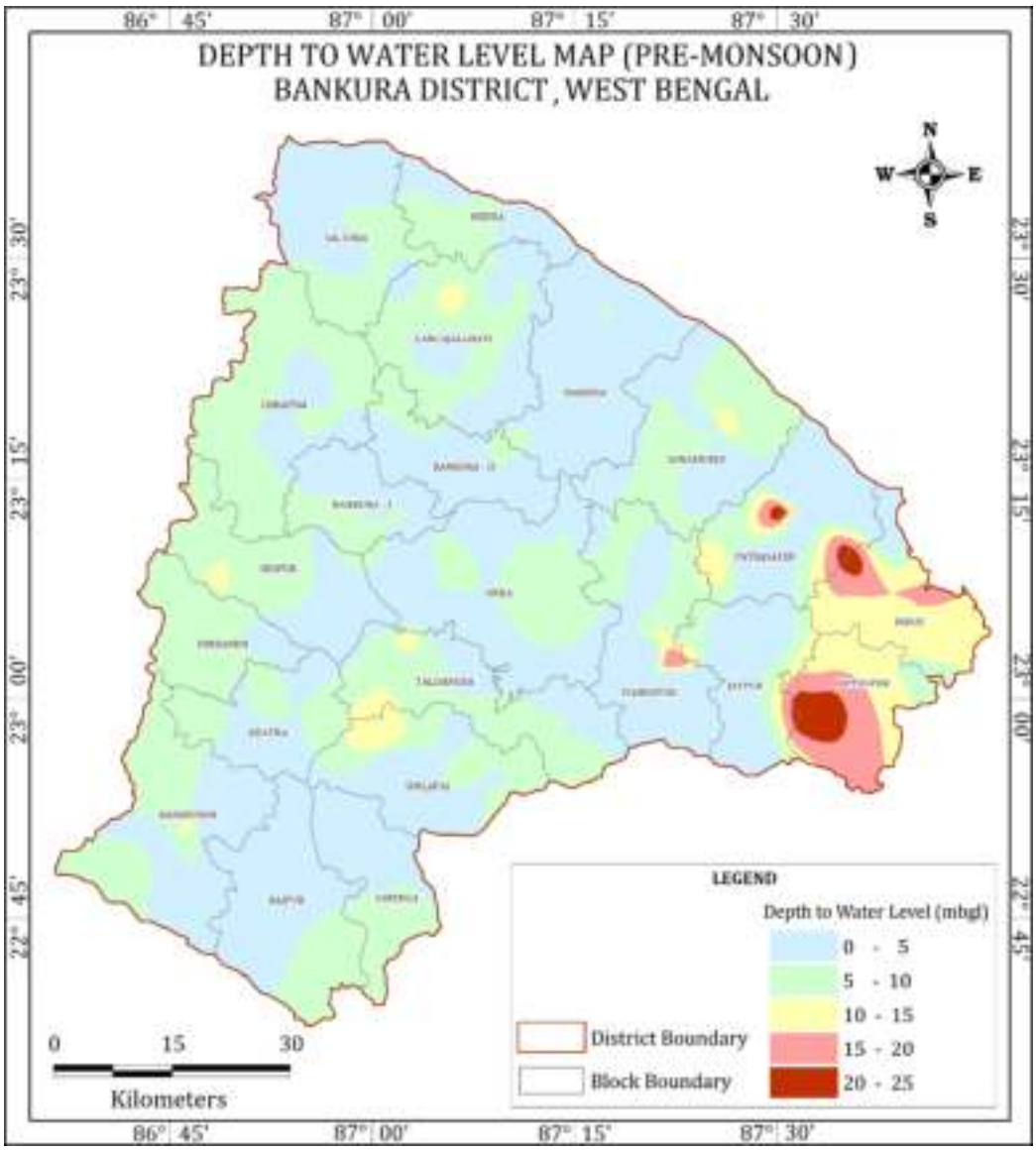


Figure 6.3.1 Pre-Monsoon Depth to Water Level map for Shallow Aquifer of Bankura District

During the pre-monsoon period in major part of the area depth to water level has been found to be in the ranges between 5 to 10 m bgl.

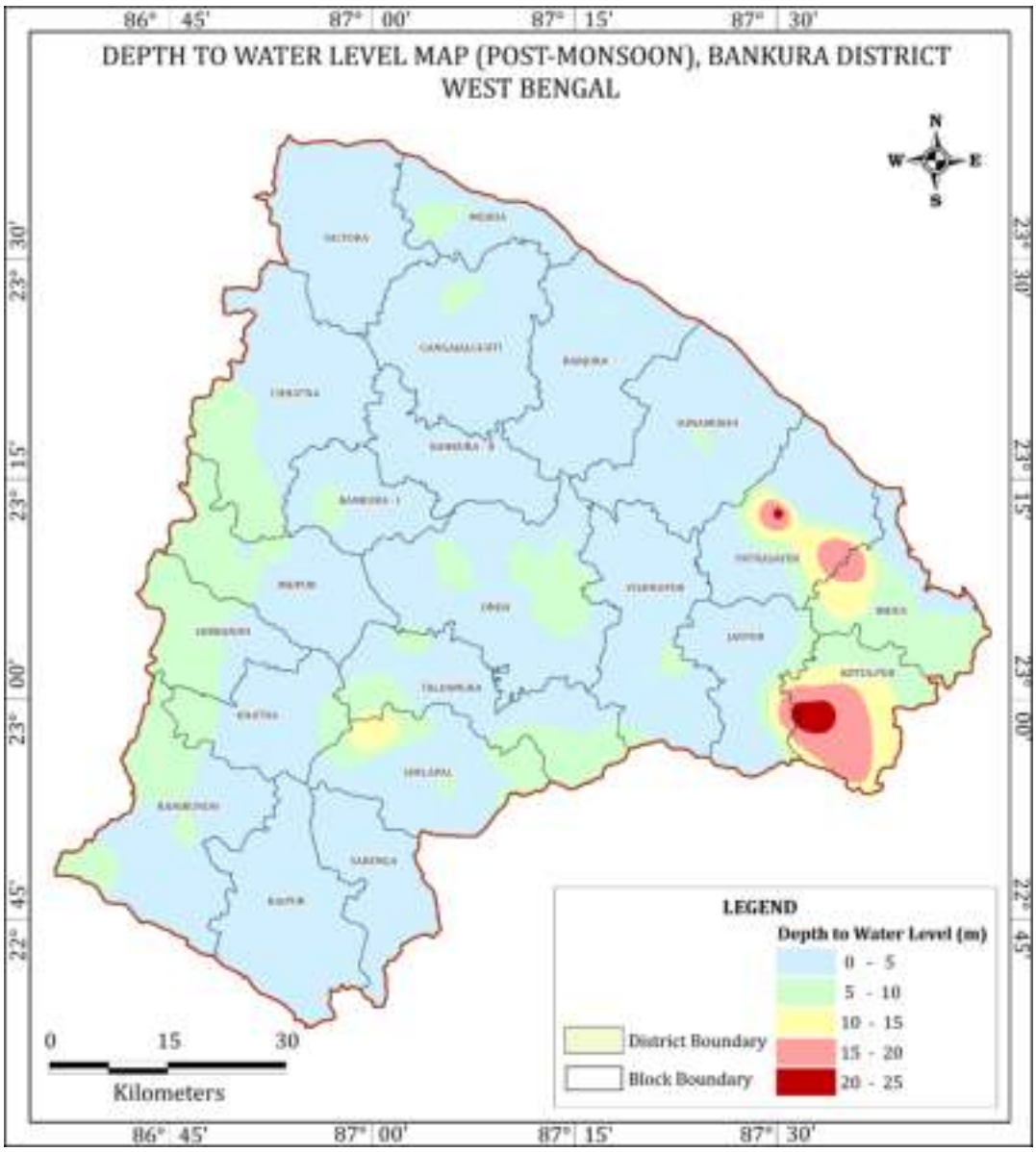


Figure 6.3.2 Post-Monsoon Depth to Water Level map for Shallow Aquifer of Bankura District

During post-monsoon period depth to water level has been found to be ranging between 2 to 5 m bgl

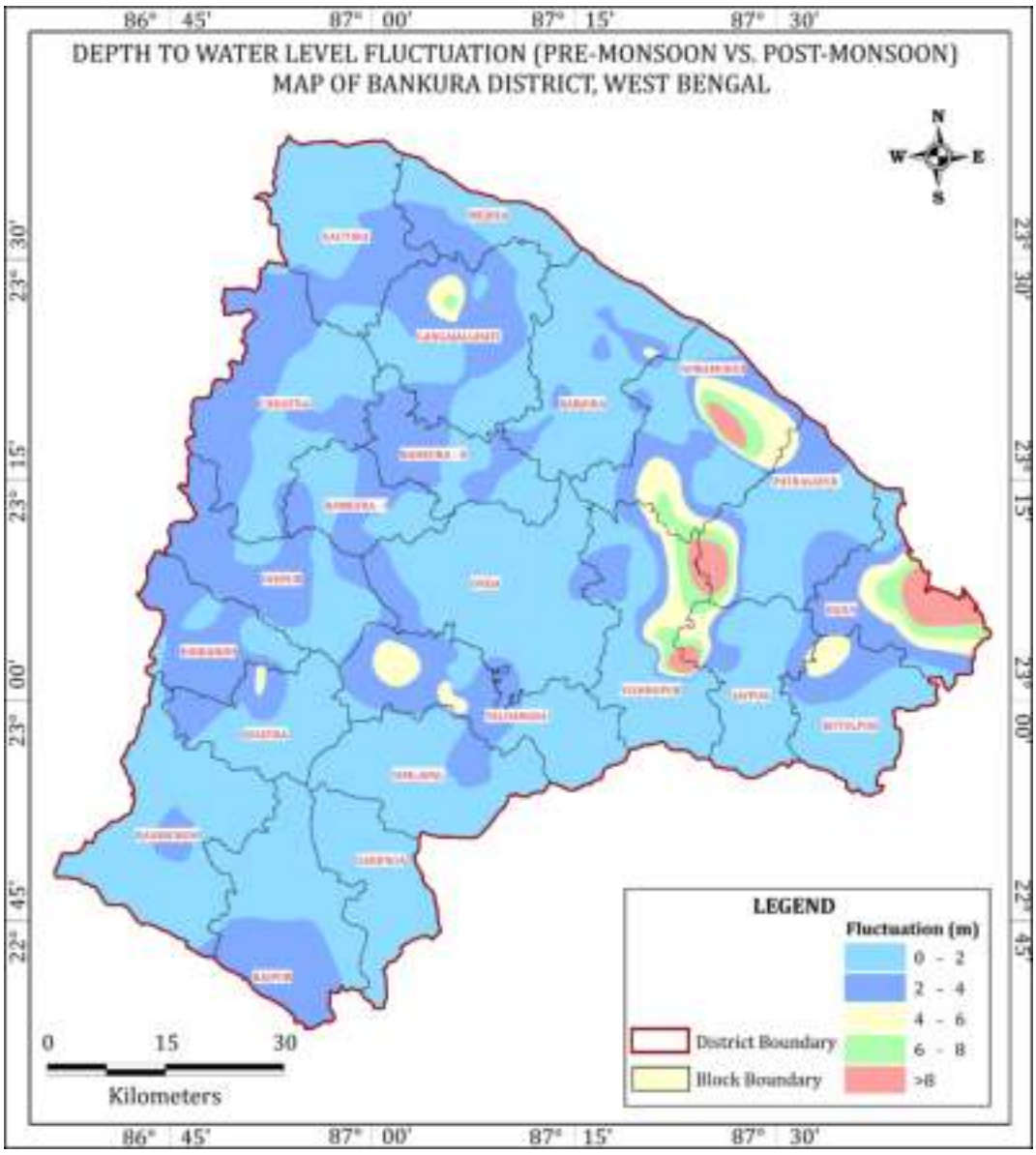


Figure 6.3.3 Fluctuation of Depth to Water Level map for Shallow Aquifer of Bankura District

Seasonal fluctuation in water level between pre-monsoon and post-monsoon period has been compared and it has been found that there is a general rise in water level to the tune of 2-6 m except in restricted places where a fall has been recorded between 0-1 m.

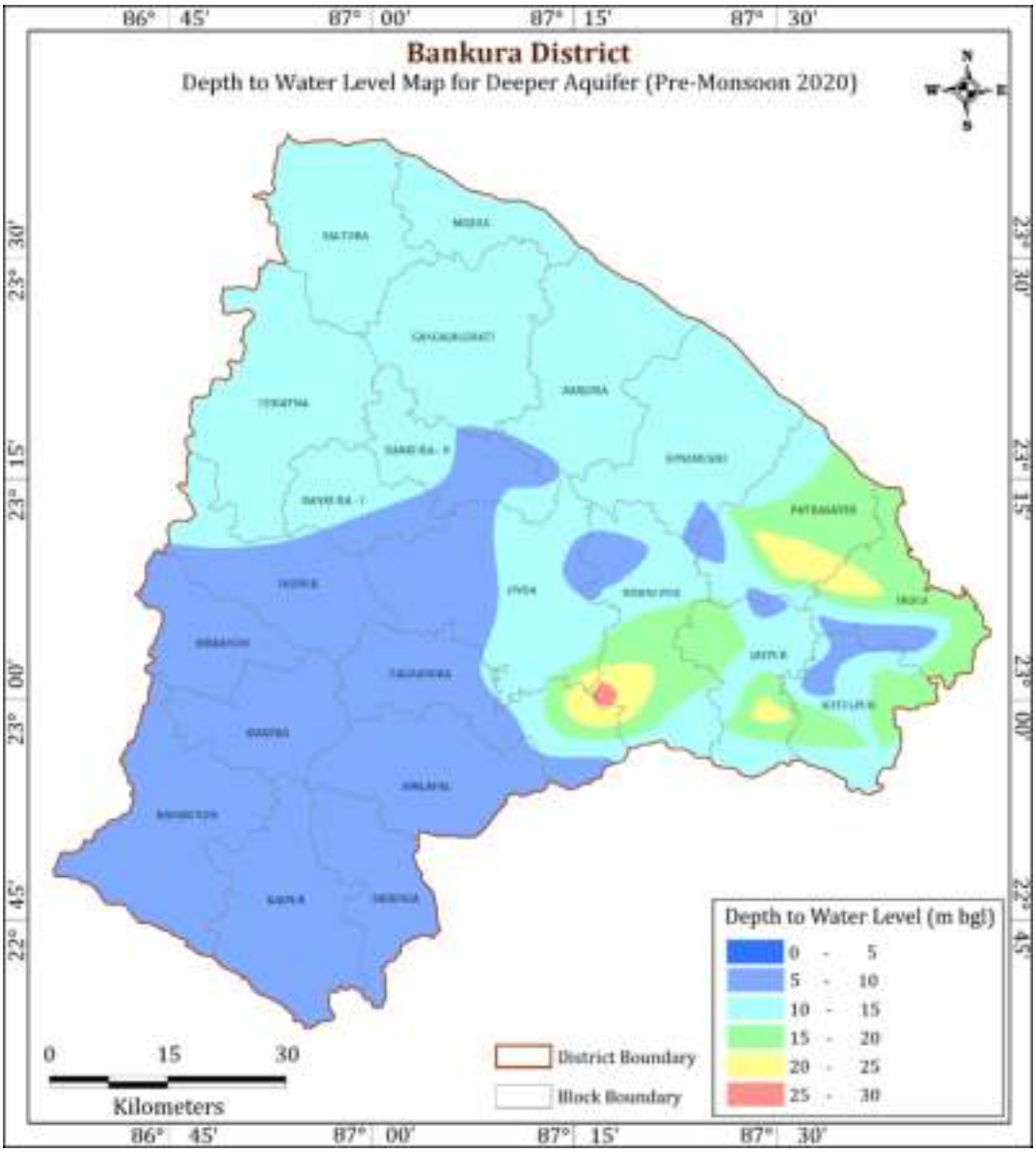


Figure 6.3.4 Pre-Monsoon Depth to Water Level map for Deeper Aquifer of Bankura District

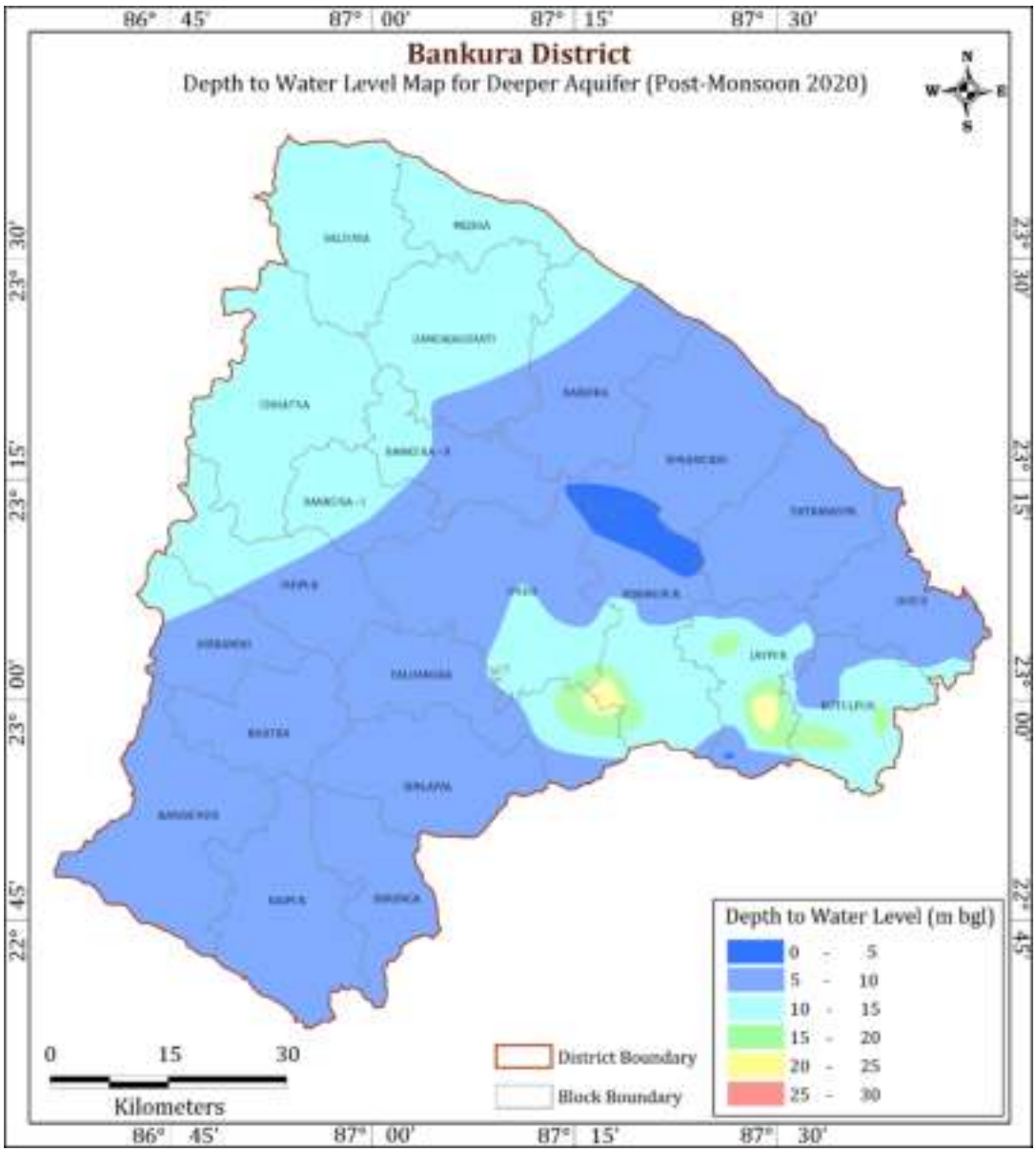


Figure 6.3.5 Post-Monsoon Depth to Water Level map for Deeper Aquifer of Bankura District

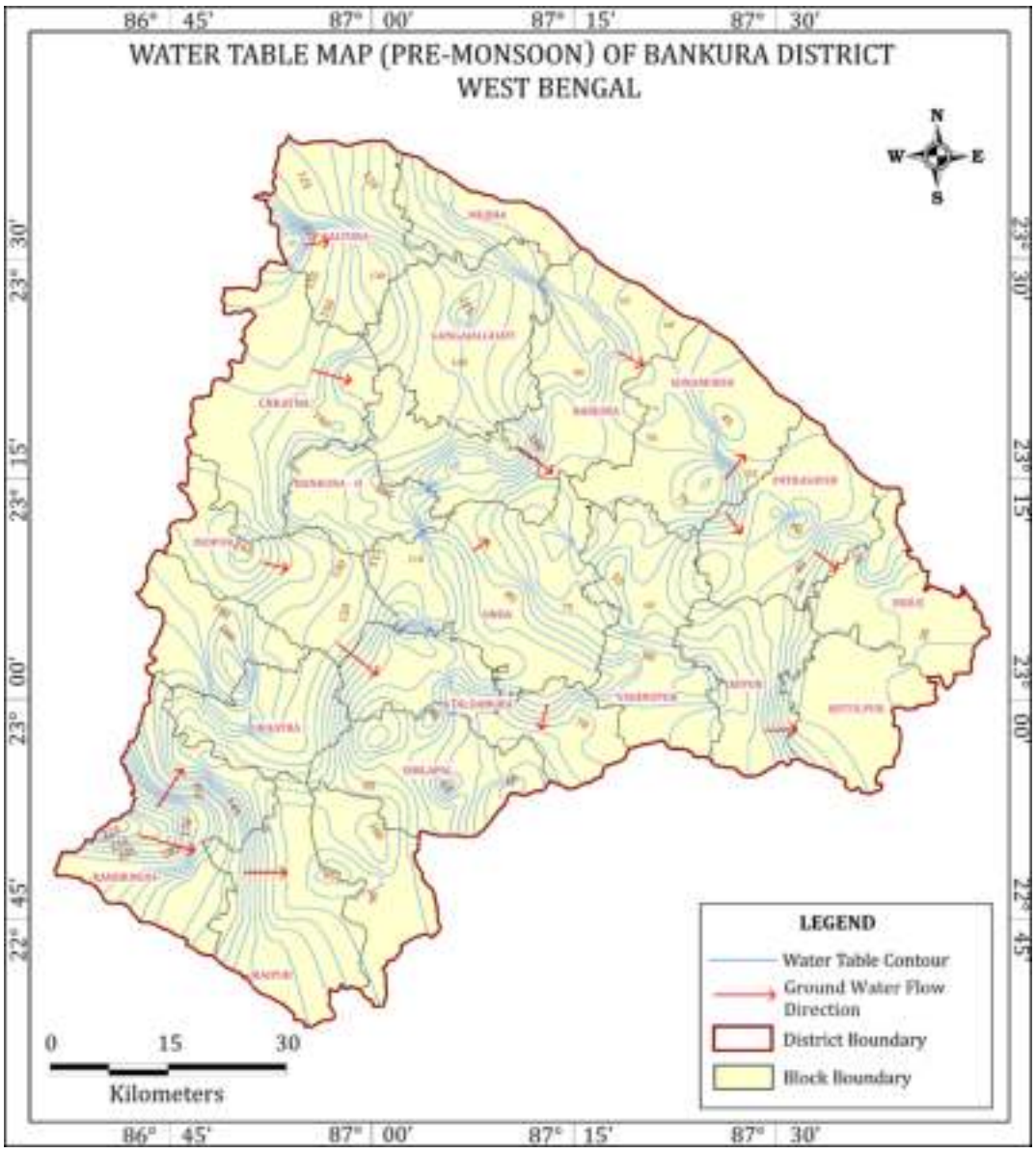


Figure 6.3.6 Pre-Monsoon Water Table map of Bankura District

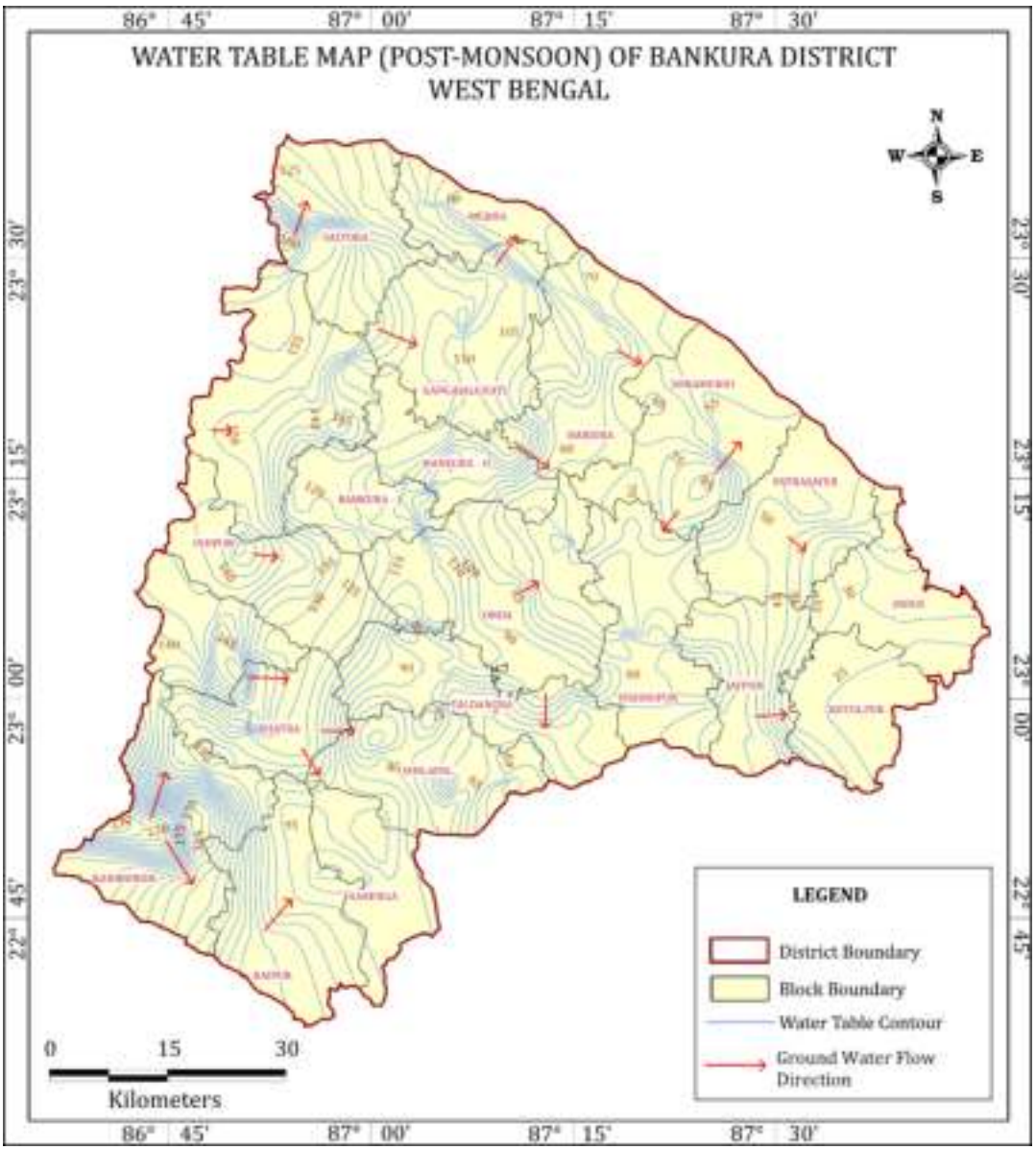


Figure 6.3.7 Post-Monsoon Water Table map of Bankura District

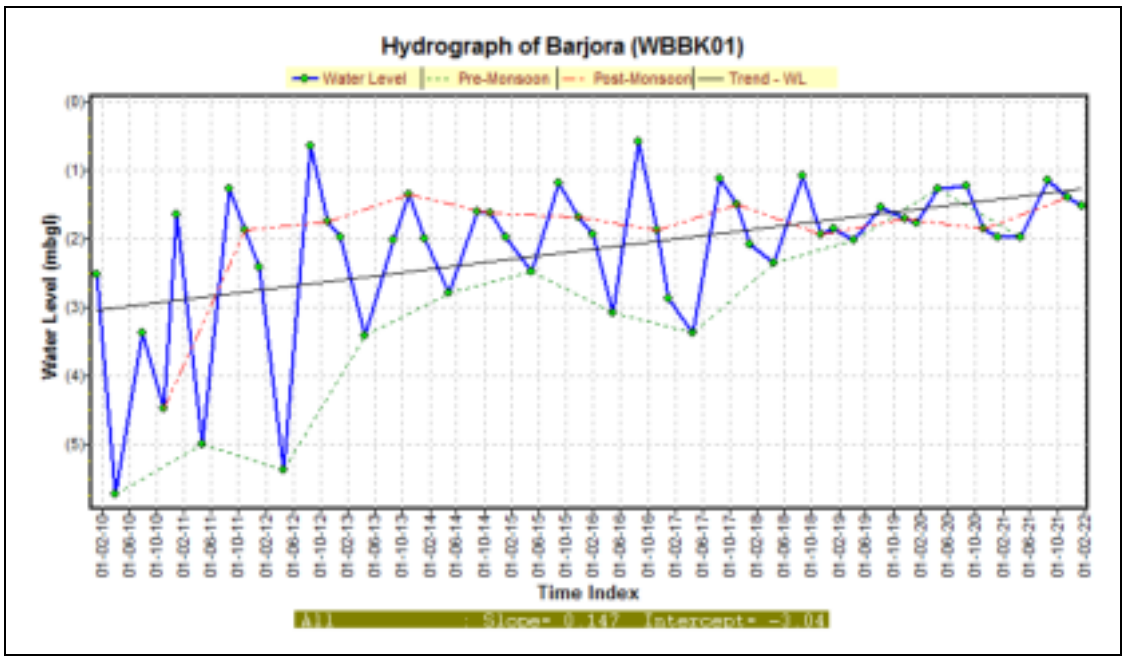


Figure 6.3.8 Rising Water level trend in Barjora Block

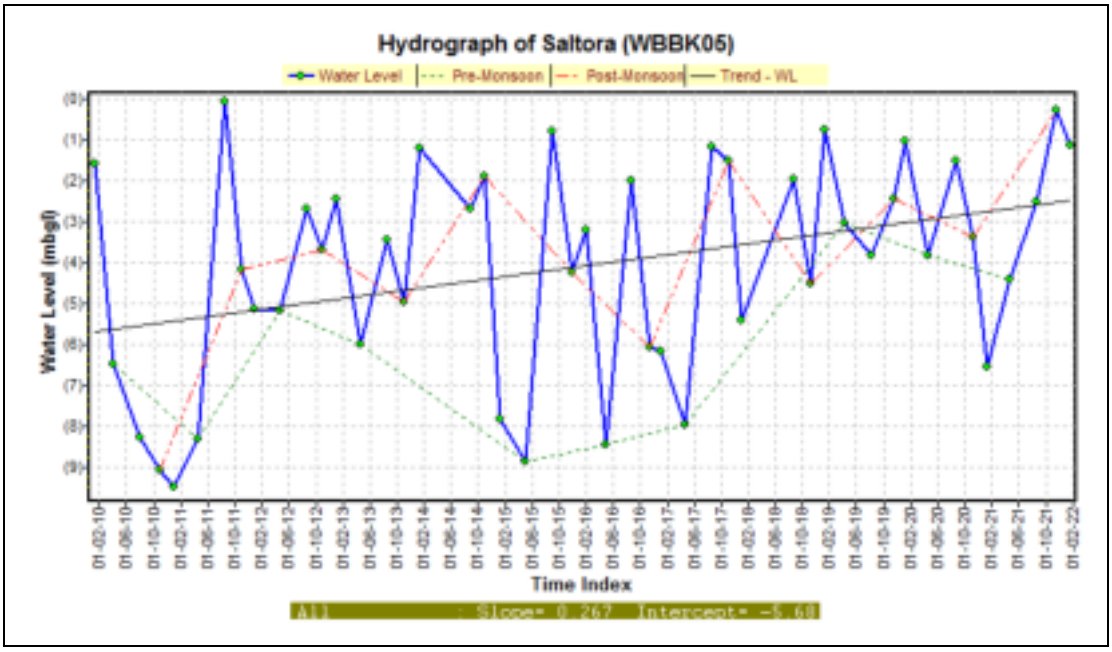


Figure 6.3.9 Rising Water level trend in Saltora Block

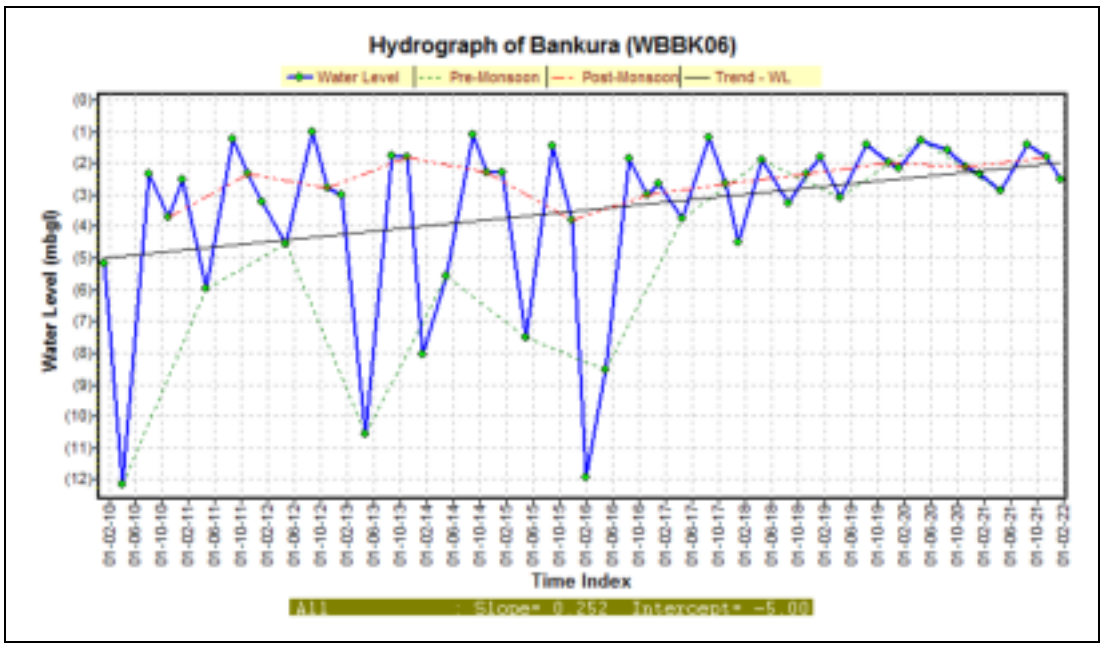


Figure 6.3.10 Rising Water level trend in Bankura Block

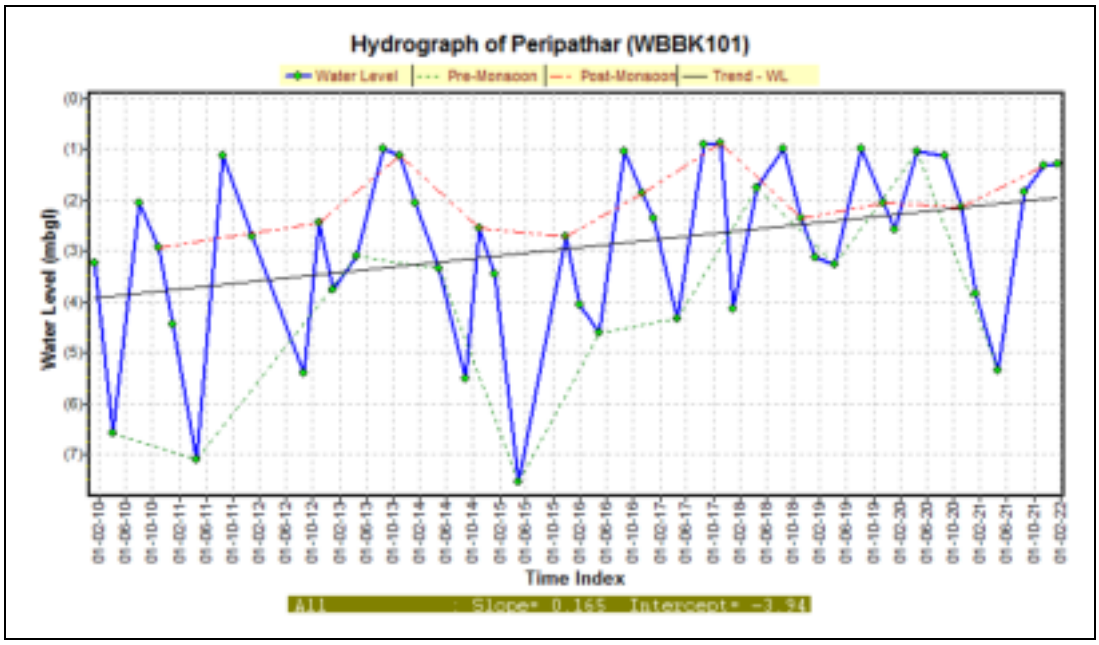


Figure 6.3.11 Rising Water level trend in Khatra-II Block

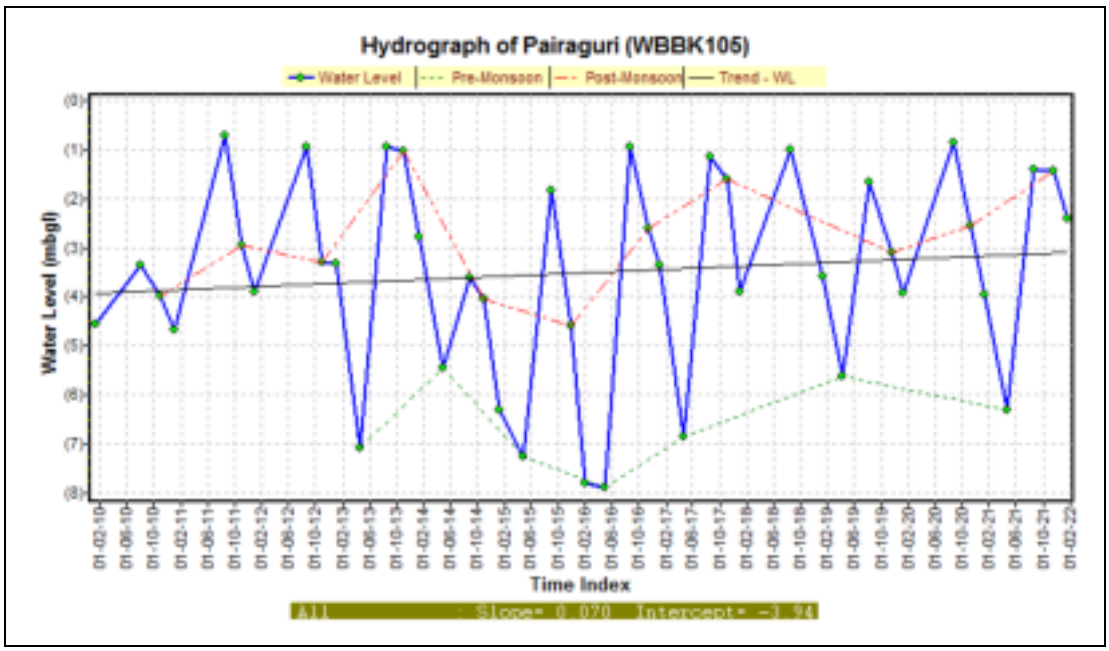


Figure 6.3.12 Rising Water level trend in Raipur-I Block

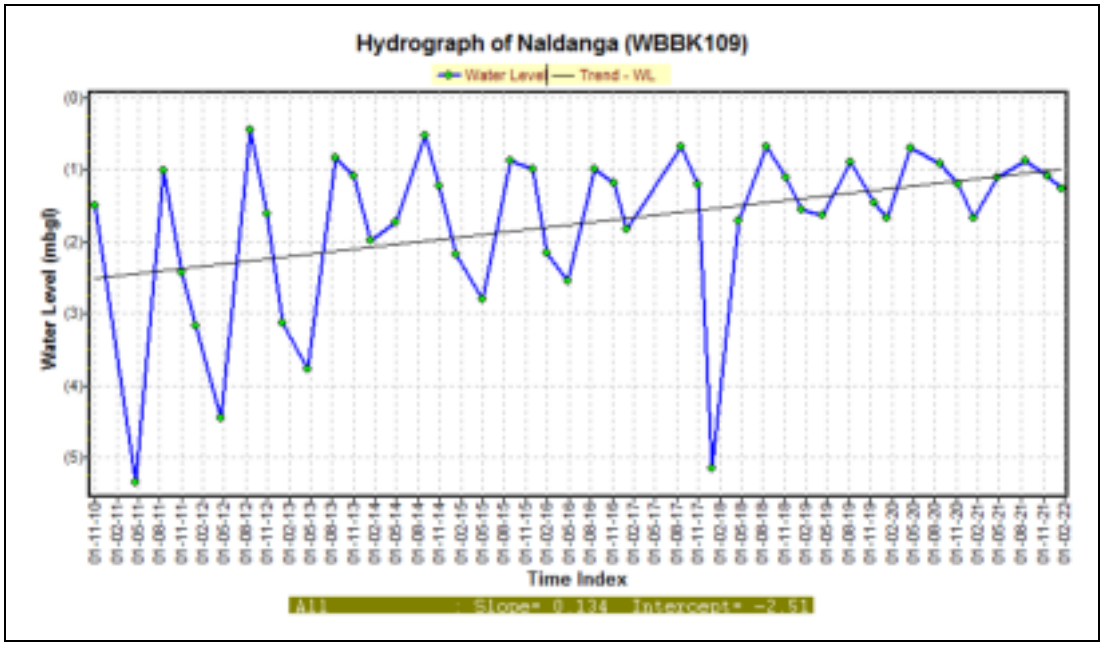


Figure 6.3.13 Rising Water level trend in Indus Block

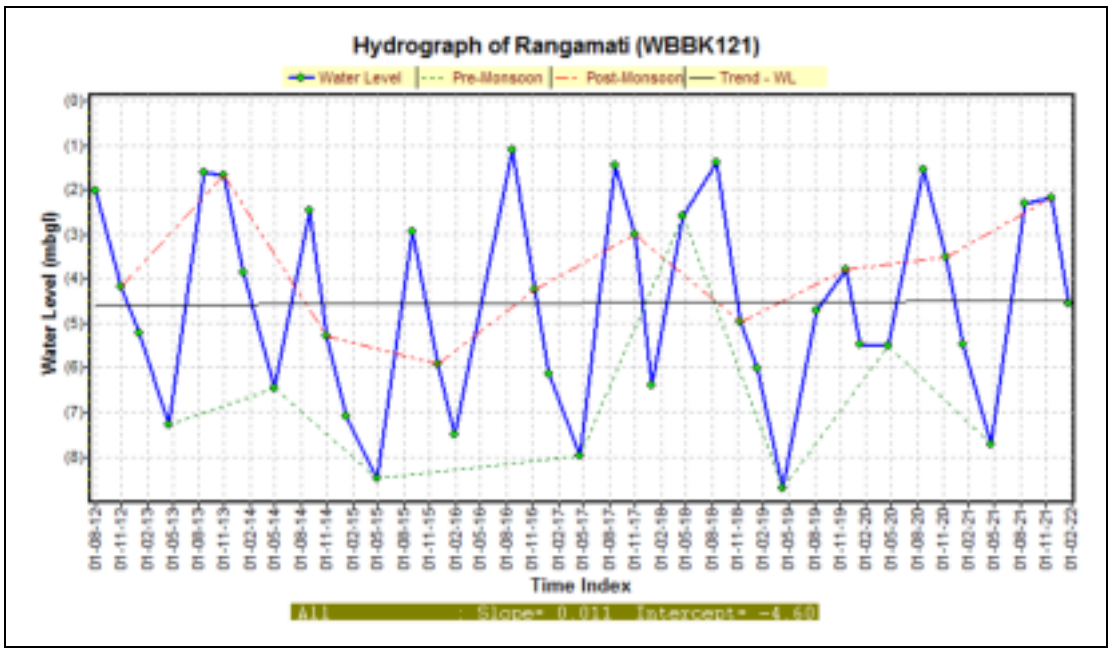


Figure 6.3.14 Rising Water level trend in Gangajalghati Block

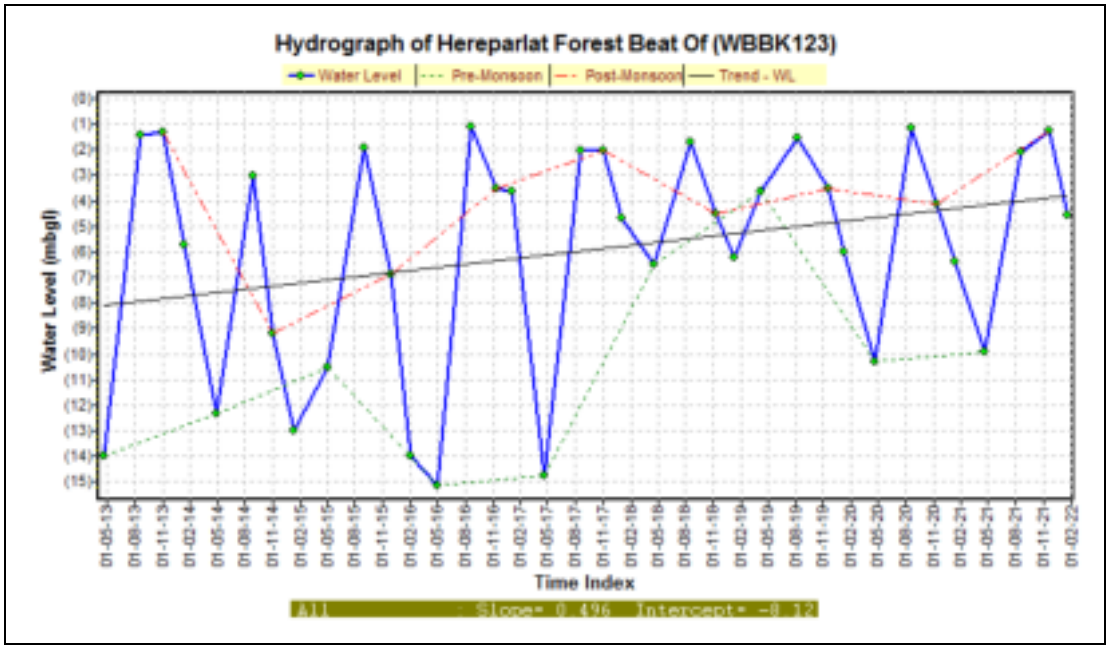


Figure 6.3.15 Rising Water level trend in Vishnupur Block

CHAPTER 7

GROUND WATER RESOURCES

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

As per the computation, the net ground water availability for recharge for Bankura district is estimated at 258599.38 Ham, while the total extraction for all uses is estimated at 91228.9Ham. The categorization of the blocks has been done based on their Stage of Development and long-term water level trend.

7.1.1 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 lift and 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.

7.1.2 Ground water draft

Groundwater draft has been computed on the basis of quantum of water likely to be used for domestic, irrigation and industrial purposes. The estimate is done by projecting the population and the number of ground water abstraction structures. The total extraction for the blocks as a whole is 91228.9 Ham.

Table 7.1.2.1 Ground water Recharge, Resource and Stage of Development of Bankura district

Name of the Block	Total Annual Ground Water Recharge (Ham)	Total Natural Discharges (Ham)	Annual Extractable Ground Water Recharge (Ham)	Total Extraction (Ham)	Annual GW Allocation for Domestic Use as on 2042	Net Ground Water Availability for future use (Ham)	Stage of Ground Water Extraction (%	Categorization (OE/ Critical/ Semi critical/ Safe)
BANKURA- I	5041.3	504.13	4537.17	829.19	319.53	3657.91	18.28	Safe
BANKURA- II	5627.66	562.77	5064.89	1734.72	178.69	3306.36	34.25	Safe
BISHNUPUR	17494.17	1749.42	15744.75	10622.84	309.45	5059.42	67.47	Safe
BORJORA	16154.87	1615.49	14539.38	4514.83	238.63	10008.07	31.05	Safe
CHHATNA	10796.73	1079.67	9717.06	715.07	253.35	8963.09	7.36	Safe
GANGAJALGHATI	8770.81	438.54	8332.27	477.27	242.61	7811.37	5.73	Safe
HIRBUNDH	4577.22	457.72	4119.5	329.87	109.51	3772.3	8.01	Safe
INDAS	13414.95	1341.5	12073.45	8089.02	249.93	3921.18	67	Safe
INDPUR	7060	353	6707	313.15	210.16	6355.79	4.67	Safe
JOYPUR	14574.52	728.73	13845.79	5664.61	220.88	8132.84	40.91	Safe
KHATRA	5055.28	505.53	4549.75	214.02	152.93	4311.48	4.70	Safe
KOTULPUR	23872.92	2387.29	21485.63	13507.94	289.02	7896.23	62.87	Safe
MEJHIA	7590.56	759.06	6831.5	360.94	115.66	6449.66	5.28	Safe
ONDA	25306.7	2530.67	22776.03	15708.84	338.55	7006.8	68.97	Safe
PATRASAYER	21344.37	2134.44	19209.93	9220.18	262.23	9929.9	48.00	Safe
RAIPUR	10654.73	1065.47	9589.26	2655.25	176.51	6945.93	27.69	Safe
RANIBANDH	5839.1	583.91	5255.19	441.21	156.95	4787.97	8.40	Safe
SALTORA	8314.95	831.5	7483.45	581.07	178.08	6873.81	7.76	Safe
SARENGA	9930.93	993.09	8937.84	2607.95	139.56	6307.76	29.18	Safe
SIMLAPAL	9663.78	966.38	8697.4	2239.1	193.2	6422.37	25.74	Safe
SONAMUKHI	17631.33	1763.13	15868.2	6603.92	238.26	9229.18	41.62	Safe
TALDANGRA	9882.5	988.25	8894.25	3797.91	199.66	5059.29	42.70	Safe
Total	**258599.38**	**24339.69**	**234259.69**	**91228.9**	**4773.35**	**142208.71**	**38.94**	

7.1.3 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 Bankura district is 38.94%. All the blocks in the district are under 'Safe' category as their stage 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, allocation of resource for future use, stage of development and categorization of the blocks in Bankura district.

7.1.4 Irrigation Potential created and utilized

The net ground water availability for future use in the district is estimated at 84426.39 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. 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 table 7.1.4.1.

Table 7.1.4.1 Irrigation potential created in Bankura District

Sl. No.	Block Name	Total irrigated area (Ha)	Ground Water irrigated Area (Ha)	Irrigation met through Ground Water (%)
1	BANKURA-I	5303.04	1531.61	29
2	BANKURA-II	5070.75	1251.26	25
3	BISHNUPUR	6216.4	5176.4	83
4	BORJORA	4411.6	1989.7	45
5	CHHATNA	4334.02	483.2	11
6	GANGAJAL GHATI	5818.72	218.9	4
7	HIRBUNDH	3144.89	205.83	7
8	INDPUR	5954.41	487	8
9	INDUS	7541.65	5928.8	79
10	JOYPUR	3919.58	2791.62	71
11	KATUL PUR	6502.39	5896.69	91
12	KHATRA-I	2256.3	7	0
13	MEJIA	2125.87	232.1	11
14	ONDA	9609.6	6942.71	72
15	PATRASAYER	5807.09	4902.09	84
16	RAIPUR	3938.63	1746.63	44
17	RANIBUNDH	2545.13	251.31	10
18	SALTORA	6254.65	410.24	7
19	SARENGA	3219.25	1986.05	62
20	SIMLAPAL	3882.28	1732.07	45
21	SONAMUKHI	7313.51	4998.11	68
22	TALDANGRA	3997.89	2512.59	63

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.

7.2 Static water resource/In-storage

Computation of in-storage is essential not only for estimation of emergency storage available for utilization in case of natural extremities like drought conditions but also for assessment of storage depletion in over-exploited areas for sensitizing stakeholders about the damage done to environment. The in-storage for the blocks under study area is listed in the table 7.2.1 (as of 2009).

Table 7.2.1 In-storage of groundwater for Bankura District

Sl. No.	District	Assessment Unit/ District	Net Groundwater Availability (Dynamic GW Resource as on 31-3-2009)	Fresh In-Storage Ground Water Resources	Total Availability of Ground Water Resources [(3) +(4)]
1	**1a**	**2**	**3**	**4**	**5**
1	Bankura	BISHNUPUR	12689	87974	100663
2	Bankura	BORJORA	11550	89587	101136
3	Bankura	INDAS	12877	88023	100900
4	Bankura	JOYPUR	12913	85639	98552
5	Bankura	KOTULPUR	11901	110495	122396
6	Bankura	ONDA	18698	199709	218407
7	Bankura	PATRASAYER	15078	150884	165962
8	Bankura	SIMLAPAL	7086	62436	69522
9	Bankura	SONAMUKHI	10311	122544	132855
10	Bankura	TALDANGRA	9225	81629	90855
Soft Rock/Alluvium Total			**122329**	**1078918**	**1201247**
1	Bankura	BANKURA- I	3587	4920	8507
2	Bankura	BANKURA- II	5670	8386	14057
3	Bankura	CHHATNA	9446	12456	21902
4	Bankura	GANGAJALGHATI	6314	13252	19566
5	Bankura	HIRBUNDH	4328	4146	8474
6	Bankura	INDPUR	11447	8009	19456
7	Bankura	KHATRA	3813	5625	9438
8	Bankura	MEJHIA	2968	6097	9065
9	Bankura	RAIPUR	7195	16512	23706
10	Bankura	RANIBANDH	6959	4592	11551
11	Bankura	SALTORA	5436	6734	12170
12	Bankura	SARENGA	5833	12151	17984
Hard Rock Total			**72995**	**102881**	**175876**
District Total			**195324**	**1181799**	**1377123**

CHAPTER 8

HYDROCHEMISTRY

8.1 Major Ion Chemistry and Hydrogeochemical Facies of Bankura district.

For demarcating the Hydro chemical facies existing in the phreatic and confined aquifer systems Piper (1953) and the modified Piper diagram by Chadha (1999) were used. The sample plotting falls in different areas is:

- The Piper's trilinear diagram [**Figure 8.1.1 (A)]** shows that 43.4% of groundwater samples fall into No dominant cation type. Whereas 32% of the fall into the Calcium Type and remaining24% samples in Sodium and Potassium type in the Cation facies. Hence, the plotting on the Piper diagram for the samples from the study area shows dominance of mixed cation.
- Regarding anions, 38% of samples fall into HCO_3^- type, 47% Cl^- type and rest 15% samples fall into no dominant type of anion facies.

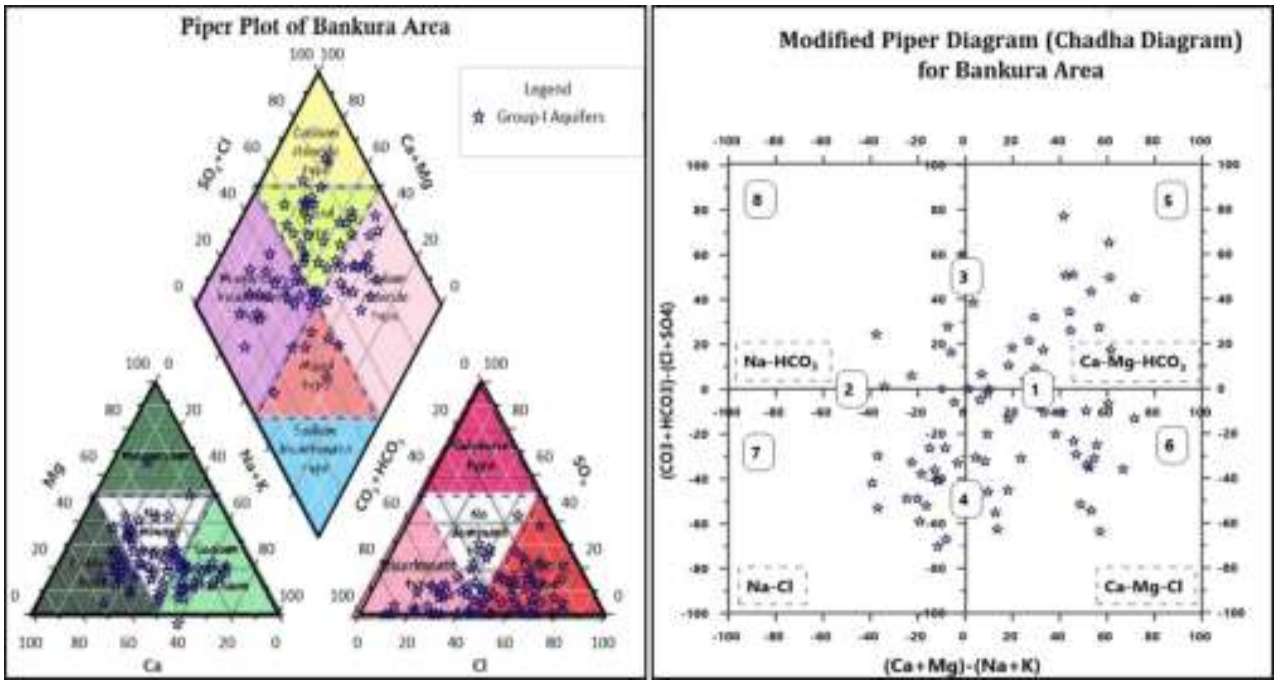


Fig 8.1.1: Groundwater samples from Phreatic aquifers of the Study Area plotted on (A) Piper tri-linear diagram (B) Modified Piper Diagram (Chadha,1999) for identification of hydrogeochemical facies

- The plot of chemical data on diamond shaped trilinear diagram reveals that 71% of the groundwater samples fall in the fields of alkaline earth exceeds alkalis and remaining 29% fall in the fields of alkalis exceed alkaline earth.63.2% of groundwater sample fall in the strong acids (SO_4 + Cl) exceeds weak acids (CO_3 + HCO_3), 36.8% fall in Weak acids (CO_3 + HCO_3) exceed strong acids (SO_4 + Cl).

- 27% Groundwater samples were attributed to Ca-Mg-HCO_3facies, 43% fall into Ca-Mg-Cl type, 21% fall into Na-K-Cl-SO_4type. Therefore, facies classification indicates that maximum groundwater samples belong to Ca-Mg-Cl and Ca-Mg-HCO_3type (Fig.).

The above analysis indicates that the hydro chemical characteristics of groundwater in the phreatic aquifers show considerable variations, which could be ascribed to various factors such as the composition of the litho-units, soil type and even water contamination. The Ca-Mg-Cl and Ca-Mg-HCO_3type water indicates water type with temporary hardness.

Table 8.1.1: Characteristics of groundwater samples in different zones derived from Chadha's diagram.

Chemical facies	Characteristics
Ca-Mg-HCO_3 type of recharge waters	water type with temporary hardness
Ca-Mg-Cl Type of reverse ion-exchange waters	water type with temporary hardness
Na-Cl type of end-member waters (seawater intrusion)	water type with permanent hardness
Na-HCO_3 type of base ion-exchange waters	water type which causes foaming

Rock-water interaction

Rock-water interaction has been assessed using Gibbs Diagram (Gibbs, 1970), which is a widely used method to establish the relationship of water composition and source conditions/characteristics. Three distinct fields such as precipitation dominance, evaporation dominance and rock-water interaction dominance areas are shown in the Gibbs diagram (**Figure 8.1.2**). The distribution of samples in the rock dominance region of the plot in the Gibbs diagram suggests that the major ion chemistry of groundwater is controlled by chemical weathering of rock forming minerals.

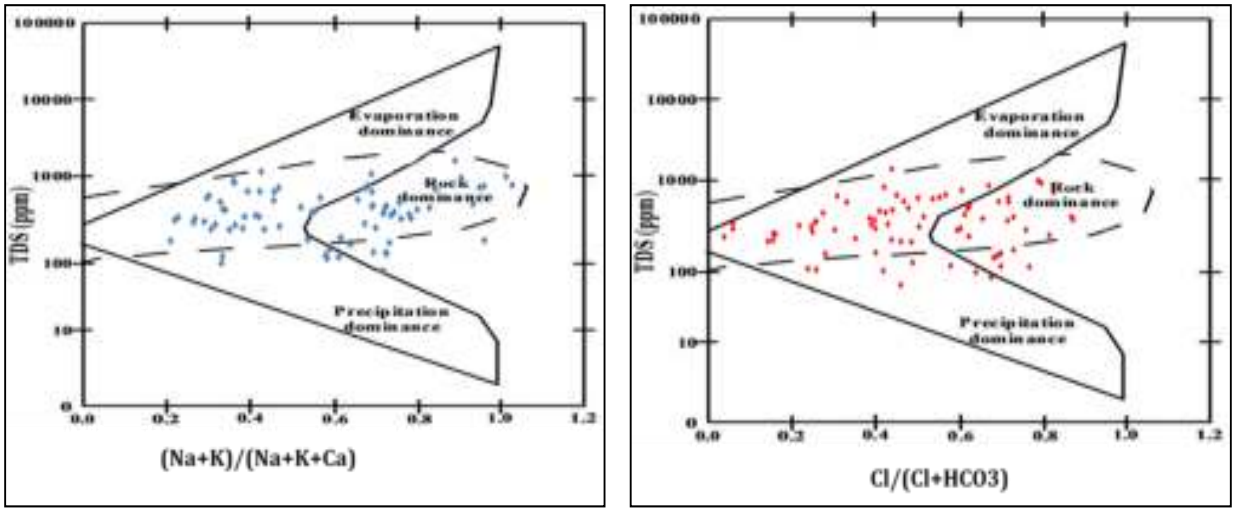


Fig 8.1.2: Gibbs diagram for controlling factor of groundwater quality

8.2 Water Quality Assessment

Since groundwater is intensively used for irrigation and drinking purposes, an effort has been made to evaluate the suitability of groundwater for drinking and irrigation uses.

8.3 Suitability for Drinking Uses

To check the suitability of groundwater, hydrochemical parameters of groundwater samples of the Study area were assessed with respect to prescribed limits of Bureau of Indian Standard (BIS, 2012) for drinking water. The details of the samples and parameters exceeding the prescribed limit are mentioned in the **Table 8.3.1**

Table 8.3.1: Spatial Variation of Ionic Concentration in Study Area

Constituents (mg/L)	Acceptable Limit	Permissible Limit	Sample Exceeding Acceptable Limit (%)	Sample Exceeding Permissible Limit (%)	Max	Min
pH	6.5-8.5	No Relaxation	-	-	8.5	7.2
Electrical Conductivity (µS/cm)	-	-	-	-	2493	104
Total Dissolved Solid (mg/L)	500	2000	31.6	-	1666.1	63.3
Total Alkalinity (as $CaCO_3$) (mg/L)	200	600	21.1	1.3	610	15
Chloride (mg/L)	250	1000	7.9	-	407.7	17.7
Nitrate (mg/L)	45	No Relaxation	27.6	-	319	2.1
Sulfate (mg/L)	200	400	-	-	161.9	2.2
Fluoride (mg/L)	1	1.5	26.3	11.8	2.9	Traces
Sodium (mg/L)	-	-	-	-	255.4	7.2
Potassium (mg/L)	-	-	-	-	220.6	0.5
Calcium (as Ca) (mg/L)	75	200	15.8	-	150	6
Magnesium (as Mg) (mg/L)	30	100	23.7	1.3	100.8	18.2
Total Hardness (as $CaCO_3$) (mg/L)	200	600	50	3.9	790	30
Iron (Fe) (mg/L)	1.0	No Relaxation	3.9	-	4.2	Traces

NOTE — *It is recommended that the acceptable limit is to be implemented. Values in excess of those mentioned under 'acceptable' render the water not suitable, but still may be tolerated in the absence of an alternative source but up to the limits indicated under 'permissible limit in the absence of alternate source' in col 4, above which the sources will have to be rejected.*

The data in **Table 8.3.1** shows that some of the physiochemical parameters exceeded the Acceptable limits in a number of water samples, though mostly they are well within the maximum permissible limits.

- 31.6% of the sample locations were found to have the TDS concentration was more than the BIS's (2012) Acceptable limit of 500 mgL^{-1}however, all samples were found within the Permissible limit of 2000 mgL^{-1}. The higher concentration of EC and TDS in ground water samples may cause gastrointestinal irritation to the consumers.
- The Total Hardness (TH) varies from 30-790 mgL^{-1}in the study area indicating soft to very hard water types. Hardness of the water is attributable to the presence of alkaline earths elements, i.e., Ca^{2+} andMg^{2+} which agrees the water type as interpreted from Piper diagram. 3.9% water sample has TH beyond the BIS (2012) Permissible limit of600 mgL^{-1} for drinking water.

Table 8.3.2: Hardness Classification of groundwater of the study area

Water Class	TH as $CaCO_3$ in mg /L	% of Samples
Soft	<75	17
Moderately Hard	75–150	25
Hard	150–300	37
Very Hard	>300	21

- The consumption of water containing higher TDS concentration may cause several diseases like nausea, lung irritation, rashes, vomiting, dizziness etc. Drinking water with elevated amount of TDS for longer periods will expose body to various chemicals, toxins and may cause chronic health conditions like cancer, liver, kidney.
- Ca^{2+}concentrations are also found within the highest permissible limits (BIS 2012) with the values ranging from 06-150 mgL^{-1}.

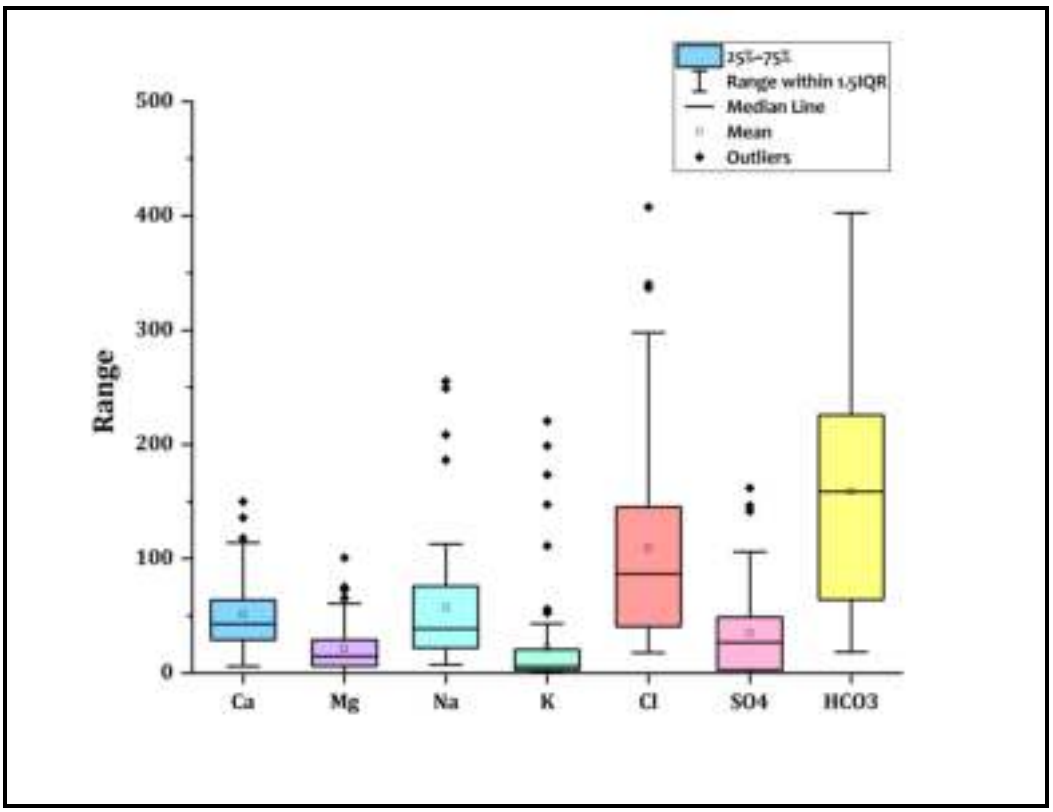


Figure 8.3.1: Box and Whisker Plot sowing Spatial Distribution of Major Cations and Anions in the study area

Distribution of Fluoride in the study area

Fluoride concentrations in the water samples of the study area were presented in **Figure 8.3.2** that displays values of Fluoride concentration in mgL^{-1}. In the study area the Fluoride concentration varied from Trace-2.9 mg/Land 11.8% samples were detected with Fluoride concentration more than permissible limit.

The excess concentration of fluoride (F^-) in groundwater has immense impact on human health. A small dose of F^- (≤0.6 mg/L) in drinking water is an essential nutrient in regard to development of teeth and bones but prolonged ingestion of water with progressively higher concentrations of F^- above the guideline value (1.5 mg/ L) lead to increasing risks of dental and skeletal fluorosis. The intake of excess F^- may also cause reproductive, renal, neurological, gastrointestinal and carcinogenic problems. In view of the environmental and socio-economic conditions of the Indian subcontinent and drinking water consumption, the Acceptable limit of F^- is considered as 1 mg/L and permissible limit of F^- is 1.5 mg/L (BIS 2012).

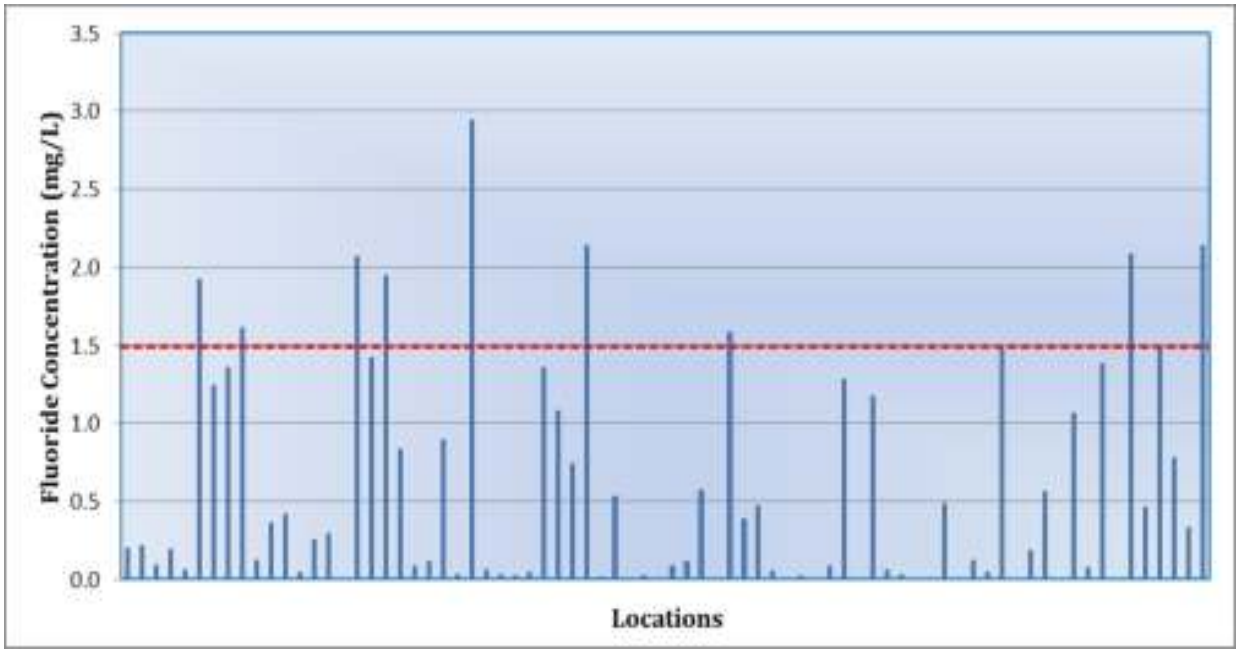


Figure 8.3.2: Distribution of Fluoride in the study area

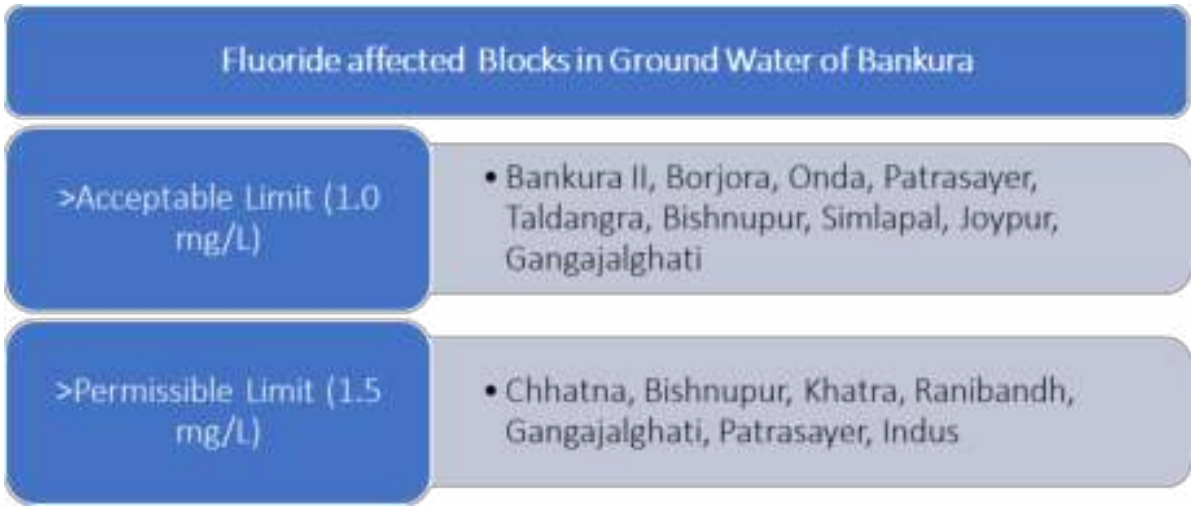


Figure 8.3.3: Fluoride affected Blocks in Ground Water of Bankura District

8.4 Suitability for Irrigation Uses

In the present study the suitability of the groundwater for irrigation is assessed by considering the irrigation indexes like Conductivity (EC), Soluble Sodium Percentage (SSP), Sodium Adsorption Ratio (SAR), Residual Sodium Carbonate (RSC), Magnesium Hazard (MH) and Permeability Index (PI) along with the USSL salinity and Wilcox diagrams and the result has been summarized in **Table 8.4.1**

Wilcox diagram has been used to study the quality of groundwater suitability for irrigation purpose. The SAR and EC values of water samples of the study area were plotted in the graphical representation [**Figure 8.4.1 (B)]**and found that majority of the samples fall in the low to medium category in salinity hazard group and low in sodium

hazard group. Hence, most of the locations of the study area the ground water is suitable for the irrigation purpose.

Table 8.4.1: Summarized result for various indices to assess the suitability of the ground water for irrigation

Indices	Range	Water Class	Maximum	Minimum	Average
SAR	< 10	Excellent	6.7	0.3	1.7
	10 to 18	Good			
	18 to 26	Moderate			
	> 26	Unsuitable			
SSP	< 50	Good	81.9	11.8	42.9
	> 50	Unsuitable			
RSC	< 1.25	Good	2.5	-13.5	-1.7
	1.25 to 2.50	Moderate			
	> 2.50	Unsuitable			
MH	< 50	Good	83.7	-94.0	34.9
	> 50	Unsuitable			
PI	> 75	Good	111.6	30.2	66.2
	25 to 75	Moderate			
	< 25	Unsuitable			
KI	<1	Suitable	2.1	0.1	0.7
	>1	Unsuitable			

Similar results found when the USSL diagram is plotted for classification of water for irrigation suitability. In this diagram, the EC was plotted against the percentage of Na. According to Wilcox classification, 51.5% of the water samples from the study area belonged to Excellent to good category and 35.5% of the water samples belong to good to permissible category. Remaining 9.2% groundwater samples falls in the permissible to doubtful category [**Figure 8.4.1(A)]** and 3.9% in doubtful to unsuitable category.

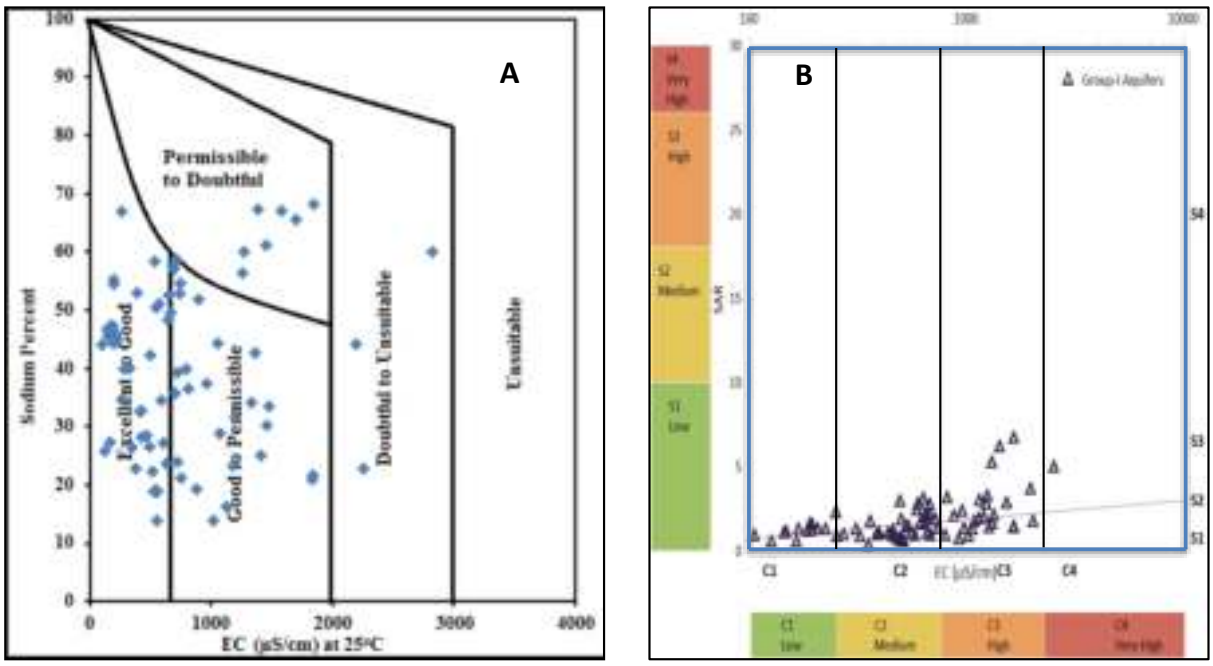


Figure 8.4.1 (A) Wilcox Diagram and (B) United States Salinity Laboratory (USSL) for assessing the Irrigation water quality of the study area

Major findings in Water Quality Assessment of the study area

- The reflections from the overall survey carried out in the study area revealed that the ground water quality in the area is suitable for drinking purposes with a few locations having Hardness and alkalinity problems.
- 31.6% of the study area depicted the TDS concentration more than the Acceptable limit of 500 mgL^{-1} (as per BIS, 2012).
- Higher concentration of Fluoride exceeding the permissible limit of 1.5 mg/L was found in few pockets.
- In respect of suitability assessment for Irrigation water, the ground water of majority of the study area was in suitable category.
- Facies classification of the area indicates that maximum groundwater samples belong to Ca-Mg-$HCO_3$and Ca-Mg-Cl type (as high as 70% locations), which indicates, water type with temporary hardness.

CHAPTER-9

GROUND WATER RELATED ISSUES AND PROBLEMS

No water-logged area was noticed/ marked in the district though considerable area is covered by canal irrigation.

The district is a drought prone area and the parts of the district e.g., Chhatna, Gangajalghati, Indpur, Hirabundh, Mejia, Ranibundh, Saltora blocks face severe drought and declared as drought blocks. The area stretching from NW, W & SW covering almost half of the area underlain by Archean and Gondwana suffer from water scarcity owing to poor potentiality of the formations. In these, ground water occurs under water table conditions in the weathered zone and semi-confined to confined conditions in the zone of secondary porosities. The drought prone blocks as mentioned above are severely water scarce in the district.

It has been observed from the record that in Khatra block a large No. of hand pumps fitted tube wells have become nonfunctional due to lowering of water level in the peak summer months. The State authority has constructed river bed tube wells to cater drinking water.

Ground water in the district is contaminated with fluoride. In the district about 718000 population in 309 habitations of 10 blocks are at risk zone.

The collective information from different drilling agencies indicates that the half of the area is covered by massive crystalline rock and the thickness of the weathering is less and devoid of secondary porosity. Hence drilling of tube wells in the areas may not be successful. It is suggested that the areas for drilling be selected in a scientific manner especially in geophysical investigations. This will reduce wanton expenditure.

Till date no record of significant natural disaster was reported.

9.1 Water conservation and artificial recharge:

In modern days water conservation and artificial recharge through rain water harvesting is essential mainly in Bankura district where majority of the area faces severe water scarcity during lean period. The annual rainfall is 1300 mm and which is sufficient to design suitable rainwater harvesting structures.

9.2 Conservation of Water:

In the areas along the western boundary and southwestern part of the district, where hard formation is prevalent, potentiality of aquifer is limited to poor. Dug wells are the ground water abstraction structures in this district. However, with the onset of summer these dug wells go dry and the scope for further development is not feasible as to mitigate the crisis of drinking water problem. Therefore, conservation through rainwater harvesting practices is a viable option. Conservation of Rainwater can be done through the water which is available from both rooftops and also from the land.

- Water available from roofs can be stored giving considerations of all types of loses in cemented tanks or in PVC tanks. Before conserving the water should be passed through a filter media.
- Rainwater available from the surrounding land surface can be stored in any ponds and in this case design of ponds are to be finalized considering local hydrogeological condition.
- In undulating terrain gully plugs are feasible on cultivated land to conserve limited quantity of water and thereby soil moisture can be increased and will be beneficial for crop production.
- In the alluvial areas of the district rainwater conservation is also feasibility depending upon the requirement and prevailing hydrogeological condition.

CHAPTER-10

GROUND WATER 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.

10.1 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 Panchayat of Bankura. 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 and rig wells are commonly used for water supply to rural area.

10.2Future Ground Water Development and Management:

The district has net available ground water resource as 161769ham and the average stage of development is 38.94%. The mode of ground water development in Bankura district can be summarized as follows:

In western and northern parts of the district falling within Gangajalghati, Mejia and parts of Barjora blocks, ground water utilization will be made mainly for drinking purpose. Though irrigation through ground water can be possible by construction of dug well, dug cum bore wells with limited command area.

Dug well, dug cum borewells and limited number of bore wells may be the main mode of ground water development in consolidated formations specially in Ranibundh, Khatra, Indpur, Raipur, parts of Bankura and Simlapal blocks. The selection ground water structures need to be made preferably with the help of geophysical resistivity survey.

Low duty, medium duty and heavy-duty tube wells may be constructed in unconsolidated formation of Quaternary and Tertiary sediments specially in Bishnupur, Onda, Taldangra, Simlapal blocks. In the marginal tracts where thickness of sediments are not considerable, heavy duty tube wells may not be suitable.

Selection of tube wells, dug wells and bore wells site may be based on;

1. Beneficiary involvement i.e., small or marginal farmers
2. Sufficient irrigable land adjoining it.

3. Ground Water availability and suitability for irrigation in adjoining soil condition and
4. Area should not be submerged during flood.

Conjunctive use of surface water and ground water wherever technically feasible can be adopted specially in consolidated formation and in areas of limited ground water structures. Tank excavation, river lift structure, nala bounds can be constructed at suitable locations which can facilitate irrigation as well as artificial recharge of ground water in shallow aquifer.

Recommendations:

Block wise recommendations for ground water abstraction structures are given as follows;

- Block wise recommendation for further development of ground water resources can be made according to the data presented under item 'Status of Ground Water Development'. For development activity, aquifer data are the main factors to be studied in detail. Besides, ground water conservation and artificial recharge can be implemented in large scale following a scientific way.
- In parts Taldangra block along the Siali river, Simlapal block along the Joypanda, river a number of autoflowing tube wells were found. Hence it ie suggested that the extension of the autoflow areas be marked and conjunctive use of surface and ground water may be implemented in a planned manner. The same may be done in Bishnupur block also.
- The majority of the district is underlain by hard crystalline rocks. As such ground water development is to be done in a scientific manner.
- There are five vast water bodies (ponds) in Bishnupur town area namely Krishna Bandh, Lal Bandh, Jamma Bandh, Shyam Bandh, Gatai Bandh. These ponds if properly renovated including desilting, huge quantity of rainwater can be conserved and Bishnupur Municipality, which faces acute scarcity during summer, may cater the domestic need.
- Similar steps may be taken up for Bankura Municipality near Kesekole site situated east of Gondheswari river in its flood plain a large water reservoir can be constructed.
- Check dams, Subsurface dykes may be useful if constructed at certain intervals along the drainage channel of Kangasobati in its lower reaches. Silaboti, Joypanda, Tarafeni, Burai etc. It has been observed that small drainage channels of these rivers contain base flow and if these can be arrested lowering of water level in the surrounding area can be restricted along with the submergence in the downstream side. Flow of excess water through small drainage channel in the command area of Kangsobati river can be utilized as per need during kharif and rabi period.

- In the blocks where excess fluoride concentration in ground water has been recorded proper defluorination technique is to be adopted prior to use for drinking.
- This district receives abundant rainfall part of which recharges both ground water and surface reservoirs.
- In a part of Taldangra block near Sitai river and in Simlapal block near Joyponda river,

  a number autoflow tube wells have been encountered; it is proposed to explore the possibility of existence of extension of this '**auto flow"** zone, if any.
- Conjunctive use of groundwater and surface water is also a possible option in certain

  parts of this district and this may be done in a planned manner. This could be implemented in parts of Bishnupur block.
- There are 5 vast water bodies (pond) in Bishnupur Town, viz. Krishnabundh,

  Lalbundh, Jamma Bandh, Shyambandh, Gatai Bandh. These ponds, if properly renovated including de-silting huge quantity of rainwater could be conserved and the Bishnupur Municipality which faces acute water scarcity during summer may cater the domestic need of drinking water.
- Similar steps may be taken up in Bankura Municipality too, eg. near Kesekole, situated east of Gondeswari river, a large water reservoir can be constructed in the flood plain of the said river.

- In the blocks where excess fluoride concentration in groundwater has been recorded, its proper de-fluoridation of technique has to be adopted prior to its use for drinking.

10.3 Scope for Artificial recharge to Ground water:

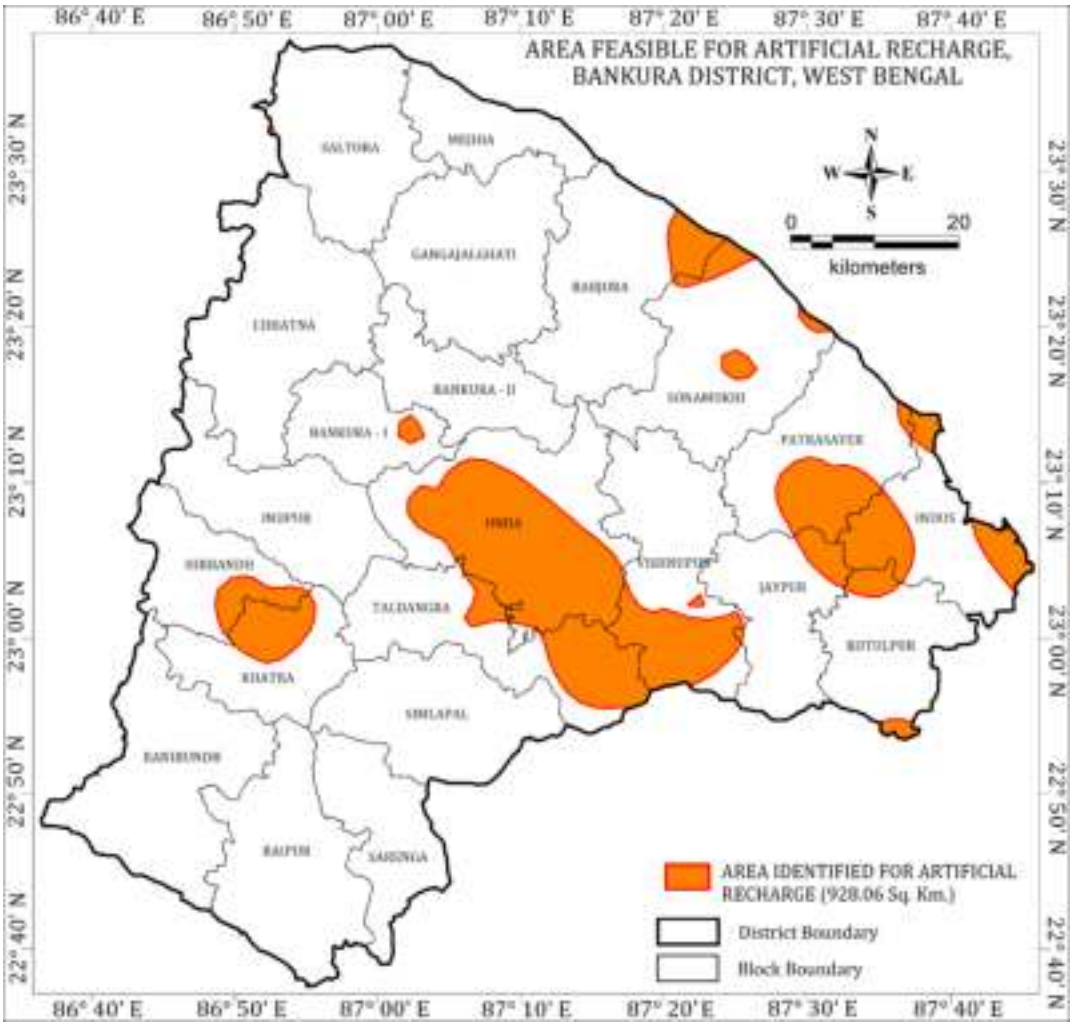


Figure 10.3.1 Area feasible for Artificial Recharge Map of Bankura District

Table 10.3.1 feasible structures and their cost of constructions in lakhs for the blocks in study area (CGWB, ER)

District	Block	Formation type	Area feasible for AR (Sq.km)	Number of Proposed Recharge Structures							Cost of Recharge structures (Rs. In lakhs)							Availability of surface non committed monsoon run off (MCM)
				Percolation Tanks	REET with RS	Injection Well	Check Dam	Gabion/ Contour Bund	Sub surface dykes	Dug Well Recharge	Percolation Tanks	REET with RS	Injection Well	Check Dam	Gabion/ Contour Bund	Sub surface dykes	Dug Well Recharge	
Bankura	Barjora	Alluvium	32.858	10	20	10	0	0	0	0	80	80	30	0	0	0	0	9.857
Bankura	Indus	Alluvium	103.623	31	62	31	0	0	0	0	248	248	93	0	0	0	0	31.087
Bankura	Jaypur	Alluvium	26.7434	8	16	8	0	0	0	0	64	64	24	0	0	0	0	8.023
Bankura	Kotulpur	Alluvium	25.6913	8	15	8	0	0	0	0	64	60	24	0	0	0	0	7.707
Bankura	Onda	Alluvium	299.352	90	180	90	0	0	0	0	720	720	270	0	0	0	0	89.806
Bankura	Patrasayer	Alluvium	86.4342	26	52	26	0	0	0	0	208	208	78	0	0	0	0	25.930
Bankura	Ranibundh	Alluvium	0.01113	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.003
Bankura	Saltora	Alluvium	0.63765	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.191
Bankura	Sonamukhi	Alluvium	33.9798	10	20	10	0	0	0	0	80	80	30	0	0	0	0	10.194
Bankura	Taldangra	Alluvium	114.835	34	69	34	0	0	0	0	272	276	102	0	0	0	0	34.451
Bankura	Vishnupur	Alluvium	108.835	33	65	33	0	0	0	0	264	260	99	0	0	0	0	32.650
Total			**833**	**250**	**499**	**250**	**0**	**0**	**0**	**0**	**2000**	**1996**	**750**	**0**	**0**	**0**	**0**	**249.900**
Bankura	Bankura-I	Hard Rock	6.62846	1	0	0	2	6	3	1	12	0	0	3	3	3	1.1	0.597
Bankura	Hirbandh	Hard Rock	33.436	5	0	0	16	40	20	4	60	0	0	24	20	20	4.4	4.012
Bankura	Khatra	Hard Rock	54.9912	6	0	0	20	49	25	5	72	0	0	30	24.5	25	5.5	4.949
Total			**95.056**	**12**	**0**	**0**	**38**	**95**	**48**	**10**	**144**	**0**	**0**	**57**	**47.5**	**48**	**11**	**9.558**

PART – II

CHAPTER-11
BLOCK MANAGEMENT PLANS
BANKURA DISTRICT
(22 Nos. OF BLOCK)

11.1 SALIENT INFORMATION

Block Name: ***Bankura-I***

Geographical area (sq. km): **179**

Mappable area (sq. km): **179**

District: **Bankura**

State: **West Bengal**

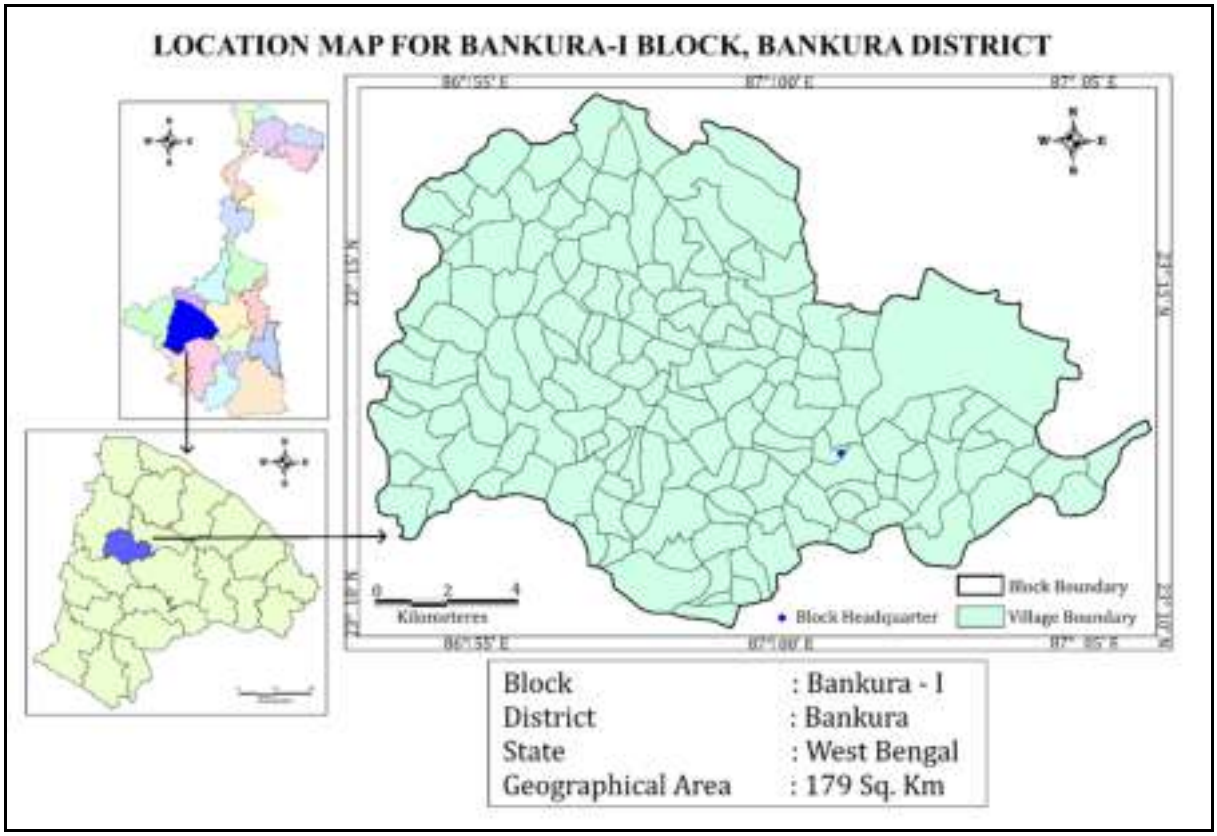


Figure11.1.1: Location Map of *Bankura-I* Block

Population (as on 2011):

Table 11.1.1: ***Details of population in Bankura-I block.***

Rural	Urban	Total	Population Density per Sq.km
107685	137386	245071	1369

Rainfall: Average annual rainfall for the period 2015 -19 is 1300.36 (in mm)

Table 11.1.2: Details of Annual Rainfall for the last five years in *Bankura-I* block.

Block Name	Normal Rainfall	Rain Fall				
		2014	2015	2016	2017	2018
Bankura-I	1386	1075.5	1127.2	1335.9	1780.2	1334.3

Agriculture& Irrigation (area in ha):

Table *11.*1.3: Salient Land use features of *Bankura-I* block

Block	Reporting Area	Forest Area	Area Under Non-Agricultural Waste	Barren and Un-culturable land	Permanent pastures and grazing lands	Land under misc tree crops	Culturable wastes	Fallow land Other than current fallow	Current fallow	Net area sown	Cultivable Area
Bankura-I	18764	1772	6605	36	2	5	71	19	200	10054	10349

Table *11.1.*4: Crop pattern of *Bankura-I* block

Block	Aus			Aman			Boro			Wheat			Maize		
	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield
Bankura-I	15	0.31	2054.19	9255	25.440	2749	4	0.012	2944	6	0.014	2335	-	-	-
	Mustard			Til			Potato			Musur			Gram		
	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	
	0.019	799	-	-	-	55	1524.000	27700	3	0.002	749	-	-	-	

Table *11.1.5* Command area (ha) of *Bankura-I* block

Block Name	Dug well		Shallow Tube well		Medium Tube well		Deep Tube well		Surface Flow		Surface Lift		CCA (ha.)		Total CCA (ha.)
	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	Ground Water	Surface Water	
BANKURA-I	47	88.1	121	438.51	1	5	0	1000	37	217	587	3554.43	1531.61	3771.43	5303.04

Table 11.1.6: Command area (ha) of *Bankura-I* block

Name of Block	Canal Area	Tank		RLI		DTW		STW		ODW		Others		Total	
		No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area
Bankura-I	198	845	925	17	660	-	-	28	78	600	300	26	165	1516	2326

Disposition of Aquifers:

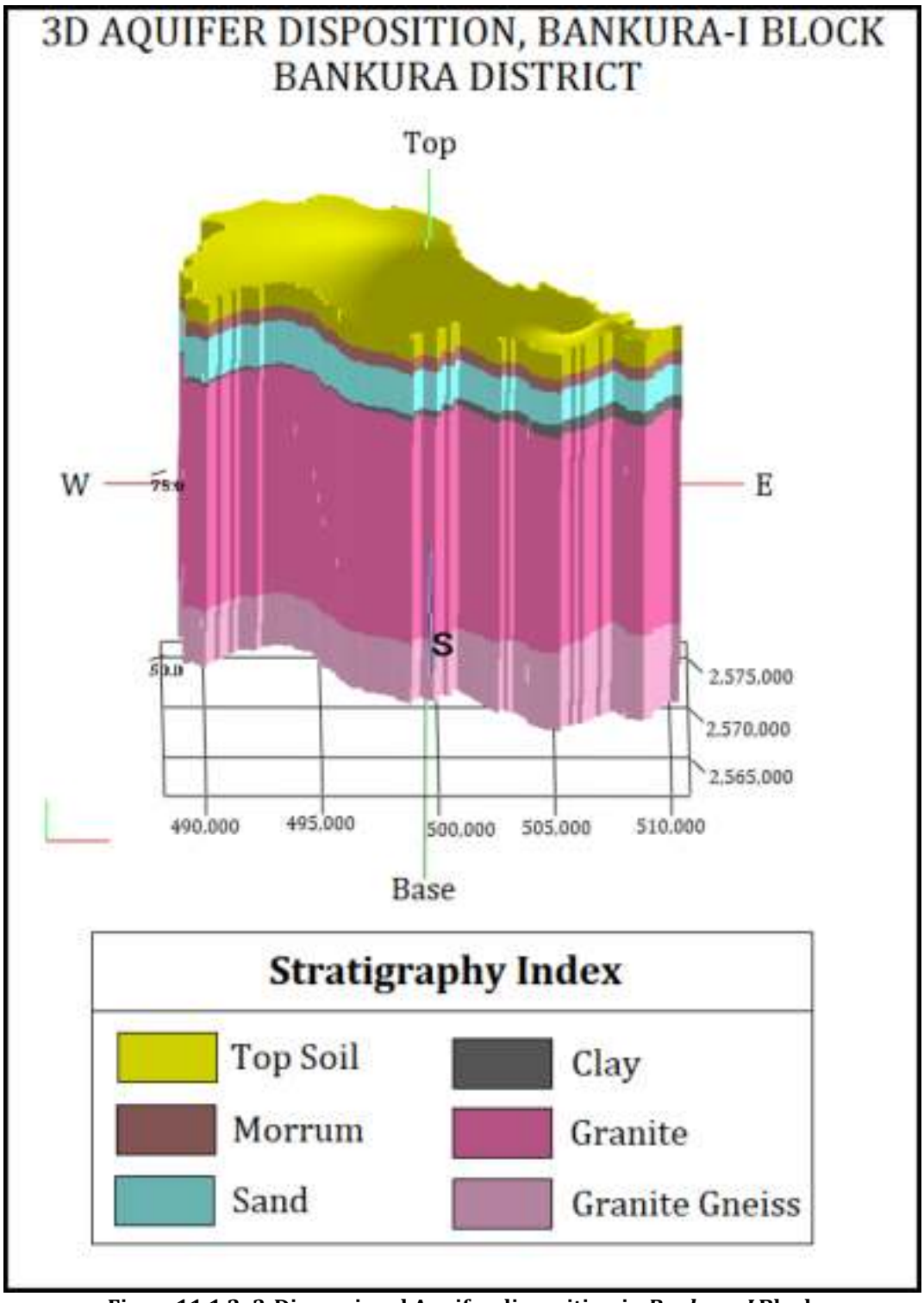


Figure11.1.2: 3-Dimensional Aquifer disposition in *Bankura-I* Block

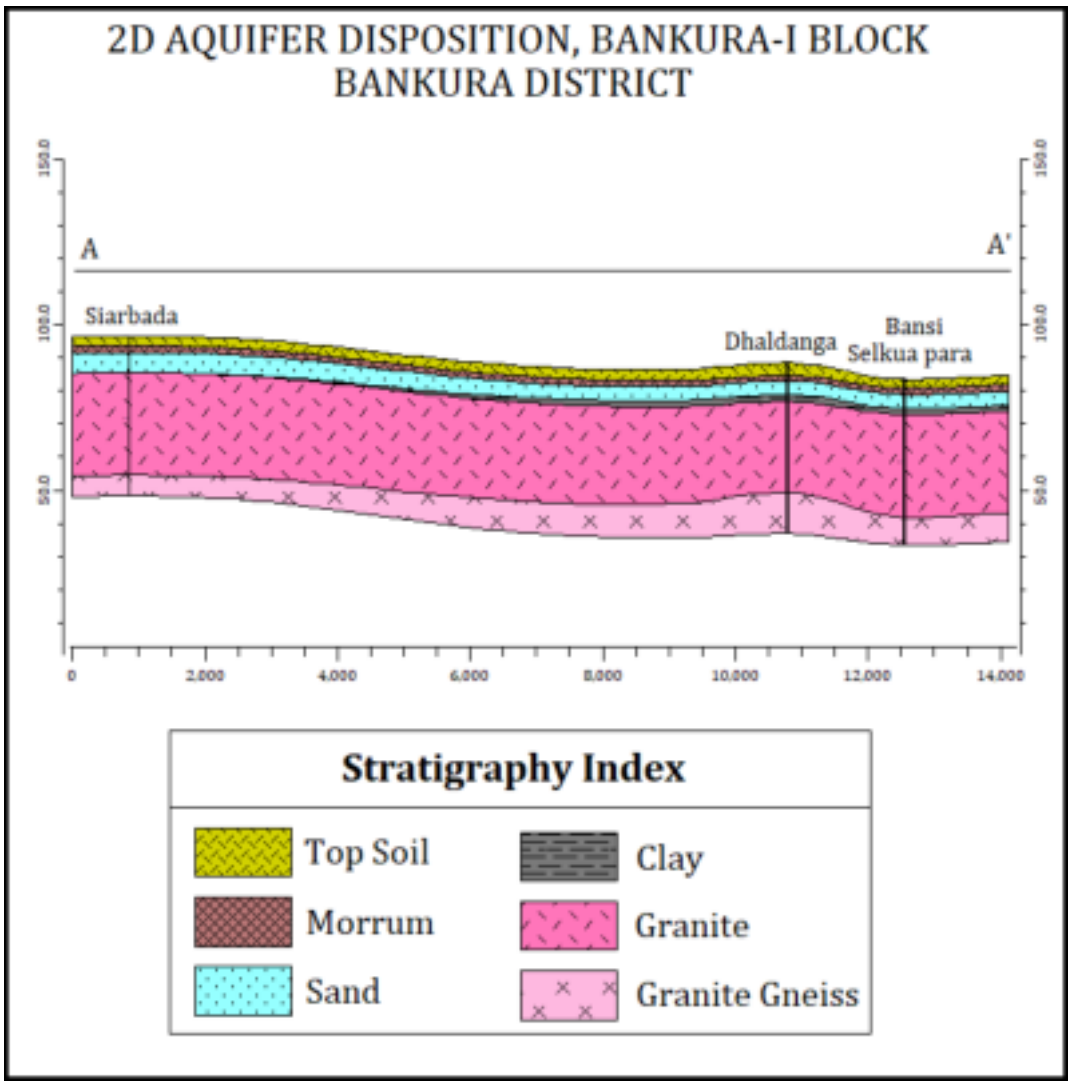


Figure*11*.1.3: 2-Dimensional Section in *Bankura-I* Block

The principal aquifer systems encountered in this block is hard rock.
Two aquifers are encountered in this block.

The range of **Aquifer-I** is also known as Shallow aquifer/ weathered zone. The casing depth is here upto 24mbgl. The water bearing zone varied between 4-11 mbgl.

The range of **Aquifer-II** is also known as fracture zone where the interconnected fracture (secondary porosity of the rock) is responsible for the presence of GW. Fractures encountered at a depth of 38 mbgl & 45 mbgl.

Table 11.1.7: Details of aquifer disposition in Bankura-*I* Block

Blocks (dominant in hard rock)	No. of Aquifers	Water bearing zone	Casing depth	Aquifer Thickness (m)		Discharge (lpm)	T (m^2/ day)	SWL (mbgl)	Drawdown (mbgl)	S
				Aquifer-I weathered Zone	Aquifer-II Fracture zone					
Bankura-I	2	4-11	(upto 24m)	7	38, 45,	20	--	8.5	--	--

Table 11.1.8: Details of Aquifer Wise Water Level Ranges & seasonal long term water level trends

Block	Pre-monsoon Trend			Post-monsoon Trend		
	WL Range (mbgl)	Rise (m/year)	Fall (m/year)	WL Range (mbgl)	Rise (m/year)	Fall (m/year)
Bankura-I	2.65-5.32	--	0.083	1.5-4.38	0.083	--

Ground water quality and issues:

Based on four NHS, four exploratory wells and three observation wells, the range of chemical parameter for the block is given below.

Table 11.1.9: Range of chemical parameters in Bankura-I Block

Block	Aquifer Type	pH	EC (µS/cm)	Na (mg/l)	Cl (mg/l)	F (mg/l)	NO_3 (mg/l)	Fe (mg/l)	Measured Hardness (mg/l)
Bankura-I	Aquifer-I	7.89-8.07	260-1984	12-94	10-60	0.10-0.94	2-9	0.03-0.07	105-565
	Aquifer-II	7.81-8.29	416-884	19-76	22-196	0.43-0.62	1-12	Traces	155-335

Ground Water Resource:

Table *11*.1.10: Details of Ground Water Resource Availability and Utilization in *Bankura-I* Block.

Name of the Block	BANKURA-I
Total Annual Ground Water Recharge (Ham)	5041.3
Total Natural Discharges (Ham)	504.13
Annual Extractable Ground Water Recharge (Ham)	4537.17
Total Extraction	829.19
Annual GW Allocation for Domestic Use as on 2042	319.53
Net Ground Water Availability for future use	3657.91
Stage of Ground Water Extraction (%)	18.28
Categorization (OE/CRITICAL/ SEMI-CRITICAL/ SAFE)	Safe
In storage (Ham)	4920

Aquifer Management Plan:

Ground Water Management Plan for drinking purpose:

The block has two commissioned public water supply schemes by PHED. There is one ongoing as well. However, there is still recorded deficit in supply of drinking water as the schemes do not reach to every mouza in the block. Therefore, there should be a general practice of conservation through rainwater harvesting, considering an adequate normal monsoon rainfall of 1347 mm which the block receives. The conserved rainwater can be utilized for drinking purpose by filtering through Horizontal Roughing

Filters. The water from the lands can be channeled to ponds for recharge in the weathered zones and this water can be tapped through open dug wells for domestic and drinking purpose.

Ground Water Management Plan for irrigation purposes:

- Although ground water development in the block is low with stage of ground water development at 18.28%, further development should be done in planned manner to harness the additional available resource for site specific sustainable development.
- In view of low yield of the area, large diameter dug wells with adequate storage are another viable option for irrigation in favorable condition, thus creating a small command area. Owing to its distinct hydrogeology, it is evident that very less cultivable command area is created by both surface as well as groundwater.
- Modern methods of irrigation like sprinkler and drip irrigation methods are encouraged.
- Crops with low water requirement should be preferred.

In view of adequate rainfall in the area, excavation of tanks with large catchment areas, construction of check dam, nallah bunds, sub-surface dykes along the stream channels at suitable locations can be implemented to raise ground water level as well as to augment irrigation facilities.

Irrigation by surface water may be increased. In addition to surface lift from canal & surface flows, rain water harvesting may also be considered.

Management Intervention through Harvesting of Surface Runoff and Artificial Recharge:

It has been estimated that the utilizable surface runoff produced in the block is **0.597** MCM. This surface runoff is proposed to be utilized to recharge the shallow aquifer (weathered zone) in the block. Therefore, 1 percolation tank, 2 check dam, 2 gabion/ contour bund and 1 sub-surface dyke structures are recommended in the block.

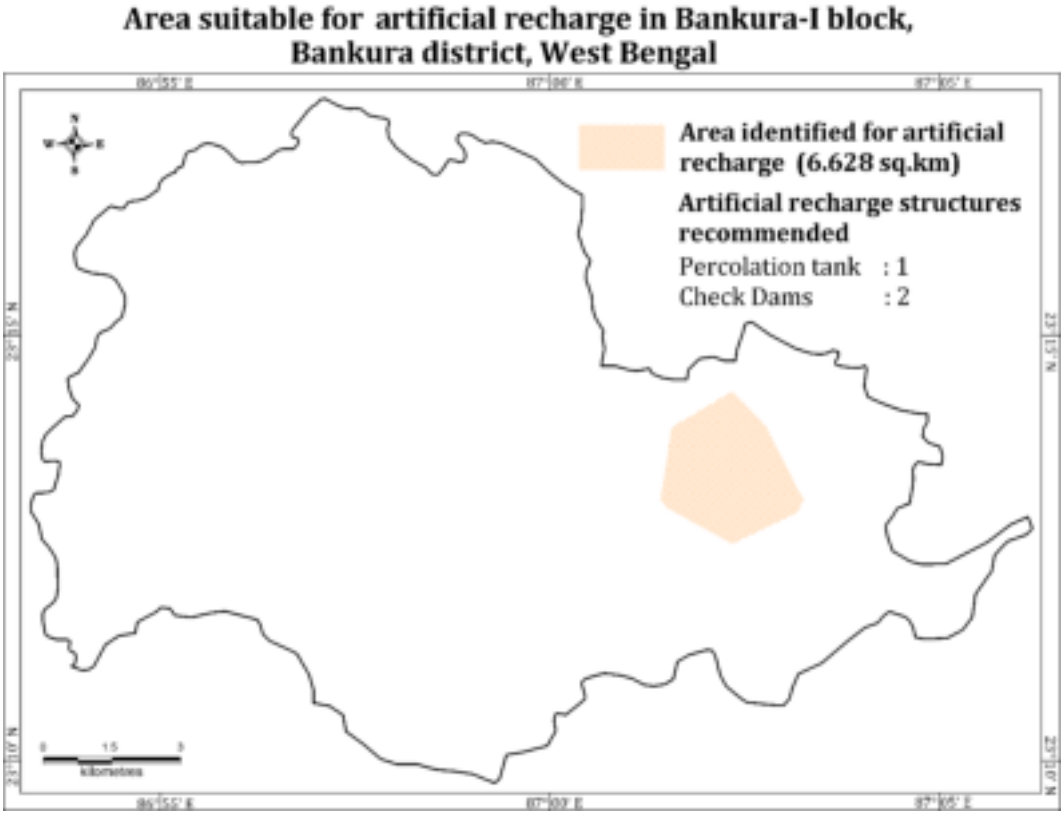


Figure11.1.4: Area Feasible for Artificial Recharge of groundwater for *Bankura-I* Block

Table *11.*1.11: Details of structures recommended in feasible area of artificial recharge for Bankura-*I* Block.

Name of the Block	Utilizable Surface Run Off	Allocation of Utilizable Recourse (MCM)							Structures Feasible							Cost of Structures (in lakhs)								
		Percolation Tank	REET with RS	Injection Well	Check Dam	Gabion/ Contour Bund	Sub-Surface Dyke	Dug Well Recharge	Percolation Tank	REET with RS	Injection Well	Check Dam	Gabion/ Contour Bund	Sub-Surface Dyke	Dug Well Recharge	Percolation Tank	REET with RS	Injection Well	Check Dam	Gabion/ Contour Bund	Sub-Surface Dyke	Dug Well Recharge	TOTAL
Bankura-I	0.597	0.388	0	0	0.119	0.03	0.03	0.03	1	0	0	2	6	3	1	12	0	0	3	3	3	1.1	22.1

11.2 SALIENT INFORMATION

Block Name: ***Bankura-II***

Geographical area (sq. km): **219**

Mappable area (sq. km): **219**

District: **Bankura**

State: **West Bengal**

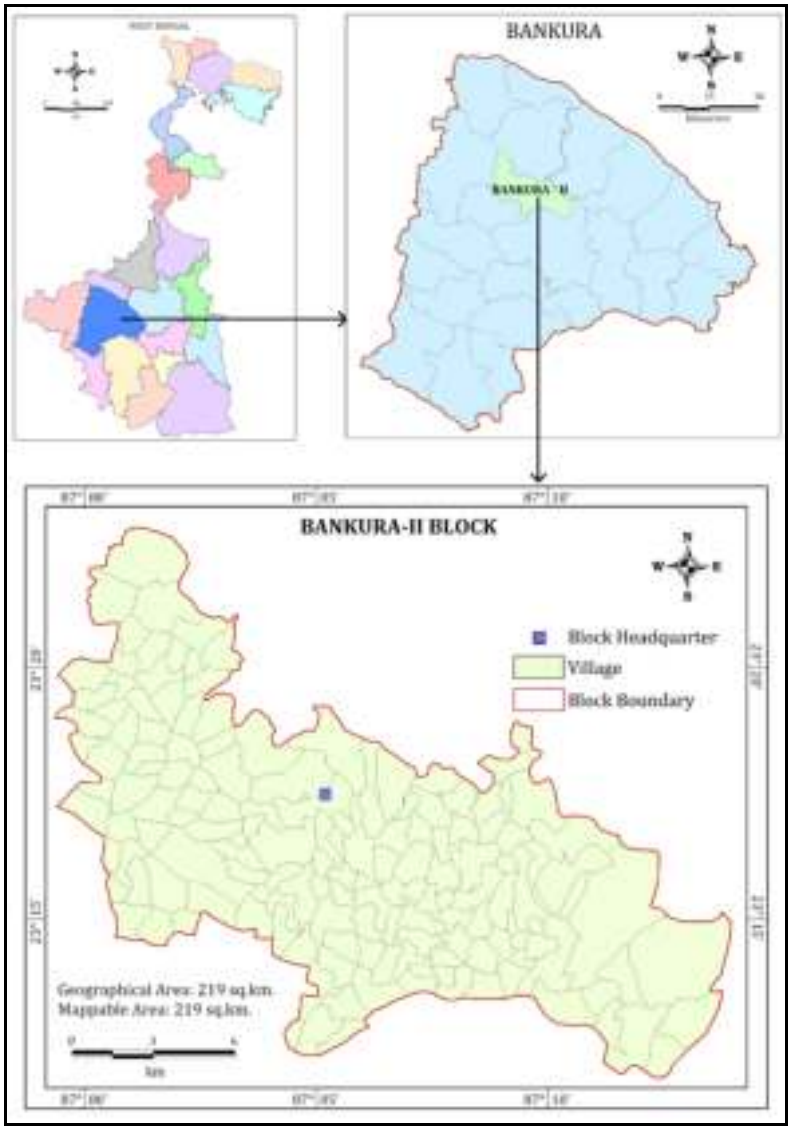


Figure *11.2.1*: Location Map of *Bankura-II* Block

Population (as on 2011):

Table *11.2.*1: ***Details of population in Bankura-II block.***

Rural	Urban	Total	Population Density per Sqkm
140864	-	140864	643

Rainfall: Average annual rainfall for the period 2015 -19 is 1300.36 (in mm)

Table *11.2.2*: Details of Annual Rainfall for the last five years in *Bankura-II* block.

Block Name	Normal Rainfall	Rain Fall				
		2014	2015	2016	2017	2018
Bankura-II	1386	1075.5	1127.2	1335.9	1780.2	1334.3

Agriculture& Irrigation (area in ha):

Table *11.2*.3: Salient Land use features of *Bankura-II* block

Block	Reporting Area	Forest Area	Area Under Non-Agricultural Waste	Barren and Un-culturable land	Permanent pastures and grazing lands	Land under misc tree crops	Culturable wastes	Fallow land Other than current fallow	Current fallow	Net area sown	Cultivable Area
Bankura-II	22093	4472	6498	214	8	130	184	35	956	9596	10901

Table*11.2.*4: Crop pattern of *Bankura-II* block

Block	Aus			Aman			Boro			Wheat			Maize		
	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield
Bankura-II	-	-	-	32270	95.513	2960	19	0.061	3202	72	0.185	2573	-	-	-
	Mustard			Til			Potato			Musur			Gram		
	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	
	344	0.192	574	48	0.032	663	3128	86596.000	27684	5	0.003	547	1	0.001	1024

Table *11.2*.5: Command area (ha) of *Bankura-II* block

Block Name	Dug well		Shallow Tube well		Medium Tube well		Deep Tube well		Surface Flow		Surface Lift		CCA (ha.)		Total CCA (ha.)
	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	Ground Water	Surface Water	
BANKURA-II	3	7	317	1244.26	0		0		54	235	644	3584.49	1251.26	3819.49	5070.75

Table *11.2.6*: Command area (ha) of *Bankura-II* block

Name of Block	Canal Area	Tank		RLI		DTW		STW		ODW		Others		Total	
		No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area
Bankura-II	-	650	1350	18	680	-	-	675	1300	490	200	37	72	1870	3602

Disposition of Aquifers:

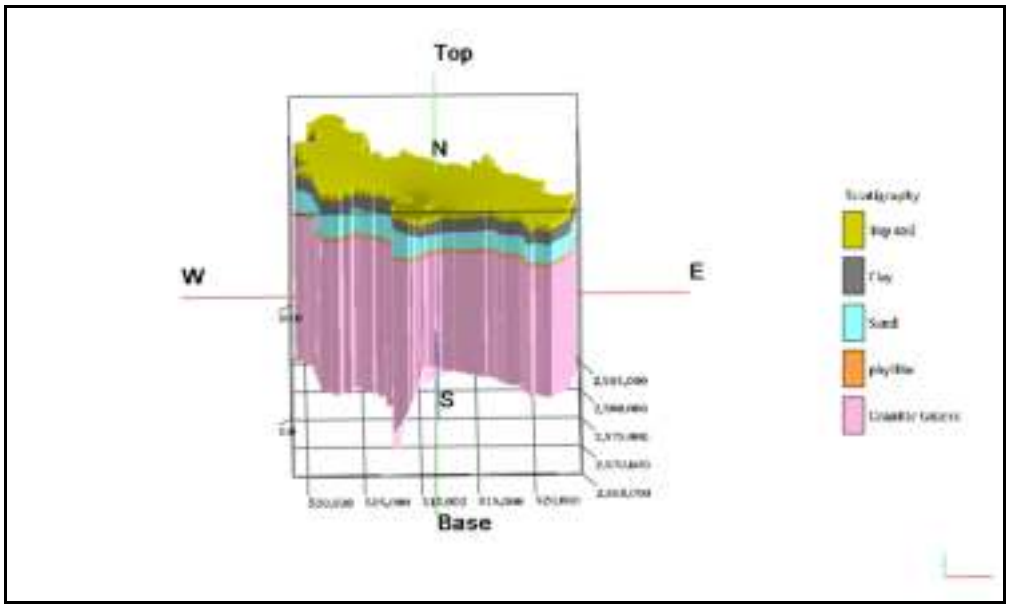


***Figure112.2*: 3-DimensionalAquifer disposition in *Bankura-II* Block**

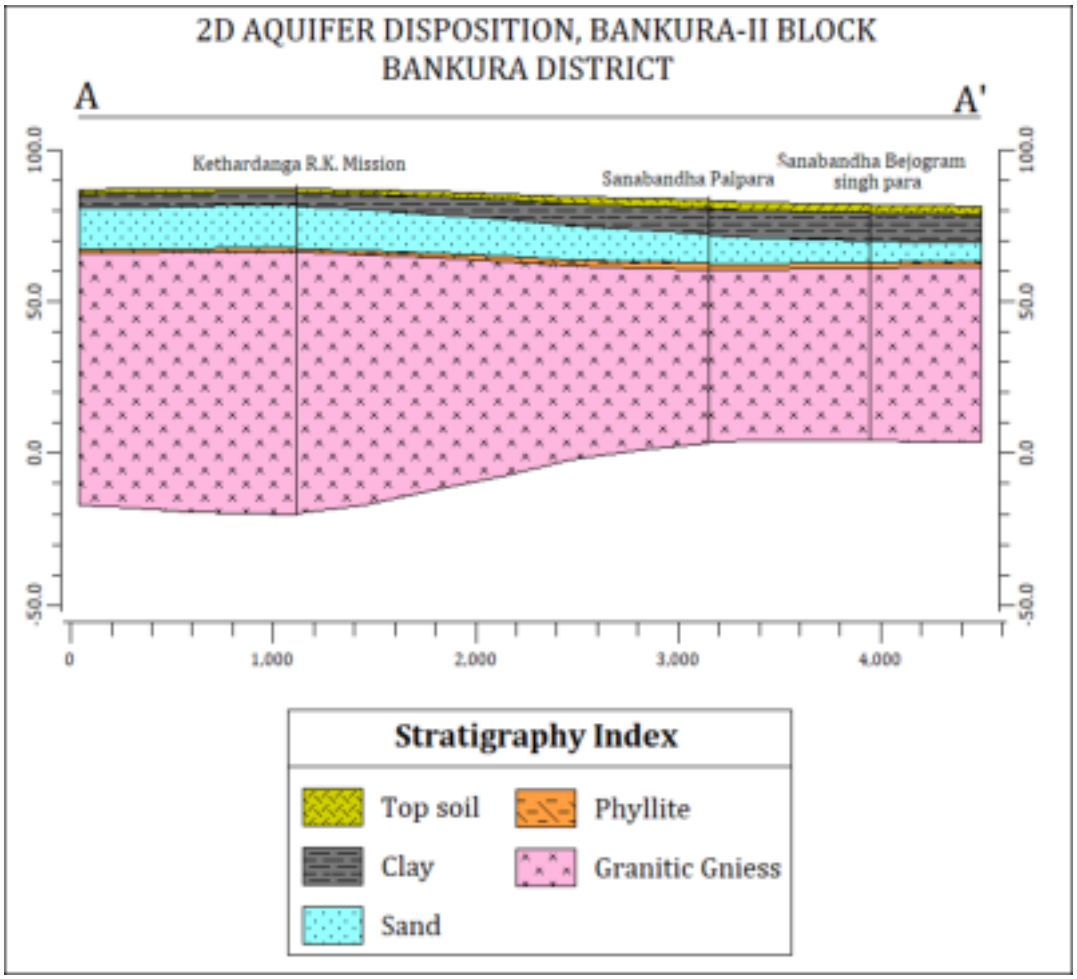


Figure*11.2*.3: 2-Dimensional Section in *Bankura-II* Block

The principal aquifer systems encountered in this block is hard rock.

Two aquifers are encountered in this block.

The range of **Aquifer-I** is also known as Shallow aquifer/ weathered zone. The casing depth is here upto 26mbgl. The water bearing zone varied between 6-18 mbgl.

The range of **Aquifer-II** is also known as fracture zone where the interconnected fracture (secondary porosity of the rock) is responsible for the presence of GW. Fractures encountered at a depth of 35 mbgl & 70 mbgl.

Table *11.2*.7: Details of aquifer disposition in Bankura-II Block

Blocks (dominant in hard rock)	No. of Aquifers	Water bearing zone	Casing depth	Aquifer Thickness (m)		Discharge (lpm)	T (m^2/ day)	SWL (mbgl)	Drawdown (mbgl)	S
				Aquifer-I weathered Zone	Aquifer-II Fracture zone					
Bankura-II	2	6-18	(upto 26m)	12	35, 70	15	--	7.3	--	--

Table *11.2*.8: Details of Aquifer Wise Water Level Ranges & seasonal long term water level trends

Block	Pre-monsoon Trend			Post-monsoon Trend		
	WL Range (mbgl)	Rise (m/year)	Fall (m/year)	WL Range (mbgl)	Rise (m/year)	Fall (m/year)
Bankura-II	1.33-4.89	0.186	--	1.9-5.43	0.175	--

Ground water quality and issues:

Based on four NHS, four exploratory wells and three observation wells, the range of chemical parameter for the block is given below.

Table *11.2*.9: Range of chemical parameters in Bankura -II Block

Block	Aquifer Type	pH	EC (µS/cm)	Na (mg/l)	Cl (mg/l)	F (mg/l)	NO_3 (mg/l)	Fe (mg/l)	Measured Hardness (mg/l)
Bankura-II	Aquifer-I	7.89-8.07	260-1984	12-94	10-60	0.10-0.94	2-9	0.03-0.07	105-865
	Aquifer-II	7.81-8.29	416-884	19-76	22-196	0.43-1.62	1-12	Traces	155-335

As per PHED report Fluoride concentration is above the permissible limit this block. More intensive sampling from this block is recommended.

Ground Water Resource:

Table *11.2*.10: Details of Ground Water Resource Availability and Utilization in *Bankura-II* Block.

Name of the Block	BANKURA-II
Total Annual Ground Water Recharge (Ham)	5627.66
Total Natural Discharges (Ham)	562.77
Annual Extractable Ground Water Recharge (Ham)	5064.89
Total Extraction	1734.72
Annual GW Allocation for Domestic Use as on 2042	178.69
Net Ground Water Availability for future use	3306.36
Stage of Ground Water Extraction (%)	34.25
Categorization (OE/CRITICAL/ SEMI-CRITICAL/ SAFE)	Safe
In storage (Ham)	8386

Aquifer Management Plan:

Ground Water Management Plan for drinking purpose:

The block has two commissioned public water supply schemes by PHED. There is one ongoing as well. However, there is still recorded deficit in supply of drinking water as the schemes do not reach to every mouza in the block. Therefore, there should be a general practice of conservation through rainwater harvesting, considering an adequate normal monsoon rainfall of 1347 mm which the block receives. The conserved rainwater can be utilized for drinking purpose by filtering through Horizontal Roughing Filters. The water from the lands can be channeled to ponds for recharge in the weathered zones and this water can be tapped through open dug wells for domestic and drinking purpose.

Ground Water Management Plan for irrigation purposes:

- Although ground water development in the block is low with stage of ground water development at 34.25%, further development should be done in planned manner to harness the additional available resource for site specific sustainable development.
- In view of low yield of the area, large diameter dug wells with adequate storage are another viable option for irrigation in favorable condition, thus creating a small command area. Owing to its distinct hydrogeology, it is evident that very less cultivable command area is created by both surface as well as groundwater.
- Modern methods of irrigation like sprinkler and drip irrigation methods are encouraged.
- Crops with low water requirement should be preferred.

In view of adequate rainfall in the area, excavation of tanks with large catchment areas, construction of check dam, nallah bunds, sub-surface dykes along the stream channels at suitable locations can be implemented to raise ground water level as well as to augment irrigation facilities.

11.3. SALIENT INFORMATION

Block Name: ***Chhatna***

Geographical area (sq. km): **457**

Mappable area (sq. km): **357**

District: **Bankura**

State: **West Bengal**

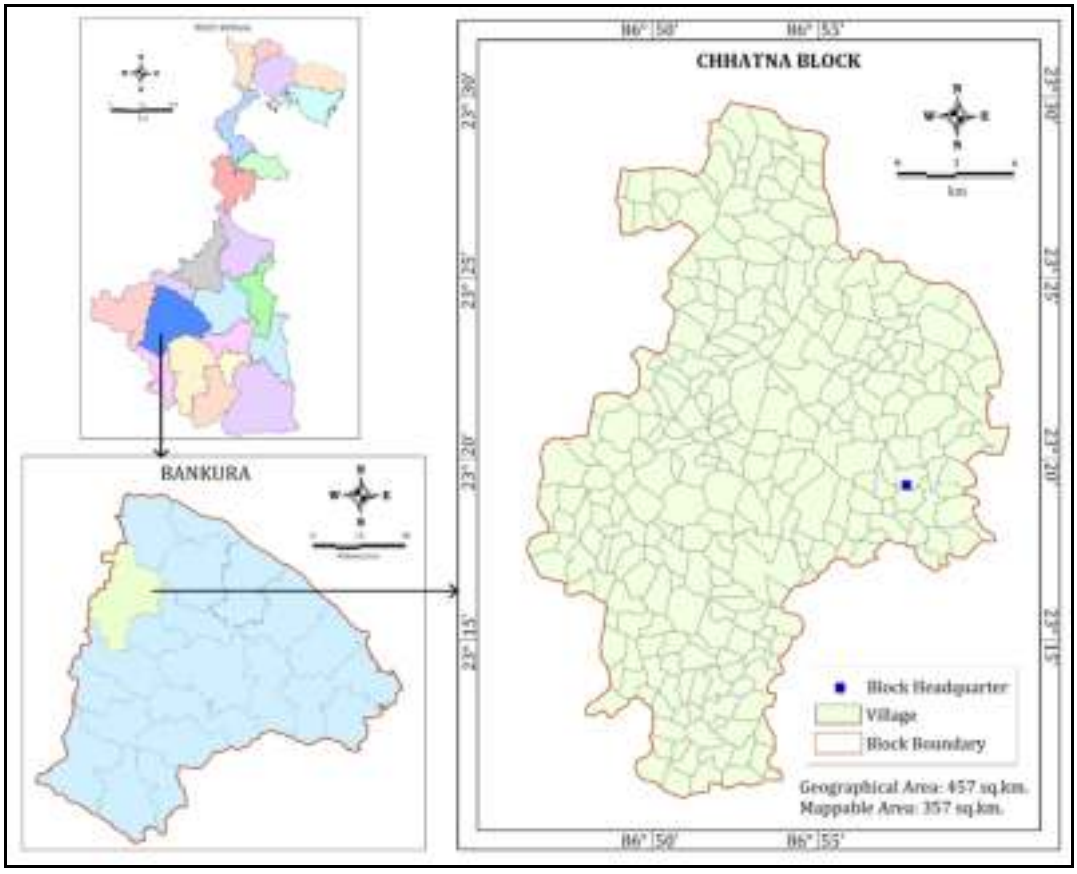


Figure *11.3*.1: Location Map of *Chhatna* Block

Population (as on 2011):

Table *11.3*.1: *Details of population in Chhatna block.*

Rural	Urban	Total	Population Density per Sqkm
189712	5326	195038	427

Rainfall: Average annual rainfall for the period 2015 -19 is 1300.36 (in mm)

Table *11.3.2*: Details of Annual Rainfall for the last five years in *Chhatna* block.

Block Name	Normal Rainfall	Rain Fall				
		2014	2015	2016	2017	2018
Chhatna	1386	1075.5	1127.2	1335.9	1780.2	1334.3

Agriculture& Irrigation (area in ha):

Table *11.3.3*: Salient Land use features of *Chhatna* block

Block	Reporting Area	Forest Area	Area Under Non-Agricultural Waste	Barren and Un-culturable land	Permanent pastures and grazing lands	Land under misc tree crops	Culturable wastes	Fallow land Other than current fallow	Current fallow	Net area sown	Cultivable Area
Chhatna	44955	4471	8865	416	109	134	61		4400	26499	31094

Table *11.3.4*: Crop pattern of *Chhatna* block

Block	Aus			Aman			Boro			Wheat			Maize		
	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield
Chhatna	-	-	-	2756	6.976	2531	-	-	-				-	-	-
	Mustard			Til			Potato			Musur			Gram		
	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	
	25	0.020	805	-	-	-	-	-	-	-	-	-	-	-	-

Table*11.3.5*: Command area (ha) of *Chhatna* block

Block Name	Dug well		Shallow Tube well		Medium Tube well		Deep Tube well		Surface Flow		Surface Lift		CCA (ha.)		Total CCA (ha.)
	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	Ground Water	Surface Water	
CHHATNA	10	43	130	440.2	0		0		44	274.42	813	3576.4	483.2	3850.82	4334.02

Table *11.3.6*: Command area (ha) of *Chhatna* block

Name of Block	Canal Area	Tank		RLI		DTW		STW		ODW		Others		Total	
		No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area
Chhatna	-	970	1695	23	860	-	-	17	45	137	25	-	-	1147	2625

Disposition of Aquifers:

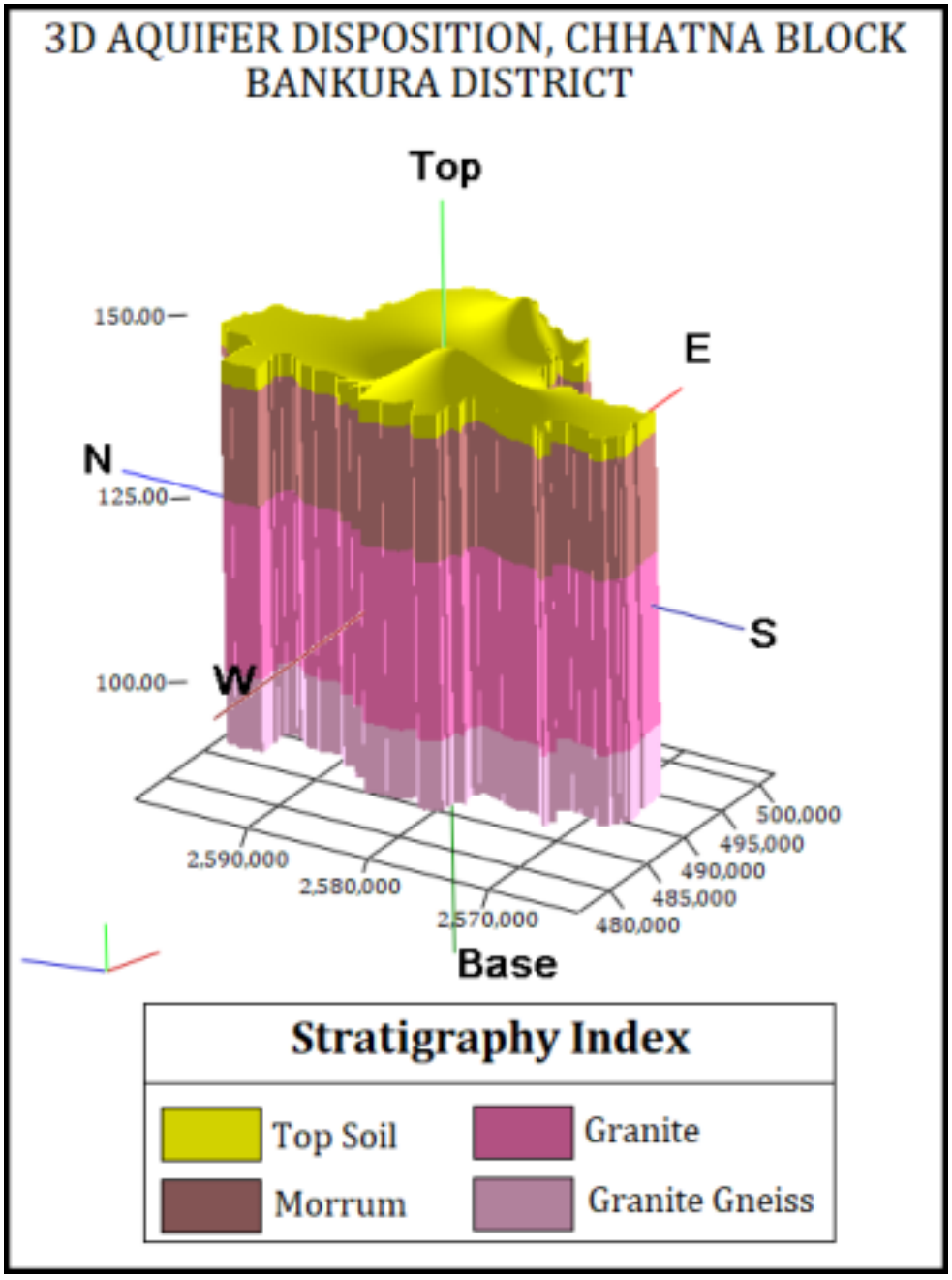


Figure *11.3.2*: 3-Dimensional Aquifer disposition in *Chhatna* Block

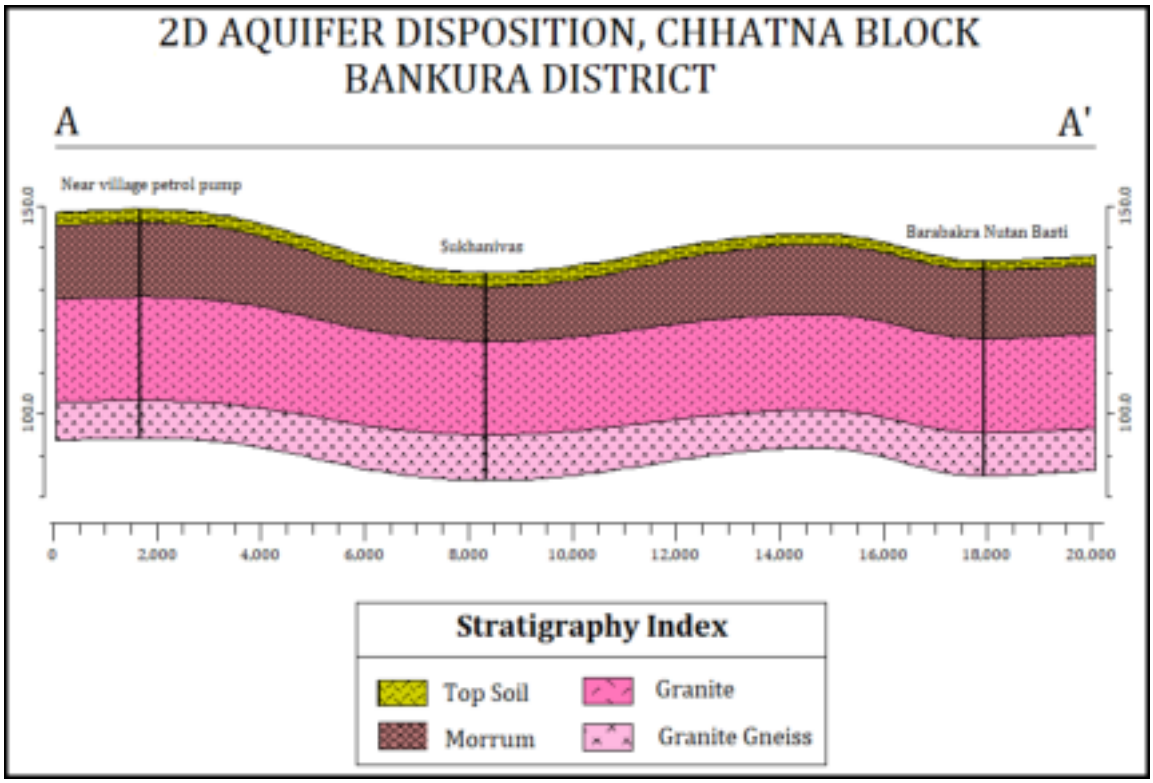


Figure *11.3.3*: 2-Dimensional Section in *Chhatna* Block

The principal aquifer systems encountered in this block is hard rock.

Two aquifers are encountered in this block.

The range of **Aquifer-I** is also known as Shallow aquifer/ weathered zone. The casing depth is here upto 24mbgl. The water bearing zone varied between 4-11 mbgl.

The range of **Aquifer-II** is also known as fracture zone where the interconnected fracture (secondary porosity of the rock) is responsible for the presence of GW. Fractures encountered at a depth of 38 mbgl & 45 mbgl.

Table *11.3.7*: Details of aquifer disposition in Chhatna Block

Blocks (dominant in hard rock)	No. of Aquifers	Water bearing zone	Casing depth	Aquifer Thickness (m)		Discharge (lpm)	T (m^2/day)	SWL (mbgl)	Drawdown (mbgl)	S
				Aquifer-I weathered Zone	Aquifer-II Fracture zone					
Chhatna	2	3-18	(upto 20m)	15	38, 45	25	--	11	--	--

Table *11.3.8*: Details of Aquifer Wise Water Level Ranges & seasonal long term water level trends

Block	Pre-monsoon Trend			Post-monsoon Trend		
	WL Range (mbgl)	Rise (m/year)	Fall (m/year)	WL Range (mbgl)	Rise (m/year)	Fall (m/year)
Chhatna	1.74-7.28	--	0.085	1.47-7.44	0.109	--

Ground water quality and issues:

Based on four NHS, four exploratory wells and three observation wells, the range of chemical parameter for the block is given below.

Table *11.3*.9: Range of chemical parameters in Chhatna Block

Block	Aquifer Type	pH	EC (µS/cm)	Na (mg/l)	Cl (mg/l)	F (mg/l)	NO_3 (mg/l)	Fe (mg/l)	Measured Hardness (mg/l)
Chhatna	Aquifer-I	7.89-8.07	260-1984	12-94	10-60	0.10-0.94	2-9	0.03-0.07	105-865
	Aquifer-II	7.81-8.29	416-884	19-76	22-196	0.43-1.62	1-12	Traces	155-335

As per PHED report Fluoride concentration is above the permissible limit this block. More intensive sampling from this block is recommended

Ground Water Resource:

Table *11.3*.10: Details of Ground Water Resource Availability and Utilization in *Chhatna* Block.

Name of the Block	CHHATNA
Total Annual Ground Water Recharge (Ham)	10796.73
Total Natural Discharges (Ham)	1079.67
Annual Extractable Ground Water Recharge (Ham)	9717.06
Total Extraction	715.07
Annual GW Allocation for Domestic Use as on 2042	253.35
Net Ground Water Availability for future use	8963.09
Stage of Ground Water Extraction (%)	7.36
Categorization (OE/CRITICAL/ SEMI-CRITICAL/ SAFE)	Safe
In storage (Ham)	12456

Aquifer Management Plan:

Ground Water Management Plan for drinking purpose:

The block has two commissioned public water supply schemes by PHED. There is one ongoing as well. However, there is still recorded deficit in supply of drinking water as the schemes do not reach to every mouza in the block. Therefore, there should be a general practice of conservation through rainwater harvesting, considering an adequate normal monsoon rainfall of 1347 mm which the block receives. The conserved rainwater can be utilized for drinking purpose by filtering through Horizontal Roughing Filters. The water from the lands can be channeled to ponds for recharge in the weathered zones and this water can be tapped through open dug wells for domestic and drinking purpose

Ground Water Management Plan for irrigation purposes:

- Although ground water development in the block is low with stage of ground water development at 7.36%, further development should be done in planned manner to harness the additional available resource for site specific sustainable development.
- In view of low yield of the area, large diameter dug wells with adequate storage are another viable option for irrigation in favorable condition, thus creating a small command area. Owing to its distinct hydrogeology, it is evident that very less cultivable command area is created by both surface as well as groundwater.
- Modern methods of irrigation like sprinkler and drip irrigation methods are encouraged.
- Crops with low water requirement should be preferred.

In view of adequate rainfall in the area, excavation of tanks with large catchment areas, construction of check dam, nallah bunds, sub-surface dykes along the stream channels at suitable locations can be implemented to raise ground water level as well as to augment irrigation facilities.

Irrigation by surface water may be increased. In addition to surface lift from canal & surface flows, rain water harvesting may also be considered.

11.4: SALIENT INFORMATION

Block Name: *Gangajalghati*

Geographical area (sq. km): **404**

Mappable area (sq. km): **354**

District: **Bankura**

State: **West Bengal**

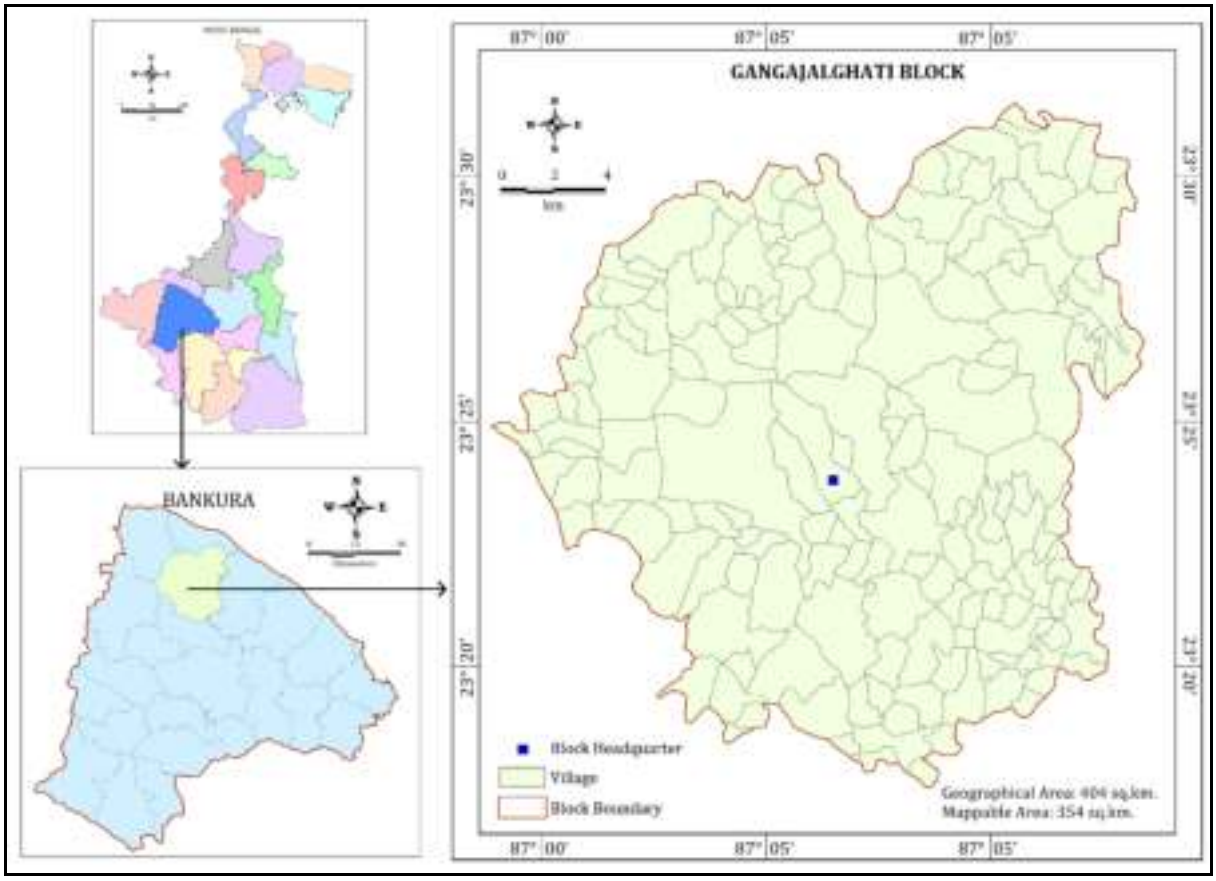


Figure *11.4*.1: Location Map of *Gangajalghati* Block

Population (as on 2011):

Table *11.4*.1: *Details of population in Gangajalghati block.*

Rural	Urban	Total	Population Density per Sq.km
180974	-	180974	448

Rainfall: Average annual rainfall for the period 2015 -19 is 1300.36 (in mm)

Table *11.4*.2: Details of Annual Rainfall for the last five years in *Gangajalghati* block.

Block Name	Normal Rainfall	Rain Fall				
		2014	2015	2016	2017	2018
Gangajalghati	1386	1075.5	1127.2	1335.9	1780.2	1334.3

Agriculture& Irrigation (area in ha):

Table *11.4*.3: Salient Land use features of *Gangajalghati* block

Block	Reporting Area	Forest Area	Area Under Non-Agricultural Waste	Barren and Un-culturable land	Permanent pastures and grazing lands	Land under misc tree crops	Culturable wastes	Fallow land Other than current fallow	Current fallow	Net area sown	Cultivable Area
Gangajalghati	37137	7774	8424	22				98	1250	19569	20917

Table *11.4*.4: Crop pattern of *Gangajalghati* block

Block	Aus			Aman			Boro			Wheat			Maize		
	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield
Gangajalghati	-	-	-	2109	5.781	2741	-	-	-	5	0.012	2418	-	-	-
	Mustard			Til			Potato			Musur			Gram		
	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	
	1500	1.376	918	-	-	-	1010	29539.000	29247	8	0.009	1091	1	-	471

Table *11.4*.5: Command area (ha) of *Gangajalghati* block

Block Name	Dug well		Shallow Tube well		Medium Tube well		Deep Tube well		Surface Flow		Surface Lift		CCA (ha.)		Total CCA (ha.)
	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	Ground Water	Surface Water	
GANGAJALGHATI	6	9.55	60	209.35	0		0		26	88	1098	5511.82	218.9	5599.82	5818.72

Table *11.4*.6: Command area (ha) of *Gangajalghati* block

Name of Block	Canal Area	Tank		RLI		DTW		STW		ODW		Others		Total	
		No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area
Gangajalghati	443	2300	6095	13	480	-	-	**2**	**5**	625	245	-	-	2940	7268

Disposition of Aquifers:

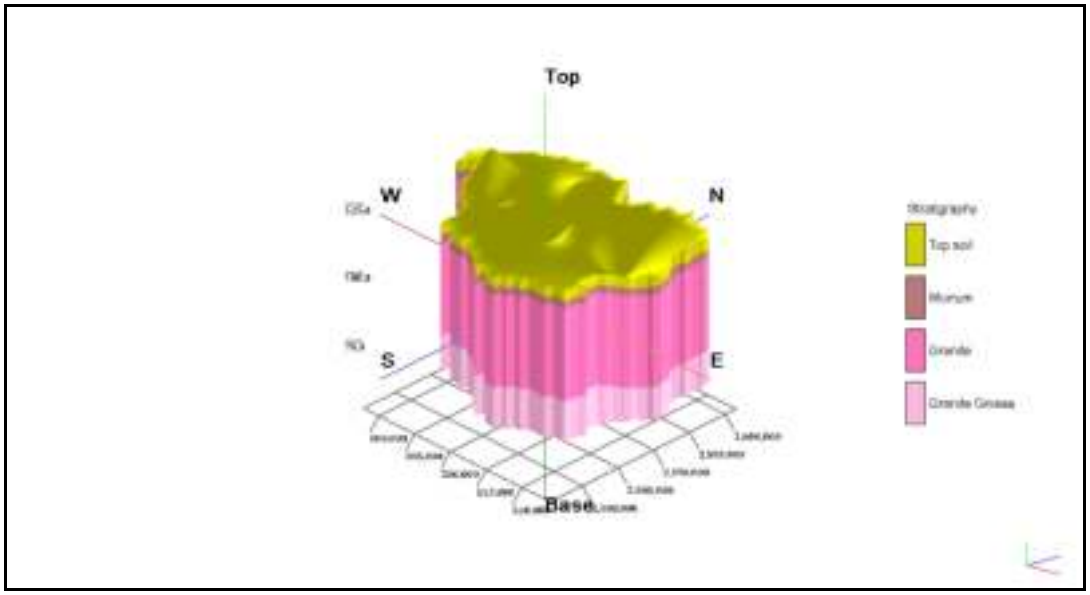


Figure *11.4.2*: 3-DimensionalAquifer disposition in *Gangajalghati* Block

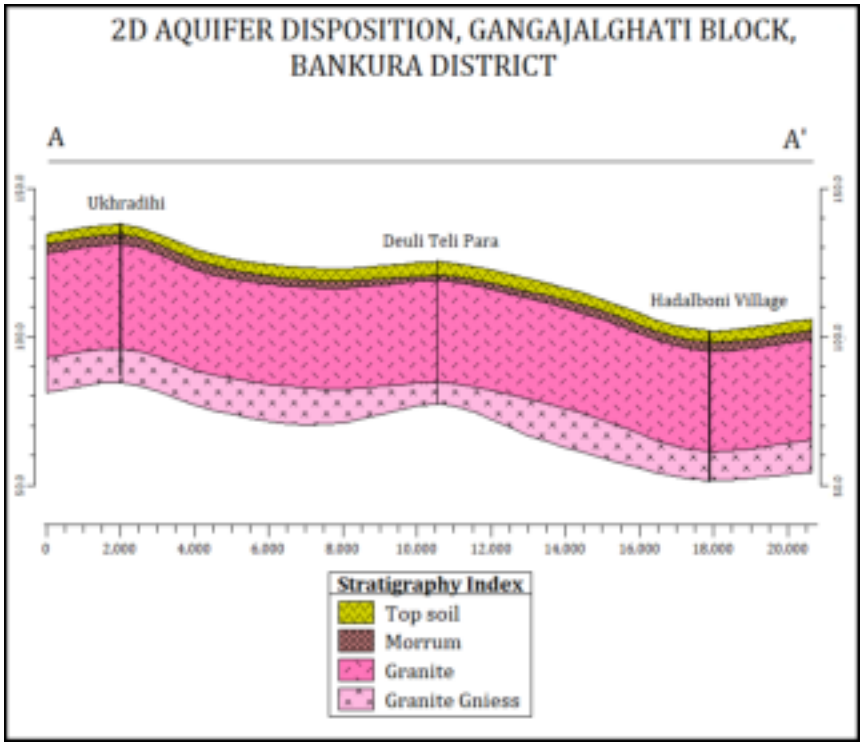


Figure *11.4.3*: 2-Dimensional Section in *Gangajalghati* Block

The principal aquifer systems encountered in this block is hard rock.

Two aquifers are encountered in this block.

The range of **Aquifer-I** is also known as Shallow aquifer/ weathered zone. The casing depth is here upto 17mbgl. The water bearing zone varied between 4-8 mbgl.

The range of **Aquifer-II** is also known as fracture zone where the interconnected fracture (secondary porosity of the rock) is responsible for the presence of GW. Fractures encountered at a depth of 32 mbgl & 45 mbgl.

Table *11.4*.7: Details of aquifer disposition in Gangajalghati Block

Blocks (dominant in hard rock)	No. of Aquifers	Water bearing zone	Casing depth	Aquifer Thickness (m)		Discharge (lpm)	T (m^2/day)	SWL (mbgl)	Drawdown (mbgl)	S
				Aquifer-I weathered Zone	Aquifer-II Fracture zone					
Gangajalghati	2	4-8	(upto 17m)	4	32, 45	20	--	11.3	--	--

Table *11.4*.8: Details of Aquifer Wise Water Level Ranges & seasonal long term water level trends

Block	Pre-monsoon Trend			Post-monsoon Trend		
	WL Range (mbgl)	Rise (m/year)	Fall (m/year)	WL Range (mbgl)	Rise (m/year)	Fall (m/year)
Gangajalghati	1.6-5.52	--	0.497	2.95-6.33	--	0.096

Ground water quality and issues:

Based on four NHS, four exploratory wells and three observation wells, the range of chemical parameter for the block is given below.

Table *11.4*.9: Range of chemical parameters in Gangajalghati Block

Block	Aquifer Type	pH	EC (µS/cm)	Na (mg/l)	Cl (mg/l)	F (mg/l)	NO_3 (mg/l)	Fe (mg/l)	Measured Hardness (mg/l)
Gangajalghati	Aquifer-I	7.89-8.07	260-1984	12-94	10-60	0.10-0.94	2-9	0.03-0.07	105-865
	Aquifer-II	7.81-8.29	416-884	19-76	22-196	0.43-0.62	1-12	Traces	155-335

Ground Water Resource:

Table *11.4*.10: Details of Ground Water Resource Availability and Utilization in *Gangajalghati* Block.

Name of the Block	**GANGAJALGHATI**
Total Annual Ground Water Recharge (Ham)	8770.81
Total Natural Discharges (Ham)	438.54
Annual Extractable Ground Water Recharge (Ham)	8332.27
Total Extraction	477.27
Annual GW Allocation for Domestic Use as on 2042	242.61
Net Ground Water Availability for future use	7811.37
Stage of Ground Water Extraction (%)	5.73
Categorization (OE/CRITICAL/ SEMI-CRITICAL/ SAFE)	Safe
In storage (Ham)	13252

Aquifer Management Plan:

Ground Water Management Plan for drinking purpose:

- The block has two commissioned public water supply schemes by PHED. There is one ongoing as well. However, there is still recorded deficit in supply of drinking water as the schemes do not reach to every mouza in the block. Therefore, there should be a general practice of conservation through rainwater harvesting, considering an adequate normal monsoon rainfall of 1347 mm which the block receives. The conserved rainwater can be utilized for drinking purpose by filtering through Horizontal Roughing Filters. The water from the lands can be channeled to ponds for recharge in the weathered zones and this water can be tapped through open dug wells for domestic and drinking purpose.
- The block shows a falling trend of 0.096 m/year during post-monsoon. For monitoring of change in ground water regime in the area, cost of construction of Observation well should be included.

Ground Water Management Plan for irrigation purposes:

- Although ground water development in the block is low with stage of ground water development at 5.73%, further development should be done in planned manner to harness the additional available resource for site specific sustainable development.
- In view of low yield of the area, large diameter dug wells with adequate storage are another viable option for irrigation in favorable condition, thus creating a small command area. Owing to its distinct hydrogeology, it is evident that very less cultivable command area is created by both surface as well as groundwater.
- Modern methods of irrigation like sprinkler and drip irrigation methods are encouraged.
- Crops with low water requirement should be preferred.

In view of adequate rainfall in the area, excavation of tanks with large catchment areas, construction of check dam, nallah bunds, sub-surface dykes along the stream channels at suitable locations can be implemented to raise ground water level as well as to augment irrigation facilities.

Irrigation by surface water may be increased. In addition to surface lift from canal & surface flows, rain water harvesting may also be considered.

11.5 SALIENT INFORMATION

Block Name: ***Hirabundh***

Geographical area (sq. km): **202**

Mappable area (sq. km): **202**

District: **Bankura**

State: **West Bengal**

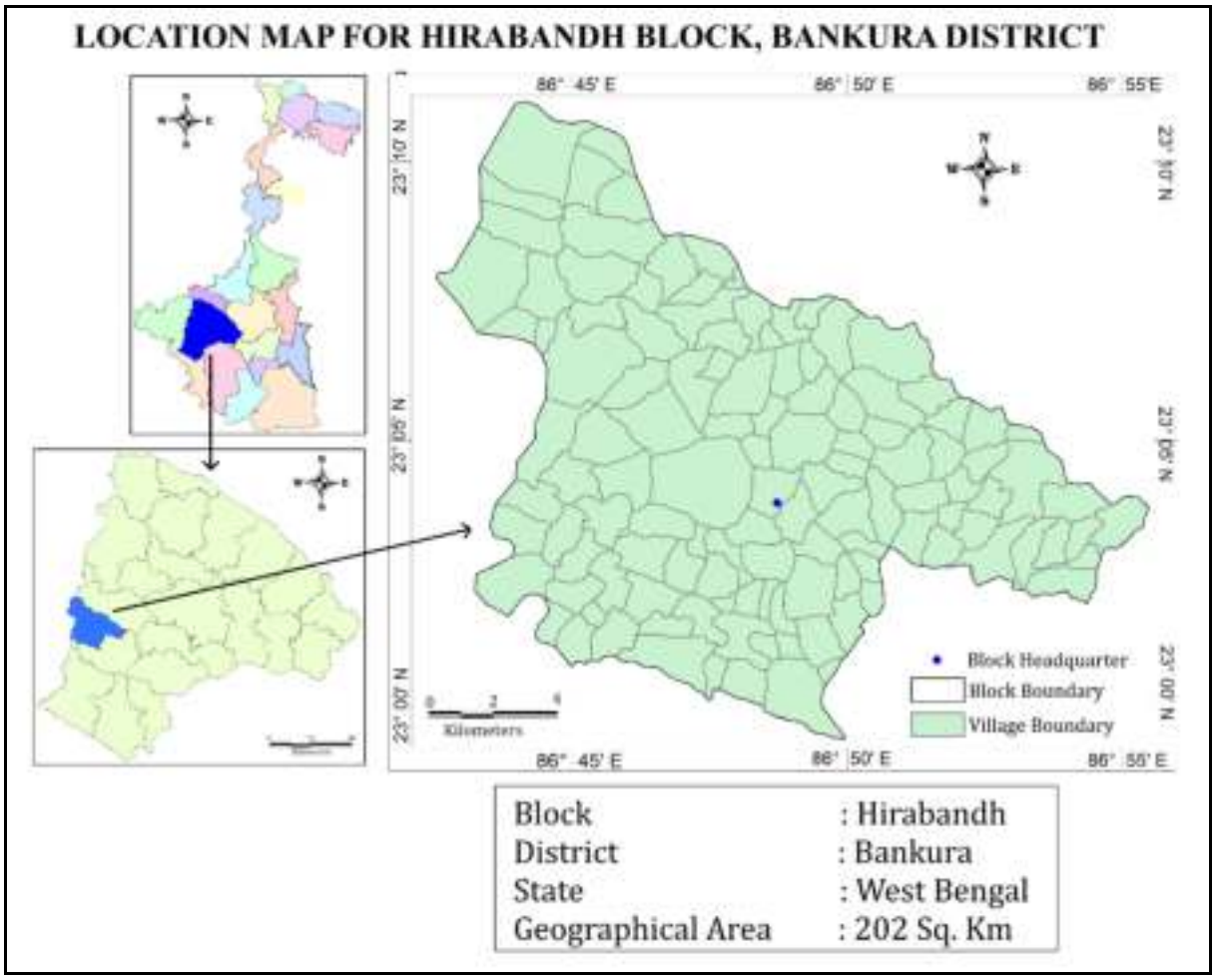


Figure 11.5.1: Location Map of *Hirabundh* Block

Population (as on 2011):

Table 11.5.1: ***Details of population in Hirabundh block.***

Rural	Urban	Total	Population Density per Sq.km
83834	-	83834	415

Rainfall: Average annual rainfall for the period 2015 -19 is 1300.36 (in mm)

Table 11.5.2: Details of Annual Rainfall for the last five years in *Hirabundh* block.

Block Name	Normal Rainfall	Rain Fall				
		2014	2015	2016	2017	2018
Hirabundh	1386	1075.5	1127.2	1335.9	1780.2	1334.3

Agriculture& Irrigation (area in ha):

Table 11.5.3: Salient Land use features of *Hirabundh* block

Block	Reporting Area	Forest Area	Area Under Non-Agricultural Waste	Barren and Un-culturable land	Permanent pastures and grazing lands	Land under misc tree crops	Culturable wastes	Fallow land Other than current fallow	Current fallow	Net area sown	Cultivable Area
Hirabundh	19367	3505	6057	-	-	-	-	-	1009	8796	9805

Table 11.5.4: Crop pattern of *Hirabundh* block

Block	Aus			Aman			Boro			Wheat			Maize		
	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield
Hirabundh	-	-	-	7829	19.285	2463	-	-	-	50	0.107	2147	-	-	
	Mustard			Til			Potato			Musur			Gram		
	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	
	322	0.272	845	144	0.086	601	53	1431.000	27000	2	0.001	534	1	0.001	796

Table 11.5.5: Command area (ha) of *Hirabundh* block

Block Name	Dug well		Shallow Tube well		Medium Tube well		Deep Tube well		Surface Flow		Surface Lift		CCA (ha.)		Total CCA (ha.)
	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	Ground Water	Surface Water	
HIRABUNDH	7	7	62	198.83	0		0		69	379.3	403	2559.76	205.83	2939.06	3144.89

Table 11.5.6: Command area (ha) of *Hirabundh* block

Name of Block	Canal Area	Tank		RLI		DTW		STW		ODW		Others		Total	
		No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area
Hirabundh	929	570	1050	26	940	-	-	-	-	580	70	5	220	1181	3209

Disposition of Aquifers:

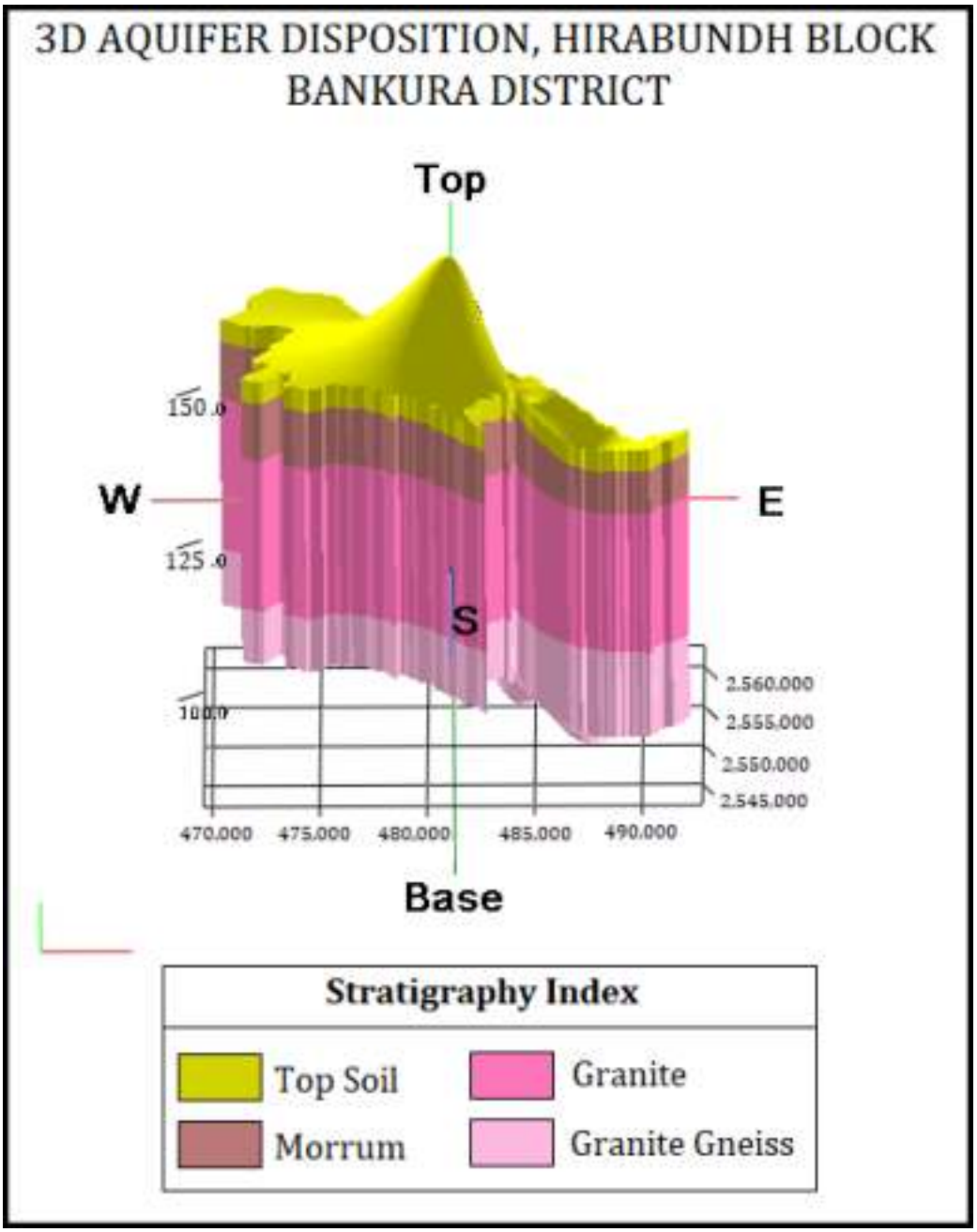


Figure 11.5.2: 3-Dimensional Aquifer disposition in *Hirabundh* Block

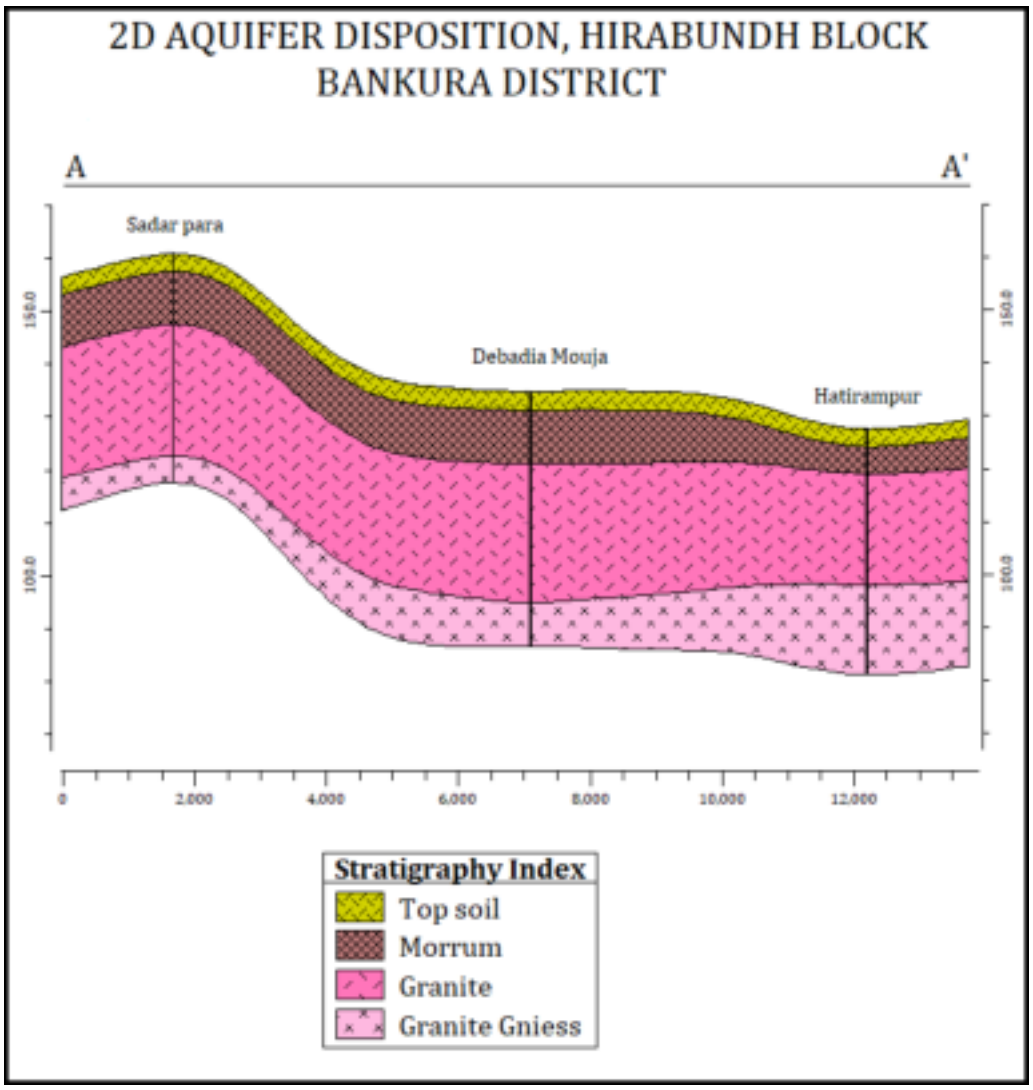


Figure11.5.3: 2-Dimensional Section in *Hirabundh* Block

The principal aquifer systems encountered in this block is hard rock.

Two aquifers are encountered in this block.

The range of **Aquifer-I** is also known as Shallow aquifer/ weathered zone. The casing depth is here upto 15mbgl. The water bearing zone varied between 4-12 mbgl.

The range of **Aquifer-II** is also known as fracture zone where the interconnected fracture (secondary porosity of the rock) is responsible for the presence of GW. Fractures encountered at a depth of 36 mbgl & 45 mbgl.

Table 11.5.7: Details of aquifer disposition in Hirabundh Block

Blocks (dominant in hard rock)	No. of Aquifers	Water bearing zone	Casing depth	Aquifer Thickness (m)		Discharge (lpm)	T (m^2/ day)	SWL (mbgl)	Drawdown (mbgl)	S
				Aquifer-I weathered Zone	Aquifer-II Fracture zone					
Hirabundh	2	4-12	(upto 15m)	8	36,45	15	--	9.2	--	--

Table 11.5.8: Details of Aquifer Wise Water Level Ranges & seasonal long term water level trends

Block	Pre-monsoon Trend			Post-monsoon Trend		
	WL Range (mbgl)	Rise (m/year)	Fall (m/year)	WL Range (mbgl)	Rise (m/year)	Fall (m/year)
Hirabundh	NA	NA	NA	NA	NA	NA

Ground water quality and issues:

Based on four NHS, four exploratory wells and three observation wells, the range of chemical parameter for the block is given below.

Table 11.5.9: Range of chemical parameters in Hirabundh Block

Block	Aquifer Type	pH	EC (µS/cm)	Na (mg/l)	Cl (mg/l)	F (mg/l)	NO_3 (mg/l)	Fe (mg/l)	Measured Hardness (mg/l)
Hirabundh	Aquifer-I	7.89-8.07	260-1984	12-94	10-60	0.10-0.94	2-9	0.03-0.07	105-865
	Aquifer-II	7.81-8.29	416-884	19-76	22-196	0.43-1.62	1-12	Traces	155-335

As per PHED report Fluoride concentration is above the permissible limit this block. More intensive sampling from this block is recommended.

Ground Water Resource:

Table 11.5.10: Details of Ground Water Resource Availability and Utilization in *Hirabundh* Block.

Name of the Block	HIRABUNDH
Total Annual Ground Water Recharge (Ham)	4577.22
Total Natural Discharges (Ham)	457.72
Annual Extractable Ground Water Recharge (Ham)	4119.5
Total Extraction	329.87
Annual GW Allocation for Domestic Use as on 2042	109.51
Net Ground Water Availability for future use	3772.3
Stage of Ground Water Extraction (%)	8.01
Categorization (OE/CRITICAL/ SEMI-CRITICAL/ SAFE)	Safe
In storage (Ham)	4146

Aquifer Management Plan:

Ground Water Management Plan for drinking purpose:

The block has two commissioned public water supply schemes by PHED. There is one ongoing as well. However, there is still recorded deficit in supply of drinking water as the schemes do not reach to every mouza in the block. Therefore, there should be a general practice of conservation through rainwater harvesting, considering an adequate normal monsoon rainfall of 1347 mm which the block receives. The conserved rainwater can be utilized for drinking purpose by filtering through Horizontal Roughing Filters. The water from the lands can be channeled to ponds for recharge in the

weathered zones and this water can be tapped through open dug wells for domestic and drinking purpose.

Ground Water Management Plan for irrigation purposes:

- Although ground water development in the block is low with stage of ground water development at 8.01%, further development should be done in planned manner to harness the additional available resource for site specific sustainable development.
- In view of low yield of the area, large diameter dug wells with adequate storage are another viable option for irrigation in favorable condition, thus creating a small command area. Owing to its distinct hydrogeology, it is evident that very less cultivable command area is created by both surface as well as groundwater.
- Modern methods of irrigation like sprinkler and drip irrigation methods are encouraged.
- Crops with low water requirement should be preferred.

In view of adequate rainfall in the area, excavation of tanks with large catchment areas, construction of check dam, nallah bunds, sub-surface dykes along the stream channels at suitable locations can be implemented to raise ground water level as well as to augment irrigation facilities.

Irrigation by surface water may be increased. In addition to surface lift from canal & surface flows, rain water harvesting may also be considered

Table 11.5.11: Details of structures recommended in feasible area of artificial recharge for Hirabundh Block.

Name of the Block	Utilizable Surface Run Off	Allocation of Utilizable Recourse (MCM)							Structures Feasible							Cost of Structures							
		Percolation Tank	REET with RS	Injection Well	Check Dam	Gabion/ Contour Bund	Sub-Surface Dyke	Dug Well Recharge	Percolation Tank	REET with RS	Injection Well	Check Dam	Gabion/ Contour Bund	Sub-Surface Dyke	Dug Well Recharge	Percolation Tank	REET with RS	Injection Well	Check Dam	Gabion/ Contour Bund	Sub-Surface Dyke	Dug Well Recharge	TOTAL
Hirabundh	4.012	2.608	0	0	0.802	0.201	0.201	0.201	5	0	0	16	40	20	4	60	0	0	24	20	20	4.4	128.4

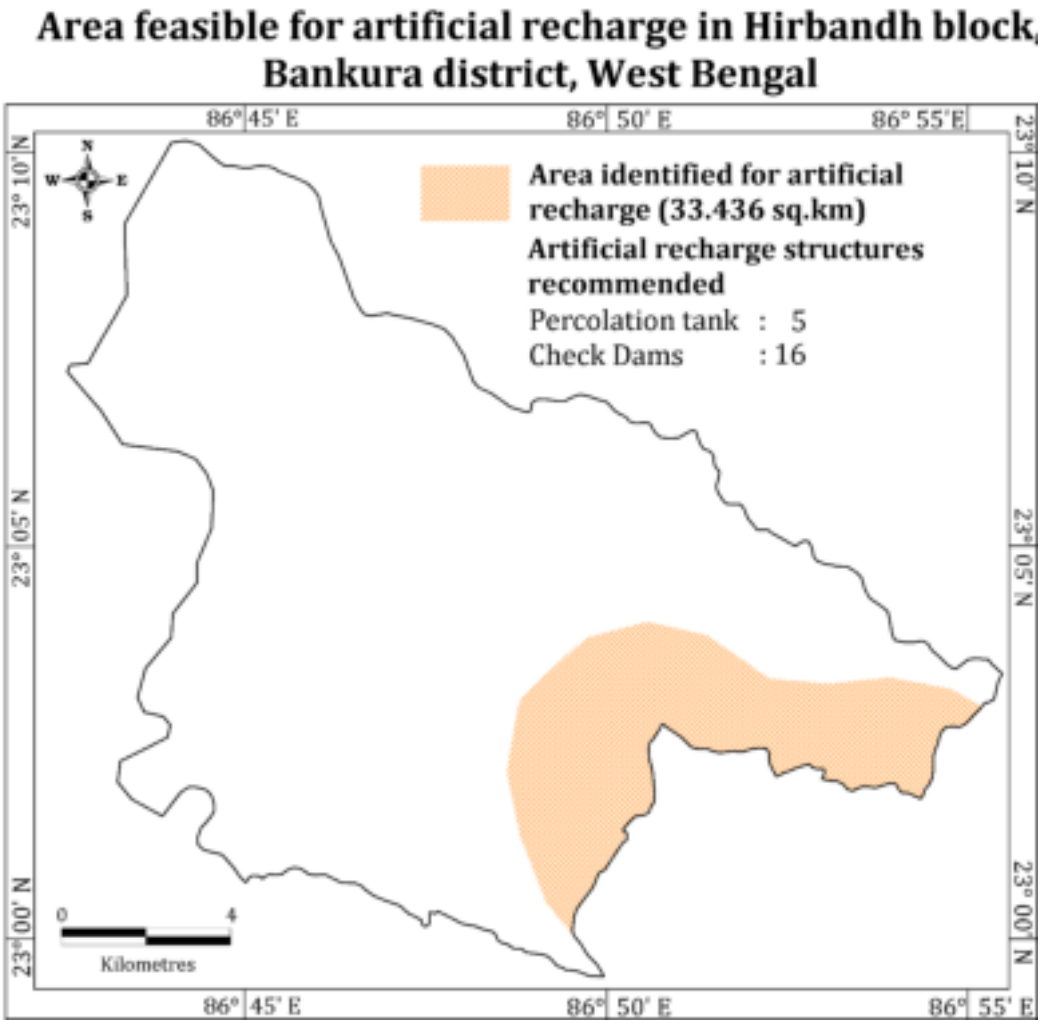


Figure 11.5.4: Area Feasible for Artificial Recharge of groundwater for *Hirabundh* Block

Management Intervention through Harvesting of Surface Runoff and Artificial Recharge:

It has been estimated that the utilizable surface runoff produced in the block is **4.012** MCM. This surface runoff is proposed to be utilized to recharge the shallow aquifer (weathered zone) in the block. Therefore, **5** perclation tanks and **16** check dams are recommended in this block

11.6 SALIENT INFORMATION

Block Name: ***Indpur***

Geographical area (sq. km): **308**

Mappable area (sq. km): **308**

District: **Bankura**

State: **West Bengal**

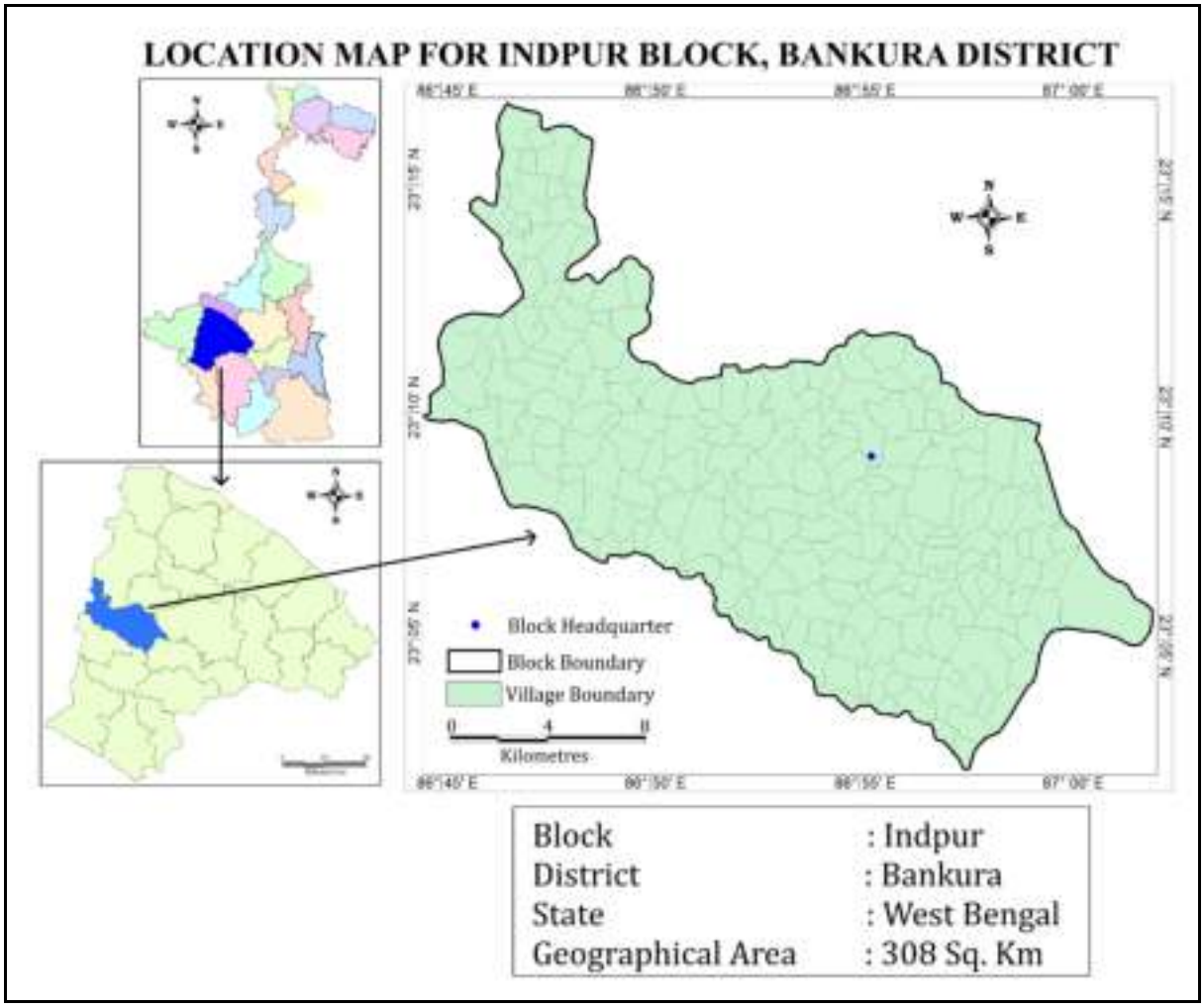


Figure *11.6*.1: Location Map of *Indpur* Block

Population (as on 2011):

Table *11.6*.1: *Details of population in Indpur block.*

Rural	Urban	Total	Population Density per Sq.km
156522	-	156522	508

Rainfall: Average annual rainfall for the period 2015 -19 is 1300.36 (in mm)

Table *11.6.2*: Details of Annual Rainfall for the last five years in *Indpur* block.

Block Name	Normal Rainfall	Rain Fall				
		2014	2015	2016	2017	2018
Indpur	1386	1075.5	1127.2	1335.9	1780.2	1334.3

Agriculture& Irrigation (area in ha):

Table *11.6.3*: Salient Land use features of *Indpur* block

Block	Reporting Area	Forest Area	Area Under Non-Agricultural Waste	Barren and Un-culturable land	Permanent pastures and grazing lands	Land under misc tree crops	Culturable wastes	Fallow land Other than current fallow	Current fallow	Net area sown	Cultivable Area
Indpur	30264	5836	5608	36				3	524	18257	18784

Table *11.6.4*: Crop pattern of *Indpur* block

Block	Aus			Aman			Boro			Wheat			Maize		
	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield
Indpur	-	-	-	1611	3.573	2218	-	-	-	128	0.284	2221	-	-	-
	Mustard			Til			Potato			Musur			Gram		
	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	
	228	0.102	446	98	0.055	557	7	182.000	26000	10	0.005	492	1	-	454

Table *11.6.5*: Command area (ha) of *Indpur* block

Block Name	Dug well		Shallow Tube well		Medium Tube well		Deep Tube well		Surface Flow		Surface Lift		CCA (ha.)		Total CCA (ha.)
	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	Ground Water	Surface Water	
INDPUR	2	8	4	69	0	410	0		198	1703.73	568	3763.68	487	5467.41	5954.41

Table *11.6.6*: Command area (ha) of *Indpur* block

Name of Block	Canal Area	Tank		RLI		DTW		STW		ODW		Others		Total	
		No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area
Indpur	3570	366	850	38	1800	-	-	-	-	250	40	3	30	657	6290

Disposition of Aquifers:

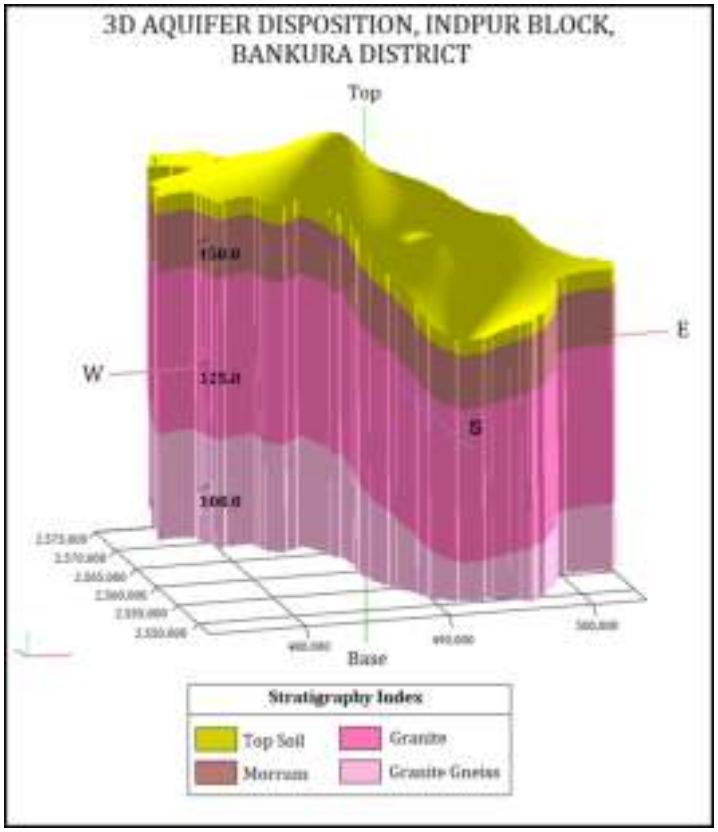


Figure *11.6*.2: 3-DimensionalAquifer disposition in *Indpur* Block

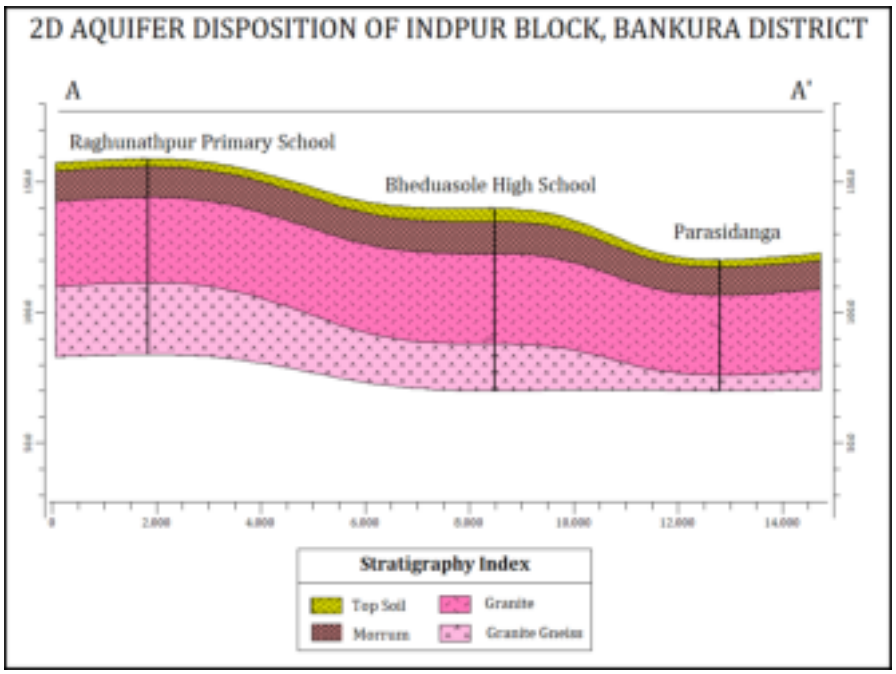


Figure *11.6*.3: 2-Dimensional Section in *Indpur* Block

The principal aquifer systems encountered in this block is hard rock.
Two aquifers are encountered in this block.

The range of **Aquifer-I** is also known as Shallow aquifer/ weathered zone. The casing depth is here upto 18mbgl. The water bearing zone varied between 2-11 mbgl.

The range of **Aquifer-II** is also known as fracture zone where the interconnected fracture (secondary porosity of the rock) is responsible for the presence of GW. Fractures encountered at a depth of 41 mbgl.

Table *11.6*.7: Details of aquifer disposition in Indpur Block

Blocks (dominant in hard rock)	No. of Aquifers	Water bearing zone	Casing depth	Aquifer Thickness (m)		Discharge (lpm)	T (m^2/ day)	SWL (mbgl)	Drawdown (mbgl)	S
				Aquifer-I weathered Zone	Aquifer-II Fracture zone					
Indpur	2	2-11	(upto 18m)	9	41	20	--	9.9	--	--

Table *11.6*.8: Details of Aquifer Wise Water Level Ranges & seasonal long term water level trends

Block	Pre-monsoon Trend			Post-monsoon Trend		
	WL Range (mbgl)	Rise (m/year)	Fall (m/year)	WL Range (mbgl)	Rise (m/year)	Fall (m/year)
Indpur	0.8-2.43	0.029	--	1.7-2.9	--	0.090

Ground water quality and issues:

Based on four NHS, four exploratory wells and three observation wells, the range of chemical parameter for the block is given below.

Table *11.6*.9: Range of chemical parameters in Indpur Block

Block	Aquifer Type	pH	EC (µS/cm)	Na (mg/l)	Cl (mg/l)	F (mg/l)	NO_3 (mg/l)	Fe (mg/l)	Measured Hardness (mg/l)
Indpur	Aquifer-I	7.89-8.07	260-1984	12-94	10-60	0.10-0.94	2-9	0.03-0.07	105-865
	Aquifer-II	7.81-8.29	416-884	19-76	22-196	0.43-0.82	1-12	Traces	155-335

Ground Water Resource:

Table *11.6*.10: Details of Ground Water Resource Availability and Utilization in *Indpur* Block.

Name of the Block	**INDPUR**
Total Annual Ground Water Recharge (Ham)	7060
Total Natural Discharges (Ham)	353
Annual Extractable Ground Water Recharge (Ham)	6707
Total Extraction	313.15
Annual GW Allocation for Domestic Use as on 2042	210.16
Net Ground Water Availability for future use	6355.79
Stage of Ground Water Extraction (%)	4.67
Categorization (OE/CRITICAL/ SEMI-CRITICAL/ SAFE)	Safe
In storage (Ham)	8009

Aquifer Management Plan:

Ground Water Management Plan for drinking purpose:

- The block has two commissioned public water supply schemes by PHED. There is one ongoing as well. However, there is still recorded deficit in supply of drinking water as the schemes do not reach to every mouza in the block. Therefore, there should be a general practice of conservation through rainwater harvesting, considering an adequate normal monsoon rainfall of 1347 mm which the block receives. The conserved rainwater can be utilized for drinking purpose by filtering through Horizontal Roughing Filters. The water from the lands can be channeled to ponds for recharge in the weathered zones and this water can be tapped through open dug wells for domestic and drinking purpose.
- The block shows a falling trend of 0.090 m/year during post-monsoon. For monitoring of change in ground water regime in the area, cost of construction of Observation well should be included.

Ground Water Management Plan for irrigation purposes:

- Although ground water development in the block is low with stage of ground water development at 4.67%, further development should be done in planned manner to harness the additional available resource for site specific sustainable development.
- In view of low yield of the area, large diameter dug wells with adequate storage are another viable option for irrigation in favorable condition, thus creating a small command area. Owing to its distinct hydrogeology, it is evident that very less cultivable command area is created by both surface as well as groundwater.
- Modern methods of irrigation like sprinkler and drip irrigation methods are encouraged.
- Crops with low water requirement should be preferred.

In view of adequate rainfall in the area, excavation of tanks with large catchment areas, construction of check dam, nallah bunds, sub-surface dykes along the stream channels at suitable locations can be implemented to raise ground water level as well as to augment irrigation facilities.

Irrigation by surface water may be increased. In addition to surface lift from canal & surface flows, rain water harvesting may also be considered.

11.7 SALIENT INFORMATION

Block Name: ***Khatra***

Geographical area (sq. km): **230**

Mappable area (sq. km): **130**

District: **Bankura**

State: **West Bengal**

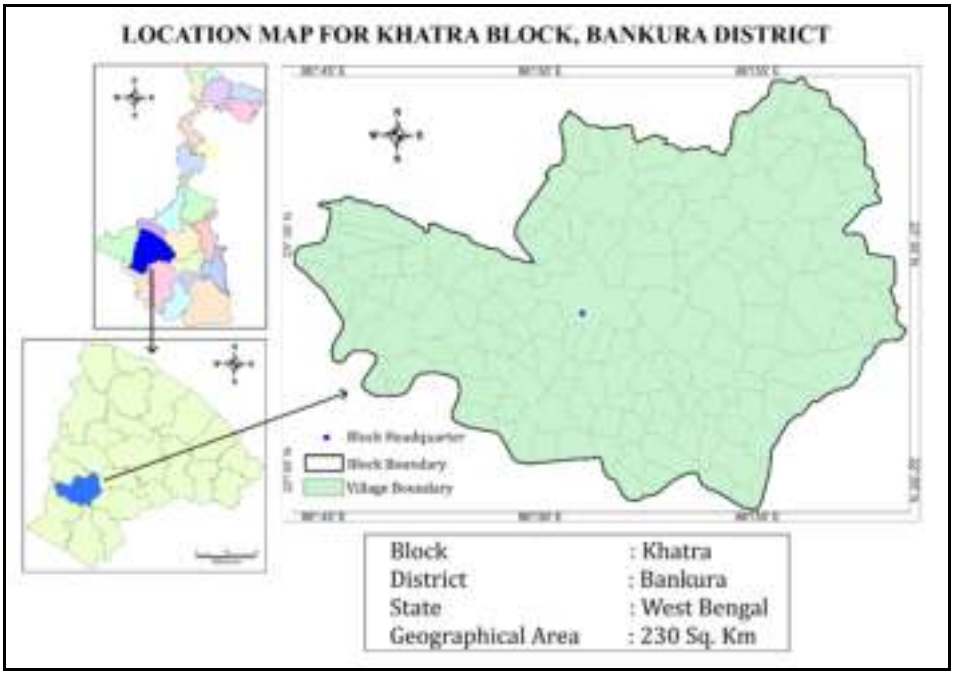


Figure *11.7.*1: Location Map of *Khatra* Block

Population (as on 2011):

Table *11.7.*1: *Details of population in Khatra block.*

Rural	Urban	Total	Population Density per Sq.km
104592	12438	117030	509

Rainfall: Average annual rainfall for the period 2015 -19 is 1347.36 (in mm)

Table *11.7.*2: Details of Annual Rainfall for the last five years in *Khatra* block.

Block Name	Normal Rainfall	Rain Fall				
		2014	2015	2016	2017	2018
Khatra	1386	1075.5	1127.2	1335.9	1780.2	1334.3

Agriculture& Irrigation (area in ha):

Table *11.7*.3: Salient Land use features of *Khatra* block

Block	Reporting Area	Forest Area	Area Under Non-Agricultural Waste	Barren and Un-culturable land	Permanent pastures and grazing lands	Land under misc tree crops	Culturable wastes	Fallow land Other than current fallow	Current fallow	Net area sown	Cultivable Area
Khatra	23273	5101	6316	-	-	-	143	78	1089	10546	11856

Table*11.7*.4: Crop pattern of *Khatra* block

Block	Aus			Aman			Boro			Wheat			Maize		
	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield
Khatra	-	-	-	9222	22.770	2469	973	2.552	2623	51	0.121	2367	-	-	-
	Mustard			Til			Potato			Musur			Gram		
	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	
	316	0.208	659	53	0.046	873	25	694.000	27765	4	0.002	388	1	0.001	811

Table *11.7*.5: Command area (ha) of *Khatra* block

Block Name	Dug well		Shallow Tube well		Medium Tube well		Deep Tube well		Surface Flow		Surface Lift		CCA (ha.)		Total CCA (ha.)
	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	Ground Water	Surface Water	
KHATRA	0		2	2	0		1	5	84	491	360	1758.3	7	2249.3	2256.3

Table *11.7*.6: Command area (ha) of *Khatra* block

Name of Block	Canal Area	Tank		RLI		DTW		STW		ODW		Others		Total	
		No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area
Khatra	5246	475	1500	17	600	-	-	-	-	525	370	6	280	1023	7996

Disposition of Aquifers:

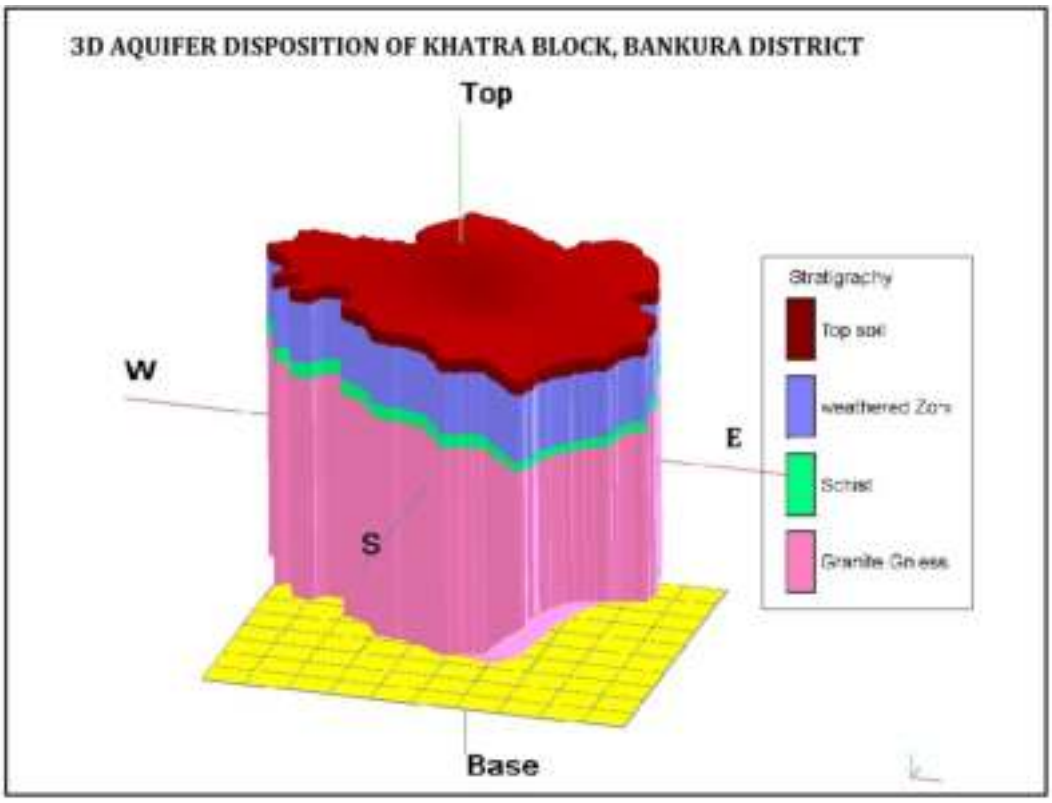


Figure*11.7.*2: 3-DimensionalAquifer disposition in *Khatra* Block

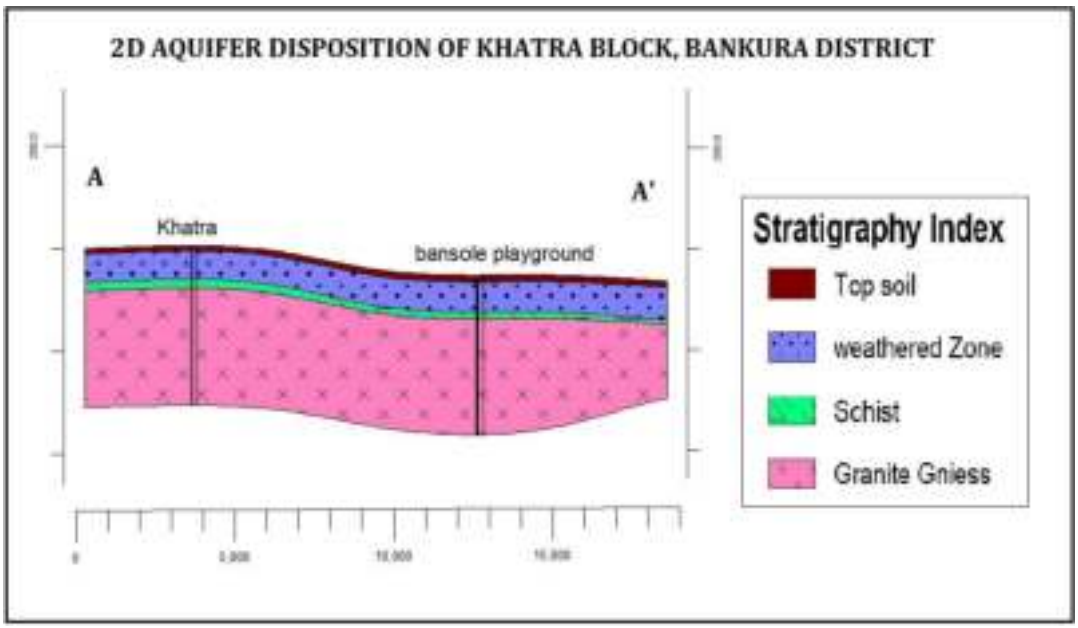


Figure*11.7.*3: 2-Dimensional Section in *Khatra* Block

The principal aquifer systems encountered in this block is hard rock.
Two aquifers are encountered in this block.

The range of **Aquifer-I** is also known as Shallow aquifer/ weathered zone. The casing depth is here upto 15mbgl. The water bearing zone varied between 4-12 mbgl.

The range of **Aquifer-II** is also known as fracture zone where the interconnected fracture (secondary porosity of the rock) is responsible for the presence of GW. Fractures encountered at a depth of 36 mbgl & 45 mbgl.

Table *11.7*.7: Details of aquifer disposition in Khatra Block

Blocks (dominant in hard rock)	No. of Aquifers	Water bearing zone	Casing depth	Aquifer Thickness (m)		Discharge (lpm)	T (m^2/ day)	SWL (mbgl)	Drawdown (mbgl)	S
				Aquifer-I weathered Zone	Aquifer-II Fracture zone					
Khatra	2	4-17	(upto 17m)	13	30, 45	18	--	13.4	--	--

Table *11.7*.8: Details of Aquifer Wise Water Level Ranges & seasonal long term water level trends

Block	Pre-monsoon Trend			Post-monsoon Trend		
	WL Range (mbgl)	Rise (m/year)	Fall (m/year)	WL Range (mbgl)	Rise (m/year)	Fall (m/year)
Khatra	1.05-2.38	0.135	--	1.3-3.41	--	0.034

Ground water quality and issues:

Based on four NHS, four exploratory wells and three observation wells, the range of chemical parameter for the block is given below.

Table *11.7*.9: Range of chemical parameters in Khatra Block

Block	Aquifer Type	pH	EC (µS/cm)	Na (mg/l)	Cl (mg/l)	F (mg/l)	NO_3 (mg/l)	Fe (mg/l)	Measured Hardness (mg/l)
Khatra	Aquifer-I	7.89-8.07	260-1984	12-94	10-60	0.10-0.94	2-9	0.03-0.07	105-865
	Aquifer-II	7.81-8.29	416-884	19-76	22-196	0.43-0.75	1-12	Traces	155-335

Ground Water Resource:

Table *11.7*.10: Details of Ground Water Resource Availability and Utilization in *Khatra* Block.

Name of the Block	KHATRA
Total Annual Ground Water Recharge (Ham)	5055.28
Total Natural Discharges (Ham)	505.53
Annual Extractable Ground Water Recharge (Ham)	4549.75
Total Extraction	214.02
Annual GW Allocation for Domestic Use as on 2042	152.93
Net Ground Water Availability for future use	4311.48
Stage of Ground Water Extraction (%)	4.7
Categorization (OE/CRITICAL/ SEMI-CRITICAL/ SAFE)	Safe
In storage (Ham)	5625

Aquifer Management Plan:

Ground Water Management Plan for drinking purpose:

- The block has two commissioned public water supply schemes by PHED. There is one ongoing as well. However, there is still recorded deficit in supply of drinking water as the schemes do not reach to every mouza in the block. Therefore, there should be a general practice of conservation through rainwater harvesting, considering an adequate normal monsoon rainfall of 1347 mm which the block receives. The conserved rainwater can be utilized for drinking purpose by filtering through Horizontal Roughing Filters. The water from the lands can be channeled to ponds for recharge in the weathered zones and this water can be tapped through open dug wells for domestic and drinking purpose.
- The block shows a falling trend of 0.034 m/year during post-monsoon. For monitoring of change in ground water regime in the area, cost of construction of observation well should be included.

Ground Water Management Plan for irrigation purposes:

- Although ground water development in the block is low with stage of ground water development at 4.7%, further development should be done in planned manner to harness the additional available resource for site specific sustainable development.
- In view of low yield of the area, large diameter dug wells with adequate storage are another viable option for irrigation in favorable condition, thus creating a small command area. Owing to its distinct hydrogeology, it is evident that very less cultivable command area is created by both surface as well as groundwater.
- Modern methods of irrigation like sprinkler and drip irrigation methods are encouraged.
- Crops with low water requirement should be preferred.

In view of adequate rainfall in the area, excavation of tanks with large catchment areas, construction of check dam, nallah bunds, sub-surface dykes along the stream channels at suitable locations can be implemented to raise ground water level as well as to augment irrigation facilities.

Irrigation by surface water may be increased. In addition to surface lift from canal & surface flows, rain water harvesting may also be considered.

Management Intervention through Harvesting of Surface Runoff and Artificial Recharge:

It has been estimated that the utilizable surface runoff produced in the block is **4.949** MCM. This surface runoff is proposed to be utilized to recharge the shallow aquifer (weathered zone) in the block. Therefore, **6** percolation tanks, **20** check dams are recommended in the block.

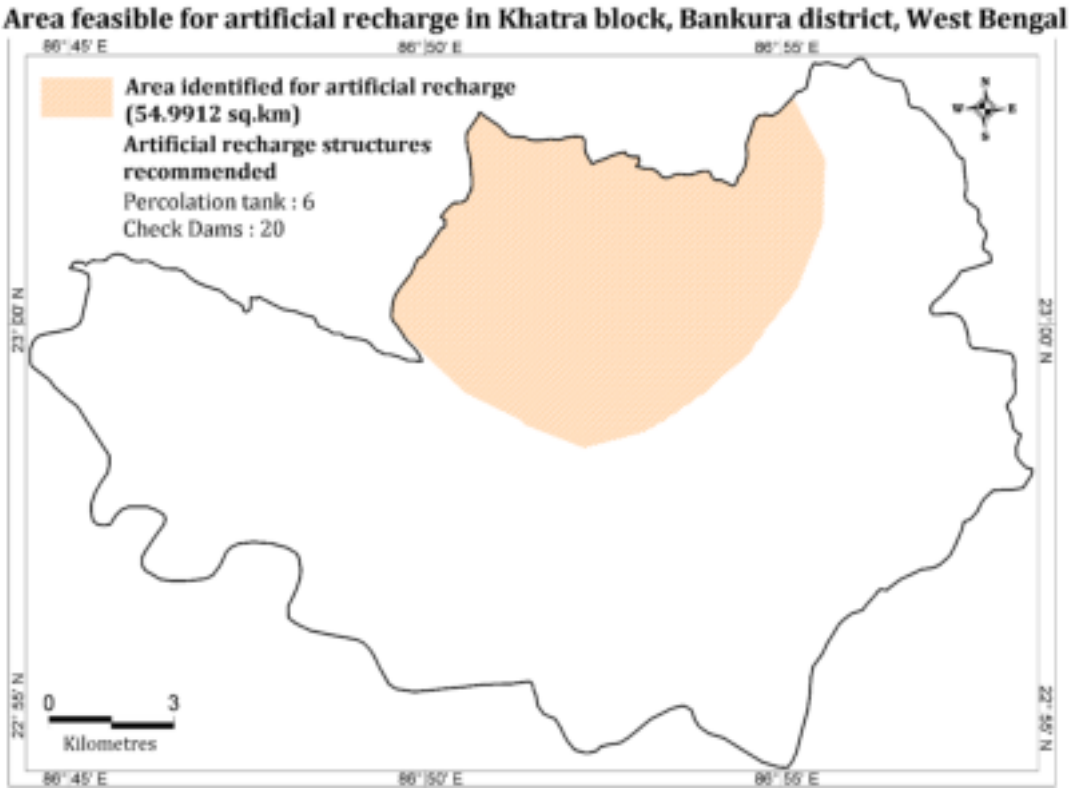


Figure*11.7.*4: Area Feasible for Artificial Recharge of groundwater for *Khatra* Block

Table *11.7.*11: Details of structures recommended in feasible area of artificial recharge for Khatra Block.

Name of the Block	Utilizable Surface Run Off	Allocation of Utilizable Recourse (MCM)							Structures Feasible							Cost of Structures							
		Percolation Tank	REET with RS	Injection Well	Check Dam	Gabion/ Contour Bund	Sub-Surface Dyke	Dug Well Recharge	Percolation Tank	REET with RS	Injection Well	Check Dam	Gabion/ Contour Bund	Sub-Surface Dyke	Dug Well Recharge	Percolation Tank	REET with RS	Injection Well	Check Dam	Gabion/ Contour Bund	Sub-Surface Dyke	Dug Well Recharge	TOTAL
Khatra	4.949	3.217	0	0	0.99	0.247	0.247	0.247	6	0	0	20	49	25	5	72	0	0	30	24.5	25	5.5	157

11.8 SALIENT INFORMATION

Block Name: *Mejhia*

Geographical area (sq. km): **164**

Mappable area (sq. km): **164**

District: **Bankura**

State: **West Bengal**

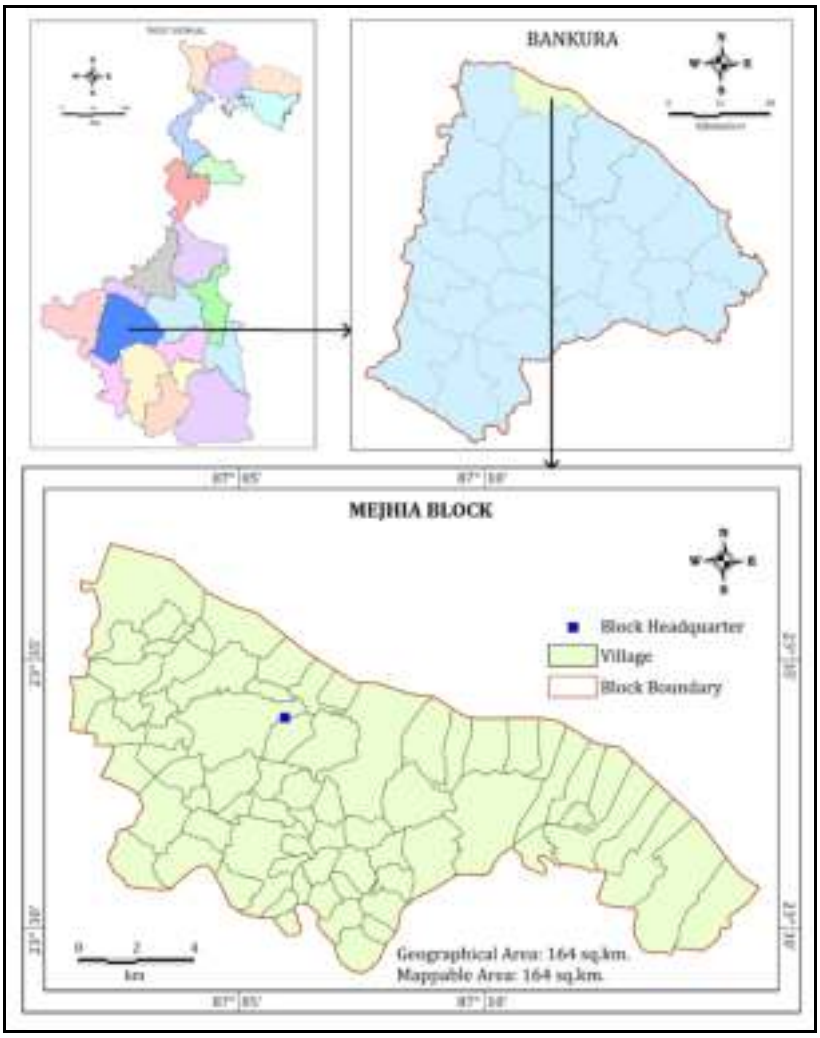


Figure *11.8.1*: *Location Map of Mejhia Block*

Population (as on 2011):

Table 11.8.1: *Details of population in Mejhia block.*

Rural	Urban	Total	Population Density per Sq.km
86188	-	86188	526

Rainfall: Average annual rainfall for the period 2015 -19 is 1300.36 (in mm)

Table *11.8*.2: Details of Annual Rainfall for the last five years in *Mejhia* block.

Block Name	Normal Rainfall	Rain Fall				
		2014	2015	2016	2017	2018
Mejhia	1386	1075.5	1127.2	1335.9	1780.2	1334.3

Agriculture& Irrigation (area in ha):

Table *11.8*.3: Salient Land use features of *Mejhia* block

Block	Reporting Area	Forest Area	Area Under Non-Agricultural Waste	Barren and Un-culturable land	Permanent pastures and grazing lands	Land under misc tree crops	Culturable wastes	Fallow land Other than current fallow	Current fallow	Net area sown	Cultivable Area
Mejhia	16287	535	4189	-	-	10	-	30	422	11101	11563

Table *11.8*.4: Crop pattern of *Mejhia* block

Block	Aus			Aman			Boro			Wheat			Maize		
	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield
Mejhia	-	-	-	1371	2.858	2084	-	-	-	6	0.012	2044	-	-	-
	Mustard			Til			Potato			Musur			Gram		
	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	
	27	0.017	639	-	-	-	-	-	-	9	0.005	577			

Table *11.8*.5: Command area (ha) of *Mejhia* block

Block Name	Dug well		Shallow Tube well		Medium Tube well		Deep Tube well		Surface Flow		Surface Lift		CCA (ha.)		Total CCA (ha.)
	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	Ground Water	Surface Water	
MEJHIA	11	26	50	185.1	0		4	21	83	426.45	276	1467.32	232.1	1893.77	2125.87

Table *11.8*.6: Command area (ha) of *Mejhia* block

Name of Block	Canal Area	Tank		RLI		DTW		STW		ODW		Others		Total	
		No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area
Mejhia	-	647	1556	16	720	-	-	215	327	260	100	7	150	1145	2853

Disposition of Aquifers:

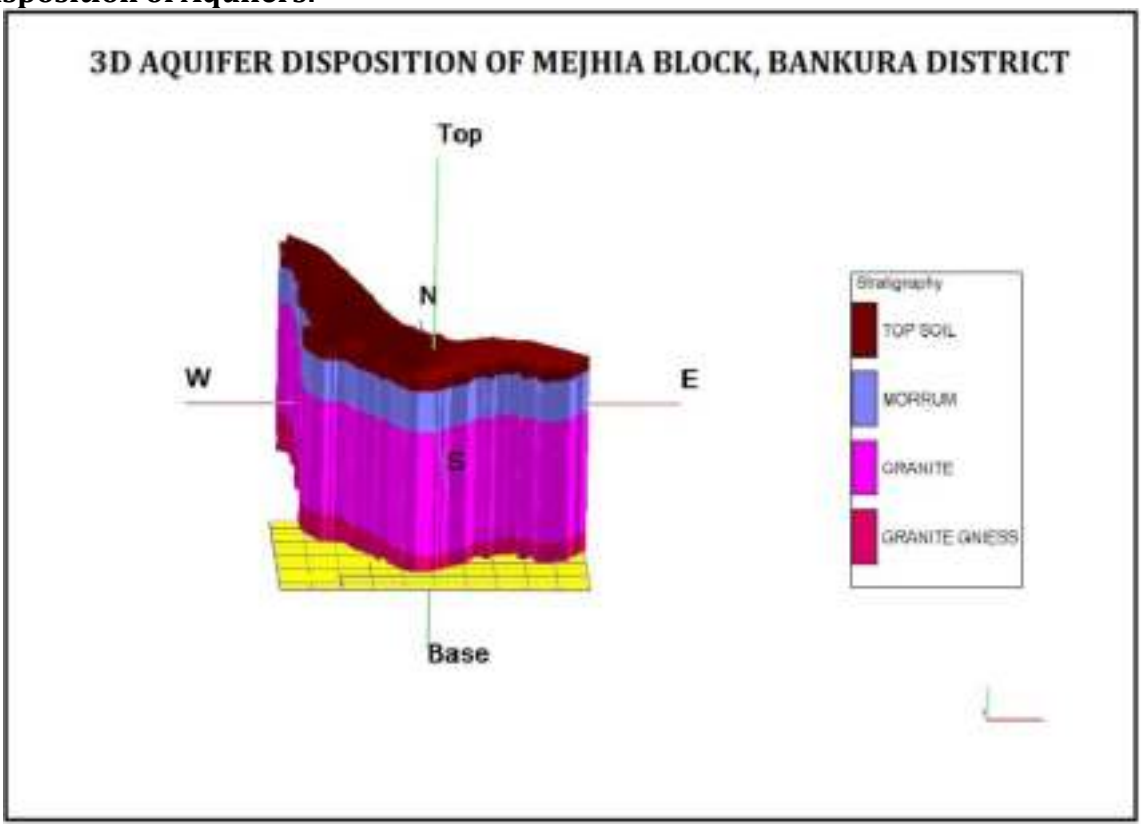


Figure *11.8*.2: 3-DimensionalAquifer disposition in *Mejhia* Block

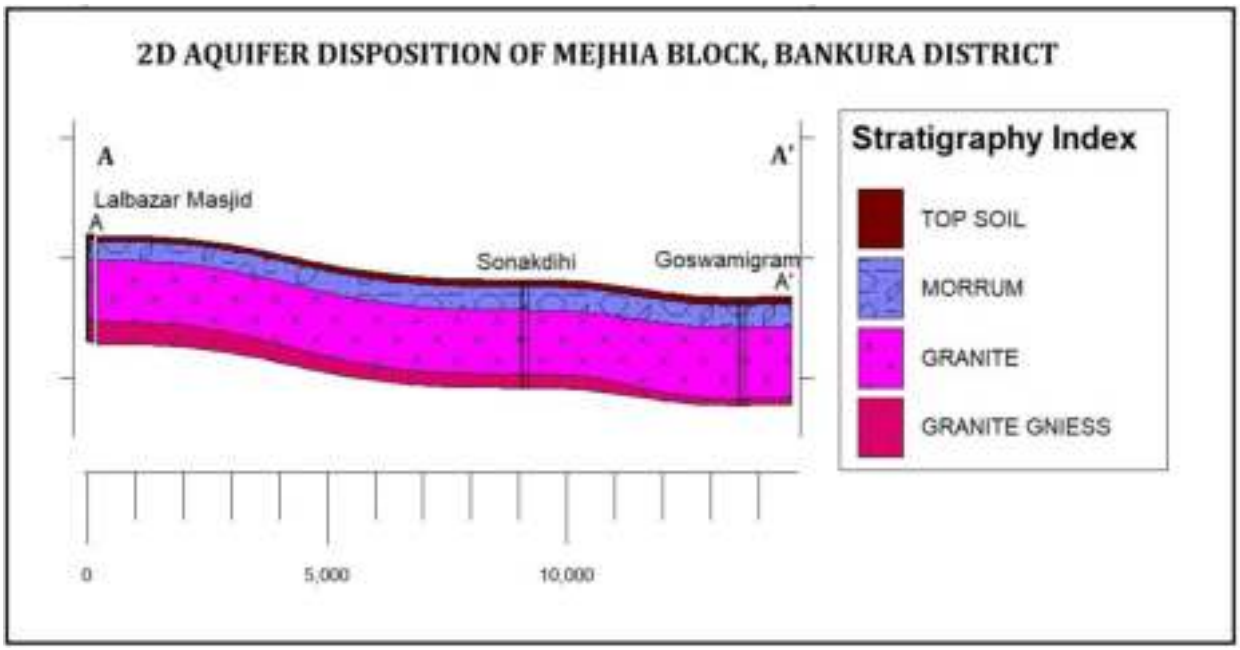


Figure *11.8*.3: 2-Dimensional Section in *Mejhia* Block

The principal aquifer systems encountered in this block is hard rock.
Two aquifers are encountered in this block.
The range of **Aquifer-I** is also known as Shallow aquifer/ weathered zone. The casing depth is here upto 14mbgl. The water bearing zone varied between 3-12 mbgl.

The range of **Aquifer-II** is also known as fracture zone where the interconnected fracture (secondary porosity of the rock) is responsible for the presence of GW. Fractures encountered at a depth of 28 mbgl & 38 mbgl.

Table *11.8*.7: Details of aquifer disposition in Mejhia Block

Blocks (dominant in hard rock)	No. of Aquifers	Water bearing zone	Casing depth	Aquifer Thickness (m)		Discharge (lpm)	T (m^2/day)	SWL (mbgl)	Drawdown (mbgl)	S
				Aquifer-I weathered Zone	Aquifer-II Fracture zone					
Mejhia	2	3-12	(upto 14m)	9	28, 38	20	--	10.6	--	--

Table *11.8*.8: Details of Aquifer Wise Water Level Ranges & seasonal long term water level trends

Block	Pre-monsoon Trend			Post-monsoon Trend		
	WL Range (mbgl)	Rise (m/year)	Fall (m/year)	WL Range (mbgl)	Rise (m/year)	Fall (m/year)
Mejhia	2.93-4.45	--	0.056	1.9-4.23	0.214	--

Ground water quality and issues:

Based on four NHS, four exploratory wells and three observation wells, the range of chemical parameter for the block is given below.

Table*11.8*. 9: Range of chemical parameters in Mejhia Block

Block	Aquifer Type	pH	EC (µS/cm)	Na (mg/l)	Cl (mg/l)	F (mg/l)	NO_3 (mg/l)	Fe (mg/l)	Measured Hardness (mg/l)
Mejhia	Aquifer-I	7.89-8.07	260-1984	12-94	10-60	0.10-0.94	2-9	0.03-0.07	105-865
	Aquifer-II	7.81-8.29	416-884	19-76	22-196	0.43-0.68	1-12	Traces	155-335

Ground Water Resource:

Table *11.8*.10: Details of Ground Water Resource Availability and Utilization in *Mejhia* Block.

Name of the Block	MEJHIA
Total Annual Ground Water Recharge (Ham)	7590.56
Total Natural Discharges (Ham)	759.06
Annual Extractable Ground Water Recharge (Ham)	6831.5
Total Extraction	360.94
Annual GW Allocation for Domestic Use as on 2042	115.66
Net Ground Water Availability for future use	6449.66
Stage of Ground Water Extraction (%)	5.28
Categorization (OE/CRITICAL/ SEMI-CRITICAL/ SAFE)	Safe
In storage (Ham)	6097

Aquifer Management Plan:

Ground Water Management Plan for drinking purpose:

The block has two commissioned public water supply schemes by PHED. There is one ongoing as well. However, there is still recorded deficit in supply of drinking water as the schemes do not reach to every mouza in the block. Therefore, there should be a general practice of conservation through rainwater harvesting, considering an adequate normal monsoon rainfall of 1347 mm which the block receives. The conserved rainwater can be utilized for drinking purpose by filtering through Horizontal Roughing Filters. The water from the lands can be channeled to ponds for recharge in the weathered zones and this water can be tapped through open dug wells for domestic and drinking purpose.

Ground Water Management Plan for irrigation purposes:

- Although ground water development in the block is low with stage of ground water development at 5.28%, further development should be done in planned manner to harness the additional available resource for site specific sustainable development.
- In view of low yield of the area, large diameter dug wells with adequate storage are another viable option for irrigation in favorable condition, thus creating a small command area. Owing to its distinct hydrogeology, it is evident that very less cultivable command area is created by both surface as well as groundwater.
- Modern methods of irrigation like sprinkler and drip irrigation methods are encouraged.
- Crops with low water requirement should be preferred.

In view of adequate rainfall in the area, excavation of tanks with large catchment areas, construction of check dam, nallah bunds, sub-surface dykes along the stream channels at suitable locations can be implemented to raise ground water level as well as to augment irrigation facilities.

Irrigation by surface water may be increased. In addition to surface lift from canal & surface flows, rain water harvesting may also be considered.

11.9 SALIENT INFORMATION

Block Name: ***Ranibundh***

Geographical area (sq. km): **428**

Mappable area (sq. km): **260**

District: **Bankura**

State: **West Bengal**

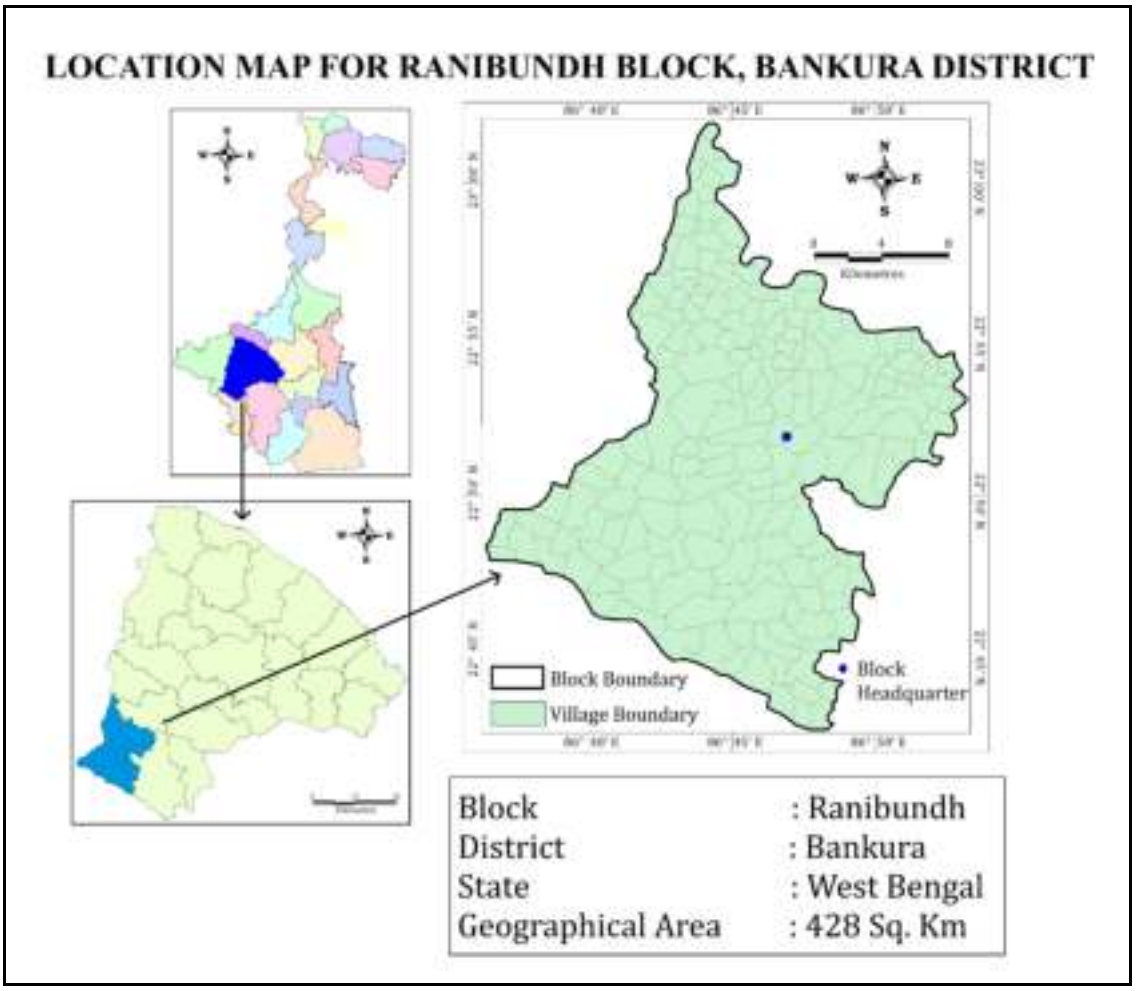


Figure *11.9.*1: Location Map of *Ranibundh* Block

Population (as on 2011):

Table *11.9.*1: *Details of population in Ranibundh block.*

Rural	Urban	Total	Population Density per Sq.km
119089	-	119089	278

Rainfall: Average annual rainfall for the period 2015 -19 is 1300.36 (in mm)

Table *11.9*.2: Details of Annual Rainfall for the last five years in *Ranibundh* block.

Block Name	Normal Rainfall	Rain Fall				
		2014	2015	2016	2017	2018
Ranibundh	1386	1075.5	1127.2	1335.9	1780.2	1334.3

Agriculture& Irrigation (area in ha):

Table *11.9*.3: Salient Land use features of *Ranibundh* block

Block	Reporting Area	Forest Area	Area Under Non-Agricultural Waste	Barren and Un-culturable land	Permanent pastures and grazing lands	Land under misc tree crops	Culturable wastes	Fallow land Other than current fallow	Current fallow	Net area sown	Cultivable Area
Ranibundh	19367	3505	6057	-	-	-	-	-	1009	8796	9805

Table *11.9*.4: Crop pattern of *Ranibundh* block

Block	Aus			Aman			Boro			Wheat			Maize		
	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield
Ranibundh	-	-	-	7829	19.285	2463	-	-	-	50	0.107	2147	-	-	
	Mustard			Til			Potato			Musur			Gram		
	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	
	444	0.411	926	-	-	-	207	6052.000	29235	-	-	-	1	0.001	817

Table *11.9*.5: Command area (ha) of *Ranibundh* block

Block Name	Dug well		Shallow Tube well		Medium Tube well		Deep Tube well		Surface Flow		Surface Lift		CCA (ha.)		Total CCA (ha.)
	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	Ground Water	Surface Water	
RANIBUNDH	11	47.96	77	201.35	1	2	0		254	1244	316	1049.82	251.31	2293.82	2545.13

Table *11.9*.6: Command area (ha) of *Ranibundh* block

Name of Block	Canal Area	Tank		RLI		DTW		STW		ODW		Others		Total	
		No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area
Ranibundh	2890	535	260	20	800	-	-	-	-	250	95	-	-	805	4045

Disposition of Aquifers:

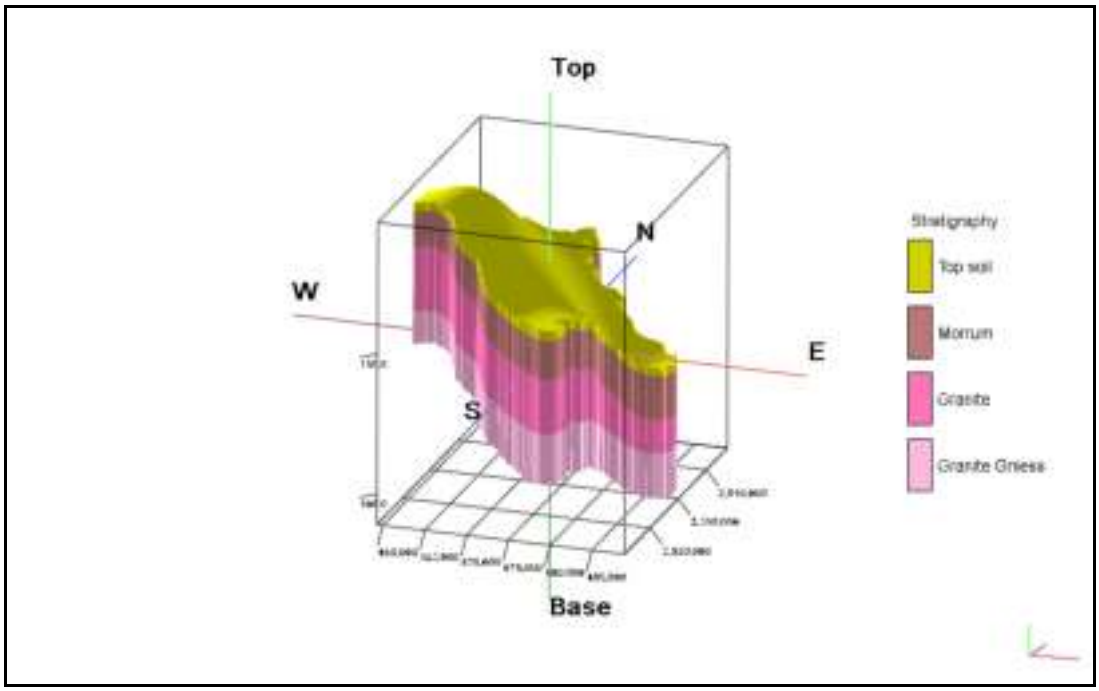


Figure *11.9*.2: 3-DimensionalAquifer disposition in *Ranibundh* Block

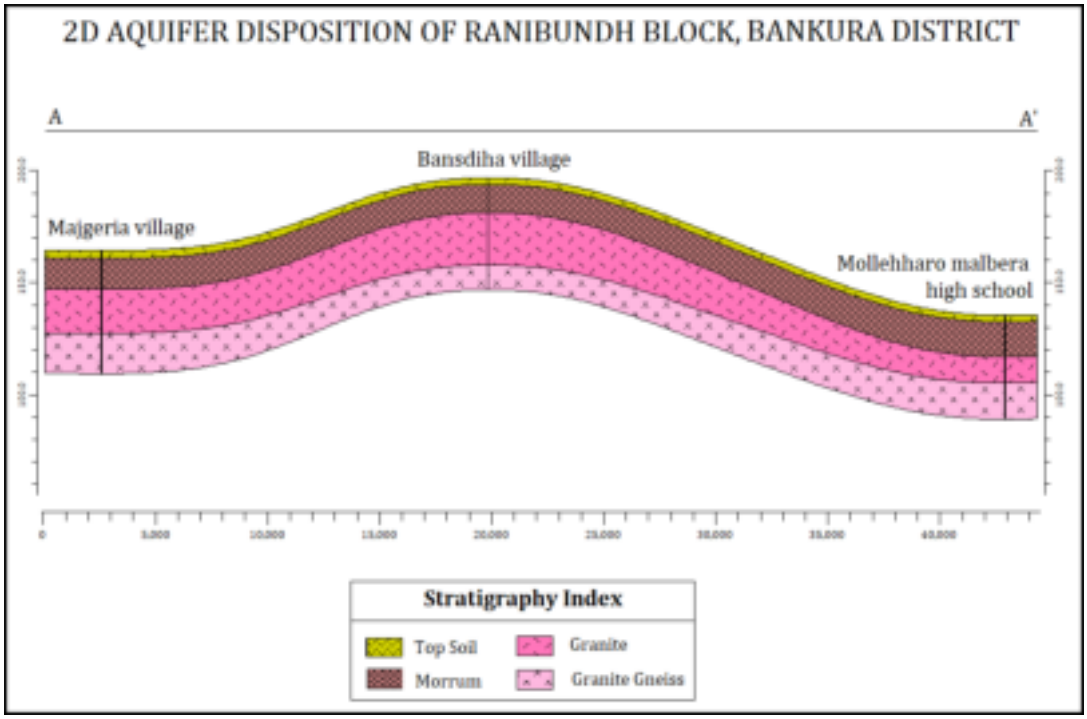


Figure *11.9*.3: 2-Dimensional Section in *Ranibundh* Block

The principal aquifer systems encountered in this block is hard rock.
Two aquifers are encountered in this block.
The range of **Aquifer-I** is also known as Shallow aquifer/ weathered zone. The casing depth is here upto 14mbgl. The water bearing zone varied between 3-15 mbgl.
The range of **Aquifer-II** is also known as fracture zone where the interconnected fracture (secondary porosity of the rock) is responsible for the presence of GW. Fractures encountered at a depth of 35 mbgl & 42 mbgl.

Table *11.9*.7: Details of aquifer disposition in Ranibundh Block

Blocks (dominant in hard rock)	No. of Aquifers	Water bearing zone	Casing depth	Aquifer Thickness (m)		Discharge (lpm)	T (m^2/day)	SWL (mbgl)	Drawdown (mbgl)	S
				Aquifer-I weathered Zone	Aquifer-II Fracture zone					
Ranibundh	2	3-15	(Upto 14m)	12	35, 42	18	--	14.3	--	--

Table 12.1.8: Details of Aquifer Wise Water Level Ranges & seasonal long term water level trends

Block	Pre-monsoon Trend			Post-monsoon Trend		
	WL Range (mbgl)	Rise (m/year)	Fall (m/year)	WL Range (mbgl)	Rise (m/year)	Fall (m/year)
Ranibundh	1.88-7.56	--	0.174	0.35-5.84	--	0.079

Ground water quality and issues:

Based on four NHS, four exploratory wells and three observation wells, the range of chemical parameter for the block is given below.

Table*11.9*. 9: Range of chemical parameters in Ranibundh Block

Block	Aquifer Type	pH	EC (µS/cm)	Na (mg/l)	Cl (mg/l)	F (mg/l)	NO_3 (mg/l)	Fe (mg/l)	Measured Hardness (mg/l)
Ranibundh	Aquifer-I	7.89-8.07	260-1984	12-94	10-60	0.10-0.94	2-9	0.03-0.07	105-865
	Aquifer-II	7.81-8.29	416-884	19-76	22-196	0.43-1.89	1-12	Traces	155-335

As per PHED report Fluoride concentration is above the permissible limit this block. More intensive sampling from this block is recommended.

Ground Water Resource:

Table *11.9*.10: Details of Ground Water Resource Availability and Utilization in *Ranibundh* Block.

Name of the Block	RANIBUNDH
Total Annual Ground Water Recharge (Ham)	5839.1
Total Natural Discharges (Ham)	583.91
Annual Extractable Ground Water Recharge (Ham)	5255.19
Total Extraction	441.21
Annual GW Allocation for Domestic Use as on 2042	156.95
Net Ground Water Availability for future use	4787.97
Stage of Ground Water Extraction (%)	8.4
Categorization (OE/CRITICAL/ SEMI-CRITICAL/ SAFE)	Safe
In storage (Ham)	4592

Aquifer Management Plan:

Ground Water Management Plan for drinking purpose:

- The block has two commissioned public water supply schemes by PHED. There is one ongoing as well. However, there is still recorded deficit in supply of drinking water as the schemes do not reach to every mouza in the block. Therefore, there should be a general practice of conservation through rainwater harvesting, considering an adequate normal monsoon rainfall of 1347 mm which the block receives. The conserved rainwater can be utilized for drinking purpose by filtering through Horizontal Roughing Filters. The water from the lands can be channeled to ponds for recharge in the weathered zones and this water can be tapped through open dug wells for domestic and drinking purpose.
- The block shows a falling trend of 0.079 m/year during post-monsoon. For monitoring of change in ground water regime in the area, cost of construction of Observation well should be included.

Ground Water Management Plan for irrigation purposes:

- Although ground water development in the block is low with stage of ground water development at 8.4%, further development should be done in planned manner to harness the additional available resource for site specific sustainable development.
- In view of low yield of the area, large diameter dug wells with adequate storage are another viable option for irrigation in favorable condition, thus creating a small command area. Owing to its distinct hydrogeology, it is evident that very less cultivable command area is created by both surface as well as groundwater.
- Modern methods of irrigation like sprinkler and drip irrigation methods are encouraged.
- Crops with low water requirement should be preferred.

In view of adequate rainfall in the area, excavation of tanks with large catchment areas, construction of check dam, nallah bunds, sub-surface dykes along the stream channels at suitable locations can be implemented to raise ground water level as well as to augment irrigation facilities.

Irrigation by surface water may be increased. In addition to surface lift from canal & surface flows, rain water harvesting may also be considered.

11.10 SALIENT INFORMATION

Block Name: ***Saltora***

Geographical area (sq. km): **332**

Mappable area (sq. km): **282**

District: **Bankura**

State: **West Bengal**

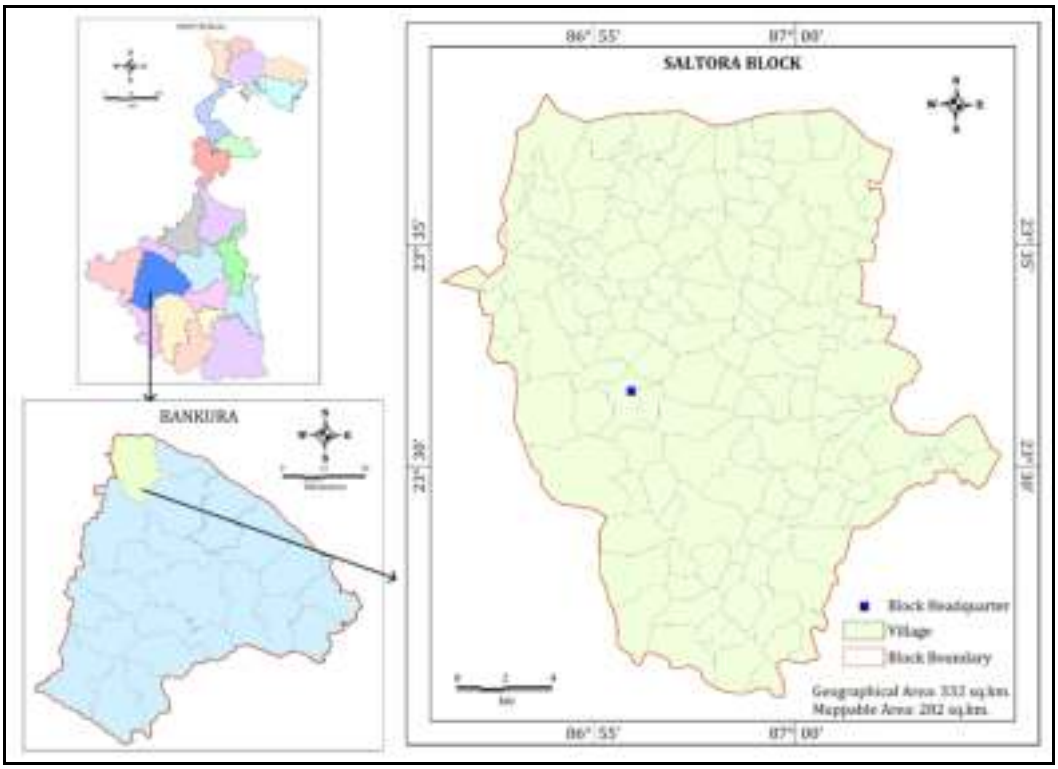


Figure *11.10*.1: Location Map of *Saltora* Block

Population (as on 2011):

Table *11.10*.1: *Details of population in Saltora block.*

Rural	Urban	Total	Population Density per Sqkm
135980	-	135980	410

Rainfall: Average annual rainfall for the period 2015 -19 is 1300.36 (in mm)

Table *11.10*.2: Details of Annual Rainfall for the last five years in *Saltora* block.

Block Name	Normal Rainfall	Rain Fall				
		2014	2015	2016	2017	2018
Saltora	1386	1075.5	1127.2	1335.9	1780.2	1334.3

Agriculture& Irrigation (area in ha):

Table *11.10*.3: Salient Land use features of *Saltora* block

Block	Reporting Area	Forest Area	Area Under Non-Agricultural Waste	Barren and Un-culturable land	Permanent pastures and grazing lands	Land under misc tree crops	Culturable wastes	Fallow land Other than current fallow	Current fallow	Net area sown	Cultivable Area
Saltora	31093	3818	5612	360			514	87	1603	19099	21303

Table *11.10*.4: Crop pattern of *Saltora* block

Block	Aus			Aman			Boro			Wheat			Maize		
	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield
Saltora				2006	3.771	1880	-	-	-	10	0.025	2461	-	-	-
	Mustard			Til			Potato			Musur			Gram		
	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	
	2	0.001	473	168	0.167	996	-	-	-	1	0.001	715	-	-	-

Table *11.10*.5: Command area (ha) of *Saltora* block

Block Name	Dug well		Shallow Tube well		Medium Tube well		Deep Tube well		Surface Flow		Surface Lift		CCA (ha.)		Total CCA (ha.)
	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	Ground Water	Surface Water	
SALTORA	26	69.3	102	334.94	0	0	2	6	21	167.5	790	5676.91	410.24	5844.41	6254.65

Table *11.10*.6: Command area (ha) of *Saltora* block

Name of Block	Canal Area	Tank		RLI		DTW		STW		ODW		Others		Total	
		No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area
Saltora	-	2010	2400	14	560	-	-	-	-	170	90	320	250	2514	3300

Disposition of Aquifers:

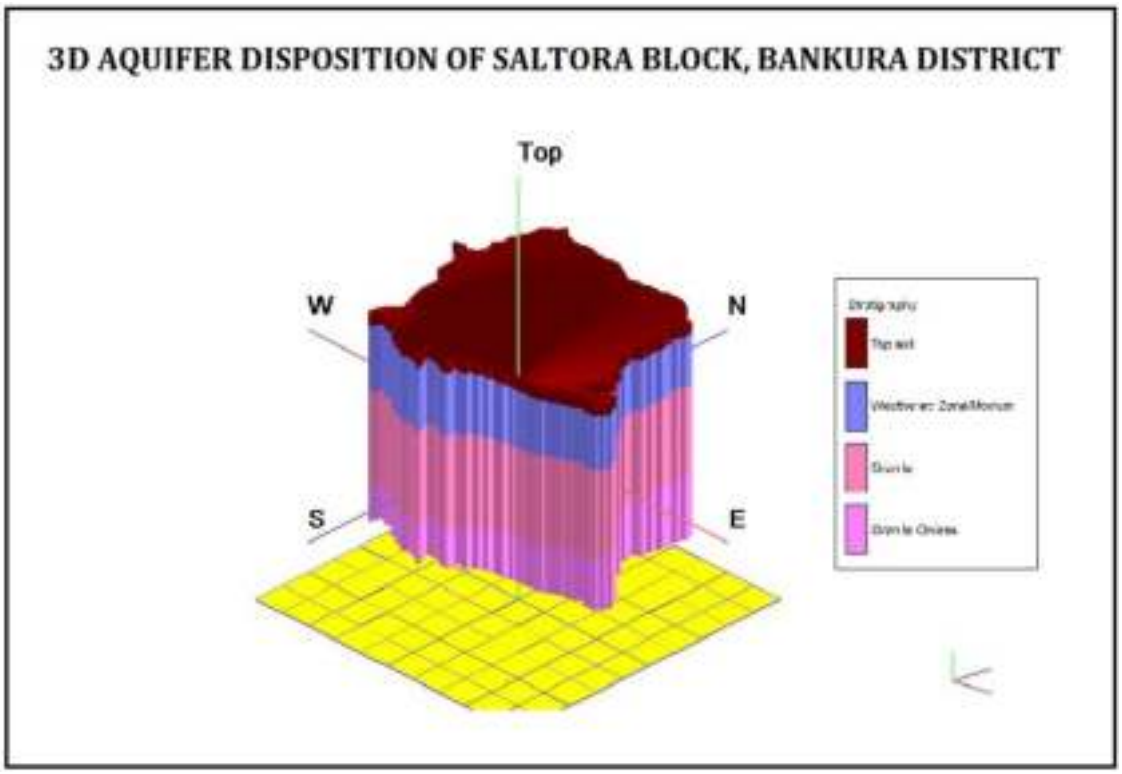


Figure *11.10*.2: 3-DimensionalAquifer disposition in *Saltora* Block

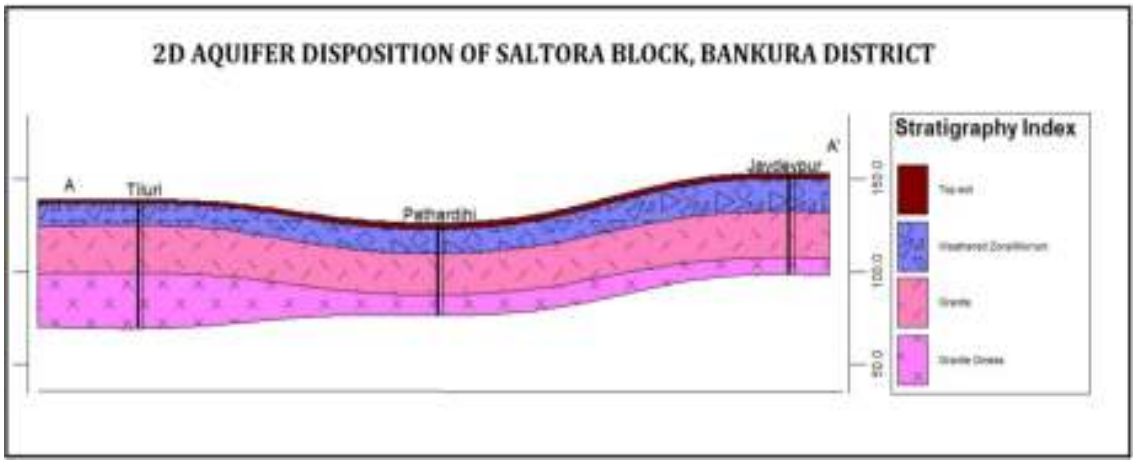


Figure *11.10*.3: 2-Dimensional Section in *Saltora* Block

The principal aquifer systems encountered in this block is hard rock.

Two aquifers are encountered in this block.

The range of **Aquifer-I** is also known as Shallow aquifer/ weathered zone. The casing depth is here upto 18mbgl. The water bearing zone varied between 4-15 mbgl.

The range of **Aquifer-II** is also known as fracture zone where the interconnected fracture (secondary porosity of the rock) is responsible for the presence of GW. Fractures encountered at a depth of 31 mbgl & 42 mbgl.

Table *11.10*.7: Details of aquifer disposition in Saltora Block

Blocks (dominant in hard rock)	No. of Aquifers	Water bearing zone	Casing depth	Aquifer Thickness (m)		Discharge (lpm)	T (m^2/day)	SWL (mbgl)	Drawdown (mbgl)	S
				Aquifer-I weathered Zone	Aquifer-II Fracture zone					
Saltora	2	4-15	(upto 18m)	11	31,42	25	--	7.5	--	--

Table *11.10*.8: Details of Aquifer Wise Water Level Ranges & seasonal long term water level trends

Block	Pre-monsoon Trend			Post-monsoon Trend		
	WL Range (mbgl)	Rise (m/year)	Fall (m/year)	WL Range (mbgl)	Rise (m/year)	Fall (m/year)
Saltora	1.75-5.22	0.091	--	2.58-5.43	--	0.038

Ground water quality and issues:

Based on four NHS, four exploratory wells and three observation wells, the range of chemical parameter for the block is given below.

Table *11.10*.9: Range of chemical parameters in Saltora Block

Block	Aquifer Type	pH	EC (µS/cm)	Na (mg/l)	Cl (mg/l)	F (mg/l)	NO_3 (mg/l)	Fe (mg/l)	Measured Hardness (mg/l)
Saltora	Aquifer-I	7.89-8.07	260-1984	12-94	10-60	0.10-0.94	2-9	0.03-0.07	105-865
	Aquifer-II	7.81-8.29	416-884	19-76	22-196	0.43-2.24	1-12	Traces	155-335

As per PHED report Fluoride concentration is above the permissible limit this block. More intensive sampling from this block is recommended.

Ground Water Resource:

Table *11.10*.10: Details of Ground Water Resource Availability and Utilization in *Saltora* Block.

Name of the Block	**SALTORA**
Total Annual Ground Water Recharge (Ham)	8314.95
Total Natural Discharges (Ham)	831.5
Annual Extractable Ground Water Recharge (Ham)	7483.45
Total Extraction	581.07
Annual GW Allocation for Domestic Use as on 2042	178.08
Net Ground Water Availability for future use	6873.81
Stage of Ground Water Extraction (%)	7.76
Categorization (OE/CRITICAL/ SEMI-CRITICAL/ SAFE)	Safe
In storage (Ham)	6734

Aquifer Management Plan:

Ground Water Management Plan for drinking purpose:

- The block has two commissioned public water supply schemes by PHED. There is one ongoing as well. However, there is still recorded deficit in supply of drinking water as the schemes do not reach to every mouza in the block. Therefore, there should be a general practice of conservation through rainwater harvesting, considering an adequate normal monsoon rainfall of 1347 mm which the block receives. The conserved rainwater can be utilized for drinking purpose by filtering through Horizontal Roughing Filters. The water from the lands can be channeled to ponds for recharge in the weathered zones and this water can be tapped through open dug wells for domestic and drinking purpose.
- The block shows a falling trend of 0.038 m/year during post-monsoon. For monitoring of change in ground water regime in the area, cost of construction of Observation well should be included.

Ground Water Management Plan for irrigation purposes:

- Although ground water development in the block is low with stage of ground water development at 7.76%, further development should be done in planned manner to harness the additional available resource for site specific sustainable development.
- In view of low yield of the area, large diameter dug wells with adequate storage are another viable option for irrigation in favorable condition, thus creating a small command area. Owing to its distinct hydrogeology, it is evident that very less cultivable command area is created by both surface as well as groundwater.
- Modern methods of irrigation like sprinkler and drip irrigation methods are encouraged.
- Crops with low water requirement should be preferred.

In view of adequate rainfall in the area, excavation of tanks with large catchment areas, construction of check dam, nallah bunds, sub-surface dykes along the stream channels at suitable locations can be implemented to raise ground water level as well as to augment irrigation facilities.

Irrigation by surface water may be increased. In addition to surface lift from canal & surface flows, rain water harvesting may also be considered.

11.11 SALIENT INFORMATION

Block Name: ***Barjora***

Geographical area (sq. km): **423**

Mappable area (sq. km): **373**

District: **Bankura**

State: **West Bengal**

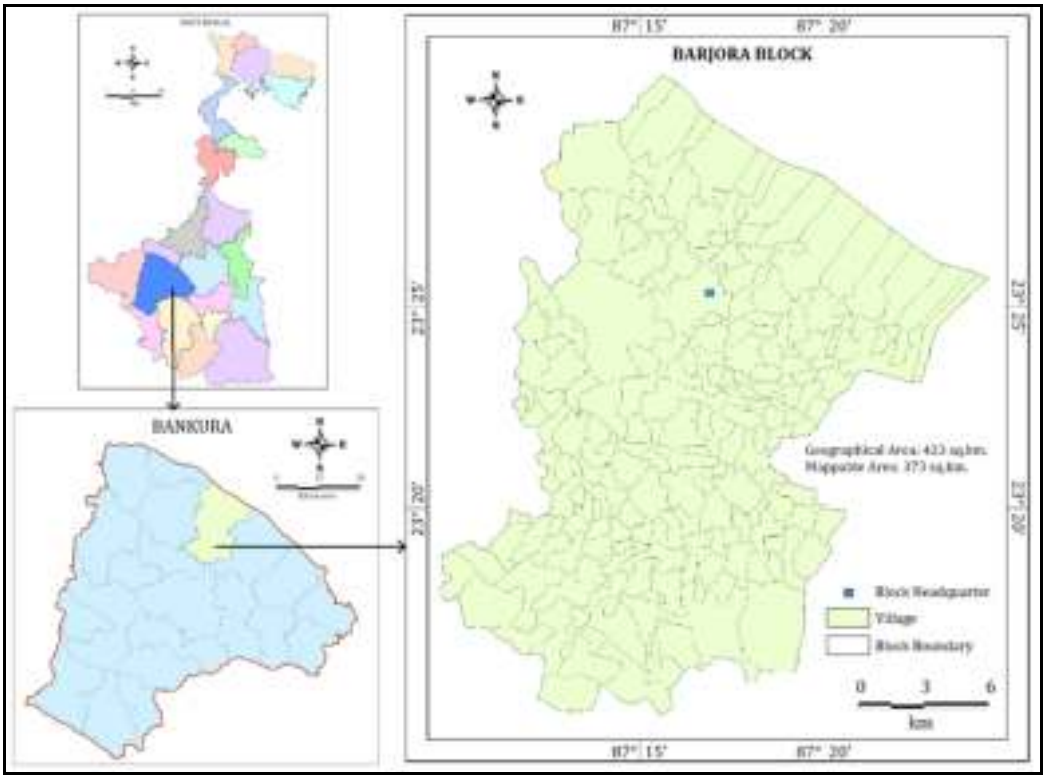


Figure *11.11*.1: Location Map of *Barjora* Block

Population (as on 2011):

Table *11.11*.1: *Details of population in Barjora block.*

Rural	Urban	Total	Population Density per Sqkm
176263	25786	202049	478

Rainfall: Average annual rainfall for the period 2015 -19 is 1300.36 (in mm)

Table *11.11*.2: Details of Annual Rainfall for the last five years in *Barjora* block.

Block Name	Normal Rainfall	Rain Fall				
		2014	2015	2016	2017	2018
Barjora	1386	1075.5	1127.2	1335.9	1780.2	1334.3

Agriculture& Irrigation (area in ha):

Table *11.11*.3: Salient Land use features of *Barjora* block

Block	Reporting Area	Forest Area	Area Under Non-Agricultural Waste	Barren and Un-culturable land	Permanent pastures and grazing lands	Land under misc tree crops	Culturable wastes	Fallow land Other than current fallow	Current fallow	Net area sown	Cultivable Area
Barjora	39390	10646	7546	101		103	378	112	601	19903	21097

Table *11.11*.4: Crop pattern of *Barjora* block

Block	Aus			Aman			Boro			Wheat			Maize		
	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield
Barjora	300	0.853	2844.55	16611	44.594	2685	122	0.414	3397	195	0.345	1772	-	-	-
	Mustard			Til			Potato			Musur			Gram		
	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	
	95	0.035	372	246	0.193	783	2135	69208.000	32416	5	0.002	470	1	0.001	804

Table *11.11*.5: Command area (ha) of *Barjora* block

Block Name	Dug well		Shallow Tube well		Medium Tube well		Deep Tube well		Surface Flow		Surface Lift		CCA (ha.)		Total CCA (ha.)
	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	Ground Water	Surface Water	
BARJORA	2	6	501	1558.9	47	338.8	3	86	214	1035	344	1386.9	1989.7	2421.9	4411.6

Table *11.11*.6: Command area (ha) of *Barjora* block

Name of Block	Canal Area	Tank		RLI		DTW		STW		ODW		Others		Total	
		No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area
Barjora	3043	1010	660	27	1320	21	224	1498	2089	314	112	125	799	2995	8247

Disposition of Aquifers:

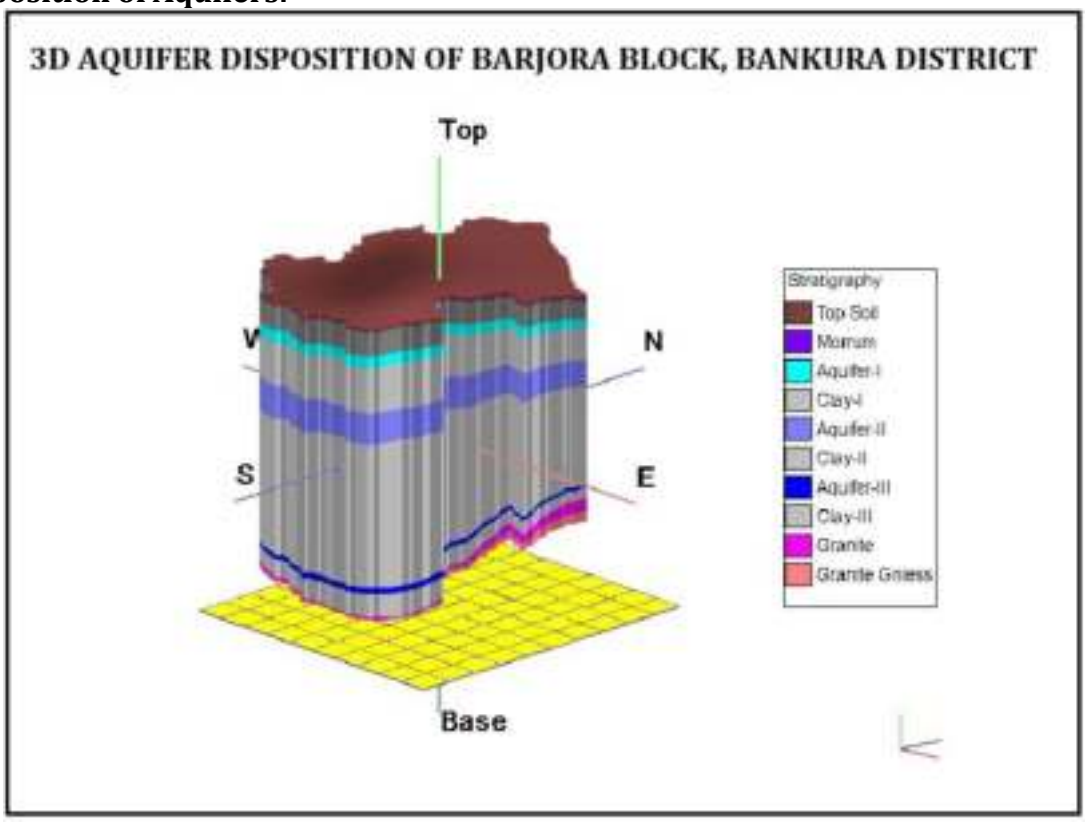


Figure *11.11*.2: 3-Dimensional Aquifer disposition in *Barjora* Block

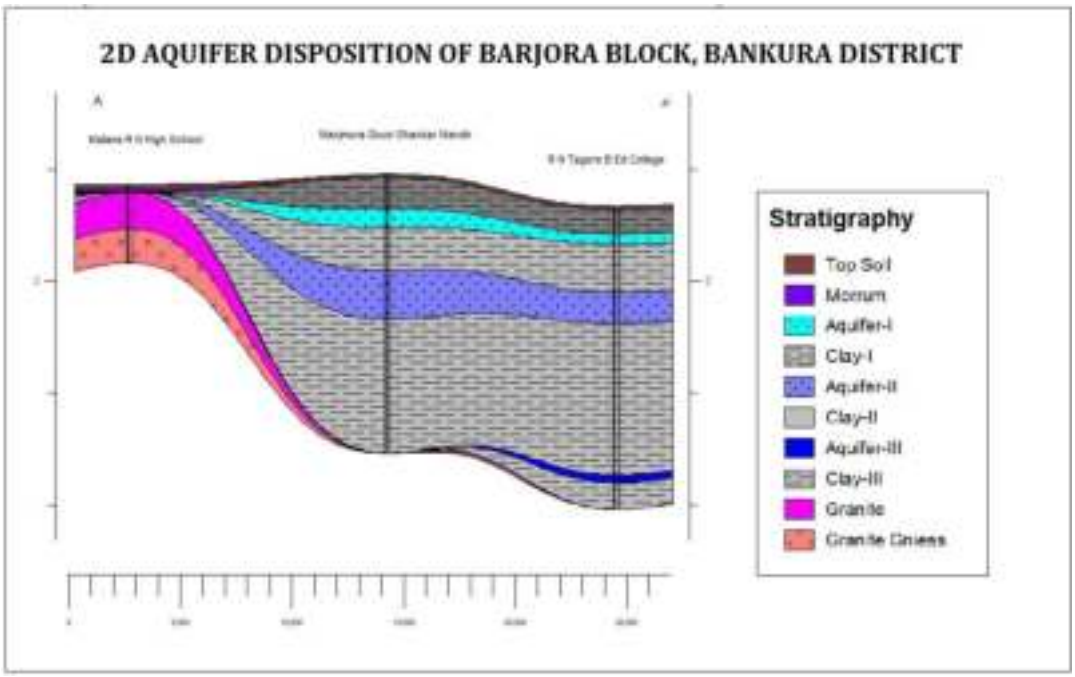


Figure *11.11*.3: 2-Dimensional Section in *Barjora* Block

The principal aquifer systems encountered in this block are alluvial formation

Two aquifers are encountered in this block.

The range of **Aquifer-I** is also known as Shallow aquifer. The range varies from 25-48 mbgl. Thickness of the granular Zone is 23m.

The range of **Aquifer-II** is also known as 2nd Aquifer. The range varies from 77-130 mbgl.
Thickness of the granular Zone is 53m.

The Range of **Aquifer-III** is also known as Deeper Aquifer. The range varies from 241-248 mbgl. Thickness of the granular Zone is 7m

Table *11.11*.7: Details of aquifer disposition in Barjora Block

Blocks (dominant in soft rock)	No. of Aquifers	Water bearing zone	Aquifer Thickness (m)			Discharge (lpm)	T (m^2/day)	SWL (mbgl)	Draw down (mbgl)	S
			Aquifer-I (Within 50 mbgl)	Aquifer-II (above 50 mbgl)	Aquifer-III (above 150 mbgl)					
Barjora	3	25-48, 77-130, 241-248	23	53	7	1620	--	8.6	--	--

Table *11.11*.8: Details of Aquifer Wise Water Level Ranges & seasonal long term water level trends

Block	Pre-monsoon Trend			Post-monsoon Trend		
	WL Range (mbgl)	Rise (m/year)	Fall (m/year)	WL Range (mbgl)	Rise (m/year)	Fall (m/year)
Barjora	2.05-7.09	--	0.303	1.45-5.98	--	0.120

Ground water quality and issues:

Based on four NHS, four exploratory wells and three observation wells, the range of chemical parameter for the block is given below.

Table *11.11*.9: Range of chemical parameters in Barjora Block

Block	Aquifer Type	pH	EC (µS/cm)	Na (mg/l)	Cl (mg/l)	F (mg/l)	NO_3 (mg/l)	Fe (mg/l)	Measured Hardness (mg/l)
Barjora	Aquifer-I	7.89-8.07	260-1984	12-94	10-60	0.10-0.94	2-9	0.03-0.07	105-865
	Aquifer-II	7.81-8.29	416-884	19-76	22-196	0.43-0.67	1-12	Traces	155-335

As per PHED report Fluoride concentration is above the permissible limit this block. More intensive sampling from this block is recommended.

Ground Water Resource:

Table *11.11*.10: Details of Ground Water Resource Availability and Utilization in *Barjora* Block.

Name of the Block	**BARJORA**
Total Annual Ground Water Recharge (Ham)	16154.87
Total Natural Discharges (Ham)	1615.49
Annual Extractable Ground Water Recharge (Ham)	14539.38
Total Extraction	4514.83
Annual GW Allocation for Domestic Use as on 2042	238.63
Net Ground Water Availability for future use	10008.07
Stage of Ground Water Extraction (%)	31.05
Categorization (OE/CRITICAL/ SEMI-CRITICAL/ SAFE)	Safe
In storage (Ham)	89587

Aquifer Management Plan:

Ground Water Management Plan for drinking purpose:

The block has two commissioned public water supply schemes by PHED. There is one ongoing as well. However, there is still recorded deficit in supply of drinking water as the schemes do not reach to every mouza in the block. Therefore, there should be a general practice of conservation through rainwater harvesting, considering an adequate normal monsoon rainfall of 1347 mm which the block receives. The conserved rainwater can be utilized for drinking purpose by filtering through Horizontal Roughing Filters. The water from the lands can be channeled to ponds for recharge in the weathered zones and this water can be tapped through open dug wells for domestic and drinking purpose.

Ground Water Management Plan for irrigation purposes:

- Although ground water development in the block is low with stage of ground water development at 31.05%, further development should be done in planned manner to harness the additional available resource for site specific sustainable development.
- In view of low yield of the area, large diameter dug wells with adequate storage are another viable option for irrigation in favorable condition, thus creating a small command area. Owing to its distinct hydrogeology, it is evident that very less cultivable command area is created by both surface as well as groundwater.
- Modern methods of irrigation like sprinkler and drip irrigation methods are encouraged.
- Crops with low water requirement should be preferred.

In view of adequate rainfall in the area, excavation of tanks with large catchment areas, construction of check dam, nallah bunds, sub-surface dykes along the stream channels at suitable locations can be implemented to raise ground water level as well as to augment irrigation facilities.
Irrigation by surface water may be increased. In addition to surface lift from canal & surface flows, rain water harvesting may also be considered

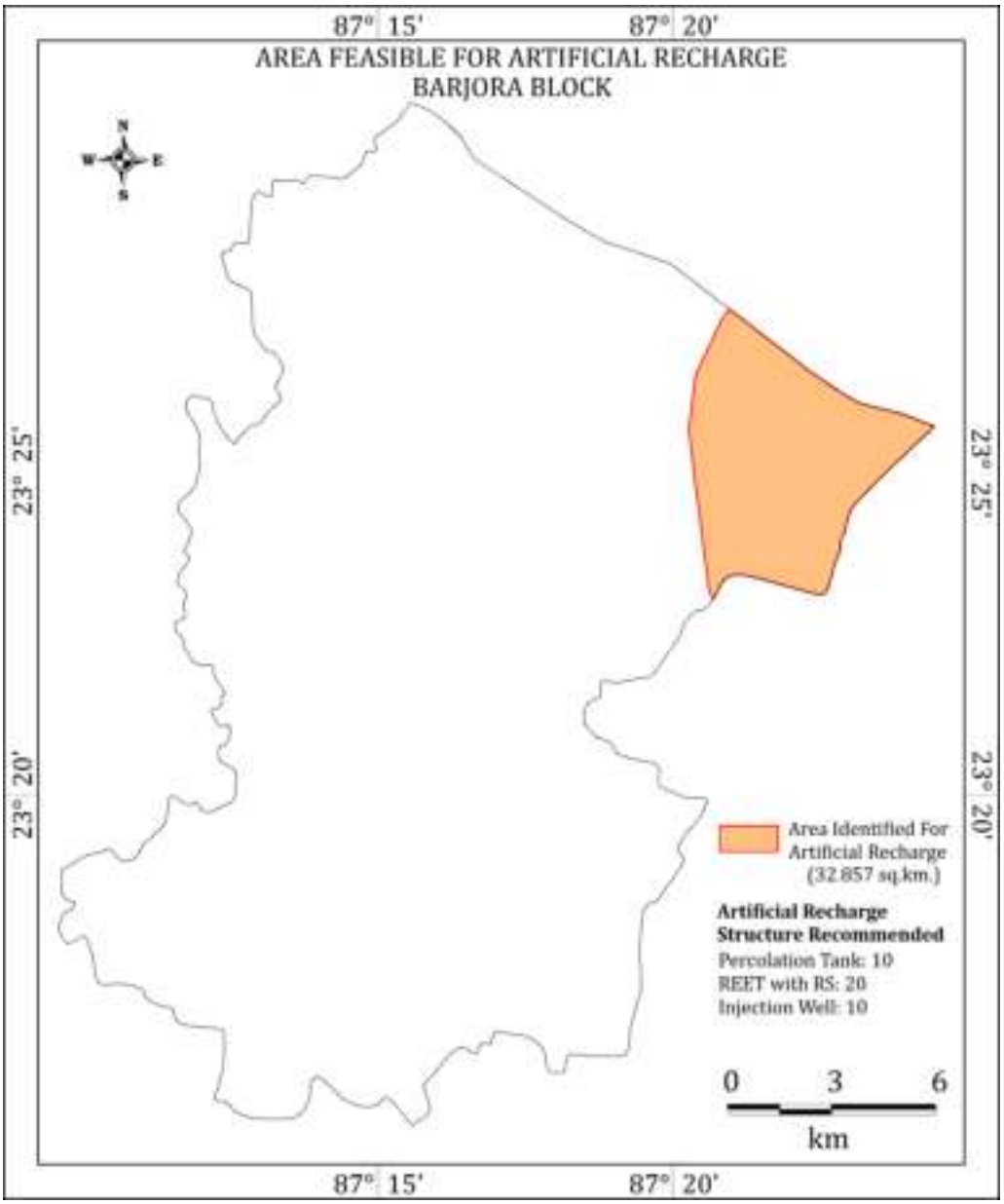


Figure *11.11.4*: Area Feasible for Artificial Recharge of groundwater for *Barjora* Block

Table *11.11*.11: Details of structures recommended in feasible area of artificial recharge for Barjora Block.

Name of the Block	Utilizable Surface Run Off	Allocation of Utilizable Recourse (MCM)							Structures Feasible							Cost of Structures							
		Percolation Tank	REET with RS	Injection Well	Check Dam	Gabion/ Contour Bund	Sub-Surface Dyke	Dug Well Recharge	Percolation Tank	REET with RS	Injection Well	Check Dam	Gabion/ Contour Bund	Sub-Surface Dyke	Dug Well Recharge	Percolation Tank	REET with RS	Injection Well	Check Dam	Gabion/ Contour Bund	Sub-Surface Dyke	Dug Well Recharge	TOTAL
Barjora	9.857	4.929	1.971	2.957	0	0	0	0	10	20	10	0	0	0	0	80	80	30	0	0	0	0	190

Management Intervention through Harvesting of Surface Runoff and Artificial Recharge:

It has been estimated that the utilizable surface runoff produced in the block is **9.857** MCM. This surface runoff is proposed to be utilized to recharge the depleted aquifer (aquifer III) in the block. As per the available storage space, **2.957** MCM water is required to fill the deeper aquifers in block. Therefore, **10** injection wells with roof top rain water harvesting structures are recommended in the block. The remaining surface runoff, **6.900** MCM is recommended to be utilized in storage tanks for generation of irrigation potential and thus, **10** percolation tanks and **20** REET with RS have been proposed.

11.12 SALIENT INFORMATION

Block Name: ***Bishnupur***

Geographical area (sq. km): **371**

Mappable area (sq. km): **371**

District: **Bankura**

State: **West Bengal**

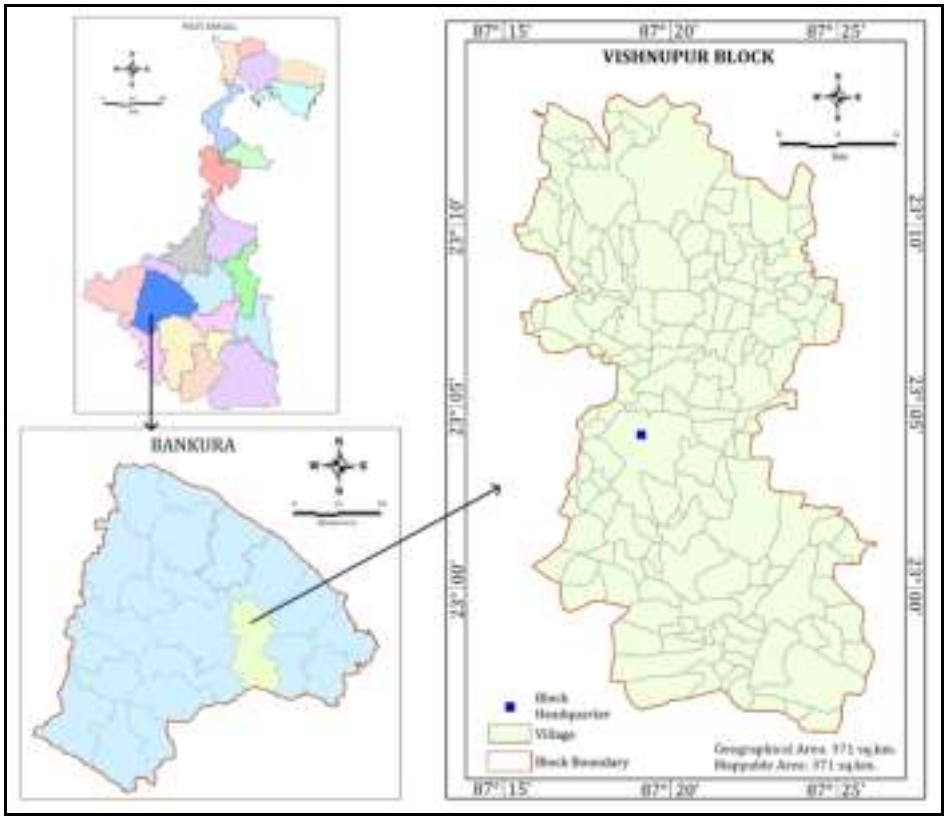


Figure *11.12*.1: Location Map of *Bishnupur* Block

Population (as on 2011):

Table *11.12*.1: *Details of population in Bishnupur block.*

Rural	Urban	Total	Population Density per Sqkm
156822	67783	224605	605

Rainfall: Average annual rainfall for the period 2015 -19 is 1300.36 (in mm)

Table *11.12*.2: Details of Annual Rainfall for the last five years in *Bishnupur* block.

Block Name	Normal Rainfall	Rain Fall				
		2014	2015	2016	2017	2018
Bishnupur	1386	1075.5	1127.2	1335.9	1780.2	1334.3

Agriculture& Irrigation (area in ha):

Table *11.12*.3: Salient Land use features of *Bishnupur* block

Block	Reporting Area	Forest Area	Area Under Non-Agricultural Waste	Barren and Un-culturable land	Permanent pastures and grazing lands	Land under misc tree crops	Culturable wastes	Fallow land Other than current fallow	Current fallow	Net area sown	Cultivable Area
Bishnupur	38844	13514	11346	95		129			7	13753	13889

Table*11.12*.4: Crop pattern of *Bishnupur* block

Block	Aus			Aman			Boro			Wheat			Maize		
	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield
Bishnupur	236	0.358	1514.99	37032	103.234	2788	561	1.707	3042	14	0.030	2138	-	-	-
	Mustard			Til			Potato			Musur			Gram		
	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	
	744	0.531	713	19	0.014	751	2005	26873	13403	9	0.012	1360	1	0.001	899

Table *11.12*.5: Command area (ha) of *Bishnupur* block

Block Name	Dug well		Shallow Tube well		Medium Tube well		Deep Tube well		Surface Flow		Surface Lift		CCA (ha.)		Total CCA (ha.)
	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	Ground Water	Surface Water	
BISHNUPUR	3	10	1246	4252.4	160	914	25		48	261	132	779	5176.4	1040	6216.4

Table *11.12*.6: Command area (ha) of *Bishnupur* block

Name of Block	Canal Area	Tank		RLI		DTW		STW		ODW		Others		Total	
		No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area
Bishnupur	6760	475	350	24	820	71	1050	3810	11094	100	20	522	290	5002	20384

Disposition of Aquifers:

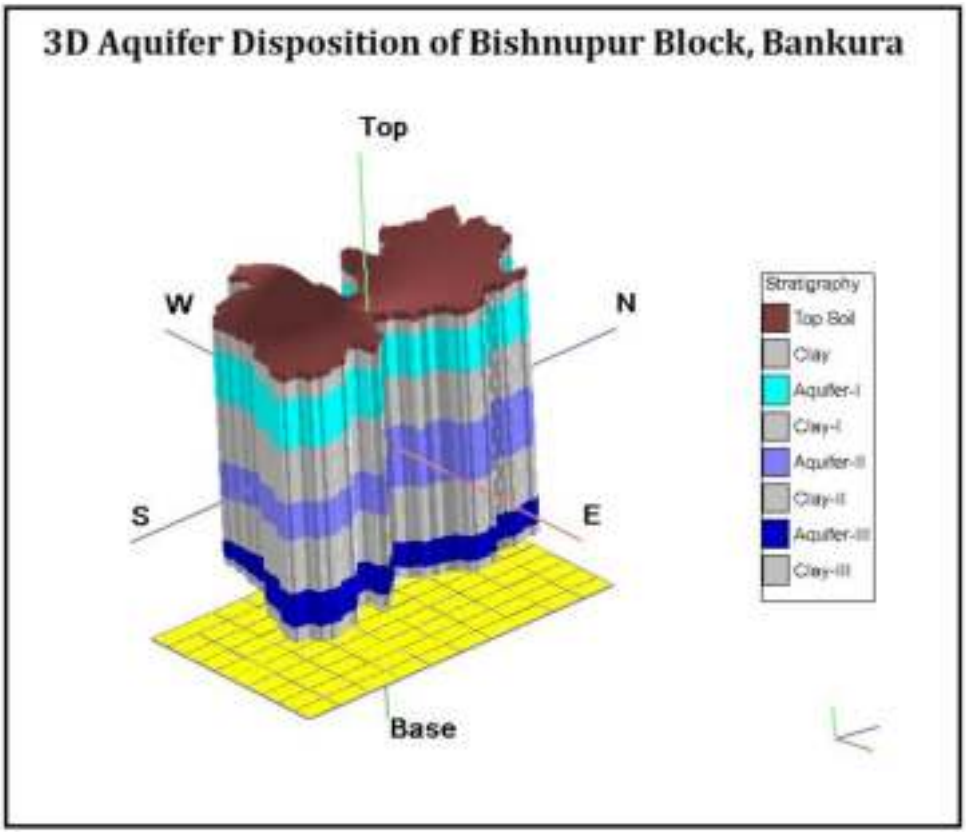


Figure *11.12*.2: 3-Dimensional Aquifer disposition in *Bishnupur* Block

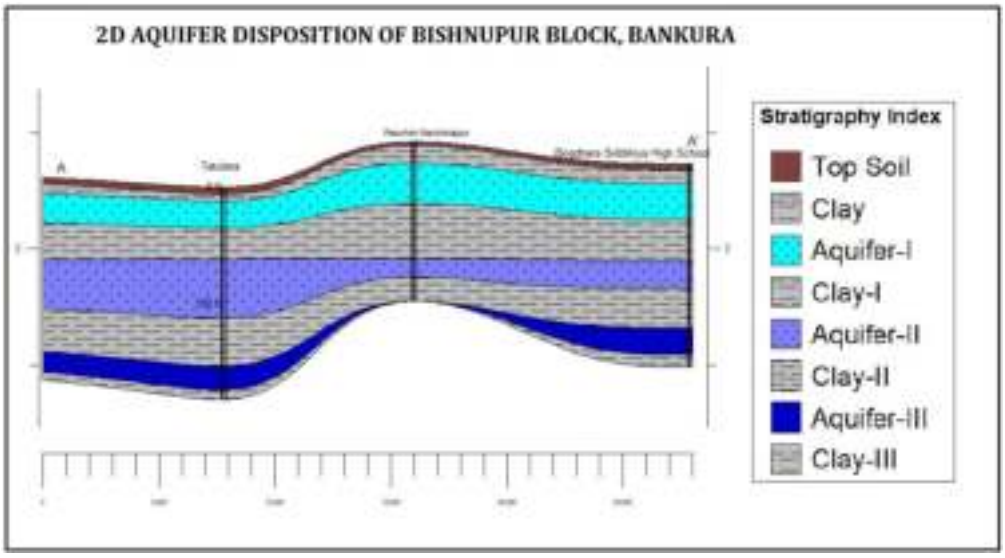


Figure *11.12*.3: 2-Dimensional Section in *Bishnupur* Block

The principal aquifer systems encountered in this block are alluvial formation
Two aquifers are encountered in this block. The range of **Aquifer-I** is also known as Shallow aquifer. The range varies from 18-53 mbgl. Thickness of the granular Zone is 35m.

The range of **Aquifer-II** is also known as 2nd Aquifer. The range varies from 62-112 mbgl. Thickness of the granular Zone is 60m. The Range of **Aquifer-III** is also known as Deeper Aquifer. The range varies from 153-174 mbgl. Thickness of the granular Zone is 21m

Table *11.12*.7: Details of aquifer disposition in Bishnupur Block

Blocks (dominant in soft rock)	No. of Aquifers	Water bearing zone	Aquifer Thickness (m)			Discharge (lpm)	T (m^2/day)	SWL (mbgl)	Draw down (mbgl)	S
			Aquifer-I (Within 50 mbgl)	Aquifer-II (above 50 mbgl)	Aquifer-III (above 150 mbgl)					
Bishnupur	3	18-53, 62-112, 153-174	35	60	21	2220	--	12.5	--	--

Table *11.12*.8: Details of Aquifer Wise Water Level Ranges & seasonal long term water level trends

Block	Pre-monsoon Trend			Post-monsoon Trend		
	WL Range (mbgl)	Rise (m/year)	Fall (m/year)	WL Range (mbgl)	Rise (m/year)	Fall (m/year)
Bishnupur	0.88-10.28	--	0.360	0.9-8.53	0.510	--

Ground water quality and issues:

Based on four NHS, four exploratory wells and three observation wells, the range of chemical parameter for the block is given below.

Table *11.12*.9: Range of chemical parameters in Bishnupur Block

Block	Aquifer Type	pH	EC (µS/cm)	Na (mg/l)	Cl (mg/l)	F (mg/l)	NO_3 (mg/l)	Fe (mg/l)	Measured Hardness (mg/l)
Bishnupur	Aquifer-I	7.89-8.07	260-1984	12-94	10-60	0.10-0.94	2-9	0.03-0.07	105-865
	Aquifer-II	7.81-8.29	416-884	19-76	22-196	0.43-0.62	1-12	Traces	155-335

Ground Water Resource:

Table *11.12*.10: Details of Ground Water Resource Availability and Utilization in *Bishnupur* Block.

Name of the Block	**BISHNUPUR**
Total Annual Ground Water Recharge (Ham)	17494.17
Total Natural Discharges (Ham)	1749.42
Annual Extractable Ground Water Recharge (Ham)	15744.75
Total Extraction	10622.84
Annual GW Allocation for Domestic Use as on 2042	309.45
Net Ground Water Availability for future use	5059.42
Stage of Ground Water Extraction (%)	67.47
Categorization (OE/CRITICAL/ SEMI-CRITICAL/ SAFE)	Safe
In storage	87974

Aquifer Management Plan:

Ground Water Management Plan for drinking purpose:

The block has two commissioned public water supply schemes by PHED. There is one ongoing as well. However, there is still recorded deficit in supply of drinking water as the schemes do not reach to every mouza in the block. Therefore, there should be a general practice of conservation through rainwater harvesting, considering an adequate normal monsoon rainfall of 1347 mm which the block receives. The conserved rainwater can be utilized for drinking purpose by filtering through Horizontal Roughing Filters. The water from the lands can be channeled to ponds for recharge in the weathered zones and this water can be tapped through open dug wells for domestic and drinking purpose.

Ground Water Management Plan for irrigation purposes:

- Although ground water development in the block is low with stage of ground water development at 67.47%, further development should be done in planned manner to harness the additional available resource for site specific sustainable development.
- In view of low yield of the area, large diameter dug wells with adequate storage are another viable option for irrigation in favorable condition, thus creating a small command area. Owing to its distinct hydrogeology, it is evident that very less cultivable command area is created by both surface as well as groundwater.
- Modern methods of irrigation like sprinkler and drip irrigation methods are encouraged.
- Crops with low water requirement should be preferred.

In view of adequate rainfall in the area, excavation of tanks with large catchment areas, construction of check dam, nallah bunds, sub-surface dykes along the stream channels at suitable locations can be implemented to raise ground water level as well as to augment irrigation facilities.

Irrigation by surface water may be increased. In addition to surface lift from canal & surface flows, rain water harvesting may also be considered.

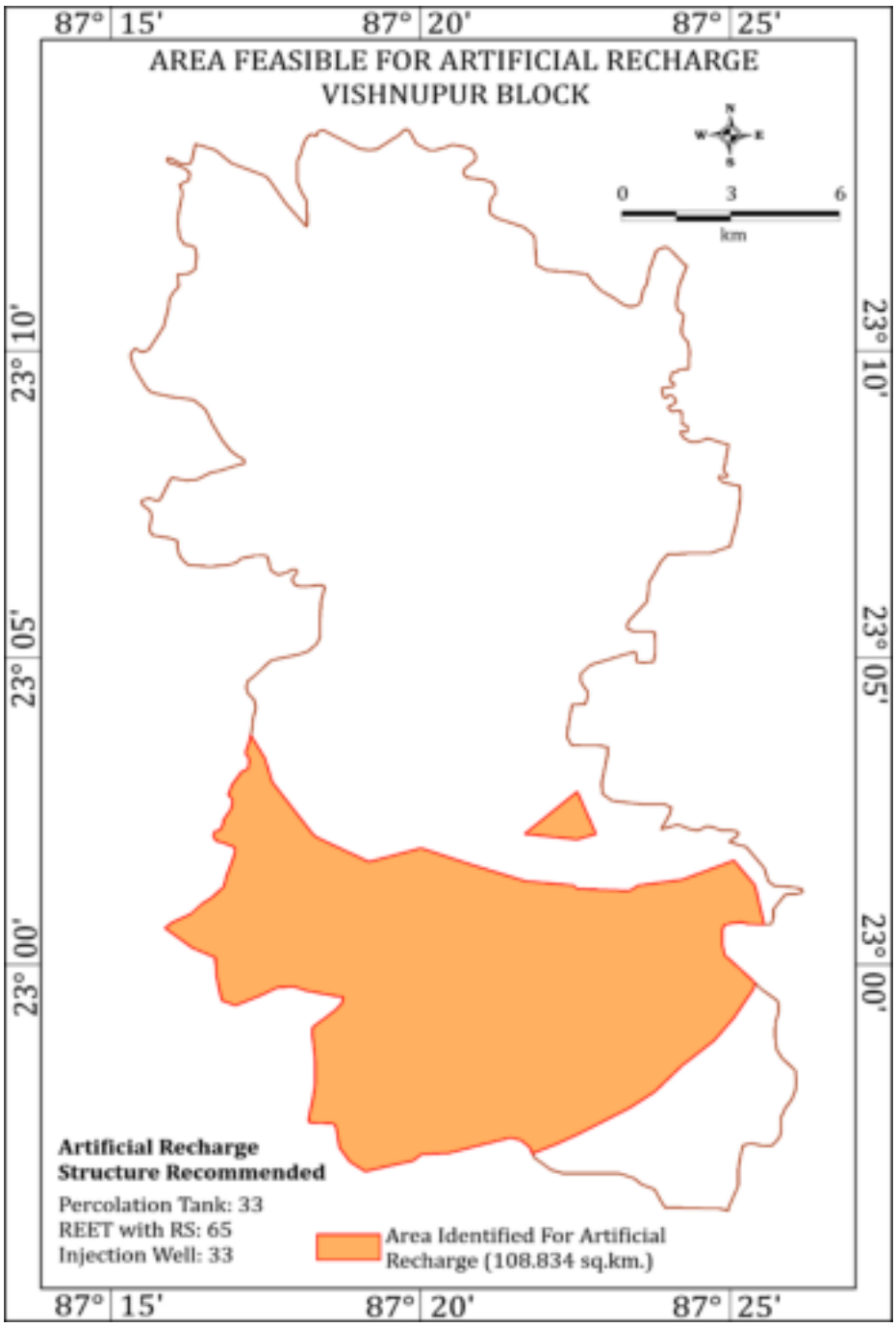


Figure *11.12.4*: Area Feasible for Artificial Recharge of groundwater for *Bishnupur* Block

Table *11.12*.11: Details of structures recommended in feasible area of artificial recharge for Bishnupur Block.

Name of the Block	Utilizable Surface Run Off	Allocation of Utilizable Recourse (MCM)							Structures Feasible							Cost of Structures							
		Percolation Tank	REET with RS	Injection Well	Check Dam	Gabion/ Contour Bund	Sub-Surface Dyke	Dug Well Recharge	Percolation Tank	REET with RS	Injection Well	Check Dam	Gabion/ Contour Bund	Sub-Surface Dyke	Dug Well Recharge	Percolation Tank	REET with RS	Injection Well	Check Dam	Gabion/ Contour Bund	Sub-Surface Dyke	Dug Well Recharge	TOTAL
Bishnupur	32.650	16.325	6.53	9.795	0	0	0	0	33	65	33	0	0	0	0	264	260	99	0	0	0	0	623

Management Intervention through Harvesting of Surface Runoff and Artificial Recharge:

It has been estimated that the utilizable surface runoff produced in the block is **32.650** MCM. This surface runoff is proposed to be utilized to recharge the depleted aquifer (aquifer III) in the block. As per the available storage space, **9.795** MCM water is required to fill the deeper aquifers in block. Therefore, **33** injection wells with roof top rain water harvesting structures are recommended in the block.

The remaining surface runoff, **22.378** MCM is recommended to be utilized in storage tanks for generation of irrigation potential and thus, **33** percolation tanks and **65** REET with RS have been proposed.

11.13 SALIENT INFORMATION

Block Name: ***Indus***

Geographical area (sq. km): **250**

Mappable area (sq. km): **250**

District: **Bankura**

State: **West Bengal**

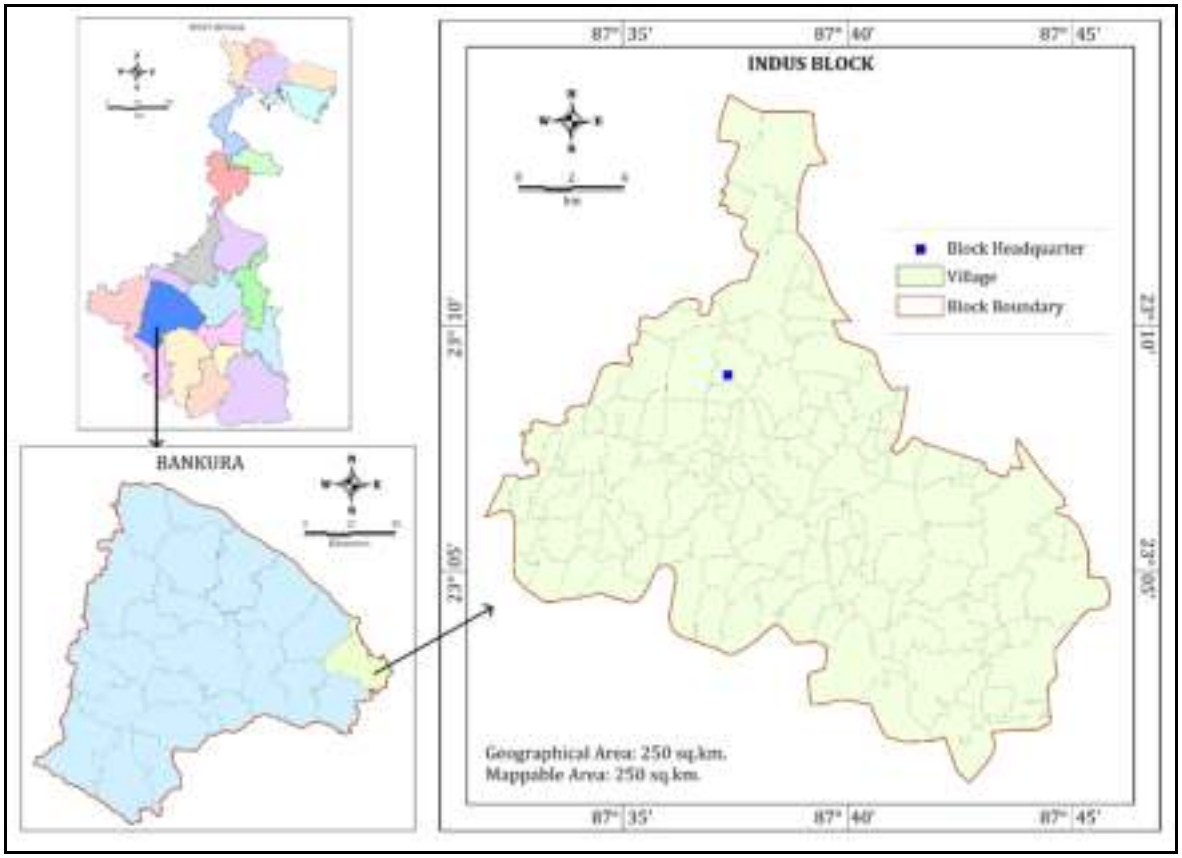


Figure *11.13*.1: Location Map of *Indus* Block

Population (as on 2011):

Table *11.13*.1: *Details of population in Indus block.*

Rural	Urban	Total	Population Density per Sqkm
169783	-	169783	679

Rainfall: Average annual rainfall for the period 2015 -19 is 1300.36 (in mm)

Table *11.13*.2: Details of Annual Rainfall for the last five years in *Indus* block.

Block Name	Normal Rainfall	Rain Fall				
		2014	2015	2016	2017	2018
Indus	1386	1075.5	1127.2	1335.9	1780.2	1334.3

Agriculture& Irrigation (area in ha):

Table *11.13*.3: Salient Land use features of *Indus* block

Block	Reporting Area	Forest Area	Area Under Non-Agricultural Waste	Barren and Un-culturable land	Permanent pastures and grazing lands	Land under misc tree crops	Culturable wastes	Fallow land Other than current fallow	Current fallow	Net area sown	Cultivable Area
Indus	25498	0	8800				-		377	16321	16698

Table *11.13*.4: Crop pattern of *Indus* block

Block	Aus			Aman			Boro			Wheat			Maize		
	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield
Indus	1853	4.38	2363.6	1646	3.726	2264	4422	12.370	2797	235	0.452	1921	-	-	-
	Mustard			Til			Potato			Musur			Gram		
	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	
	1265	1.031	815	1165	0.912	782	940	6368.000	6774	12	0.017	1431	1	0.001	898

Table *11.13*.5: Command area (ha) of *Indus* block

Block Name	Dug well		Shallow Tube well		Medium Tube well		Deep Tube well		Surface Flow		Surface Lift		CCA (ha.)		Total CCA (ha.)
	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	Ground Water	Surface Water	
INDUS	5	25	1239	4824.05	58	834.75	21	245	31	196	331	1416.85	5928.8	1612.85	7541.65

Table *11.13*.6: Command area (ha) of *Indus* block

Name of Block	Canal Area	Tank		RLI		DTW		STW		ODW		Others		Total	
		No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area
Indus	13001	2000	200	9	420	42	538	4300	6644	-	-	-	-	6351	20803

Disposition of Aquifers:

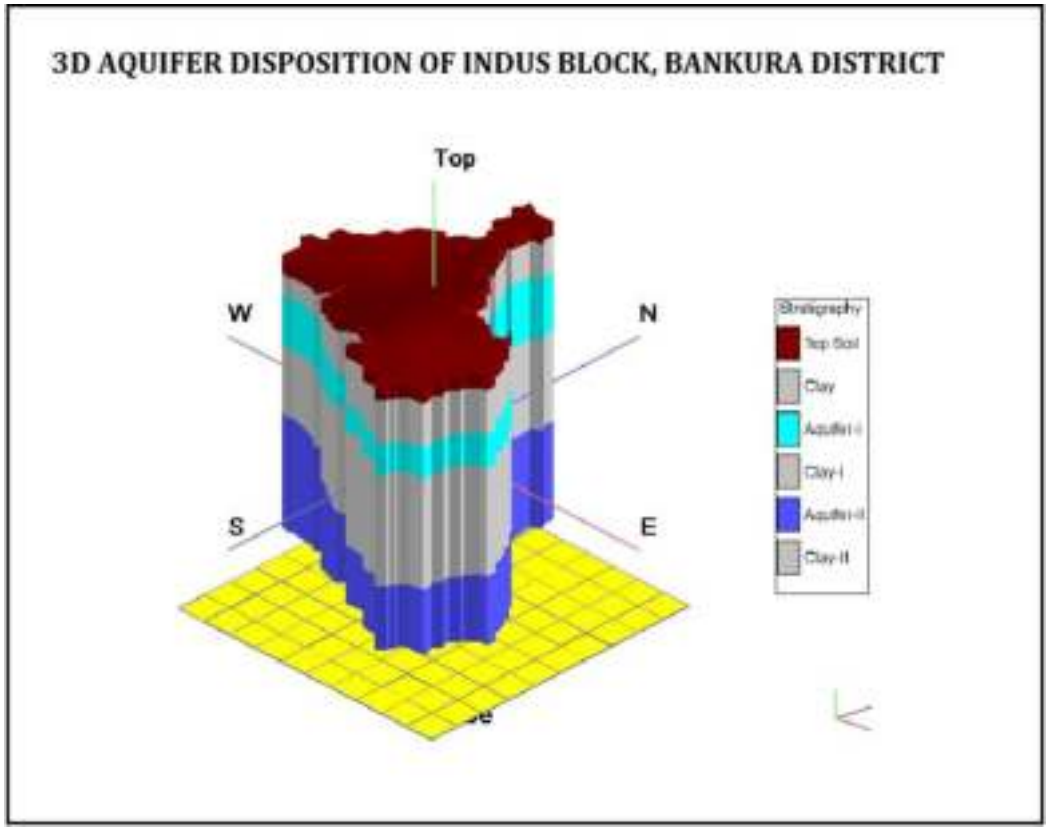


Figure *11.13*.2: 3-Dimensional Aquifer disposition in *Indus* Block

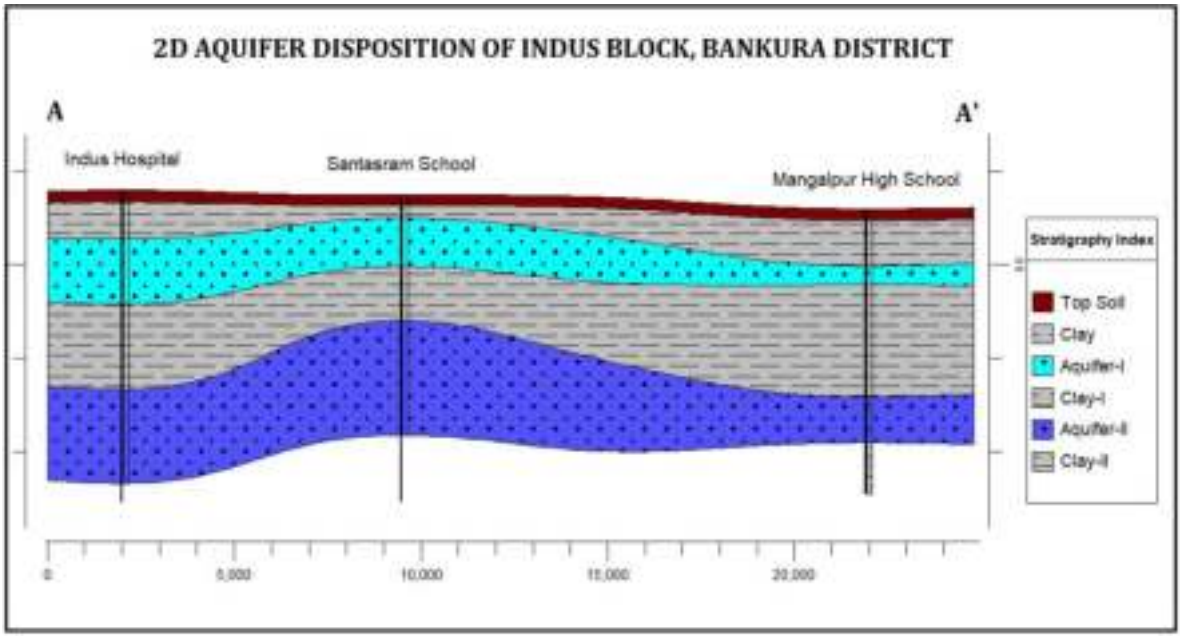


Figure *11.13*.3: 2-Dimensional Section in *Indus* Block

The principal aquifer systems encountered in this block are alluvial formation
Two aquifers are encountered in this block.

The range of **Aquifer-I** is also known as Shallow aquifer. The range varies from 13-60 mbgl. Thickness of the granular Zone is 47m.

The range of **Aquifer-II** is also known as 2nd Aquifer. The range varies from 67-156 mbgl.
Thickness of the granular Zone is 89m.

Table *11.13*.7: Details of aquifer disposition in Indus Block

Blocks (dominant in soft rock)	No. of Aquifers	Water bearing zone	Aquifer Thickness (m)			Discharge (lpm)	T (m^2/day)	SWL (mbgl)	Draw down (mbgl)	S
			Aquifer-I (Within 50 mbgl)	Aquifer-II (above 50 mbgl)	Aquifer-III (above 150 mbgl)					
Indus	2	13-60, 67-156	47	89	--	3060	--	8.6	--	--

Table *11.13*.8: Details of Aquifer Wise Water Level Ranges & seasonal long term water level trends

Block	Pre-monsoon Trend			Post-monsoon Trend		
	WL Range (mbgl)	Rise (m/year)	Fall (m/year)	WL Range (mbgl)	Rise (m/year)	Fall (m/year)
Indus	0.93-11.6	0.539	--	1.55-10.87	0.071	--

Ground water quality and issues:

Based on four NHS, four exploratory wells and three observation wells, the range of chemical parameter for the block is given below.

Table *11.13*.9: Range of chemical parameters in Indus Block

Block	Aquifer Type	pH	EC (µS/cm)	Na (mg/l)	Cl (mg/l)	F (mg/l)	NO_3 (mg/l)	Fe (mg/l)	Measured Hardness (mg/l)
Indus	Aquifer-I	7.89-8.07	260-1984	12-94	10-60	0.10-0.94	2-9	0.03-0.07	105-865
	Aquifer-II	7.81-8.29	416- 884	19-76	22-196	0.43-0.86	1-12	Traces	155-335

Ground Water Resource:

Table *11.13*.10: Details of Ground Water Resource Availability and Utilization in *Indus* Block.

Name of the Block	**INDUS**
Total Annual Ground Water Recharge (Ham)	13414.95
Total Natural Discharges (Ham)	1341.5
Annual Extractable Ground Water Recharge (Ham)	12073.45
Total Extraction	8089.02
Annual GW Allocation for Domestic Use as on 2042	249.93
Net Ground Water Availability for future use	3921.18
Stage of Ground Water Extraction (%)	67
Categorization (OE/CRITICAL/ SEMI-CRITICAL/ SAFE)	Safe
In storage (Ham)	88023

Aquifer Management Plan:

Ground Water Management Plan for drinking purpose:

The block has two commissioned public water supply schemes by PHED. There is one ongoing as well. However, there is still recorded deficit in supply of drinking water as the schemes do not reach to every mouza in the block. Therefore, there should be a general practice of conservation through rainwater harvesting, considering an adequate normal monsoon rainfall of 1347 mm which the block receives. The conserved rainwater can be utilized for drinking purpose by filtering through Horizontal Roughing Filters. The water from the lands can be channeled to ponds for recharge in the weathered zones and this water can be tapped through open dug wells for domestic and drinking purpose.

Ground Water Management Plan for irrigation purposes:

- Although ground water development in the block is low with stage of ground water development at 67%, further development should be done in planned manner to harness the additional available resource for site specific sustainable development.
- In view of low yield of the area, large diameter dug wells with adequate storage are another viable option for irrigation in favorable condition, thus creating a small command area. Owing to its distinct hydrogeology, it is evident that very less cultivable command area is created by both surface as well as groundwater.
- Modern methods of irrigation like sprinkler and drip irrigation methods are encouraged.
- Crops with low water requirement should be preferred.

In view of adequate rainfall in the area, excavation of tanks with large catchment areas, construction of check dam, nallah bunds, sub-surface dykes along the stream channels at suitable locations can be implemented to raise ground water level as well as to augment irrigation facilities.

Irrigation by surface water may be increased. In addition to surface lift from canal & surface flows, rain water harvesting may also be considered.

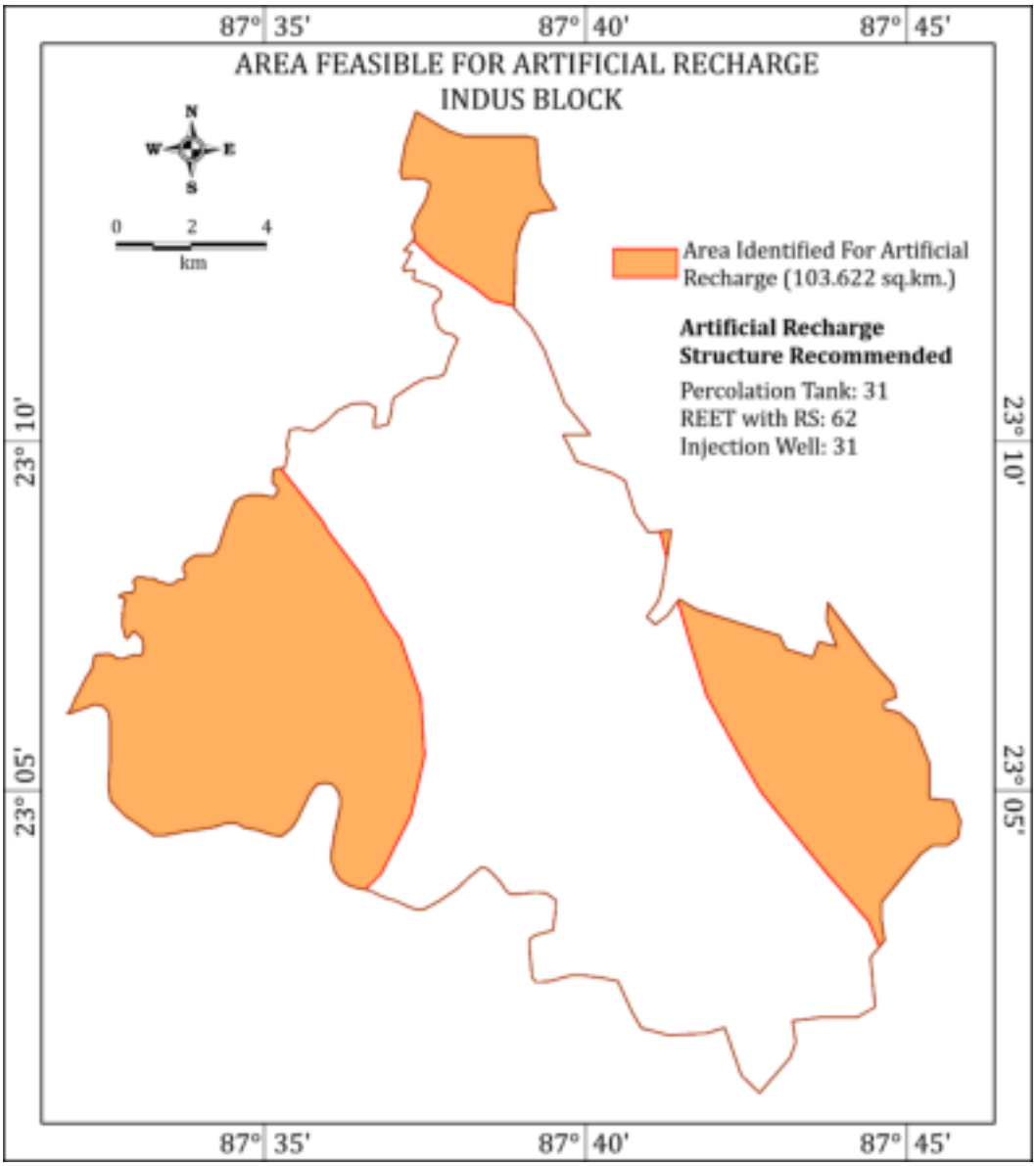


Figure *11.13.4*: Area Feasible for Artificial Recharge of groundwater for *Indus* Block

Table *11.13*.11: Details of structures recommended in feasible area of artificial recharge for Indus Block.

Name of the Block	Utilizable Surface Run Off	Allocation of Utilizable Recourse (MCM)							Structures Feasible							Cost of Structures							
		Percolation Tank	REET with RS	Injection Well	Check Dam	Gabion/ Contour Bund	Sub-Surface Dyke	Dug Well Recharge	Percolation Tank	REET with RS	Injection Well	Check Dam	Gabion/ Contour Bund	Sub-Surface Dyke	Dug Well Recharge	Percolation Tank	REET with RS	Injection Well	Check Dam	Gabion/ Contour Bund	Sub-Surface Dyke	Dug Well Recharge	TOTAL
Indus	31.087	15.543	6.217	9.326	0	0	0	0	31	62	31	0	0	0	0	248	248	93	0	0	0	0	589

Management Intervention through Harvesting of Surface Runoff and Artificial Recharge:

It has been estimated that the utilizable surface runoff produced in the block is **31.087** MCM. This surface runoff is proposed to be utilized to recharge the depleted aquifer (aquifer III) in the block. As per the available storage space, **9.326** MCM water is required to fill the deeper aquifers in block. Therefore, **31** injection wells with roof top rain water harvesting structures are recommended in the block.

The remaining surface runoff, **21.760** MCM is recommended to be utilized in storage tanks for generation of irrigation potential and thus, **31** percolation tanks and **62** REET with RS have been proposed.

11.14 SALIENT INFORMATION

Block Name: *Joypur*

Geographical area (sq. km): **204**

Mappable area (sq. km): **154**

District: **Bankura**

State: **West Bengal**

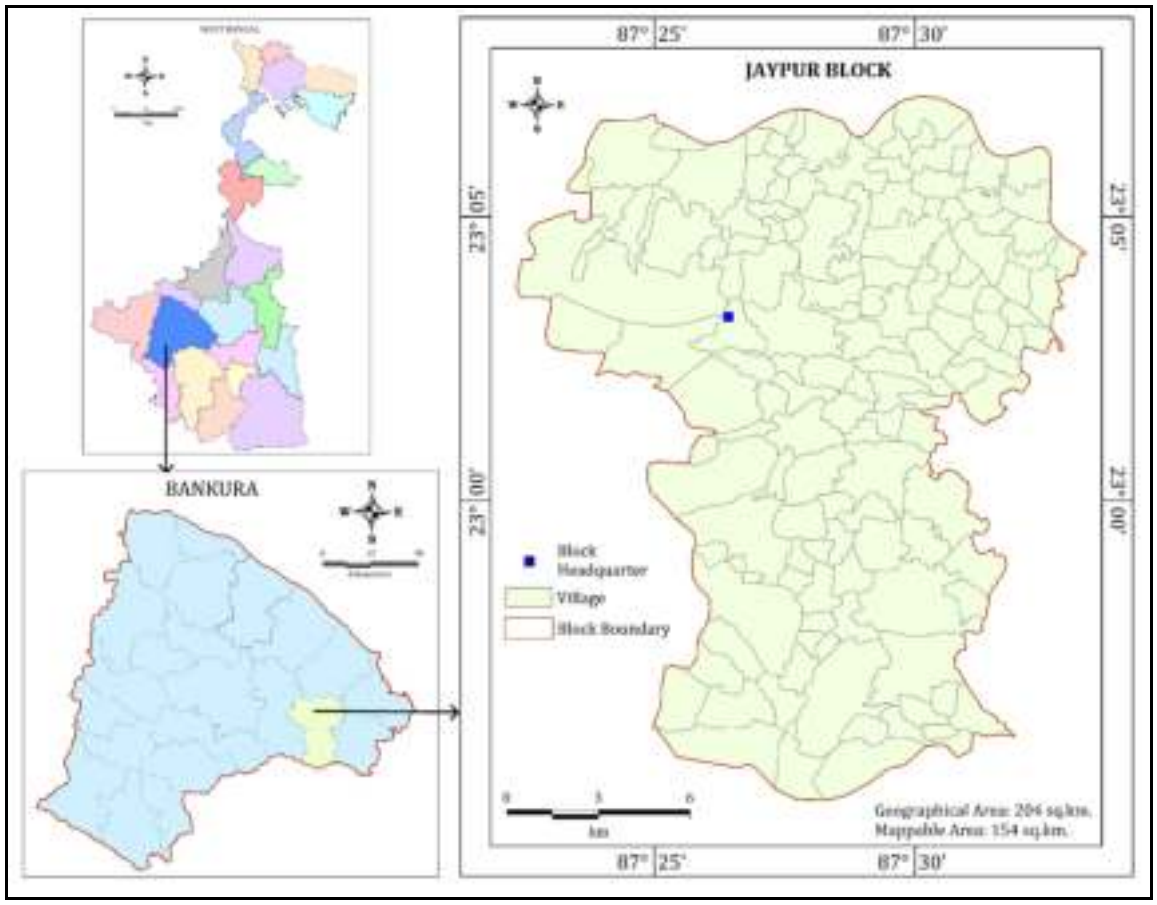


Figure *11.14*.1: Location Map of *Joypur* Block

Population (as on 2011):

Table *11.14*.1: *Details of population in Joypur block.*

Rural	Urban	Total	Population Density per Sq. km
156920	-	156920	769

Rainfall: Average annual rainfall for the period 2015 -19 is 1300.36 (in mm)

Table *11.14*.2: Details of Annual Rainfall for the last five years in *Joypur* block.

Block Name	Normal Rainfall	Rain Fall				
		2014	2015	2016	2017	2018
Joypur	1386	1075.5	1127.2	1335.9	1780.2	1334.3

Agriculture& Irrigation (area in ha):

Table *11.14*.3: Salient Land use features of *Joypur* block

Block	Reporting Area	Forest Area	Area Under Non-Agricultural Waste	Barren and Un-culturable land	Permanent pastures and grazing lands	Land under misc tree crops	Culturable wastes	Fallow land Other than current fallow	Current fallow	Net area sown	Cultivable Area
Joypur	26382	6182	4646	-	-	160	-	-	1463	13931	15554

Table *11.14*.4: Crop pattern of *Joypur* block

Block	Aus			Aman			Boro			Wheat			Maize		
	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield
Joypur	2699	7.016	2599.46	10990	29.897	2720	5569	14.715	2642	450	1.046	2324	-	-	-
	Mustard			Til			Potato			Musur			Gram		
	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	
	322	0.258	802	2636	2.091	793	2384	21585.000	9054	-	-	-	-	-	-

Table *11.14*.5: Command area(ha) of *Joypur* block

Block Name	Dug well		Shallow Tube well		Medium Tube well		Deep Tube well		Surface Flow		Surface Lift		CCA (ha.)		Total CCA (ha.)
	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	Ground Water	Surface Water	
JOYPUR	1	5	756	2545.62	142		53	241	63	330	182	797.96	2791.62	1127.96	3919.58

Table *11.14*.6: Command area (ha) of *Joypur* block

Name of Block	Canal Area	Tank		RLI		DTW		STW		ODW		Others		Total	
		No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area
Joypur	14474	3835	2021	14	560	43	524	2569	2178	435	150	-	-	6896	19907

Disposition of Aquifers:

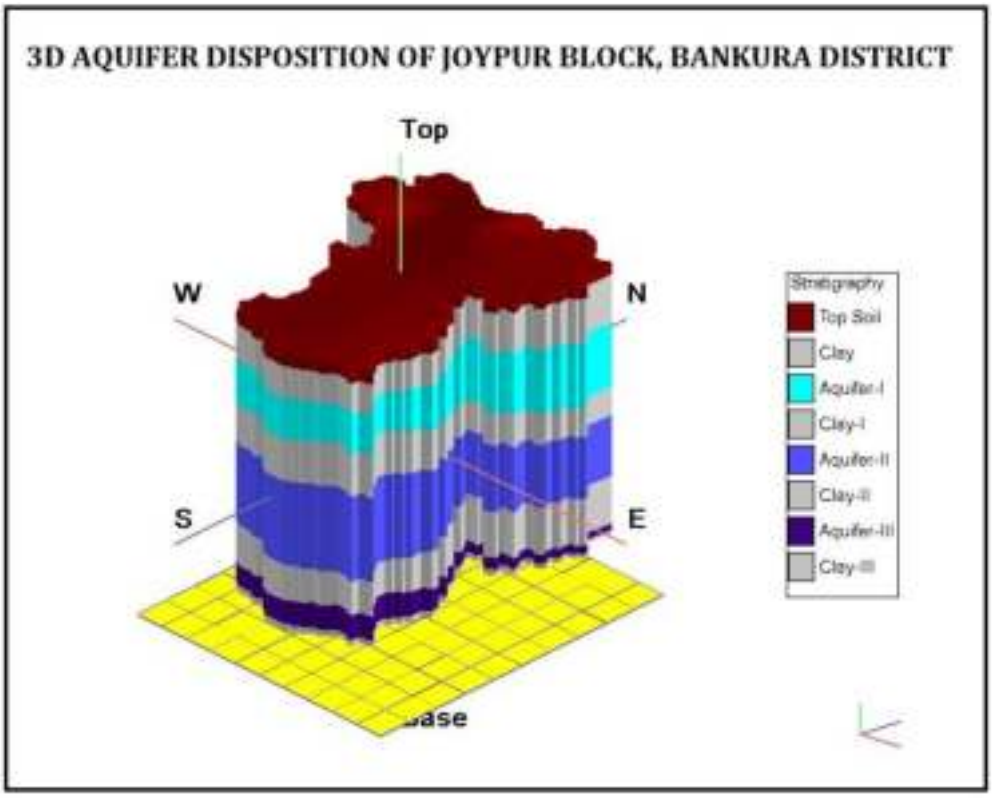


Figure *11.14*.2: 3-Dimensional Aquifer disposition in *Joypur* Block

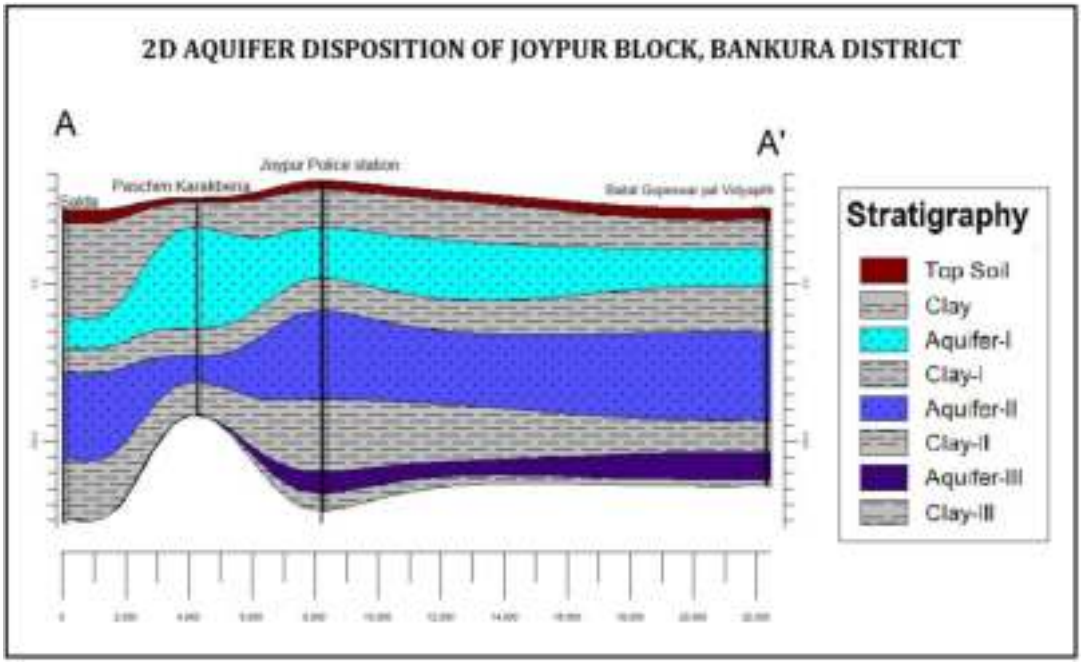


Figure *11.14*.3: 2-Dimensional Section in *Joypur* Block

The principal aquifer systems encountered in this block are alluvial formation

Two aquifers are encountered in this block.

The range of **Aquifer-I** is also known as Shallow aquifer. The range varies from 28-85 mbgl. Thickness of the granular Zone is 57m.

The range of **Aquifer-II** is also known as 2nd Aquifer. The range varies from 113-148 mbgl. Thickness of the granular Zone is 35m.

Table *11.14.*7: Details of aquifer disposition in Joypur Block

Blocks (dominant in soft rock)	No. of Aquifers	Water bearing zone	Aquifer Thickness (m)			Discharge (lpm)	T (m^2/day)	SWL (mbgl)	Draw down (mbgl)	S
			Aquifer-I (Within 50 mbgl)	Aquifer-II (above 50 mbgl)	Aquifer-III (above 150 mbgl)					
Joypur	2	28-85, 113-148	57	35	--	2280	--	7.8	--	--

Table *11.14.*8: Details of Aquifer Wise Water Level Ranges & seasonal long term water level trends

Block	Pre-monsoon Trend			Post-monsoon Trend		
	WL Range (mbgl)	Rise (m/year)	Fall (m/year)	WL Range (mbgl)	Rise (m/year)	Fall (m/year)
Joypur	0.45-2.84	0.172	--	1.28-3.10	0.012	--

Ground water quality and issues:

Based on four NHS, four exploratory wells and three observation wells, the range of chemical parameter for the block is given below.

Table *11.14.*9: Range of chemical parameters in Joypur Block

Block	Aquifer Type	pH	EC (µS/cm)	Na (mg/l)	Cl (mg/l)	F (mg/l)	NO_3 (mg/l)	Fe (mg/l)	Measured Hardness (mg/l)
Joypur	Aquifer-I	7.89-8.07	260-1984	12-94	10-60	0.10-0.94	2-9	0.03-0.07	105-865
	Aquifer-II	7.81-8.29	416-884	19-76	22-196	0.43-0.67	1-12	Traces	155-335

Ground Water Resource:

Table *11.14*.10: Details of Ground Water Resource Availability and Utilization in *Joypur* Block.

Name of the Block	**JOYPUR**
Total Annual Ground Water Recharge (Ham)	14574.52
Total Natural Discharges (Ham)	728.73
Annual Extractable Ground Water Recharge (Ham)	13845.79
Total Extraction	5664.61
Annual GW Allocation for Domestic Use as on 2042	220.88
Net Ground Water Availability for future use	8132.84
Stage of Ground Water Extraction (%)	40.91
Categorization (OE/CRITICAL/ SEMI-CRITICAL/ SAFE)	Safe
In storage (Ham)	85639

Aquifer Management Plan:

Ground Water Management Plan for drinking purpose:

The block has two commissioned public water supply schemes by PHED. There is one ongoing as well. However, there is still recorded deficit in supply of drinking water as the schemes do not reach to every mouza in the block. Therefore, there should be a general practice of conservation through rainwater harvesting, considering an adequate normal monsoon rainfall of 1347 mm which the block receives. The conserved rainwater can be utilized for drinking purpose by filtering through Horizontal Roughing Filters. The water from the lands can be channeled to ponds for recharge in the weathered zones and this water can be tapped through open dug wells for domestic and drinking purpose.

Ground Water Management Plan for irrigation purposes:

- Although ground water development in the block is low with stage of ground water development at 40.91%, further development should be done in planned manner to harness the additional available resource for site specific sustainable development.
- In view of low yield of the area, large diameter dug wells with adequate storage are another viable option for irrigation in favorable condition, thus creating a small command area. Owing to its distinct hydrogeology, it is evident that very less cultivable command area is created by both surface as well as groundwater.
- Modern methods of irrigation like sprinkler and drip irrigation methods are encouraged.
- Crops with low water requirement should be preferred.

In view of adequate rainfall in the area, excavation of tanks with large catchment areas, construction of check dam, nallah bunds, sub-surface dykes along the stream channels at suitable locations can be implemented to raise ground water level as well as to augment irrigation facilities.

Irrigation by surface water may be increased. In addition to surface lift from canal & surface flows, rain water harvesting may also be considered

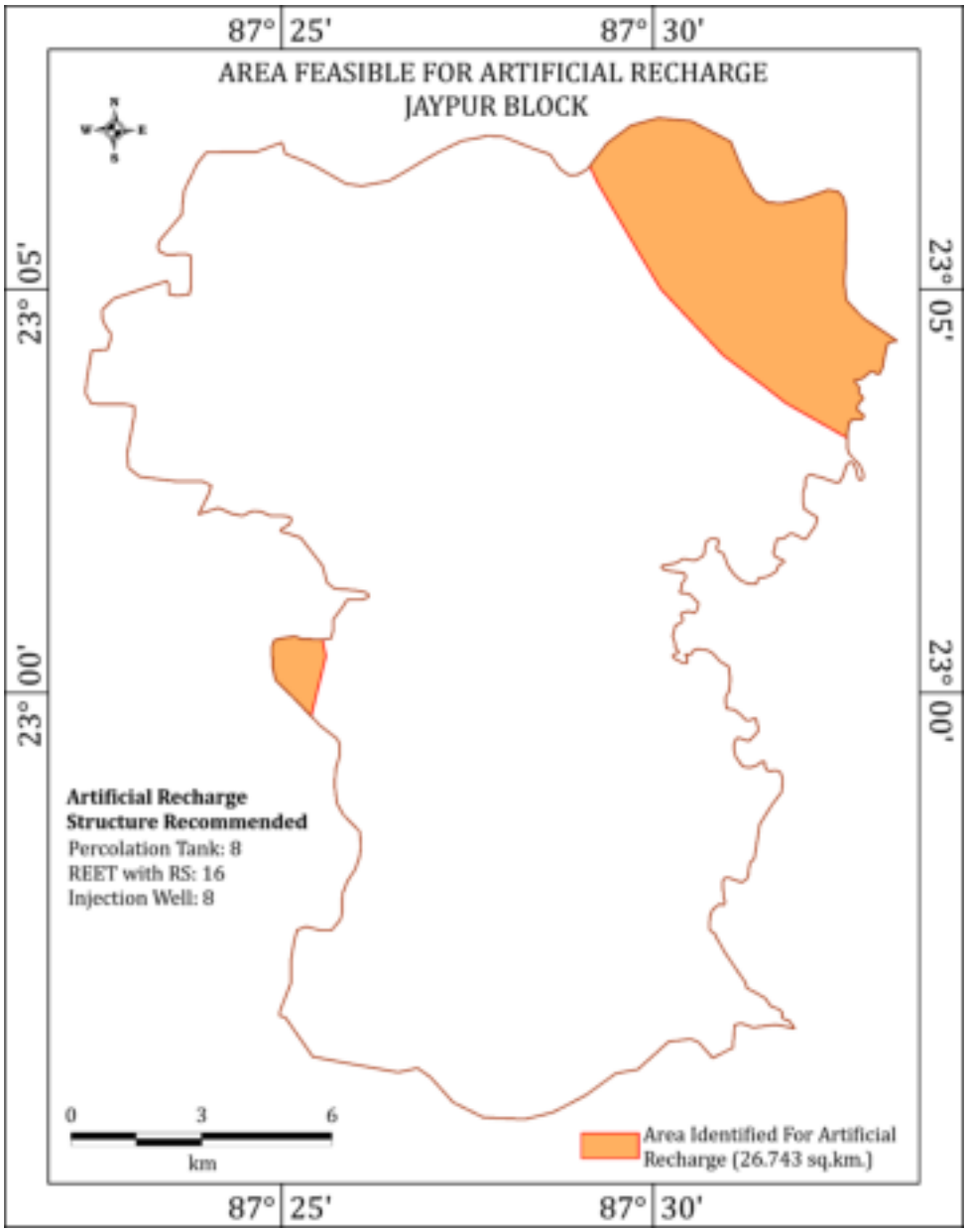


Figure *11.14.4*: Area Feasible for Artificial Recharge of groundwater for *Joypur* Block

Table *11.14*.11: Details of structures recommended in feasible area of artificial recharge for Joypur Block.

Name of the Block	Utilizable Surface Run Off	Allocation of Utilizable Recourse (MCM)							Structures Feasible							Cost of Structures							
		Percolation Tank	REET with RS	Injection Well	Check Dam	Gabion/ Contour Bund	Sub-Surface Dyke	Dug Well Recharge	Percolation Tank	REET with RS	Injection Well	Check Dam	Gabion/ Contour Bund	Sub-Surface Dyke	Dug Well Recharge	Percolation Tank	REET with RS	Injection Well	Check Dam	Gabion/ Contour Bund	Sub-Surface Dyke	Dug Well Recharge	TOTAL
Joypur	8.023	4.012	1.605	2.407	0	0	0	0	8	16	8	0	0	0	0	64	64	24	0	0	0	0	152

Management Intervention through Harvesting of Surface Runoff and Artificial Recharge:

It has been estimated that the utilizable surface runoff produced in the block is **8.023** MCM. This surface runoff is proposed to be utilized to recharge the depleted aquifer (aquifer III) in the block. As per the available storage space, **2.407** MCM water is required to fill the deeper aquifers in block. Therefore, **8** injection wells with roof top rain water harvesting structures are recommended in the block.

The remaining surface runoff, **5.617** MCM is recommended to be utilized in storage tanks for generation of irrigation potential and thus, **8** percolation tank and **16** REET with RS have been proposed.

11.15 SALIENT INFORMATION

Block Name: ***Kotulpur***

Geographical area (sq. km): **234**

Mappable area (sq. km): **234**

District: **Bankura**

State: **West Bengal**

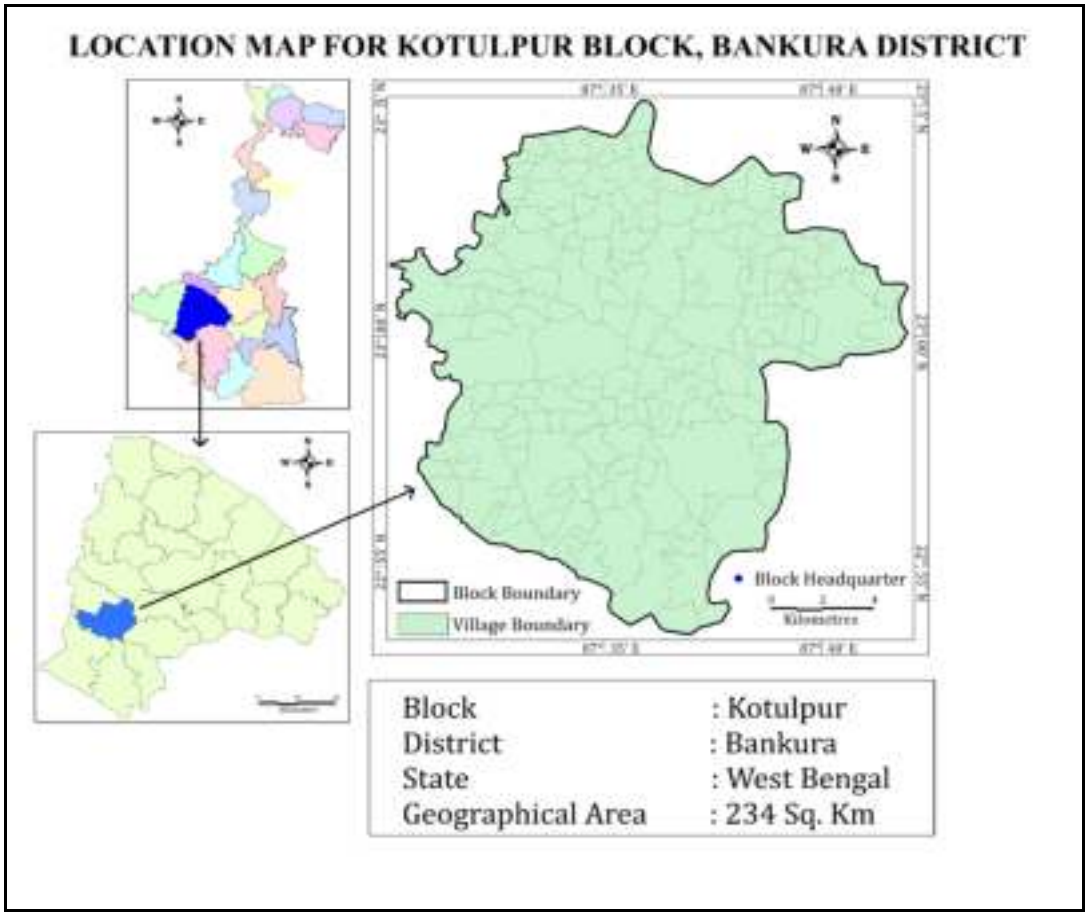


Figure *11.15*.1: Location Map of *Kotulpur* Block

Population (as on 2011):

Table *11.15*.1: *Details of population in Kotulpur block.*

Rural	Urban	Total	Population Density per Sqkm
180292	8483	188775	807

Rainfall: Average annual rainfall for the period 2015 -19 is 1300.36 (in mm)

Table *11.15*.2: Details of Annual Rainfall for the last five years in *Kotulpur* block.

Block Name	Normal Rainfall	Rain Fall				
		2014	2015	2016	2017	2018
Kotulpur	1386	1075.5	1127.2	1335.9	1780.2	1334.3

Agriculture& Irrigation (area in ha):

Table *11.15*.3: Salient Land use features of *Kotulpur* block

Block	Reporting Area	Forest Area	Area Under Non-Agricultural Waste	Barren and Un-culturable land	Permanent pastures and grazing lands	Land under misc tree crops	Culturable wastes	Fallow land Other than current fallow	Current fallow	Net area sown	Cultivable Area
Kotulpur	25038	257	5401	321		26	202	101	3008	15722	19059

Table *11.15*.4: Crop pattern of *Kotulpur* block

Block	Aus			Aman			Boro			Wheat			Maize		
	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield
Kotulpur	6424	16.917	2633.39	37750	108.046	2862	5147	18.746	3642	104	0.244	2349	-	-	-
	Mustard			Til			Potato			Musur			Gram		
	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	
	575	0.448	779	4744	4.413	930	4633	28196.000	6086	7	0.009	1260	-	-	-

Table *11.15*.5: Command area (ha) of *Kotulpur* block

Block Name	Dug well		Shallow Tube well		Medium Tube well		Deep Tube well		Surface Flow		Surface Lift		CCA (ha.)		Total CCA (ha.)
	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	Ground Water	Surface Water	
KOTULPUR	2	10	1175	4014.97	239	1262.37	81	609.35	52	287	119	318.7	5896.69	605.7	6502.39

Table *11.15*.6: Command area (ha) of *Kotulpur* block

Name of Block	Canal Area	Tank		RLI		DTW		STW		ODW		Others		Total	
		No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area
Kotulpur	13192	1515	1612	16	820	42	702	2562	3661	-	-	-	-	4135	19987

Disposition of Aquifers:

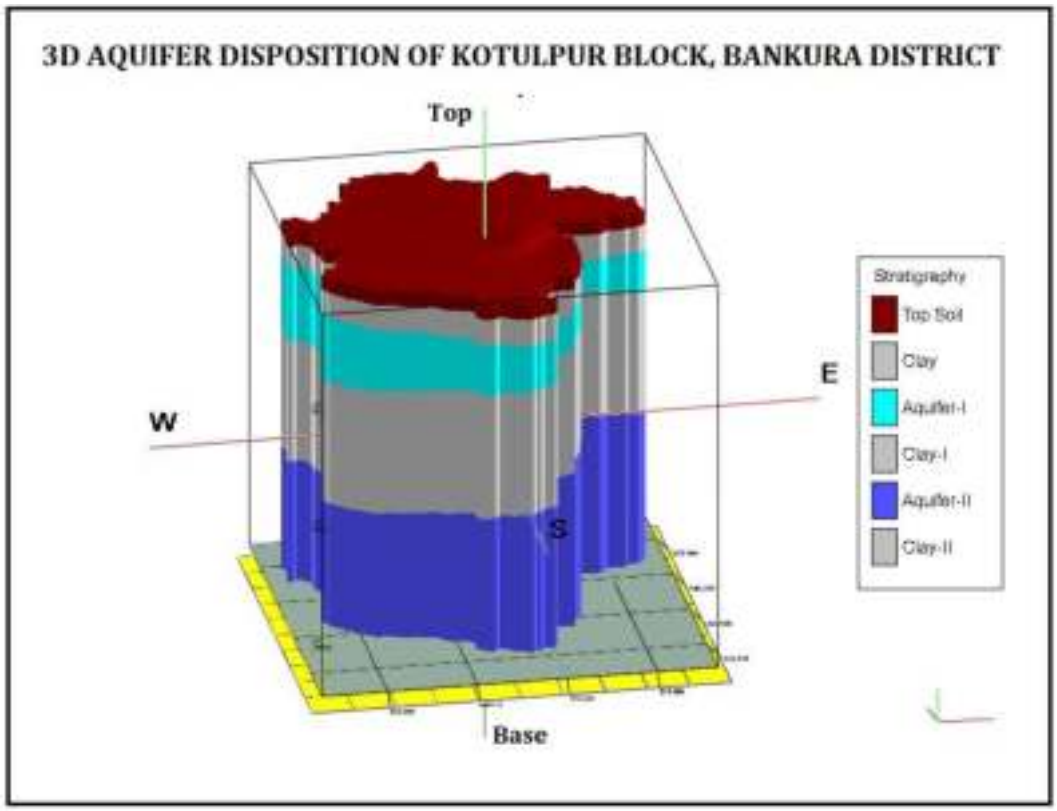


Figure *11.15*.2: 3-Dimensional Aquifer disposition in *Kotulpur* Block

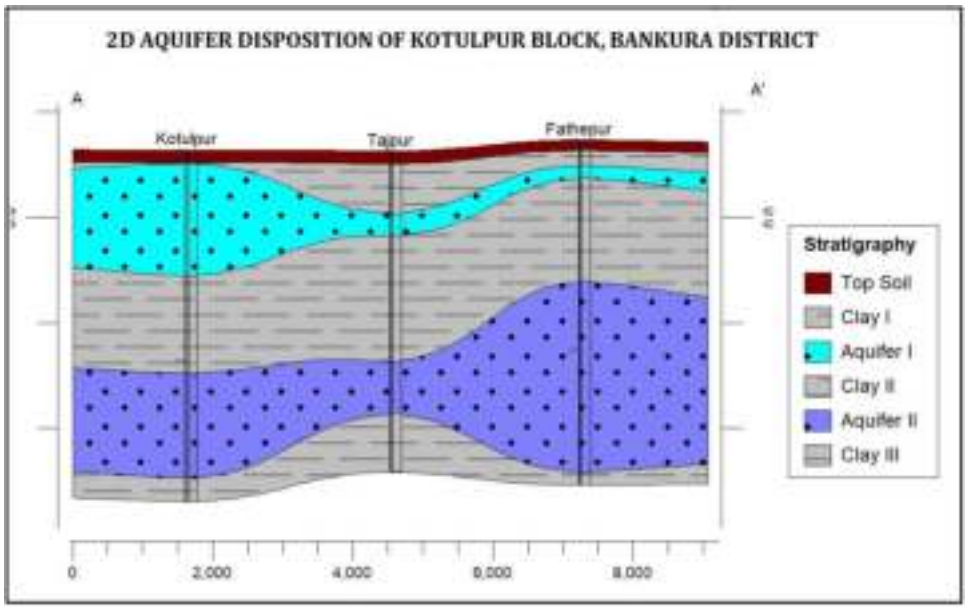


Figure *11.15*.3: 2-Dimensional Section in *Kotulpur* Block

The principal aquifer systems encountered in this block is alluvial formation**.** Two aquifers are encountered in this block. The range of **Aquifer-I** is also known as Shallow aquifer. The range varies from 23-55 mbgl. Thickness of the granular Zone is 32m. The

range of **Aquifer-II** is also known as 2nd Aquifer. The range varies from 106-148 mbgl. Thickness of the granular Zone is 44m.

Table *11.15*.7: Details of aquifer disposition in Kotulpur Block

Blocks (dominant in soft rock)	No. of Aquifers	Water bearing zone	Aquifer Thickness (m)			Discharge (lpm)	T (m^2/day)	SWL (mbgl)	Draw down (mbgl)	S
			Aquifer-I (Within 50 mbgl)	Aquifer-II (above 50 mbgl)	Aquifer-III (above 150 mbgl)					
Kotulpur	2	23-55, 106-148	32	44	--	3300	--	10.6	--	--

Table *11.15*.8: Details of Aquifer Wise Water Level Ranges & seasonal long term water level trends

Block	Pre-monsoon Trend			Post-monsoon Trend		
	WL Range (mbgl)	Rise (m/year)	Fall (m/year)	WL Range (mbgl)	Rise (m/year)	Fall (m/year)
Kotulpur	5.49-12.86	0.164	--	4.73-13.12	0.320	--

Ground water quality and issues:

Based on four NHS, four exploratory wells and three observation wells, the range of chemical parameter for the block is given below.

Table *11.15*.9: Range of chemical parameters in Kotulpur Block

Block	Aquifer Type	pH	EC (µS/cm)	Na (mg/l)	Cl (mg/l)	F (mg/l)	NO_3 (mg/l)	Fe (mg/l)	Measured Hardness (mg/l)
Kotulpur	Aquifer-I	7.89-8.07	260-1984	12-94	10-60	0.10-0.94	2-9	0.03-0.07	105-865
	Aquifer-II	7.81-8.29	416-884	19-76	22-196	0.43-0.87	1-12	Traces	155-335

Ground Water Resource:

Table *11.15*.10: Details of Ground Water Resource Availability and Utilization in *Kotulpur* Block.

Name of the Block	KOTULPUR
Total Annual Ground Water Recharge (Ham)	23872.92
Total Natural Discharges (Ham)	2387.29
Annual Extractable Ground Water Recharge (Ham)	21485.63
Total Extraction	13507.94
Annual GW Allocation for Domestic Use as on 2042	289.02
Net Ground Water Availability for future use	7896.23
Stage of Ground Water Extraction (%)	62.87
Categorization (OE/CRITICAL/ SEMI-CRITICAL/ SAFE)	Safe
In storage	110495

Aquifer Management Plan:

Ground Water Management Plan for drinking purpose:

The block has two commissioned public water supply schemes by PHED. There is one ongoing as well. However, there is still recorded deficit in supply of drinking water as the schemes do not reach to every mouza in the block. Therefore, there should be a general practice of conservation through rainwater harvesting, considering an adequate normal monsoon rainfall of 1347 mm which the block receives. The conserved rainwater can be utilized for drinking purpose by filtering through Horizontal Roughing Filters. The water from the lands can be channeled to ponds for recharge in the weathered zones and this water can be tapped through open dug wells for domestic and drinking purpose.

Ground Water Management Plan for irrigation purposes:

- Although ground water development in the block is low with stage of ground water development at 62.87%, further development should be done in planned manner to harness the additional available resource for site specific sustainable development.
- In view of low yield of the area, large diameter dug wells with adequate storage are another viable option for irrigation in favorable condition, thus creating a small command area. Owing to its distinct hydrogeology, it is evident that very less cultivable command area is created by both surface as well as groundwater.
- Modern methods of irrigation like sprinkler and drip irrigation methods are encouraged.
- Crops with low water requirement should be preferred.

In view of adequate rainfall in the area, excavation of tanks with large catchment areas, construction of check dam, nallah bunds, sub-surface dykes along the stream channels at suitable locations can be implemented to raise ground water level as well as to augment irrigation facilities.

Irrigation by surface water may be increased. In addition to surface lift from canal & surface flows, rain water harvesting may also be considered.

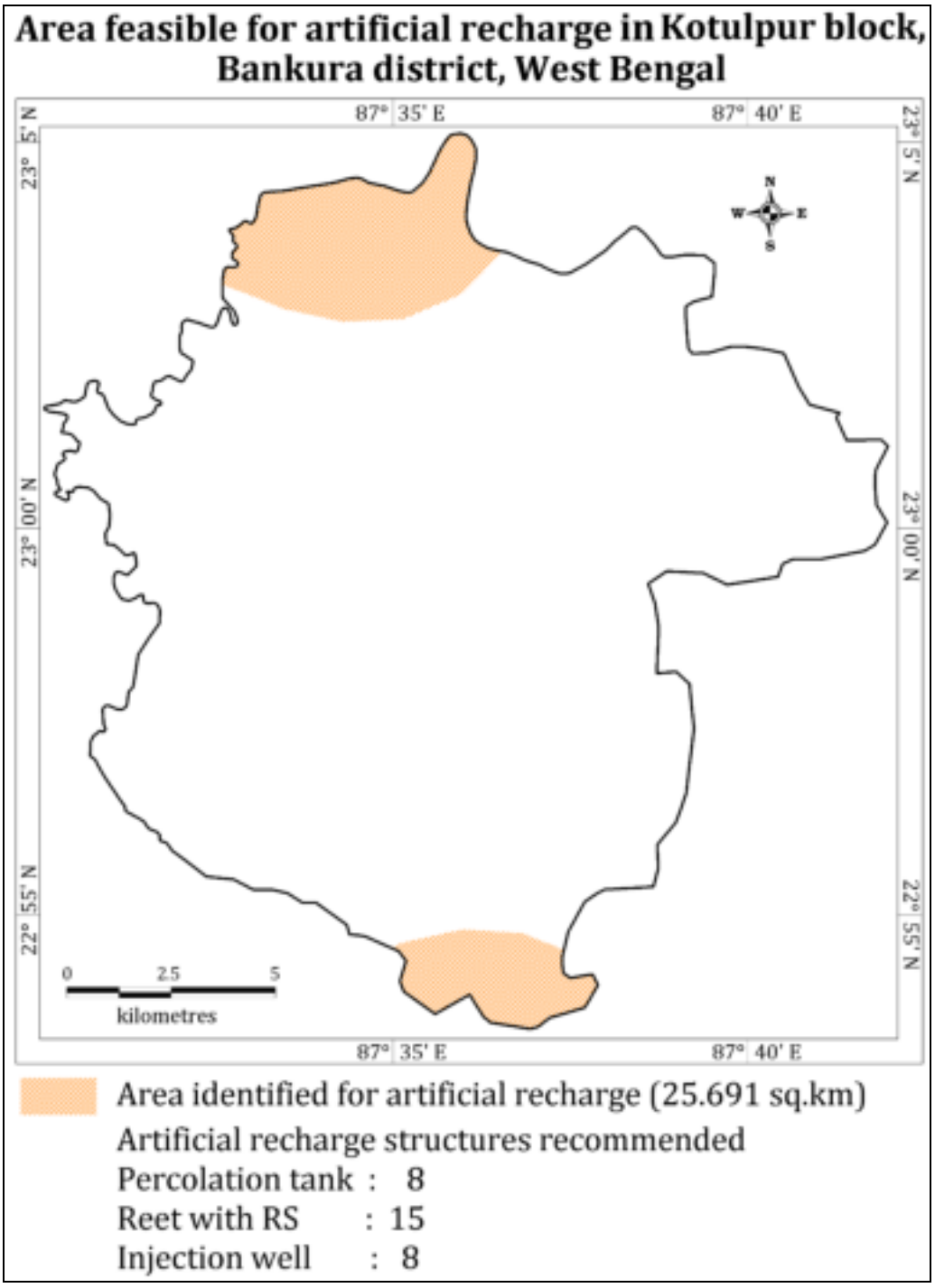


Figure *11.15.4*: Area Feasible for Artificial Recharge of groundwater for *Kotulpur* Block

Table *11.15*.11: Details of structures recommended in feasible area of artificial recharge for Kotulpur Block.

Name of the Block	Utilizable Surface Run Off	Allocation of Utilizable Recourse (MCM)							Structures Feasible							Cost of Structures							
		Percolation Tank	REET with RS	Injection Well	Check Dam	Gabion/ Contour Bund	Sub-Surface Dyke	Dug Well Recharge	Percolation Tank	REET with RS	Injection Well	Check Dam	Gabion/ Contour Bund	Sub-Surface Dyke	Dug Well Recharge	Percolation Tank	REET with RS	Injection Well	Check Dam	Gabion/ Contour Bund	Sub-Surface Dyke	Dug Well Recharge	TOTAL
Kotulpur	7.707	3.854	1.541	2.312	0	0	0	0	8	15	8	0	0	0	0	64	60	24	0	0	0	0	148

Management Intervention through Harvesting of Surface Runoff and Artificial Recharge:

It has been estimated that the utilizable surface runoff produced in the block is **7.707** MCM. This surface runoff is proposed to be utilized to recharge the depleted aquifer (aquifer III) in the block. As per the available storage space, **2.312** MCM water is required to fill the deeper aquifers in block. Therefore, **8** injection wells with roof top rain water harvesting structures are recommended in the block.

The remaining surface runoff, **5.395** MCM is recommended to be utilized in storage tanks for generation of irrigation potential and thus, **8** percolation tanks and **15** REET with RS have been proposed.

11.16 SALIENT INFORMATION

Block Name: ***Onda***

Geographical area (sq. km): **510**

Mappable area (sq. km): **410**

District: **Bankura**

State: **West Bengal**

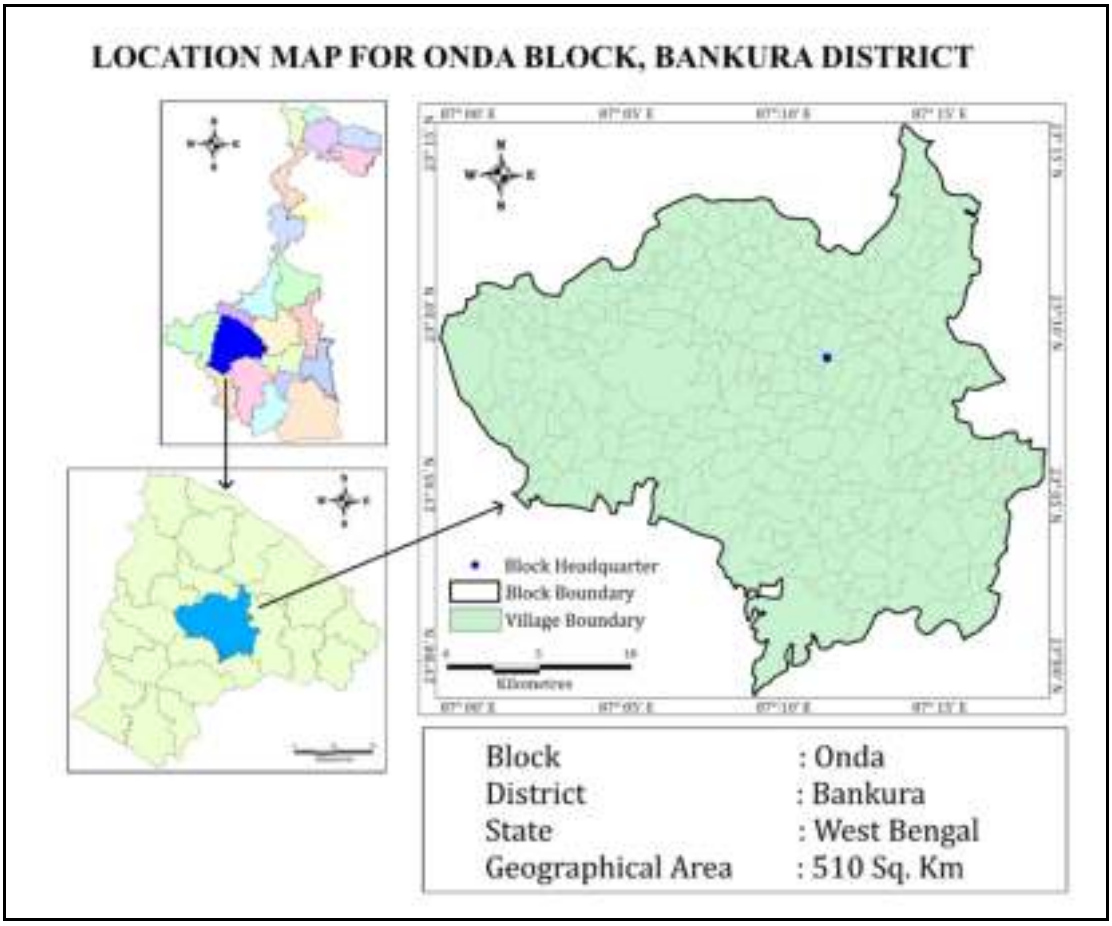


Figure *11.16*.1: Location Map of *Onda* Block

Population (as on 2011):

Table *11.16*.1: *Details of population in Onda block.*

Rural	Urban	Total	Population Density per Sqkm
252984	-	252984	496

Rainfall: Average annual rainfall for the period 2015 -19 is 1300.36 (in mm)

Table *11.16*.2: Details of Annual Rainfall for the last five years in *Onda* block.

Block Name	Normal Rainfall	Rain Fall				
		2014	2015	2016	2017	2018
Onda	1386	1075.5	1127.2	1335.9	1780.2	1334.3

Agriculture& Irrigation (area in ha):

Table *11.16*.3: Salient Land use features of *Onda* block

Block	Reporting Area	Forest Area	Area Under Non-Agricultural Waste	Barren and Un-culturable land	Permanent pastures and grazing lands	Land under misc tree crops	Culturable wastes	Fallow land Other than current fallow	Current fallow	Net area sown	Cultivable Area
Onda	50240	15370	7615				-		3936	23319	27255

Table *11.16*.4: Crop pattern of *Onda* block

Block	Aus			Aman			Boro			Wheat			Maize		
	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield
Onda	2246	6.525	2905.25	19947	53.122	2663	5020	15.395	3067	327	0.969	2962	-	-	-
	Mustard			Til			Potato			Musur			Gram		
	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	
	1322	1.363	1031	2453	2.310	942	1984	44557.000	22458	6	0.006	1082	1	0.001	835

Table *11.16*.5: Command area (ha) of *Onda* block

Block Name	Dug well		Shallow Tube well		Medium Tube well		Deep Tube well		Surface Flow		Surface Lift		CCA (ha.)		Total CCA (ha.)
	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	Ground Water	Surface Water	
ONDA	2	9	1761	5181.48	205	1131.24	195	620.99	169	833.1	451	1833.79	6942.71	2666.89	9609.6

Table *11.16*.6: Command area (ha) of *Onda* block

Name of Block	Canal Area	Tank		RLI		DTW		STW		ODW		Others		Total	
		No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area
Onda	9796	1455	900	27	1140	76	606	3541	6080	812	30	24	115	5935	18667

Disposition of Aquifers:

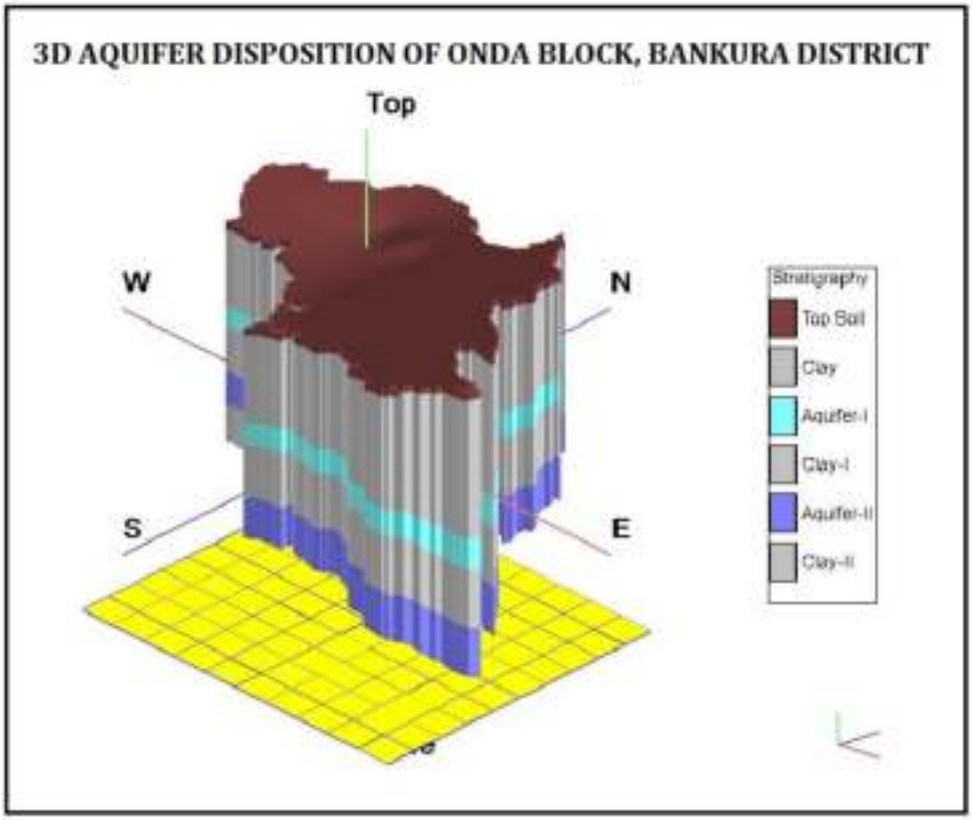


Figure *11.16*.2: 3-Dimensional Aquifer disposition in *Onda* Block

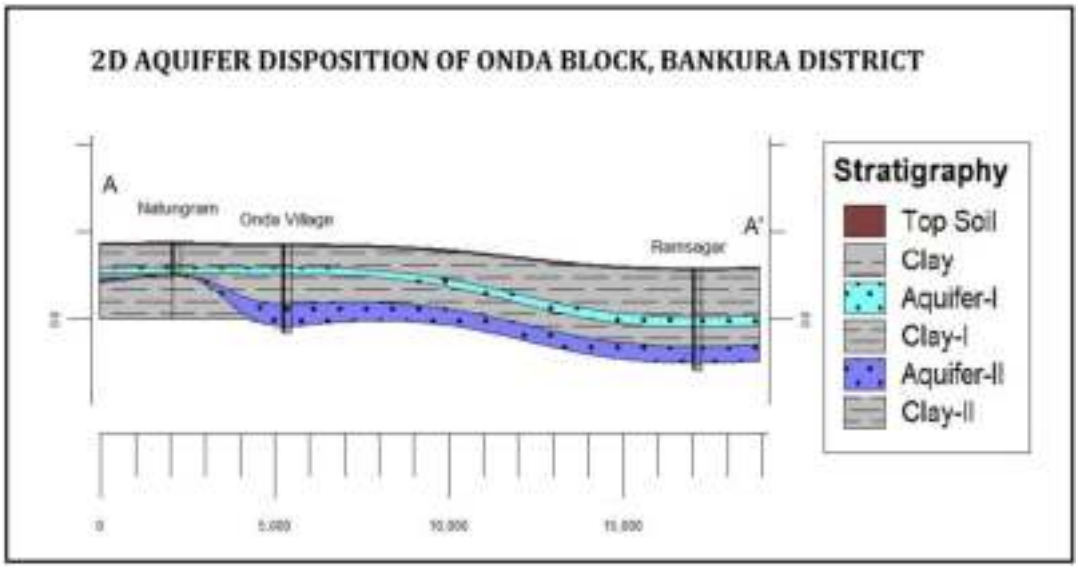


Figure *11.16*.3: 2-Dimensional Section in *Onda* Block

The principal aquifer systems encountered in this block is alluvial formation**.** Two aquifers are encountered in this block. The range of **Aquifer-I** is also known as Shallow aquifer. The range varies from 29-68 mbgl. Thickness of the granular Zone is 39m. The range of **Aquifer-II** is also known as 2nd Aquifer. The range varies from 70-114 mbgl. Thickness of the granular Zone is 44m.

Table *11.16*.7: Details of aquifer disposition in Onda Block

Blocks (dominant in soft rock)	No. of Aquifers	Water bearing zone	Aquifer Thickness (m)			Discharge (lpm)	T (m^2/day)	SWL (mbgl)	Draw down (mbgl)	S
			Aquifer-I (Within 50 mbgl)	Aquifer-II (above 50 mbgl)	Aquifer-III (above 150 mbgl)					
Onda	2	29-68, 70-114	39	44	--	1680	--	6.7	--	--

Table *11.16*.8: Details of Aquifer Wise Water Level Ranges & seasonal long term water level trends

Block	Pre-monsoon Trend			Post-monsoon Trend		
	WL Range (mbgl)	Rise (m/year)	Fall (m/year)	WL Range (mbgl)	Rise (m/year)	Fall (m/year)
Onda	0.9-4.2	--	0.036	1.36-4.44	0.008	--

Ground water quality and issues:

Based on four NHS, four exploratory wells and three observation wells, the range of chemical parameter for the block is given below.

Table *11.16*.9: Range of chemical parameters in Onda Block

Block	Aquifer Type	pH	EC (µS/cm)	Na (mg/l)	Cl (mg/l)	F (mg/l)	NO_3 (mg/l)	Fe (mg/l)	Measured Hardness (mg/l)
Onda	Aquifer-I	7.89-8.07	260-1984	12-94	10-60	0.10-0.94	2-9	0.03-0.07	105-865
	Aquifer-II	7.81-8.29	416-884	19-76	22-196	0.43-1.62	1-12	Traces	155-335

Ground Water Resource:

Table *11.16*.10: Details of Ground Water Resource Availability and Utilization in *Onda* Block.

Name of the Block	**ONDA**
Total Annual Ground Water Recharge (Ham)	25306.7
Total Natural Discharges (Ham)	2530.67
Annual Extractable Ground Water Recharge (Ham)	22776.03
Total Extraction	15708.84
Annual GW Allocation for Domestic Use as on 2042	338.55
Net Ground Water Availability for future use	7006.8
Stage of Ground Water Extraction (%)	68.97
Categorization (OE/CRITICAL/ SEMI-CRITICAL/ SAFE)	Safe
In storage (Ham)	199709

Aquifer Management Plan:

Ground Water Management Plan for drinking purpose:

The block has two commissioned public water supply schemes by PHED. There is one ongoing as well. However, there is still recorded deficit in supply of drinking water as the schemes do not reach to every mouza in the block. Therefore, there should be a general practice of conservation through rainwater harvesting, considering an adequate normal monsoon rainfall of 1347 mm which the block receives. The conserved rainwater can be utilized for drinking purpose by filtering through Horizontal Roughing Filters. The water from the lands can be channeled to ponds for recharge in the weathered zones and this water can be tapped through open dug wells for domestic and drinking purpose.

Ground Water Management Plan for irrigation purposes:

- Although ground water development in the block is low with stage of ground water development at 68.97%, further development should be done in planned manner to harness the additional available resource for site specific sustainable development.
- In view of low yield of the area, large diameter dug wells with adequate storage are another viable option for irrigation in favorable condition, thus creating a small command area. Owing to its distinct hydrogeology, it is evident that very less cultivable command area is created by both surface as well as groundwater.
- Modern methods of irrigation like sprinkler and drip irrigation methods are encouraged.
- Crops with low water requirement should be preferred.

In view of adequate rainfall in the area, excavation of tanks with large catchment areas, construction of check dam, nallah bunds, sub-surface dykes along the stream channels at suitable locations can be implemented to raise ground water level as well as to augment irrigation facilities.

Irrigation by surface water may be increased. In addition to surface lift from canal & surface flows, rain water harvesting may also be considered

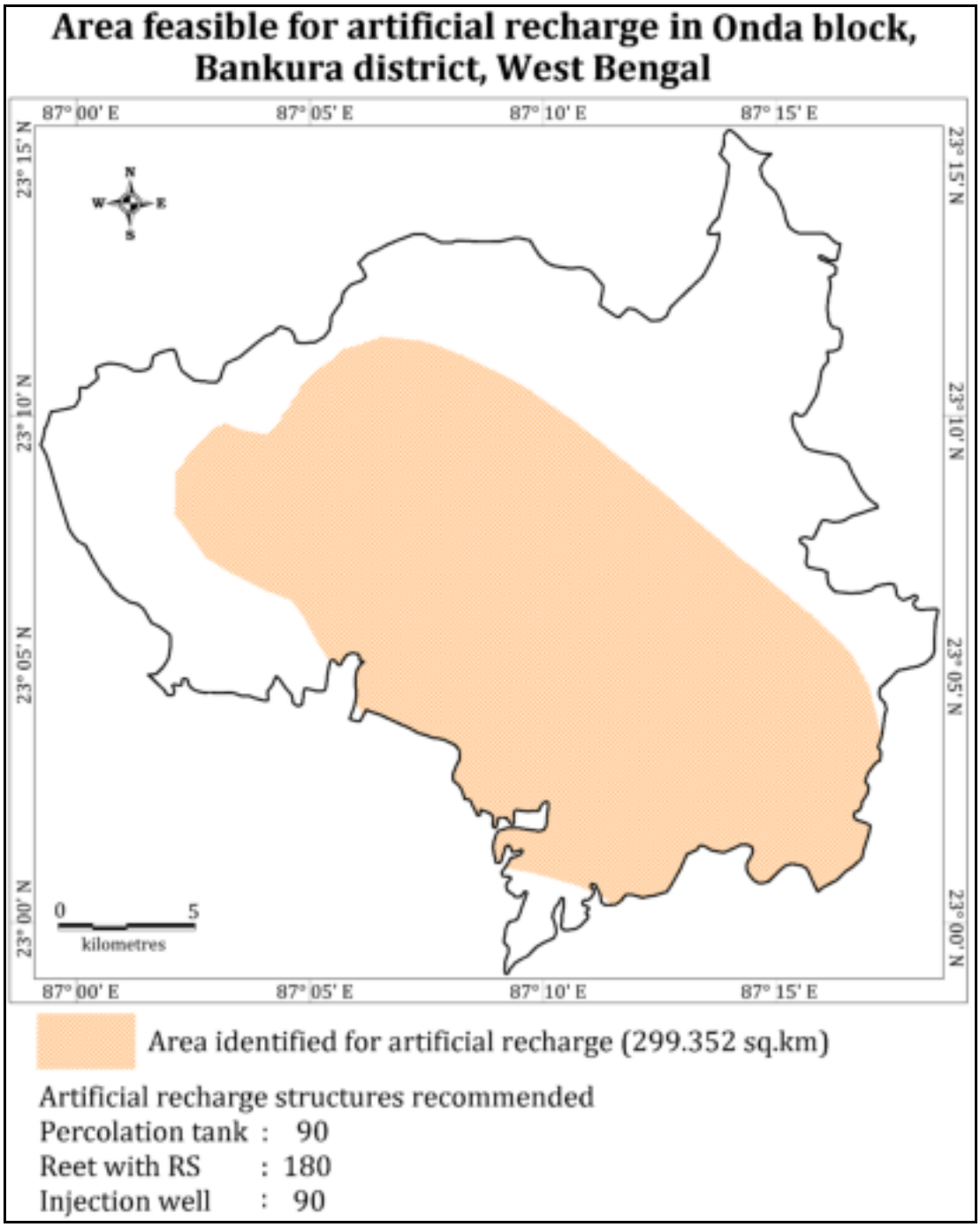


Figure *11.16*.4: Area Feasible for Artificial Recharge of groundwater for *Onda* Block

Table *11.16*.11: Details of structures recommended in feasible area of artificial recharge for Onda Block.

Name of the Block	Utilizable Surface Run Off	Allocation of Utilizable Recourse (MCM)							Structures Feasible							Cost of Structures							
		Percolation Tank	REET with RS	Injection Well	Check Dam	Gabion/ Contour Bund	Sub-Surface Dyke	Dug Well Recharge	Percolation Tank	REET with RS	Injection Well	Check Dam	Gabion/ Contour Bund	Sub-Surface Dyke	Dug Well Recharge	Percolation Tank	REET with RS	Injection Well	Check Dam	Gabion/ Contour Bund	Sub-Surface Dyke	Dug Well Recharge	TOTAL
Onda	89.806	44.903	17.961	26.942	0	0	0	0	90	180	90	0	0	0	0	720	720	270	0	0	0	0	1710

Management Intervention through Harvesting of Surface Runoff and Artificial Recharge:

It has been estimated that the utilizable surface runoff produced in the block is **89.806** MCM. This surface runoff is proposed to be utilized to recharge the depleted aquifer (aquifer III) in the block. As per the available storage space, **26.942** MCM water is required to fill the deeper aquifers in block. Therefore, **90** injection wells with roof top rain water harvesting structures are recommended in the block.

The remaining surface runoff, **62.864** MCM is recommended to be utilized in storage tanks for generation of irrigation potential and thus, **90** percolation tanks and **180** REET with RS have been proposed.

11.17 SALIENT INFORMATION

Block Name: ***Patrasayer***

Geographical area (sq. km): **329**

Mappable area (sq. km): **329**

District: **Bankura**

State: **West Bengal**

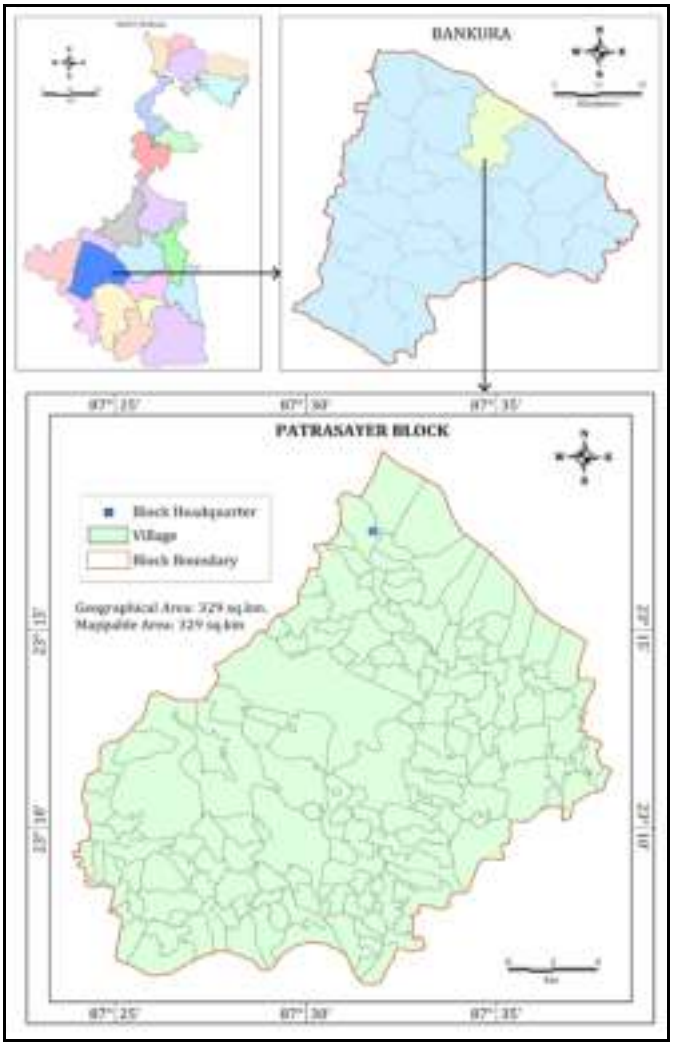


Figure *11.17*.1: Location Map of *Patrasayer* Block

Population (as on 2011):

Table *11.17*.1: ***Details of population in Patrasayer block.***

Rural	Urban	Total	Population Density per Sqkm
184070	-	184070	559

Rainfall: Average annual rainfall for the period 2015 -19 is 1300.36 (in mm)

Table *11.17*.2: Details of Annual Rainfall for the last five years in *Patrasayer* block.

Block Name	Normal Rainfall	Rain Fall				
		2014	2015	2016	2017	2018
Patrasayer	1386	1075.5	1127.2	1335.9	1780.2	1334.3

Agriculture& Irrigation (area in ha):

Table *11.17*.3: Salient Land use features of *Patrasayer* block

Block	Reporting Area	Forest Area	Area Under Non-Agricultural Waste	Barren and Un-culturable land	Permanent pastures and grazing lands	Land under misc tree crops	Culturable wastes	Fallow land Other than current fallow	Current fallow	Net area sown	Cultivable Area
Patrasayer	32260	5157	8725	-	-	154	-	-	1600	16624	18378

Table *11.17*.4: Crop pattern of *Patrasayer* block

Block	Aus			Aman			Boro			Wheat			Maize		
	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield
Patrasayer	3191	7.964	2495.83	1405	3.390	2413	4851	16.859	3475	152	0.293	1927	-	-	-
	Mustard			Til			Potato			Musur			Gram		
	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	
	893	0.613	687	1246	0.935	751	2030	12578.000	6196	9	0.007	767	-	-	-

Table *11.17*.5: Command area (ha) of *Patrasayer* block

Block Name	Dug well		Shallow Tube well		Medium Tube well		Deep Tube well		Surface Flow		Surface Lift		CCA (ha.)		Total CCA (ha.)
	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	Ground Water	Surface Water	
PATRASAYER	2	8	1155	3641.09	97	707	62	546	19	254	78	651	4902.09	905	5807.09

Table *11.17*.6: Command area (ha) of *Patrasayer* block

Name of Block	Canal Area	Tank		RLI		DTW		STW		ODW		Others		Total	
		No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area
Patrasayer	7727	60	225	26	980	34	438	4025	8432	70	55	6	10	4221	17867

Disposition of Aquifers:

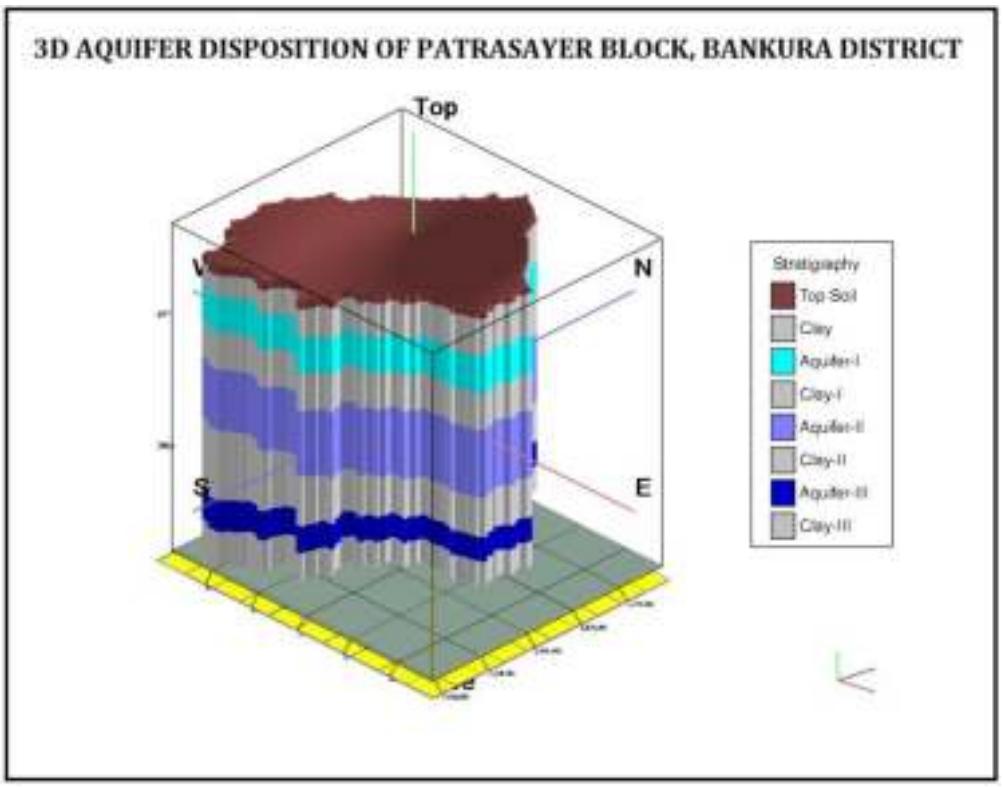


Figure *11.17*.2: 3-Dimensional Aquifer disposition in *Patrasayer* Block

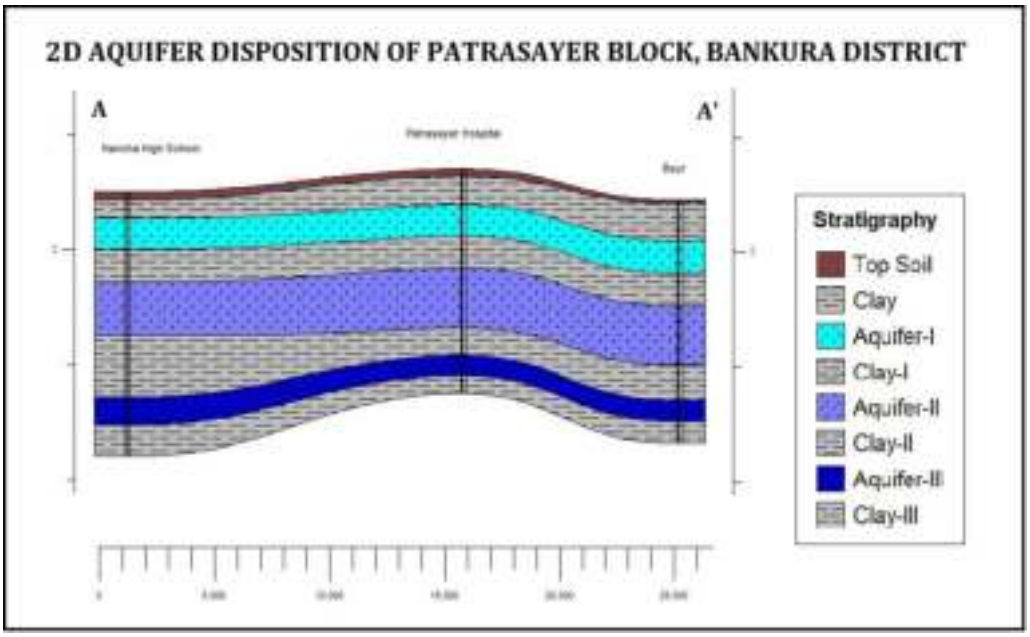


Figure *11.17*.3: 2-Dimensional Section in *Patrasayer* Block

The principal aquifer systems encountered in this block is alluvial formation. Three aquifers are encountered in this block. The range of **Aquifer-I** is also known as Shallow aquifer. The range varies from 35-64 mbgl. Thickness of the granular Zone is 29m. The range of **Aquifer-II** is also known as 2nd Aquifer. The range varies from 92-144 mbgl.

Thickness of the granular Zone is 52m. The Range of **Aquifer-III** is also known as Deeper Aquifer. The range varies from 174-193 mbgl. Thickness of the granular Zone is 19m.

Table *11.17*.7: Details of aquifer disposition in Patrasayer Block

Blocks (dominant in soft rock)	No. of Aquifers	Water bearing zone	Aquifer Thickness (m)			Discharge (lpm)	T (m^2/day)	SWL (mbgl)	Draw down (mbgl)	S
			Aquifer-I (Within 50 mbgl)	Aquifer-II (above 50 mbgl)	Aquifer-III (above 150 mbgl)					
Patrasayer	3	35-64, 92-144, 174-193	29	52	19	2520	--	12.6	--	--

Table *11.17*.8: Details of Aquifer Wise Water Level Ranges & seasonal long term water level trends

Block	Pre-monsoon Trend			Post-monsoon Trend		
	WL Range (mbgl)	Rise (m/year)	Fall (m/year)	WL Range (mbgl)	Rise (m/year)	Fall (m/year)
Patrasayer	1.7-13.56	0.368	--	1.8-12.99	0.034	--

Ground water quality and issues:

Based on four NHS, four exploratory wells and three observation wells, the range of chemical parameter for the block is given below.

Table *11.17*.9: Range of chemical parameters in Patrasayer Block

Block	Aquifer Type	pH	EC (µS/cm)	Na (mg/l)	Cl (mg/l)	F (mg/l)	NO_3 (mg/l)	Fe (mg/l)	Measured Hardness (mg/l)
Patrasayer	Aquifer-I	7.89-8.07	260-1984	12-94	10-60	0.10-0.94	2-9	0.03-0.07	105-865
	Aquifer-II	7.81-8.29	416-884	19-76	22-196	0.43-0.91	1-12	Traces	155-335

Ground Water Resource:

Table *11.17*.10: Details of Ground Water Resource Availability and Utilization in *Patrasayer* Block.

Name of the Block	PATRASAYER
Total Annual Ground Water Recharge (Ham)	21344.37
Total Natural Discharges (Ham)	2134.44
Annual Extractable Ground Water Recharge (Ham)	19209.93
Total Extraction	9220.18
Annual GW Allocation for Domestic Use as on 2042	262.23
Net Ground Water Availability for future use	9929.9
Stage of Ground Water Extraction (%)	48
Categorization (OE/CRITICAL/ SEMI-CRITICAL/ SAFE)	Safe
In storage (Ham)	150884

Aquifer Management Plan:

Ground Water Management Plan for drinking purpose:

The block has two commissioned public water supply schemes by PHED. There is one ongoing as well. However, there is still recorded deficit in supply of drinking water as the schemes do not reach to every mouza in the block. Therefore, there should be a general practice of conservation through rainwater harvesting, considering an adequate normal monsoon rainfall of 1347 mm which the block receives. The conserved rainwater can be utilized for drinking purpose by filtering through Horizontal Roughing Filters. The water from the lands can be channeled to ponds for recharge in the weathered zones and this water can be tapped through open dug wells for domestic and drinking purpose.

Ground Water Management Plan for irrigation purposes:

- Although ground water development in the block is low with stage of ground water development at 48%, further development should be done in planned manner to harness the additional available resource for site specific sustainable development.
- In view of low yield of the area, large diameter dug wells with adequate storage are another viable option for irrigation in favorable condition, thus creating a small command area. Owing to its distinct hydrogeology, it is evident that very less cultivable command area is created by both surface as well as groundwater.
- Modern methods of irrigation like sprinkler and drip irrigation methods are encouraged.
- Crops with low water requirement should be preferred.

In view of adequate rainfall in the area, excavation of tanks with large catchment areas, construction of check dam, nallah bunds, sub-surface dykes along the stream channels at suitable locations can be implemented to raise ground water level as well as to augment irrigation facilities.

Irrigation by surface water may be increased. In addition to surface lift from canal & surface flows, rain water harvesting may also be considered.

Management Intervention through Harvesting of Surface Runoff and Artificial Recharge:

It has been estimated that the utilizable surface runoff produced in the block is **25.930** MCM. This surface runoff is proposed to be utilized to recharge the depleted aquifer (aquifer III) in the block. As per the available storage space, **7.779** MCM water is required to fill the deeper aquifers in block. Therefore, **26** injection wells with roof top rain water harvesting structures are recommended in the block.

The remaining surface runoff, **18.151** MCM is recommended to be utilized in storage tanks for generation of irrigation potential and thus, **26** percolation tanks and **52** REET with RS have been proposed.

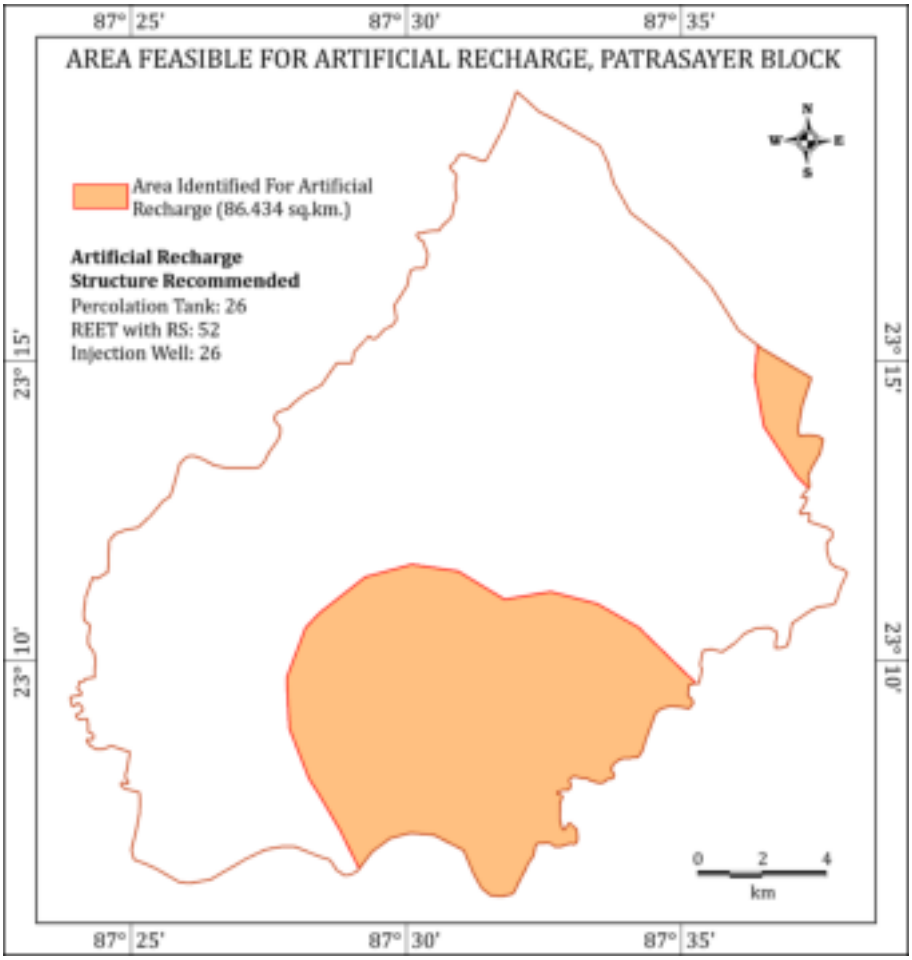


Figure *11.17.4*: Area Feasible for Artificial Recharge of groundwater for *Patrasayer* Block

Table*11.17.*11: Details of structures recommended in feasible area of artificial recharge for Patrasayer Block.

Name of the Block	Utilizable Surface Run Off	Allocation of Utilizable Recourse (MCM)							Structures Feasible							Cost of Structures							
		Percolation Tank	REET with RS	Injection Well	Check Dam	Gabion/ Contour Bund	Sub-Surface Dyke	Dug Well Recharge	Percolation Tank	REET with RS	Injection Well	Check Dam	Gabion/ Contour Bund	Sub-Surface Dyke	Dug Well Recharge	Percolation Tank	REET with RS	Injection Well	Check Dam	Gabion/ Contour Bund	Sub-Surface Dyke	Dug Well Recharge	TOTAL
Patrasayer	25.930	12.965	5.186	7.779	0	0	0	0	26	52	26	0	0	0	0	208	208	78	0	0	0	0	494

11.18 SALIENT INFORMATION

Block Name: ***Raipur***

Geographical area (sq. km): **364**

Mappable area (sq. km): **364**

District: **Bankura**

State: **West Bengal**

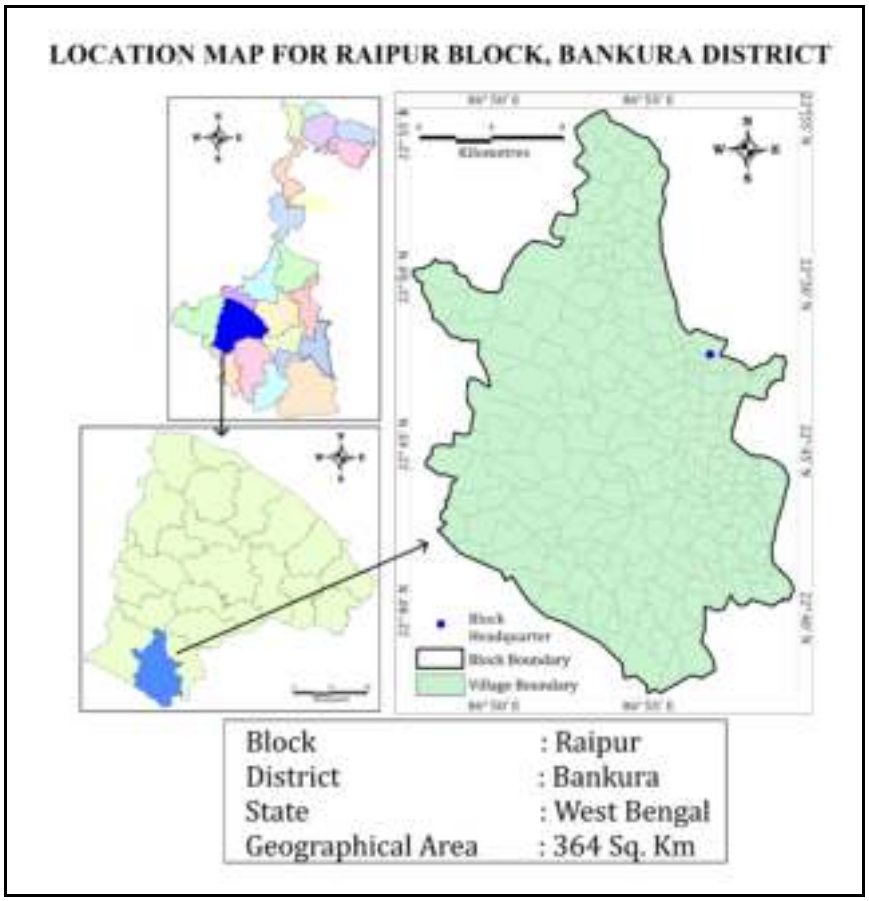


Figure 11.18.1: Location Map of *Raipur* Block

Population (as on 2011):

Table 11.18.1: ***Details of population in Raipur block.***

Rural	Urban	Total	Population Density per Sqkm
165097	6280	171377	471

Rainfall: Average annual rainfall for the period 2015 -19 is 1300.36 (in mm)

Table 11.18.2: Details of Annual Rainfall for the last five years in *Raipur* block.

Block Name	Normal Rainfall	Rain Fall				
		2014	2015	2016	2017	2018
Raipur	1386	1075.5	1127.2	1335.9	1780.2	1334.3

Agriculture& Irrigation (area in ha):

Table 11.18.3: Salient Land use features of *Raipur* block

Block	Reporting Area	Forest Area	Area Under Non-Agricultural Waste	Barren and Un-culturable land	Permanent pastures and grazing lands	Land under misc tree crops	Culturable wastes	Fallow land Other than current fallow	Current fallow	Net area sown	Cultivable Area
Raipur	36993	7165	9194					101	2565	17968	20634

Table 11.18.4: Crop pattern of *Raipur* block

Block	Aus			Aman			Boro			Wheat			Maize		
	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield
Raipur	31	0.084	2708.07	16373	44.430	2714	363	0.840	2315	666	0.939	1410	2	0.004	1841
	Mustard			Til			Potato			Musur			Gram		
	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	
	115	0.056	491	2202	1.106	502	1883	39760.000	21115	10	0.003	282	1	0.001	1024

Table 11.18.5: Command area (ha) of *Raipur* block

Block Name	Dug well		Shallow Tube well		Medium Tube well		Deep Tube well		Surface Flow		Surface Lift		CCA (ha.)		Total CCA (ha.)
	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	Ground Water	Surface Water	
RAIPUR	2	10	399	1301.93	47	210.7	63	224	164	811	280	1381	1746.63	2192	3938.63

Table11.18.6: Command area (ha) of *Raipur* block

Name of Block	Canal Area	Tank		RLI		DTW		STW		ODW		Others		Total	
		No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area
Raipur	14072	527	2030	32	1360	-	-	165	385	235	480	20	600	979	18927

Disposition of Aquifers:

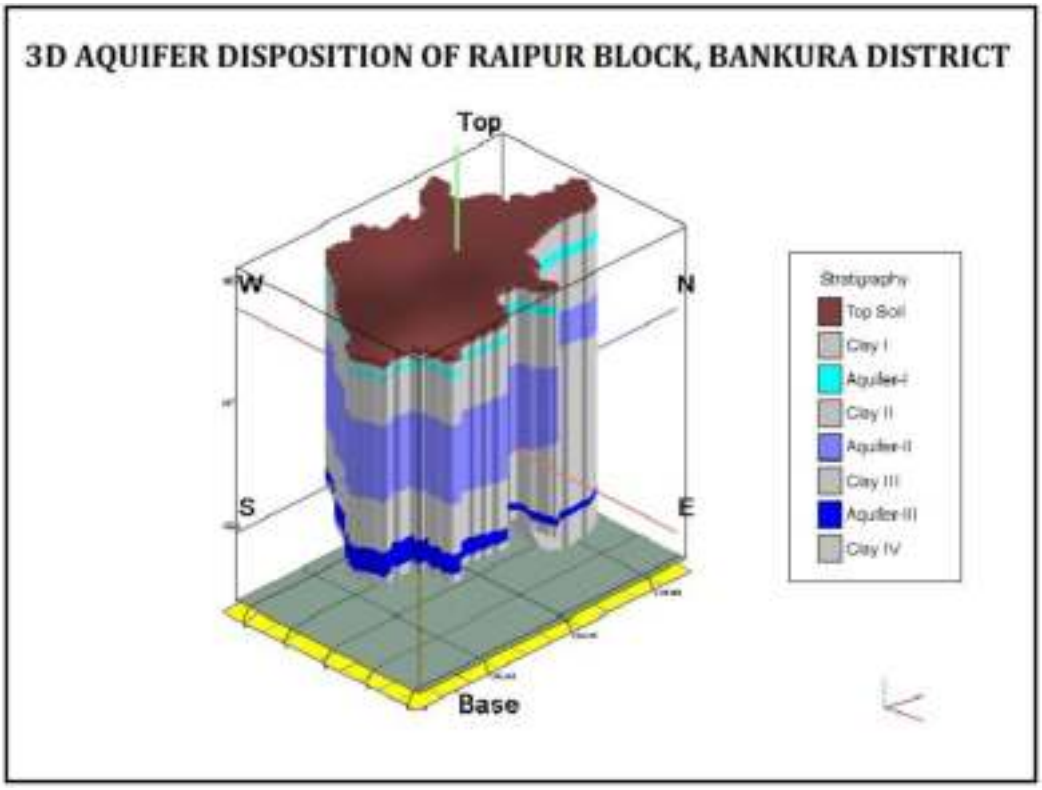


Figure 11.18.2: 3-Dimensional Aquifer disposition in *Raipur* Block

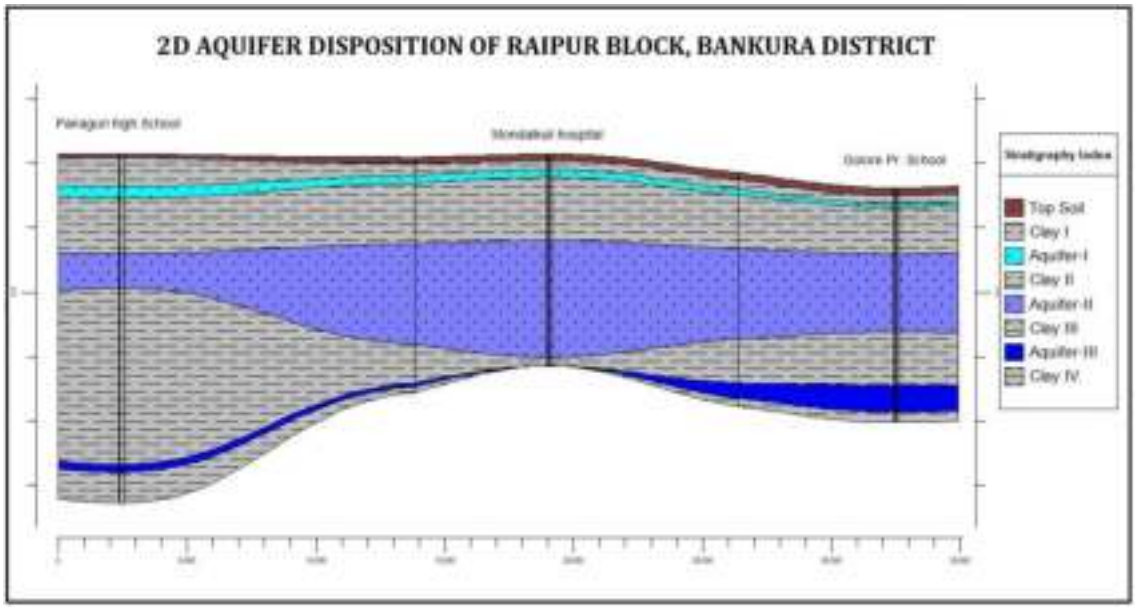


Figure 11.18.3: 2-Dimensional Section in *Raipur* Block

The principal aquifer systems encountered in this block is alluvial formation**.** Three aquifers are encountered in this block. The range of **Aquifer-I** is also known as Shallow aquifer. The range varies from 12-34 mbgl. Thickness of the granular Zone is 22m. The range of **Aquifer-II** is also known as 2nd Aquifer. The range varies from 67-158 mbgl. Thickness of the granular Zone is 91m. The Range of **Aquifer-III** is also known as Deeper Aquifer. The range varies from 163-178, 241-248 mbgl. Thickness of the granular Zone is 22m.

Table 11.18.7: Details of aquifer disposition in Raipur Block

Blocks (dominant in soft rock)	No. of Aquifers	Water bearing zone	Aquifer Thickness (m)			Discharge (lpm)	T (m^2/day)	SWL (mbgl)	Draw down (mbgl)	S
			Aquifer-I (Within 50 mbgl)	Aquifer-II (above 50 mbgl)	Aquifer-III (above 150 mbgl)					
Raipur	3	12-34, 67-158, 163-178, 241-248	22	91	22	1080	--	6.3	--	--

Table 11.18.8: Details of Aquifer Wise Water Level Ranges & seasonal long term water level trends

Block	Pre-monsoon Trend			Post-monsoon Trend		
	WL Range (mbgl)	Rise (m/year)	Fall (m/year)	WL Range (mbgl)	Rise (m/year)	Fall (m/year)
Raipur	1.32-4.44	0.143	--	2.1-4.94	--	0.004

Ground water quality and issues:

Based on four NHS, four exploratory wells and three observation wells, the range of chemical parameter for the block is given below.

Table 11.18.9: Range of chemical parameters in Raipur Block

Block	Aquifer Type	pH	EC (µS/cm)	Na (mg/l)	Cl (mg/l)	F (mg/l)	NO_3 (mg/l)	Fe (mg/l)	Measured Hardness (mg/l)
Raipur	Aquifer-I	7.89-8.07	260-1984	12-94	10-60	0.10-0.94	2-9	0.03-0.07	105-865
	Aquifer-II	7.81-8.29	416-884	19-76	22-196	0.43-0.85	1-12	Traces	155-335

As per PHED report Fluoride concentration is above the permissible limit this block. More intensive sampling from this block is recommended.

Ground Water Resource:

Table 11.18.10: Details of Ground Water Resource Availability and Utilization in *Raipur* Block.

Name of the Block	**RAIPUR**
Total Annual Ground Water Recharge (Ham)	10654.73
Total Natural Discharges (Ham)	1065.47
Annual Extractable Ground Water Recharge (Ham)	9589.26
Total Extraction	2655.25
Annual GW Allocation for Domestic Use as on 2042	176.51
Net Ground Water Availability for future use	6945.93
Stage of Ground Water Extraction (%)	27.69
Categorization (OE/CRITICAL/ SEMI-CRITICAL/ SAFE)	Safe
In storage (Ham)	16512

Aquifer Management Plan:
Ground Water Management Plan for drinking purpose:

The block has two commissioned public water supply schemes by PHED. There is one ongoing as well. However, there is still recorded deficit in supply of drinking water as the schemes do not reach to every mouza in the block. Therefore, there should be a general practice of conservation through rainwater harvesting, considering an adequate normal monsoon rainfall of 1347 mm which the block receives. The conserved rainwater can be utilized for drinking purpose by filtering through Horizontal Roughing Filters. The water from the lands can be channeled to ponds for recharge in the weathered zones and this water can be tapped through open dug wells for domestic and drinking purpose.

Ground Water Management Plan for irrigation purposes:

- Although ground water development in the block is low with stage of ground water development at 27.69%, further development should be done in planned manner to harness the additional available resource for site specific sustainable development.
- In view of low yield of the area, large diameter dug wells with adequate storage are another viable option for irrigation in favorable condition, thus creating a small command area. Owing to its distinct hydrogeology, it is evident that very less cultivable command area is created by both surface as well as groundwater.
- Modern methods of irrigation like sprinkler and drip irrigation methods are encouraged.
- Crops with low water requirement should be preferred.

In view of adequate rainfall in the area, excavation of tanks with large catchment areas, construction of check dam, nallah bunds, sub-surface dykes along the stream channels at suitable locations can be implemented to raise ground water level as well as to augment irrigation facilities.
Irrigation by surface water may be increased. In addition to surface lift from canal & surface flows, rain water harvesting may also be considered.

11.19 SALIENT INFORMATION

Block Name: *Sarenga*

Geographical area (sq. km): **220**

Mappable area (sq. km): **170**

District: **Bankura**

State: **West Bengal**

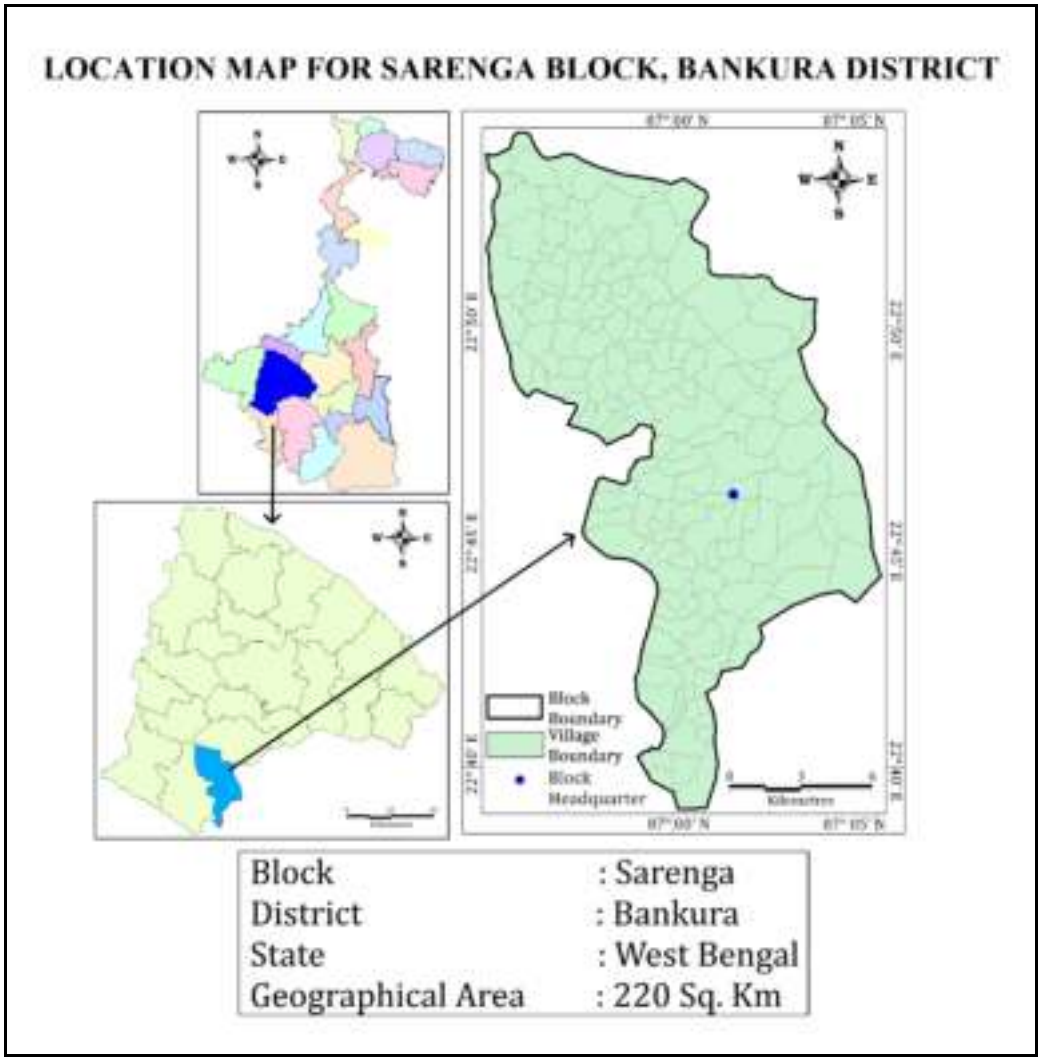


Figure 11.19.1: Location Map of *Sarenga* Block

Population (as on 2011):

Table 11.19.1: *Details of population in Sarenga block.*

Rural	Urban	Total	Population Density per Sq. km
106808	-	106808	485

Rainfall: Average annual rainfall for the period 2015 -19 is 1300.36 (in mm)

Table 11.19.2: Details of Annual Rainfall for the last five years in *Sarenga* block.

Block Name	Normal Rainfall	Rain Fall				
		2014	2015	2016	2017	2018
Sarenga	1386	1075.5	1127.2	1335.9	1780.2	1334.3

Agriculture& Irrigation (area in ha):

Table 11.19.3: Salient Land use features of *Sarenga* block

Block	Reporting Area	Forest Area	Area Under Non-Agricultural Waste	Barren and Un-culturable land	Permanent pastures and grazing lands	Land under misc tree crops	Culturable wastes	Fallow land Other than current fallow	Current fallow	Net area sown	Cultivable Area
Sarenga	22385	5868	8360	47		42	60		2123	5885	8110

Table 11.19.4: Crop pattern of *Sarenga* block

Block	Aus			Aman			Boro			Wheat			Maize		
	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield
Sarenga	-	-	-	36541	102.823	2814	-	-	-	142	0.308	2171	-	-	-
	Mustard			Til			Potato			Musur			Gram		
	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	
	835	0.645	773	287	0.192	668	1310	22557.000	17219	5	0.007	1373	1	0.001	810

Table 11.19.5: Command area (ha) of *Sarenga* block

Block Name	Dug well		Shallow Tube well		Medium Tube well		Deep Tube well		Surface Flow		Surface Lift		CCA (ha.)		Total CCA (ha.)
	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	Ground Water	Surface Water	
SARENGA	1	1	495	1542.3	53	244.75	46	198	128	614	146	619.2	1986.05	1233.2	3219.25

Table 11.19.6: Command area (ha) of *Sarenga* block

Name of Block	Canal Area	Tank		RLI		DTW		STW		ODW		Others		Total	
		No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area
Sarenga	9723	305	950	18	700	-	-	1315	2905	135	17	66	1075	1839	15370

Disposition of Aquifers:

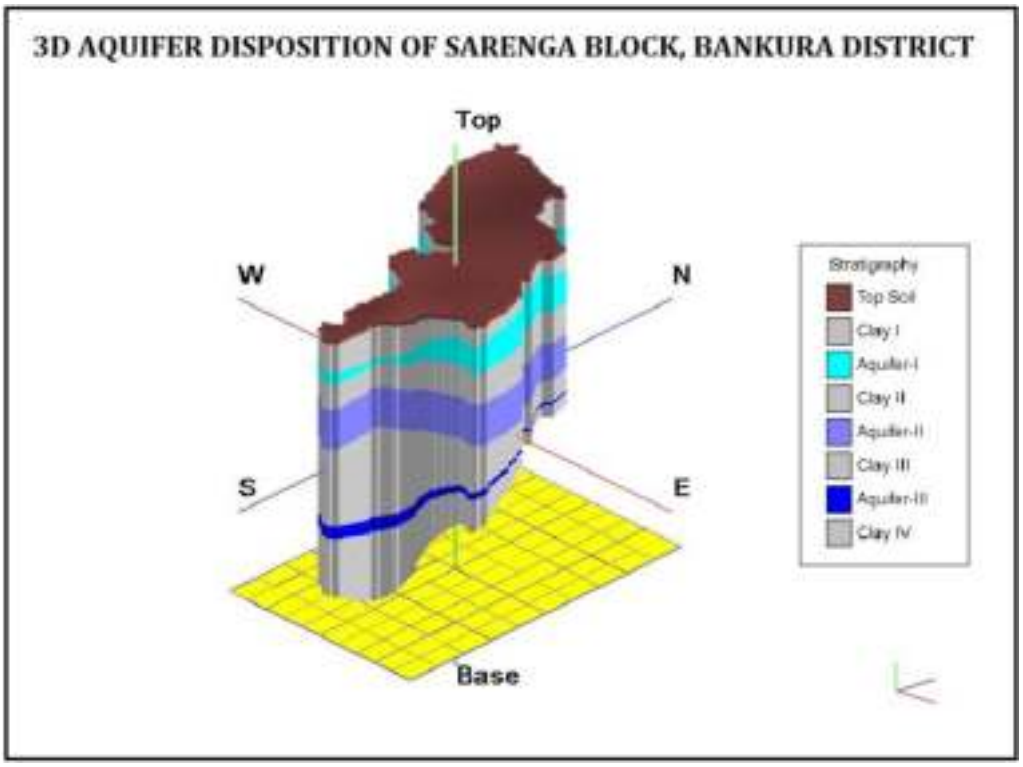


Figure 11.19.2: 3-Dimensional Aquifer disposition in *Sarenga* Block

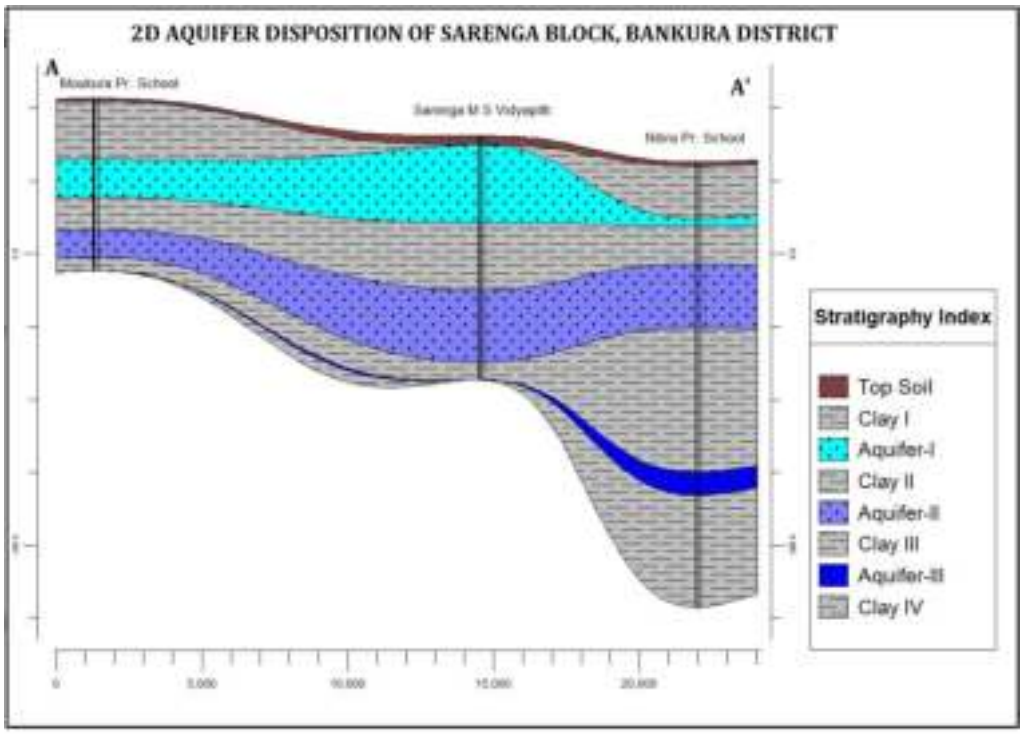


Figure 11.19.3: 2-Dimensional Section in *Sarenga* Block

The principal aquifer systems encountered in this block is alluvial formation**.** Three aquifers are encountered in this block. The range of **Aquifer-I** is also known as Shallow aquifer. The range varies from 30-60 mbgl. Thickness of the granular Zone is 27m. The

range of **Aquifer-II** is also known as 2nd Aquifer. The range varies from 70-98, 133-156 mbgl. Thickness of the granular Zone is 51m. The Range of **Aquifer-III** is also known as Deeper Aquifer. The range varies from 213-229 mbgl. Thickness of the granular Zone is 16m.

Table 11.19.7: Details of aquifer disposition in Sarenga Block

Blocks (dominant in soft rock)	No. of Aquifers	Water bearing zone	Aquifer Thickness (m)			Discharge (lpm)	T (m^2/day)	SWL (mbgl)	Draw down (mbgl)	S
			Aquifer-I (Within 50 mbgl)	Aquifer-II (above 50 mbgl)	Aquifer-III (above 150 mbgl)					
Sarenga	3	33-60, 70-98, 133-156, 213-229	27	51	16	1560	--	8.5	--	--

Table 11.19.8: Details of Aquifer Wise Water Level Ranges & seasonal long term water level trends

Block	Pre-monsoon Trend			Post-monsoon Trend		
	WL Range (mbgl)	Rise (m/year)	Fall (m/year)	WL Range (mbgl)	Rise (m/year)	Fall (m/year)
Sarenga	NA	NA	NA	NA	NA	NA

Ground water quality and issues:

Based on four NHS, four exploratory wells and three observation wells, the range of chemical parameter for the block is given below.

Table 11.19.9: Range of chemical parameters in Sarenga Block

Block	Aquifer Type	pH	EC (µS/cm)	Na (mg/l)	Cl (mg/l)	F (mg/l)	NO_3 (mg/l)	Fe (mg/l)	Measured Hardness (mg/l)
Sarenga	Aquifer-I	7.89-8.07	260-1984	12-94	10-60	0.10-0.94	2-9	0.03-0.07	105-865
	Aquifer-II	7.81-8.29	416-884	19-76	22-196	0.43-0.75	1-12	Traces	155-335

Ground Water Resource:

Table 11.19.10: Details of Ground Water Resource Availability and Utilization in *Sarenga* Block.

Name of the Block	SARENGA
Total Annual Ground Water Recharge (Ham)	9930.93
Total Natural Discharges (Ham)	993.09
Annual Extractable Ground Water Recharge (Ham)	8937.84
Total Extraction	2607.95
Annual GW Allocation for Domestic Use as on 2042	139.56
Net Ground Water Availability for future use	6307.76
Stage of Ground Water Extraction (%)	29.18
Categorization (OE/CRITICAL/ SEMI-CRITICAL/ SAFE)	Safe
In storage (Ham)	12151

Aquifer Management Plan:

Ground Water Management Plan for drinking purpose:

The block has two commissioned public water supply schemes by PHED. There is one ongoing as well. However, there is still recorded deficit in supply of drinking water as the schemes do not reach to every mouza in the block. Therefore, there should be a general practice of conservation through rainwater harvesting, considering an adequate normal monsoon rainfall of 1347 mm which the block receives. The conserved rainwater can be utilized for drinking purpose by filtering through Horizontal Roughing Filters. The water from the lands can be channeled to ponds for recharge in the weathered zones and this water can be tapped through open dug wells for domestic and drinking purpose.

Ground Water Management Plan for irrigation purposes:

I. Although ground water development in the block is low with stage of ground water development at 29.18%, further development should be done in planned manner to harness the additional available resource for site specific sustainable development.
II. In view of low yield of the area, large diameter dug wells with adequate storage are another viable option for irrigation in favorable condition, thus creating a small command area. Owing to its distinct hydrogeology, it is evident that very less cultivable command area is created by both surface as well as groundwater.
III. Modern methods of irrigation like sprinkler and drip irrigation methods are encouraged.
IV. Crops with low water requirement should be preferred.

In view of adequate rainfall in the area, excavation of tanks with large catchment areas, construction of check dam, nallah bunds, sub-surface dykes along the stream channels at suitable locations can be implemented to raise ground water level as well as to augment irrigation facilities.

Irrigation by surface water may be increased. In addition to surface lift from canal & surface flows, rain water harvesting may also be considered.

11.20 SALIENT INFORMATION

Block Name: ***Simlapal***

Geographical area (sq. km): **316**

Mappable area (sq. km): **216**

District: **Bankura**

State: **West Bengal**

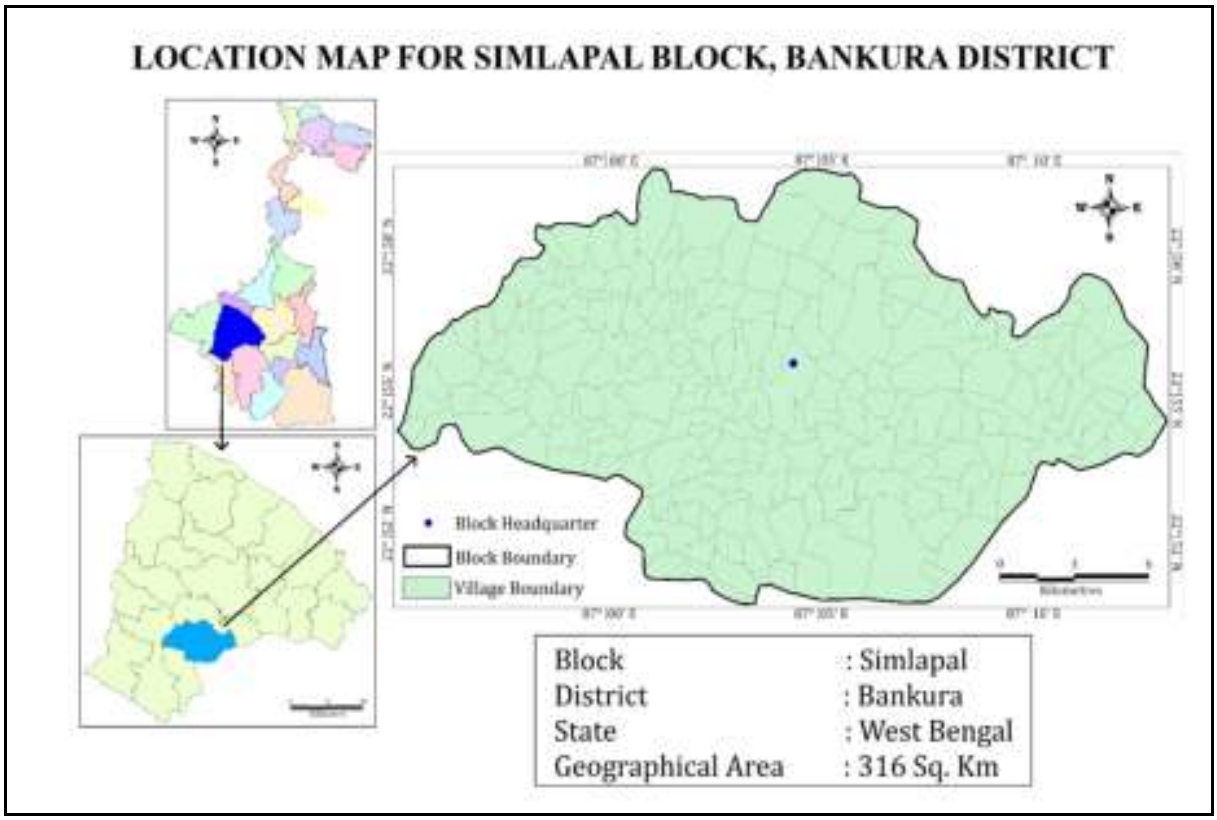


Figure *11.20*.1: Location Map of *Simlapal* Block

Population (as on 2011):

Table *11.20*.1: *Details of population in Simlapal block.*

Rural	Urban	Total	Population Density per Sqkm
135832	7206	143038	453

Rainfall: Average annual rainfall for the period 2015 -19 is 1300.36 (in mm)

Table *11.20*.2: Details of Annual Rainfall for the last five years in *Simlapal* block.

Block Name	Normal Rainfall	Rain Fall				
		2014	2015	2016	2017	2018
Simlapal	1386	1075.5	1127.2	1335.9	1780.2	1334.3

Agriculture& Irrigation (area in ha):

Table *11.20*.3: Salient Land use features of *Simlapal* block

Block	Reporting Area	Forest Area	Area Under Non-Agricultural Waste	Barren and Un-culturable land	Permanent pastures and grazing lands	Land under misc tree crops	Culturable wastes	Fallow land Other than current fallow	Current fallow	Net area sown	Cultivable Area
Simlapal	31015	9709	5657			160			1180	14309	15649

Table *11.20*.4: Crop pattern of *Simlapal* block

Block	Aus			Aman			Boro			Wheat			Maize		
	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield
Simlapal	65	0.181	2781.13	34047	99.087	2910	1239	3.290	2655	105	0.237	2261	3	0.006	1841
	Mustard			Til			Potato			Musur			Gram		
	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	
	588	0.414	704	971	0.846	871	2214	40671.000	18370	-	-	-	-	-	-

Table *11.20*.5: Command area (ha) of *Simlapal* block

Block Name	Dug well		Shallow Tube well		Medium Tube well		Deep Tube well		Surface Flow		Surface Lift		CCA (ha.)		Total CCA (ha.)
	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	Ground Water	Surface Water	
SIMLAPAL	4	10	378	1292.01	46	249.63	8	180.43	107	479	308	1671.21	1732.07	2150.21	3882.28

Table *11.20*.6: Command area (ha) of *Simlapal* block

Name of Block	Canal Area	Tank		RLI		DTW		STW		ODW		Others		Total	
		No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area
Simlapal	11853	630	1790	28	1120	10	116	690	2400	250	45	538	1820	2146	19144

Disposition of Aquifers:

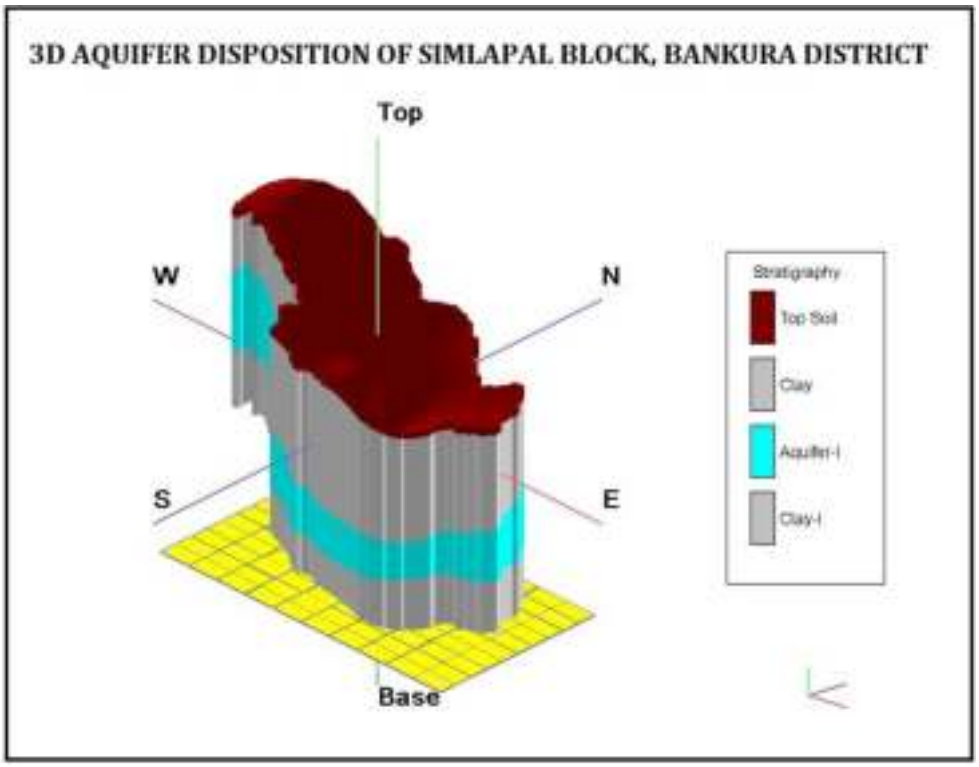


Figure *11.20*.2: 3-Dimensional Aquifer disposition in *Simlapal* Block

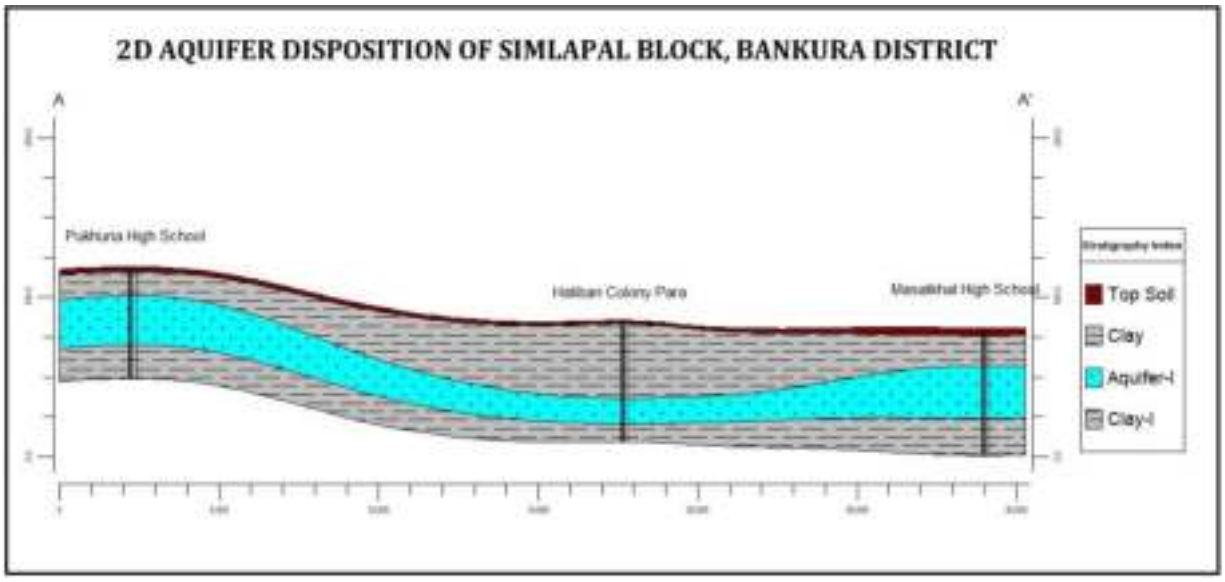


Figure *11.20*.3: 2-Dimensional Section in *Simlapal* Block

The principal aquifer systems encountered in this block is alluvial formation**.** One aquifer is encountered in this block. The range of **Aquifer-I** is also known as Shallow aquifer. The range varies from 39-65 mbgl. Thickness of the granular Zone is 26m.

Table *11.20*.7: Details of aquifer disposition in Simlapal Block

Blocks (dominant in soft rock)	No. of Aquifers	Water bearing zone	Aquifer Thickness (m)			Discharge (lpm)	T (m^2/day)	SWL (mbgl)	Draw down (mbgl)	S
			Aquifer-I (Within 50 mbgl)	Aquifer-II (above 50 mbgl)	Aquifer-III (above 150 mbgl)					
Simlapal	1	39-65,	26	--	--	1260	--	6.9	--	--

Table *11.20*.8: Details of Aquifer Wise Water Level Ranges & seasonal long term water level trends

Block	Pre-monsoon Trend			Post-monsoon Trend		
	WL Range (mbgl)	Rise (m/year)	Fall (m/year)	WL Range (mbgl)	Rise (m/year)	Fall (m/year)
Simlapal	1.57-4.98	0.996	--	1.26-5.32	--	0.078

Ground water quality and issues:

Based on four NHS, four exploratory wells and three observation wells, the range of chemical parameter for the block is given below.

Table *11.20*.9: Range of chemical parameters in Simlapal Block

Block	Aquifer Type	pH	EC (µS/cm)	Na (mg/l)	Cl (mg/l)	F (mg/l)	NO_3 (mg/l)	Fe (mg/l)	Measured Hardness (mg/l)
Simlapal	Aquifer-I	7.89-8.07	260-1984	12-94	10-60	0.10-0.94	2-9	0.03-0.07	105-865
	Aquifer-II	7.81-8.29	416-884	19-76	22-196	0.43-0.78	1-12	Traces	155-335

As per PHED report Fluoride concentration is above the permissible limit this block. More intensive sampling from this block is recommended.

Ground Water Resource:

Table *11.20*.10: Details of Ground Water Resource Availability and Utilization in *Simlapal* Block.

Name of the Block	**SIMLAPAL**
Total Annual Ground Water Recharge (Ham)	9663.78
Total Natural Discharges (Ham)	966.38
Annual Extractable Ground Water Recharge (Ham)	8697.4
Total Extraction	2239.1
Annual GW Allocation for Domestic Use as on 2042	193.2
Net Ground Water Availability for future use	6422.37
Stage of Ground Water Extraction (%)	25.74
Categorization (OE/CRITICAL/ SEMI-CRITICAL/ SAFE)	Safe
In storage (Ham)	62436

Aquifer Management Plan:

Ground Water Management Plan for drinking purpose:

The block has two commissioned public water supply schemes by PHED. There is one ongoing as well. However, there is still recorded deficit in supply of drinking water as the schemes do not reach to every mouza in the block. Therefore, there should be a general practice of conservation through rainwater harvesting, considering an adequate normal monsoon rainfall of 1347 mm which the block receives. The conserved rainwater can be utilized for drinking purpose by filtering through Horizontal Roughing Filters. The water from the lands can be channeled to ponds for recharge in the weathered zones and this water can be tapped through open dug wells for domestic and drinking purpose.

Ground Water Management Plan for irrigation purposes:

- Although ground water development in the block is low with stage of ground water development at 25.74%, further development should be done in planned manner to harness the additional available resource for site specific sustainable development.
- In view of low yield of the area, large diameter dug wells with adequate storage are another viable option for irrigation in favorable condition, thus creating a small command area. Owing to its distinct hydrogeology, it is evident that very less cultivable command area is created by both surface as well as groundwater.
- Modern methods of irrigation like sprinkler and drip irrigation methods are encouraged.
- Crops with low water requirement should be preferred.

In view of adequate rainfall in the area, excavation of tanks with large catchment areas, construction of check dam, nallah bunds, sub-surface dykes along the stream channels at suitable locations can be implemented to raise ground water level as well as to augment irrigation facilities.

Irrigation by surface water may be increased. In addition to surface lift from canal & surface flows, rain water harvesting may also be considered.

11.21 SALIENT INFORMATION

Block Name: ***Sonamukhi***

Geographical area (sq. km): **400**

Mappable area (sq. km): **400**

District: **Bankura**

State: **West Bengal**

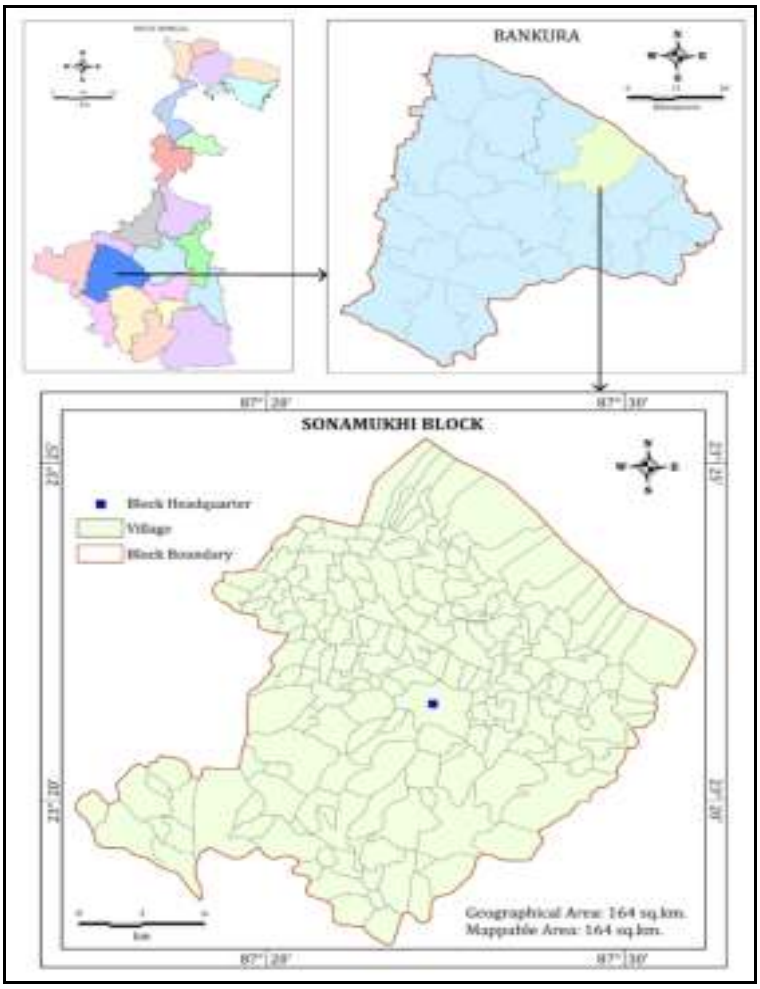


Figure *11.21*.1: Location Map of *Sonamukhi* Block

Population (as on 2011):

Table *11.21*.1: *Details of population in Sonamukhi block.*

Rural	Urban	Total	Population Density per Sq.km
158697	29085	187782	469

Rainfall: Average annual rainfall for the period 2015 -19 is 1300.36 (in mm)

Table *11.21*.2: Details of Annual Rainfall for the last five years in *Sonamukhi* block.

Block Name	Normal Rainfall	Rain Fall				
		2014	2015	2016	2017	2018
Sonamukhi	1386	1075.5	1127.2	1335.9	1780.2	1334.3

Agriculture& Irrigation (area in ha):

Table *11.21*.3: Salient Land use features of *Sonamukhi* block

Block	Reporting Area	Forest Area	Area Under Non-Agricultural Waste	Barren and Un-culturable land	Permanent pastures and grazing lands	Land under misc tree crops	Culturable wastes	Fallow land Other than current fallow	Current fallow	Net area sown	Cultivable Area
Sonamukhi	39049	12147	10870			17	9		903	15103	16032

Table *11.21*.4: Crop pattern of *Sonamukhi* block

Block	Aus			Aman			Boro			Wheat			Maize		
	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield
Sonamukhi	662	1.466	2214.64	17209	45.542	2646	11216	32.128	2864	404	0.766	1896	-	-	-
	Mustard			Til			Potato			Musur			Gram		
	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	
	736	0.424	577	347	0.208	600	2843	29573.000	10402	1	0.001	1088	-	-	-

Table *11.21*.5: Command area (ha) of *Sonamukhi* block

Block Name	Dug well		Shallow Tube well		Medium Tube well		Deep Tube well		Surface Flow		Surface Lift		CCA (ha.)		Total CCA (ha.)
	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	Ground Water	Surface Water	
SONAMUKHI	2	10	871	2908.96	161	961.65	163	1117.5	119	672	417	1643.4	4998.11	2315.4	7313.51

Table *11.21*.6: Command area (ha) of *Sonamukhi* block

Name of Block	Canal Area	Tank		RLI		DTW		STW		ODW		Others		Total	
		No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area
Sonamukhi	14900	35	250	19	580	70	866	4015	4825	13	12	15	242	4167	21675

Disposition of Aquifers:

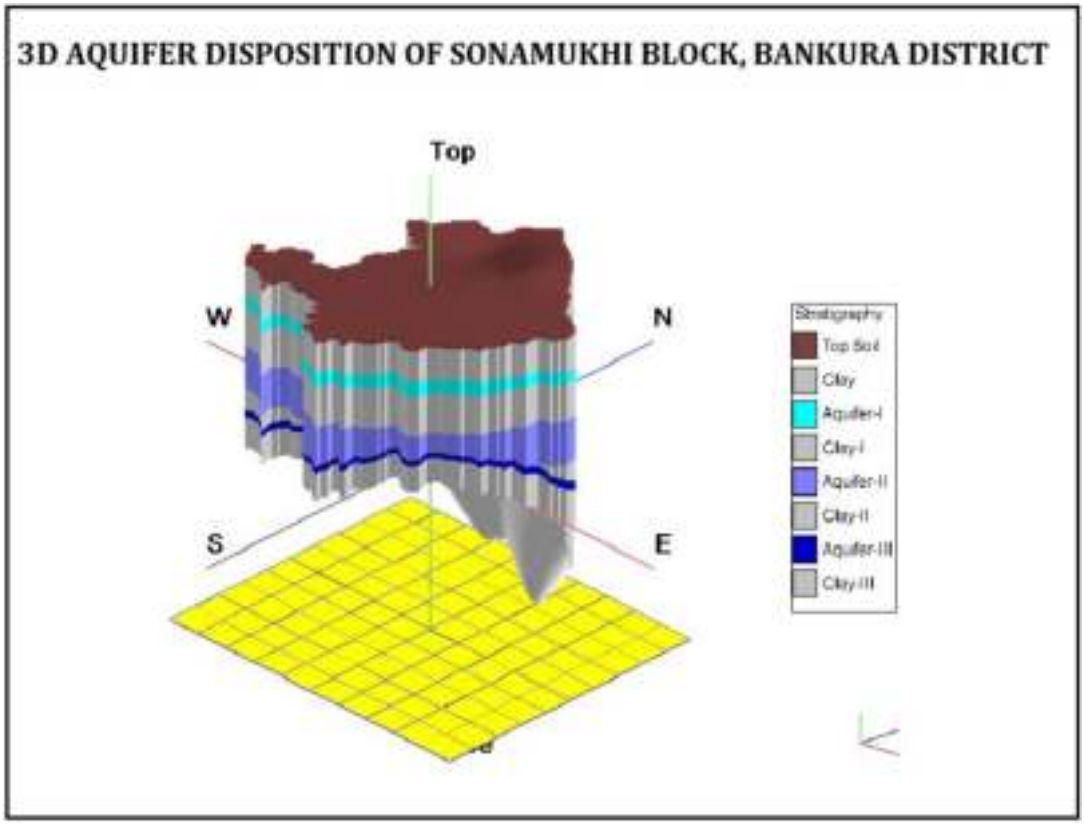


Figure *11.21*.2: 3-Dimensional Aquifer disposition in *Sonamukhi* Block

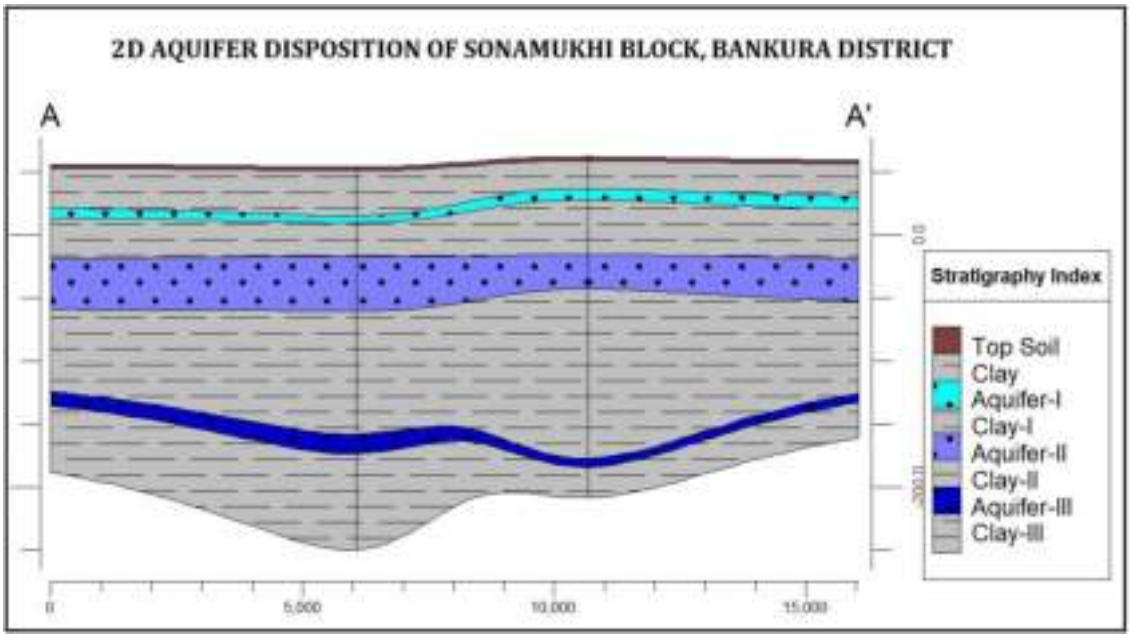


Figure *11.21*.3: 2-Dimensional Section in *Sonamukhi* Block

The principal aquifer systems encountered in this block is alluvial formation**.** Three aquifers are encountered in this block. The range of **Aquifer-I** is also known as Shallow aquifer. The range varies from 31-48 mbgl. Thickness of the granular Zone is 17m. The range of **Aquifer-II** is also known as 2nd Aquifer. The range varies from 70-130 mbgl.

Thickness of the granular Zone is 60m. The Range of **Aquifer-III** is also known as Deeper Aquifer. The range varies from 213-248 mbgl. Thickness of the granular Zone is 35m.

Table *11.21*.7: Details of aquifer disposition in Sonamukhi Block

Blocks (dominant in soft rock)	No. of Aquifers	Water bearing zone	Aquifer Thickness (m)			Discharge (lpm)	T (m^2/day)	SWL (mbgl)	Draw down (mbgl)	S
			Aquifer-I (Within 50 mbgl)	Aquifer-II (above 50 mbgl)	Aquifer-III (above 150 mbgl)					
Sonamukhi	3	31-48, 70-130, 213-248	17	60	35	1980	--	9.8	--	--

Table *11.21*.8: Details of Aquifer Wise Water Level Ranges & seasonal long term water level trends

Block	Pre-monsoon Trend			Post-monsoon Trend		
	WL Range (mbgl)	Rise (m/year)	Fall (m/year)	WL Range (mbgl)	Rise (m/year)	Fall (m/year)
Sonamukhi	0.37-6.74	--	0.355	0.9-7.85	1.224	--

Ground water quality and issues:

Based on four NHS, four exploratory wells and three observation wells, the range of chemical parameter for the block is given below.

Table *11.21*.9: Range of chemical parameters in Sonamukhi Block

Block	Aquifer Type	pH	EC (µS/cm)	Na (mg/l)	Cl (mg/l)	F (mg/l)	NO_3 (mg/l)	Fe (mg/l)	Measured Hardness (mg/l)
Sonamukhi	Aquifer-I	7.89-8.07	260-1984	12-94	10-60	0.10-0.94	2-9	0.03-0.07	105-865
	Aquifer-II	7.81-8.29	416-884	19-76	22-196	0.43-0.86	1-12	Traces	155-335

Ground Water Resource:

Table *11.21*.10: Details of Ground Water Resource Availability and Utilization in *Sonamukhi* Block.

Name of the Block	**SONAMUKHI**
Total Annual Ground Water Recharge (Ham)	17631.33
Total Natural Discharges (Ham)	1763.13
Annual Extractable Ground Water Recharge (Ham)	15868.2
Total Extraction	6603.92
Annual GW Allocation for Domestic Use as on 2042	238.26
Net Ground Water Availability for future use	9229.18
Stage of Ground Water Extraction (%)	41.62
Categorization (OE/CRITICAL/ SEMI-CRITICAL/ SAFE)	Safe
In storage (Ham)	122544

Aquifer Management Plan:

Ground Water Management Plan for drinking purpose:

The block has two commissioned public water supply schemes by PHED. There is one ongoing as well. However, there is still recorded deficit in supply of drinking water as the schemes do not reach to every mouza in the block. Therefore, there should be a general practice of conservation through rainwater harvesting, considering an adequate normal monsoon rainfall of 1347 mm which the block receives. The conserved rainwater can be utilized for drinking purpose by filtering through Horizontal Roughing Filters. The water from the lands can be channeled to ponds for recharge in the weathered zones and this water can be tapped through open dug wells for domestic and drinking purpose.

Ground Water Management Plan for irrigation purposes:

- Although ground water development in the block is low with stage of ground water development at 41.62%, further development should be done in planned manner to harness the additional available resource for site specific sustainable development.
- In view of low yield of the area, large diameter dug wells with adequate storage are another viable option for irrigation in favorable condition, thus creating a small command area. Owing to its distinct hydrogeology, it is evident that very less cultivable command area is created by both surface as well as groundwater.
- Modern methods of irrigation like sprinkler and drip irrigation methods are encouraged.
- Crops with low water requirement should be preferred.

In view of adequate rainfall in the area, excavation of tanks with large catchment areas, construction of check dam, nallah bunds, sub-surface dykes along the stream channels at suitable locations can be implemented to raise ground water level as well as to augment irrigation facilities.

Irrigation by surface water may be increased. In addition to surface lift from canal & surface flows, rain water harvesting may also be considered

Management Intervention through Harvesting of Surface Runoff and Artificial Recharge:

It has been estimated that the utilizable surface runoff produced in the block is **10.194** MCM. This surface runoff is proposed to be utilized to recharge the depleted aquifer (aquifer III) in the block. As per the available storage space, **3.058** MCM water is required to fill the deeper aquifers in block. Therefore, **10** injection wells with roof top rain water harvesting structures are recommended in the block.

The remaining surface runoff, **7.136** MCM is recommended to be utilized in storage tanks for generation of irrigation potential and thus, **10** percolation tanks and **20** REET with RS 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.

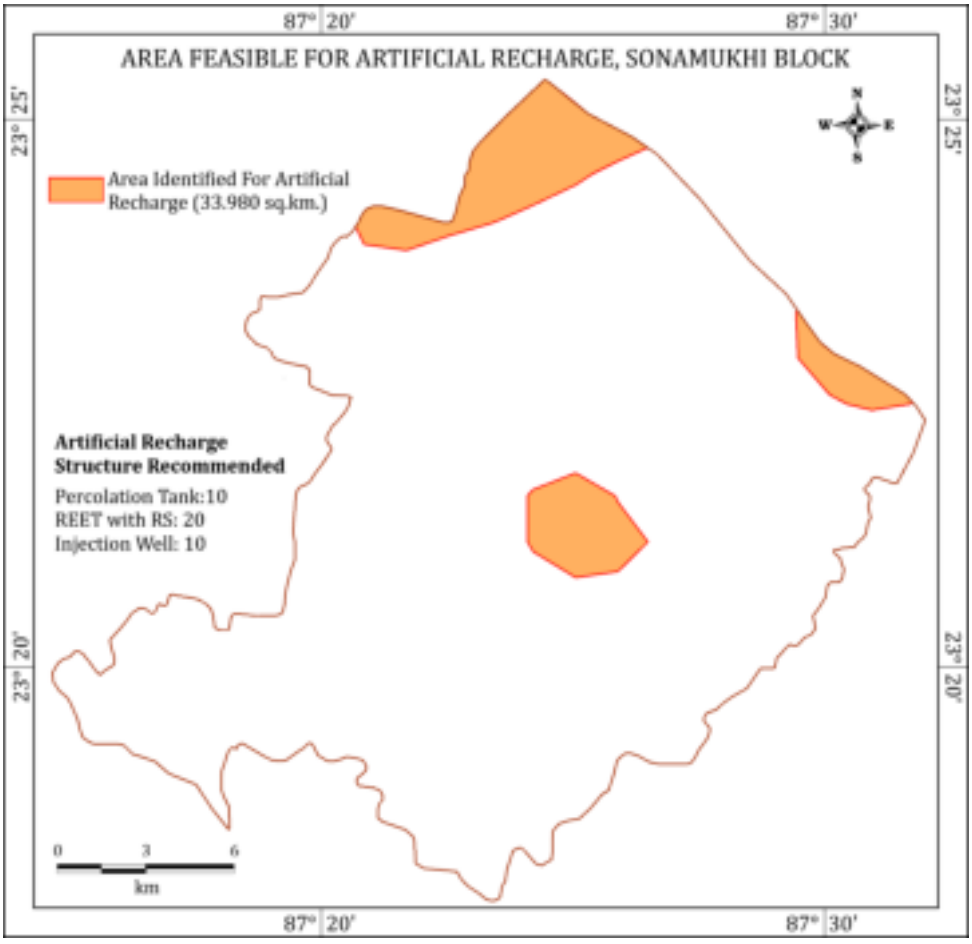


Figure *11.21.4*: Area Feasible for Artificial Recharge of groundwater for *Sonamukhi* Block

Table *11.21*.11: Details of structures recommended in feasible area of artificial recharge for Sonamukhi Block.

Name of the Block	Utilizable Surface Run Off	Allocation of Utilizable Recourse (MCM)							Structures Feasible							Cost of Structures							
		Percolation Tank	REET with RS	Injection Well	Check Dam	Gabion/ Contour Bund	Sub-Surface Dyke	Dug Well Recharge	Percolation Tank	REET with RS	Injection Well	Check Dam	Gabion/ Contour Bund	Sub-Surface Dyke	Dug Well Recharge	Percolation Tank	REET with RS	Injection Well	Check Dam	Gabion/ Contour Bund	Sub-Surface Dyke	Dug Well Recharge	TOTAL
Sonamukhi	10.194	5.097	2.039	3.058	0	0	0	0	10	20	10	0	0	0	0	80	80	30	0	0	0	0	190

11.22 SALIENT INFORMATION

Block Name: *Taldangra*

Geographical area (sq. km): **338**

Mappable area (sq. km): **238**

District: **Bankura**

State: **West Bengal**

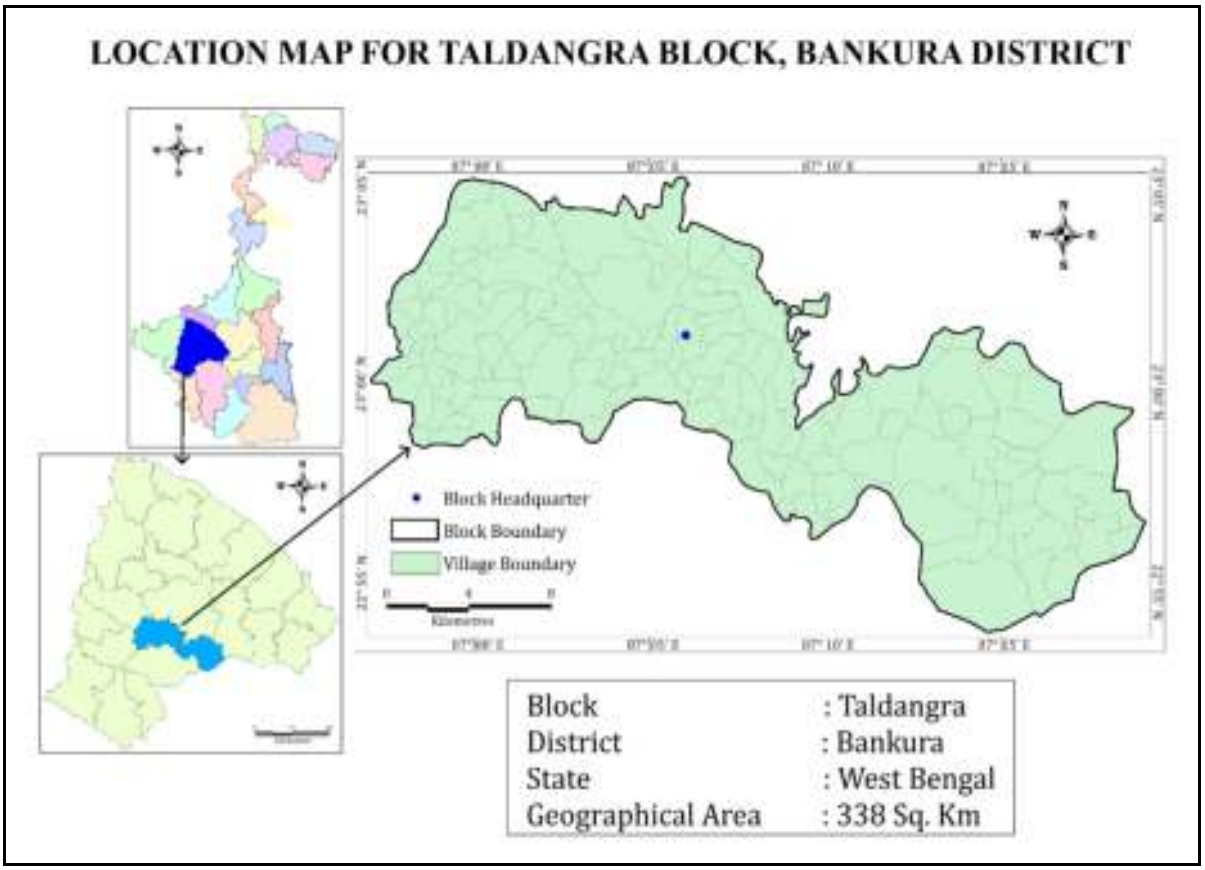


Figure *11.22*.1: Location Map of *Taldangra* Block

Population (as on 2011):

Table *11.22*.1: *Details of population in Taldangra block.*

Rural	Urban	Total	Population Density per Sqkm
147893	-	147893	438

Rainfall: Average annual rainfall for the period 2015 -19 is 1300.36 (in mm)

Table *11.22*.2: Details of Annual Rainfall for the last five years in *Taldangra* block.

Block Name	Normal Rainfall	Rain Fall				
		2014	2015	2016	2017	2018
Taldangra	1386	1075.5	1127.2	1335.9	1780.2	1334.3

Agriculture& Irrigation (area in ha):

Table *11.22*.3: Salient Land use features of *Taldangra* block

Block	Reporting Area	Forest Area	Area Under Non-Agricultural Waste	Barren and Un-culturable land	Permanent pastures and grazing lands	Land under misc tree crops	Culturable wastes	Fallow land Other than current fallow	Current fallow	Net area sown	Cultivable Area
Taldangra	34921	11300	10017	-	-	-	-	-	-	13604	13604

Table *11.22*.4: Crop pattern of *Taldangra* block

Block	Aus			Aman			Boro			Wheat			Maize		
	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield
Taldangra	1921	4.424	2303.15	1922	4.429	2304	503	1.474	2930	329	0.549	1669	-	-	-
	Mustard			Til			Potato			Musur			Gram		
	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield	
	551	0.300	545	1415	0.862	609	879	11080.000	12605	5	0.003	553	1	0.001	817

Table *11.22*.5: Command area (ha) of *Taldangra* block

Block Name	Dug well		Shallow Tube well		Medium Tube well		Deep Tube well		Surface Flow		Surface Lift		CCA (ha.)		Total CCA (ha.)
	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	Ground Water	Surface Water	
TALDANGRA	5	17	481	1770.09	17	157.5	137	568	83	436	186	1049.3	2512.59	1485.3	3997.89

Table *11.22*.6: Command area (ha) of *Taldangra* block

Name of Block	Canal Area	Tank		RLI		DTW		STW		ODW		Others		Total	
		No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area
Taldangra	12262	260	1435	31	1300	20	232	578	1350	10	5	16	400	915	16984

Disposition of Aquifers:

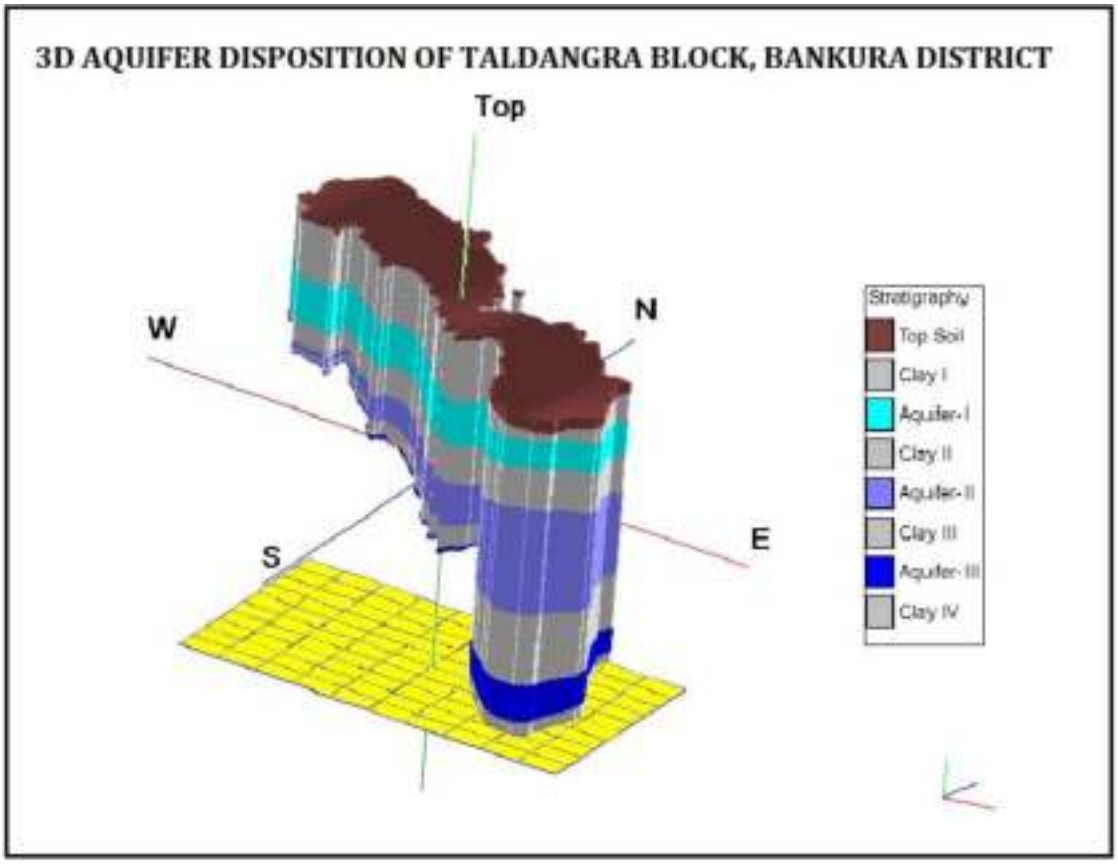


Figure *11.22*.2: 3-Dimensional Aquifer disposition in *Taldangra* Block

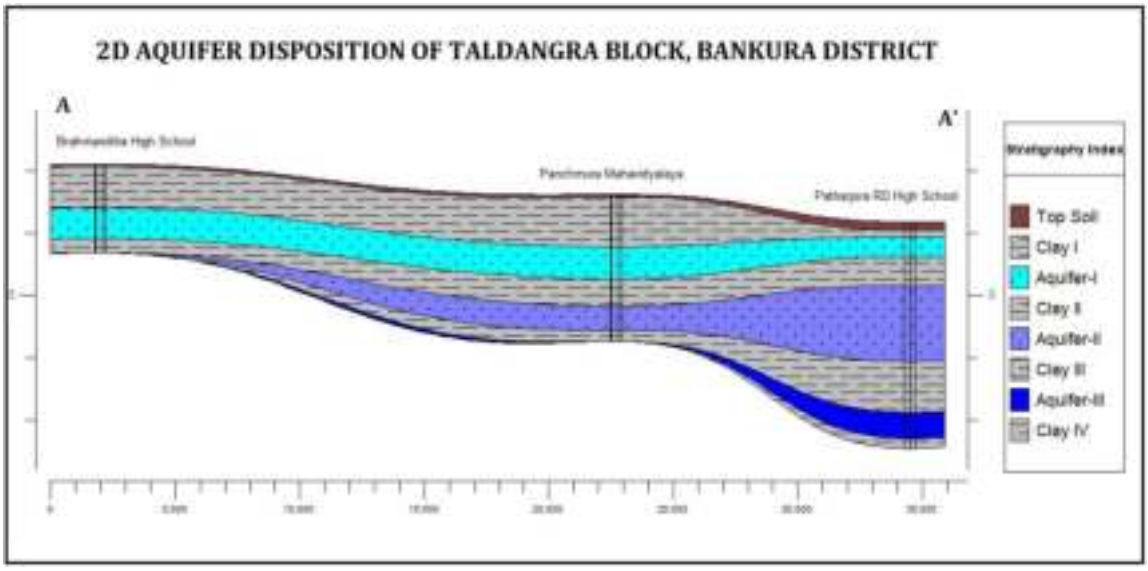


Figure *11.22*.3: 2-Dimensional Section in *Taldangra* Block

The principal aquifer systems encountered in this block is alluvial formation. Two aquifers are encountered in this block. The range of **Aquifer-I** is also known as Shallow aquifer. The range varies from 35-60 mbgl. Thickness of the granular Zone is 25m. The range of **Aquifer-II** is also known as 2nd Aquifer. The range varies from 90-109 mbgl.

Thickness of the granular Zone is 19m.

Table *11.22*.7: Details of aquifer disposition in Taldangra Block

Blocks (dominant in soft rock)	No. of Aquifers	Water bearing zone	Aquifer Thickness (m)			Discharge (lpm)	T (m^2/day)	SWL (mbgl)	Draw down (mbgl)	S
			Aquifer-I (Within 50 mbgl)	Aquifer-II (above 50 mbgl)	Aquifer-III (above 150 mbgl)					
Taldangra	2	35-60, 90-109	25	19	--	1800	--	7.9	--	--

Table *11.22*.8: Details of Aquifer Wise Water Level Ranges & seasonal long term water level trends

Block	Pre-monsoon Trend			Post-monsoon Trend		
	WL Range (mbgl)	Rise (m/year)	Fall (m/year)	WL Range (mbgl)	Rise (m/year)	Fall (m/year)
Taldangra	0.74-6.53	--	0.433	1.83-6.16	0.022	--

Ground water quality and issues:

Based on four NHS, four exploratory wells and three observation wells, the range of chemical parameter for the block is given below.

Table*11.22*. 9: Range of chemical parameters in Taldangra Block

Block	Aquifer Type	pH	EC (µS/cm)	Na (mg/l)	Cl (mg/l)	F (mg/l)	NO_3 (mg/l)	Fe (mg/l)	Measured Hardness (mg/l)
Taldangra	Aquifer-I	7.89-8.07	260-1984	12-94	10-60	0.10-0.94	2-9	0.03-0.07	105-865
	Aquifer-II	7.81-8.29	416-884	19-76	22-196	0.43-0.81	1-12	Traces	155-335

Ground Water Resource:

Table *11.22.*10: Details of Ground Water Resource Availability and Utilization in *Taldangra* Block.

Name of the Block	TALDANGRA
Total Annual Ground Water Recharge (Ham)	9882.5
Total Natural Discharges (Ham)	988.25
Annual Extractable Ground Water Recharge (Ham)	8894.25
Total Extraction	3797.91
Annual GW Allocation for Domestic Use as on 2042	199.66
Net Ground Water Availability for future use	5059.29
Stage of Ground Water Extraction (%)	42.7
Categorization (OE/CRITICAL/ SEMI-CRITICAL/ SAFE)	Safe
In storage (Ham)	81629

Aquifer Management Plan:

Ground Water Management Plan for drinking purpose:

The block has two commissioned public water supply schemes by PHED. There is one ongoing as well. However, there is still recorded deficit in supply of drinking water as the schemes do not reach to every mouza in the block. Therefore, there should be a general practice of conservation through rainwater harvesting, considering an adequate normal monsoon rainfall of 1347 mm which the block receives. The conserved rainwater can be utilized for drinking purpose by filtering through Horizontal Roughing Filters. The water from the lands can be channeled to ponds for recharge in the weathered zones and this water can be tapped through open dug wells for domestic and drinking purpose.

Ground Water Management Plan for irrigation purposes:

- Although ground water development in the block is low with stage of ground water development at 42.7%, further development should be done in planned manner to harness the additional available resource for site specific sustainable development.
- In view of low yield of the area, large diameter dug wells with adequate storage are another viable option for irrigation in favorable condition, thus creating a small command area. Owing to its distinct hydrogeology, it is evident that very less cultivable command area is created by both surface as well as groundwater.
- Modern methods of irrigation like sprinkler and drip irrigation methods are encouraged.
- Crops with low water requirement should be preferred.

In view of adequate rainfall in the area, excavation of tanks with large catchment areas, construction of check dam, nallah bunds, sub-surface dykes along the stream channels at suitable locations can be implemented to raise ground water level as well as to augment irrigation facilities.

Irrigation by surface water may be increased. In addition to surface lift from canal & surface flows, rain water harvesting may also be considered

Management Intervention through Harvesting of Surface Runoff and Artificial Recharge:

It has been that the utilizable surface runoff produced in the block is **34.451** MCM. This surface runoff is proposed to be utilized to recharge the depleted aquifer (aquifer III) in the block. As per the available storage space, **10.335** MCM water is required to fill the deeper aquifers in block. Therefore, **34** injection wells with roof top rain water harvesting structures are recommended in the block. The remaining surface runoff, **24.115** MCM is recommended to be utilized in storage tanks for generation of irrigation potential and thus, **34** percolation tanks and **69** REET with RS have been proposed.

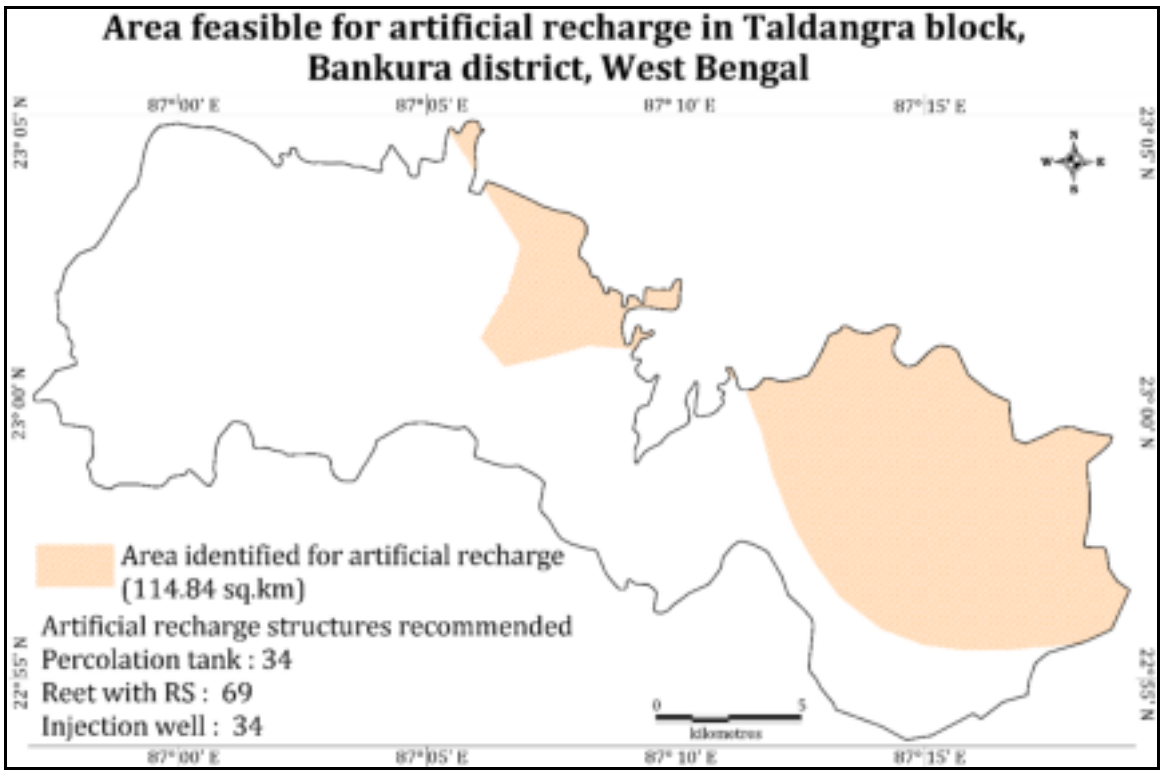


Figure *11.22.4*: Area Feasible for Artificial Recharge of groundwater for *Taldangra* Block

Table*11.22.11*: Details of structures recommended in feasible area of artificial recharge for Taldangra Block.

Name of the Block	Utilizable Surface Run Off	Allocation of Utilizable Recourse (MCM)							Structures Feasible							Cost of Structures							
		Percolation Tank	REET with RS	Injection Well	Check Dam	Gabion/Contour Bund	Sub-Surface Dyke	Dug Well Recharge	Percolation Tank	REET with RS	Injection Well	Check Dam	Gabion/Contour Bund	Sub-Surface Dyke	Dug Well Recharge	Percolation Tank	REET with RS	Injection Well	Check Dam	Gabion/Contour Bund	Sub-Surface Dyke	Dug Well Recharge	TOTAL
Taldangra	34.451	17.225	6.89	10.335	0	0	0	0	34	69	34	0	0	0	0	272	276	102	0	0	0	0	650

PART – III

CHAPTER 12

DATA GAP ANALYSIS OF BANKURA DISTRICT

12. DATA GAP ANALYSIS FOR AQUIFER MAPPING PROGRAMME IN BANKURA DISTRICT

The study area comprises Twenty-Two (22) blocks of Bankura district were considered under study. The total geographical area encompassed under the project is 6882 sq. km. The mapable area for the same is about 5864 sq. km. It is bounded by the north latitudes 22° 38' 27" and 23° 35' 50" & east longitudes of 86° 35' 58" & 87°47'42" in Survey of India toposheet Nos 73I/14,15 & 16, 73J/9, 13 & 14, 73M/2, 3, 4, 7, 8 & 12, 73N/1, 5 & 9. 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 toposheet.

12.1 Data Gap for Exploratory Wells

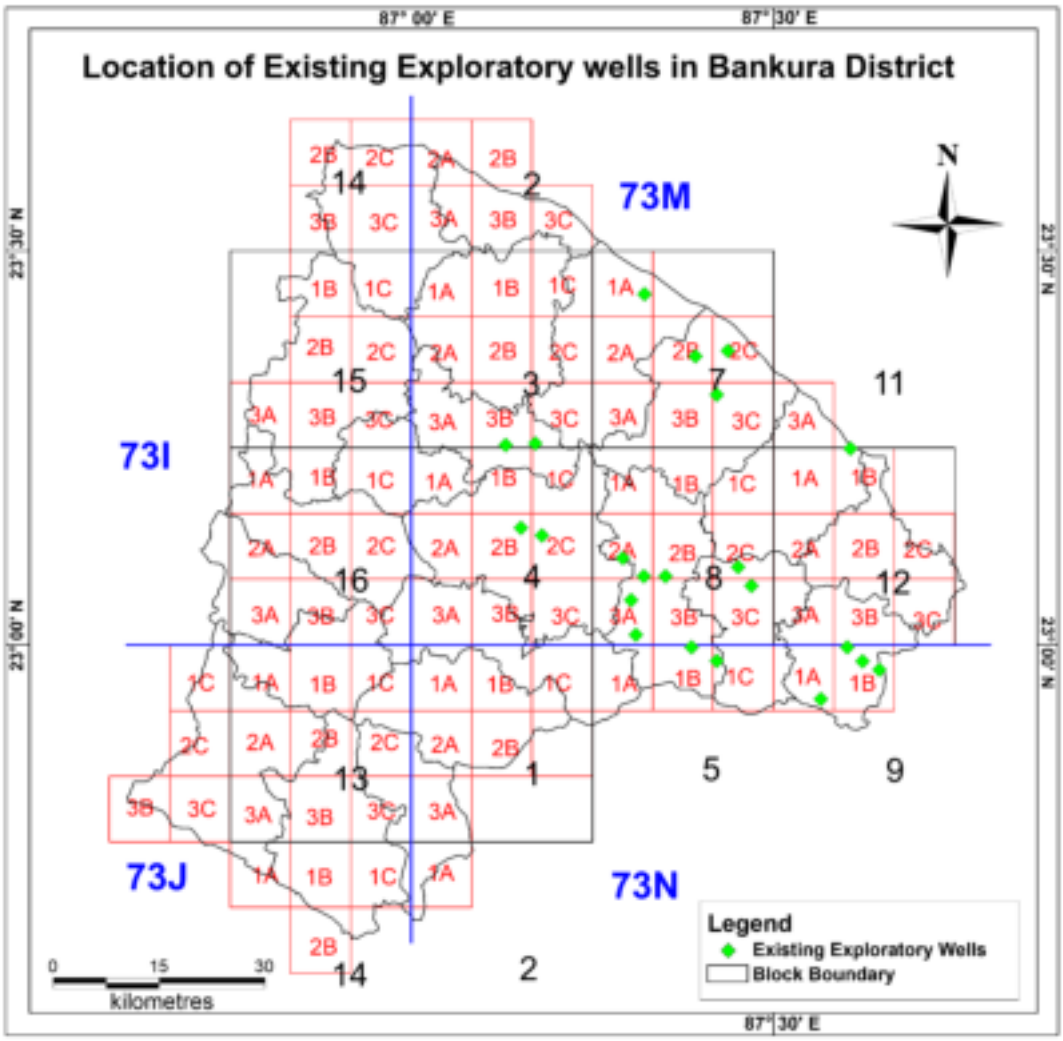


Figure12.1.1: Map of existing exploratory wells in Bankura district.

Exploratory wells constructed by CGWB, ER, Kolkata and wells outsourced by private company has been considered for the study. After plotting the existing exploratory wells and following the guidelines it is seen that a total of 48 Exploratory wells (EW) and 58 Observation wells (OW) are required in whole Bankura district tabulated in Table12.1.1.

Table 12.1.1: Table suggesting extra Exploratory wells and their depths in Bankura district.

Toposheet No.	Quadrant	No. of Additional EW/OW required	Depth of Drilling (Meters)
73I/14	2B	1 EW 1 OW	200, 200
	3C	1 EW 1 OW	200, 200
	1C	1 EW 1 OW	200, 200
	2B	1 EW 1 OW	200, 200
	3A	1 EW 1 OW	200, 200
	3C	1 EW 1 OW	200, 200
73I/15	1C	1 EW 1 OW	200, 200
	2B	1 EW 1 OW	200, 200
	3A	1 EW 1 OW	200, 200
	3C	1 EW 1 OW	200, 200
73I/16	1A	1 EW 1 OW	200, 200
	1C	1 EW 1 OW	200, 200
	2B	1 EW 1 OW	200, 200
	3A	1 EW 1 OW	200, 200
	3C	1 EW 1 OW	200, 200
73M/2	3A	1 EW 1 OW	200, 200
	3C	1 EW 1 OW	200, 200
73M/3	1A	1 EW 1 OW	200, 200
	1C	1 EW 1 OW	200, 200
	2B	1 EW 1 OW	200, 200
	3A	1 EW 1 OW	200, 200
	3C	0 EW 1 OW	200, 200
73M/4	1A	1 EW 1 OW	300, 300
	1C	1 EW 1 OW	300, 300
	2B	0 EW 2 OW	300, 300
	3A	1 EW 1 OW	300, 300
	3C	1 EW 1 OW	300, 300
73M/7	1A	0 EW 1 OW	300, 300
	2B	0 EW 2 OW	300, 300
	3A	1 EW 1 OW	300, 300
	3C	0 EW 1 OW	300, 300
73M/8	1A	1 EW 1 OW	300, 300
	1C	1 EW 1 OW	300, 300
	2B	0 EW 2 OW	300, 300
	3A	0 EW 0 OW	300, 300
	3C	0 EW 0 OW	300, 300
73M/12	1A	1 EW 1 OW	300, 300
	2B	2 EW 2 OW	300, 300
	3A	1 EW 1 OW	300, 300
	3C	1 EW 1 OW	300, 300
73J/9	1C	1 EW 1 OW	200, 200
	3C	1 EW 1 OW	200, 200
73J/13	1A	1 EW 1 OW	200, 200
	1C	1 EW 1 OW	200, 200
	2B	1 EW 1 OW	200, 200
	3A	1 EW 1 OW	200, 200
	3C	1 EW 1 OW	200, 200
73J/14	1A	1 EW 1 OW	200, 200
	1C	1 EW 1 OW	200, 200
73N/1	1A	1 EW 1 OW	300, 300
	1C	1 EW 1 OW	300, 300

	2B	2 EW 2 OW	300, 300
	3A	1 EW 1 OW	300, 300
73N/5	1A	0 EW 1 OW	300, 300
	1C	0 EW 0 OW	300, 300
73N/9	1A	1 EW 1 OW	300, 300

12.2 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 and SWID (State Water Investigation Directorate) has been combined for the study. It has been found that an extra of 66 wells tapping Aquifer- I, 49 wells tapping Aquifer-II and 26 wells tapping Aquifer-III are required for future monitoring in Bankura district shown in Figure 12.2.1.

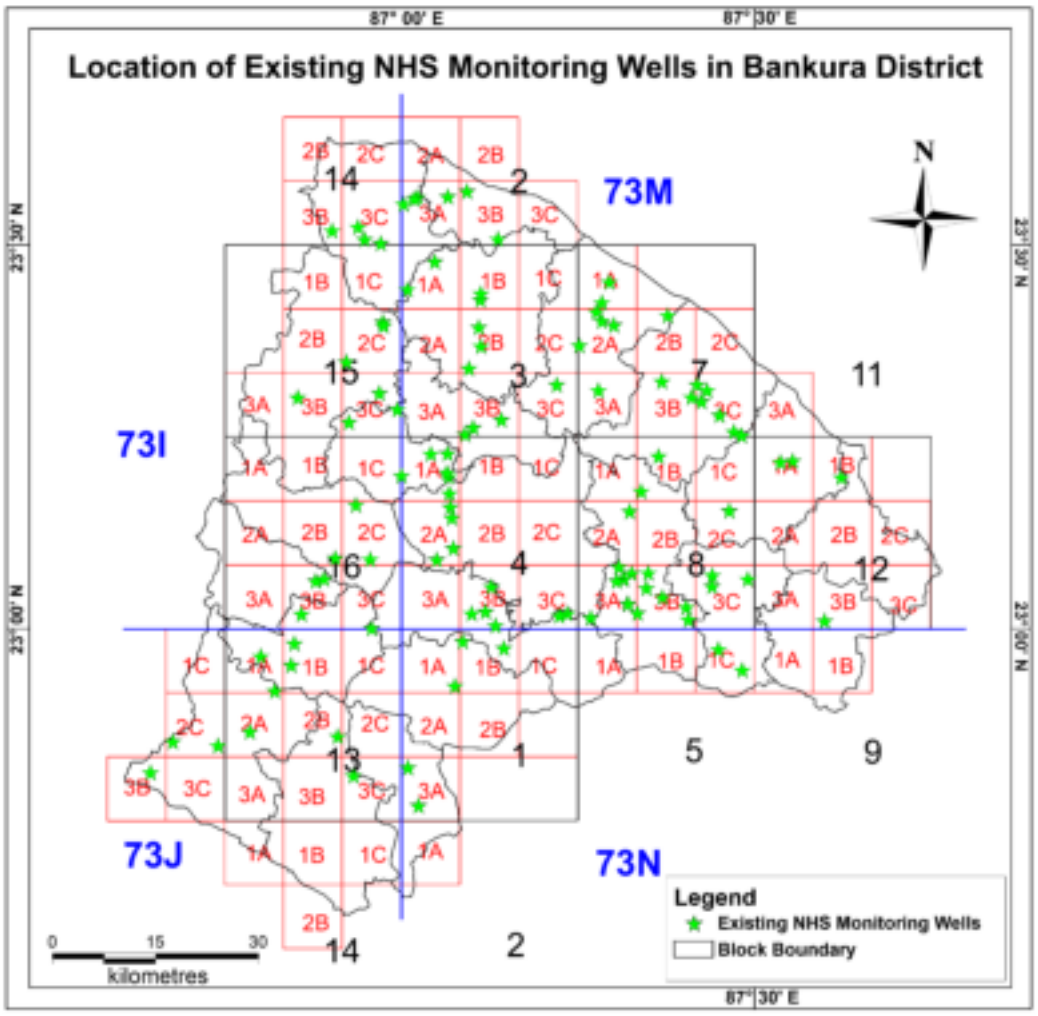


Figure 12.2:1 Map of existing NHS monitoring Wells in Bankura district.

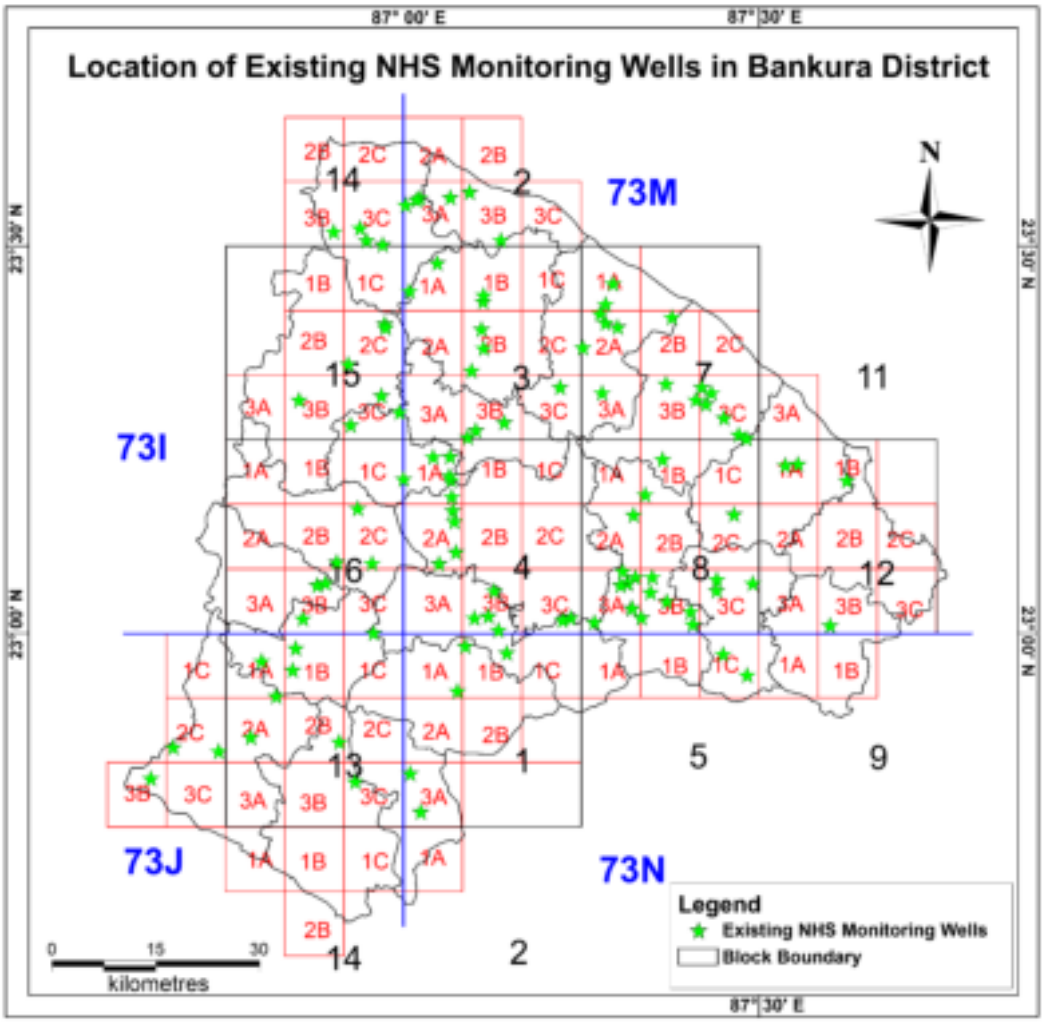
Table 12.2:1 Table suggesting aquifer wise extra key-wells in Bankura district.

Toposheet No	Quadrant	No of Additional Required Aquifer wise
73I/14	2B	Aquifer I: 1,
	2C	Aquifer I: 1,
	3C	Aquifer II: 1
73I/15	1B	Aquifer I: 1,
	1C	Aquifer I: 1, Aquifer II: 1
	2B	Aquifer I: 1, Aquifer II: 1
	3A	Aquifer I: 1, Aquifer II: 1
	3C	Aquifer II: 1
73I/16	1A	Aquifer I: 1, Aquifer II: 1
	1B	Aquifer I: 1,
	1C	Aquifer I: 1, Aquifer II: 1
	2A	Aquifer I: 1,
	2B	Aquifer II: 1
	3A	Aquifer I: 1, Aquifer II: 1
	3C	Aquifer II: 1
73M/2	3A	Aquifer II: 1
	3C	Aquifer I: 1, Aquifer II: 1
73M/3	1A	Aquifer II: 1
	1C	Aquifer I: 2, Aquifer II: 1, Aquifer III: 1
	2A	Aquifer I: 1,
	2B	Aquifer II: 1
	2C	, Aquifer III: 1
	3A	Aquifer I: 1, Aquifer II: 1
	3C	Aquifer I: 1, Aquifer II: 1, Aquifer III: 1
73M/4	1A	Aquifer II: 1
	1B	Aquifer I: 2,
	1C	Aquifer I: 2, Aquifer II: 1, Aquifer III: 1
	2B	Aquifer I: 2, Aquifer II: 1
	2C	Aquifer I: 2, Aquifer III: 1
	3A	Aquifer I: 1, Aquifer II: 1
	3C	Aquifer II: 1, Aquifer III: 1
73M/7	1A	Aquifer II: 1, Aquifer III: 1
	2B	Aquifer II: 1, Aquifer III: 1
	2C	Aquifer I: 1,
	3A	Aquifer I: 1, Aquifer II: 1, Aquifer III: 1
	3C	, Aquifer III: 1
73M/8	1A	Aquifer I: 2, Aquifer II: 1, Aquifer III: 1
	1C	Aquifer I: 1, Aquifer II: 1, Aquifer III: 1
	2B	Aquifer I: 2, Aquifer II: 1, Aquifer III: 1
	2C	Aquifer I: 1,
	3A	Aquifer II: 1, Aquifer III: 1
	3C	Aquifer II: 1, Aquifer III: 1
73M/11	2A	Aquifer I: 1, , Aquifer III: 1
73M/12	1A	Aquifer II: 1
	1B	Aquifer I: 1,
	2A	Aquifer I: 2,
	2B	Aquifer I: 2, Aquifer II: 1, Aquifer III: 1
	2C	Aquifer I: 1,
	3A	Aquifer I: 2, Aquifer II: 1, Aquifer III: 1
	3B	Aquifer I: 1,
	3C	Aquifer I: 1, Aquifer II: 1, Aquifer III: 1
	3C	Aquifer I: 1, Aquifer II: 1
73J/13	1A	Aquifer II: 1
	1C	Aquifer I: 1, Aquifer II: 1
	2A	Aquifer I: 1,
	2B	Aquifer I: 1, Aquifer II: 1
	2C	Aquifer I: 2,
	3A	Aquifer I: 1, Aquifer II: 1
	3B	Aquifer I: 2,

	3C	Aquifer I: 1, Aquifer II: 1
73J/14	1A	Aquifer II: 1
	1B	Aquifer I: 1,
	1C	Aquifer I: 1, Aquifer II: 1
73N/1	1A	Aquifer II: 1, Aquifer III: 1
	1C	Aquifer I: 2, Aquifer II: 1, Aquifer III: 1
	2A	Aquifer I: 2,
	2B	Aquifer I: 1, Aquifer II: 1, Aquifer III: 1
	3A	Aquifer II: 1, Aquifer III: 1
73N/5	1A	Aquifer I: 1, Aquifer II: 1, Aquifer III: 1
	1B	Aquifer I: 1,
	1C	Aquifer II: 1, Aquifer III: 1
73N/9	1A	Aquifer I: 1, Aquifer II: 1, Aquifer III: 1
	1B	Aquifer I: 1,

12.3 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 66 wells tapping Aquifer- I, 49 wells tapping Aquifer-II and 26 wells tapping Aquifer-III are required for future monitoring shown in Figure 12.3.1 & tabulated in Table12.3.1.



Figur12.3.1: Map of existing water quality monitoring Wells in Bankura district.

Table 12.3.1: Table suggesting aquifer wise extra water quality monitoring stations in Bankura District

Toposheet No	Quadrant	No of Additional Required Aquifer wise
73I/14	2B	Aquifer I: 1,
	2C	Aquifer I: 1,
	3C	Aquifer II: 1
73I/15	1B	Aquifer I: 1,
	1C	Aquifer I: 1, Aquifer II: 1
	2B	Aquifer I: 1, Aquifer II: 1
	3A	Aquifer I: 1, Aquifer II: 1
	3C	Aquifer II: 1
73I/16	1A	Aquifer I: 1, Aquifer II: 1
	1B	Aquifer I: 1,
	1C	Aquifer I: 1, Aquifer II: 1
	2A	Aquifer I: 1,
	2B	Aquifer II: 1
	3A	Aquifer I: 1, Aquifer II: 1
	3C	Aquifer II: 1
73M/2	3A	Aquifer II: 1
	3C	Aquifer I: 1, Aquifer II: 1
73M/3	1A	Aquifer II: 1
	1C	Aquifer I: 2, Aquifer II: 1, Aquifer III: 1
	2A	Aquifer I: 1,
	2B	Aquifer II: 1
	2C	, Aquifer III: 1
	3A	Aquifer I: 1, Aquifer II: 1
	3C	Aquifer I: 1, Aquifer II: 1, Aquifer III: 1
73M/4	1A	Aquifer II: 1
	1B	Aquifer I: 2,
	1C	Aquifer I: 2, Aquifer II: 1, Aquifer III: 1
	2B	Aquifer I: 2, Aquifer II: 1
	2C	Aquifer I: 2, , Aquifer III: 1
	3A	Aquifer I: 1, Aquifer II: 1
	3C	Aquifer II: 1, Aquifer III: 1
73M/7	1A	Aquifer II: 1, Aquifer III: 1
	2B	Aquifer II: 1, Aquifer III: 1
	2C	Aquifer I: 1,
	3A	Aquifer I: 1, Aquifer II: 1, Aquifer III: 1
	3C	, Aquifer III: 1
73M/8	1A	Aquifer I: 2, Aquifer II: 1, Aquifer III: 1
	1C	Aquifer I: 1, Aquifer II: 1, Aquifer III: 1
	2B	Aquifer I: 2, Aquifer II: 1, Aquifer III: 1
	2C	Aquifer I: 1,
	3A	Aquifer II: 1, Aquifer III: 1
	3C	Aquifer II: 1, Aquifer III: 1
73M/11	2A	Aquifer I: 1, , Aquifer III: 1
73M/12	1A	Aquifer II: 1
	1B	Aquifer I: 1,
	2A	Aquifer I: 2,
	2B	Aquifer I: 2, Aquifer II: 1, Aquifer III: 1
	2C	Aquifer I: 1,
	3A	Aquifer I: 2, Aquifer II: 1, Aquifer III: 1
	3B	Aquifer I: 1,
	3C	Aquifer I: 1, Aquifer II: 1, Aquifer III: 1
	3C	Aquifer I: 1, Aquifer II: 1
73J/13	1A	Aquifer II: 1
	1C	Aquifer I: 1, Aquifer II: 1
	2A	Aquifer I: 1,
	2B	Aquifer I: 1, Aquifer II: 1
	2C	Aquifer I: 2,
	3A	Aquifer I: 1, Aquifer II: 1

	3B	Aquifer I: 2,
	3C	Aquifer I: 1, Aquifer II: 1
73J/14	1A	Aquifer II: 1
	1B	Aquifer I: 1,
	1C	Aquifer I: 1, Aquifer II: 1
73N/1	1A	Aquifer II: 1, Aquifer III: 1
	1C	Aquifer I: 2, Aquifer II: 1, Aquifer III: 1
	2A	Aquifer I: 2,
	2B	Aquifer I: 1, Aquifer II: 1, Aquifer III: 1
	3A	Aquifer II: 1, Aquifer III: 1
73N/5	1A	Aquifer I: 1, Aquifer II: 1, Aquifer III: 1
	1B	Aquifer I: 1,
	1C	Aquifer II: 1, Aquifer III: 1
73N/9	1A	Aquifer I: 1, Aquifer II: 1, Aquifer III: 1
	1B	Aquifer I: 1,

12.4 Data Gap for Geophysical studies (VES)

CGWB has not carried out TEM in Saltora block of Bankura district. Additional 261 no. of VES/TEM is suggested to carry out in the whole block. The details of numbers of VES/TEM required is explained quadrant wise in the following table 12.4.1 and shown in Figure 12.4.1.

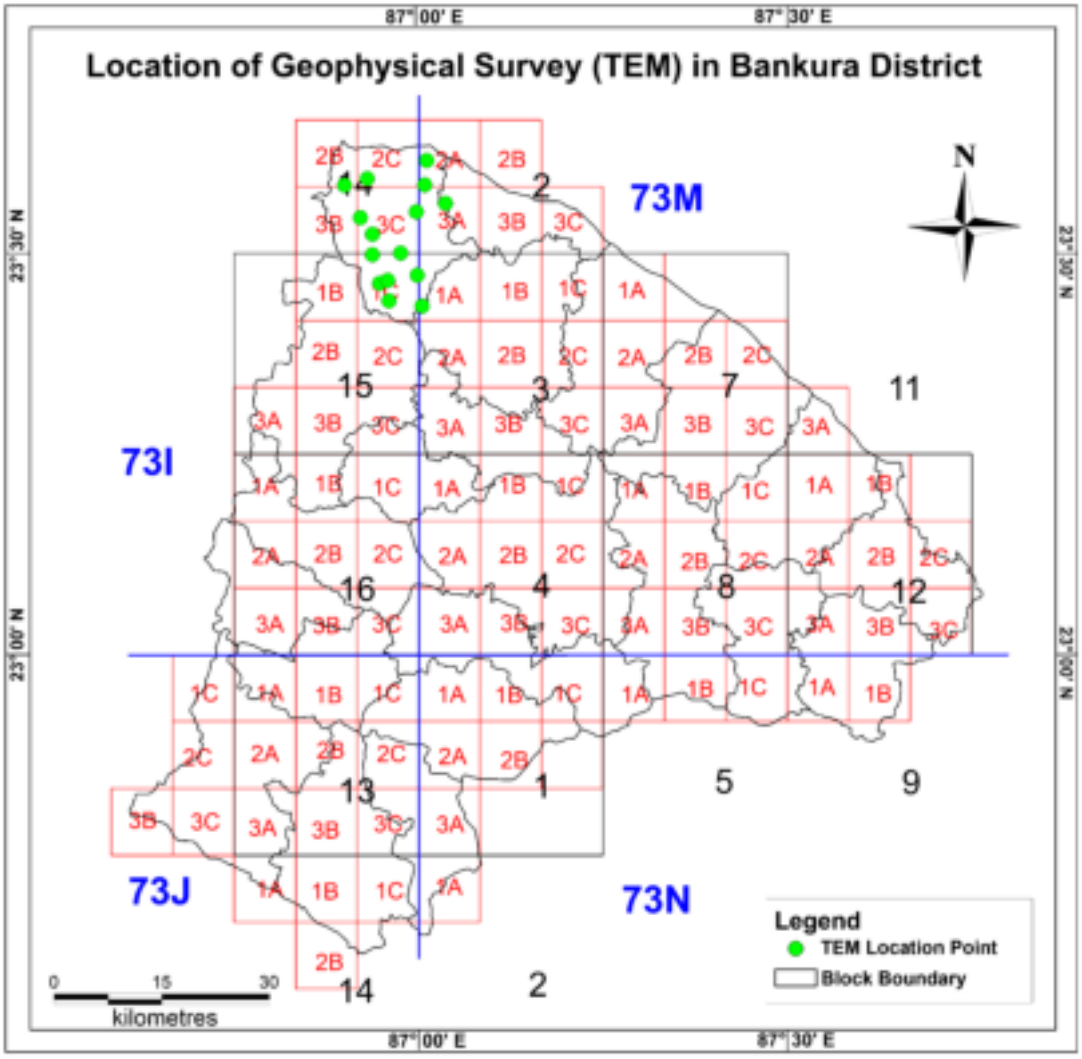


Figure12.4.1: Map of location of TEM survey in Bankura district.

Table 12.4.1: Table suggesting no. of VES/TEM stations in Bankura District

Toposheet No.	Quadrant	No. of Additional VES/ TEM required Quadrant wise
73I/14	2B	0
	2C	0
	3B	0
	3C	0
73I/15	1B	3
	1C	0
	2B	3
	2C	3
	3A	3
	3B	3
	3C	3
73I/16	1A	3
	1B	3
	1C	3
	2A	3
	2B	3
	2C	3
	3A	3
	3B	3
	3C	3
73M/2	3A	0
	3B	3
	3C	3
73M/3	1A	3
	1B	3
	1C	3
	2A	3
	2B	3
	2C	3
	3A	3
	3B	3
	3C	3
73M/4	1A	3
	1B	3
	1C	3
	2A	3
	2B	3
	2C	3
	3A	3
	3B	3
	3C	3
73M/7	1A	3
	2A	3
	2B	3
	2C	3
	3A	3
	3B	3
	3C	3
73M/8	1A	3
	1B	3
	1C	3
	2A	3
	2B	3
	2C	3
	3A	3
	3B	3
	3C	3

73M/11	2A	3
73M/12	1A	3
	1B	3
	2A	3
	2B	3
	2C	3
	3A	3
	3B	3
	3C	3
73J/9	1C	3
	2C	3
	3B	3
	3C	3
73J/13	1A	3
	1B	3
	1C	3
	2A	3
	2B	3
	2C	3
	3A	3
	3B	3
	3C	3
73J/14	1A	3
	1B	3
	1C	3
73N/1	1A	3
	1B	3
	1C	3
	2A	3
	2B	3
	3A	3
73N/5	1A	3
	1B	3
	1C	3
73N/9	1A	3
	1B	3

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