केन्द्रीय भूमि जल बोर्ड

जल संसाधन, नदी विकास और गंगा संरक्षण विभाग, जल शक्ति मंत्रालय

भारत सरकार

Central Ground Water Board Department of Water Resources, River Development and Ganga Rejuvenation,Ministry of Jal Shakti

Government of India

AQUIFER MAPPING AND MANAGEMENTOF GROUND WATER RESOURCES

IN PARTS OF PURBA BARDHMAN & PASCHIM BARDHAMAN DISTRICT WEST BENGAL

पूर्वी क्षेत्र, कोलकाता

Eastern Region, Kolkata

CONTRIBUTORS

Data Acquisition	**:** Bibhuti Bhusan sahu (Scientist-B) & Tapas Kumar Sahoo (AHG)
Data Processing	**:** Bibhuti Bhusan sahu (Scientist-B) & Tapas Kumar Sahoo (AHG)
Data Compilation & Editing	**:** Bibhuti Bhusan sahu (Scientist-B) & Tapas Kumar Sahoo (AHG)
Data Interpretation	**:** Bibhuti Bhusan sahu (Scientist-B) & Tapas Kumar Sahoo (AHG)
Chemical Analysis & Interpretation	: Atalanta Narayan Chowdhury, Asstt. Chemist
GIS & Thematic Map Preparation	**:** Bibhuti Bhusan Sahu (Scientist-B) & Tapas Kumar Sahoo (AHG) Mahashweta Mukherjee (YP) Rajyashree Nandi (YP)
Report Compilation	**:** Bibhuti Bhusan sahu (Scientist-B) & Tapas Kumar Sahoo (AHG)
Technical Guidance	**:** Sandhya Yadav (Scientist-E) Dr. Indranil Roy (Scientist-)
Overall Supervision	**:** Dr. Anadi Gayen(Scientist-E)

FOREWORD

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

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

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

Compilation of this report, evaluation of data and preparation of relevant maps, 2D cross-sections & 3D models of aquifers and their reproduction in the form of present report is outcome of the efforts given by Shri Bibhuti Bhusan Sahu, Scientist-B and Shri Tapas Kumar Sahoo, AHG, Central Ground Water Board, Eastern Region, Kolkata.

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

(Dr Anadi Gayen)
Scientist E & H.O.O

EXECUTIVE SUMMARY

The total geographical area encompassed under the project is 3070 sq. km. The mapable area for the same is about 2974 sq. km. The study rea comprises of 13 blocks (11 blocks of Purba Bardhamn and 2 blocks of PaschimBardhaman district). The study area can be located in Survey of India Toposheet No.- 73M/10, 73M/11, 73M/12, 73/14,73M/15, 73M/16, 73N/13, 79A/1, 79A/2, 79 A/4, 79A/5, 79A/6, 79A/7, 79A/8, 79B/1, 81A/3,75M/13, 73M/1, 73M/2, 73M/6, 73M/7, 73I/13, and 79I/14. The district head quarter of Purba Bardhhaman is at Bardhhaman, with 4 subdivision and 6 Municipality. Paschim Bardhhaman is known for its industrial infrastructure and mining. The district head quarter of Paschim Bardhhaman is at Asansol with 2 subdivision and 2 Municipal Corp.The total population of the study area is 3228368 as per 2011 Census with rural population accounting for almost 67% and the rest 33% 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 30 °C to 45 °C in the month of May and June while minimum temperature varies from 10 °C to 14 °C during December and January. The normal rainfall of the study area is from 1381 mm. About 80% of rainfall occurs during monsoon and the rest 20% occurs during non-monsoon.The study area consists of two major physiographical divisions viz. Low dissected plateau interspersed with hillocks, mounds most area of in Paschim Bardhhaman and Alluvial plain with meander plain in Purba Bardhhaman area. The general slope of the district is from North West to southeast. The river system in Bardhaman includes the Bhagirathi-Hooghly in the east, the Ajoy and its tributaries in the north and the Damodar and its branches in the south-west. Besides, there are innumerable Khals and old riverbeds all over the area. The major soil types of this area are gangetic soil, vindhyan and Red lateritic soil.

Important crops grown in the district are paddy (*Aus, Aman* and *Boro*), potato, Til, jute, mustard, etc. 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 of 853 RLI, 616 DTW, 22 DW and 15530 STW as sources for irrigation in the district. There is a large-scale industrial infrastructure developed in Asansol area but in most of the study area, there is no large-scale industries as such except for some small-scale industries.

The most area of the Purba Barddhaman district forms a part of the alluvial terrain of the Damodar Basin, which occupies a part of southwestern shelf area of Bengal Basin. As per GSI studies described the delta building processes of the Bardhaman area and identified three terraces in the area viz. (i) the Orgram terrace, (ii) the Kushumgram terrace and (iii) the Kalna terrace. Study of subsurface geology based on correlation of lithologs reveals the existence of Gondwana rocks at the shallower depth (34-40mbgl) at Parulia, which gradually slopes towards east, occurs within the depth of 129mbgl at Kanksa and 108mbgl at shibpur, and ceases to exist beyond Panagarh. Recent studies by different departments have established the extension of Gondwana basin around Durgapur where it forms a sub basin known as Durgapur –sub basin. Unconsolidated formations of Quaternary and Tertiary age groups are Recent alluvium and Older alluvium, which were deposited in the Bengal basin to the east of Gondwana basin and composed of sand, silt, and clay.

In the present study area, CGWB, ER has not conducted any surface geophysical survey. However, a total of 18 VES and 2-resistivity logging by UPTRON logger was carried out in exploratory boreholes up to a depth of 300 meters.

From hydrogeological point of view, the the study areacan be divide in to two groups namely Semi-consolidated Gondwana sediments and Unconsolidated Tertiary and Quaternary sediments. It is observed groundwater within weathered zone, which is limited to around 20 m depth, occurs under unconfined condition and at deeper levels, it occurs under semi-confined and confined condition. Panchet formation is one of the important hydrogeological units in Asansol block. Around Asansol within Panchet formation at a few sites namely Kanyapur and Ramkrishna Mission groundwater exploration down to a depth of 122m confirmed the absence of water yielding fractures, discharges from the bore wells are around $3m^3$/hr. In the southeastern part of the study area underlain by older alluvium, laterite, Tertiary and Quaternary sediments, groundwater occurs under unconfined conditions within a maximum depth of 70 mbgl. It is observed around Bud Bud and Galsi a layer of gravel with thickness in the range of 9 to 15m occur within shallow aquifer. Around Bud Bud the thickness of aquifers with in the explored depth of 250m is about 110m. The deeper sand zone splits up into several sand layers separated by clay/sandy clay layers constitutes the deeper aquifers. The cumulative thickness of the deeper aquifers varies from 7m in the west to 22m found to be in confined condition and the recharge zones lie at the western marginal ridge area. .The aquifers in the study area can be broadly categorized as Shallow aquifers (Aquifer-I) and Deeper aquifers (Aquifer-II & III). The cumulative thickness varies from 6-41m. The discharge from the aquifers range from 522-64200 lpm. Transmissivity value range from 2.446–186.32 m^2/day. The depth to water level range for Aquifer-I varies from 1.65-19.8 m and Aquifer-II range varies from 7.38-23.79m during the pre-monsoons. The post-monsoon variation for Aquifer-I is from 0.67-18.24 m and 1.68-17.17 m for Aquifer-II respectively

As per the computation, the net ground water availability for recharge for Dakshin Dinajpur district is estimated at 163192.38Ham, while the total extraction for all uses is estimated at 70945.53Ham.The total in-storage for the district is 1267086 MCM. The stage of ground water development in the district stands at 53.12%, deemed as 'Safe'. At present, all the 13 blocks in the study area are 'Safe' category except Raina-II block which declared as a' Semi critical' block with a stage of groundwater development 89%. From the chemical analysis of the samples collected from the study area shows that all the chemical parameters are under permissible limit, Except at few instances of Asansol and Raina-I where the the EC Value goes above 500 µS/cm.
At present, all the 12 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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PART – I

AQUIFER MAPPING & MANAGEMENT PLAN PARTS OF PURBA AND PASCHIM BARDHAMAN DISTRICT (13 NO. OF BLOCK)

CHAPTER-I

INTRODUCTION

The State of West Bengal blessed with huge thickness of unconsolidated and semi consolidated formation, which accounts for its substantial ground water resource. Abundant land and water resource, rich and fertile soils, intensive agriculture activities and high population density characterise the alluvial parts of the State. The geological set up and the Palaeo-depositional environment of the area control the occurrence and distribution of the sediments. Multi-layered aquifer systems are very much significant in the area. The fluviatile sediments forming the fresh water aquifers deposited by the ancient river systems has been subjected to multiple marine transgression and regression from sea to inlands, which resulted in erosion, redistribution and re-deposition of sediments. Thus, it created a system of complex, continuous or discontinuous disposition of aquifers with widely varying hydraulic characters and water quality.

Groundwater is one of the prime sources of fresh water contributing significantly for the survival of humankind. 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 taken up by CGWB under XIIthPlan. As per the annual action plan, groundwater management studies in 13 blocks of Purba and Paschim Bardhaman district have been taken up by CGWB, ER, Kolkata. In these report 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 has covered.

National Aquifer Mapping and Management Programme (NAQUIM) of Central Ground Water Board (CGWB) has been envisaged to focus on the aquifer geometry, occurrences, availability of ground water resources and quality and to formulate management plan of the individual aquifer system for the sustainable development.

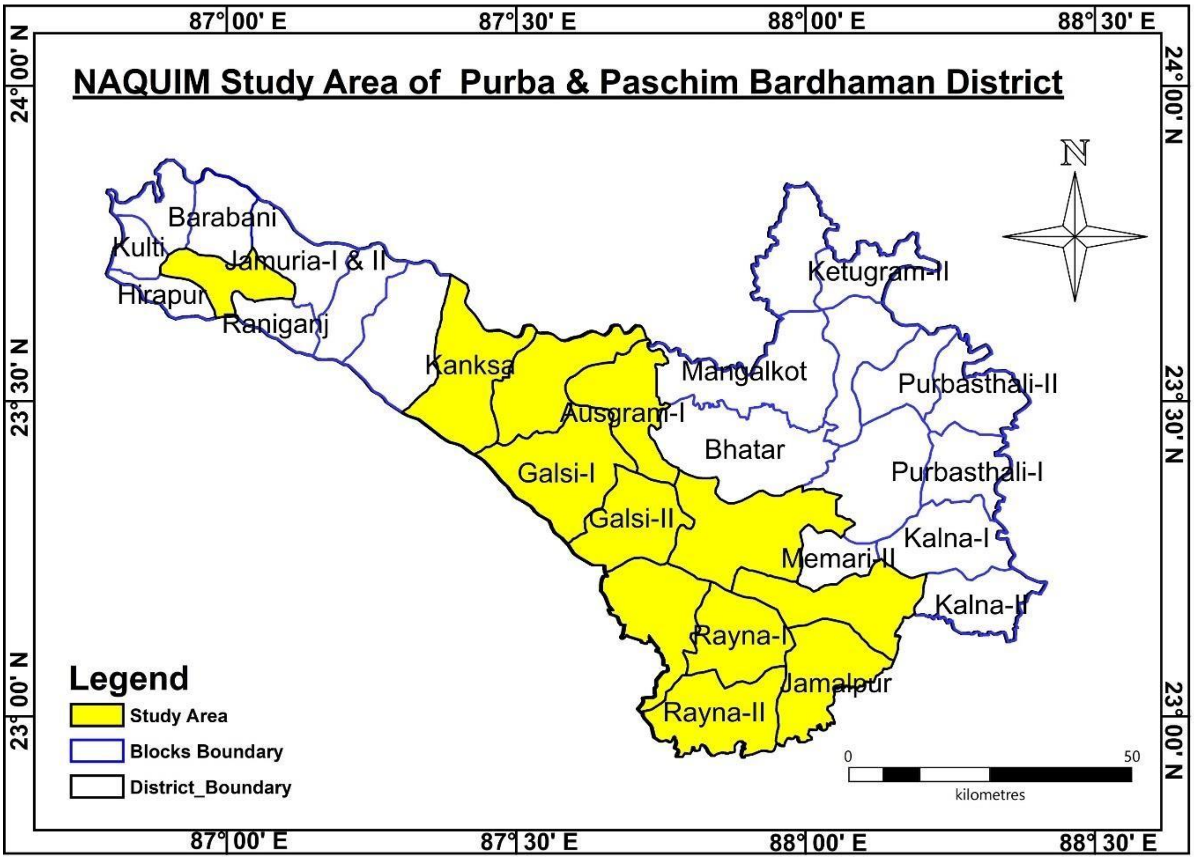


Fig.1.1 Blocks under NAQUIM study area

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 hydrogeolgocial 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.

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 to achieve the major objective have been shown below step-wise.

I. Compilation of existing data

II. Identification of data gaps

III. Data generation based on data gaps

IV. Preparation of thematic maps on GIS platform

V. Preparation of 2D/3D aquifer disposition maps

VI. Compilation of Block-wise Aquifer Maps and Management Plan.

PurbaBardhaman

PurbaBardhaman district is a flat alluvial plain area that divided into four prominenttopographical regions. On the northern part of the district, Ausgram - Ketugram plain lies along the Ajoywhich joins the Bhagirathi. Bardhaman plain occupies the central area of thedistrict with the Damodar River on the south and south–east, on the southern part is theKhandoghosh plain. The Bhagirathi flows along the eastern boundary of the district and theBhagirathi basin lies on the eastern part of the district. The undulating lateritic topography ofPaschim Bardhaman extended up Ausgram area of the district.

The district can be located in Survey of India Toposheet No.- 73M/10, 73M/11, 73M/12, 73/14,73M/15, 73M/16, 73N/13, 79A/1, 79A/2, 79 A/4, 79A/5, 79A/6, 79A/7, 79A/8, 79B/1, 81A/3, and75M/13.

Paschim Bardhhaman

Paschim Bardhaman district is the 23rd district of West Bengal. It was formed on 7th April, 2017 bifurcated from the erstwhile Bardhaman district. The total geographical area of the district is 1603.17 sq. km. The district comprises of two subdivisions viz., Asansol Sadar and Durgapur. The co-ordinates of Asansol subdivision are 23.68°N and 86.990E. The other subdivision, Durgapur is located at 23.48° North latitude, and 87.32° East longitude. The agrarian part of Bardhaman now fall under PurbaBardhaman, while the industrial hub is in West Bardhaman. Asansol is the divisional as well as District Headquarters. It is the second largest city in West Bengal after Kolkata and 39th largest urban agglomeration in India. Durgapur, the Divisional Headquarters is the third largest urban agglomeration in West Bengal and happens to be the second planned city of India after Chandigarh. Durgapur is by far the most industrialized city in eastern India.

The district can be located in Survey of India Toposheet No.- 73M/1, 73M/2, 73M/6, 73M/7, 73I/13, 79I/14.

1.3 Location, Extent & The Accessibility:

Purba Bardhhaman district extends from 23º53’ N to 22º56’N Latitude and 88º25′ E to 87º56’E Longitude. Lying within Burdwan Division, the district is bounded on the north by Birbhum and Murshidabad, on the east by Nadia, on the south by Hooghly and Bankura, and on the west by Paschim Bardhaman districts.

Accessibility:

The area is connected with Calcutta by the main line of Eastern Railway in which Brahman is a very Important Railway junction. The Grand-Trunk Road or National Highway no.2 is also running from one end of the area. The block offices like Rayna, Khandaghosh, Jamalpur etc. are connected with Bardhaman by state roads but the village roads and cart tracks are poorly developed in the area thus making the accessibility to the villages poor

1.4 Administrative Divisions and Population

Table 1.1: Administrative division of the study area with Geographical and mappable area

District	Sub-Division	Block Name	Geographical Area	Mappable Area
PURBA BARDDHAMAN	Burdhaman Sub-Division(S)	JAMALPUR	254	241
		Khandaghosh	193	165
		Memari-I	194	194
		Raina-I	241	208
		Raina-II	276	276
	Burdhaman Sub-Division(N)	Ausgram-I	211	211
		Ausgram-II	342	342
		Burdwan-I	252	252
		Burdwan-II	189	189
		Galsi-I	253	253
		Galsi-II	227	227
PASCHIM BARDDHAMAN		ASANSOL	155	147
		KANKSA	283	269

Table 1.2: Major Administrative Divisions of the study area including the Municipal areas (as per Census 2011)

Sub-Division	C.D.Block / M.C. / M	Panchayat Samity	Panchayat Gram	Panchayat Gram Sansad	Mouzas* -2001	Inhabited Villages* -2011	House-holds* -2011
Purba Badhaman							
Burdwa Sub-Division (N)	Burdwan(M)	-	-	-	-	-	71618
	Burdwan-I	1	9	162	80	75	49695
	Burdwan-II	1	9	116	89	83	36438
	Ausgram-I	1	7	92	61	58	29197
	Ausgram-II	1	7	113	106	102	37011
	Galsi-I	1	9	141	87	85	44656
	Galsi-II	1	9	116	73	73	35615
	Total	6	50	740	496	476	304230
Burdwa Sub-Division (S)	Memari-I	1	10	171	113	111	51148
	Memari(M)	-	-	-	-	-	9638
	Jamalpur	1	13	205	123	121	62889
	Raina-I	1	8	139	113	110	40787
	Raina-II	1	8	119	94	87	33973
	Khandaghosh	1	10	143	111	107	42911

	Total	5	49	777	554	536	276405
Paschim Bardhaman							
Assansol (MC)	Assansol						
Durgapur	Kanksa	1	7	119	86	81	30367
Total		**13**	**106**	**1639**	**1136**	**1093**	**611002**

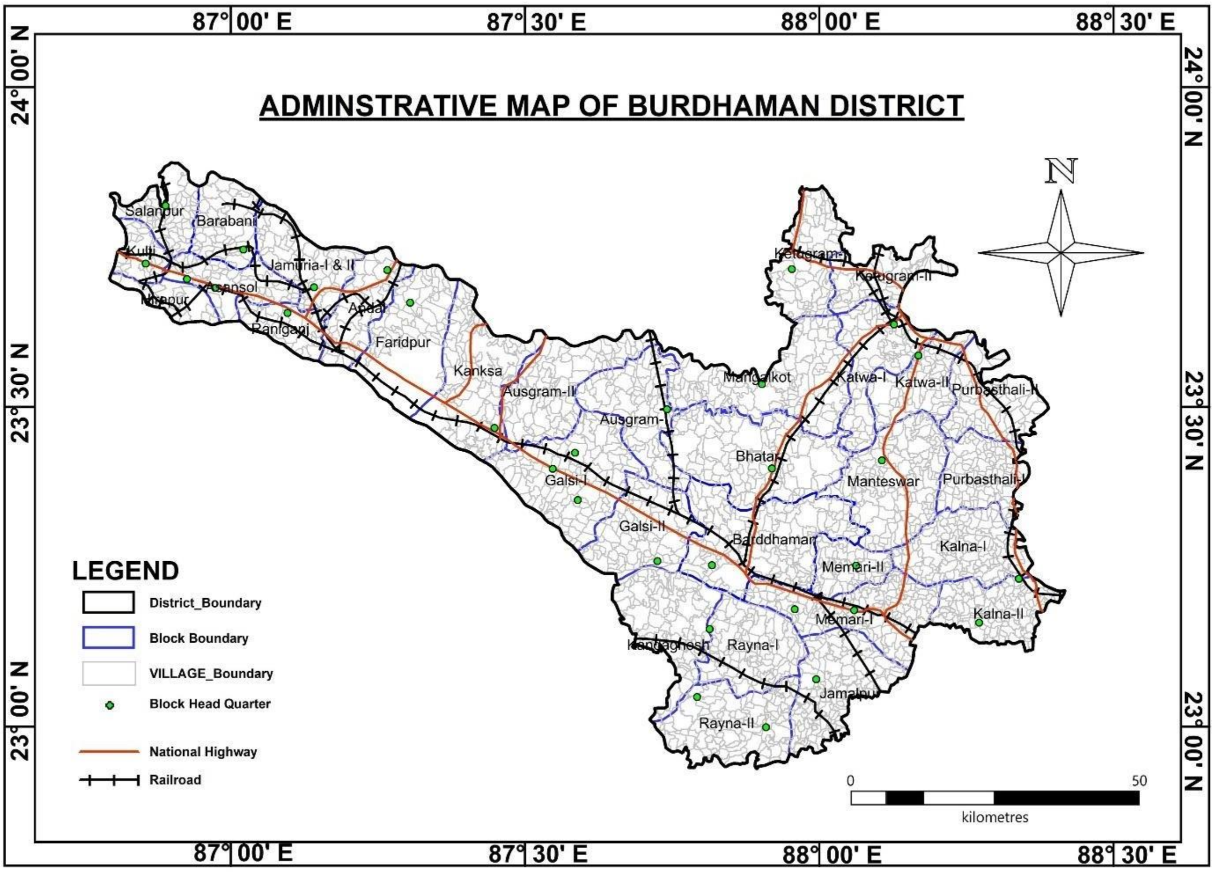


Fig.1.2 District administrative map of the study are

Table 1.3 Population Detail in the Study Area (as per Census 2011)

Block / M.C. / M	Rural Population			Urban Population			Total Population			Population Denity Per Sqkm
	Male	Female	Total	Male	Female	Total	Male	Female	Total	
Purba Bardhaman										
Burdwan-I	89471	86365	175836	20370	19737	40107	109841	106102	215943	862
Burdwan-II	74013	72579	146592	3263	3084	6347	77276	75663	152939	807
Burdwan(M)	-	-	-	159936	154329	314265	159936	154329	314265	13640
Ausgram-I	60521	58842	119363	-	-	-	60521	58842	119363	537
Ausgram-II	77184	73712	150896	-	-	-	77184	73712	150896	419
Galsi-II	74751	72426	147177	-	-	-	74751	72426	147177	672
Galsi-I	84915	79552	164467	11840	11281	23121	96755	90833	187588	729
Memari-I	108465	105540	214005	2247	2173	4420	110712	107713	218425	1169
Memari-II	76500	73752	150252	-	-	-	76500	73752	150252	804
Memari(M)	-	-	-	20957	20494	41451	20957	20494	41451	2824
Jamalpur	134529	131809	266338	-	-	-	134529	131809	266338	1013
Raina-I	88396	84698	173094	3996	3862	7858	92392	88560	180952	680
Raina-II	77538	73863	151401	-	-	-	77538	73863	151401	666
Khandaghosh	97092	92244	189336	-	-	-	97092	92244	189336	714
Paschim Bardhaman										
Asansol (MC)				292387	271530	563917	292387	271530	563917	4410
Kanksa	53213	50381	103594	38137	36394	74531	91350	86775	178125	637

As per census 2011, a majority of population resides in rural area. The total rural population in study area is around 2152351 that is 68% of the total population. The rest 32% around 1076017 lives in urban areas. About 59% of the total working population is involved in agricultural sector.

Land use, Agriculture and Irrigation

Land use:

Land use over an area is greatly dependent upon socio-economic factor. The study area has reporting area of about 119,565 hectares covering the Barddhaman .The net sown area is about 38% covering Paschim Barddhaman blocks. No forest area is recorded from the Paschim Barddhaman blocks. There are very less areas under barren and uncultivable lands and permanent pastures and grazing land. The details of the land utilization under study area are shown through the table below.

Table 1.4 Block-wise details of Land-use pattern (Source- West Bengal Land use Land cover Department)

Name of the block	Reporting area (Ha)	Forest area	Area under non-agriculture wastes	Area under Agriculture				Barren and un-culturable lands	Permanent pastures and grazing lands	Land under misc. tree crops	Culturable wastes	Fallow land Other than current fallow	Current fallow
				Gross cropped Area	Net Sown Area	Area Sown More than once	Crop Intensity %						
Burdwan-I	26272	16	7911	56565	18240	24165	177	-	-	14	68	17	6
Burdwan-II	18686	0	4990		13679			15	2	-	-	-	-
Ausgram-I	24374	3190	5544	30087	15538	10385	194	-	-	30	66	1	5
Ausgram-II	35594	10926	3279	29110	21116	4630	138	-	-	81	158	34	-
Galsi-I	24706	-	7015	31406	17687	14391	178	-	-	4	-	-	-
Galsi-II	21632	108	3200	40559	18307	21779	222	-	-	17	-	-	-
Memari-I	19474	-	7628	49884	11836	32884	421	-	-	10	-	-	-
Memari-II	18664	-	4165	32549	14318	16020	227	144	-	36	1	-	-
Jamalpur	26358	-	6729	50063	19483	28863	257	-	2	40	104	-	-
Raina-I	25597	-	4200	47151	21286	25651	222	-		30	80	-	1
Raina-II	22484	47	3100	30325	19246	12323	158	22	4	30	35	-	
Khandaghosh	26416	-	6200	37338	20210	13817	185	-	-	3	3	-	-
Kanksa	27582	8249	9675	17187	9460	2837	188	18	-	5	155	20	-
Asansol	-	-	-	-	-	-	-	-	-	-	-	-	-

A) Forest:

The forest zones of the district are situated in the lateritic and red soil uplands in the Asansol subdivision. Up to the middle of 19th century, the region was intact from any kind of significant development due to its uncultivable red lateritic soil with dense and wild impenetrable jungles. The detection of presence of coal in the 18th century led to industrialization of the western part of the subdivision. Most of the forests in the western part of the subdivision have been cleared but in the eastern part, some still exist in Kanksa and its adjoining Faridpur-Ukhra area. Kanksa Block accounts for 67.20% i.e 8249ha of the total notified forest area of the district and divided in to 5 forest beats. Ramnabagan Wildlife Sanctuary is spread over a part of this forest. The forests of West Bardhaman district mainly comprises of Sal and Kendu trees. Besides these, Mohua, Palas, Simul, Neem, Shireesha, Arjun and Ashan are also available. The main forest products are timber, kendu leaves and fuel. The aggregate forest area of West Bardhaman is 17586ha including plantation and notified forest area is 10068ha. In Purba Bardhaman, district 23278ha of area under forestland out of which 16,292 ha and 2,991ha declared as Protected Forest and Reserve Forest restively, rest 3,994 ha are remain Unclassed State Forest.

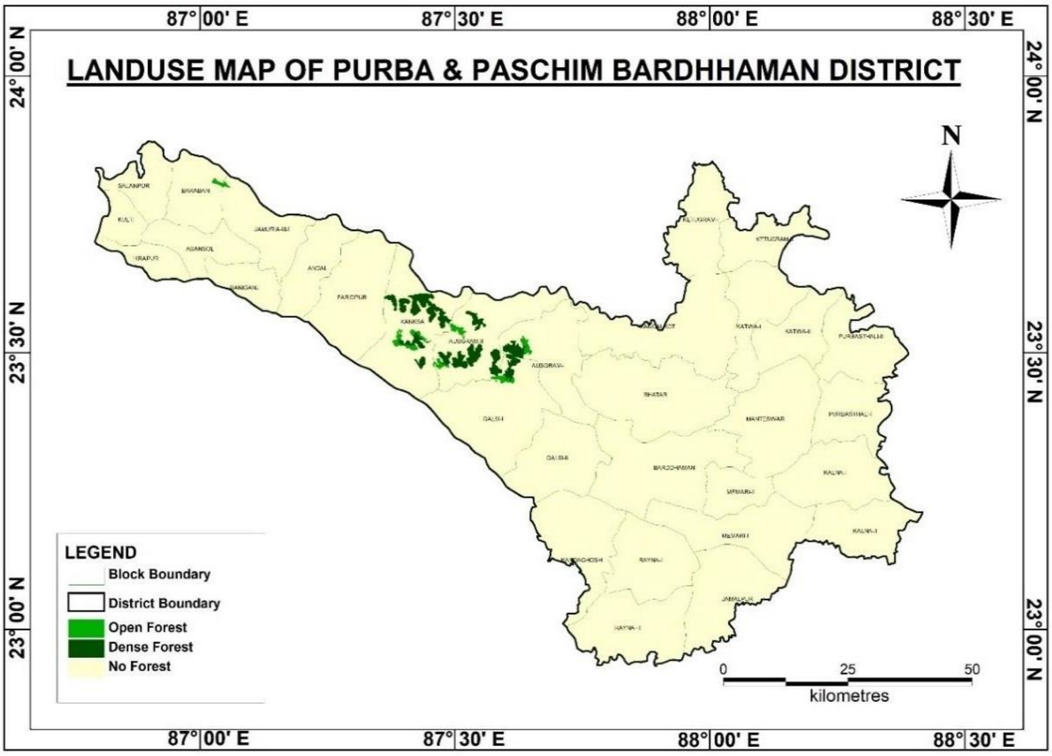


Fig.1.3: Landuse & Land Cover map of Purba & Paschim Bardhaman District.

B) Agriculture & Irrigation:

As of 2014-15 the total grossed cropped area of the district is 77735 hectares, the non-agricultural land is 62998 hectares, and the cultivable barren land is 2202 hectares [District Industrial Profile, 2017-2018, Paschim Bardhaman, Ministry of MSME, Govt. of India]. As per current scenario the total grossed cropped area of the district is 452224 Ha, the non-agricultural land is 73636ha. On an average about 58% of the total population belongs to the agricultural population while the non-agricultural sector accounts for the remaining 42 percent. The eastern, northern, southern and central areas of the district are extensively cultivated but the soils of the western portion being extreme lateritic type are unfit for cultivation except in the narrow valleys and depressions having rich soil. Rice is the most important crop of the district and covers maximum of the gross cropped area and commercial crops like jute, sugarcane, potato and oilseeds are also widely cultivate in this area.

Major cropping patterns of Bardhaman district includes paddy, wheat, vegetables, paddy, potato, sesame, paddy, vegetable, mustard, jute etc. Irrigation is the application of controlled amounts of water to plants at needed intervals. Irrigation helps to grow agricultural crops, maintain landscapes, and re-nutritioning the sequestrated soils in dry areas and during dry periods and/or the time of less than average rainfall.. The major sources of irrigation in the district are ponds, dug wells, LI points, drift/shallow tube wells, rivers, creeks and canals [District Disaster Management Plan, 2015-2016]. As per “Agriculture Contingency Plan of Bardhaman” the major agricultural crops grown in the district are rice, wheat, pulses, oilseeds, jute and potato. Jute and rice are the kharif crops grown in the district, whereas rice, wheat, pulses, oilseeds and potato are the rabi crops grown in the district. Apart from this, livestock rising, poultry farming and fisheries form major part of the horticulture of the district.

Table 1.6 Source of Irrigation and Area Irrigated by different sources in part of Purba and Paschim Barddhaman blocks (Source: District Statistical Handbook-2017)

DISTRICT	BLOCK	CANAL AREA	RLI		DTW		STW		TOTAL	
			No	Area	No	Area	No	Area	No	Area
1	Burdwan-I	16057.06	5	140.12	55	832.13	6	72	66	17101.31
2	Burdwan-II	9578.17	1	65.92	53	850.59	9	108	63	10602.68
3	Ausgram-I	13584.94	-	-	19	225.28	-	-	19	13810.22
4	Ausgram-II	12639.76	9	299.2	73	1043.54	-	-	82	13982.5
5	Galsi-I	21356.25	-	-	11	582.31	-	-	11	21938.56
6	Galsi-II	15892.75	-	-	103	1342.98	-	-	103	17235.73
7	Memari-I	15324.01	1	60.07	77	1646.07	-	-	78	17030.15
8	Jamalpur	17428.74	12	734.57	84	2506.22	-	-	96	20669.53
9	Raina-I	13204	3	200.13	112	3842.61	12	144	127	17390.74
10	Raina-II	13181	5	201.56	132	2941.25	-	-	137	16323.81
11	Khandaghosh	15265.2	1	64.3	94	1652.28	6	72	101	17053.78

C) Mining:

Purba Bardhaman is an agriculturally prosperous district of West Bengal. The soil and Climate of the district favour the production of food grains. The minerals found in the district are Sand, Silt and Clay. Black earth Bricks manufacturing industries found in Purba Bardhaman area.

Paschim Bardhaman is accomplished with an economically rich infrastructure. Durgapur of Paschim Bardhaman is one of the biggest industrial hubs of India and was planned as an integrated industrial town. The state of West Bengal is blessed with the enormous natural resources. The traditional industrial base of the district is mainly sustained by coal, iron and steel and has experienced a rapid development over the year. The district has a rich minor mineral base which is the reliable indicator of bountiful convenience for commercial use and economic development. The Raniganj coalfield was the prime land of the coal industry. Asansol sub-division of this district lies upon a mammoth reserves of non-coking coal. The mining activity was started in this province as early as 1774, however efficient withdrawal of coal initiated in the second half of the nineteenth century by depending upon this coal stockpile [District Industrial Profile, 2017- 2018, Paschim Bardhaman, Ministry of MSME, Govt. of India]. Originally the area was known as 'Raniganj Coalfield' which has huge numbers of collieries that extracted coal from these reserves until all coal mines were nationalized in 1975 and renamed as 'Eastern Coalfields Limited (ECL) which is the second highest coal reserve in India, after Talcher. 'Raniganj Coalfield' expanses over 443.50 sq.km area and is currently estimated to have over 30.61 billion tons of coal.

D) Urban Areas:

Coal is an important mineral resource. Kulti, which is a part of the Asansol Sadar is an important coal based industrial centre. Various industrial Park are settled in Paragraph area, which is going to be the next industrial hub after Durgapur. Mostly the economic development in Purba Bardhaman district is an agrarian based still some part of Burdwan city developed as planed townships

Table 1.7 Area and yield under Major Crops in the study area (Source: District Statistical census of West Bengal 2014)

DISTRICT	NAME OF THE BLOCK	Aus		Aman		Boro		Wheat		Musur		Gram		Mustard		Til		Potato		Khesari	
		Area	Yield	Area	Yield	Area	Yield	Area	Yield	Area	Yield	Area	Yield	Area	Yield	Area	Yield	Area	Yield	Area	Yield
Purba Bardhaman	Burdwan-I	499	2391	18270	3018	5689	1858	60	2660	..	..	..	..	440	1481	464	1039	839	35075	53	987
	Burdwan-II	452	2391	12003	3336	6179	1790	7	2660	..	..	..	..	119	956	384	864	894	36185	95	987
	Ausgram-I	1119	2388	15580	3321	2919	3088	109	2823	10	721	94	1261	1195	981	855	984	775	32151	31	987
	Ausgram-II	116	2391	21485	3454	1373	2176	8	3096	..	..	..	..	878	1082	540	986	954	34638	16	987
	Galsi-I	..	..	13879	3216	753	2735	6	2660	1	723	..	..	1141	932	107	800	850	29666	..	
	Galsi-II	162	2391	17010	4160	7158	1971	..	..	..	..	..	..	606	1055	877	1079	2472	37630	..	
	Memari-I	2423	3064	9908	3246	1016	3095	..	..	..	..	..	..	771	587	1226	1101	6367	29876	..	
	Jamalpur	809	2706	17172	3124	1286	3351	115	2271	..	..	..	..	412	786	2385	891	14566	34510	..	
	Raina-I	..	..	18208	2946	1334	3705	3	2271	1	1059	..	..	412	1193	465	876	3498	41714	..	
	Raina-II	..	..	19153	2596	6239	4004	..	..	28	996	..	..	960	990	811	1347	1928	38654	..	
	Khandaghosh	..	..	15165	3115	4829	3408	4	2271	102	1100	..	..	2169	1170	2383	916	4484	40294	..	
Paschim Bardhaman	Kanksa	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	Asansol	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

CHAPTER-II

CLIMATE

The district experiences a climate which is transitional between CWg3 and AW1 types, where 'C' stands for 'warm temperate rainy climates with mild winter', 'W' for 'dry winter not compensated for by total rain in the rest of the year', 'g3' for 'eastern Ganges type of temperature trend' and 'AW1' for 'tropical savannah climates'(*District Gazetter, Burdwan)*. The summer season starts from middle of March month and lasts until mid-June intervened by tropical cyclones and storms. Monsoon prevails from mid of June to October. The cold season starts from about the middle of November and continues until the end of February.

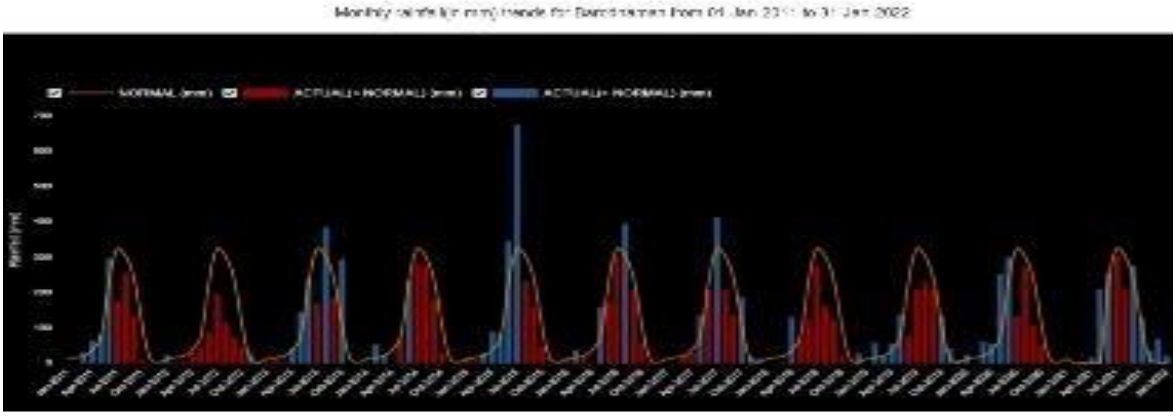
2.1 Rainfall

Bardhaman district normal rainfall is 1381mm. Precipitation for Bardhaman district in the month November to February is remain less than 25mm, 25-50mm in March and April. There is a rapid rise of precipitation in Bardhaman district during the monsoon period from June to September. The actual monthly rainfall for the districts from 2011 to 2020 given in the table below.

Table 2.1 Monthly Rainfall data for the districts of Barddhaman from 2011-2020. (Source: Rainfall statistics of India)

YEAR	Normal Rainfall in mm	Actual Rainfall in mm									
		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
JAN	12.8	0	23.5	3.29	1.49	11.83	9.74	0.9	0	0	25.43
FEB	16.9	0.74	3.79	15.29	53.64	10.29	38.08	0	1.07	59.14	1.99
MAR	20.6	31.37	3.79	4.37	25.5	29.44	16.51	16.93	4.25	20.6	61.84
APR	37.6	63.8	29.59	43	0.99	90.25	2.33	30.83	129.76	56.69	56.53
MAY	73	84.12	43.81	145.57	69.34	84.9	159.96	135.7	69.84	137.06	252.18
JUN	229.4	296.36	86.78	238.85	233.98	345.58	173.31	208.07	123.42	76.97	300.4
JUL	324.8	174.9	196.49	170.78	283.68	674.78	301.62	413.73	276.26	208.4	133.06
AUG	303.6	256.45	113.99	385.03	275.05	232.72	394.5	211.36	162.51	232.5	272.41
SEPT	240.3	135.19	73.93	186	180.56	161.5	205.84	137.25	120.56	209.32	108.1
OCT	108	8.63	45.98	294.2	31.46	49.26	56.11	187.05	21.81	133.77	52.4
NOV	11	1.32	27.31	0	0	2.12	6.43	19.72	0.35	42.09	2.38
DEC	3.1	0	5.13	0.41	0.29	2.15	0	14.16	28.47	9.52	0.02
Total	1381.1	1052.88	654.09	1486.79	1155.98	1694.82	1364.43	1375.7	938.3	1186.06	1266.74

Fig: 2.1 Monthly Rainfall data for the districts of Barddhaman from January 2011-Jan 2022 (Source: WRIS)



2.2 Climate of Purba Bardhhaman

I. Intensity of Rainfall: The monsoon period starts in this area starts from June and ends in the September where approximately 80% rainfall experienced during this period. Seasonal rainfall occurs due to the South-Western monsoon every year and floods occur depending on the intensity of the storms. The highest rainfall is occurred in the southern part of the river basin and decreases gradually towards the northern part of the Barakar catchment. The river is seasonal and flood prone especially in the lower part of the river basin at Birbhum and Bardhaman district if West-Bengal.

II. Climatic Zone: Ajay River basin exists in the tropical climatic zone. The study area experiences moderate climatic condition with cold dry winter, hot humid summer and prolonged rainy season

III. Temperature Variations: The summer season starts from the month of March with hot and humid conditions and ends in June. The maximum highest temperature varies from 30 °C to 45 °C in the month of May and June while minimum temperature varies from 10 °C to 14 °C during December and January.

2.3 Climate of Paschim Bardhhaman

Being a part of tropics, the climate of the district is hot and humid. There is marked difference between the winter and the summer temperatures. The average summer temperature is 30°C and average winter temperature is 14°C. The hottest month is May and the coldest month is January. In monsoon period from June to September, wind blows from the south-west direction recognized as south-west monsoon. During winter, i.e., from December to February winds are mainly northerly or north-easterly with clear or patchily clouded sky. Temperatures are fairly cool between winter and spring (Ghosh et. al., 2018). The summers are much rainier than the winters in Bardhhaman.

- Summer Temperature: Max: ≈40°C
- Winter Temperature: Min: ≈14°
- Summer Paschim Bardhaman district experiences dry and hot summer with maximum temperature of near about ≈ 40°C during summer. The district shows a fierce dry heat in the warmer months. The summers in Paschim Bardhaman usually start from month of March and last till the middle of June.
- Monsoon The arrival of the month of June marks the onset of monsoon in Paschim Bardhaman. The district receives a high average rainfall. June to September has shown maximum average rainfall with moderate temperature. Average rainfall being 1400 mm.
- Winter Winters in Paschim Bardhaman are pleasant and enjoyable, with mercury dropping to about 14°C or below. The winter starts from December and last till the month of February. Due to such favorable conditions, winter is deemed as the best time for the tourists to visit Paschim Bardhaman.

Rainfall (month wise) and Humidity

The average annual rainfall of the area is about 1400 mm. Rainfall during the monsoon period (June to September) constitutes 75 % of the annual rainfall. The driest month is December, with 2 mm or 0.1 inch of rain. The greatest amount of precipitation occurs in July, with an average of 309 mm or 12.2 inch. On an average, the district has 70 rainy days in a year. Most of the tropical cyclonic storms strike with speed of 65 to 100 km/hr with rainfall ranging from 10 mm to 50 mm and marked by a consequent fall of temperature (Ghosh et. al., 2018).

CHAPTER-III

GEOMORPHOLOGY

Purba Bardhhaman

Barddhaman district consists of two major physiographical divisions viz.

1) Low dissected plateau interspersed with hillocks, mounds and low-lying valleys
2) Alluvial plain with meander plain. The general slope of the district is from North West to south east.

The low dissected plateau is an extension of Chotanagpur gneissic complex extends onwards west. The area mostly lateritic in lithology of differential relief. The alluvial plain extends from the 80 m contour in west to 40 m contour in the east and formed by the alluvial deposits of rivers Damodar ,Ajoy and their tributaries. The meander flood plains extend below 20 m contour is a recent deposition of river Bhagirathi. A number of rivers and streams intersects the area, which responsible for water logging in this zone. River Bhagirathi has changed its course often and has left disused channels all along its western bank creating a string of marshes and swamps. Barddhaman district with riverine features is a transitional zone between the Chotanagpur plateau, which constitutes a portion of peninsular shield in the west, and Ganga-Brahmaputra alluvial plain in the north and east. In general, the Jharkhand plateau consists of the metasedimentary rocks of pre-cambrian age, Gondwana sedimentary rocks, Rajmahal basalts and upper tertiary sediments. Laterite has developed on these older rocks as well as on early Quaternary sediments. Towards south, the alluvial plain merges with Damodar-kasain-Subarnarekha deltaic plains. Ajoy-barakar divide is a convex plateau, the avarage altitude being 150 m. The gradient is westerly to the west and to the east it is northerly towards Ajay and southerly towards Damodar below the latitude. The Ajoy- Damodar inter-stream tract is made up of several stows consisting of vales and low convex spurs which run in almost all directions except north-east and thus lends a very complicated character to local relief.

The western half of the district resembles a of Chotanagpur plateau and consists of barren, rocky and rolling country with a laterite soil rising into rocky hillocks, the highest being 227 m. Ajoy-barakar divide is a convex plateau, the avarage altitude being 150 m. The gradient is westerly to the west and to the east it is northerly towards Ajay and southerly towards Damodar below the latitude. The Ajoy- Damodar inter-stream tract is made up of several deposits consisting of vales and low convex spurs, which run in almost all directions except northeast, and thus lends a very complicated character to local relief.

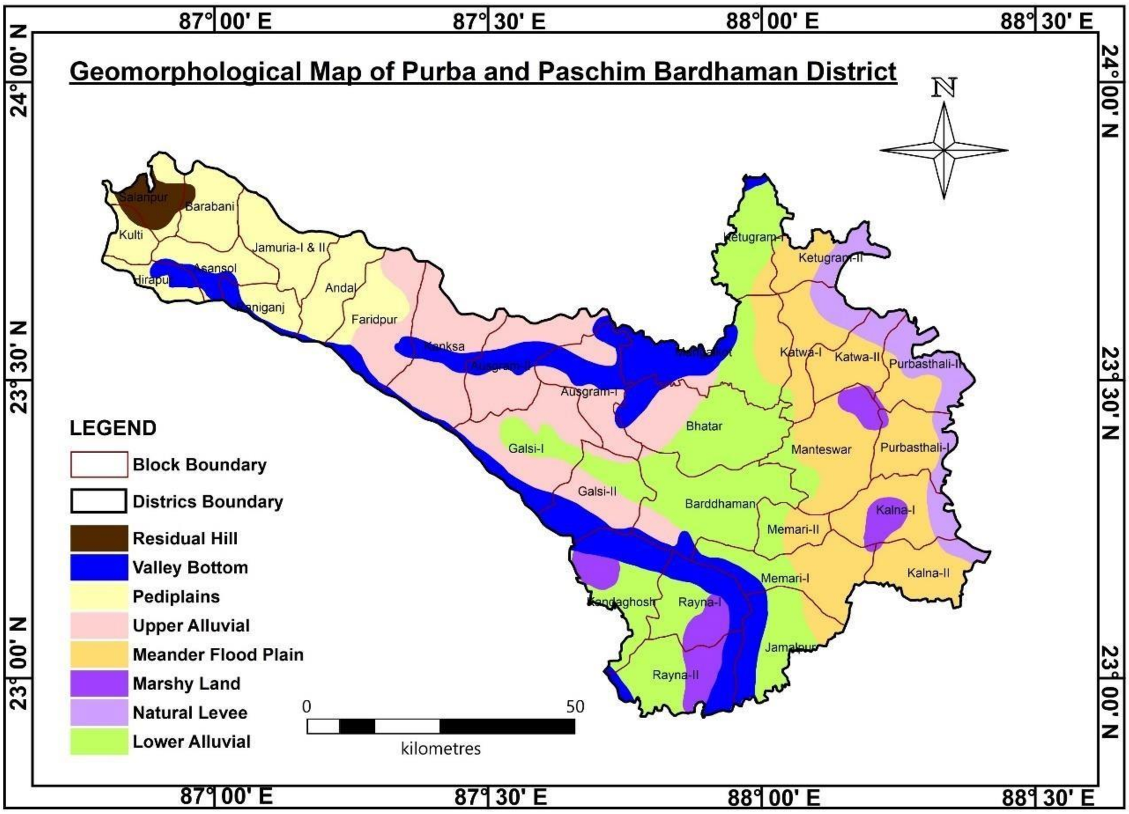


Fig 3.1: Geomorphological Map of Purba & Paschim Bardhaman District.

Bardhaman district is divided in to three geomorphic units: -

1) Plateau area (extension of Chotanagpur area of Bihar)- the Westernmost Asansol.
2) Undulatory area- Asansol- Durgapur sector.
3) Flat alluvium terrain- From Durgapur eatwards.

PurbaBardhaman district is a flat alluvial plain area that can be divided into following prominent topographical regions. On the north, Kanksa and Ketugram Plain lies along the Ajay, which joins the Bhagirathi. The Bardhaman Plain occupies the central area of the district, with the Damodar on the south and the south-east. On the southern part is the Khandaghosh Plain. The Bhagirathi flows along the eastern boundary of the district, and the Bhagirathi Basin occupies the eastern part of the district. The undulating laterite topography of Paschim Bardhaman district extends up to Ausgram area of this district.

Drainage

The river system in Bardhaman includes the Bhagirathi-Hooghly in the east, the Ajoy and its tributaries in the north and the Damodar and its branches in the south-west. Besides, there are innumerable Khals and old riverbeds all over the area. The Bhagirathi flows along the eastern boundary of the district, and the Bhagirathi Basin occupies the eastern part of the district. The notable drainage channels are Damodar, Bhagirathi, Barakar, Ajay, Dwarakeswar, Nonia, Singaram, Tamla, Kukua, Kunur, Tumuni, Khari, Banka, Chanda-kanki nala, Behula, Gangur, Brahmani, Khandesvari, Karulia nala, Dwaraka or Babla, Koiya nala, Kandarkahal, Kanadamodar, Kananadi, Ghea, Kakinadi etc.

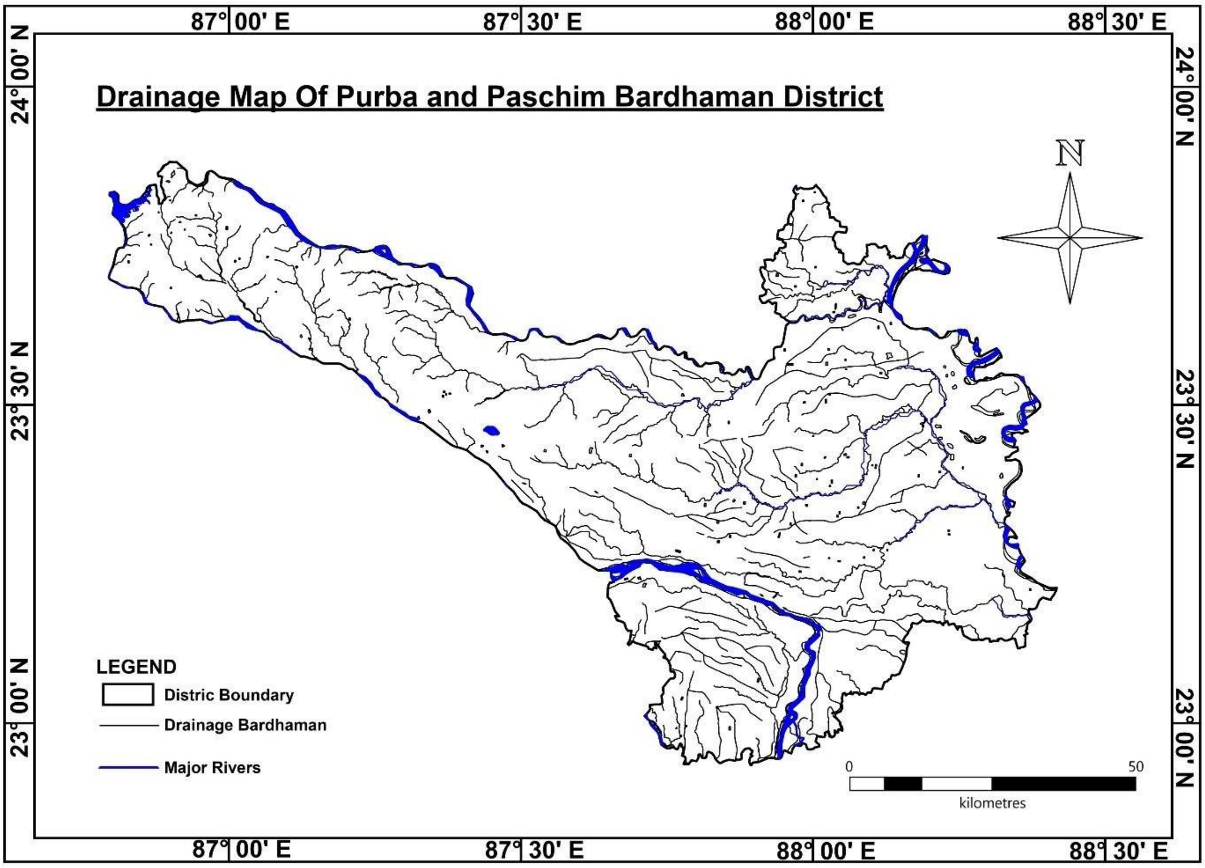


Fig 3.2: Drainage Map of Purba & Paschim Bardhaman District.

Ajay River:

Ajay River originates from Batpar of Jamui district in Bihar. It drains through Bihar then Jharkhand and enters West Bengal at Simjuri, near Chittaranjan. It forms the border between Paschim Bardhaman district and Jharkhand and then between Paschim Bardhaman district and Birbhum district, and finally it enters Katwa subdivision of Purba Bardhaman district at Nareng village, and then joins the Bhagirathi River at Katwa Town. Total length of the Ajay is 288 kilometres out of which 152 kilometres are in West Bengal. The catchment area of Ajay River is 6,000 square kilometres.

Damodar River:

The city of Bardhaman is situated on the banks of the River Damodar and acts as an anchor for this town. The River Damodar originates from the Sonajuria Falls of the Bijonsa Hill, which is located in the district of Palampur, Bihar. The river joins Barakar at the town of Dishergarh in the Asansol subdivision and then flows through the rest of the district of Bardhaman. It continues to flow through the districts of Hooghly and Howrah in West Bengal before finally joining the Bhagirathi to be part of Ganga river system.

Bardhaman takes up the shape of a delta along with the branch rivers of the Damodar surrounding it, namely Balluka, Behula, Gangur, Banka and so on, some of which have almost become extinct at present. The civilization of 'Rarh-Bangla' has also developed with this river as its centre. A bridge has been constructed over the River Damodar at Sadarghat which is known as 'Krishok Setu' (as pronounced in Bangla). The catchment area of this river is 25,820 Sq. Km.

Bhagirathi River:

The Bhagirathi River is a major drainage for north-eastern India. A distributary of the Ganges River system joins the Jalangi at Nabadwip to form the Hugli (Hooghly) River after a total course of 120 miles (190 km). The Bhagirathi formed the original riverbed of the Ganges. The Bhagirathi River originally flowed down the west of Nabadwip in the past, forming a natural boundary between the districts of Purba Bardhaman and Nadia. With time, it has shifted its course to where it is at present, cutting the city off from the rest of the Nadia district. The Origin of this river is foot of the Gangotri glacier and Khatling glaciers in the Garhwal Himalaya and the Catchment area is 6,921 Sq. Km.

Soil:-

Soil forming material of major portion of the district consists of alluvium of the rivers Damodar, Ajoy and Bhagirathi. Dominant influence of Damodar alluvium is apparent in the southern half and of Ajoy alluvium in the northern half of the district. In the easternmost part of the district, influence of Bhagirathi River is dominant. However, influence of the mixed alluvium of Damodar and Ajoy River should beexpected in some parts of the central portion and that of Damodar, Ajoy and Bhagirathi in the eastern part of the district. Texture of the materials and occurrence of mica, ferruginous and calcium carbonate concretions distinguishes the soils developed from different types of alluvium.

In western most part of Paschim Bardhamn district, the predominating parent rock is granite, which in some places becomes gneissic. These rocks contain quarts, felspar, tourmalin and biotite. Gondwana deposits are mainly located in the Raniganj coalfield area, but are also found scattered over other places in the western part of the district under alluvium cover. Older alluvium, laterite, sandstone, conglomerate and grit are found in the eastern part of Asansol sub-division, which also extends to the adjacent areas in the eastern part of the district. Some Research works on soils of Barddhaman district indicate that in the alluvial soils, illite is the dominant clay mineral and kaolinite and illite are associated clay minerals. Thus mineralogy of the soils may be described as mixed. Soils in the western part of the district have been formed from older to younger tertiary formation and Gondwana and are considered to be of Miocene age

Morphology of the soils of the area is distinguished by the nature of the soil forming material. Depending upon the soil Bardhaman district is divided into three separated zones: -

i. Gangetic soil, which found along the Ganga River belt i.e. most of the eastern alluvial part of the district. Highly rich in calcium clay content is significant.
ii. Vindhyan soil, dominant between Ajoy and Damodar Rivers in the central and eastern parts. Iron and other bases are low to medium on surface increases with depth of soil profile. i
iii. Red lateritic soils, occurring in the undulating and coal field areas in the western parts of the district. Iron concretions are dispersed on the surface, kaolinite content is predominant high.

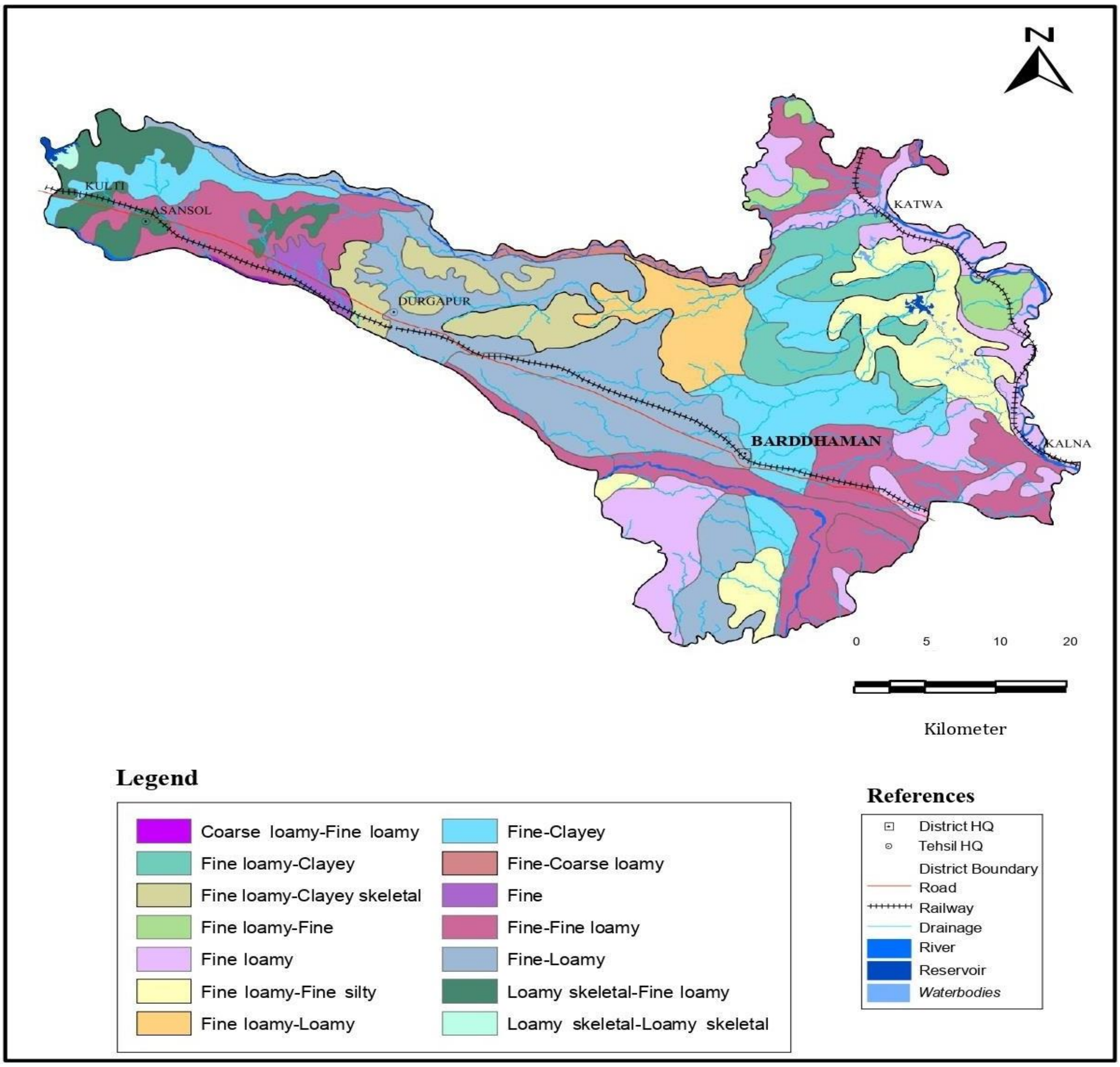


Fig 3.3: Soil Map of Purba & Paschim Bardhaman District.

(Source: National Bureau of Soil survey & Land use plan)

Paschim Bardhhaman

General landform of an area represents natural and/or human influenced facets of the earth's crust and involves portraying vertical and horizontal dimensions along with their arrangements. Paschim Bardhaman is a sort of an extension of the Chotanagpur Plateau. Almost rectangular shaped district Paschim Bardhaman is mostly a transitional between Chotanagpur Plateau that constitutes a part of peninsular shield in west and alluvial plain of Ganga-Brahmaputra River system in the north and east. The district is influenced by the rivers e.g., Ajay on the north; Damodar on the south and the Barakar on the west and therefore, the district is sharing a portion of the Ajay Damodar -Barakar tract. Numbers of streams and Khals criss-crosses the district and differentiated landscape. Ajay-Damodar inter-stream tract adorned the areas in and around the Asansol and Durgapur subdivision (District Industrial Profile, Paschim Bardhaman, Ministry of MSME, and Government of India 2017-2018). The surface gradient of this province is southerly towards the Damodar and westerly towards the west, northerly towards the Ajay (Peterson, J.C.K.1910: 7). The western part of Paschim Bardhaman district illustrates the occurrence of hillocks and the elevated area of the Chotanagpur Plateau progressively slopes down to the riverine plain areas (http://wbdmd.gov.in/pages/earthquake.aspx). As per the survey report from National Bureau of Soil Survey & Land Use Planning, Indian Council of Agricultural Research, Regional Centre Calcutta, Paschim Bardhaman district can be ordered into four classes of slope profile e.g.,

(i) gently sloping predominantly in western part of the districts,

(ii) gently sloping to moderatly sloping in Salapur and Barabani areas,

(iii) gently sloping to very gently sloping profile in Raniganj, Pandabeshwar, Ondal, Asansol, parts of Durgapur and

(iv) Very gently sloping belt along the river bank of Ajoy.

Following geomorphological units are evident in district, physiographic zones namely as follows

(i) Flood plain

(ii) Pediplain with scattered rock

(iii) Upper mature deltaic plain.

As the geomorphology of the region is the expression of surface or subsurface lithostratigraphy, therefore, the geomorphological profile of the district is transparently bestowing the soils are heterogeneous in their morphological characteristics such as soil depth, colour, texture, structure, drainage, slope etc. Paschim Bardhaman district lies at the eastern fringe of Chotanagpur Plateau and possesses predominantly sandstone, conglomerate micaceous shale and siltstone along with granite gneiss and migmatite type of rocks. The area has the highest relief and extends from 80 metre contour and above in the west. The region is highly eroded and dissected. The district consists of three (3) major physiographic zones are described briefly.

FLOOD PLAIN Flood plain is formed due to successive floods and deposition which gradually raised the tract above flood level. The riverine area has developed through alluviation. The river gradient has decreased from east to west. This part is mostly inter-bedded layers of sand and clay. This region extends from 80-meter contour which is formed of alluvium brought by the river Damodar and Ajoy. The surface is undulating, interspersed with low ridges and valleys (Soil survey and land use plan of Bardhaman district, West Bengal National Bureau of Soil Survey & Land Use Planning, Indian Council of Agricultural Research, 2013).

PEDIPLAIN WITH SCATTERED ROCK Pediplain with scattered rock fragment constituting pebbles & gravels of quartz, feldspar & basic rocks of Permo Carboniferous to Triassic and Archean ages (Projection & Geodetic Reference System: GCS, WGS 1984; CGWB & GSI, 1984). The western part of the district comprises the interfluve of the rivers.

UPPER MATURE DELTAIC PLAIN This region is built up of the deltaic fans of the streams flowing from the western hills. (Soil survey and land use plan of Bardhaman district, West Bengal National Bureau of Soil Survey & Land Use Planning, Indian Council of Agricultural Research, 2013) and mainly curbed under the areas ofKangsa towards east

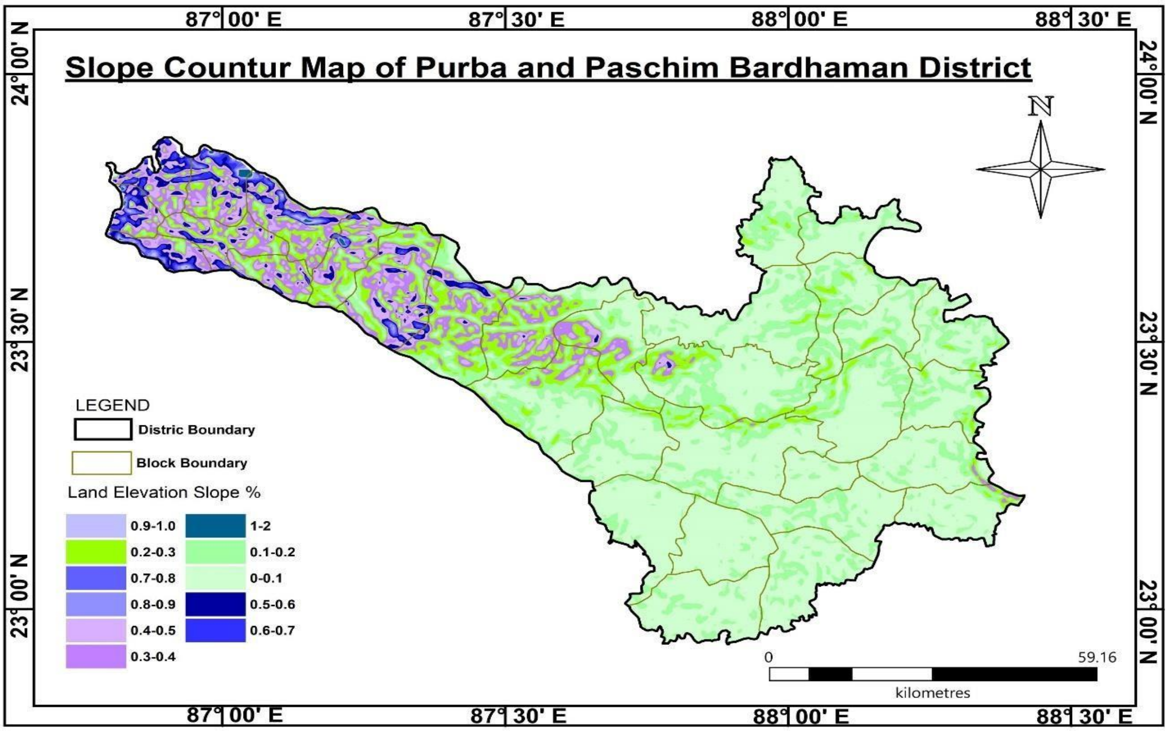


Fig3.4: Slope Contour Map of Purba & Paschim Bardhaman District.

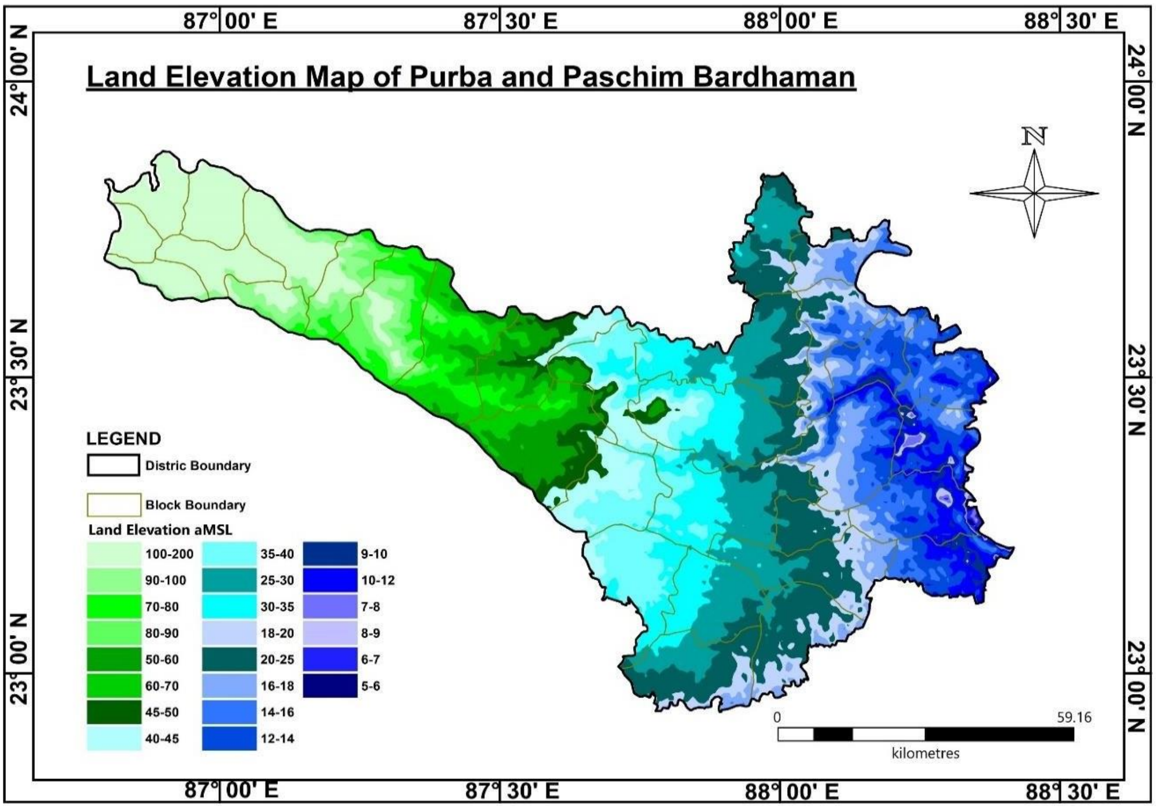


Fig 3.5: Elevation Map of Purba & Paschim Bardhaman District.

CHAPTER-IV

GEOLOGY

Purba Bardhhaman

Regional Geological set up

The most area of the Purba Barddhaman district forms a part of the alluvial terrain of the Damodar Basin, which occupies a part of southwestern shelf area of Bengal Basin. The existing Damodar or his tributaries and distributaries have very lean flow during dry months of the year. The channels are very narrow and shallow because of which they cannot accommodate the entire monsoon flows, which spills over the banks, and flood the low-lying areas. As per GSI studies described the delta building processes of the Bardhaman area and identified three terraces in the area viz. (i) the Orgram terrace, (ii) the Kushumgram terrace and (iii) the Kalna terrace. The lower Damodar Basin is bordered to the west by rocks of Peninsular shield, to the east by gangetic sediments, to the north this basin has a common water divide with the A Joy river. Study area of Purba Bardhaman occupies lower Damodar Basin extreme is flooded by the alluvial sediments of Quaternary age. As per GSI the Stratigraphy in the area is as follows

Stratigraphic succession of Purba Bardhaman, source: GSI

AGE	GEOLOGIC UNIT	NATURE OF SEDIMENTS
Late Holocene to Recent		Flood plain deposit, Light brown fine to medium sand with little silt and clay of grey colour.
Middle to Late Holocene	Chinsura formation	Yellowish brown Silty clay, fine sand and plastic grey clay.
	-----------Unconformity ……………	
Late Pleistocene to Early Holocene	Sijua formation	Loose ferruginous silty and sandy loam. Khaki coloured plastic clay with calcareous concretions, brownish clay, yellowish brown clay, silt and fine sand
	-------------Unconformity ……………	
Early to Middle Pleistocene	Lalgarh formation	Sandy latosol ,brownish to pinkish white litho-margic clay

LOCAL GEOLOGY

Lalgarh formation

Lalgarh formation mainly well exposed in the area to the south of the Dwarkeswar River. This formation mostly exposed in southern parts of Purba Bardhaman district. It comprises lateritic hardpan with reddish brown latosol cover followed by a lithomarge part consisting of brownish white sandy clay with few iron nodules. The contact between this formation with the over-lying Sijua formation is erosional.

Sijua formation:

This is a part alluvial formation found in the Purba Bardhaman and has a vast aerial extent. It consists mainly of pale yellowish with greenish tinge or khaki grey coloured, very compact clay. Besides, pale brown sandy or silty loam is also present. Sijua formation are well exposed along the banks of kanta khals and Amodar nala near Sipta village of Rayna-I block be considered as the type section of the Sijua formation. From recent studies, indicate that the thickness of the Sijua formation increases from west to east and from north to south. The maximum thickness of the Sijua formation deciphered is about 30m at Sarangs village and the minimum thickness 20m near Kshatriya village.

Chinsura formation:

This is a younger alluvial formation lies unconformable over the Sijua formation and named after the town Chinsura, Hooghly district, West Bengal. It exposed on both the banks of the Damodar and the Dwarkeswar rivers. This formation comprises mainly of loose, yellowish brown to brownish grey silty loam without any calcareous concretions and belonging to upper delta plain. Recent alluvial and flood sediments are lies over this formation.

Paschim Bardhhaman

GEOLOGY OF THE DISTRICT

REGIONAL GEOLOGY

Geologically Bardhaman district is divided into three parts.

A) The extreme northwestern small part of this district, near Rupnarainpur in Salanpur Block, is occupied by the Archaean metamorphic rock, viz., granite gneiss, hornblende schist, which are traversed by bands/patches of amphibolites, pegmatites and quartz veins.

B) The western part of about 2063 sq.km is covered by Up Palaeozoic-Mesozoic-Tertiary sequence of Gondwana Supergroup of sedimentary rocks of fluviatile-lacustrine origin, deposited in intracratonic basins. The Lr. Gondwana Damuda Group of rocks of Permo-Carboniferous age contains valuable resources of coal seams and the palaeo-depositional mechanism and palaeoclimatic inference in the Gondwana Formation it has been inferred that the lobes of semi-consolidated gravel beds exposed in the northen part of Durgapur city is the main spatial unit to analyse.

C) The major central and the eastern parts of the district is covered by alluvium blanket comprising of Older Alluvium, Younger Alluvium, Laterite, Sand, Gravel, lithomargic clay, etc., of upper Tertiary-Quaternary age. Tertiary Deposits of Debris flow, grain flow, inertia flow, turbidity current, channel and non-channel in a fan-deltaic sequence. Hundy and Banerjee (1962) had found few patches of lateritic gravels and grits in the plateau fringes of Bardhaman district of West Bengal. The sedimentation profile of Ajay-Damodar interfluve on the eastern margin of Raniganj Coal-field. The surrounding geology of

Durgapur city is the secondary formation of laterites on the gravel beds which may be derived from the conglomerate bed of Mahadeva Group.. The upland terrain of the Ajay-Damodar interfluve, fringing the peninsular shield on the eastern margin of the Raniganj Coal-field and western part of lateritic Plain. The master slope of the district is from west to east and southeast with the land having the highest altitude at the extreme western corner of approx. The district remarkably presents the entire geological succession from Archaean to recent. General geology of study area has given below:

Age	**Formation**		**Maximum thickness**	**Description of strata**
Quarternary to Recent				Alluvium deposit of clay and sand
--------------------------------------**Unconformity**---				
Jurassic	**Upper Gondwana**	Igneous intrusive	**305**	Basic dykes and sills
Upper Triassic		Supra- Panchet		Sandstones and quartzitic conglomerates
--------------------------------------**Unconformity**---				
Lower Triassic		Panchet	610	Shale, false bedded sandstones and red clay
Upper permian	**Lower Gondwana**	Raniganj		Coal seams with sandstones and shale
Middle permian		Barren Measures	365	Carbonaceous shales , ironstones
Lower permian		Barakar	640	Coal seams, sandstone, conlomerates
Upper carboniferous		Talcher	275	Boulder beds ,sandstones
--------------------------------------**Unconformity**---				
Archaean		Archaean		Granites, gneiss,schist and pegmatite

Study of subsurface geology based on correlation of lithologs reaveals the existence of Gondwana rocks at the shallower depth (34-40mbgl) at Parulia, which gradually slopes towards east, occurs within the depth of 129mbgl at Kanksa and 108mbgl at shibpur, and ceases to exist beyond Panagarh. Several intrusive in the form of basic and ultrabasic dykes and sills of post Gondwana age traverse the sediments at many places. Recent studies by different departments have established the extension of Gondwana basin around Durgapur where it forms a sub basin known as Durgapur –sub basin and which separated from Ranganj basin by a sub-surface ridge around Andal. The Archean basement is shallowest near Panagarh and its depth increases towards east (about 204km at galsi) and west (about 2.8km at Durgapur). Unconsolidated formations of Quarternary and Tertiary age groups are Recent alluvium and Older alluvium, which were deposited in the Bengal basin to the east of Gondwana basin and composed of sand, silt, and clay.

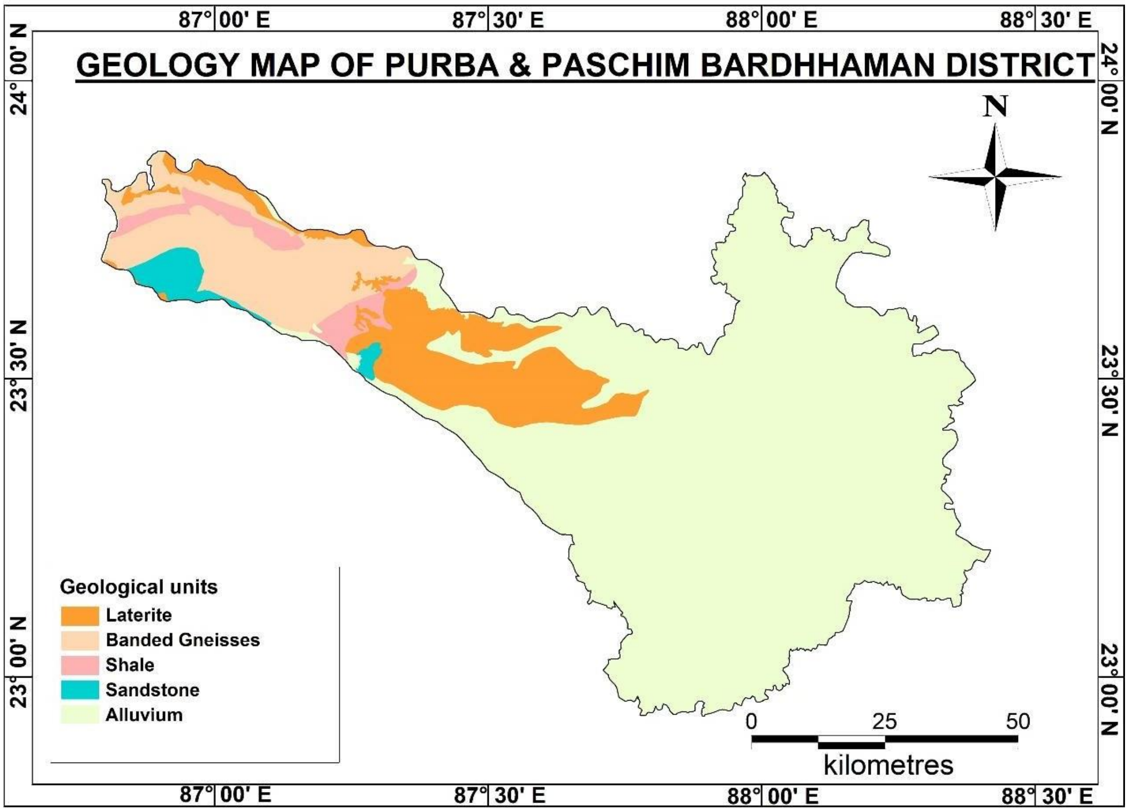


Fig 4.1: Geological Map of Purba & Paschim Bardhaman District.

CHAPTER- V

GEOPHYSICS

Geophysical study in field can be divided into two categories, namely surface geophysical and sub –surface geophysical studies. Surface geophysical investigations carried out through survey or resistivity survey (VES and Profiling) where as sub surface geophysical studies done through borehole logging.

In an alluvial terrain resistivity survey is carried out to find out the possibility of availability of aquifers with potable water in an area where saline water bearing aquifers are most common.

The possible source of contamination and its demarcation from non contaminated formation can be identified through geophysical survey.In the areas where there is possibility of occurrence of geogenically contaminated aquifers, separated from potable water bearing aquifers. Geophysical studies helps in understand the aquifer disposition in non potential area.

In hard rock terrain the resistivity survey is carried out to find out the possibility of availability of potential weathered zones and potential fractures/lineaments below the weathered zones.

Borehole logging is done only in the boreholes drilled in the loose unconsolidated sediments to identify the potential aquifers with potable quality of water. The data generated through borehole logging are being utilized in finalizing the design of tube wells.

5.1. Paschim Bardhamn

A total No. of 18 VES has been carried out in Assansol and Kaknsa blocks of Paschim Bardhamn district. Around 15 no. of VES has carred out on hardrock area in Assansol block and rest 3 VES falls under Alluvial terrain of Kansa block.

- **4** VES were conducted for lOC Ltd., Asansol, and 3 sites were recommended for drilling. Potential ground water bearing zones are expected in the depth range 16- 43 mbgl
- **3** VES were carried out in DGMS Sitarampur area 3 VES were carried out in Income tax residential complex, Gopalpur, Asansol and **3** VES were carried out at Central Exise Residential Complex, Kalyanpur, Asansol of the district
- **5** VES were conducted for CMPF complex at Ushagram, Asansol of the district and 3 sites have been recommended. The ground water bearing potential zones are expected in the depth range of 4-65 mbgl.

CMPF Complex area, Ushagram, Asansol is underlain by the sedimentary rocks belonging to Raniganj formation (medium to fine grained sandstone, siltstone and shale) of Gondwana group. Geophysical survey indicates the presence of water bearing fractures in the depth ranges of 4-28mbgl, 7.3-65mbgl and 7.1-60.3mbgl at three different sites.

In IOC area though the geological condition is same but the geophysical survey indicates the presence of probable potential fractures only in the depth ranges of 16-43mbgl.

Table 4.1 Integrated result of VES-curves at CMPF complex, Ushagram Assansol

No. of Layer	Individual Layer resitivity value(ohm.m)					Individual Layer thickness(m)				Expected Zone of inrerest	VES profile orientation	Remark
	R1	R2	R3	R4	R5	H1	H2	H3	H4			
5	40	20	255	26.7	84	2.9	9	9	13	16.8-29.8	SW-NW	Recomended
4	25	12.5	112	25.5	--	2.1	40.8	40.8	-	Below 45.6	SW-NW	For test drilling
4	18	11.7	49	21	--	4.4	4.4	57.6	-	Below 7.3	SW-NW	VES-3
5	17	25.5	10	56.3	23.5	1.7	2	2	53	Below 7.1	SW-NW	VES-4
4	15	37	108.5	20	-	24	15.4	15.4	-	4.0-28 and below 43.4	SW-NW	VES-5

- 3 VES were conducted at Radhamohanpur, Panagarh of the district. The topsoil is 1.6 m thick and is underlain by a medium grained sand having thickness 6 to 36 m and down below of which a fine sand layer is found to be extending till the occurrence of hard formation.

At Radhamohanpur Firing Range, Radhamohanpur, block- Kanksa, from Geophysical survey the following observations were made- Near temporary CRPF camp- Top Soil/Laterite- up to 2.13m, Medium sand-2.13-8.0m & Coarse sand- 8.0m-150m; adjacent to High Way- Top Soil/Laterite- up to 0.86m, Medium sand-0.86-97.07m and beyond hard formation.

As of now there is no geophysical survey carried out in most of the study areas of Purba Bardhamn district. The data gap analysis has done for this area and accordingly the reqired no. of VES are recomeded.

Two bore hole has electrically logged up to depth of 253mbgl at panagargh in Kanksa block. Details of the findings given below

CHAPTER-VI

HYDROGEOLOGY

Hydrogeological condition of any area is controlled by the geology and geomorphology of that area. The western part of the district is underlain by hard sedimentary rocks (Gondwana formation), a small area in its north being occupied by hard and consolidated formations of Archaean age. The western part of the district has got undulating topography. The entire area east of Durgapur, which is a plain land is under lain by the unconsolidated Quaternary sediments

From hydrogeological point of view, the district can be divide in to two groups namely

A. Semi-consolidated Gondwana sedimentaries.
B. Unconsolidated Tertiary and Quaternary sediments.

<u>Paschim bardhaman:</u>

Gondwana Formations

Among Gondwanas coarse sandstones are available within Barakar and Panchet formations Barakars are encountered in the northwestern corner of the district bordering the Archaeans and Panchets are available mainly in Asansol block. Among Gondwanas another important formation is Raniganj, which contain in addition to other rock types medium to coarse grained sandstones and Raniganj formation is available over a large area spreading over Asansol Barabani, Jamuria, Raniganj, Faridpur and Durgapur blocks. Barakar and Raniganj formations are traversed by a few NW-SE & NE-SW trending faults and also by dykes.

From hydrogeological point of view, faults and dykes are of significance as the faults provide natural planes of seepage, while dykes have a tendency to impound water along up gradient direction.

It is observed groundwater within weathered zone which is limited to around 20m depth occurs under unconfined condition and at deeper levels it occurs under semi-confined and confined condition. Through groundwater exploration it has been established that at most of the places water yielding fractures exist within100m depth and at a few places fractures were encountered beyond 100m depth. Generally, groundwater exploration is restricted down to a depth of 125mbgl. Panchet formation is one of the important hydrogeological units in Asansol block. Around Asansol within Panchet formation at a few sites namely Kanyapur and Ramkrishna Mission groundwater exploration down to a depth of 122m confirmed the absence of water yielding fractures.In general within Asansol except at Ismail, fractures are poor yielding e.g. at D.P. Colony and Apcar Garden obtained discharges from the bore wells are around $3m^3$/hr. At Ismail potential fractures were encountered within 90m depth and an yield of $46.8m^3$/hr was obtained from a bore well. Details of fractures encountered and the discharge obtained from the bore wells tapping different Gondwana formations are as follows: Table-10 Details of Exploratory Bore Wells Drilled in Gondwana Formation.

The studies carried out have confirmed the feasibility of constructing both shallow and deep. groundwater development strctures, if sites are properly selected in Gondwana formations. In general, two to three sets of water bearing fractures with in 100mbgl depth have been confirmed. The NW-SE trending faults appear to have better groundwater potentiality compared to the NE-SW trending faults. The yields of the exploratory bore-wells vary from 0.3 m^3/hr to 38 m^3/hr and that of transimissivity values of the aquifers vary from 50m^2/day to 200m^2/day.

Tertiary and Quaternary Sediments

From the data generated through different hydrogeological surveys it is observed that in the same groundwater development structures, both Tertiary and Quaternary sediments have been tapped combinedly.

<u>Purba Bardhaman:</u>

In the area underlain by older alluvium, laterite, Tertiary and Quaternary sediments, groundwater occurs under unconfined conditions within a maximum depth of 70 mbgl and the zone is tapped through a system of open dug wells and shallow tube wells. Shallow aquifers in Tertiary Formations are composed of coarse sand and gravel. Whereas, they are represented by layers of fine to medium sand with occasional gravel and pebble in Quaternary Formation. Sometimes these sand and gravels are separated by relatively thin layer of clays which makes them to occur under semi-confined to confined conditions

It is observed around Bud Bud and Galsi a layer of gravel with thickness in the range of 9 to 15m occur within shallow aquifer. Around Bud Bud the thickness of aquifers with in the explored depth of 250m is about 110m. The deeper sand zone splits up into several sand layers separated by clay/sandy clay layers constitutes the deeper aquifers. The cumulative thickness of the deeper aquifers varies from 7m in the west to 22m found to be in confined condition and the recharge zones lie at the western marginal ridge area

For both the shallow and the deeper aquifers. One of the important features observed in the lithological correlation diagram is the absence of aquifers in the depth ranges of 114m to 350m and the occurrence of thick pile of clay around Galsi may indicate the presence of block-fault through this area.

Yields from tube wells tapping Tertiary and alluvial sediments vary from 10 m^3/hr to 47.7 m^3/hr. The values of Co-efficient of Transmissivity (T) of the Tertiary and alluvial sediments range from 88m m^3/hr /day lo 1700 m^3/day and the values of Storage Co-efficient (S) range from 1.6X10 to 2 5X10.

The subsurface geology of the area can be visualized from lithological logs of borehole drilled in the area and around. However, the demarcation of the boundary between the Pleistocene and the recent formations in the vertical sequence has not been possible owing to their remarkable lithological similarities The alluvial sequence consists of layers and lenses of sands of various grades, occasional gravels, clay and silt. Kankar is frequently interspersed in the sequence. Subsurface correlation s of various lithological units is made on the basis of available borehole logs, geophycal investigation and lithologs (collected from exploration done by CGWB, PHED).

A conspicuous feature of the subsurface geological framework of the area is occurrence of a thick clay bed below the depth of 270-280m. Though the shallower aquifers are unconfined to semiconfined, deeper aquifers are in general semiconfined to confined.

The Quarternary alluvium underlying the area forms a rich repository of groundwater. It occurs in a thick zone of saturation within these alluvial sediments. Several promising saturated granular zones are present in the depth span of 25-210 mbgl (commonly 25-150 mbgl). Ground water in the area occurs under unconfined to semiconfined conditions, though predominantly under semiconfined.

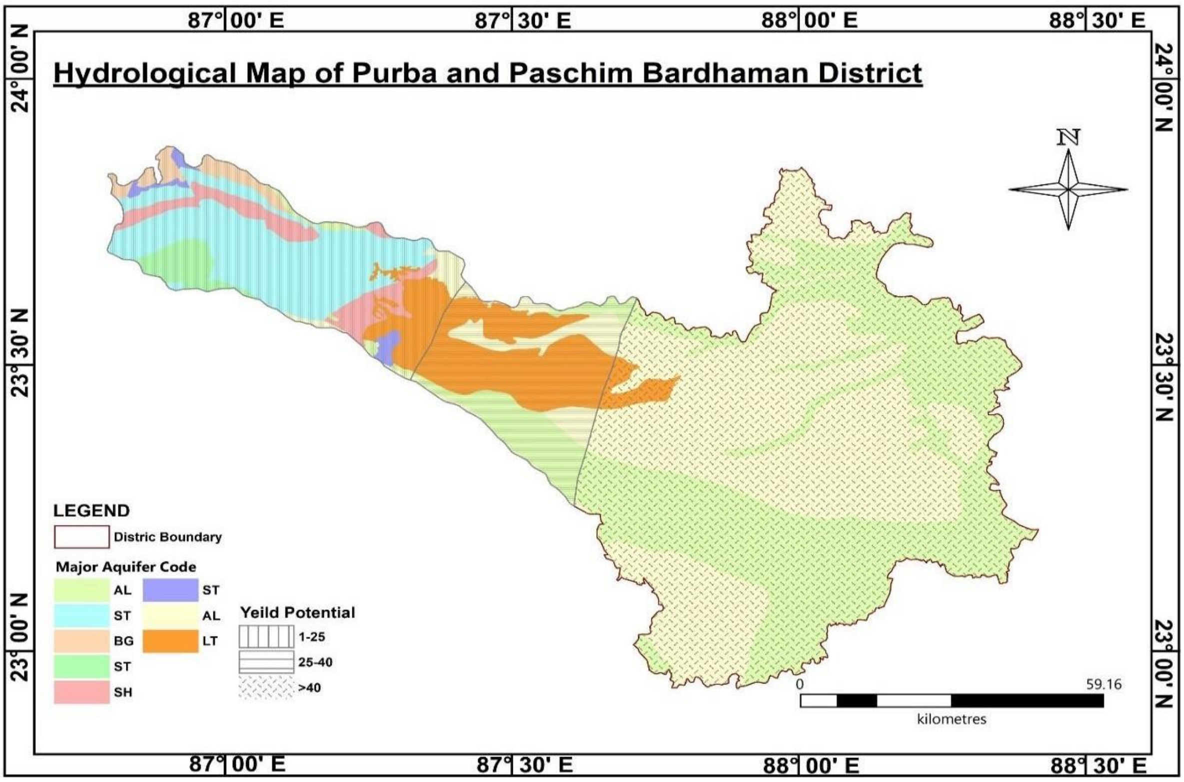


Fig6.1: Hydrogeological map of Purba & Paschim Bardhaman District

Table 6.1: Aquifer Characteristics and zones tapped in the study area of Purba Bardhaman District. (Source: CGWB, ER, Kolkata and PHED, West Bengal.)

Block	Location	No. of Aquifers	Water bearing zone (Zones Tapped)	Aquifer Thickness (m)		Discharge (lpm)	T (m^2/day)	SWL (mbgl)	Drawdown (mbgl)	S
				Aquifer-I (Within 50 mbgl)	Aquifer-II (Below 50 mbgl)					
Ausgram-II	Kota Chandipur	2	40-70	10	20	--	--	--	--	--
	Debsala	2	56-77,98-104		17	--	--	--	--	--
	Pubar	3	221-236, 248-257	18	30	--	--	--	--	--
Burdwan-II	Palsit	2	72-102	28	40	--	--	--	--	--
Galsi-I	Mankar	3	28-34, 42-50, 102-114,115-121	14	53	64200	2.446		20.26	
	Budbud	3	90-96, 186-192, 232-238	6	50	--	--	--	--	--
	Chaktentul	2	45-54, 64-73, 100-109	19	22	--	--	--	--	--
Galsi-II	Adra	2	28-43	24	29	--	--	--	--	--
	Ura	2	43-68	29	43	--	--	--	--	--
Jamalpur	Chakdighi	2	27-33	11	30	--	--	--	--	--
	Jaugram	2	96-125	26	60	--	--	--	--	--
	Abujhati	3	115-145	5-8	70	--	--	--	--	--
	Madhabpur	2	101-131	13	48	--	--	--	--	--
Khandaghosh	Sargai	2	59-62, 72-84, 86-89, 92-98	21	48	--	--	--	--	--
	Bagdipara	3	107-116, 128-146	10	63	--	--	--	--	--
Memari-I	Maheshdanga	3	113-125, 131-149	24	47	--	--	--	--	--
	Palla	3	90-120	27	52	--	--	--	--	--
Raina-I	Madanagar	2	94-124	19	30	--	--	--	--	--
	Teandul	2	74-96	41	27	--	--	--	--	--
Raina-II	Keunta	2	81-109	44	36	--	--	--	--	--
Ausgram-I	Dharapara	3	74-89, 178-190	13	27	522	80		12.65	1.03X10-3
	Banagram	3	226-232, 241-253, 282-294	19	69	2037	186.5		12.4	1.88X10-3
Burdwan-I	Mirjapur	2	42-48, 96- 108, 166-172	15	44	--	--	--	--	--

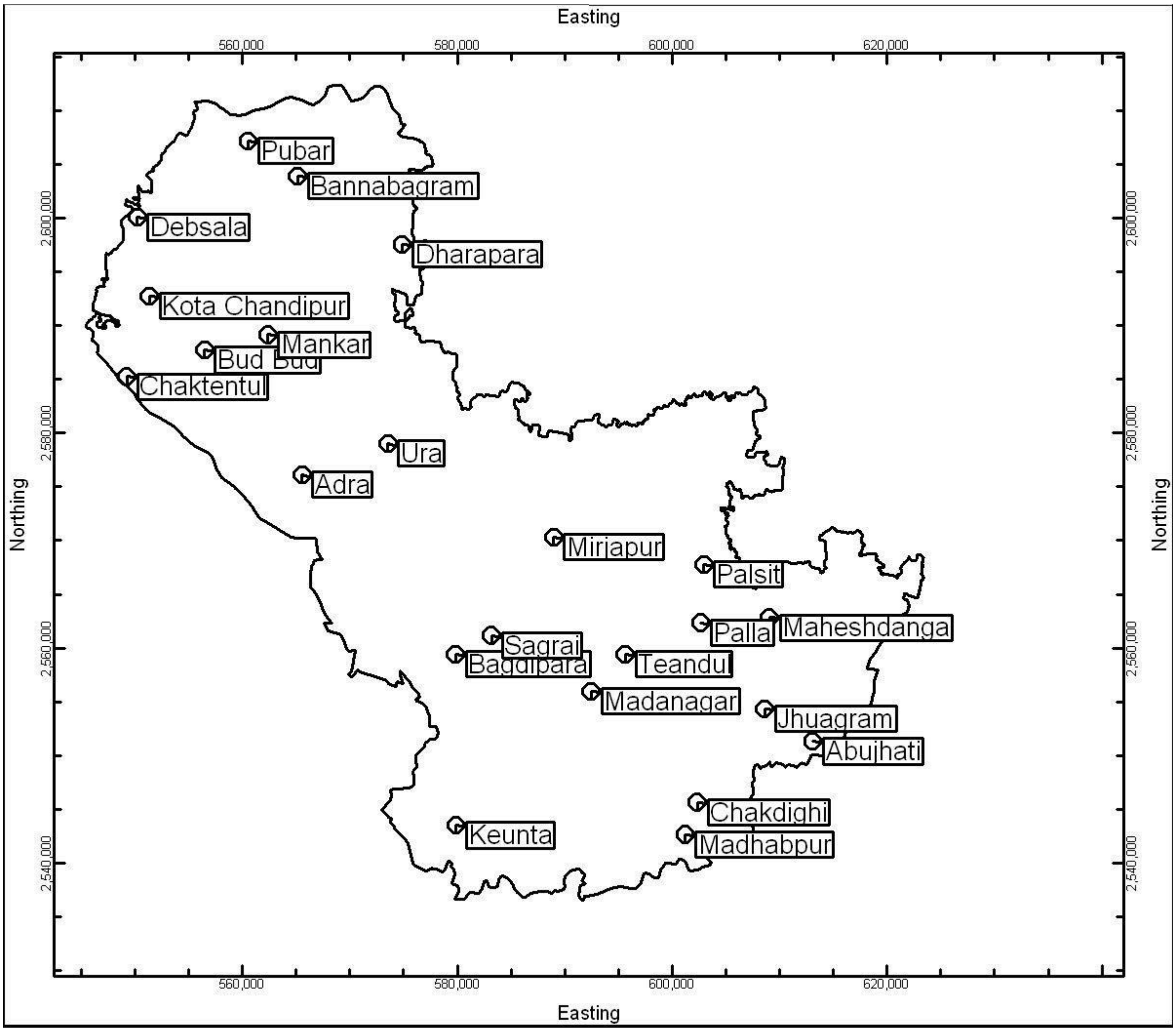


Fig 6.2: Borehole Location Map of Study area in Purba Bardhaman District

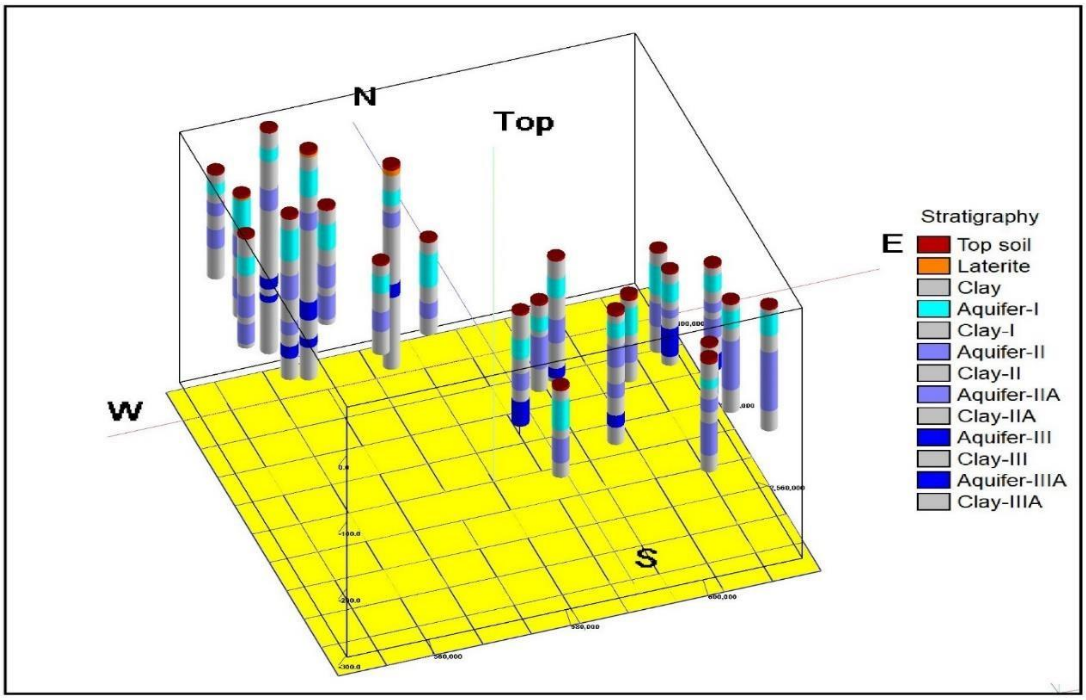


Fig 6.2.1: Strip-log of Study area in Purba Bardhaman District

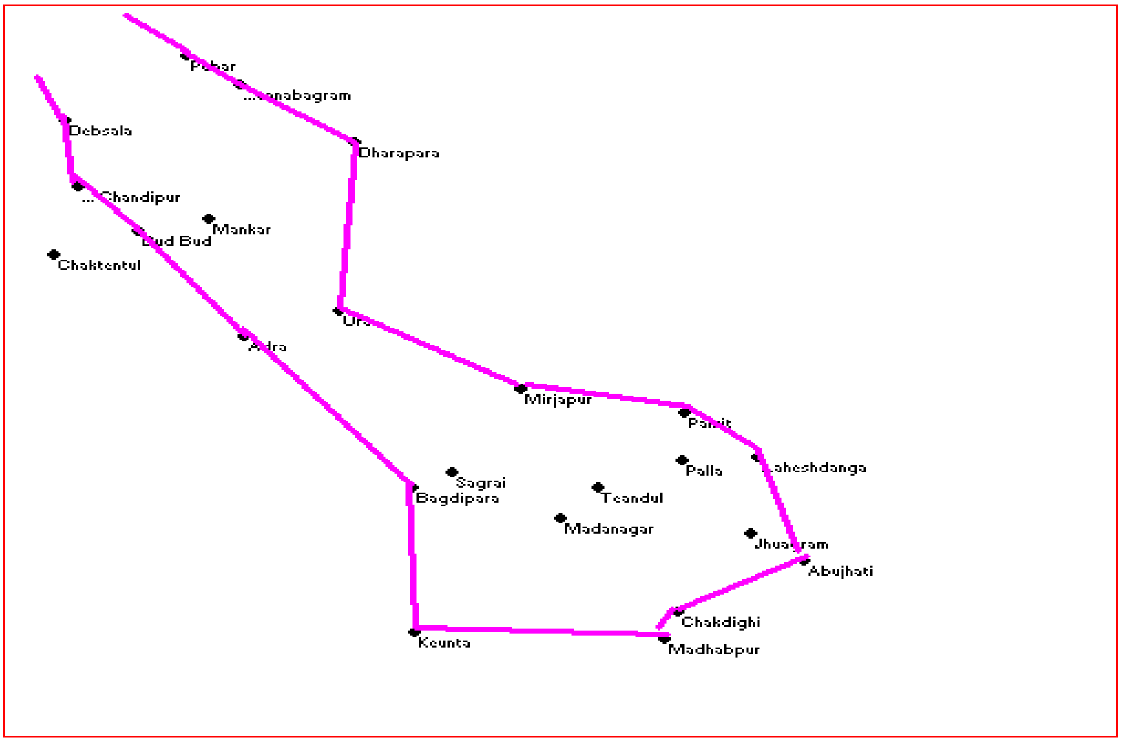


Fig 6.3.1: Profile selected for the Fence Diagram of Study area in Purba Bardhaman District

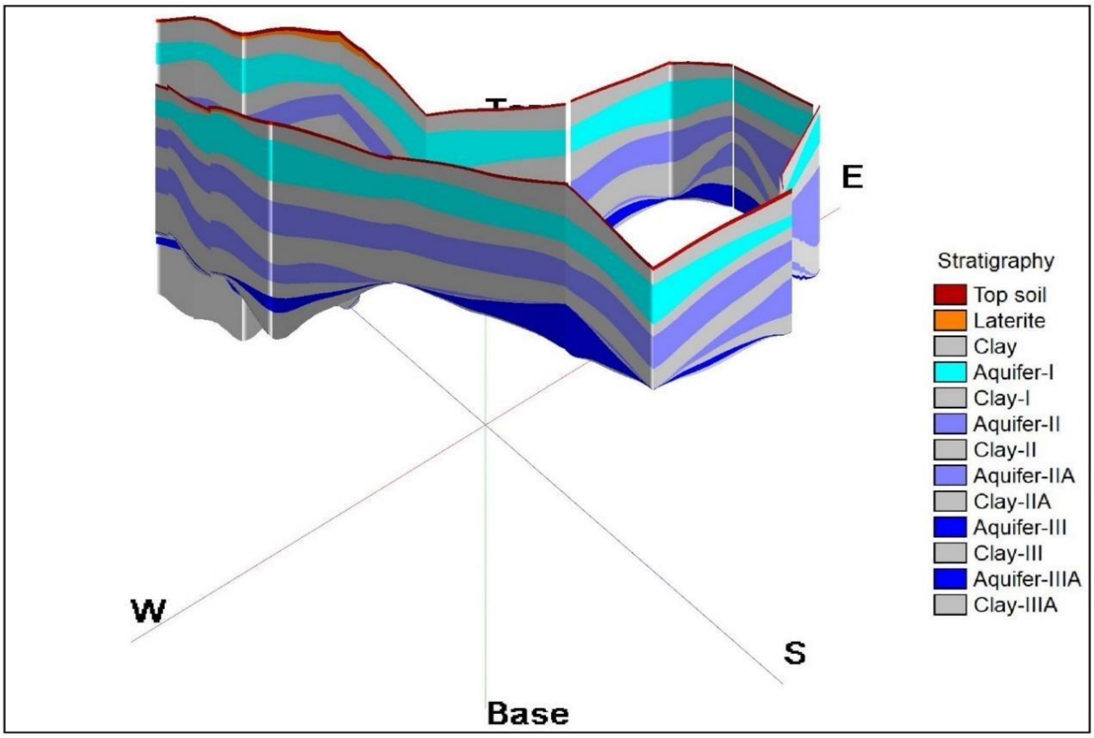


Fig 6.3.2: Fence Diagram of Study area in Purba Bardhaman District

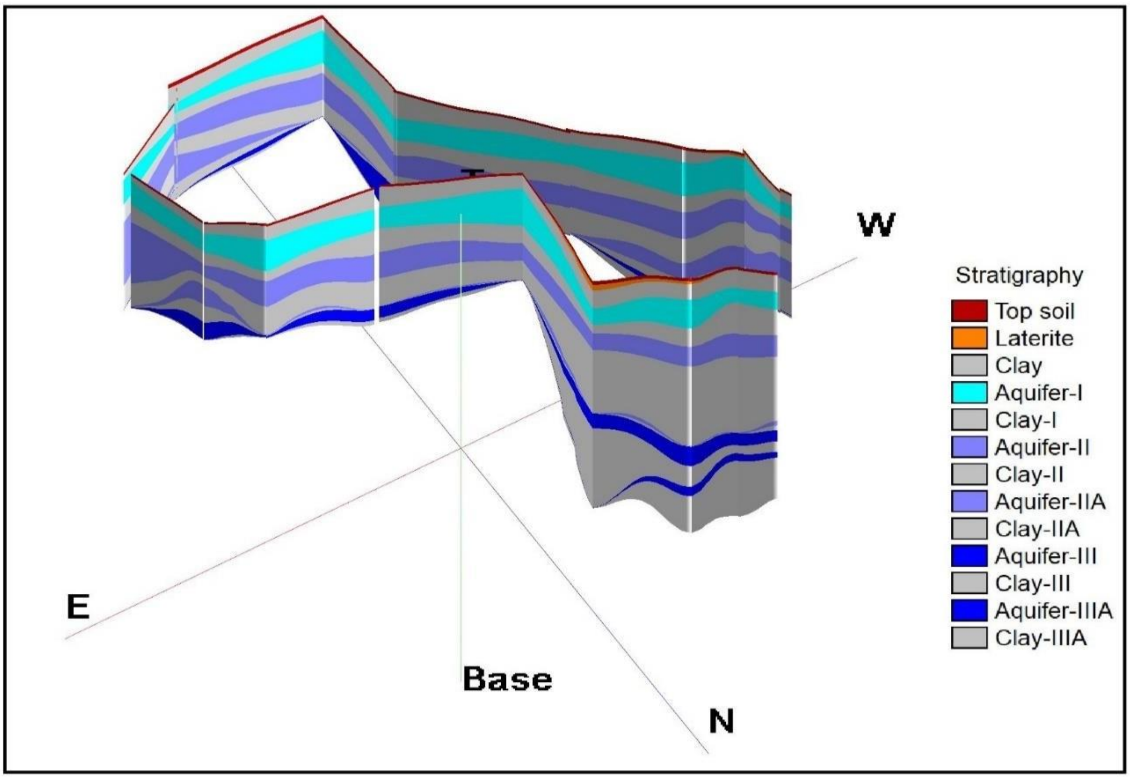


Fig 6.3.3: Fence Diagram of Study area in Purba Bardhaman District (Different Orientation only)

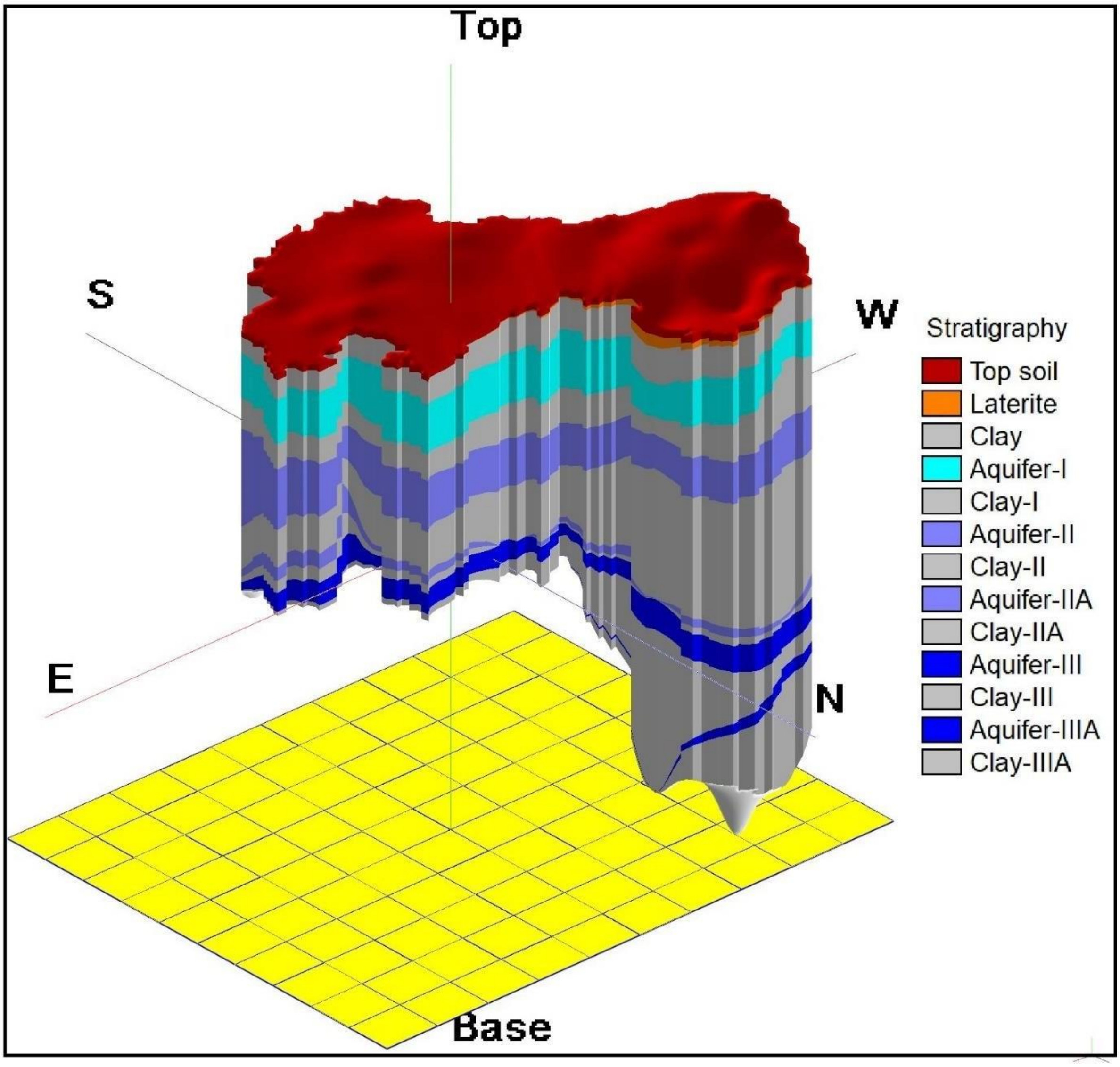


Fig6.4.1: 3D Aquifer Disposition of Study area in Purba Bardhaman District

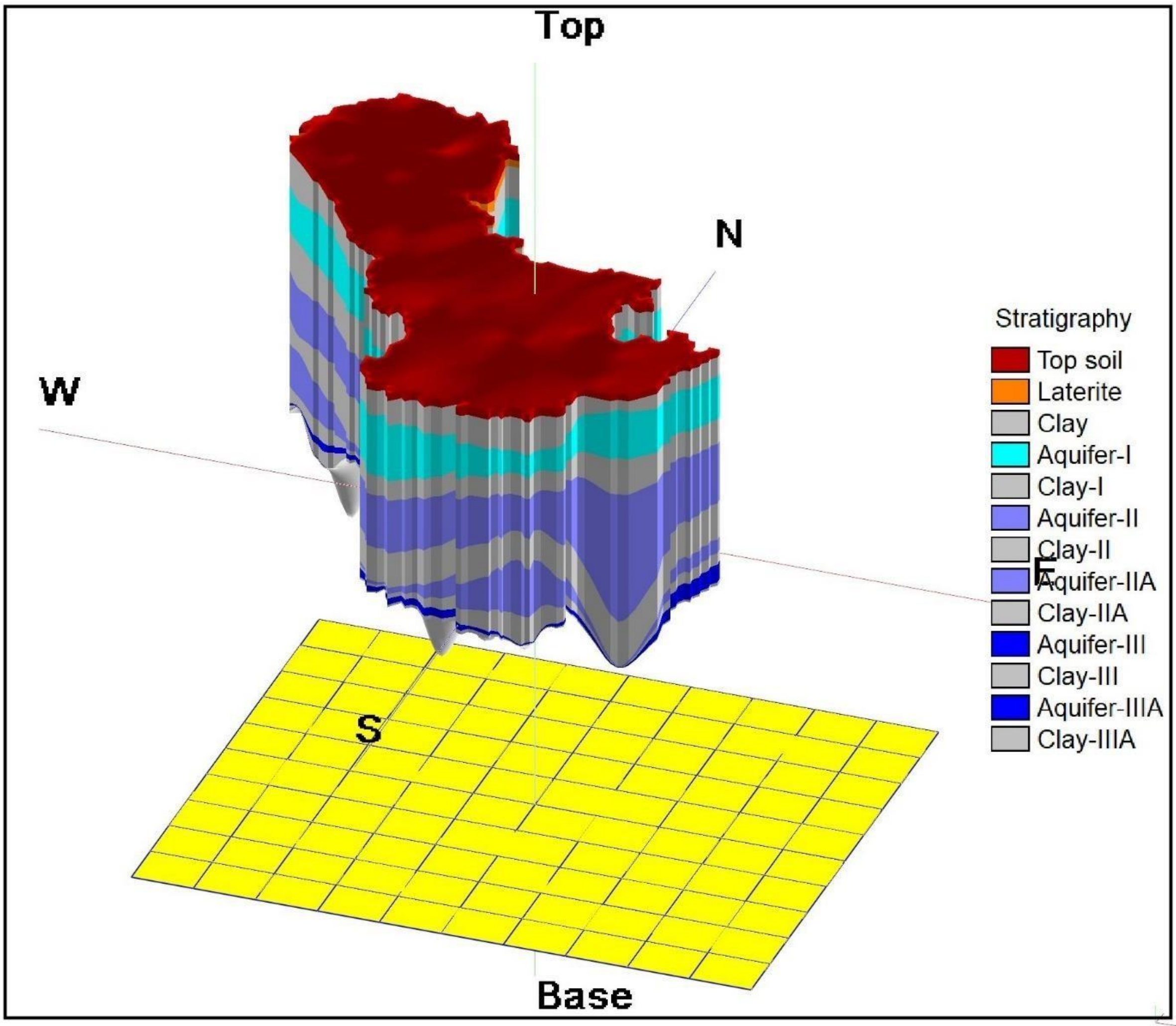


Fig6.4.2: 3D Aquifer Disposition of Study area in Purba Bardhaman District.

(Different Orientation only)

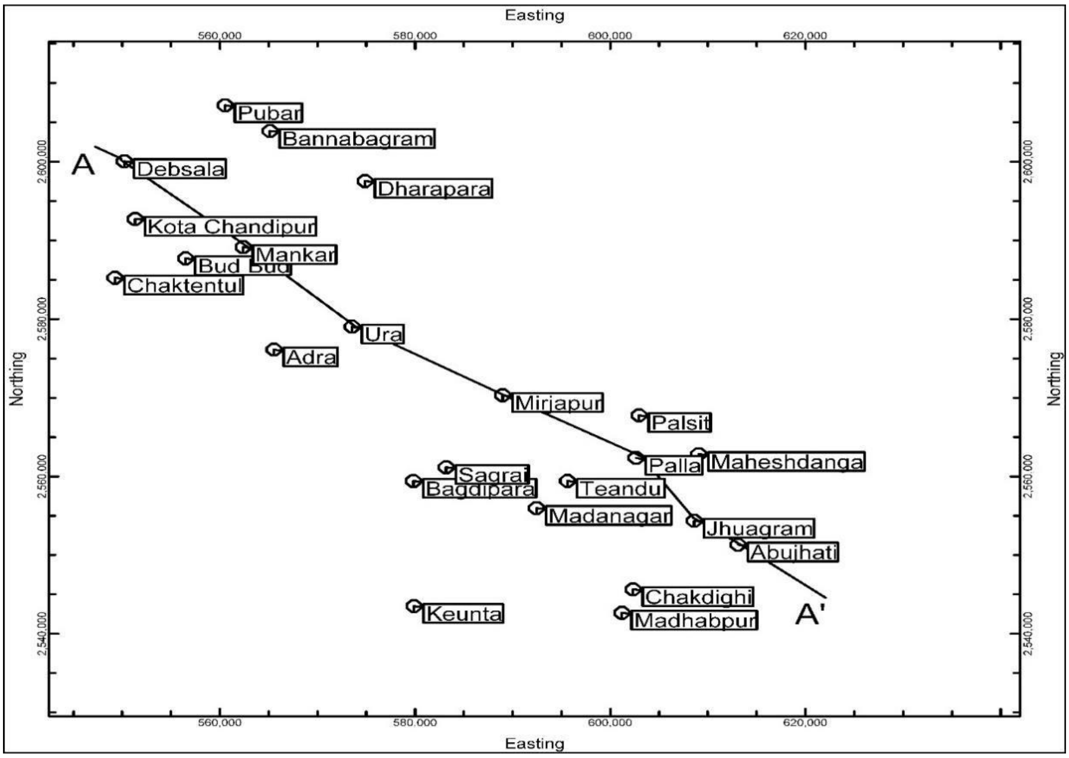


Fig6.5: Cross section selected for 2D Aquifer Disposition of Study area in Purba Bardhaman District

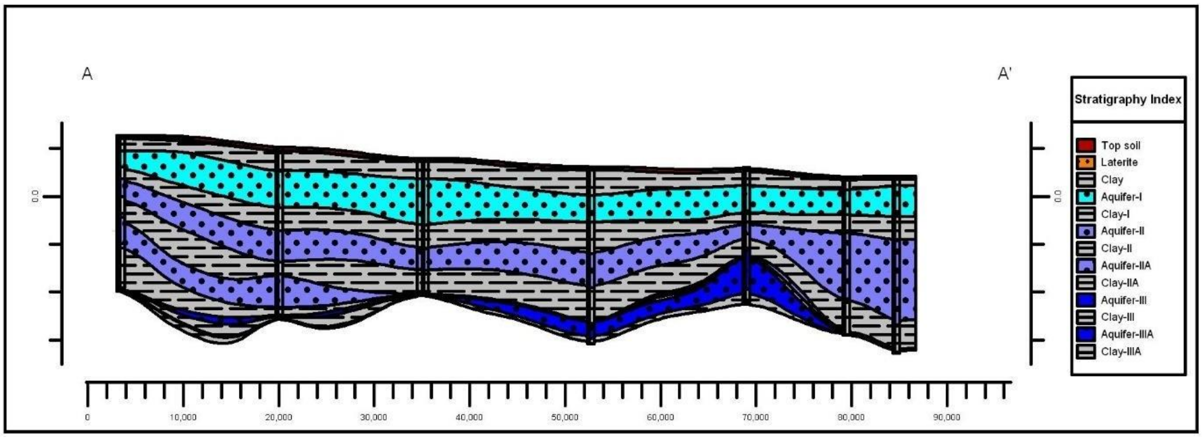


Fig6.6: 2D Aquifer Disposition of Study area in Purba Bardhaman District.

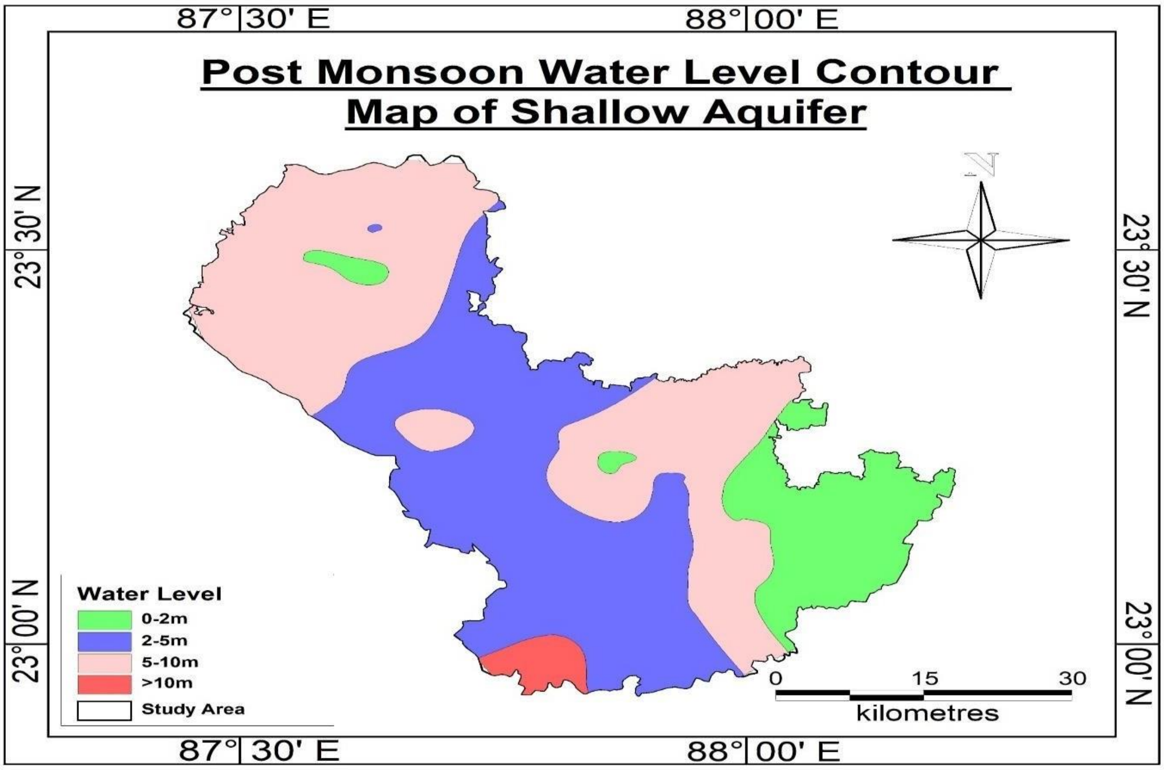


Fig6.7: Post Monsoon Water Level Contour map in Shallow Aquifer of Study area in Purba Bardhaman District.

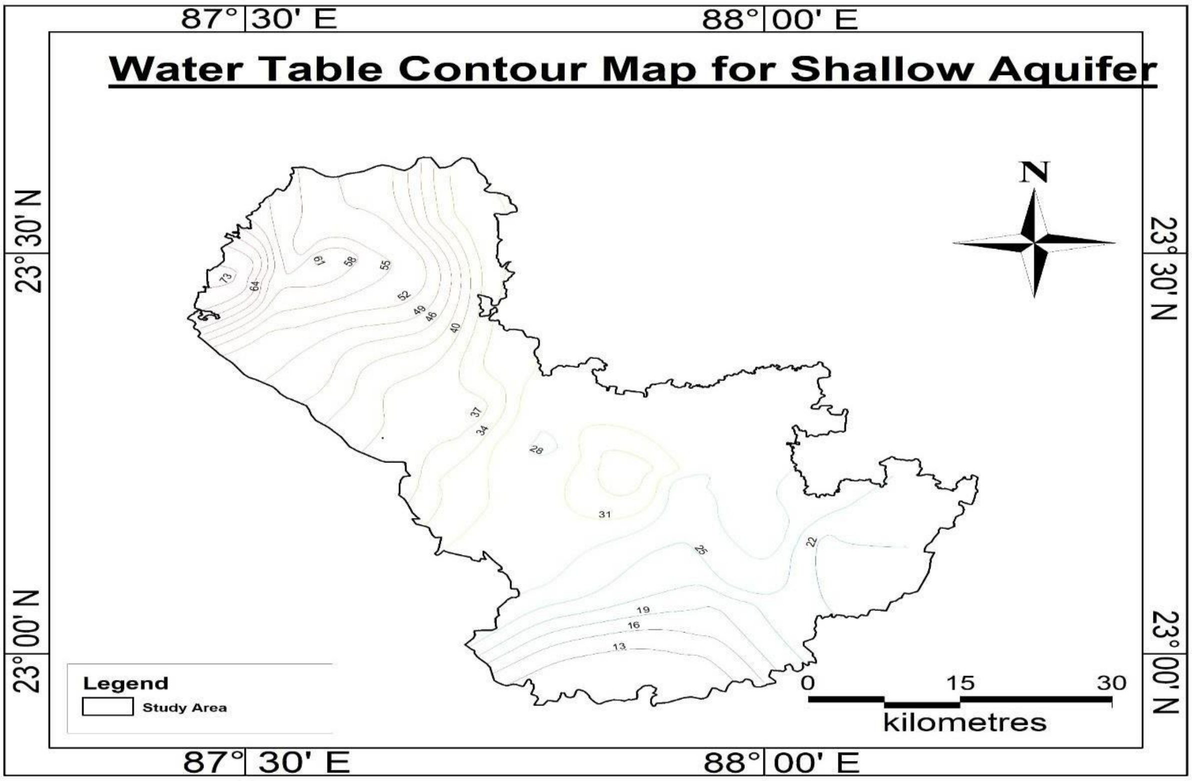


Fig6.8: Post Monsoon Water Table Contour map in Shallow Aquifer of Study area in Purba Bardhaman District.

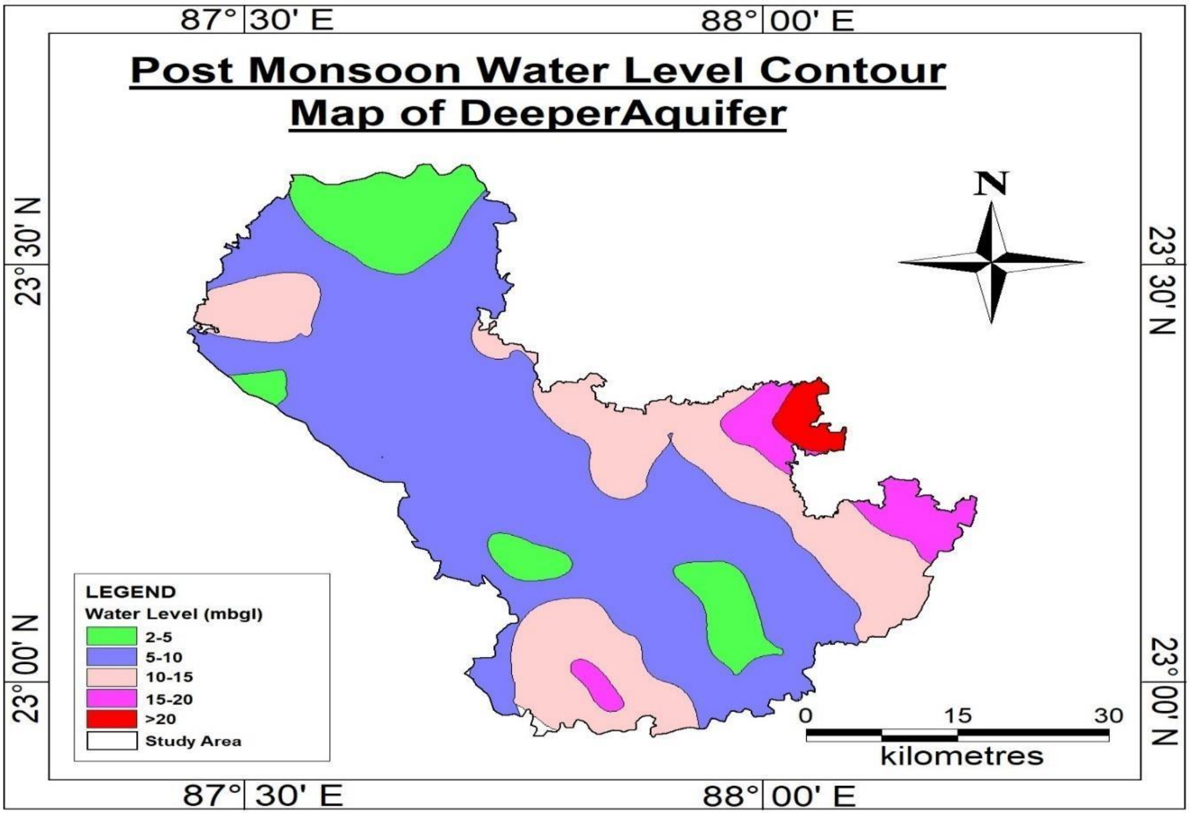


Fig6.9: Post Monsoon Water Level Contour map in Deeper Aquifer of Study area in Purba Bardhaman District.

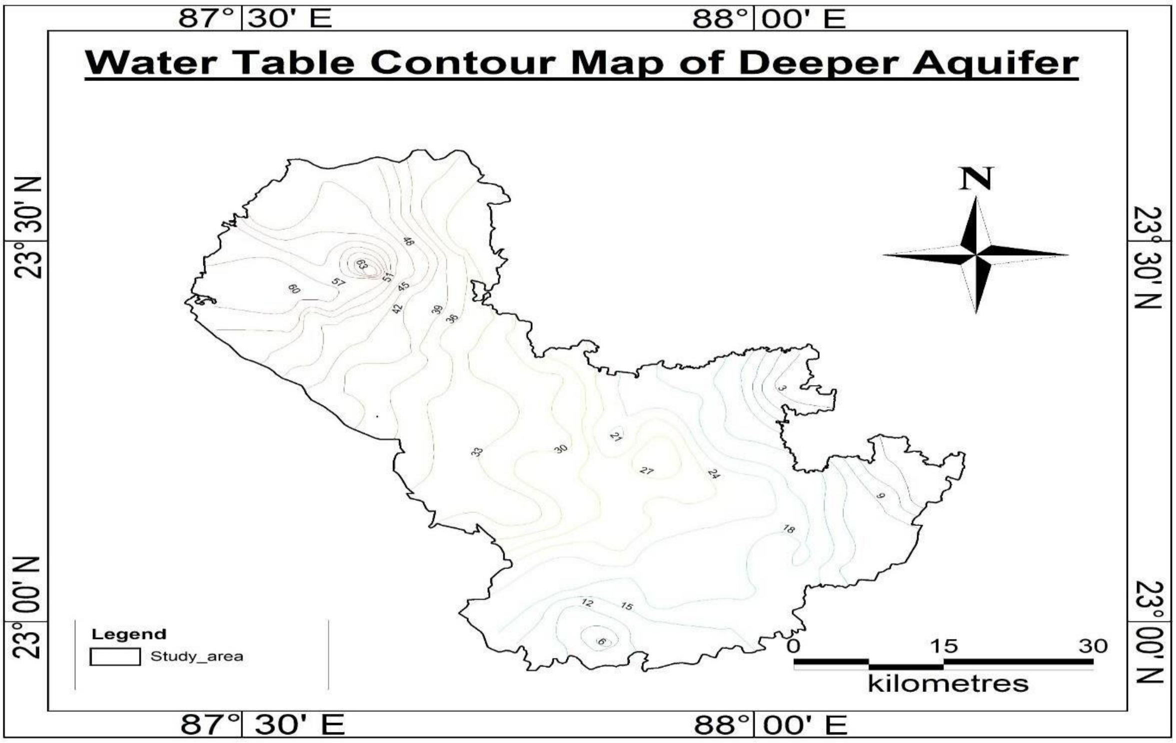


Fig6.10: Post Monsoon Water Table Contour map in Deeper Aquifer of Study area in Purba Bardhaman District.

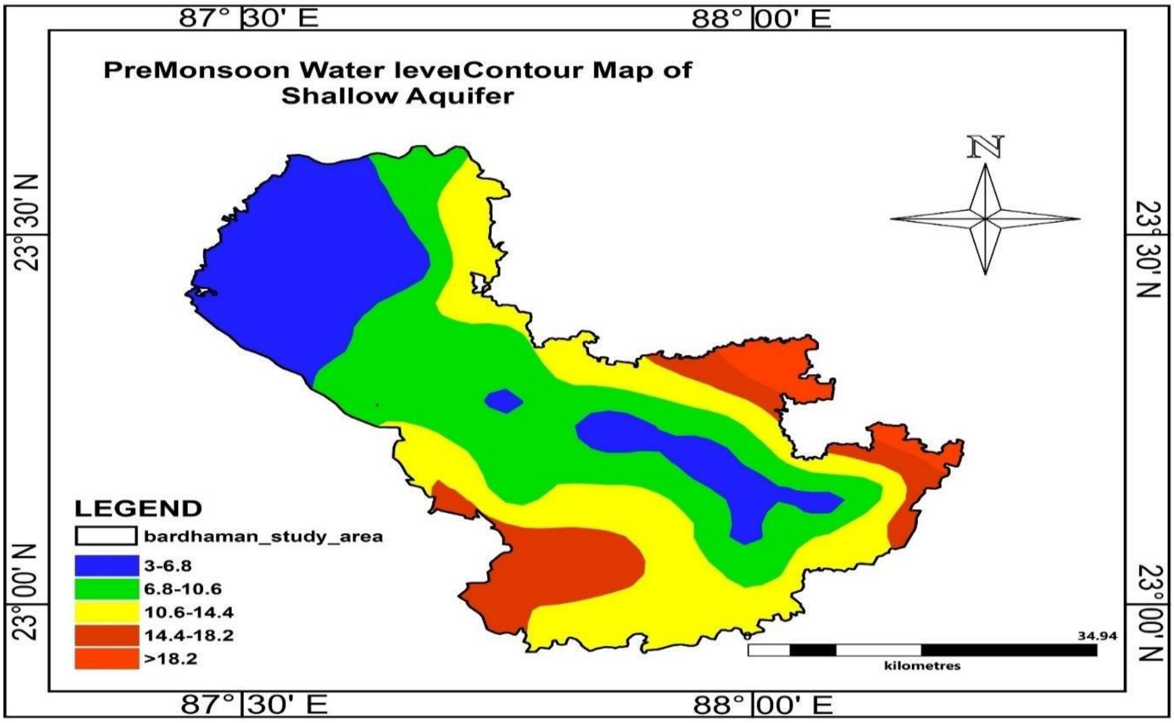


Fig6.11: Pre Monsoon Water Level Contour map in Shallow Aquifer of Study area in Purba Bardhaman District.

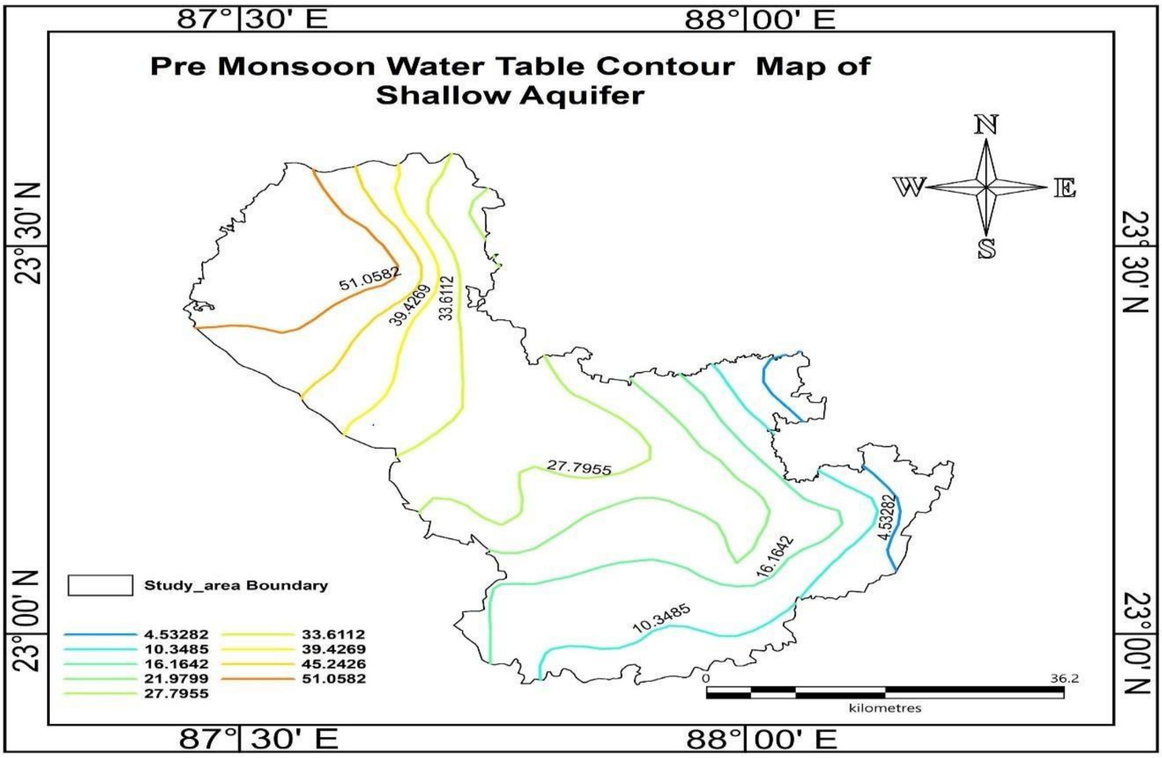


Fig6.12: Pre Monsoon Water Table Contour map in Shallow Aquifer of Study area in Purba Bardhaman District

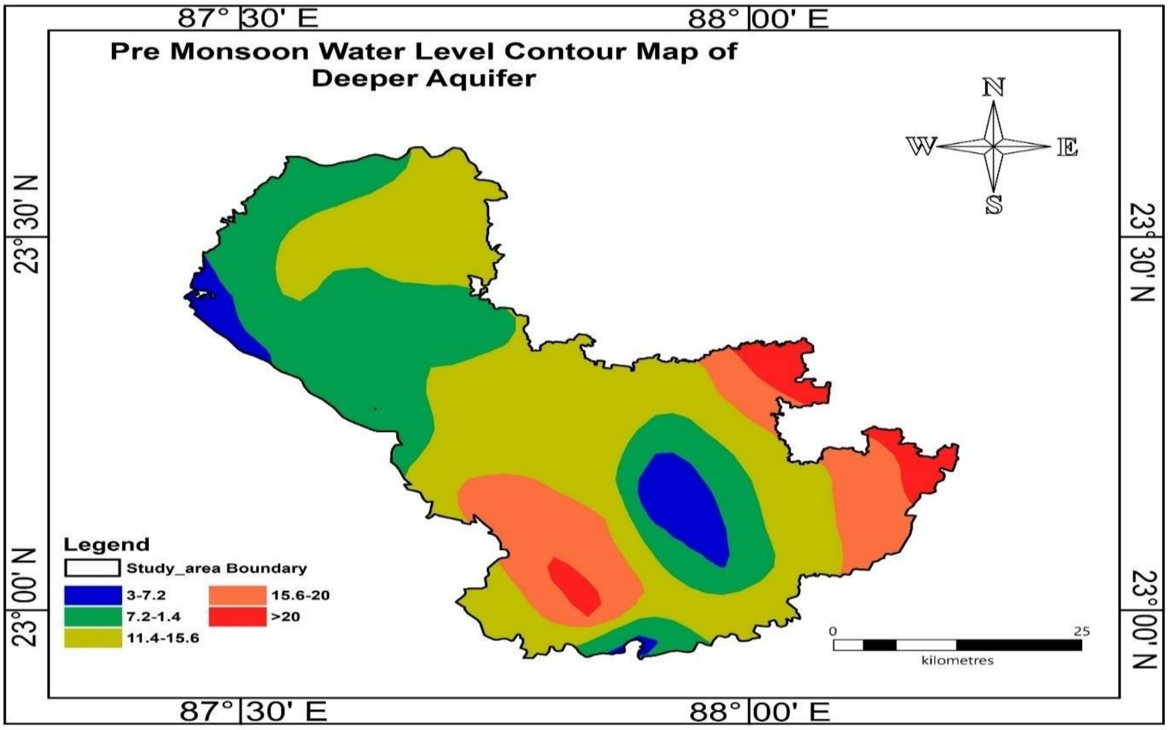


Fig6.13: Pre Monsoon Water Levele Contour map in Shallow Aquifer of Study area in Purba Bardhaman District

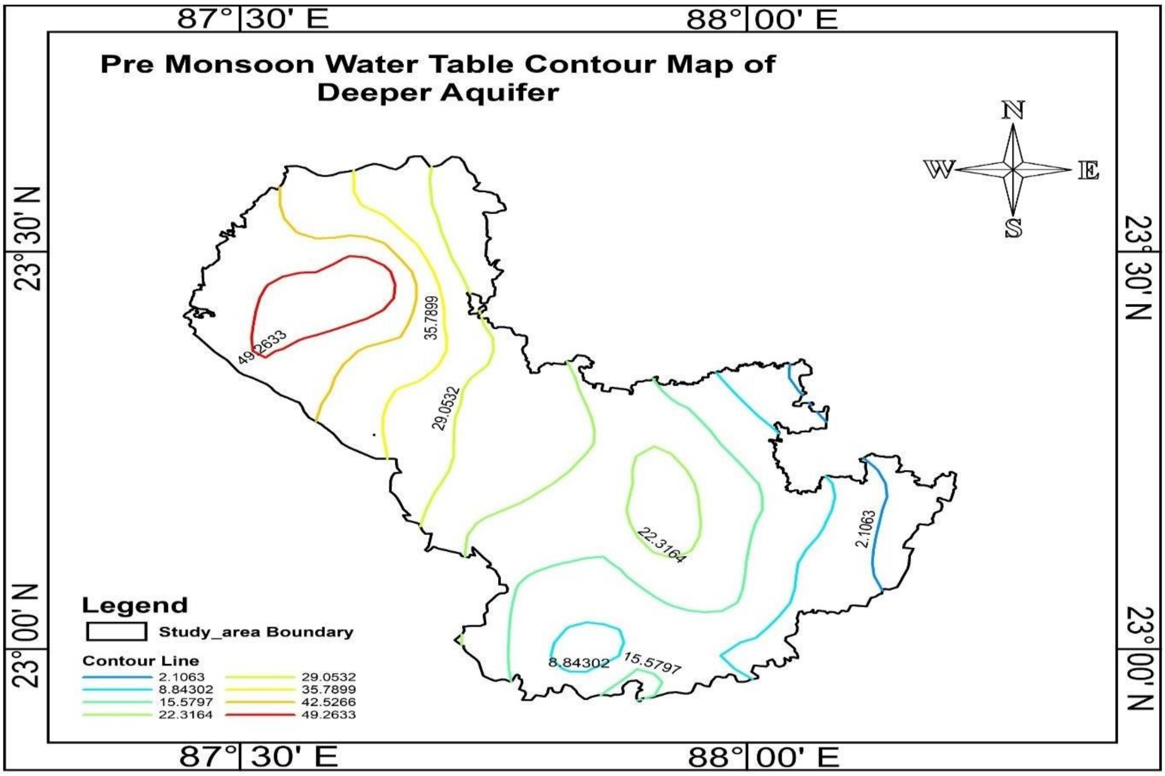
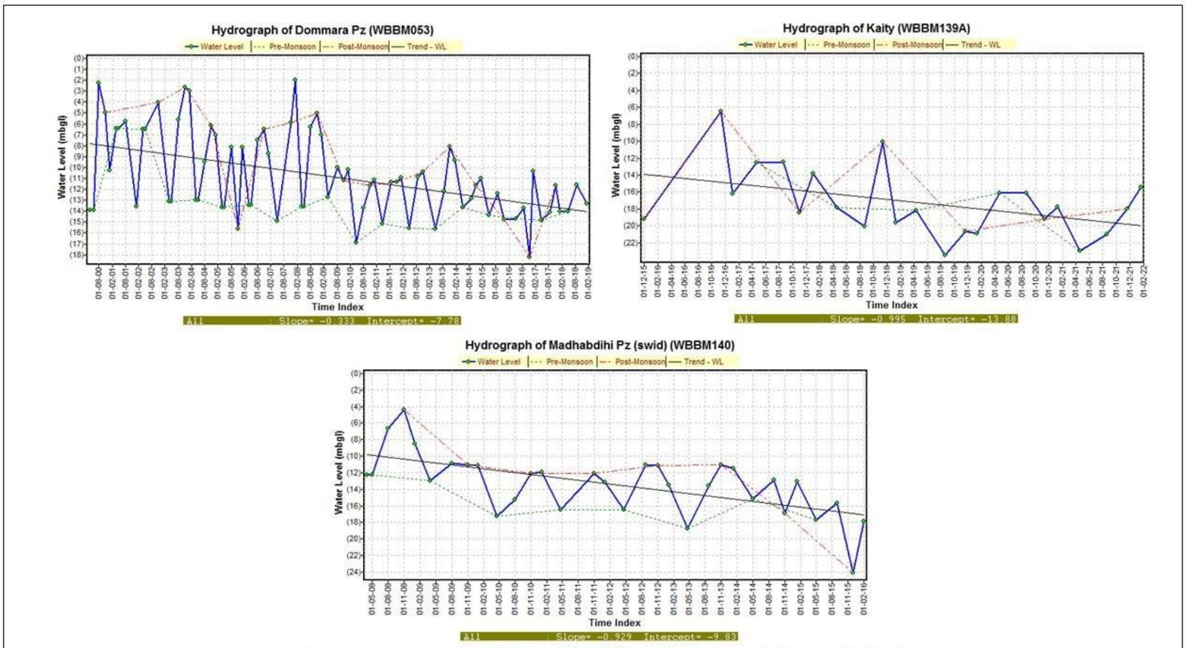
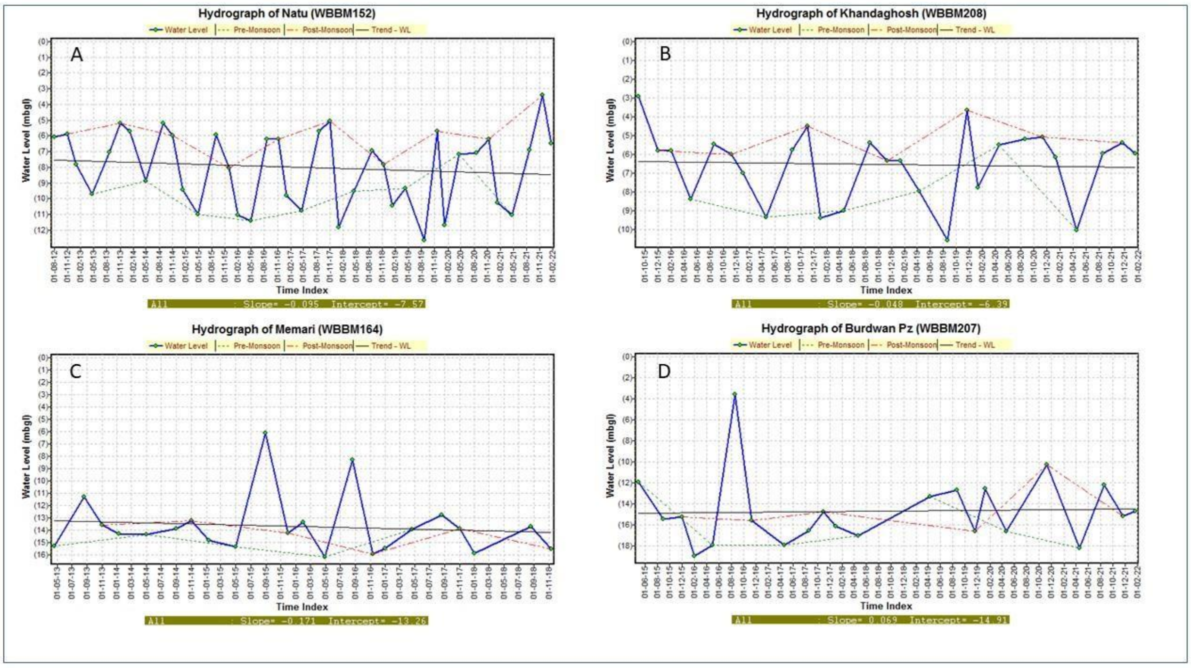


Fig6.14: Pre Monsoon Water Table Contour map in Deeper Aquifer of Study area in Purba Bardhaman District

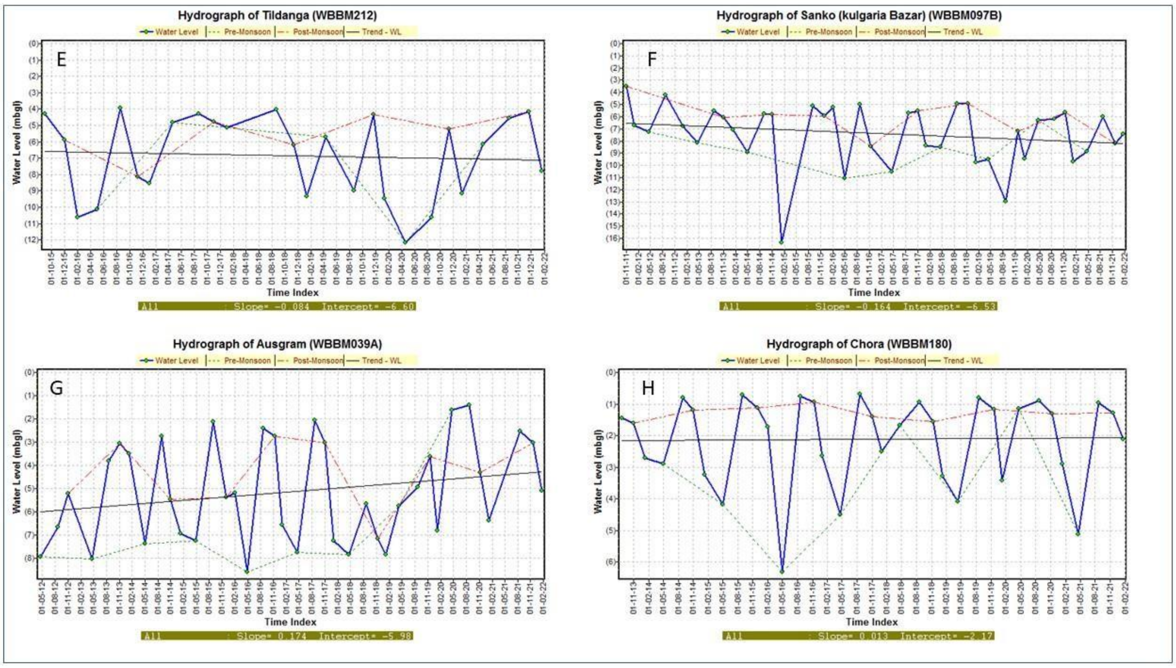


Declining water level trend in different places of Raina-II block

Declining Water level trend in different places of Raina-II Block.



Water level trend in different Blocks.



Water level trend in different Blocks.

CHAPTER-VII

GROUND WATER RESOURCES

7.1 Dynamic water resources

Ground water resources have two components replenishable ground water resources or Dynamic ground water resources and In-storage resources or Static resource. Under this chapter, The Dynamic Resource of the area for 2017 has calculated jointly by CGWB and SWID (State Water Investigation Directorate) using GEC-2015 methodology. According to the recommendations of GEC2015 following components has taken into consideration for resource calculation

I. Irrigation data from 5th Minor irrigation census, block wise population date from 2011 census and 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 considered.
II. The number of abstraction structures and their unit draft has taken into account for computation of irrigation draft
III. Normal annual rainfall data and water level data from CGWB monitoring station.
IV. Block wise Crop pattern and (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.
V. The projected population of 2025 (based on census 2011) and per capita consumption (60 lpcd) have considered for computation

The net ground water availability for recharge for the study area estimated as 132553.4 ham for Purba Barddhaman blocks, while the total extraction for all uses estimated as 68048.2 ham. The categorization of the blocks has 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. Almost all the study area in Purba Bardhaman district and Kansa block in Paschim Bardhaman district dominated by alluvial plains except Asansol area which dominated by Hard rock formation. The alluvial dominated areas in the Purba Bardhaman area get higher annual ground water recharge than the hard rock dominated area in Paschim Bardhaman district. The major factor for this high recharge component apart from Monsoon is the additional seepage from irrigation for cultivation of crops in both summer and winter. The potential of ground water is much higher in alluvial dominated areas in comparison to the area dominated by hard rock.

7.1.2 Ground water draft

Groundwater draft has estemated based on quantum of water likely to use for domestic, irrigation and industrial purposes. The estimate has done by projecting the population and the number of ground water abstraction structures. The total extraction for the study area of Purba Bardhaman blocks like Raina-II&I, Jamalpur, Khandaghosh, Burdwan-I&II, Ausgram-I & II are high (<8765.48 ham), showing there is high level use of groundwater for irrigation. The blocks like in Kanksa and Asansol Municipal Corp. the total extraction of groundwater is much low (<204ham) due to negligible agricultural development especially in Asansol area and low crop intensity in Kanksa block.

Table 7.1 Ground water Recharge, Resource and Stage of Development

BLOCK NAME	Total Annual Ground Water Recharge (Ham)	Total Natural Discharges (Ham)	Annual Extractable Ground Water Recharge (Ham)	Total Extraction (Ham)	Annual GW Allocation for Domestic and Industrial Use as on 2042	Net Ground Water Availability for future use	Stage of Ground Water Extraction (%)	Categorization
Purba Bardhaman								
AUSGRAM-I	12722.56	1272.25	11450.31	5074.61	205.67	6332.64	44.32	Safe
AUSGRAM-II	18976.43	1897.65	17078.78	5773.6	209.03	11255.88	33.81	Safe
BURDWAN-I	13593.93	1359.39	12234.54	6069.99	598.48	6111.66	49.61	Safe
BURDWAN-II	9341.36	934.14	8407.22	4718.33	154.21	3697.5	56.12	Safe
GALSI-I	9039.76	903.98	8135.78	4344.47	233.27	3762.15	53.40	Safe
GALSI-II	8508.31	850.83	7657.48	5300.58	180.32	2333.63	69.22	Safe
JAMALPUR	23140.16	1999.2	21140.96	8765.48	356.51	12304.29	41.46	Safe
KHANDAGHOSH	18560.71	1856.07	16704.64	8762	246.31	7896	52.45	Safe
MEMARI-I	10831.47	541.57	10289.9	5151.71	358.14	5054.92	50.07	Safe
RAINA-I	13400.35	1340.04	12060.31	7468.97	227.41	4554.91	61.93	Safe
RAINA-I I	8214.97	821.5	7393.47	6618.49	202.56	733.41	89.52	Semi Critical
TOTAL	**146330**	**13776.62**	**132553.4**	**68048.2**	**2971.91**	**64036.99**		
Paschim Bardhaman								
Asansol Municipal Cop.	1761.01	88.05	1672.96	138.5	104.2	1522.59	8.28	Safe
KANKSA	15101.36	755.07	14346.29	2758.8	204.06	11560.76	19.23	Safe

7.1.3 Stage of development and category

The average stage of groundwater extraction of study area mostly in Purba and Paschim Bardhaman district is 55% and 13% respectively. The level of extraction ground water in Purba Bardhaman seems higher in compared with the average stage of ground water extraction of state (42%). All the study area in Purba Bardhaman district are alluvial dominated where the quantum of ground water availability is very high. The development of ground water in this area is high (52%) due to excellent agricultural development and it is economically viable to take ground water as a major source for irrigation both in summer and winter crops. It is difficult and uneconomical to find a good potential ground water source in hard rock areas, in most of Asansol and Kanksa where poor agricultural development, negligible irrigation from groundwater source is a major reason for very low ground water development. Based on stage of groundwater development and over the year tend ground water level, all the blocks in study area in Paschim and Purba Bardhaman district declared **saf**e except Raina-II, which falls und **semi critical** category. The major crops like Aman, Boro and Patato are all high-water intensive crops cultivated in Raina-II, which required approx. 500-700mm in total growth season. Out of total cultural command area 7059ha around 94% (6674ha), area irrigated using ground water as a major source this cause the ground water development to 89%.

7.1.4 Irrigation Potential created and utilized

The ground water irrigation structures in use and the irrigation potential created through these abstraction structures given in **Table 7.2.** As seen from the table, very high irrigation potential created in most of the study area blocks under Purba Bardhaman district in compare to Asansol and Kanksa of Paschim Bardhaman district. Out of the total worker population on an average about 55 percent population linked to agricultural sector where as non-agricultural sector accounts the remaining 45 percent. Depending on the exploding population the importance of rice is going to high in coming future because of it high yield varieties and low cost expenses. Rice is the most important crop cultivated in Purba Bardhaman district due to suitable soil texture and alluvial plains. The rice grown with its numerous varieties Like Aus or autumn, the Aman or winter and Boro or summer rice cultivated along with Mustard, Til and sugarcane in most of the blocks in study area of Purba Bardhaman district. The potential of irrigation will increase in coming future due high food demand and development of agricultural sector. The gap between irrigation potential and actual irrigated area will may rise because of climate change and uncertainty of monsoonal rainfall. The population mostly in Asansol area traditionally engaged in coal mining and in industries. Therefore, utilization of ground water for irrigation is practically very low. Since these blocks falls under 'Safe' category, there is further scope for expansion of ground water irrigation through additional irrigation potential with available resource.

Apart from common abstraction structures like dug wells, shallow tube wells and deep tube wells, there are number of water bodies in use for irrigation which is listed in the table below. (**Table 7.2**)

Table 7.2 Irrigation structures, irrigation potential created and actual area irrigated with groundwater in the study area (Source: 5th MI census)

Sl. No.	Block Name	DW	STW	MTW	DTW	S.F	S.L	Total Irrigation Potential(ha.)	Actual irrigated area(ha)	Achivement %
1	ASANSOL MUNI.CORPN	0	0	0	0	0	0	0	0	0
2	KANKSHA	1	687	9	41	21	90	8152	5567.92	68
3	AUSGRAM-I	4	583	78	4	40	172	8626	5199.85	60
4	AUSGRAM-II	5	991	32	57	46	160	7325	5937.53	81
5	BURDWAN-I	2	993	18	62	9	10	5852	5772.49	99
6	BURDWAN-II	0	1235	10	30	8	16	7579	6245.37	82
7	GALSI-I	1	1098	13	11	1	23	4846	3024.1	62
8	GALSI-II	0	1373	6	65	1	60	6422	6500	101
9	JAMALPUR	1	1612	4	73	17	52	11715	7304.96	62
10	KHANDAGHOSH	0	1449	15	61	1	130	8383	7519.69	90
11	MEMARI -I	7	1006	13	53	14	101	9844	8997.67	91
12	RAINA-I	0	1293	51	61	3	14	9374	6892.5	74
13	RAINA-II	0	1470	8	88	22	23	10535	7059	67
	TOTAL	21	13790	257	606	183	851	98654	76021	77

7.2 Static water resource/In-storage

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

Table 7.3 In-storage of groundwater for the study area

Sl. No.	District	Assessment Unit/ District	Fresh In-Storage Ground Water Resources (2009)
1	Purba Barddhaman	AUSGRAM-I	9419
2	Purba Barddhaman	AUSGRAM-II	3818
3	Purba Barddhaman	BURDWAN-I & II	2498
4	Purba Barddhaman	GALSI-I	6236
5	Purba Barddhaman	GALSI-II	2580
6	Purba Barddhaman	JAMALPUR	9957
7	Purba Barddhaman	KHANDAGHOSH	10475
8	Purba Barddhaman	MEMARI-I	12076
9	Purba Barddhaman	RAINA-I	19955
10	Purba Barddhaman	RAINA-II	8355
11	Paschim Barddhaman	KANKSA	99753

12	Paschim Barddhaman	ASANSOL	--
	Soft Rock/Alluvium Total		1267086

Table7.4- No. of water bodies for use for irrigation apart from the abstraction structures (5th MI Census)

Sl. No.	Block	No. of Water Bodies used for Irrigation and in use			
		Reservoirs / Minor Dam	Ponds / Tanks	Other Storages / Check-dams	Total
Purba Bardhaman					
1	**AUSGRAM-I**	47	164	37	248
2	**AUSGRAM-II**	15	170	28	213
3	**BURDWAN-I**	5	0	0	5
4	**BURDWAN-II**	0	6	0	6
5	**GALSI-I**	7	36	5	48
6	**GALSI-II**	0	0	0	0
7	**JAMALPUR**	6	8	0	14
8	**KHANDAGHOSH**	0	0	0	0
9	**MEMARI-I**	0	0	0	0
10	**RAINA-I**	0	0	0	0
11	**RAINA-II**	0	0	0	0
Paschim Bardhaman					
12	**ASANSOL MUNI.CORPN**	0	0	2	2
13	**KANKSA**	7	100	31	138
	Total:	87	484	103	674

CHAPTER- VIII

HYDROCHEMISTRY

8.1 Quality of Shallow and Deeper Aquifer Water

Ground water samples were collected during pre-monsoon period from the monitoring key wells established for the NAQUIM studies and National Hydrograph Stations falling in the study area and those have been analysed in the departmental Chemical Laboratory. Chemical quality of ground water occurring in shallow and deeper aquifers does not vary significantly, except arsenic concentration. The water, in general, is slightly alkaline.

8.2 General range of chemical parameter

The samples from the monitoring wells in the study area, were analysed in the CGWB Laboratory. From the analytical results, it is found that,

8.2.1 In Shallow Aquifer

pH of water, in general, varies between 6.84 and 7.83 and EC ranges between 174 and 1010 µS/cm. The EC contour map **(Fig-8.1 and 8.1A)** shows that, Most the ground water in study area , EC is laying less than 500 µS/cm. EC is higher than 500 µS/cm in parts of Ausgram-I, galsi-I, Khandaghosh and some portions of Rayna-I blocks. The range of EC in Assansol area is around 980-1366 µS/cm which makes it unsuitable for drinking. Concentrations of Na ranges from 7.2 to 92.4 mg/1. Cl is mostly in the range of 14.18 – 138.2 mg/1. Fluoride ranges from 0.07 – 0.7 mg/1, whereas Nitrate concentration ranges from BDL– 15.8 mg/1. Total hardness ranges from 40-390 mg/1. The maximum contaminant level for Uranium in is 30 ppb , Uranium concentration in all these blocks are within permissible limit. Block-wise Ranges of Chemical Parameters in Shallow aquifer is shown in **Table-8.1.**

Table 8.1 Block-wise range of chemical Parameters in Shallow Aquifer

Block	pH	EC	TH	Ca	Mg	Na	K	HCO3	TA	Cl	NO3	F	TDS	U
Galsi-I	6.84-7.71	174-1010	50-265	012 -64	4.9-27.9	10.75-92.4	0.94-2.9	61-384.3	75-315	17.7-120.5	0.2-3.2	0.07-0.52	85.6-541.7	0.079-6.55
Galsi-II	7.4-7.59	360.8-466.9	170-220	30-46	18.2-31.6	11.02-35.1	0.75-2.14	189.1-280.6	155-230	28.36-42.54	0.2-1.0	0.26-0.42	212.1-305.9	0.66-1.56
Bardhaman	7.2-7.77	196.9-492.5	95-230	30-48	4.9-31.6	9.03-38.9	1.08-2.09	122-317.2	100-260	24.81-49.63	0.1-2.0	0.23-0.62	171.2-344.6	0.21-3.39
Rayna-II	7.39-7.77	472-581.4	200-260	40-56	20.6-38.8	11.33-29.7	0.86-2.7	244-347.7	200-285	17.72-56.72	0.3-2.6	0.4-0.62	263-340.9	0.95-4.19
Ausgram-II	6.87-7.48	219.5-271.4	40-145	18-30	8.5-17.0	7.1-16.2	1.61-3.76	49-195.2	55-160	14.18-28.36	0.2-0.5	0.08-0.3	70.2-203.3	<0.0030
Augram-I	6.88-7.65	179-643.3	70-240	18-48	2.4-34.0	15.9-31.92	1.04-3.24	97.6-347.7	80-305	14.18-46.085	0.1-1.1	0.12-0.57	140.6-349.1	0.16-2.30
Khandaghosh	7.5-7.74	444-996	200-390	40-52	18.2-60	19.56-42.9	0.83-11.21	268.4-366	220-300	21.27-138.255	0.1-15.8	0.4-0.75	308.8-496	0.83-4.3
Rayna-I	7.72-7.83	397.3-779.6	170-295	26-44	25.5-34.0	28.91-40.5	0.87-1.24	256.2-366	210-300	14.18-85.08	0.1-0.5	0.34-0.6	269-435.5	0.82-5.91
Jamalpur	7.28-7.79	237.8-707.2	95-225	18-54	8.5-43.7	20-68.58	0.81-32.76	158.6-408.7	130-335	14.18-77.99	7.5-8.0	0.22-0.61	173.6-433.8	0.2664-3.59
Memari-I	7.23-7.9	254.6-473.4	100-200	16-52	4.9-27.9	16.31-36.5	1.35-2.1	146.4-292.8	120-240	14.18-42.54	0.0-7.9	0.18-0.42	201-319.3	BDL-1.9023
Kanksa	6.33-7.59	102.4-841.2	65-290	18-32	4.9-51	2.86-56.7	0.7-3.52	91.5-439.2	75-360	17.72-67.35	0.1-1.2	0.04-0.47	126.1-477.3	10.5
Assansol	7.8	980.1-1366	160-420	22-100	25.48-41.26	75.24-294.3	6.2-14.2	378.2-701.5	310-575	74.44-159.52	0.49-0.98	0.39-1.23	477.29-897.49	3.40-6.25

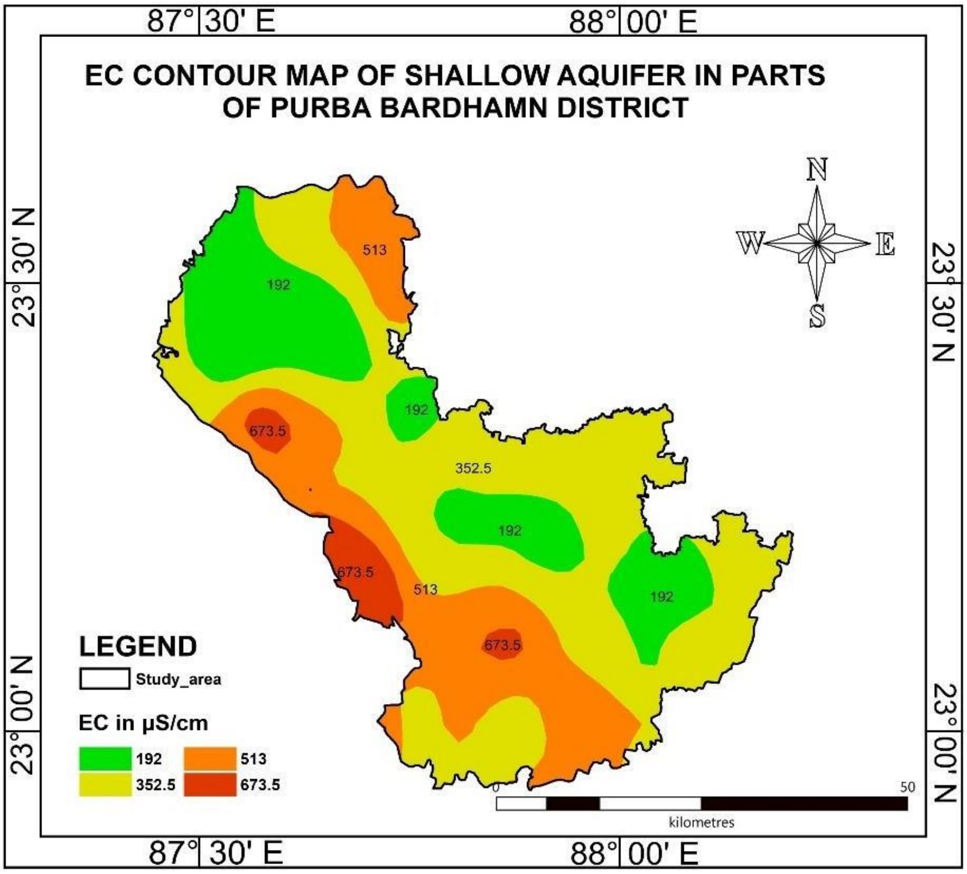


Fig8.1: EC Contour map in Shallow Aquifer of Study area in Purba Bardhaman District

8.2.2 In Deeper Aquifer

pH of water, in general, varies between 6.34 and 7.81 and EC ranges between 114 and 636 µS/cm. The EC contour map **(Fig-8.2&2A)** shows that, the ground water in deeper Aquifer is mainly having less than 500 µS/cm in most of the part and in some parts like in Galsi-I & II , Rayna-I and some parts in Jamal pur where EC value goes above 500 µS/cm. A exceptional higher Ec value noticed in assansol that is 897 µS/cm. Concentrations of Na ranges from 13.37 to 64.5 mg/1. Cl is mostly in the range of 14.18 – 53.6 mg/1. Fluoride ranges from 0.04 – 0.66 mg/1, whereas Nitrate concentration ranges from 0.1– 9.7 mg/1. Total hardness ranges from 45-285 mg/1. Block-wise Ranges of Chemical Parameters in Deeper aquifer is shown in **Table-8.2.**

Table 8.2 Block-wise range of chemical Parameters in Deeper Aquifer

Block	pH	EC	TH	Ca	Mg	Na	K	HCO3	TA	Cl	NO3	F	TDS	U
Galsi-I	7.71	583.2	210	52	19.4	34.5	0.99	292.8	240	35.45	1.9	0.52	323.4	3.4799
Galsi-II	7.25-7.72	179.2-556.3	115-255	40-52	3.6-30.3	13.54-16.07	0.92-1.02	122-305	100-250	17.72-31.90	0.5-2.5	0.28-0.58	169.6-318.4	<0.368
Bardhaman	7.36	443.5	260	48	34.0	17.35	0.75	298.9	245	35.45	1.6	0.43	319.9	2.7483
Rayna-II	7.64	436.1	205	42	24.3	26.1	1.04	317.2	260	14.18	0.1	0.46	301.6	BDL
Ausgram-II	6.43-7.81	114.5-532.2	60-160.5	16-34	4.9-18.3	20.4-42.1	1.58-9.63	48.8-298.9	40-245	21.27-42.5	0.4-9.7	0.04-0.36	125.4-312	BDL
Ausgram-I	7.18-7.49	354.4-416.9	155-190	28-40	13.3-29.1	13.37-28.4	1.17-1.41	164.7-244	200-135	21.27-53.6	0.6-2.3	0.21-0.5	228.3-254.4	<0.4170
Khandaghosh	7.58-7.7	491.6-543.9	230-260	36-46	34-35	15.61-24.06	0.8-1.14	317.2-347.7	260-285	14.18-35.45	0.1-6.2	0.56-0.61	327.2-328.3	2.44-4.22
Rayna-I	7.64-7.76	584.7-604.3	240-265	28-30	41.3-46.1	26.9-39.2	1.35-1.41	372.1-414.8	305-340	17.7-24.81	0.1-0.6	0.62-0.64	343.5-395.3	2.89-3.01
Jamalpur	7.47-7.63	385.3-636.9	125-168	36-54	15.8-30.3	26.3-64.5	1.08-2.43	183-427	150-350	17.7-31.9	4.8-8.4	0.38-0.66	217.3-426.3	0.33-1.88
Memari-I	7.65-7.8	266.7-507.1	45-285	36-40	16-44.9	18.95-39.6	1.14-2.51	183-317.2	150-260	14.18-42.54	7.6-7.9	0.3-0.44	206-349.1	0.11-1.14
Kanksa	5.8-7.16	39.4-138	55-95	0 8 -22	3.6-9.7	3.95-9.36	1.43-3.33	61-103.7	50-85	14.18-21.27	0.2-0.5	0.03-0.8	75-123.8	<0.8009
Assansol	7.8	759-.1-897	285-305	26-54	36.4-58.3	62.3-76.1	1.38-3.35	402.6-518.5	330-425	42.54-56.72	1.0-89.5	0.65	532.6-538.4	1.209-3.50

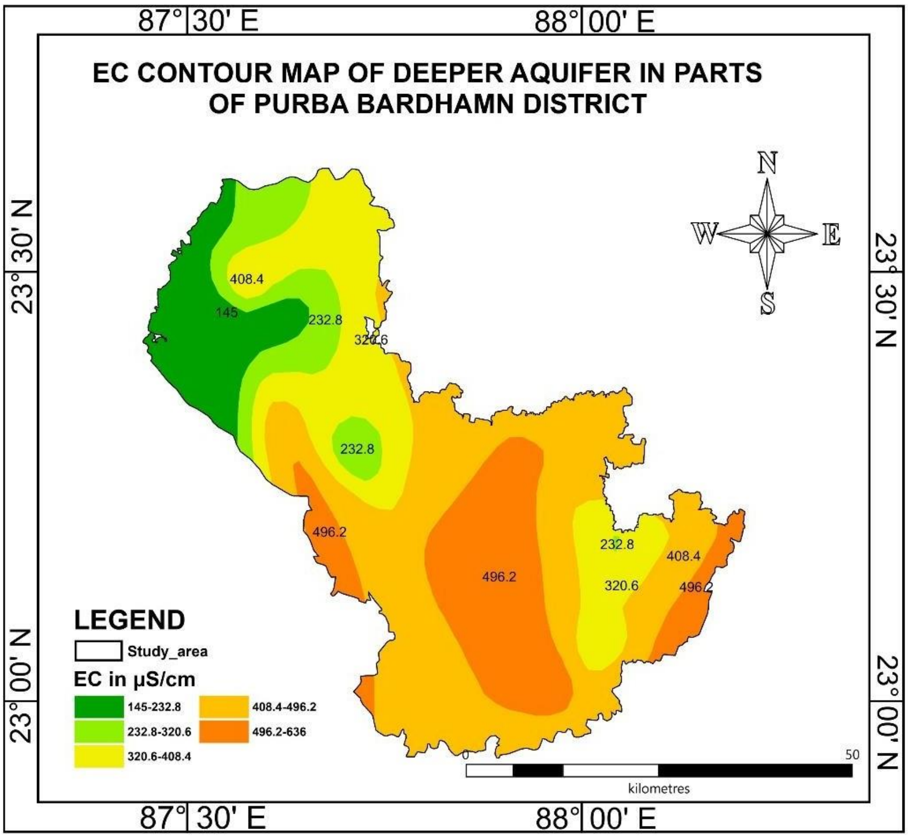


Fig8.1: EC Contour map in DeeperAquifer of Study area in Purba Bardhaman District

CHAPTER- IX

GROUNDWATER ISSUES & PROBLEMS

Groundwater Related Issues & Problems: -

Purba Bardhhaman

I. Categorisation of Blocks:
One Block of the study area has already been categorized as Semi- Critical Blocks.

II. Decline in Water Level:
Deep water level within a range of 15-20 m bgl recorded in the study area. From the long-term monitoring of water level as envisaged from the study of piezometers of CGWB, declining trend has been observed both in pre- monsoon and post- monsoon in some parts of district. Both aquifer I and aquifer II are characterized by deep water levels with falling trend in both seasons, which might be due to large scale irrigation by groundwater.

Paschim Bardhaman

III. The north western corner of the district, underlain by hard rocks, viz. granites, shallow bore wells/open wells go dry and the saturated thickness of aquifers becomes negligible for extraction of water by pump.

IV. Huge amount of ground water in being discharged into the active mines by way of percolation through the zones of weakness. The water table recedes very much during summer in the vicinity of active mine establishments due to excessive percolation of ground water into the active mines resulting in drying up of majority of open wells. The movement of ground water is, in general, towards east and the gradient of ground water flow varies from 4m/km in the west to 0.80 m/km in the east. The presence of both open cast and underground coal mines in the coal field area have a pronounced effect on the ground water regime and modified the ground water flow pattern to a large extent.

V. Ground water gets contaminated with mine seepage water in the coal mine area and the effluents from the nearby industrial units, and it becomes unsuitable for domestic consumption. As a result, high concentrations of SO_4^{2-} and Ca^{2+} have been reported in ground water in the vicinity of coal mines. Biochemical oxygen demand (BOD) is high in case of surface water and very high in case of mine seepage water and exceeds the permissible limit. The water in open wells close to mine also shows higher value of BOD and exceeds the permissible limit. The chemical oxygen demand (COD) in mine seepage water in some of the collieries exceeds the permissible limit. Concentration of phenolic compound, oil and grease in mine seepage water and surface water in some cases exceeds the permissible limit. Copper and cyanides are present in excess amount in some mine seepage water and surface water respectively

VI. The water level recedes very much during summer months in the vicinity of active mine establishments of coal belts resulting in the drying up of majority of open wells. The presence of both open cast and underground coal mines has a pronounced effect on the ground water regime and modifies the ground water flow pattern to a large extent.

Biochemical oxygen demand (BOD) is high in case of surface water and very high in case of mine seepage water and exceeds the permissible limit. The water in open wells close to mine also shows higher value of BOD and exceeds the permissible limit. The chemical oxygen demand (COD) in mine seepage water in some of the collieries exceeds the permissible limit. Concentration of phenolic compound, oil and grease in mine seepage water and surface water in some cases exceeds the permissible limit. Copper and cyanides are present in excess amount in some mine seepage water and surface water respectively.

CHAPTER X

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 Bardhaman. 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 are commonly used for water supply to rural area.

10.2 Future Ground Water Development and Management:

The district has net available ground water resource as 146330 ham and the average stage of development is 51.34%. The mode of ground water development in Purba & Paschim Bardhaman district can be summarized as follows:

Low duty, medium duty and heavy-duty tube wells may be constructed in unconsolidated formation of Quaternary and Tertiary sediments. 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 like Asansol block 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:

Reducing the area of 'Boro' cultivation and its substitution by low water requiring crops (cropping pattern change), say oilseeds, pulses and cash crops, etc., could be the possible remedial measures. Again, sowing of 'Aman' rice by one and a half months in advance than what is in practice now, as envisaged by Sen, for advancing time for Boro-sowing and lessening dependency on external irrigation, is another probable way in comprehensive management of water resources. Increase in wheat and maize cultivation is other viable option.

By application of modern irrigation techniques, water requirement of crops could be reduced manifold. During this study, agricultural expert of Bidhan Chandra Krishi Viswavidyalaya (BCKV), nominated by CGWB, opined that the water requirement could be reduced by micro-irrigation techniques like: rice 0.8 m, wheat 0.2– 0.35 m, mustard 0.2 m, pulse 0.08–0.12 m, vegetable 0.12– 0.16 m.

A part of domestic water demand can be met by tapping the sub-surface flow of Ajoy, Damodar, Mayurakshi and Barakar rivers by constructing a greater number of shallow river bed tube wells/collector wells and local water bodies may also be an alternative source to fulfil the demand partially.

In alluvial areas, where the water level is shallow, dug wells are feasible since there is presence of shallow aquifers. As can be seen from the drilling data available for the areas, the thickness of alluvium gradually increases from west to east. In those transitional areas where the thickness of the sediments varies from 50m to 70 m, low duty shallow tube wells are feasible. Towards the most eastern side where the sediment thickness is huge, heavy duty deep tube wells are feasible.

Reducing the per head use of water and minimize the abuse of water. Restricting the use of ground water only for drinking purpose and surface water in other usages to save the reservoirs of ground water. Ground water-based irrigation project should not be encouraged.

Keeping the source of surface water pollution free. Do not use it as dumping ground of urban wastes (solid and liquid).

Afforestation programme should encourage checking problems of heat island as well as enhancing the possibilities of ground water recharge.

Strictly regulation should be mandate for the installation of domestic level submersible pump.

Regular monitoring of groundwater level in individual aquifers and its quality is essentially needed for management of aquifers.

Rainwater harvesting for conservation as well as for managed aquifer recharge to ground water sources can be encouraged. The part of rain water conserved in ponds can be utilized for drinking purpose after treatment through Horizontal Roughing Filters.

Roof-Top rain water harvesting should be practiced all throughout the area and the water conserved in PVC/concrete tanks can be used for various domestic needs so as to reduce the pressure on ground water use at least for the non-drinking purpose.

10.3 Management Interventions through Rain Water Harvesting and Artificial Recharge

Rainwater harvesting is always the need of the day. Preservation and conservation of water resource should always be the top priority for any management study. It is the quintessential for ground water resource management. There are two modes of rain water harvesting:

I. Conservation

II. Artificial recharge

Conservation

As already discussed, Asansol block falls in hard rock dominated areas which have very poor ground water potential. In these areas dug wells are the only abstraction structures. With the onset of summer these areas generally face acute drinking water crisis. The area where there is limited groundwater development including the mining areas, rainwater conservation is the best option to mitigate the drinking water problem. Rainwater conservation can be done from the water that is available from roof tops as well as from the lands. The district normal for Paschim Barddhaman districts is 1347mm. This indicates that sufficient quantity of rainwater can be available from roof tops as well as from the land. The different ways of conserving the rainwater is listed below-

I. The water that can be available from the roofs can be stored considering to all types of losses in cemented tanks or in PVC tanks. The water should be filtered before storing.

II. The rainwater that can be available from the lands can be stored in any ponds and in such cases sites as well as designs of ponds are to be finalized based on local hydro-geological and terrain conditions.

III. The surface water which flows through streams or nallas could be conserved with the help of check dams giving due considerations to geology and environment.

IV. In undulating terrains, gully plugs can be feasible on cultivated lands to conserve limited quantity of water and thereby soil moisture could be increased which will be beneficial for crop produce and growth.

10.4 Managed Aquifer Recharge (MAR)

Artificial recharge or MAR is always site specific. As far as possible, the site for recharge should be a plain area, hydro geologically feasible and should have ample scope for groundwater development. The non-committed rainwater should be used for recharge. Care should be taken so that recharged water does not drain out under natural conditions into streams/nallas. And also, the post-monsoon water level should be more than 6 mbgl.

In the present study area, the recharge structures feasible and their cost of constructions, utilizable surface run-offs for the blocks under study are given in the tables below. (**Table 10.1**)

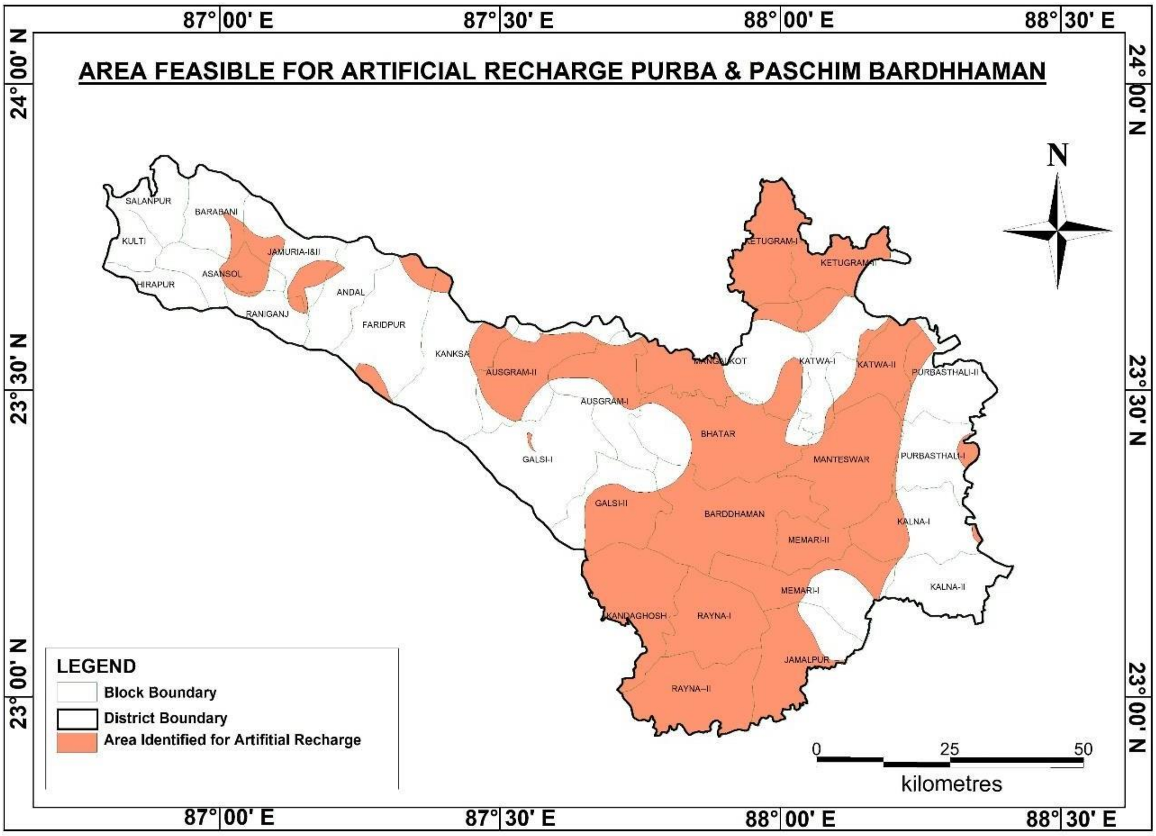


Fig 10.1: Feasible area for Artificial Recharge of Purba & Paschim Bardhaman District

Table 10.1 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	
Purba Barddhaman	Ausgram-I	Alluvium	42.76	13	27	13	0	0	0	0	104	108	39	0	0	0	0	13.27
	Ausgram-II	Alluvium	158.28	49	98	49	0	0	0	0	392	392	147	0	0	0	0	49.12
	Burdwan-I	Alluvium	226.18	70	140	70	0	0	0	0	560	560	210	0	0	0	0	70.19
	Burdwan-II	Alluvium	84.59	26	53	26	0	0	0	0	208	212	78	0	0	0	0	26.25
	Galsi-I	Alluvium	21.53	7	13	7	0	0	0	0	56	52	21	0	0	0	0	6.68
	Galsi-II	Alluvium	114.11	35	71	35	0	0	0	0	280	284	105	0	0	0	0	35.41
	Jamalpur	Alluvium	6.09	2	4	2	0	0	0	0	16	16	6	0	0	0	0	1.89
	Khandaghosh	Alluvium	147.81	46	92	46	0	0	0	0	368	368	138	0	0	0	0	45.87
	Memari-I	Alluvium	53.69	17	33	17	0	0	0	0	136	132	51	0	0	0	0	16.66
	Raina-I	Alluvium	174.13	54	108	54	0	0	0	0	432	432	162	0	0	0	0	54.04
	Raina-II	Alluvium	180.12	56	112	56	0	0	0	0	448	448	168	0	0	0	0	55.90
Total			**1209.29**	**375**	**751**	**375**	**0**	**0**	**0**	**0**	**3000**	**3004**	**1125**	**0**	**0**	**0**	**0**	**375.29**
Paschim Barddhaman	Kanksa	Alluvium	142.84	44	89	44	0	0	0	0	352	356	132	0	0	0	0	44.33
	Asansol	Hard Rock	8.36	3	0	0	10	26	13	3	36	0	0	15	13	13	3.3	2.60
Total			**151.21**	**47**	**89**	**44**	**10**	**26**	**13**	**3**	**388**	**356**	**132**	**15**	**13**	**13**	**3.3**	**46.93**

PART – II

BLOCK MANAGEMENT PLANS

SALIENT INFORMATION

Block Name: *Ausgram-I*

Geographical area (sq. km): 211

Mappable area (sq. km): 211

District: Purba Bardhaman

State: West Bengal

Basin: Lower Damodar basin

Sub Basin:

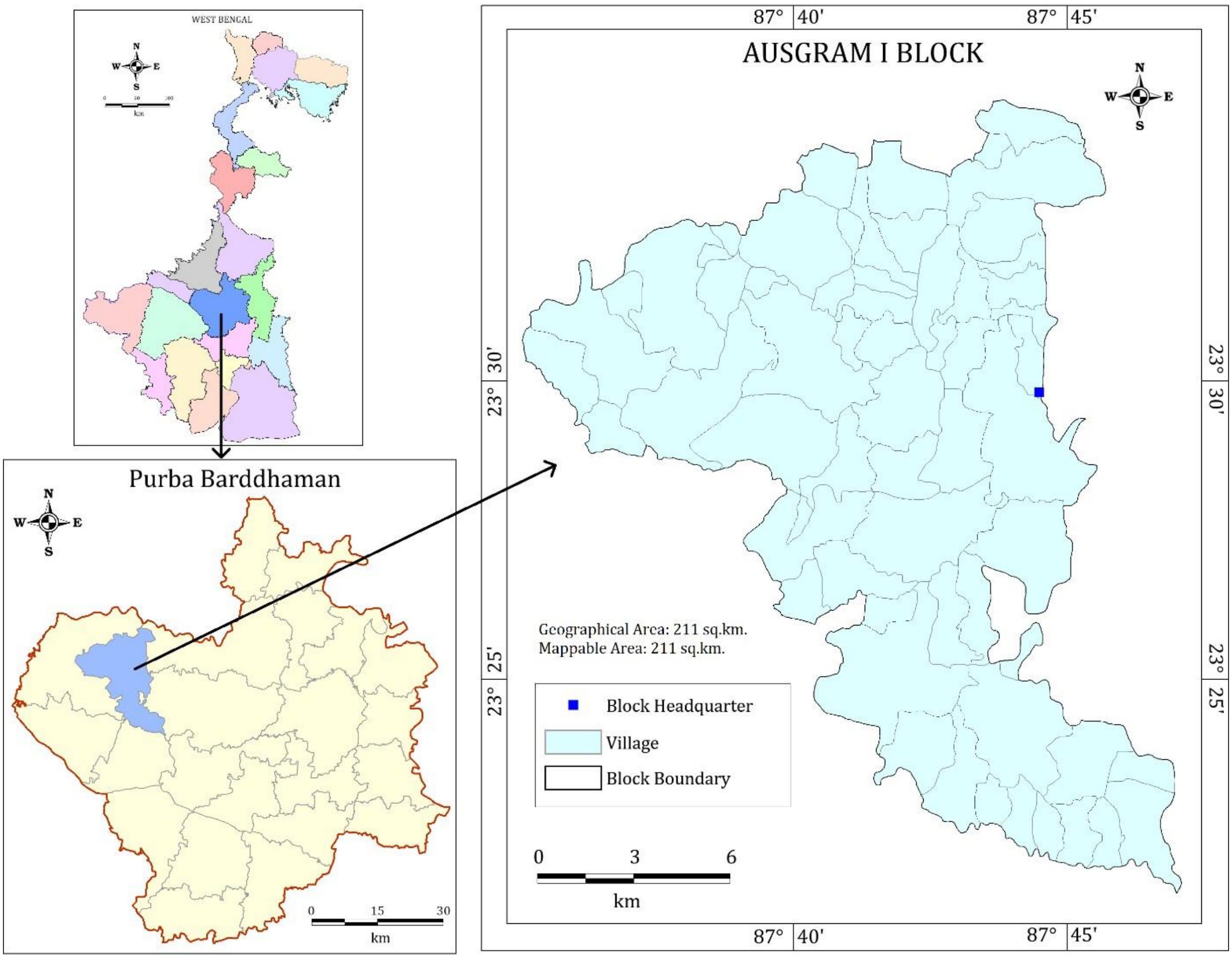


Figure *11*.1.1: Location Map of *Ausgram-I* Block

Population (as on 2011):

Table *11*.1.1: Details of population in *Ausgram-I* block.

Rural	Urban	Total	Population Density per Sqkm
119363	-	119363	537

Rainfall: Average annual rainfall for the period 2015 -19 is 1381 (in mm)

Table *11.1*.2: Details of Annual Rainfall for the last ten years in *Ausgram-I* block.

Block Name	Normal Rainfall	Rain Fall									
		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Ausgram-I	1381.1	1052.88	654.09	1486.79	1155.98	1694.82	1364.43	1375.7	938.3	1186.06	1266.74

Agriculture& Irrigation (area in ha):

Table 11.1.3: Salient Land use features of Ausgram-I block

Name of the block	Reporting area (Ha)	Forest area	Area under non-agriculture wastes	Area under Agriculture		Barren and un-culturable lands	Permanent pastures and grazing lands	Land under misc. tree crops	Culturable wastes	Fallow land Other than current fallow	Current fallow
				Gross cropped Area	Net Sown Area						
Ausgram-I	24374	3190	5544	30087	15538	-	-	30	66	1	5

Table 11.1.3.1: Command area(ha) of Ausgram-I block

Sl. No.	Block Name	Surface Lift	CCA	DW	CCA	STW	CCA	DTW	CCA	Total CCA
1	*AUSGRAM-I*	160	780.83	4	20.00	541	3523.81	4	54.50	4379.14

Ground Water Resource:

Table *11.1*.4: Details of Ground Water Resource Availability and Utilization in *Ausgram-I* Block.
(As on 31.03.2013)

BLOCK NAME	*AUSGRAM-I*I
Total Annual Ground Water Recharge (Ham)	12722.6
Total Natural Discharges (Ham)	1272.25
Annual Extractable Ground Water Recharge (Ham)	11450.3
Total Extraction	5074.61
Annual GW Allocation for Domestic and Industrial Use as on 2042	205.67
Net Ground Water Availability for future use	6332.64
Stage of Ground Water Extraction (%)	44.32
Categorization	Safe
Instorage	9419

Disposition of Aquifers:

The principal aquifer systems encountered in this block are alluvial formation
Two aquifers are encountered in this block.
The range of **Aquifer-I** is from 0-50 mbgl. This aquifer is fresh in nature.
The range of **Aquifer-II** varies from50-150mbgl. This aquifer is also fresh in nature.
The range of **Aquifer-III** varies from>150mbgl. This aquifer is also fresh in nature.
No of EW & OWs of CGWB. 4no.s of EW
No of monitoring stations of CGWB. 3
No of Key well monitoring stations. 8

Table *11.1*.5: Details of aquifer disposition in *Ausgram-I* Block

Block	No. of Aquifers	Water bearing zone	Aquifer Thickness (m)		Discharge (lpm)	T (m^2/day)	SWL (mbgl)	Drawdown (mbgl)	S
			Aquifer-I (within 50 mbgl)	Aquifer-II (Below 50 mbgl)					
Ausgram -I	3	37-56 74-89 178-190 226-253	13	54	2037	186.5		12.4	1.88X10-3

Table *11.1*.6: Details of Aquifer Wise Water Level Ranges & seasonal long term water level trends.

Block	Aquifer	Pre-monsoon Trend			Post-monsoon Trend		
		WL Range (mbgl)	Rise (m/year)	Fall (m/year)	WL Range (mbgl)	Rise (m/year)	Fall (m/year)
Ausgram-I	I	10.18-13.54	0.193	--	3.23-11.14	--	0.103
	II	10.15-12.88	-	-	4.49-8.44	-	-

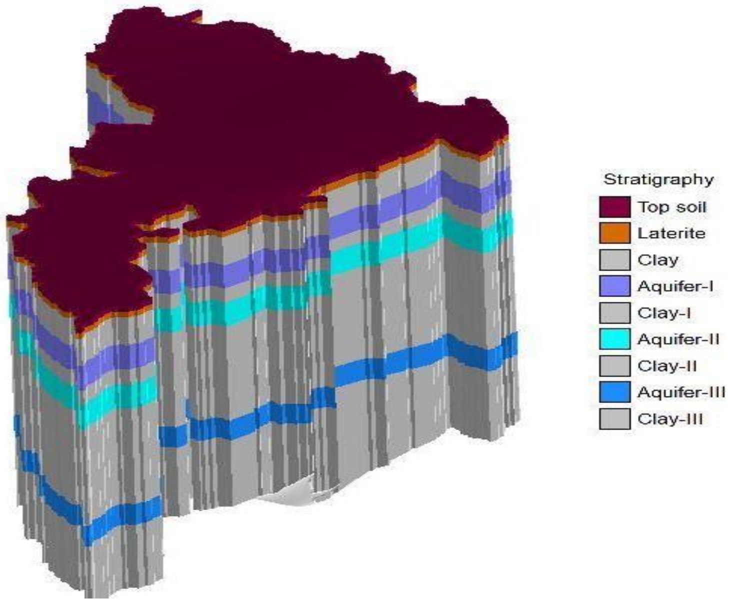


Figure*11.1*.2: 3-DimensionalAquifer disposition in *Ausgram-I* Block

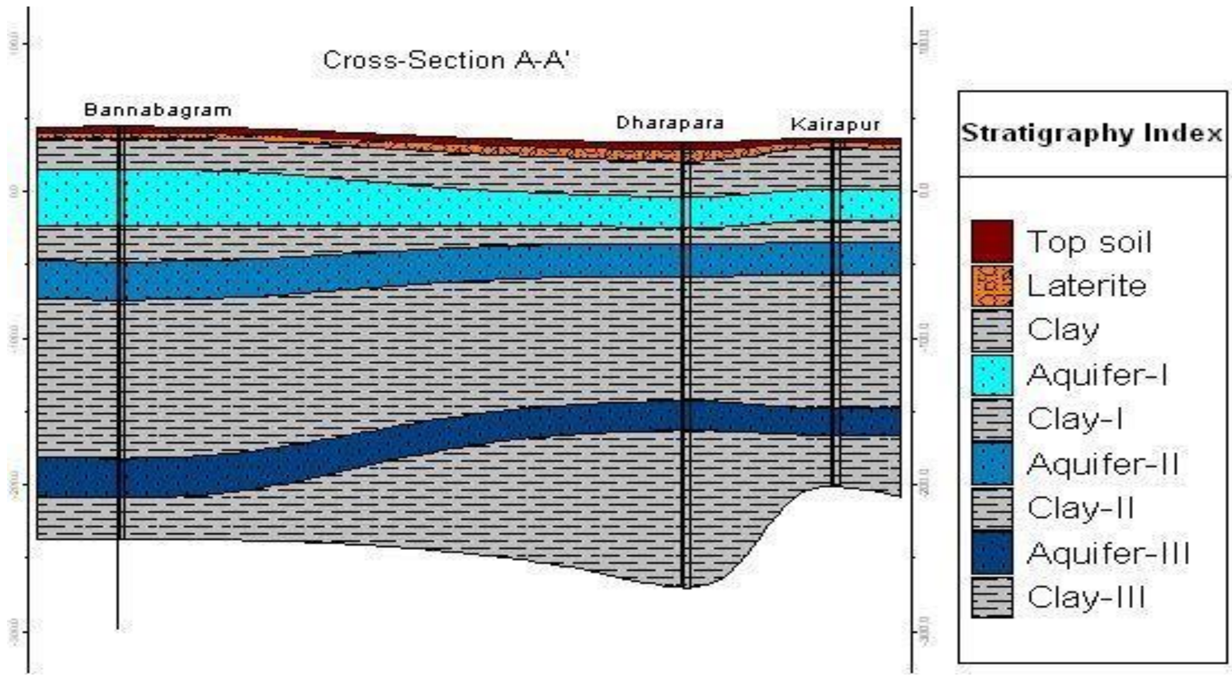


Figure*11.1*.3: 2-Dimensional Section in *Ausgram-I* Block

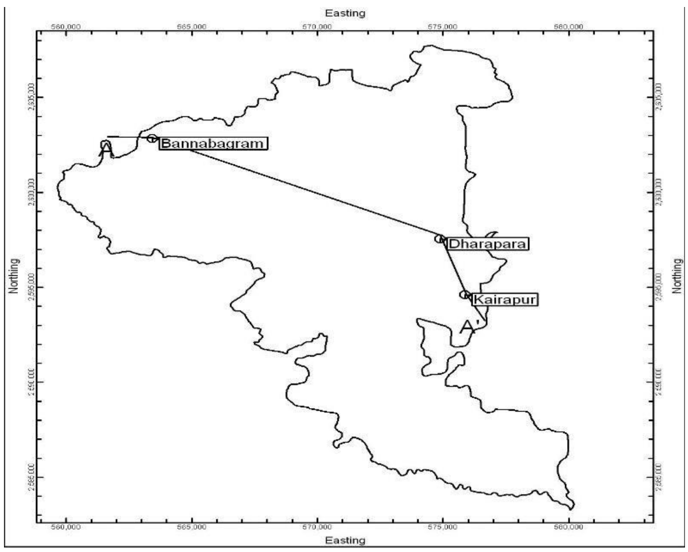


Figure*11.1*.3.1: 2-Dimensional Section profile Map in *Ausgram-I* Block

Ground water quality and issues:

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

Table 11.1.7 Range of chemical parametersin*Ausgram-I* Block

Augram-I	pH	EC	TH	Ca	Mg	Na	K	HCO3	TA	Cl	NO3	F	TDS	U
AQ-I	6.88-7.65	179-643.3	70-240	18-48	2.4-34.0	15.9-31.92	1.04-3.24	97.6-347.7	80-305	14.18-46.085	0.1-1.1	0.12-0.57	140.6-349.1	0.16-2.30
AQ-II	1.18-7.49	354.4-416.9	155-190	28-40	13.3-29.1	13.37-28.4	1.17-1.41	164.7-244	200-135	21.27-53.6	0.6-2.3	0.21-0.5	228.3-254.4	<0.4170

Aquifer Management Plan:

Ground Water Management Plan for irrigation purposes:

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 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, rainwater-harvesting may also considered

i. Although ground water development in the block is average with stage of ground water development at 44%, further development should done in planned manner to harness the additional available resource for site-specific sustainable development.
ii. Modern methods of irrigation like sprinkler and drip irrigation methods are encouraged.
iii. Crops with low water requirement should be preferred.

Management Intervention through Harvesting of Surface Runoff and Artificial Recharge:

It has been estimated that the utilizable surface runoff produced in the block is **13.27** MCM. This surface runoff is proposed to be utilized to recharge the depleted aquifers in the block. As per the available storage space, **3.981** MCM water is required to fill the deeper aquifers in block. Therefore, **13** injection wells with roof top rain water harvesting structures are recommended in the block. The remaining surface runoff, **9.3** MCM is recommended to be utilized in storage tanks for generation of irrigation potential and thus, 40 storage tanks have been proposed. The roof top rain water harvesting structures with suitably design injection wells may be proposed to construct in the census towns areas in primary phases and subsequently may be extended to the rural areas.

Table 11.1.8: Proposed Artificial Recharge Structures, allocation and cost of construction in Ausgram-I block

Block	Utilizable Surface Run Off	Allocation of Utilizable Recource(MCM)			Structures Feasible			Cost of Structures			TOTAL
		Percolation Tank	REET with RS	Injection Well	Percolation Tank	REET with RS	Injection Well	Percolation Tank	REET with RS	Injection Well	
Ausgram-I	13.27	6.635	2.654	3.981	13	27	13	104	108	39	251

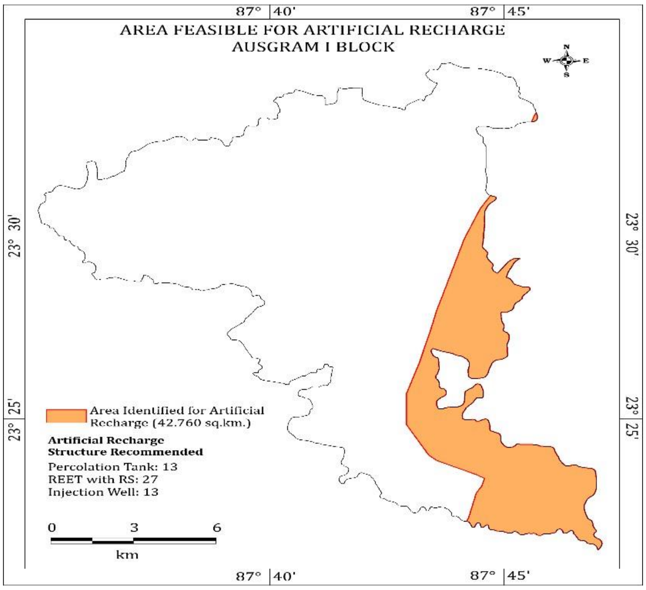


Figure11.1.4: Area Feasible for Artificial Recharge of groundwater for Ausgram-I Block

Ground Water Management Plan for drinking purpose:

i. As per Functional Household tap water connection (FHTC) inception in Ausgram-I block only 7776 households connected to tap water connection out of total 29582 households. The block has **six** ground water Based, commissioned public water supply schemes by PHED. 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 1381 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.

ii. The block shows a falling trend of 0.193 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.

iii. Regular field monitoring is necessary from time to time for any potential chemical presence.

SALIENT INFORMATION

Block Name: ***Ausgram-II***

Geographical area (sq. km): **342**

Mappable area (sq. km): **342**

District: **Purba Bardhaman**

State: **West Bengal**

Basin: **Lower Damodar basin**

Sub Basin:

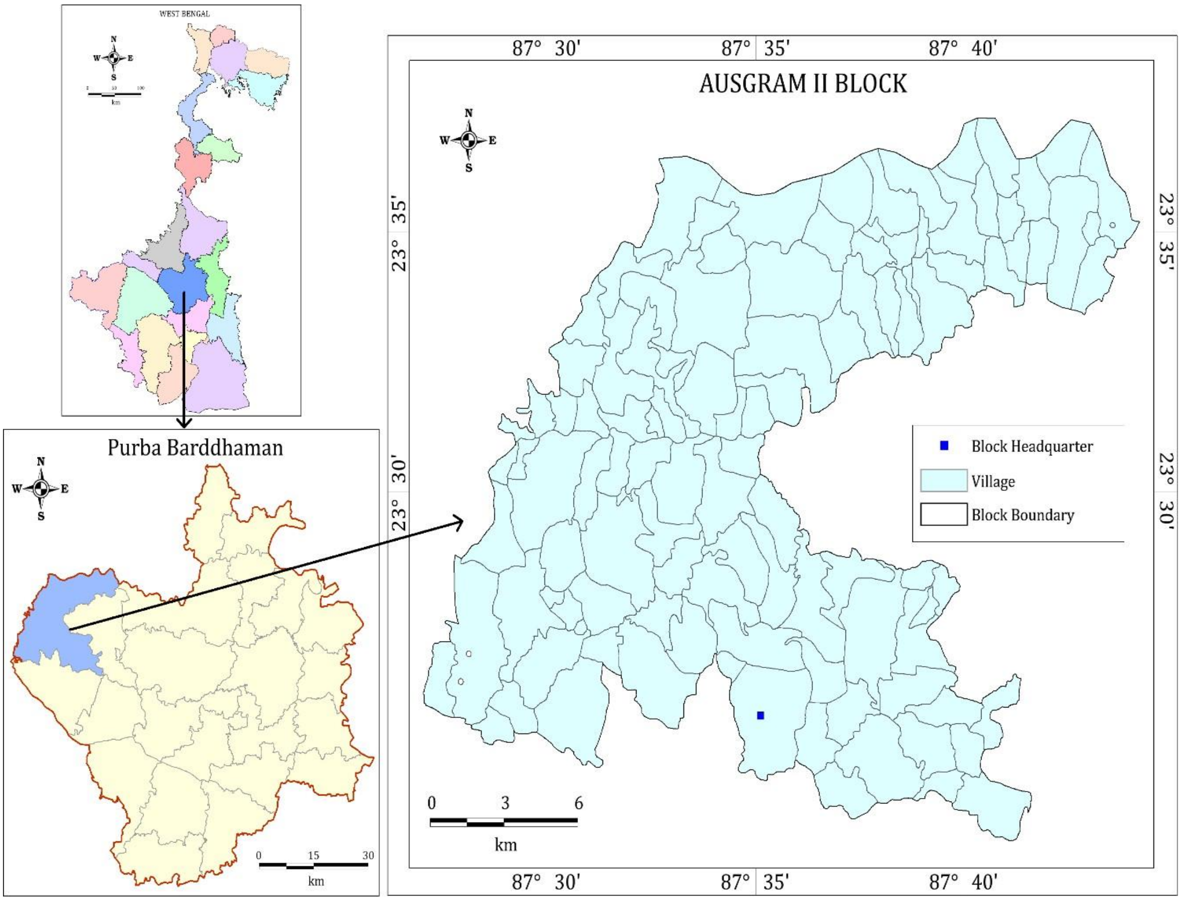


Figure 11.2.1: Location Map of *Ausgram-II* Block

Population (as on 2011):

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

Rural	Urban	Total	Population Density per Sqkm
150896	-	150896	419

Rainfall: Average annual rainfall for the period 2015 -19 is 1381.1 (in mm)

Table *11.2.*2: Details of Annual Rainfall for the last ten years in *Ausgram-II* block.

Block Name	Normal Rainfall	Rain Fall									
		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Ausgram-II	1381.1	1052.88	654.09	1486.79	1155.98	1694.82	1364.43	1375.7	938.3	1186.06	1266.74

Agriculture& Irrigation (area in ha):

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

Name of the block	Reporting area (Ha)	Forest area	Area under non-agriculture wastes	Area under Agriculture		Barren and un-culturable lands	Permanent pastures and grazing lands	Land under misc. tree crops	Culturable wastes	Fallow land Other than current fallow	Current fallow
				Gross cropped Area	Net Sown Area						
Ausgram-II	35594	10926	3279	29110	21116	-	-	81	158	34	-

Table *11.2.*3.1: Command area(ha) of *Ausgram-II* block

Sl. No.	Block Name	Surface Lift	CCA	DW	CCA	STW	CCA	DTW	CCA	Total CCA
1	*AUSGRAM-II*	153	1487.29	5	10.31	951	2100.21	56	1795.00	5392.81

Ground Water Resource:

Table *11.2.*4: Details of Ground Water Resource Availability and Utilization in *Ausgram-II* Block.
(As on 31.03.2013)

BLOCK NAME	*AUSGRAM-II*
Total Annual Ground Water Recharge (Ham)	18976.43
Total Natural Discharges (Ham)	1897.65
Annual Extractable Ground Water Recharge (Ham)	17078.78
Total Extraction	5773.6
Annual GW Allocation for Domestic and Industrial Use as on 2042	209.03
Net Ground Water Availability for future use	11255.88
Stage of Ground Water Extraction (%)	33.81
Categorization	Safe
Instorage	3818

Disposition of Aquifers:

The principal aquifer systems encountered in this block are alluvial formation

Three sets of aquifers are encountered in this block.

The range of **Aquifer-I** is from 0-50 mbgl.This aquifer is fresh in nature.

The range of **Aquifer-II** varies from50-150mbgl. This aquifer is also fresh in nature.

The range of **Aquifer-III** varies from>150mbgl. This aquifer is also fresh in nature.

No of EW & OWs of CGWB. 0 EW 0 OW

No of monitoring stations of CGWB. 5

No of Key well monitoring stations. 7

Table *11.2.*5: Details of aquifer disposition in *Ausgram-II* Block

Block	No. of Aquifers	Water bearing zone	Aquifer Thickness (m)		Discharge (lpm)	T (m^2/day)	SWL (mbgl)	Drawdown (mbgl)	S
			Aquifer-I (within 50 mbgl)	Aquifer-II (Below 50 mbgl)					
Ausgram -II	3	40-56 70-104 221-252	10	69	-	-	-	-	-

Table *11.2.*6: Details of Aquifer Wise Water Level Ranges & seasonal long-term water level trends.

Block	Aquifer	Pre-monsoon Trend			Post-monsoon Trend		
		WL Range (mbgl)	Rise (m/year)	Fall (m/year)	WL Range (mbgl)	Rise (m/year)	Fall (m/year)
Ausgram-II	I	3.79-11.64	-	6.33	6.37-8.41	--	0.258860646
	II	8.17-17.86	-	-	6.14-9.74	-	-

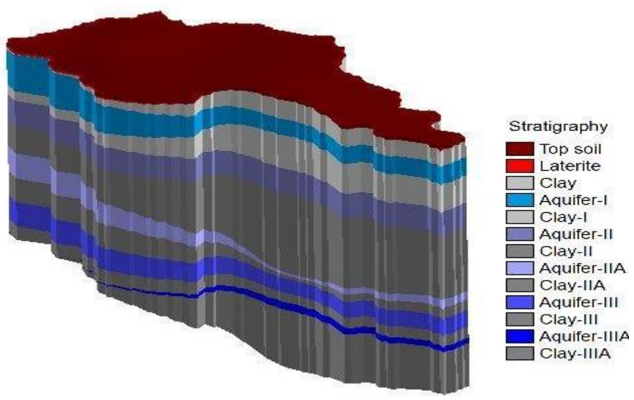


Figure*11.2.*2: 3-DimensionalAquifer disposition in *Ausgram-II* Block

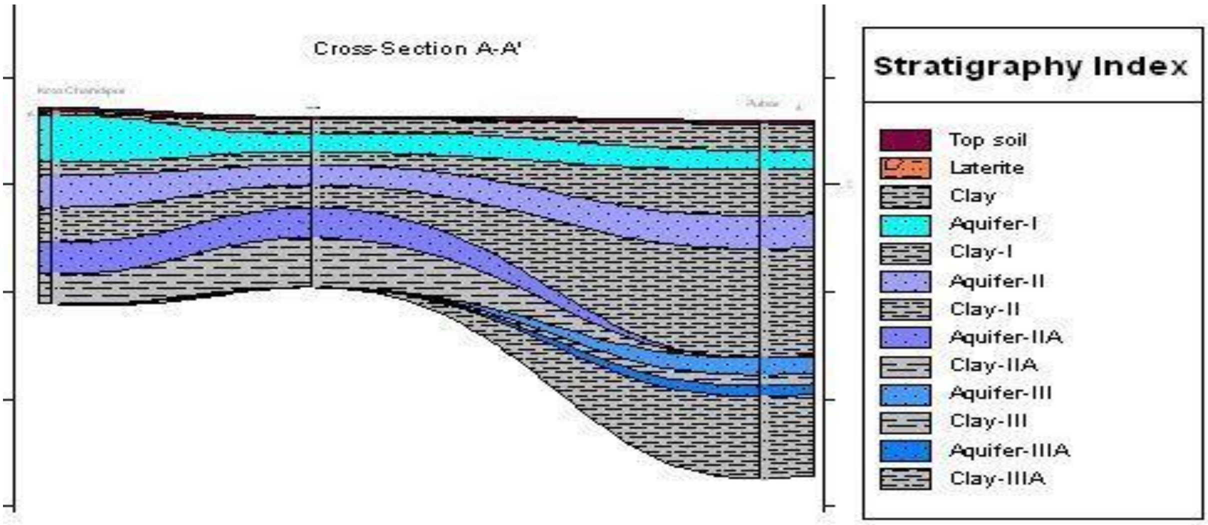


Figure*11.2*.3: 2-Dimensional Section in *Ausgram-II* Block

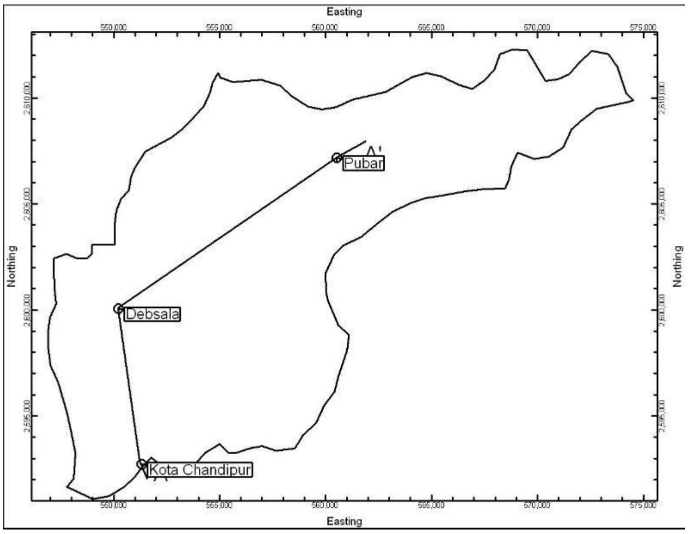


Figure*11.2*.3.1: 2-Dimensional Section profile Map in *Ausgram-II* Block

Ground water quality and issues:

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

Table 11.2.7 Range of chemical parametersin*Ausgram-II* Block

Ausgram-II	pH	EC	TH	Ca	Mg	Na	K	HCO3	TA	Cl	NO3	F	TDS	U
AQ-II	6.43-7.81	114.5-532.2	60-160.5	16-34	4.9-18.3	20.4-42.1	1.58-9.63	48.8-298.9	40-245	21.27-42.5	0.4-9.7	0.04-0.36	125.4-312	BDL
AQ-I	6.87-7.48	219.5-271.4	40-145	18-30	8.5-17.0	7.1-16.2	1.61-3.76	49-195.2	55-160	14.18-28.36	0.2-0.5	0.08-0.3	70.2-203.3	<0.0030

Aquifer Management Plan:

Ground Water Management Plan for irrigation purposes:

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 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, rainwater-harvesting may also considered

i. Although ground water development in the block is average with stage of ground water development at 44%, further development should done in planned manner to harness the additional available resource for site-specific sustainable development.
ii. Modern methods of irrigation like sprinkler and drip irrigation methods are encouraged.
iii. Crops with low water requirement should be preferred.

Management Intervention through Harvesting of Surface Runoff and Artificial Recharge:

It has been estimated that the utilizable surface runoff produced in the block is **49** MCM. This surface runoff is proposed to be utilized to recharge the depleted aquifers in the block. As per the available storage space, **14.736**MCM water is required to fill the deeper aquifers in block. Therefore, **49** injection wells with roof top rain water harvesting structures are recommended in the block. The remaining surface runoff, **34.384** MCM is recommended to be utilized in storage tanks for generation of irrigation potential and thus, 147 storage tanks have been proposed. The roof top rain water harvesting structures with suitably design injection wells may be proposed to construct in the census towns areas in primary phases and subsequently may be extended to the rural areas.

Table 11.2.8: Proposed Artificial Recharge Structures, allocation and cost of construction in Ausgram-II block

Block	Utilizable Surface Run Off	Allocation of Utilizable Recource(MCM)			Structures Feasible			Cost of Structures			TOTAL
		Percolation Tank	REET with RS	Injection Well	Percolation Tank	REET with RS	Injection Well	Percolation Tank	REET with RS	Injection Well	
Ausgram-II	49.119	24.56000	9.824	14.736	49	98	49	392	392	147	931

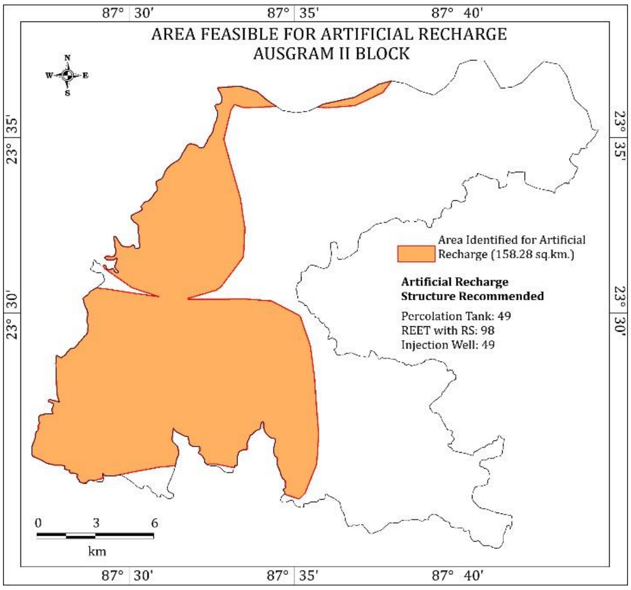


Figure11.2.4: Area Feasible for Artificial Recharge of groundwater for *Ausgram-II* Block

Ground Water Management Plan for drinking purpose:

i. As per Functional Household tap water connection (FHTC) inception in Ausgram-I block only 30% around 12,206 households connected to tap water connection out of total 40,484 households. The block has **seven** groundwater based, commissioned public water supply schemes by PHED. 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 1381 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.

ii. The block shows a falling trend of 0.253 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.

iii. Regular field monitoring is necessary from time to time for any potential chemical presence.

SALIENT INFORMATION

Block Name:	**Burdwan-I**
Geographical area (sq. km):	**252**
Mappable area (sq. km):	**252**
District:	**Purba Bardhaman**
State:	**West Bengal**
Basin:	**Lower Damodar basin**
Sub Basin:	

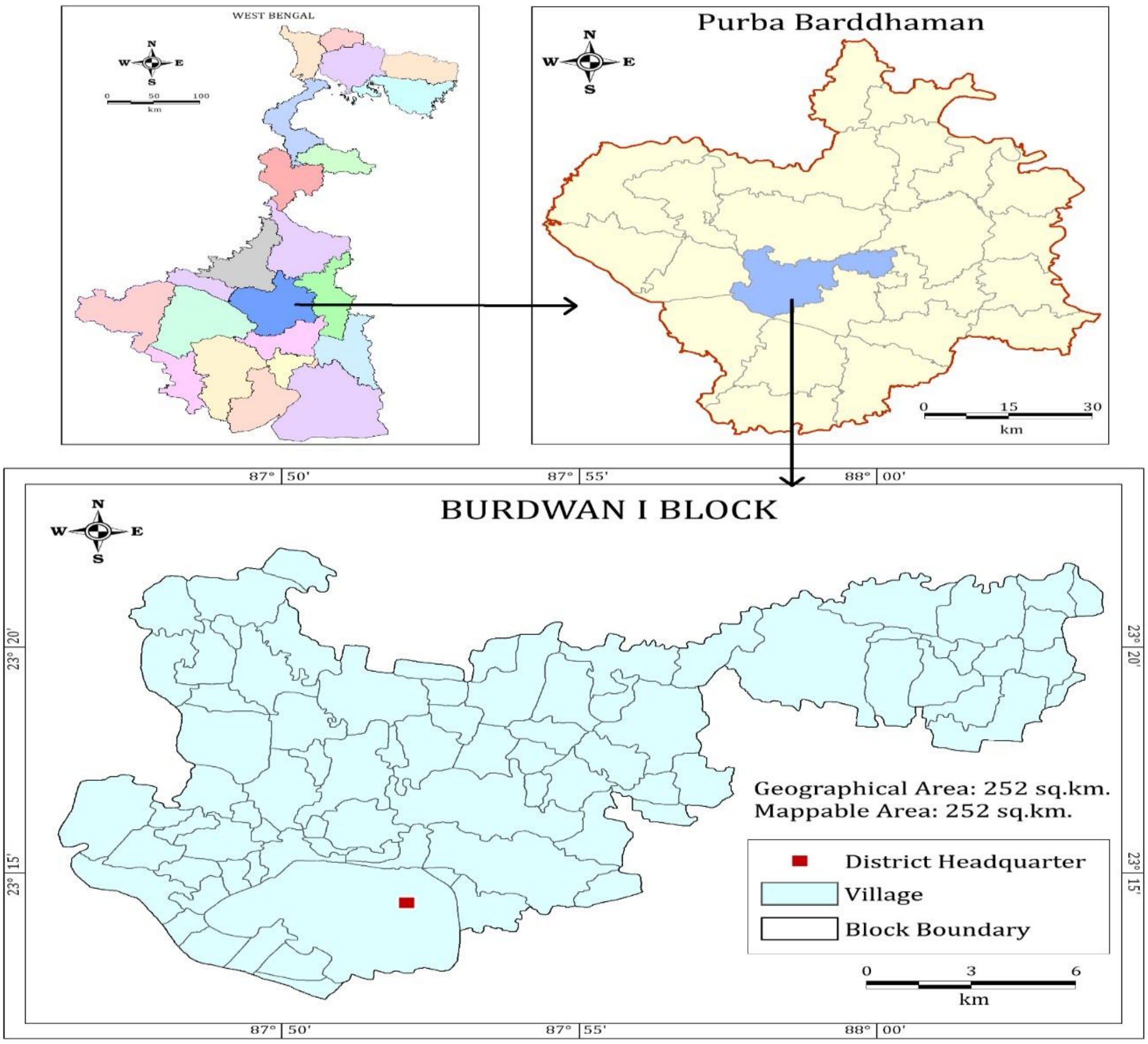


Figure 11.3.1: Location Map of Burdwan-I Block

Population (as on 2011):

Table 11.3.1: Details of population in Burdwan-I block.

Rural	Urban	Total
175836	40107	215943

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 ten years in Burdwan-I block.

Block Name	Normal Rainfall	Rain Fall									
		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Burdwan-I	1381.1	1052.88	654.09	1486.79	1155.98	1694.82	1364.43	1375.7	938.3	1186.06	1266.74

Agriculture& Irrigation (area in ha):

Table 11.3.3: Salient Land use features of Burdwan-I block

Name of the block	Reporting area (Ha)	Forest area	Area under non-agriculture wastes	Area under Agriculture		Barren and un-culturable lands	Permanent pastures and grazing lands	Land under misc. tree crops	Culturable wastes	Fallow land Other than current fallow	Current fallow
				Gross cropped Area	Net Sown Area						
Burdwan-I	26272	16	7911	56565	18240	-	-	14	68	17	6

Table 11.3.3.1: Command area(ha) of Burdwan-I block

Sl. No.	Block Name	Surface Lift	CCA	DW	CCA	STW	CCA	DTW	CCA	Total CCA
1	BURDWAN-I	10	214.00	2	8.00	993	3174.99	62	2207.00	5603.99

Ground Water Resource:

Table 11.3.4: Details of Ground WaterResource Availability and Utilization in Burdwan-I Block.
(As on 31.03.2013)

BLOCK NAME	BURDWAN-II
Total Annual Ground Water Recharge (Ham)	9341.36
Total Natural Discharges (Ham)	934.14
Annual Extractable Ground Water Recharge (Ham)	8407.22
Total Extraction	4718.33
Annual GW Allocation for Domestic and Industrial Use as on 2042	154.21
Net Ground Water Availability for future use	3697.5
Stage of Ground Water Extraction (%)	56.12
Categorization	Safe
In storage(Ham)	2498

Disposition of Aquifers:

The principal aquifer systems encountered in this block are alluvial formation

Two aquifers are encountered in this block.

The range of **Aquifer-I** is from 0-50 mbgl.This aquifer is fresh in nature.

The range of **Aquifer-II**varies from50-200mbgl. This aquifer is also fresh in nature.

No of EW & OWs of CGWB. 0no.s of EW **2** pz

No of monitoring stations of CGWB. 5

No of Key well monitoring stations. 4

Table 11.3.5: Details of aquifer disposition in Burdwan-I Block

Block	No. of Aquifers	Water bearing zone	Aquifer Thickness (m)		Discharge (lpm)	T (m^2/day)	SWL (mbgl)	Drawdown (mbgl)	S
			Aquifer-I (within 50 mbgl)	Aquifer-II (Below 50 mbgl)					
Burdwan-I	2	30-58 105-126	12	21	-	-	-	-	-

Table 11.3.6: Details of Aquifer Wise Water Level Ranges & seasonal long term water level trends.

Block	Aquifer	Pre-monsoon Trend			Post-monsoon Trend		
		WL Range (mbgl)	Rise (m/year)	Fall (m/year)	WL Range (mbgl)	Rise (m/year)	Fall (m/year)
Burdwan-I	I	6.09-17.41	0.1630001	0.24326672	5.34-21.44	--	0.893706775
	II	7.38-14.11	-	-	11.42-11.97	-	-

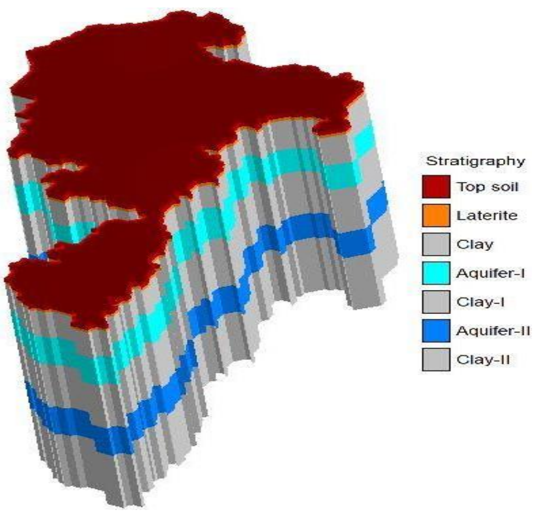


Figure11.3.2: 3-DimensionalAquifer disposition in Burdwan-I Block

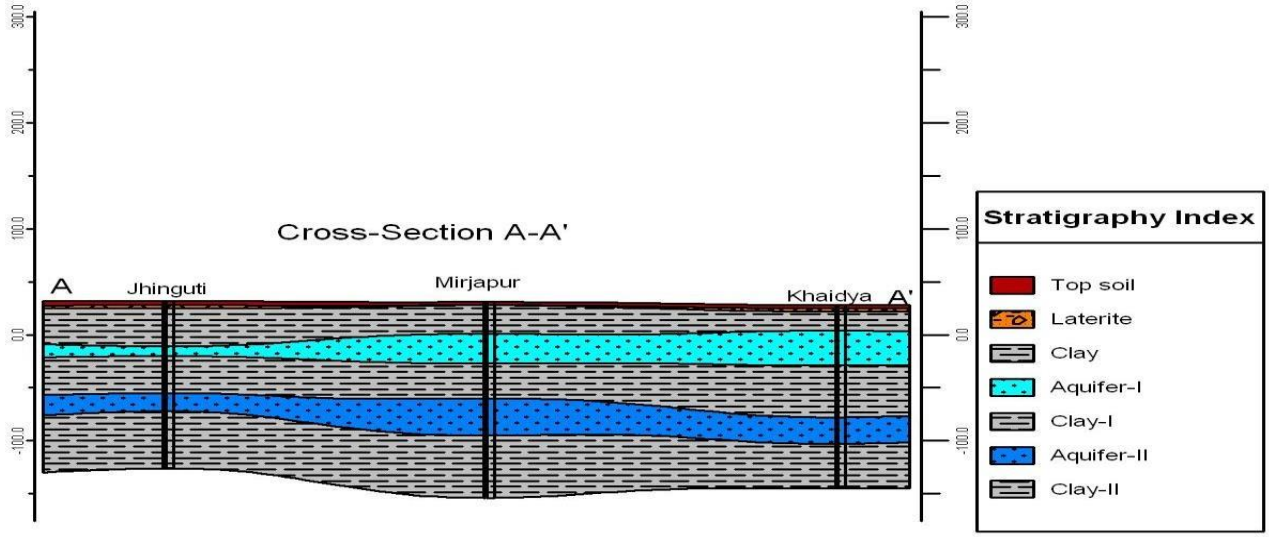


Figure11.3.3: 2-Dimensional Section in Burdwan-I Block

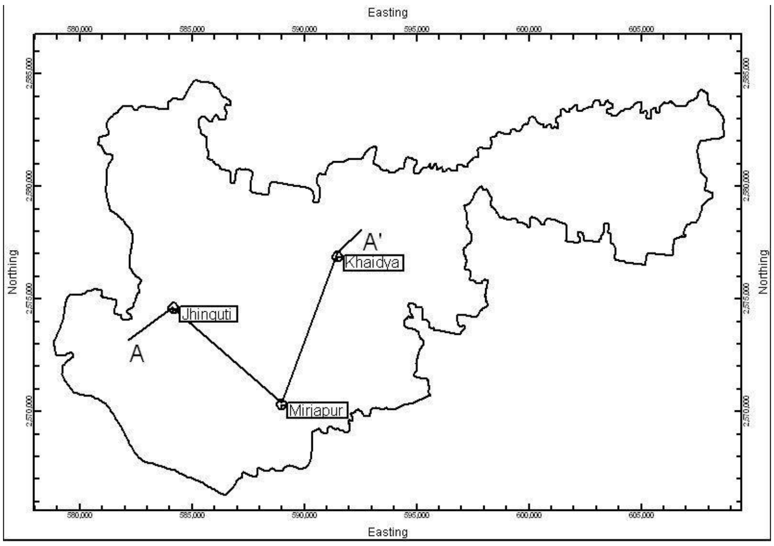


Figure11.3.3.1: 2-Dimensional Section profile map in Burdwan-I Block

Ground water quality and issues:

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

Table 11.3.7 Range of chemical parametersinBurdwan-I Block

Bardhaman	pH	EC	TH	Ca	Mg	Na	K	HCO3	TA	Cl	NO3	F	TDS	U
AQ-II	7.36	443.5	260	48	34.0	17.35	0.75	298.9	245	35.45	1.6	0.43	319.9	2.7483
AQ-I	7.2-7.77	196.9-492.5	95-230	30-48	4.9-31.6	9.03-38.9	1.08-2.09	122-317.2	100-260	24.81-49.63	0.1-2.0	0.23-0.62	171.2-344.6	0.21-3.39

Aquifer Management Plan:

Ground Water Management Plan for irrigation purposes:

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 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, rainwater-harvesting may also considered

i. Although ground water development in the block is average with stage of ground water development at 56.12%, further development should done in planned manner to harness the additional available resource for site-specific sustainable development.
ii. Modern methods of irrigation like sprinkler and drip irrigation methods are encouraged.
iii. Crops with low water requirement should be preferred.

Management Intervention through Harvesting of Surface Runoff and Artificial Recharge:

It has been estimated that the utilizable surface runoff produced in the block is 70.192 MCM. This surface runoff is proposed to be utilized to recharge the depleted aquifers in the block. As per the available storage space, 21.058 MCM water is required to fill the deeper aquifers in block. Therefore, 70 injection wells with roof top rain water harvesting structures are recommended in the block. The remaining surface runoff, 49.134 MCM is recommended to be utilized in storage tanks for generation of irrigation potential and thus, 560 storage tanks have been proposed. The roof top rain water harvesting structures with suitably design injection wells may be proposed to construct in the census towns areas in primary phases and subsequently may be extended to the rural areas.

Table 11.3.8: Proposed Artificial Recharge Structures, allocation and cost of construction in Burdwan-I block

Block	Utilizable Surface Run Off	Allocation of Utilizable Recource(MCM)			Structures Feasible			Cost of Structures			TOTAL
		Percolation Tank	REET with RS	Injection Well	Percolation Tank	REET with RS	Injection Well	Percolation Tank	REET with RS	Injection Well	
Burdwan -I	70.192	35.09600	14.038	21.058	70	140	70	560	560	210	1330

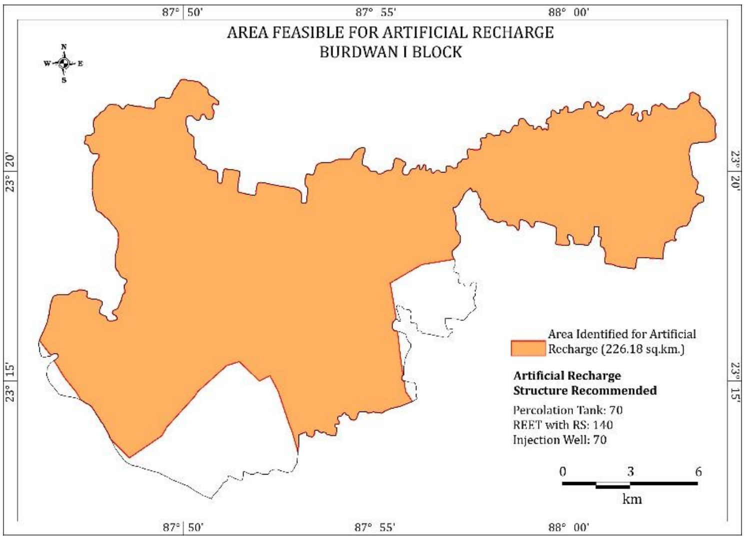


Figure11.3.4: Area Feasible for Artificial Recharge of groundwater for Burdwan-I Block

Ground Water Management Plan for drinking purpose:

i. As per Functional Household tap water connection (FHTC) inception in Ausgram-I block, only 28% that is 12669 households connected to tap water connection out of total 50154 households. The block has ten ground water Based, commissioned public water supply schemes by PHED. 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 1381 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.

ii. The block shows a falling trend of 0.89 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.

iii. Regular field monitoring is necessary from time to time for any potential chemical presence.

SALIENT INFORMATION

Block Name: *Burdwan-II*

Geographical area (sq. km): 189

Mappable area (sq. km): 189

District: Purba Bardhaman

State: West Bengal

Basin: Lower Damodar basin

Sub Basin:

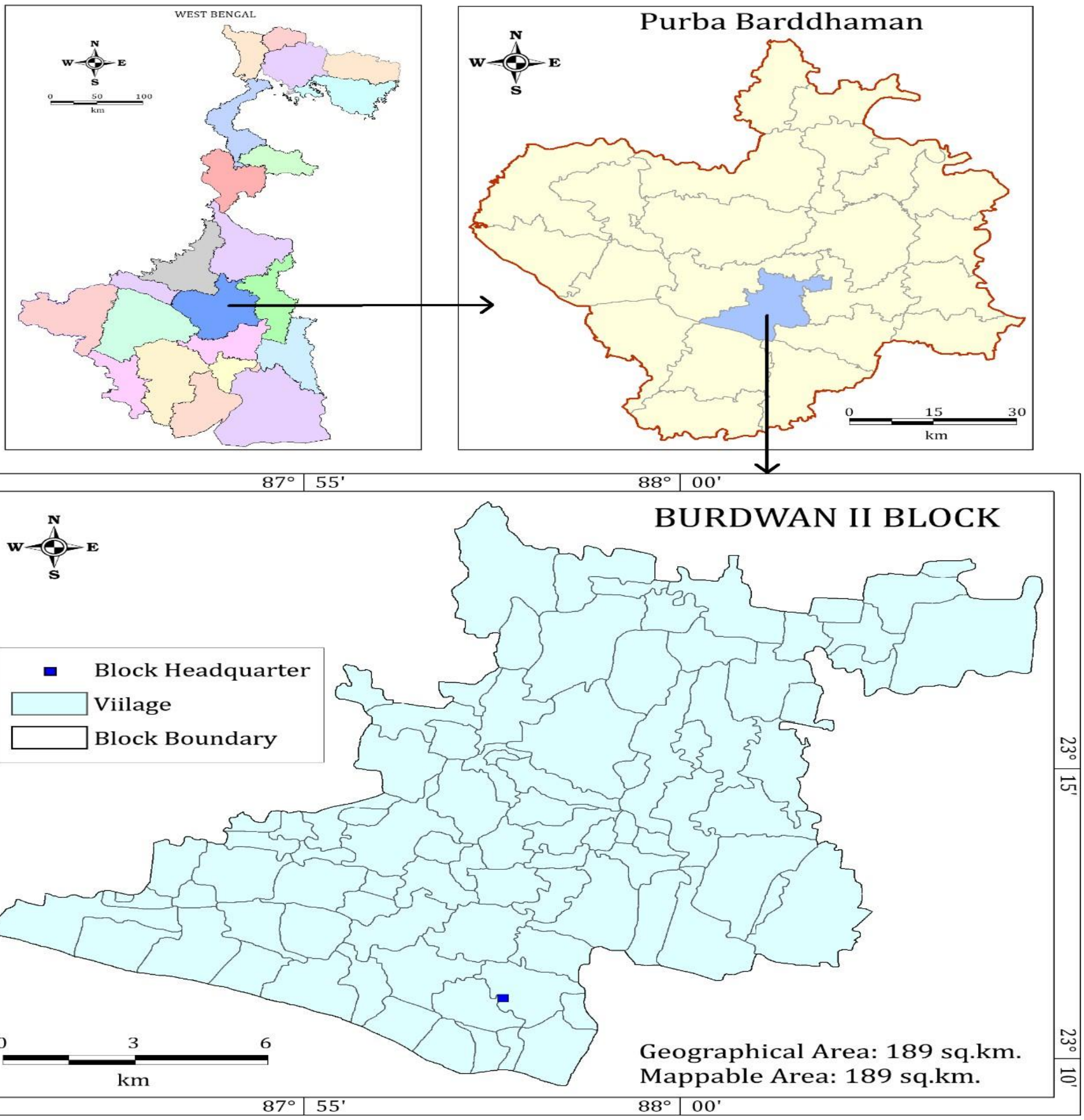


Figure *11.4.*1: Location Map of *Burdwan-II* Block

Population (as on 2011):

Table *11.4*.1: Details of population in *Burdwan-II* block.

Rural	Urban	Total	Population Density per Sqkm
146592	6347	152939	800

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 ten years in *Burdwan-II* block.

Block Name	Normal Rainfall	Rain Fall									
		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Burdwan-II	1381.1	1052.88	654.09	1486.79	1155.98	1694.82	1364.43	1375.7	938.3	1186.06	1266.74

Agriculture& Irrigation (area in ha):

Table *11.4*.3: Salient Land use features of *Burdwan-II* block

Name of the block	Reporting area (Ha)	Forest area	Area under non-agriculture wastes	Area under Agriculture		Barren and un-culturable lands	Permanent pastures and grazing lands	Land under misc. tree crops	Culturable wastes	Fallow land Other than current fallow	Current fallow
				Gross cropped Area	Net Sown Area						
Burdwan-II	18686	0	4990	56565	13679	15	2	-	-	-	-

Table *11.4*.3.1: Command area(ha) of *Burdwan-II* block

Sl. No.	Block Name	Surface Lift	CCA	DW	CCA	STW	CCA	DTW	CCA	Total CCA
1	*BURDWAN-II*	16	176.70			1190	4312.47	30	1522.00	6011.17

Ground Water Resource:

Table *11.4*.4: Details of Ground WaterResource Availability and Utilization in *Burdwan-II* Block.
(As on 31.03.2013)

BLOCK NAME	BURDWAN-II
Total Annual Ground Water Recharge (Ham)	9341.36
Total Natural Discharges (Ham)	934.14
Annual Extractable Ground Water Recharge (Ham)	8407.22
Total Extraction	4718.33
Annual GW Allocation for Domestic and Industrial Use as on 2042	154.21
Net Ground Water Availability for future use	3697.5
Stage of Ground Water Extraction (%)	56.12
Categorization	Safe
In Storage(Ham)	2498

Disposition of Aquifers:

The principal aquifer systems encountered in this block are alluvial formation

Two aquifers are encountered in this block.

The range of **Aquifer-I** is from 0-50 mbgl.This aquifer is fresh in nature.

The range of **Aquifer-II**varies from50-200mbgl. This aquifer is also fresh in nature.

No of EW & OWs of CGWB. 0no.s of EW 0 PZ

No of monitoring stations of CGWB. 5

No of Key well monitoring stations. 5

Table *11.4*.5: Details of aquifer disposition in *Burdwan-II* Block

Block	No. of Aquifers	Water bearing zone	Aquifer Thickness (m)		Discharge (lpm)	T (m^2/day)	SWL (mbgl)	Drawdown (mbgl)	S
			Aquifer-I (within 50 mbgl)	Aquifer-II (Below 50 mbgl)					
Burdwan-II	2	72-102	28	40	-	-	-	-	-

Table *11.4*.6: Details of Aquifer Wise Water Level Ranges & seasonal long term water level trends.

Block	Aquifer	Pre-monsoon Trend			Post-monsoon Trend		
		WL Range (mbgl)	Rise (m/year)	Fall (m/year)	WL Range (mbgl)	Rise (m/year)	Fall (m/year)
Burdwan-II	I	6.09-17.41	0.231727	0.230684	5.34-21.44	--	0.049761891
	II	7.38-14.11	-	-	11.42-11.97	-	-

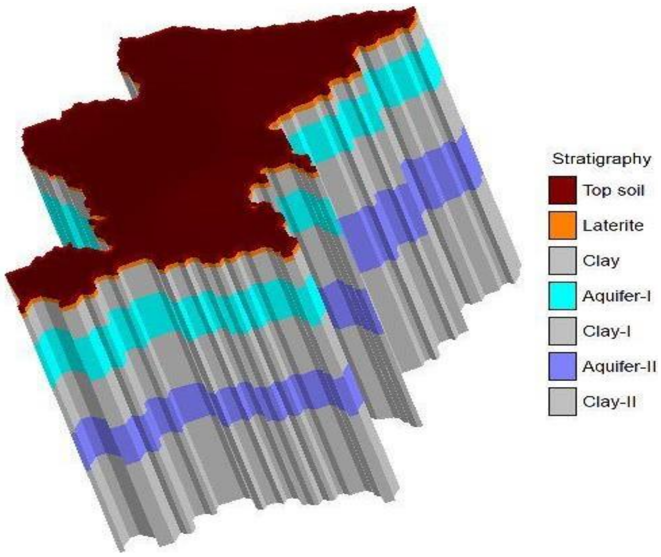


Figure*11.4*.2: 3-DimensionalAquifer disposition in *Burdwan-II* Block

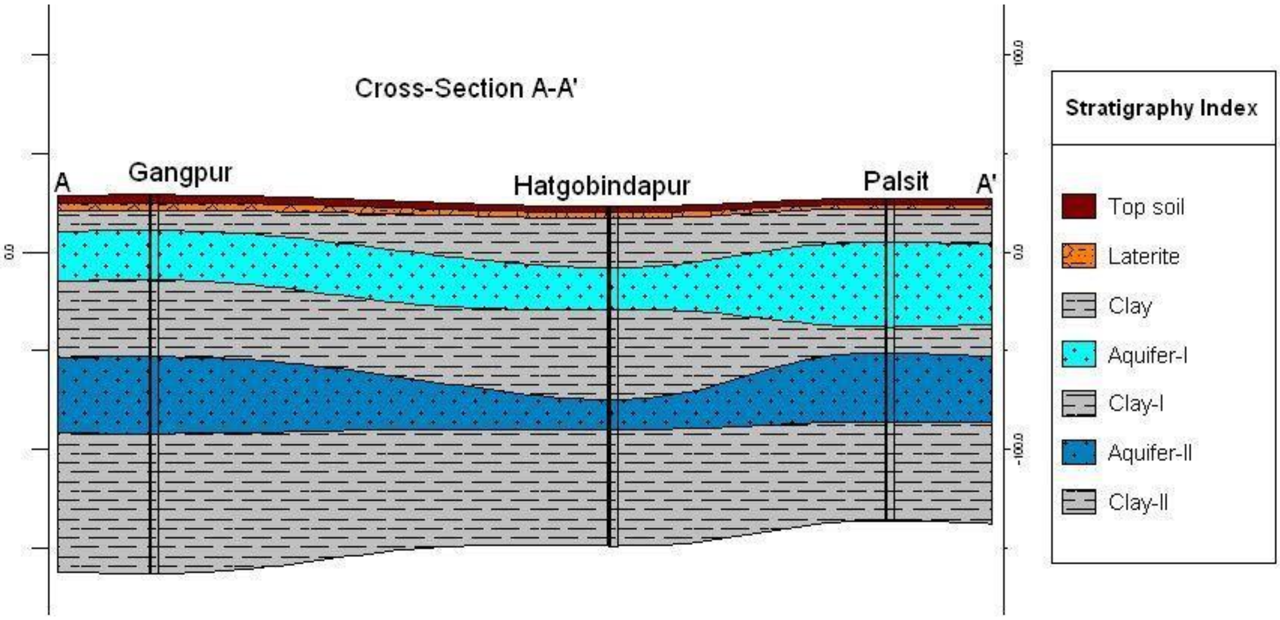


Figure*11.4.*3: 2-Dimensional Section in *Burdwan-II* Block

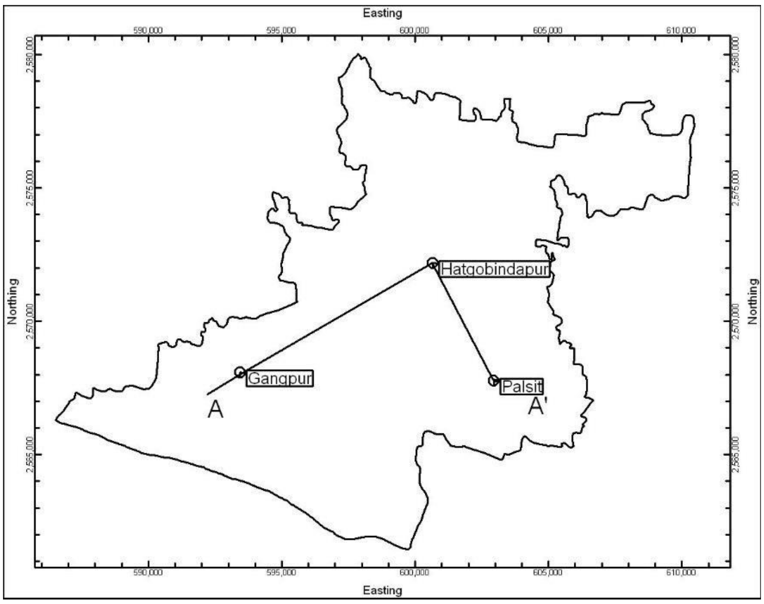


Figure11.4.3.1: 2-Dimensional Section profile map in Burdwan-II

Ground water quality and issues:

Based on four NHS, observational key wells, the range of chemical parameter for the block is given below.

Table 11.4.7 Range of chemical parametersin*Burdwan-II* Block

Bardhaman	pH	EC	TH	Ca	Mg	Na	K	HCO3	TA	Cl	NO3	F	TDS	U
AQ-II	7.36	443.5	260	48	34.0	17.35	0.75	298.9	245	35.45	1.6	0.43	319.9	2.7483
AQ-I	7.2-7.77	196.9-492.5	95-230	30-48	4.9-31.6	9.03-38.9	1.08-2.09	122-317.2	100-260	24.81-49.63	0.1-2.0	0.23-0.62	171.2-344.6	0.21-3.39

Aquifer Management Plan:

Ground Water Management Plan for irrigation purposes:

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 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, rainwater-harvesting may also considered

i. Although ground water development in the block is average with stage of ground water development at 56.12%, further development should done in planned manner to harness the additional available resource for site-specific sustainable development.
ii. Modern methods of irrigation like sprinkler and drip irrigation methods are encouraged.
iii. Crops with low water requirement should be preferred

Management Intervention through Harvesting of Surface Runoff and Artificial Recharge:

It has been estimated that the utilizable surface runoff produced in the block is 26.25 MCM. This surface runoff is proposed to be utilized to recharge the depleted aquifers in the block. As per the available storage space, 7.87 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, 18.376 MCM is recommended to be utilized in storage tanks for generation of irrigation potential and thus, 53 storage tanks have been proposed. The roof top rain water harvesting structures with suitably design injection wells may be proposed to construct in the census towns areas in primary phases and subsequently may be extended to the rural areas.

Table 11.4.7: Proposed Artificial Recharge Structures, allocation and cost of construction in Burdwan-II block

Block	Utilizable Surface Run Off	Allocation of Utilizable Recource(MCM)			Structures Feasible			Cost of Structures			TOTAL
		Percolation Tank	REET with RS	Injection Well	Percolation Tank	REET with RS	Injection Well	Percolation Tank	REET with RS	Injection Well	
Burdwan -II	26.251	13.12600	5.250	7.875	26	53	26	208	212	78	498

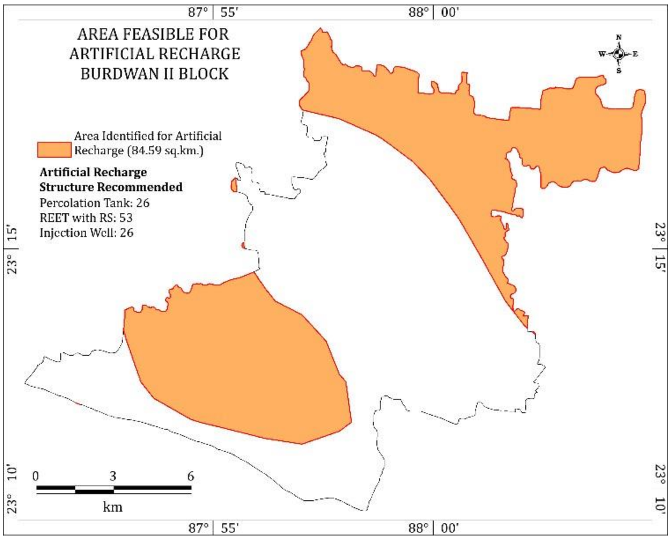


Figure11.4.4: Area Feasible for Artificial Recharge of groundwater for *Burdwan-II* Block

Ground Water Management Plan for drinking purpose:

i. As per Functional Household tap water connection (FHTC) inception in Ausgram-I block, only 34% that is 14223 households connected to tap water connection out of total 41797 households. The block has eight ground water Based, commissioned public water supply schemes by PHED. 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 1381 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.

ii. The block shows a falling trend of 0.049 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.

iii. Regular field monitoring is necessary from time to time for any potential chemical presence.

SALIENT INFORMATION

Block Name: *Galsi-I*

Geographical area (sq. km): 253

Mappable area (sq. km): 253

District: Purba Bardhaman

State: West Bengal

Basin: Lower Damodar basin

Sub Basin

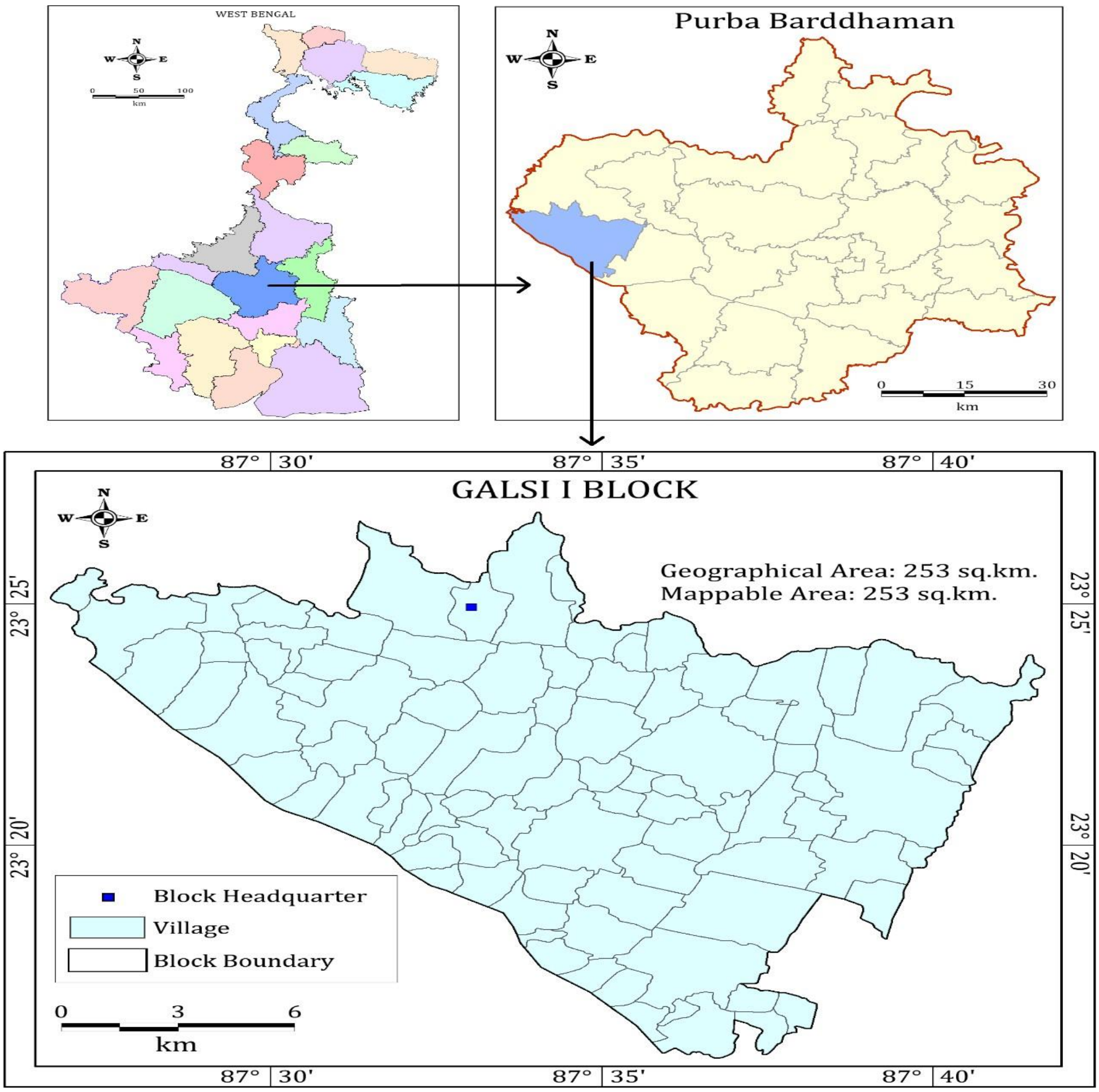


Figure *11.5.*1: Location Map of *Galsi-I* Block

Population (as on 2011):

Table *11.5*.1: Details of population in *Galsi-I* block.

Rural	Urban	Total	Population Density per Sqkm
164467	23121	187588	729

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 ten years in *Galsi-I* block.

Block Name	Normal Rainfall	Rain Fall									
		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Galsi-I	1381.1	1052.88	654.09	1486.79	1155.98	1694.82	1364.43	1375.7	938.3	1186.06	1266.74

Agriculture& Irrigation (area in ha):

Table *11.5*.3: Salient Land use features of *Galsi-I* block

Name of the block	Reporting area (Ha)	Forest area	Area under non-agriculture wastes	Area under Agriculture		Barren and un-culturable lands	Permanent pastures and grazing lands	Land under misc. tree crops	Culturable wastes	Fallow land Other than current fallow	Current fallow
				Gross cropped Area	Net Sown Area						
Galsi-I	24706	-	7015	31406	17687	-	-	4	-	-	-

Table *11.5*.3.1: Command area(ha) of *Galsi-I* block

Sl. No.	Block Name	Surface Lift	CCA	DW	CCA	STW	CCA	DTW	CCA	Total CCA
1	*GALSI-I*	23	120.30	1	1.00	897	2400.50	11	466.00	2987.80

Ground Water Resource:

Table *11.5*.4: Details of Ground WaterResource Availability and Utilization in *Galsi-I* Block.
(As on 31.03.2013)

BLOCK NAME	GALSI-I
Total Annual Ground Water Recharge (Ham)	9039.76
Total Natural Discharges (Ham)	903.98
Annual Extractable Ground Water Recharge (Ham)	8135.78
Total Extraction	4344.47
Annual GW Allocation for Domestic and Industrial Use as on 2042	233.27
Net Ground Water Availability for future use	3762.15
Stage of Ground Water Extraction (%)	53.40
Categorization	Safe
In Storage (Ham)	6236

Disposition of Aquifers:

The principal aquifer systems encountered in this block are alluvial formation

Two aquifers are encountered in this block.

The range of **Aquifer-I** is from 0-50 mbgl.This aquifer is fresh in nature.

The range of **Aquifer-II**varies from50-200mbgl. This aquifer is also fresh in nature.

No of EW & OWs of CGWB. 1 EW 0 OW 2 PZ

No of monitoring stations of CGWB. 10

No of Key well monitoring stations. 4

Table *11.5*.5: Details of aquifer disposition in *Galsi-I* Block

Block	No. of Aquifers	Water bearing zone	Aquifer Thickness (m)		Discharge (lpm)	T (m^2/day)	SWL (mbgl)	Drawdown (mbgl)	S
			Aquifer-I (within 50 mbgl)	Aquifer-II (Below 50 mbgl)					
Galsi-I	3	28-50, 102-120 225-246	14	53	64200	2.446		20.26	

Table *11.5*.6: Details of Aquifer Wise Water Level Ranges & seasonal long term water level trends.

Block	Aquifer	Pre-monsoon Trend			Post-monsoon Trend		
		WL Range (mbgl)	**Rise (m/year)**	**Fall (m/year)**	**WL Range (mbgl)**	**Rise (m/year)**	**Fall (m/year)**
Galsi-I	I	4.35-7.86		14.95	3.82-8.42	0.370259932	1.492
	II	-	-	-	-	-	-

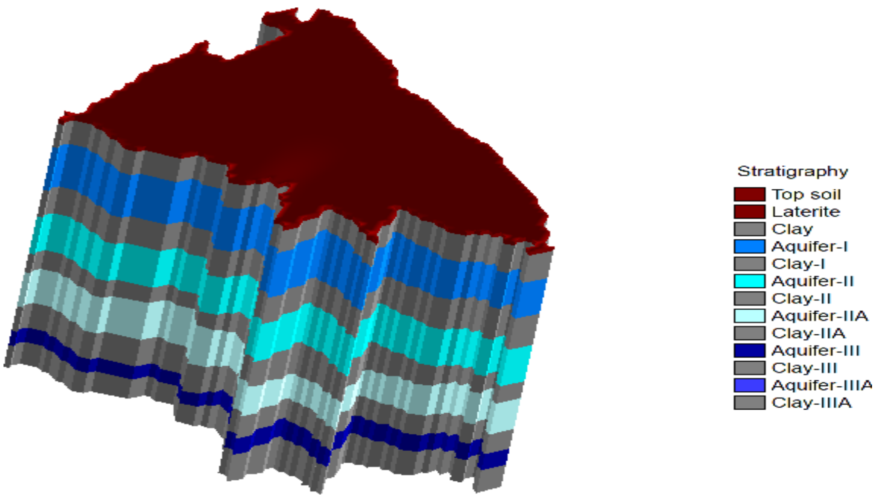


Figure*11.5*.2: 3-DimensionalAquifer disposition in *Galsi-I* Block

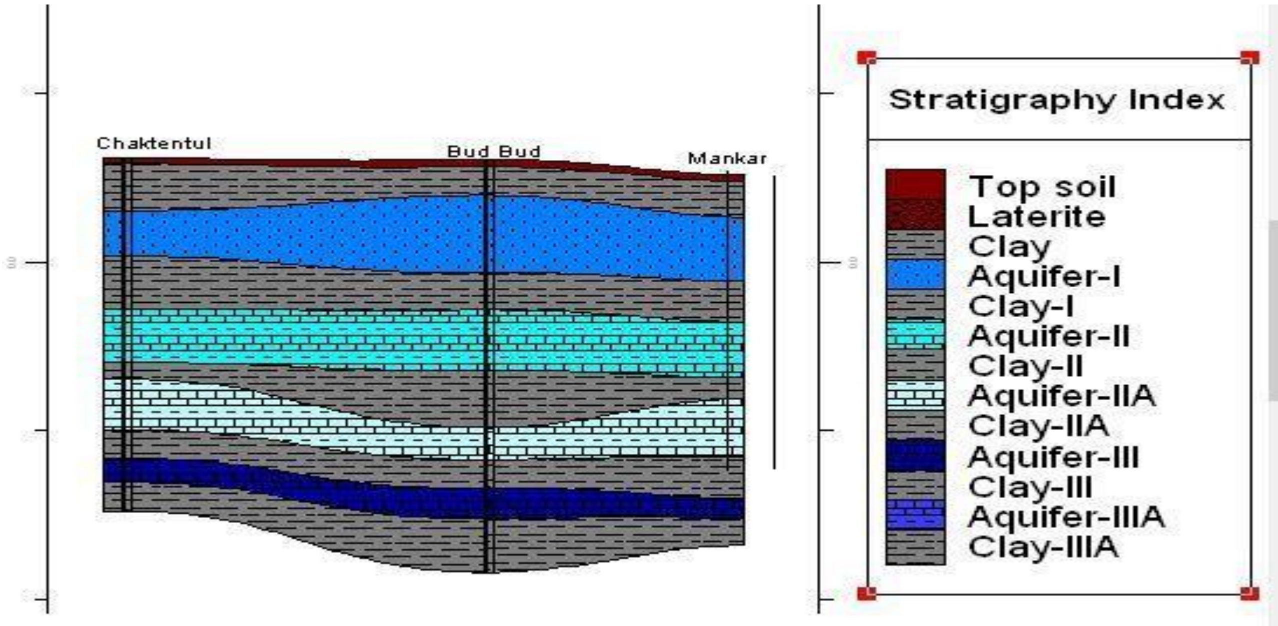


Figure*11.5*.3: 2-Dimensional Section in *Galsi-I* Block

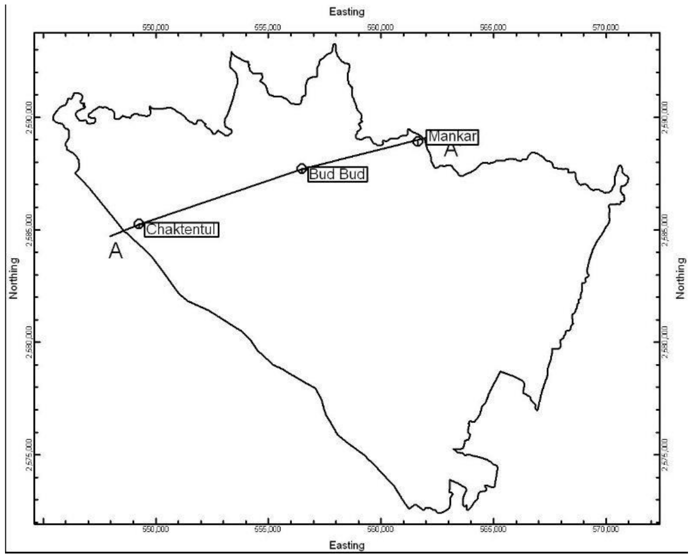


Figure*11.5*.3.1: 2-Dimensional Section in *Galsi-I* Block

Ground water quality and issues:

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

Table 11.5.7 Range of chemical parametersin*Galsi-I* Block

Galsi-I	pH	EC	TH	Ca	Mg	Na	K	HCO3	TA	Cl	NO3	F	TDS	U
AQ-II	7.71	583.2	210	52	19.4	34.5	0.99	292.8	240	35.45	1.9	0.52	323.4	3.4799
AQ-I	6.84-7.71	174-1010	50-265	012 -64	4.9-27.9	10.75-92.4	0.94-2.9	61-384.3	75-315	17.7-120.5	0.2-3.2	0.07-0.52	85.6-541.7	0.079-6.55

Aquifer Management Plan:

Ground Water Management Plan for irrigation purposes:

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 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, rainwater-harvesting may also considered

i. Although ground water development in the block is under safe category with stage of ground water development at 53%, further development should done in planned manner to harness the additional available resource for site-specific sustainable development.
ii. Modern methods of irrigation like sprinkler and drip irrigation methods are encouraged.
iii. Crops with low water requirement should be preferred.

Management Intervention through Harvesting of Surface Runoff and Artificial Recharge:

It has been estimated that the utilizable surface runoff produced in the block is **6** MCM. This surface runoff is proposed to be utilized to recharge the depleted aquifers in the block. As per the available storage space, **2.004**MCM water is required to fill the deeper aquifers in block. Therefore, **7** injection wells with roof top rain water harvesting structures are recommended in the block. The remaining surface runoff, **4.677** MCM is recommended to be utilized in storage tanks for generation of irrigation potential and thus, 108 storage tanks have been proposed. The roof top rain water harvesting structures with suitably design injection wells may be proposed to construct in the census towns areas in primary phases and subsequently may be extended to the rural areas.

Table 11.5.8: Proposed Artificial Recharge Structures, allocation and cost of construction in Galsi-I

Block	Utilizable Surface Run Off	Allocation of Utilizable Recource(MCM)			Structures Feasible			Cost of Structures			TOTAL
		Percolation Tank	REET with RS	Injection Well	Percolation Tank	REET with RS	Injection Well	Percolation Tank	REET with RS	Injection Well	
GaIsi-I	6.681	3.34100	1.336	2.004	7	13	7	56	52	21	129

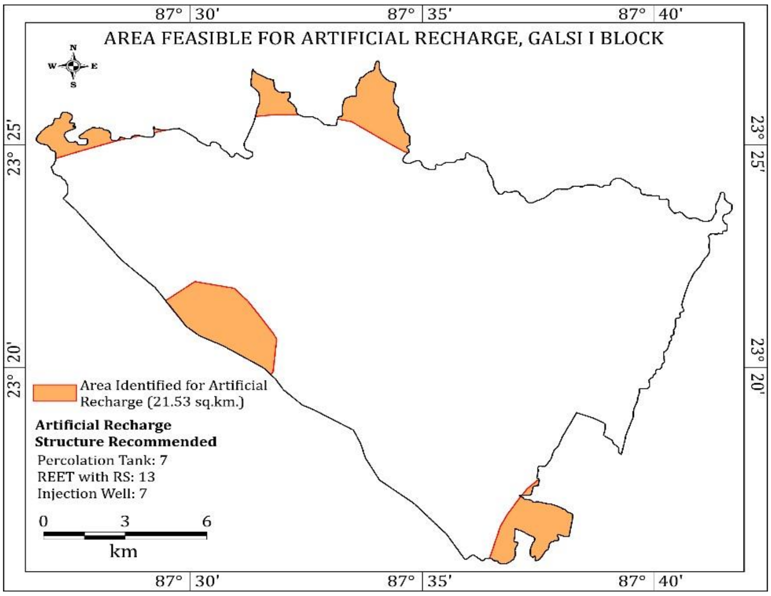


Figure11.5.4: Area Feasible for Artificial Recharge of groundwater for *Galsi-I* Block

Ground Water Management Plan for drinking purpose:

i. As per Functional Household tap water connection (FHTC) inception in Galsi-I block only 25% around 10,709 households connected to tap water connection out of total 42,767 households. The block has **three** groundwater based, commissioned public water supply schemes by PHED and there are three 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 1381 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.

ii. The block shows a falling trend of 1.492 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.

iii. Regular field monitoring is necessary from time to time for any potential chemical presence.

SALIENT INFORMATION

Block Name: *Galsi-II*

Geographical area (sq. km): 227

Mappable area (sq. km): 227

District: Purba Bardhaman

State: West Bengal

Basin: Lower Damodar basin

Sub Basin

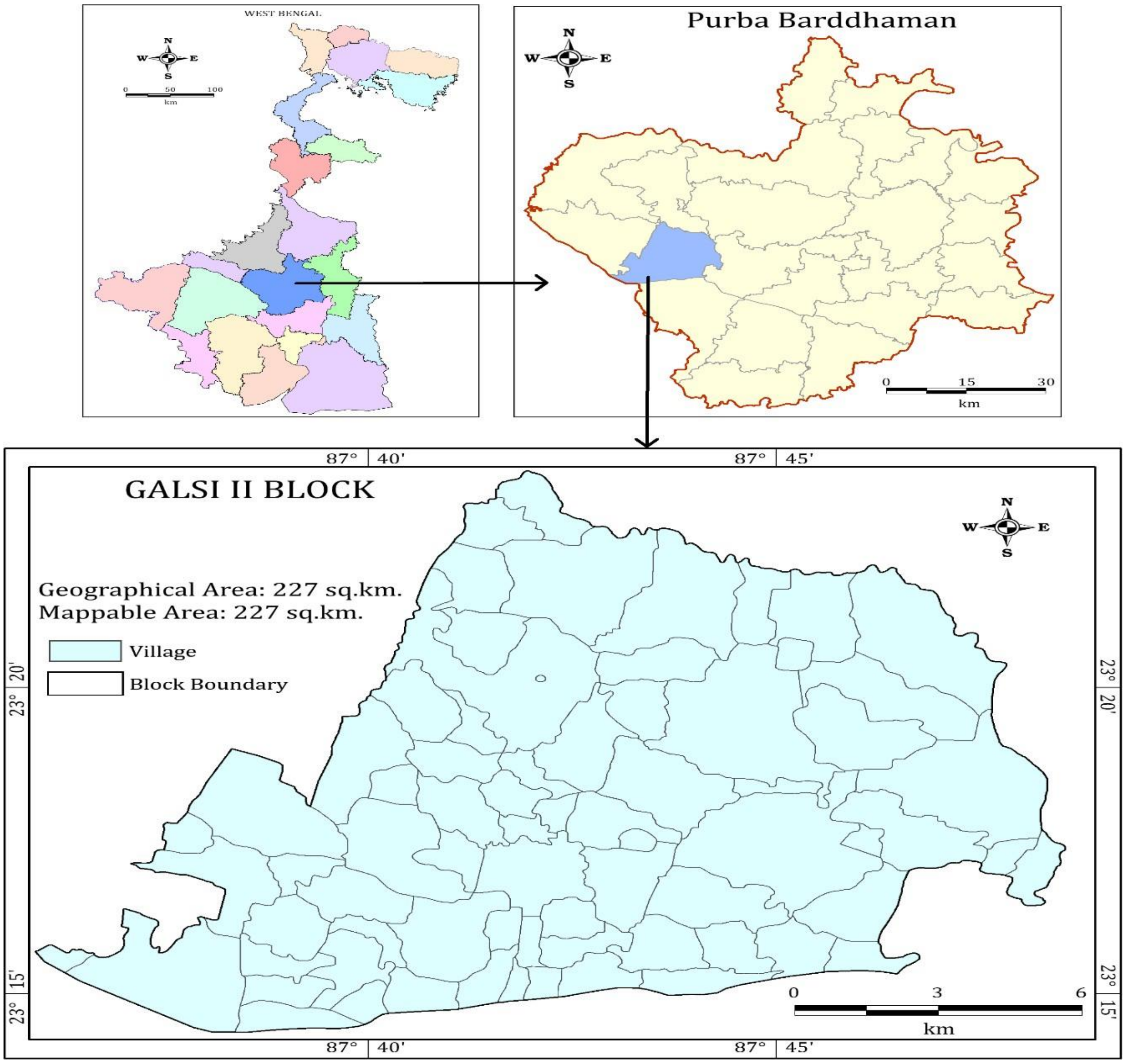


Figure *11.6.*1: Location Map of *Galsi-II* Block

Population (as on 2011):

Table *11.6*.1: Details of population in *Galsi-II* block.

Rural	Urban	Total	Population Density per Sqkm
147177	-	150896	419

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 ten years in *Galsi-II* block.

Block Name	Normal Rainfall	Rain Fall									
		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Galsi-II	1381.1	1052.88	654.09	1486.79	1155.98	1694.82	1364.43	1375.7	938.3	1186.06	1266.74

Agriculture& Irrigation (area in ha):

Table *11.6*.3: Salient Land use features of *Galsi-II* block

Name of the block	Reporting area (Ha)	Forest area	Area under non-agriculture wastes	Area under Agriculture		Barren and un-culturable lands	Permanent pastures and grazing lands	Land under misc. tree crops	Culturable wastes	Fallow land Other than current fallow	Current fallow
				Gross cropped Area	Net Sown Area						
Galsi-II	21632	108	3200	40559	18307	-	-	17	-	-	-

Table *11.6*.3.1: Command area(ha) of *Galsi-II* block

Sl. No.	Block Name	Surface Lift	CCA	DW	CCA	STW	CCA	DTW	CCA	Total CCA
1	*GALSI-II*	60	180.00	-	-	1373	3743.00	65	2562.00	6485.00

Ground Water Resource:

Table *11.6*.4: Details of Ground Water Resource Availability and Utilization in *Galsi-II* Block.
(As on 31.03.2013)

BLOCK NAME	*GALSI-II*
Total Annual Ground Water Recharge (Ham)	8508.31
Total Natural Discharges (Ham)	850.83
Annual Extractable Ground Water Recharge (Ham)	7657.48
Total Extraction	5300.58
Annual GW Allocation for Domestic and Industrial Use as on 2042	180.32
Net Ground Water Availability for future use	2333.63
Stage of Ground Water Extraction (%)	69.22
Categorization	Safe
In Storage (Ham)	2580

Disposition of Aquifers:

The principal aquifer systems encountered in this block are alluvial formation

Two aquifers are encountered in this block.

The range of **Aquifer-I** is from 0-50 mbgl.This aquifer is fresh in nature.

The range of **Aquifer-II**varies from50-150mbgl. This aquifer is also fresh in nature.

No of EW & OWs of CGWB. 2 EW 0 OW 2 PZ

No of monitoring stations of CGWB. 5

No of Key well monitoring stations. 5

Table *11.6.*5: Details of aquifer disposition in *Galsi-II* Block

Block	No. of Aquifers	Water bearing zone	Aquifer Thickness (m)		Discharge (lpm)	T (m^2/day)	SWL (mbgl)	Drawdown (mbgl)	S
			Aquifer-I (within 50 mbgl)	Aquifer-II (Below 50 mbgl)					
Galsi-II	2	28-43 72-105	15	29	-	-	-	-	-

Table *11.6.*6: Details of Aquifer Wise Water Level Ranges & seasonal long term water level trends.

Block	Aquifer	Pre-monsoon Trend			Post-monsoon Trend		
		WL Range (mbgl)	Rise (m/year)	Fall (m/year)	WL Range (mbgl)	Rise (m/year)	Fall (m/year)
Galsi-II	I	6.2-15.78	0.84	12.61	4-11.82	0.383945836	0.766563884
	II	8.18-15.78	-	-	5.58-13.76	-	-

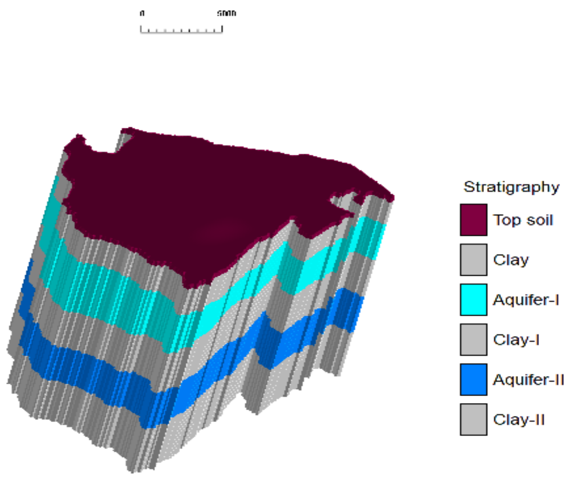


Figure*11.6.*2: 3-DimensionalAquifer disposition in *Galsi-II* Block

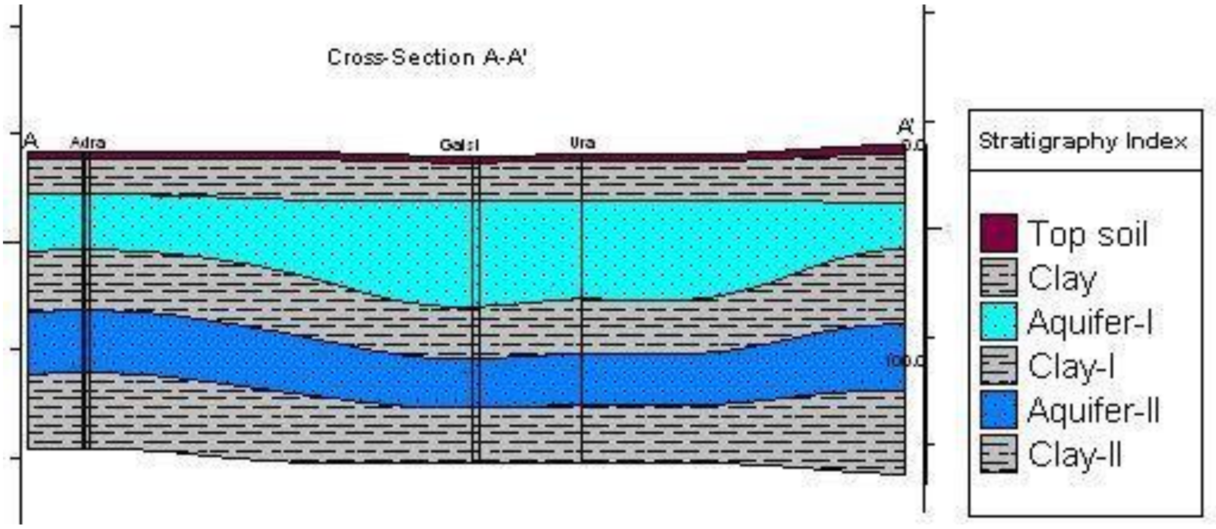


Figure*11.6*.3: 2-Dimensional Section in *Galsi-II* Block

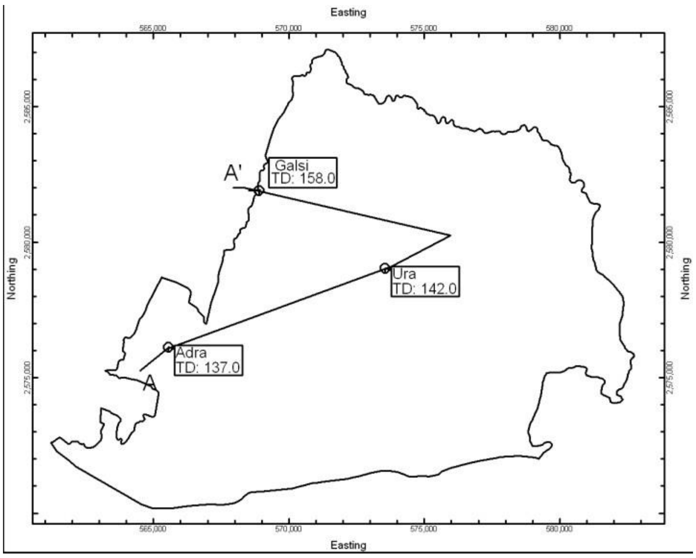


Figure*11.6*.3.1: 2-Dimensional Section profile Map in *Galsi-II* Block

Ground water quality and issues:

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

Table 11.6.7 Range of chemical parametersin*Galsi-II* Block

Galsi-II	pH	EC	TH	Ca	Mg	Na	K	HCO3	TA	Cl	NO3	F	TDS	U
AQ-I	7.4-7.59	360.8-466.9	170-220	30-46	18.2-31.6	11.02-35.1	0.75-2.14	189.1-280.6	155-230	28.36-42.54	0.2-1.0	0.26-0.42	211.4-305.9	0.66-1.56
AQ-II	7.25-7.72	179.2-556.3	115-255	40-52	3.6-30.3	13.54-16.07	0.92-1.02	122-305	100-250	17.72-31.90	0.5-2.5	0.28-0.58	169.6-318.4	<0.368

Aquifer Management Plan:

Ground Water Management Plan for irrigation purposes:

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 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, rainwater-harvesting may also considered

i. Although ground water development in the block is under safe category with stage of ground water development at 69.77%, which indicate further development should, done in planned manner to harness the additional available resource for site-specific sustainable development. Conjunctive use of surface as well groundwater is highly recommended.
ii. Modern methods of irrigation like sprinkler and drip irrigation methods are encouraged.
iii. Crops with low water requirement should be preferred.

Management Intervention through Harvesting of Surface Runoff and Artificial Recharge:

It has been estimated that the utilizable surface runoff produced in the block is 35.4 MCM. This surface runoff is proposed to be utilized to recharge the depleted aquifers in the block. As per the available storage space, 10.62MCM water is required to fill the deeper aquifers in block. Therefore, 35 injection wells with roof top rain water harvesting structures are recommended in the block. The remaining surface runoff, 24.78 MCM is recommended to be utilized in storage tanks for generation of irrigation potential and thus, 564 storage tanks have been proposed. The roof top rain water harvesting structures with suitably design injection wells may be proposed to construct in the census towns areas in primary phases and subsequently may be extended to the rural areas.

Table 11.6.8: Proposed Artificial Recharge Structures, allocation and cost of construction in Galsi-ii block

Block	Utilizable Surface Run Off	Allocation of Utilizable Recource(MCM)			Structures Feasible			Cost of Structures			TOTAL
		Percolation Tank	REET with RS	Injection Well	Percolation Tank	REET with RS	Injection Well	Percolation Tank	REET with RS	Injection Well	
GaIsi-II	35.414	17.70700	7.083	10.624	35	71	35	280	284	105	669

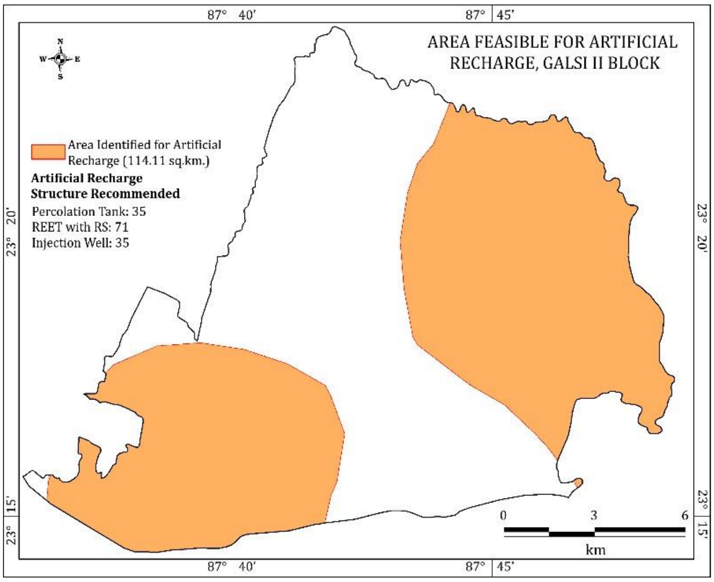


Figure11.6.4: Area Feasible for Artificial Recharge of groundwater for *Galsi-II* Block

Ground Water Management Plan for drinking purpose:

i. As per Functional Household tap water connection (FHTC) inception in Galsi-II block only 26% around 9760 households connected to tap water connection out of total 36622 households. The block has five groundwater based, commissioned public water supply schemes by PHED. 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 1381 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.

ii. The block shows a falling trend of 0.77 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.

iii. Regular field monitoring is necessary from time to time for any potential chemical presence.

SALIENT INFORMATION

Block Name:	***Jamalpur***
Geographical area (sq. km):	**254**
Mappable area (sq. km):	**241**
District:	**Purba Bardhaman**
State:	**West Bengal**
Basin:	**Lower Damodar basin**
Sub Basin	

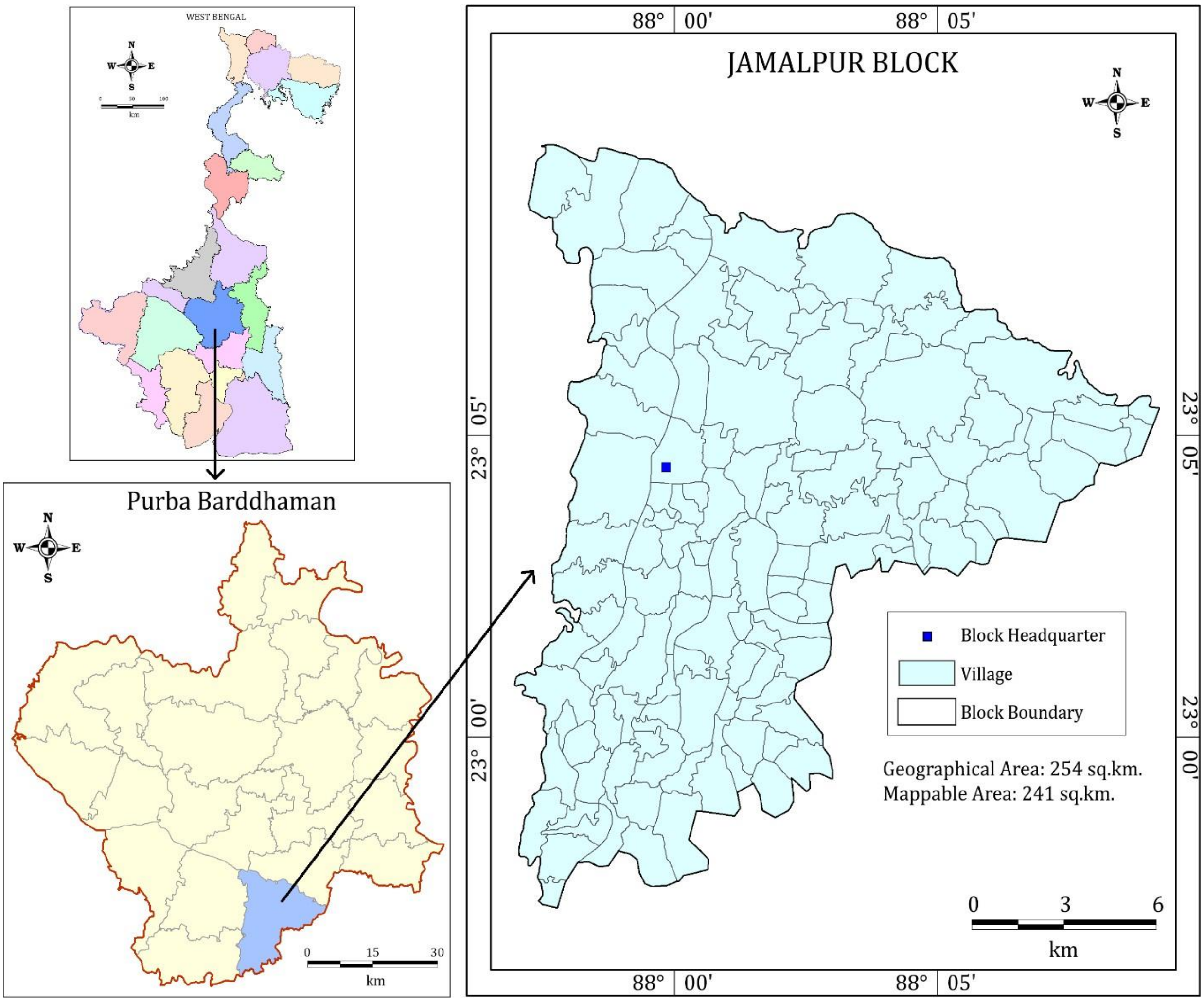


Figure *11.7.*1: Location Map of *Jamalpur* Block

Population (as on 2011):

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

Rural	Urban	Total	Population Density per Sqkm
266338	-	266338	1013

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

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

Block Name	Normal Rainfall	Rain Fall									
		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Jamalpur	1381.1	1052.88	654.09	1486.79	1155.98	1694.82	1364.43	1375.7	938.3	1186.06	1266.74

Agriculture& Irrigation (area in ha):

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

Name of the block	Reporting area (Ha)	Forest area	Area under non-agriculture wastes	Area under Agriculture		Barren and un-culturable lands	Permanent pastures and grazing lands	Land under misc. tree crops	Culturable wastes	Fallow land Other than current fallow	Current fallow
				Gross cropped Area	Net Sown Area						
Jamalpur	26358	-	6729	50063	19483	-	2	40	104	-	-

Table *11.7*.3.1: Command area(ha) of *Jamalpur* block

Sl. No.	Block Name	Surface Lift	CCA	DW	CCA	STW	CCA	DTW	CCA	Total CCA
1	*JAMALPUR*	52	1163.70	1	5.00	1612	3878.56	73	2056.00	7103.26

Ground Water Resource:

Table *11.7*.4: Details of Ground Water Resource Availability and Utilization in *Jamalpur* Block.
(As on 31.03.2013)

BLOCK NAME	*JAMALPUR*
Total Annual Ground Water Recharge (Ham)	23140.2
Total Natural Discharges (Ham)	1999.2
Annual Extractable Ground Water Recharge (Ham)	21141
Total Extraction	8765.48
Annual GW Allocation for Domestic and Industrial Use as on 2042	356.51
Net Ground Water Availability for future use	12304.3
Stage of Ground Water Extraction (%)	41.46
Categorization	Safe
In Storage(Ham)	9957

Disposition of Aquifers:

The principal aquifer systems encountered in this block are alluvial formation

Two aquifers are encountered in this block.

The range of **Aquifer-I** is from 0-50 mbgl.This aquifer is fresh in nature.

The range of **Aquifer-II and IIA** varies from50-150mbgl. This aquifer is also fresh in nature.

No of EW & OWs of CGWB. 0 EW 0 OW 2 PZ

No of monitoring stations of CGWB. 6

No of Key well monitoring stations. 10

Table *11.7*.5: Details of aquifer disposition in *Jamalpur* Block

Block	No. of Aquifers	Water bearing zone	Aquifer Thickness (m)		Discharge (lpm)	T (m^2/day)	SWL (mbgl)	Drawdown (mbgl)	S
			Aquifer-I (within 50 mbgl)	Aquifer-II (Below 50 mbgl)					
Jamalpur	2	27-33 62-83 115-145	15	58	-	-	-	-	-

Table *11.7*.6: Details of Aquifer Wise Water Level Ranges & seasonal long term water level trends.

Block	Aquifer	Pre-monsoon Trend			Post-monsoon Trend		
		WL Range (mbgl)	Rise (m/year)	Fall (m/year)	WL Range (mbgl)	Rise (m/year)	Fall (m/year)
Jamalpur	I	1.65-12.31	0.33	6.98	1.68-10.55	0.359731196	0.480024592
	II	10.19-14.52	-	-	4.9-10.33	-	-

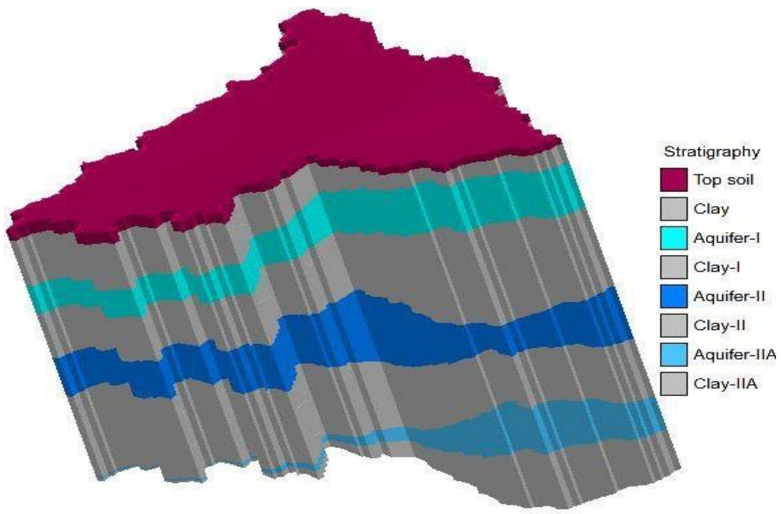


Figure*11.7*.2: 3-DimensionalAquifer disposition in *Jamalpur* Block

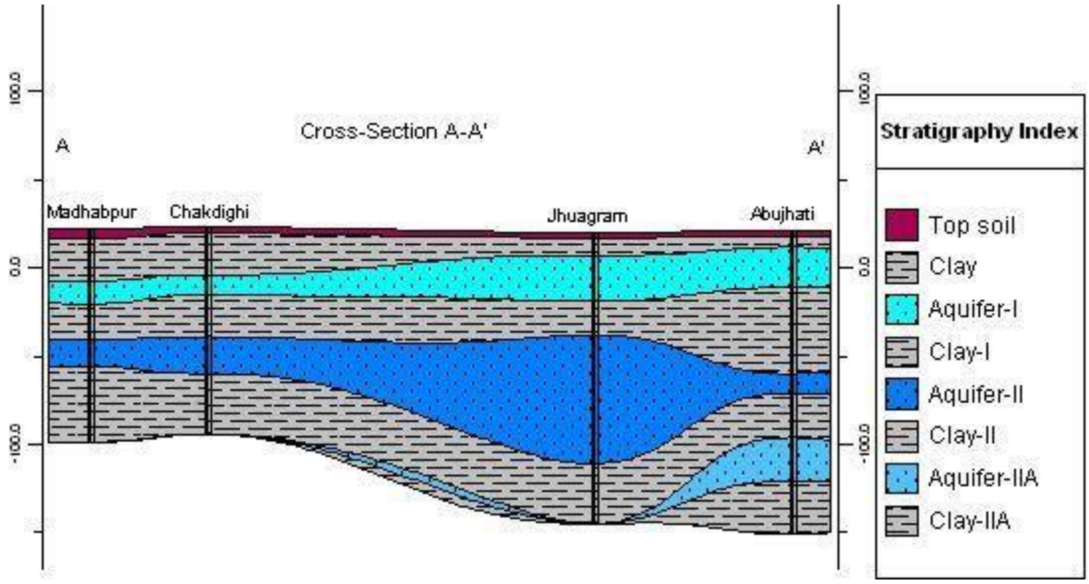


Figure*11.7.*3: 2-Dimensional Section in *Jamalpur* Block

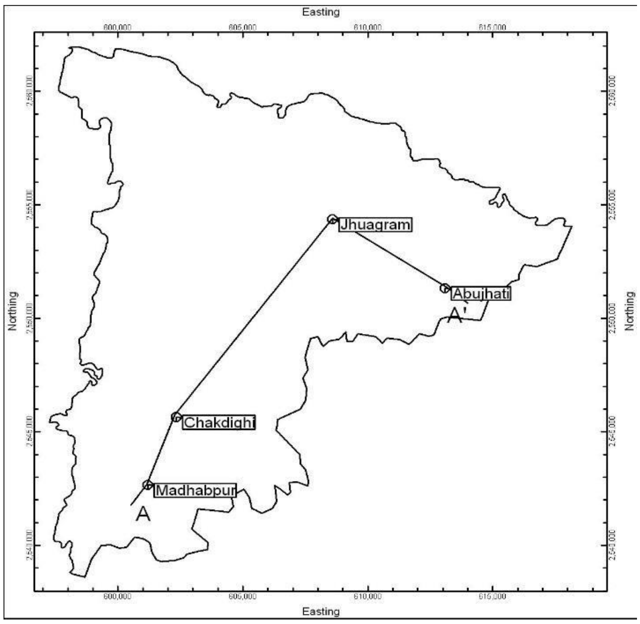


Figure*11.7.*3.1: 2-Dimensional Section profile Map in *Jamalpur* Block

Ground water quality and issues:

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

Table 11.7.7 Range of chemical parametersin*Jamalpur* Block

Jamalpur	pH	EC	TH	Ca	Mg	Na	K	HCO3	TA	Cl	NO3	F	TDS	U
AQ-I	7.28-7.79	237.8-707.2	95-225	18-54	8.5-43.7	20-68.58	0.81-32.76	158.6-408.7	130-335	14.18-77.99	7.5-8.0	0.22-0.61	173.6-433.8	0.2664-3.59
AQ-II	7.47-7.63	385.3-636.9	125-168	36-54	15.8-30.3	26.3-64.5	1.08-2.43	183-427	150-350	17.7-31.9	4.8-8.4	0.38-0.66	217.3-426.3	0.33-1.88

Aquifer Management Plan:

Ground Water Management Plan for irrigation purposes:

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 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, rainwater-harvesting may also considered

i. Although ground water development in the block is under safe category with stage of ground water development at 41%. There is a scope for further development of groundwater in planned manner to harness the additional available resource for site-specific sustainable development. Conjunctive use of surface as well groundwater is recommended to reduce the over dependency on groundwater.

ii. Modern methods of irrigation like sprinkler and drip irrigation methods are encouraged.

iii. Crops with low water requirement should be preferred.

Management Intervention through Harvesting of Surface Runoff and Artificial Recharge:

It has been estimated that the utilizable surface runoff produced in the block is 1.891 MCM. This surface runoff is proposed to be utilized to recharge the depleted aquifers in the block. As per the available storage space, 0.56MCM water is required to fill the deeper aquifers in block. Therefore, 2 injection wells with roof top rain water harvesting structures are recommended in the block. The remaining surface runoff, 1.324 MCM is recommended to be utilized in storage tanks for generation of irrigation potential and thus, 32 storage tanks have been proposed. The roof top rain water harvesting structures with suitably design injection wells may be proposed to construct in the census towns areas in primary phases and subsequently may be extended to the rural areas.

Table 11.7.8: Proposed Artificial Recharge Structures, allocation and cost of construction in Galsi-ii block

Block	Utilizable Surface Run Off	Allocation of Utilizable Recource(MCM)			Structures Feasible			Cost of Structures			TOTAL
		Percolation Tank	REET with RS	Injection Well	Percolation Tank	REET with RS	Injection Well	Percolation Tank	REET with RS	Injection Well	
GaIsi-II	1.891	0.94600	0.378	0.567	2	4	2	16	16	6	38

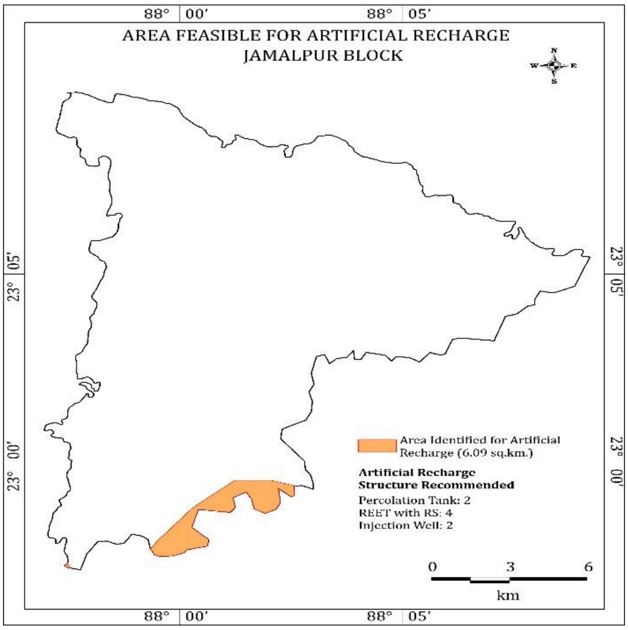


Figure11.7.4: Area Feasible for Artificial Recharge of groundwater for *Jamalpur* Block

Ground Water Management Plan for drinking purpose:

i. As per Functional Household tap water connection (FHTC) inception in Galsi-II block only 83% around 59197 households connected to tap water connection out of total 70892 households. The block has 24 groundwater based, commissioned public water supply schemes by PHED. There should be a general practice of conservation through rainwater harvesting, considering an adequate normal monsoon rainfall of 1381 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.

ii. The block shows a falling trend of 0.48 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.

iii. Regular field monitoring is necessary from time to time for any potential chemical presence.

SALIENT INFORMATION

Block Name: *Khandaghosh*

Geographical area (sq. km): 193

Mappable area (sq. km): 165

District: Purba Bardhaman

State: West Bengal

Basin: Lower Damodar basin

Sub Basin

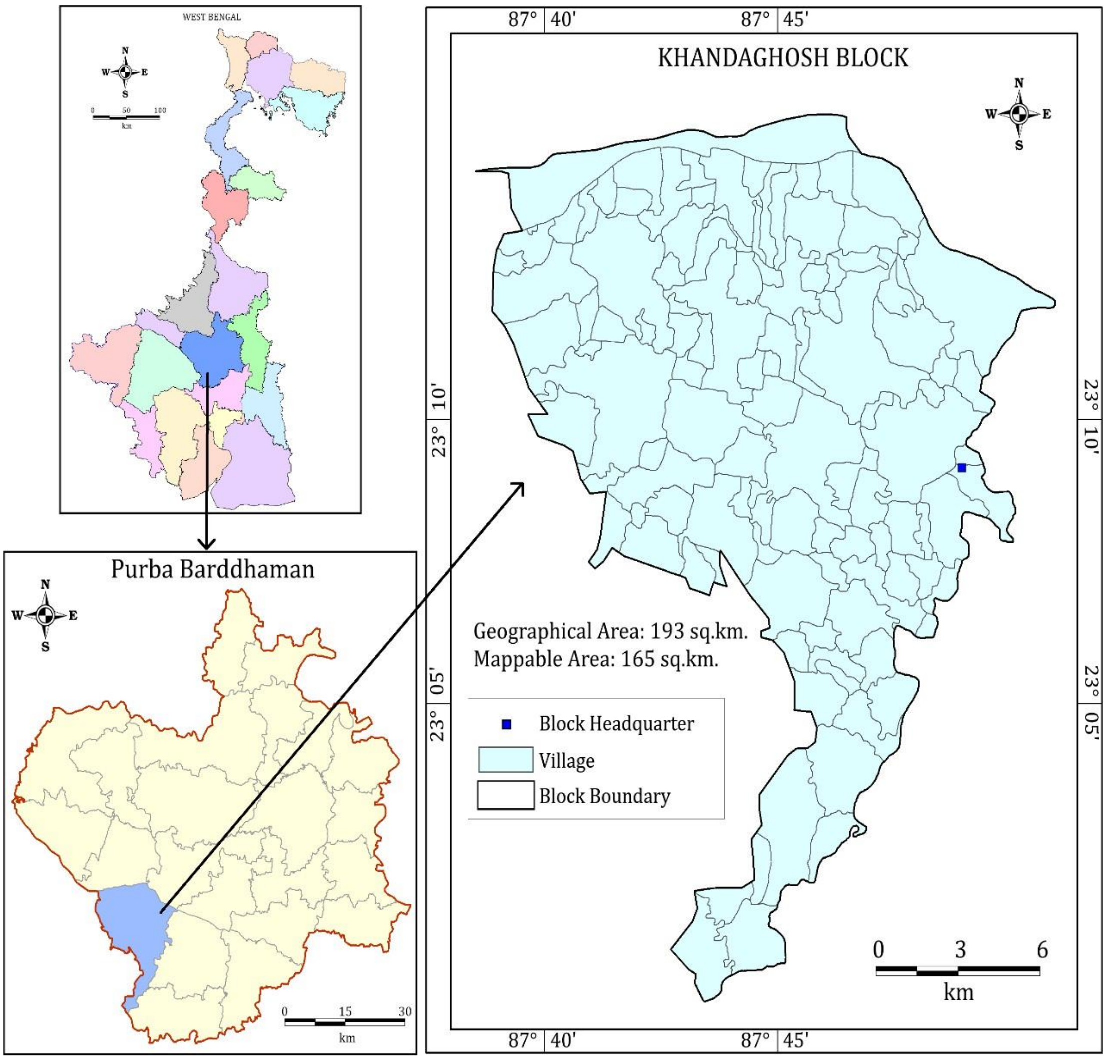


Figure *11.8.*1: Location Map of *Khandaghosh* Block

Population (as on 2011):

Table *11.8*.1: Details of population in *Khandaghosh* block.

Rural	Urban	Total	Population Density per Sqkm
189336	-	189336	714

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 ten years in *Khandaghosh* block.

Block Name	Normal Rainfall	Rain Fall									
		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Khanda ghosh	1381.1	1052.8 8	654.09	1486.79	1155.98	1694.8 2	1364.43	1375.7	938.3	1186.06	1266.74

Agriculture& Irrigation (area in ha):

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

Name of the block	Reporting area (Ha)	Forest area	Area under non-agriculture wastes	Area under Agriculture		Barren and un-culturable lands	Permanent pastures and grazing lands	Land under misc. tree crops	Culturable wastes	Fallow land Other than current fallow	Current fallow
				Gross cropped Area	Net Sown Area						
Khandaghosh	26416	-	6200	37338	20210	-	-	3	3	-	-

Table *11.8*.3.1: Command area(ha) of *Khandaghosh* block

Sl. No.	Block Name	Surface Lift	CCA	DW	CCA	STW	CCA	DTW	CCA	Total CCA
1	*KHANDAGHOSH*	130	702.46	-	-	1448	3920.23	61	2655.00	7277.69

Ground Water Resource:

Table *11.8*.4: Details of Ground Water Resource Availability and Utilization in *Khandaghosh* Block.
(As on 31.03.2013)

BLOCK NAME	*KHANDAGHOSH*
Total Annual Ground Water Recharge (Ham)	8508.31
Total Natural Discharges (Ham)	850.83
Annual Extractable Ground Water Recharge (Ham)	7657.48
Total Extraction	5300.58
Annual GW Allocation for Domestic and Industrial Use as on 2042	180.32
Net Ground Water Availability for future use	2333.63
Stage of Ground Water Extraction (%)	69.22
Categorization	Safe
In Storage (Ham)	10475

Disposition of Aquifers:
The principal aquifer systems encountered in this block are alluvial formation

Two sets of aquifers are encountered in this block.

The range of **Aquifer-I** is from 0-50 mbgl.This aquifer is fresh in nature.

The range of **Aquifer-II and IIA** varies from 50-150mbgl. This aquifers are also fresh in nature.

No of EW & OWs of CGWB. 0 EW 0 OW 0 PZ

No of monitoring stations of CGWB. 3

No of Key well monitoring stations. 7

Table *11.8*.5: Details of aquifer disposition in *Khandaghosh* Block

Block	No. of Aquifers	Water bearing zone	Aquifer Thickness (m)		Discharge (lpm)	T (m^2/day)	SWL (mbgl)	Drawdown (mbgl)	S
			Aquifer-I (within 50 mbgl)	Aquifer-II (Below 50 mbgl)					
Khandaghosh	2	28-43 72-105	15	29	-	-	-	-	-

Table *11.8*.6: Details of Aquifer Wise Water Level Ranges & seasonal long term water level trends.

Block	Aquifer	Pre-monsoon Trend			Post-monsoon Trend		
		WL Range (mbgl)	Rise (m/year)	Fall (m/year)	WL Range (mbgl)	Rise (m/year)	Fall (m/year)
Khandaghosh	I	6.77-19.8	0.32	12.23	2.34-11.57	0.39000001	0.793931535
	II	14.62-18.97	-	-	5.51-11.14	-	-

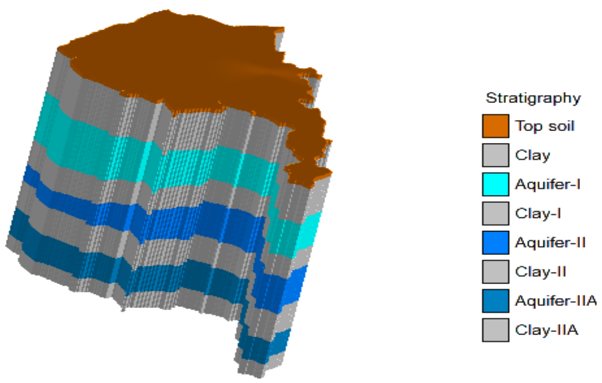


Figure*11.8*.2: 3-DimensionalAquifer disposition in *Khandaghosh* Block

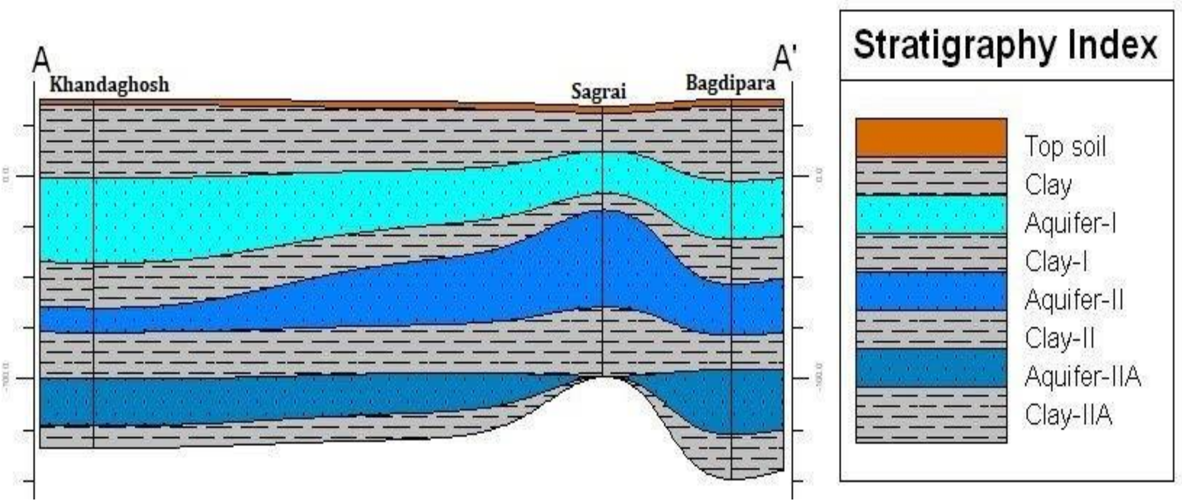


Figure*11.8.*3: 2-Dimensional Section in *Khandaghosh* Block

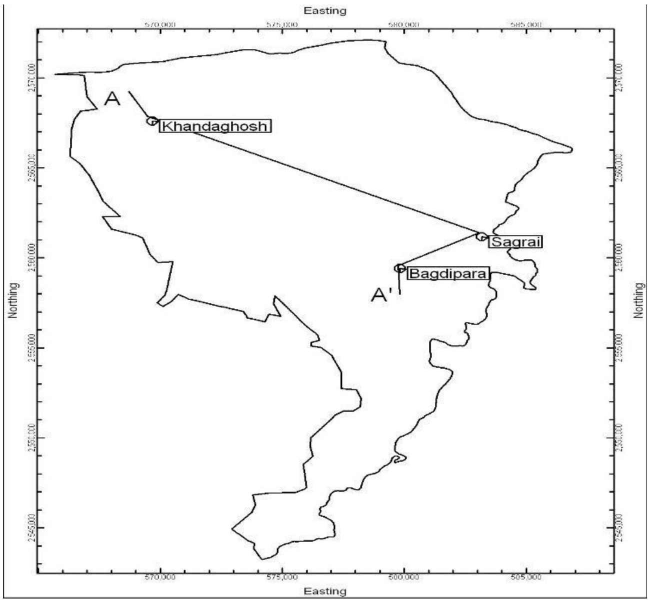


Figure*11.8.*3.1: 2-Dimensional Section profile Map in *Khandaghosh* Block

Ground water quality and issues:

Based on four NHS, and observational key wells, the range of chemical parameter for the block is given below.

Table 11.8.7 Range of chemical parametersin*Khandaghosh* Block

Khandaghosh	pH	EC	TH	Ca	Mg	Na	K	HCO3	TA	Cl	NO3	F	TDS	U
AQ-I	7.5-7.74	444-996	200-390	40-52	18.2-60	19.56-42.9	0.83-11.21	268.4-366	220-300	21.27-138.255	0.1-15.8	0.4-0.75	308.8-496	0.83-4.3
AQ-II	7.58-7.7	491.6-543.9	230-260	36-46	34-35	15.61-24.06	0.8-1.14	317.2-347.7	260-285	14.18-35.45	0.1-6.2	0.56-0.61	327.2-328.3	2.44-4.22

Aquifer Management Plan:

Ground Water Management Plan for irrigation purposes:

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 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, rainwater-harvesting may also considered

i. Although ground water development in the block is under safe category with stage of ground water development at 69.77%, which indicate further development should, done in planned manner to harness the additional available resource for site-specific sustainable development. Conjunctive use of surface as well groundwater is highly recommended to reduce the over dependency on groundwater.
ii. Modern methods of irrigation like sprinkler and drip irrigation methods are encouraged.
iii. Crops with low water requirement should be preferred.

Management Intervention through Harvesting of Surface Runoff and Artificial Recharge:

It has been estimated that the utilizable surface runoff produced in the block is 45.87 MCM. This surface runoff is proposed to be utilized to recharge the depleted aquifers in the block. As per the available storage space, 13.76 MCM water is required to fill the deeper aquifers in block. Therefore, 138 injection wells with roof top rain water harvesting structures are recommended in the block. The remaining surface runoff, 32.11 MCM is recommended to be utilized in storage tanks for generation of irrigation potential and thus, 368 storage tanks have been proposed. The roof top rain water harvesting structures with suitably design injection wells may be proposed to construct in the census towns areas in primary phases and subsequently may be extended to the rural areas.

Table 11.8.8: Proposed Artificial Recharge Structures, allocation and cost of construction in Khandaghosh block

Block	Utilizable Surface Run Off	Allocation of Utilizable Recource(MCM)			Structures Feasible			Cost of Structures			TOTAL
		Percolation Tank	REET with RS	Injection Well	Percolation Tank	REET with RS	Injection Well	Percolation Tank	REET with RS	Injection Well	
Khandaghosh	45.872	22.93600	9.174	13.762	46	92	46	368	368	138	874

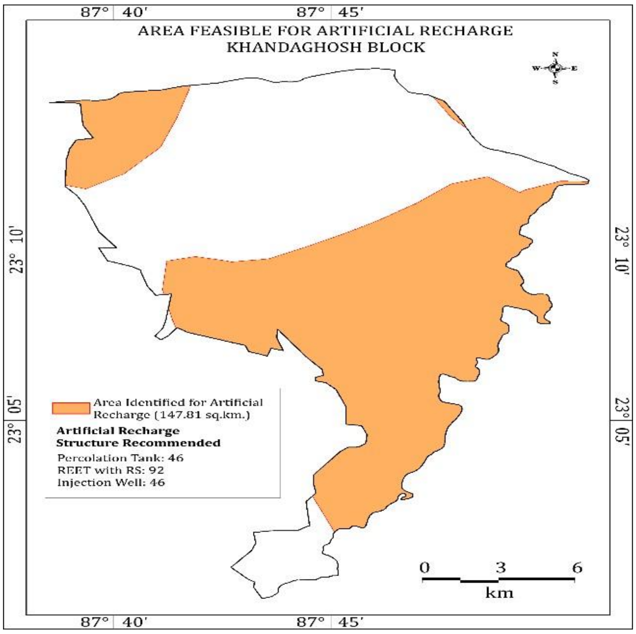


Figure11.8.4: Area Feasible for Artificial Recharge of groundwater for *Khandaghosh* Block

Ground Water Management Plan for drinking purpose:

i. As per Functional Household tap water connection (FHTC) inception in Khandaghosh block only 6%, around 2803 households connected to tap water connection out of total 44012 households. The block has four groundwater based, commissioned public water supply schemes by PHED. There should be a general practice of conservation through rainwater harvesting, considering an adequate normal monsoon rainfall of 1381 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.

ii. The block shows a falling trend of 0.8 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.

iii. Regular field monitoring is necessary from time to time for any potential chemical presence.

SALIENT INFORMATION

Block Name:	***Memari-I***
Geographical area (sq. km):	**193**
Mappable area (sq. km):	**165**
District:	**Purba Bardhaman**
State:	**West Bengal**
Basin:	**Lower Damodar basin**
Sub Basin:	

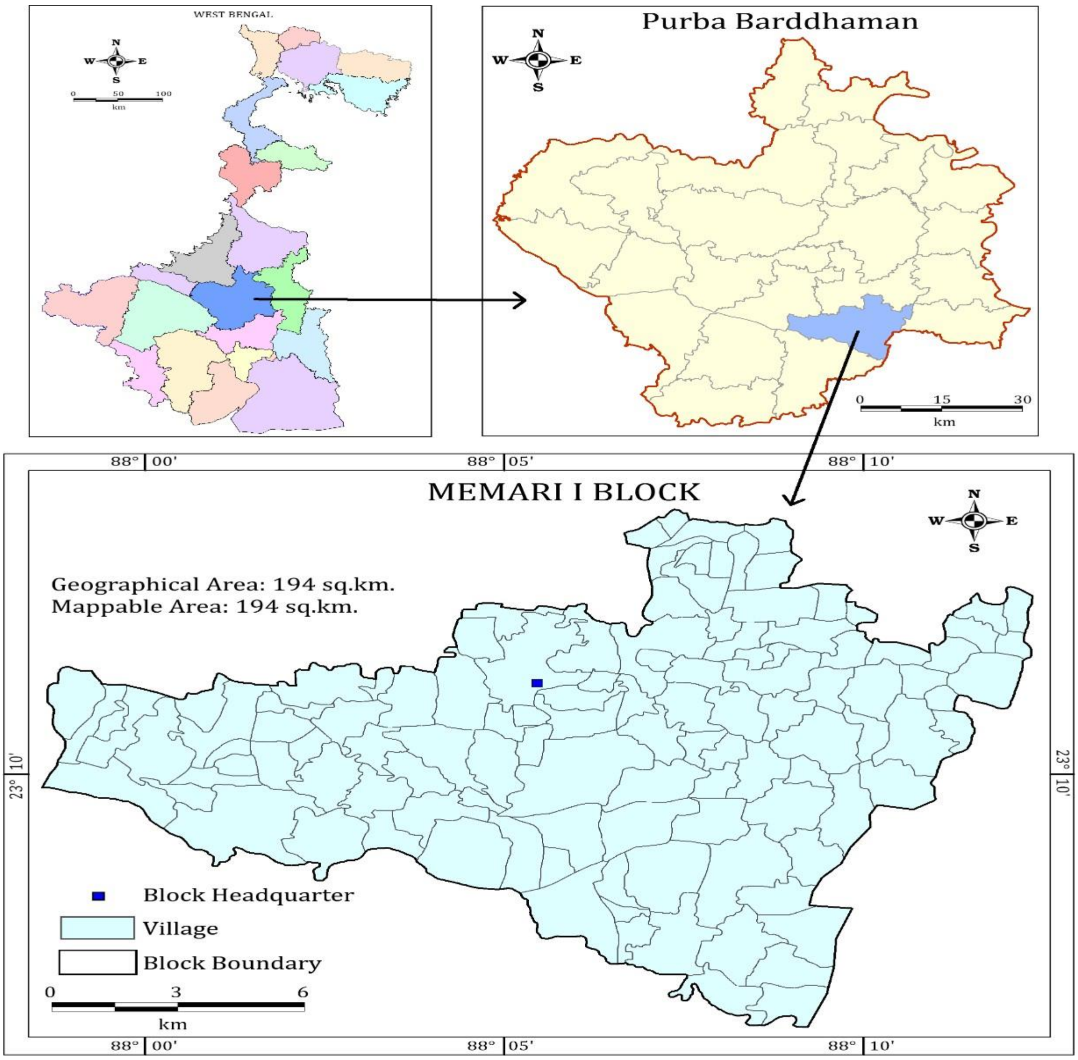


Figure *11.9*.1: Location Map of *Memari-I* Block

Population (as on 2011):

Table *11.9*.1: Details of population in *Memari-I* block.

Rural	Urban	Total	Population Density per Sqkm
214005	4420	218425	1169

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 ten years in *Memari-I* block.

Block Name	Normal Rainfall	Rain Fall									
		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Memari -I	1381.1	1052.88	654.09	1486.79	1155.98	1694.82	1364.43	1375.7	938.3	1186.06	1266.74

Agriculture& Irrigation (area in ha):

Table *11.9*.3: Salient Land use features of *Memari-I* block

Name of the block	Reporting area (Ha)	Forest area	Area under non-agriculture wastes	Area under Agriculture		Barren and un-culturable lands	Permanent pastures and grazing lands	Land under misc. tree crops	Culturable wastes	Fallow land Other than current fallow	Current fallow
				Gross cropped Area	Net Sown Area						
Memari-I	19474	-	7628	49884	11836	-	-	10	-	-	-

Table *11.9*.3.1: Command area(ha) of *Memari-I* block

Sl. No.	Block Name	Surface Lift	CCA	DW	CCA	STW	CCA	DTW	CCA	Total CCA
1	*MEMARI-I*	101	1517.00	7	115.00	1004	5494.02	53	1255.00	8381.02

Ground Water Resource:

Table *11.9*.4: Details of Ground Water Resource Availability and Utilization in *Memari-I* Block.
(As on 31.03.2013)

BLOCK NAME	*MEMARI-I*
Total Annual Ground Water Recharge (Ham)	10831.5
Total Natural Discharges (Ham)	541.57
Annual Extractable Ground Water Recharge (Ham)	10289.9
Total Extraction	5151.71
Annual GW Allocation for Domestic and Industrial Use as on 2042	358.14
Net Ground Water Availability for future use	5054.92
Stage of Ground Water Extraction (%)	50.07
Categorization	Safe
In storage	12076

Disposition of Aquifers:

The principal aquifer systems encountered in this block are alluvial formation

Two sets of aquifers are encountered in this block.

The range of **Aquifer-I** is from 0-50 mbgl.This aquifer is fresh in nature.

The range of **Aquifer-II and IIA** varies from 50-150mbgl. This aquifers are also fresh in nature.

No of EW & OWs of CGWB. 1 EW OW

No of monitoring stations of CGWB. 4

No of Key well monitoring stations. 8

Table *11.9.*5: Details of aquifer disposition in *Memari-I* Block

Block	No. of Aquifers	Water bearing zone	Aquifer Thickness (m)		Discharge (lpm)	T (m^2/day)	SWL (mbgl)	Drawdown (mbgl)	S
			Aquifer-I (within 50 mbgl)	Aquifer-II (Below 50 mbgl)					
Memari-I	3	18-45 90-125	27	48	-	-	-	-	-

Table *11.9.*6: Details of Aquifer Wise Water Level Ranges & seasonal long term water level trends.

Block	Aquifer	Pre-monsoon Trend			Post-monsoon Trend		
		WL Range (mbgl)	Rise (m/year)	Fall (m/year)	WL Range (mbgl)	Rise (m/year)	Fall (m/year)
Memari-I	I	6.15-18.96	0.06	9.61	12.77-18.24	0.40038539	0.837995191
	II	13.83-22.72	-	-	12.21-17.17	-	-

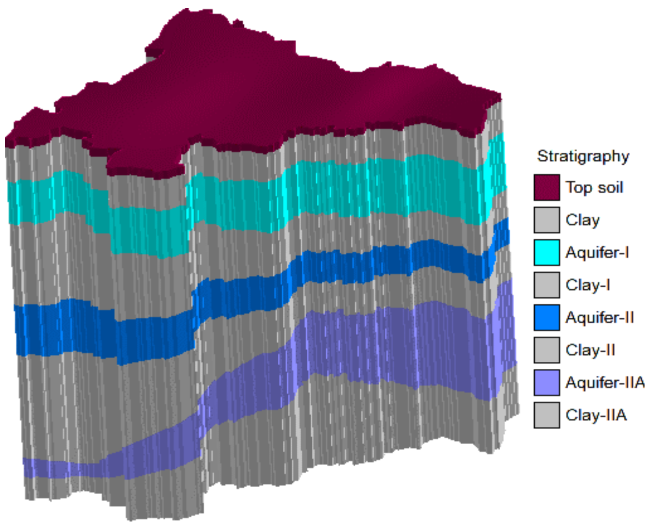


Figure*11.9.*2: 3-DimensionalAquifer disposition in *Memari-I* Block

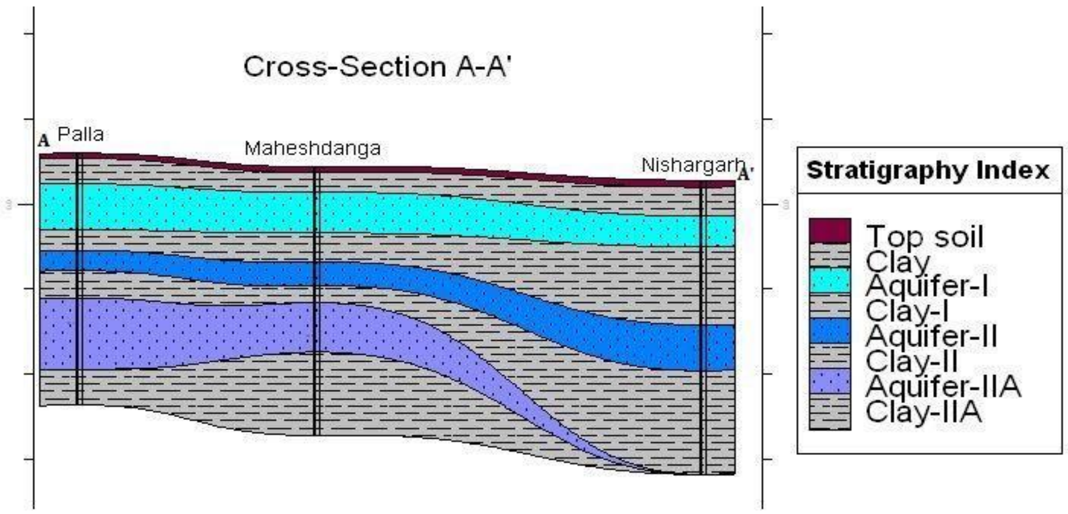


Figure*11.9*.3: 2-Dimensional Section in *Memari-I* Block

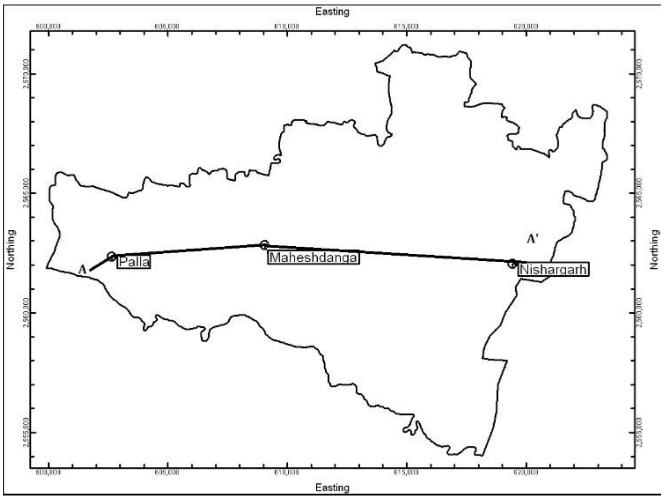


Figure*11.9*.3.1: 2-Dimensional Section profile Map in *Memari-I* Block

Ground water quality and issues:

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

Table 11.9.7 Range of chemical parametersin*Memari-I* Block

Memari-I	pH	EC	TH	Ca	Mg	Na	K	HCO3	TA	Cl	NO3	F	TDS	U
AQ-I	7.23-7.9	254.6-473.4	100-200	16-52	4.9-27.9	16.31-36.5	1.35-2.1	146.4-292.8	120-240	14.18-42.54	0.0-7.9	0.18-0.42	201-319.3	BDL-1.9023
AQ-II	7.65-7.8	266.7-507.1	45-285	36-40	16-44.9	18.95-39.6	1.14-2.51	183-317.2	150-260	14.18-42.54	7.6-7.9	0.3-0.44	206-349.1	0.11-1.14

Aquifer Management Plan:

Ground Water Management Plan for irrigation purposes:

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 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, rainwater-harvesting may also considered

i. Although ground water development in the block is average with stage of ground water development at 50%, further development should done in planned manner to harness the additional available resource for site-specific sustainable development.
ii. Modern methods of irrigation like sprinkler and drip irrigation methods are encouraged.
iii. Crops with low water requirement should be preferred.

Management Intervention through Harvesting of Surface Runoff and Artificial Recharge:

It has been estimated that the utilizable surface runoff produced in the block is 16.66 MCM. This surface runoff is proposed to be utilized to recharge the depleted aquifers in the block. As per the available storage space, 4.99 MCM water is required to fill the deeper aquifers in block. Therefore, 17 injection wells with roof top rain water harvesting structures are recommended in the block. The remaining surface runoff, 11.67 MCM is recommended to be utilized in storage tanks for generation of irrigation potential and thus, 132 storage tanks have been proposed. The roof top rain water harvesting structures with suitably design injection wells may be proposed to construct in the census towns areas in primary phases and subsequently may be extended to the rural areas.

Table 11.9.8: Proposed Artificial Recharge Structures, allocation and cost of construction in Memari-II block

Block	Utilizable Surface Run Off	Allocation of Utilizable Recource(MCM)			Structures Feasible			Cost of Structures			TOTAL
		Percolation Tank	REET with RS	Injection Well	Percolation Tank	REET with RS	Injection Well	Percolation Tank	REET with RS	Injection Well	
Memari-I	16.661	8.331	3.332	4.998	17	33	17	136	132	51	319

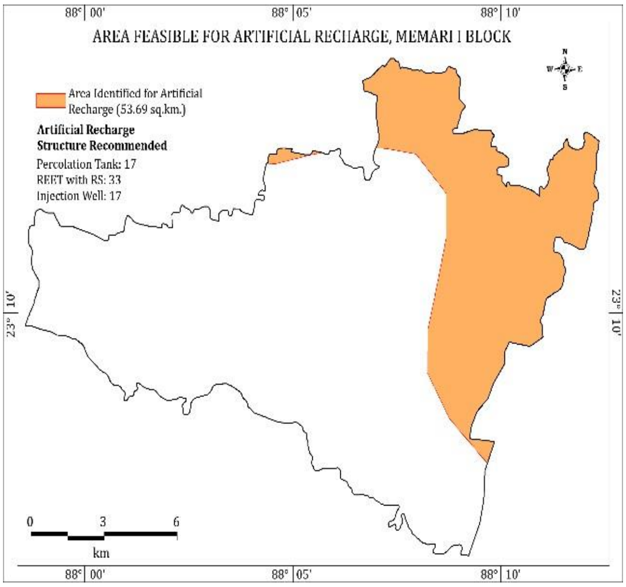


Figure11.9.4: Area Feasible for Artificial Recharge of groundwater for *Memari-I* Block

Ground Water Management Plan for drinking purpose:

i. As per Functional Household tap water connection (FHTC) inception in Memari-I block only 46% around 26,441 households connected to tap water connection out of total 56,358 households. The block has eleven groundwater based, commissioned public water supply schemes by PHED. 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 1381 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.

ii. The block shows a falling trend of 0.837 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.

iii. Regular field monitoring is necessary from time to time for any potential chemical presence.

SALIENT INFORMATION

Block Name: *Raina-I*

Geographical area (sq. km): **241**

Mappable area (sq. km): **208**

District: **Purba Bardhaman**

State: **West Bengal**

Basin: **Lower Damodar basin**

Sub Basin:

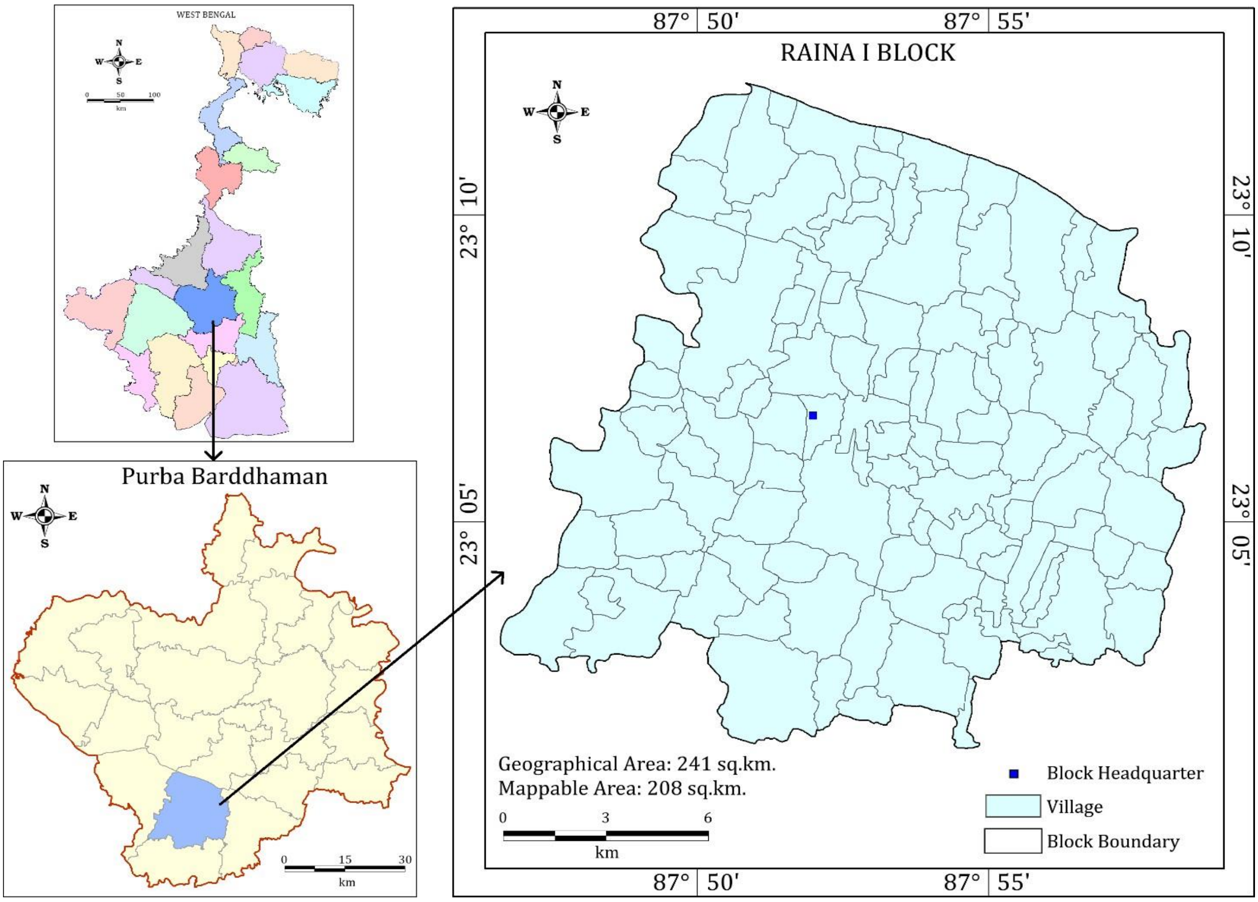


Figure *11.10*.1: Location Map of *Raina-I* Block

Population (as on 2011):

Table *11.10*.1: Details of population in *Raina-I* block.

Rural	Urban	Total	Population Density per Sqkm
173094	7858	180952	680

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 ten years in *Raina-I* block.

Block Name	Normal Rainfall	Rain Fall									
		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Raina-I	1381.1	1052.88	654.09	1486.79	1155.98	1694.82	1364.43	1375.7	938.3	1186.06	1266.74

Agriculture& Irrigation (area in ha):

Table *11.10*.3: Salient Land use features of *Raina-I* block

Name of the block	Reporting area (Ha)	Forest area	Area under non-agriculture wastes	Area under Agriculture		Barren and un-culturable lands	Permanent pastures and grazing lands	Land under misc. tree crops	Culturable wastes	Fallow land Other than current fallow	Current fallow
				Gross cropped Area	Net Sown Area						
Raina-I	25597	-	4200	47151	21286	-		30	80	-	1

Table *11.10*.3.1: Command area(ha) of *Raina-I* block

Sl. No.	Block Name	Surface Lift	CCA	DW	CCA	STW	CCA	DTW	CCA	Total CCA
1	*RAINA-I*	14	242.00			1293	3691.50	61	2366.00	6299.50

Ground Water Resource:

Table *11.10*.4: Details of Ground Water Resource Availability and Utilization in *Raina-I* Block.
(As on 31.03.2013)

BLOCK NAME	*RAINA*-I
Total Annual Ground Water Recharge (Ham)	13400.4
Total Natural Discharges (Ham)	1340.04
Annual Extractable Ground Water Recharge (Ham)	12060.3
Total Extraction	7468.97
Annual GW Allocation for Domestic and Industrial Use as on 2042	227.41
Net Ground Water Availability for future use	4554.91
Stage of Ground Water Extraction (%)	61.93
Categorization	Safe
In storage (Ham)	19955

Disposition of Aquifers:

The principal aquifer systems encountered in this block are alluvial formation

Three sets of aquifers are encountered in this block.

The range of **Aquifer-I** is from 0-50 mbgl.This aquifer is fresh in nature.

The range of **Aquifer-II** varies from50-150mbgl. This aquifer is also fresh in nature.

The range of **Aquifer-III** varies from>150mbgl. This aquifer is also fresh in nature.

No of EW & OWs of CGWB. 0 EW 0 OW

No of monitoring stations of CGWB. 3

No of Key well monitoring stations. 7

Table *11.10*.5: Details of aquifer disposition in *Raina-I* Block

Block	No. of Aquifers	Water bearing zone	Aquifer Thickness (m)		Discharge (lpm)	T (m^2/day)	SWL (mbgl)	Drawdown (mbgl)	S
			Aquifer-I (within 50 mbgl)	Aquifer-II (Below 50 mbgl)					
Raina-I	3	18-39 74-96 152-170	21	60	-	-	-	-	-

Table *11.10*.6: Details of Aquifer Wise Water Level Ranges & seasonal long-term water level trends.

Block	Aquifer	Pre-monsoon Trend			Post-monsoon Trend		
		WL Range (mbgl)	Rise (m/year)	Fall (m/year)	WL Range (mbgl)	Rise (m/year)	Fall (m/year)
Raina-I	I	10.49-15.11	0.304000016	0.706	4.44-5.94	--	0.848
	II	14.25	-	-	5.81-5.03	-	-

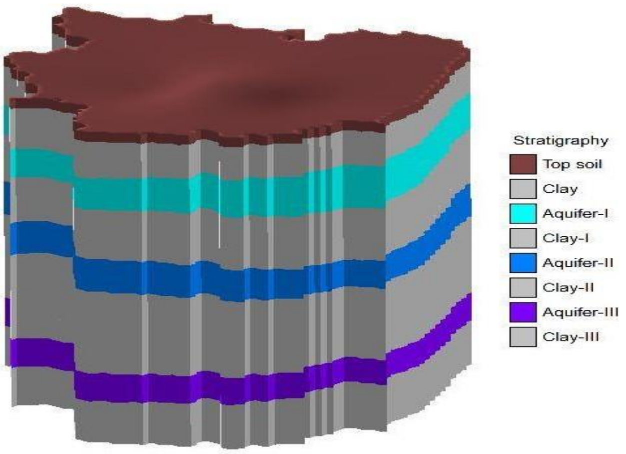


Figure*11.10*.2: 3-DimensionalAquifer disposition in *Raina-I* Block

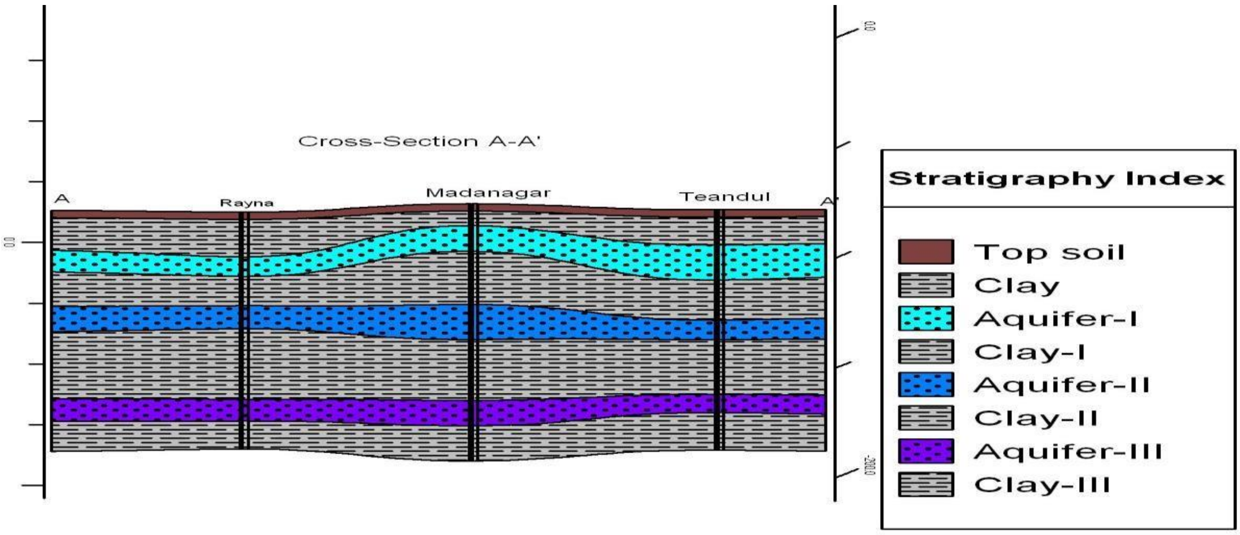


Figure*11.10*.3: 2-Dimensional Section in *Raina-I* Block

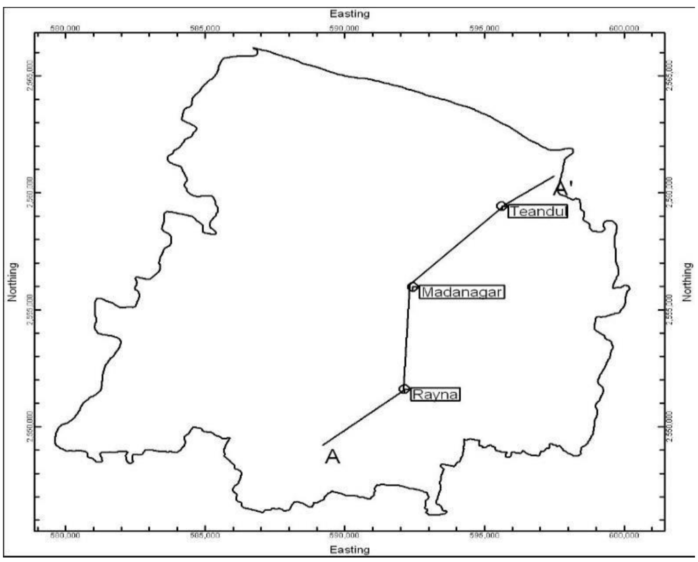


Figure*11.10*.3.1: 2-Dimensional Section profile Map in *Raina-I* Block

Ground water quality and issues:

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

Table 11.10.7 Range of chemical parametersin*Raina-I* Block

Rayna -I	pH	EC	TH	Ca	Mg	Na	K	HCO3	TA	Cl	NO 3	F	TDS	U
AQ-II	7.64-7.76	584.7-604.3	240-265	28-30	41.3-46.1	26.9-39.2	1.35-1.41	372.1-414.8	305-340	17.7-24.81	0.1-0.6	0.62-0.64	343.5-395.3	2.89-3.01
AQ-I	7.72-7.83	397.3-779.6	170-295	26-44	25.5-34.0	28.91-40.5	0.87-1.24	256.2-366	210-300	14.18-85.08	0.1-0.5	0.34-0.6	269-435.5	0.82-5.91

Aquifer Management Plan:

Ground Water Management Plan for irrigation purposes:

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 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, rainwater-harvesting may also considered

i. Although ground water development in the block is average with stage of ground water development at 62%, further development should done in planned manner to harness the additional available resource for site-specific sustainable development.
ii. Modern methods of irrigation like sprinkler and drip irrigation methods are encouraged.
iii. Crops with low water requirement should be preferred.

Management Intervention through Harvesting of Surface Runoff and Artificial Recharge:

It has been estimated that the utilizable surface runoff produced in the block is 54.03 MCM. This surface runoff is proposed to be utilized to recharge the depleted aquifers in the block. As per the available storage space, 16.212MCM water is required to fill the deeper aquifers in block. Therefore, 54 injection wells with roof top rain water harvesting structures are recommended in the block. The remaining surface runoff, 37.818 MCM is recommended to be utilized in storage tanks for generation of irrigation potential and thus, 432 storage tanks have been proposed. The roof top rain water harvesting structures with suitably design injection wells may be proposed to construct in the census towns areas in primary phases and subsequently may be extended to the rural areas.

Table 11.10.8: Proposed Artificial Recharge Structures, allocation and cost of construction in Rayna-I block

Block	Utilizable Surface Run Off	Allocation of Utilizable Recource(MCM) Percolation Tank	Allocation of Utilizable Recource(MCM) REET with RS	Allocation of Utilizable Recource(MCM) Injection Well	Structures Feasible Percolation Tank	Structures Feasible REET with RS	Structures Feasible Injection Well	Cost of Structures Percolation Tank	Cost of Structures REET with RS	Cost of Structures Injection Well	TOTAL
Raina-I	54.039	27.02	10.808	16.212	54	108	54	432	432	162	1026

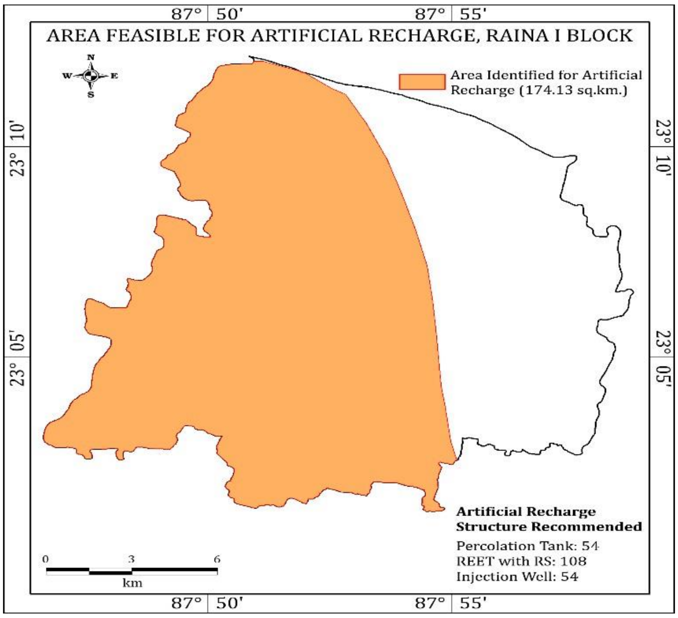


Figure11.10.4: Area Feasible for Artificial Recharge of groundwater for *Raina-I* Block

Ground Water Management Plan for drinking purpose:

i. As per Functional Household tap water connection (FHTC) inception in Raina-I block only 28% around 11,820 households connected to tap water connection out of total 41,681 households. The block has seven groundwater based, commissioned public water supply schemes by PHED. 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 1381 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.

ii. The block shows a falling trend of 0.848 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.

iii. Regular field monitoring is necessary from time to time for any potential chemical presence

SALIENT INFORMATION

Block Name: *Raina-II*

Geographical area (sq. km): 276

Mappable area (sq. km): 276

District: Purba Bardhaman

State: West Bengal

Basin: Lower Damodar basin

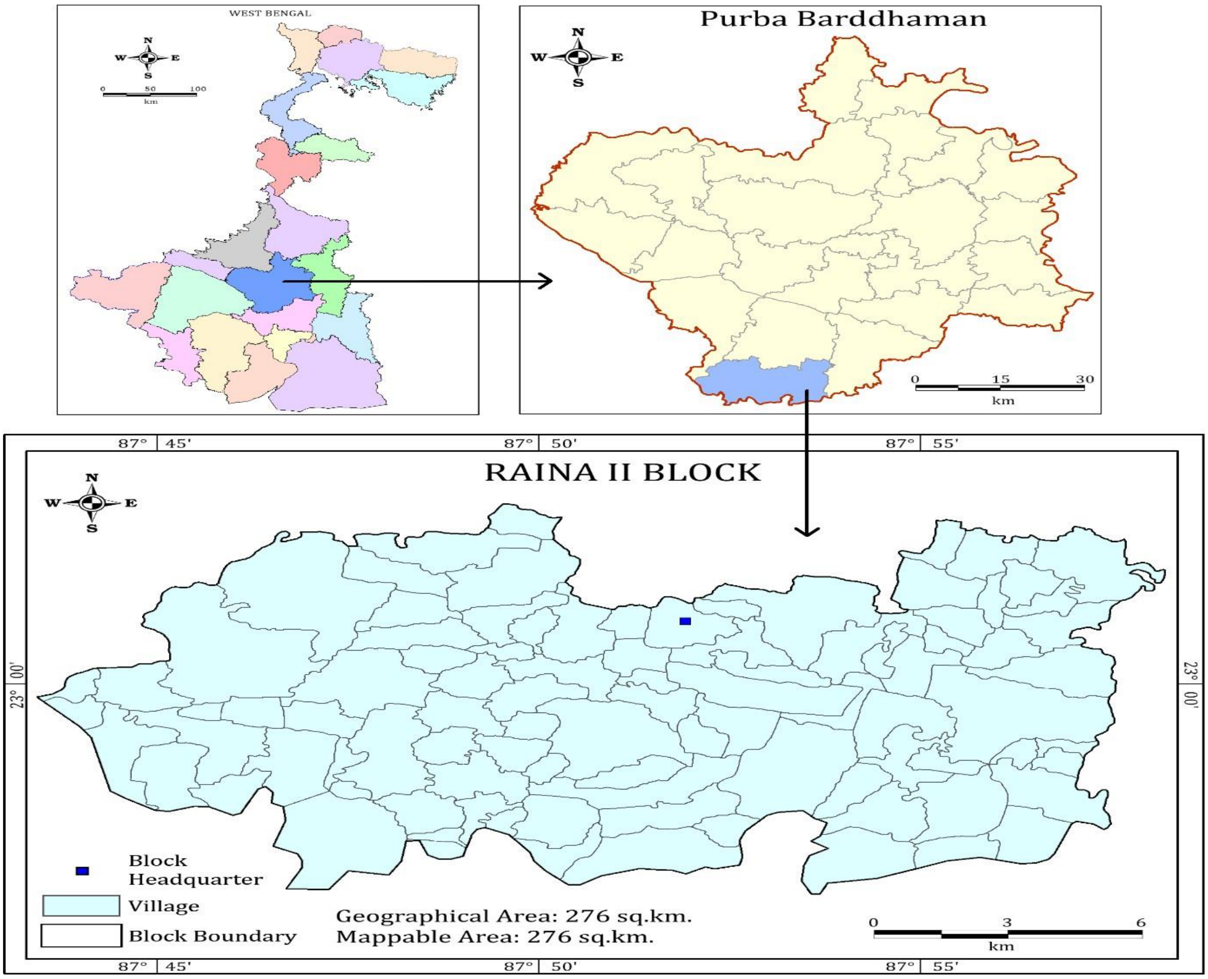


Figure *11.11*.1: Location Map of *Raina-II* Block

Population (as on 2011):

Table *11.11*.1: Details of population in *Raina-II* block.

Rural	Urban	Total	Population Density per Sqkm
151401	-	151401	666

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 ten years in *Raina-II* block.

Block Name	Normal Rainfall	Rain Fall									
		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Raina-II	1381.1	1052.88	654.09	1486.79	1155.98	1694.82	1364.43	1375.7	938.3	1186.06	1266.74

Agriculture& Irrigation (area in ha):

Table *11.11*.3: Salient Land use features of *Raina-II* block

Name of the block	Reporting area (Ha)	Forest area	Area under non-agriculture wastes	Area under Agriculture		Barren and un-culturable lands	Permanent pastures and grazing lands	Land under misc. tree crops	Culturable wastes	Fallow land Other than current fallow	Current fallow
				Gross cropped Area	Net Sown Area						
Raina-II	22484	47	3100	30325	19246	22	4	30	35	-	

Table *11.11*.3.1: Command area(ha) of *Raina-II* block

Sl. No.	Block Name	Surface Lift	CCA	DW	CCA	STW	CCA	DTW	CCA	Total CCA
1	*RAINA-II*	23	275.00			1470	4316.00	88	2342.00	6933.00

Ground Water Resource:

Table *11.11*.4: Details of Ground Water Resource Availability and Utilization in *Raina-II* Block.
(As on 31.03.2013)

BLOCK NAME	*RAINA-II*
Total Annual Ground Water Recharge (Ham)	8214.97
Total Natural Discharges (Ham)	821.5
Annual Extractable Ground Water Recharge (Ham)	7393.47
Total Extraction	6618.49
Annual GW Allocation for Domestic and Industrial Use as on 2042	202.56
Net Ground Water Availability for future use	733.41
Stage of Ground Water Extraction (%)	89.52
Categorization	Semi Critical
In Storage	8355

Disposition of Aquifers:

The principal aquifer systems encountered in this block are alluvial formation

Two aquifers are encountered in this block.

The range of **Aquifer-I** is from 0-50 mbgl.This aquifer is fresh in nature.

The range of **Aquifer-II** varies from50-150mbgl. This aquifer is also fresh in nature.

Table 11.11.5: Details of aquifer disposition in Raina-II Block

Block	No. of Aquifers	Water bearing zone	Aquifer Thickness (m)		Discharge (lpm)	T (m^2/day)	SWL (mbgl)	Drawdown (mbgl)	S
			Aquifer-I (within 50 mbgl)	Aquifer-II (Below 50 mbgl)					
Raina-II	2	81-109	16	43	--	--	--	--	--

Table *11.11*.6: Details of Aquifer Wise Water Level Ranges & seasonal long-term water level trends.

Block	Aquifer	Pre-monsoon Trend			Post-monsoon Trend		
		WL Range (mbgl)	Rise (m/year)	Fall (m/year)	WL Range (mbgl)	Rise (m/year)	Fall (m/year)
Raina-II	I	11.16-16.02	0.1290212	1.23616281	4.88-14.57		0.774440515
	II	14.49-23.79	-	-	13.69-17.08	-	-

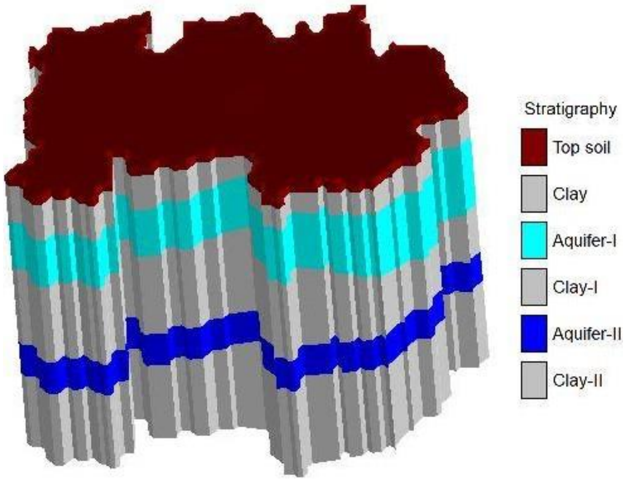


Figure*11.11*.2: 3-DimensionalAquifer disposition in *Raina-II* Block

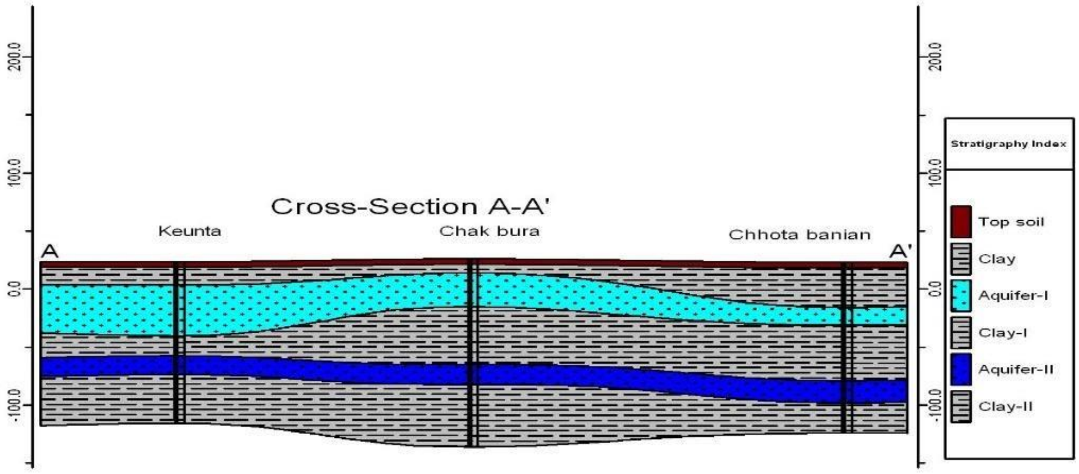


Figure*11.11*.3: 2-Dimensional Section in *Raina-II* Block

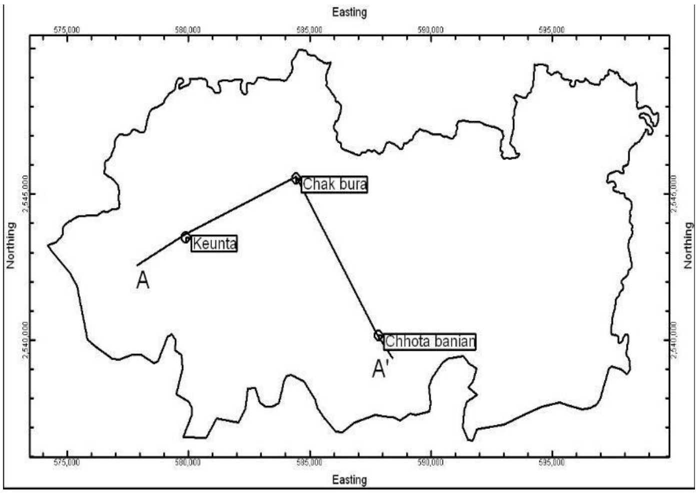


Figure*11.11*.3.1: 2-Dimensional Section profile Map in *Raina-II* Block

Ground water quality and issues:

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

Table 11.11.7 Range of chemical parametersin*Raina-II* Block

Raina-II	pH	EC	TH	Ca	Mg	Na	K	HCO3	TA	Cl	NO3	F	TDS	U
AQ-II	7.64	436.1	205	42	24.3	26.1	1.04	317.2	260	14.18	0.1	0.46	301.6	BDL
AQ-I	7.39-7.77	472-581.4	200-260	40-56	20.6-38.8	11.33-29.7	0.86-2.7	244-347.7	200-285	17.72-56.72	0.3-2.6	0.4-0.62	263-340.9	0.95-4.19

Water Demand in Various Sector:

Majority of water demand in Rayna-II block is from Agriculture and Industrial sector. Around 75% of water demand comes only from agricultural sector and the rest comes from industrial sector around 24%. The water demand from domestic and other sector is not significant. The water demand from various sector in Rayna-II block is given in Table 11.11.8

Table 11.11.8 Range of chemical parametersinRaina-II Block

Block	Water Demand in Various sector(2020) BCM *(Source:S.W.I.D)*					Total water demand (BCM)
	Domestic	Crop	Livestock's	Industrial	Power Generation	
Raina-II	0.00011052273	0.169455	0.001285851	0.0555068	0.00033856	0.22669673411

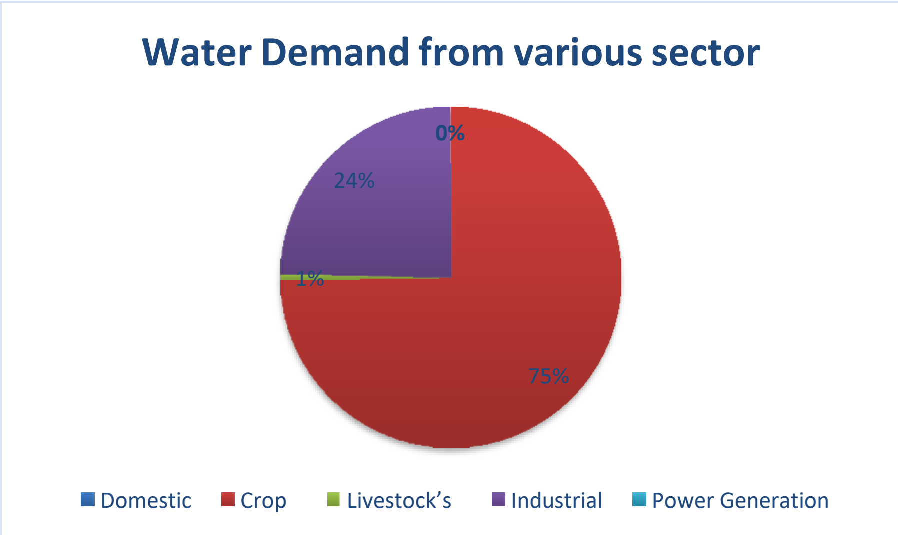


Figure*11.11*.4.: water demand from various sector in *Raina-II* Block

Aquifer Management Plan:

Ground Water Management Plan for irrigation purposes:

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 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, rainwater-harvesting may also considered. Following points should followed

- Based on the Ground Water Resource Assessment, the block is under Semi-critical condition and the Stage of Ground Water Development (SOD) is 89.5%. Hence, irrigation by exploiting the unconfined aquifer is not advisable.
- As indicated in the above-mentioned Table11.7.4, ground water available for future irrigation is 733.41ham. Surface water bodies like streams, canals, ponds should be use for irrigation purposes for the available land.
- Modern methods of irrigation like sprinkler and drip irrigation methods are encouraged. Crops with low water requirement should be preferred.
- Conjunctive use of ground water and surface water may be applied for irrigation
- Regular monitoring of Arsenic concentration in crop is also necessary.
- R & D study is necessary in arsenic affected area so we can get new solutions in future.

Management Plan for Industrial Purpose:

The block is under Semi-critical condition and is mainly agriculture based rural area. There is a less chance for growing up of small-scale industries. However, in near future, if any industry is coming up, the following steps should be considered.

- All industries proposing to draw ground water through energized means, need to obtain NOC for ground water withdrawal from the State Ground Water Authority (SGWA)
- All industries abstracting ground water > 500 m^3/day in the semi-critical assessment unit, have to implement mandatorily, artificial recharge measures, as per the norms.
- All the industries need to recharge 90 % of the quantum of ground water withdrawal.
- The Authority is to issue NOC for various uses and monitor its compliance. The NOC should be vested with the District Magistrate/ Deputy Commissioner/ State Ground Water Authority/ State Nodal Agency/ Central Ground Water Authority, as per details given in the guidelines of CGWA.

Management Intervention through Harvesting of Surface Runoff and Artificial Recharge:

It has been estimated that the utilizable surface runoff produced in the block is 55.89 MCM. This surface runoff is proposed to be utilized to recharge the depleted aquifers in the block. As per the available storage space, 16.769MCM water is required to fill the deeper aquifers in block. Therefore, 56 injection wells with roof top rain water harvesting structures are recommended in the block. The remaining surface runoff, 39.121 MCM is recommended to be utilized in storage tanks for generation of irrigation potential and thus, 448 storage tanks have been proposed. The roof top rain water harvesting structures with suitably design injection wells may be proposed to construct in the census towns areas in primary phases and subsequently may be extended to the rural areas.

Table 11.11.9: Proposed Artificial Recharge Structures, allocation and cost of construction in Rayna-II block

Block	Utilizable Surface Run Off	Allocation of Utilizable Recource(MCM)			Structures Feasible			Cost of Structures			TOTAL
		Percolation Tank	REET with RS	Injection Well	Percolation Tank	REET with RS	Injection Well	Percolation Tank	REET with RS	Injection Well	
Raina-I	55.897	27.949	11.179	16.769	56	112	56	448	448	168	1064

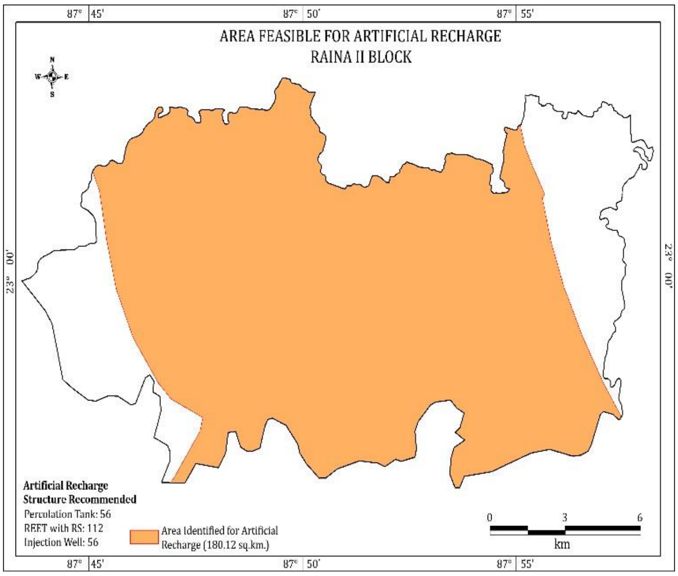


Figure11.11.5: Area Feasible for Artificial Recharge of groundwater for *Raina-II* Block

SALIENT INFORMATION

Block Name: *Asansol*

Geographical area (sq. km): 155

Mappable area (sq. km): 147

District: Paschim Bardhaman

State: West Bengal

Basin: Gondwana Basin

Sub Basin:

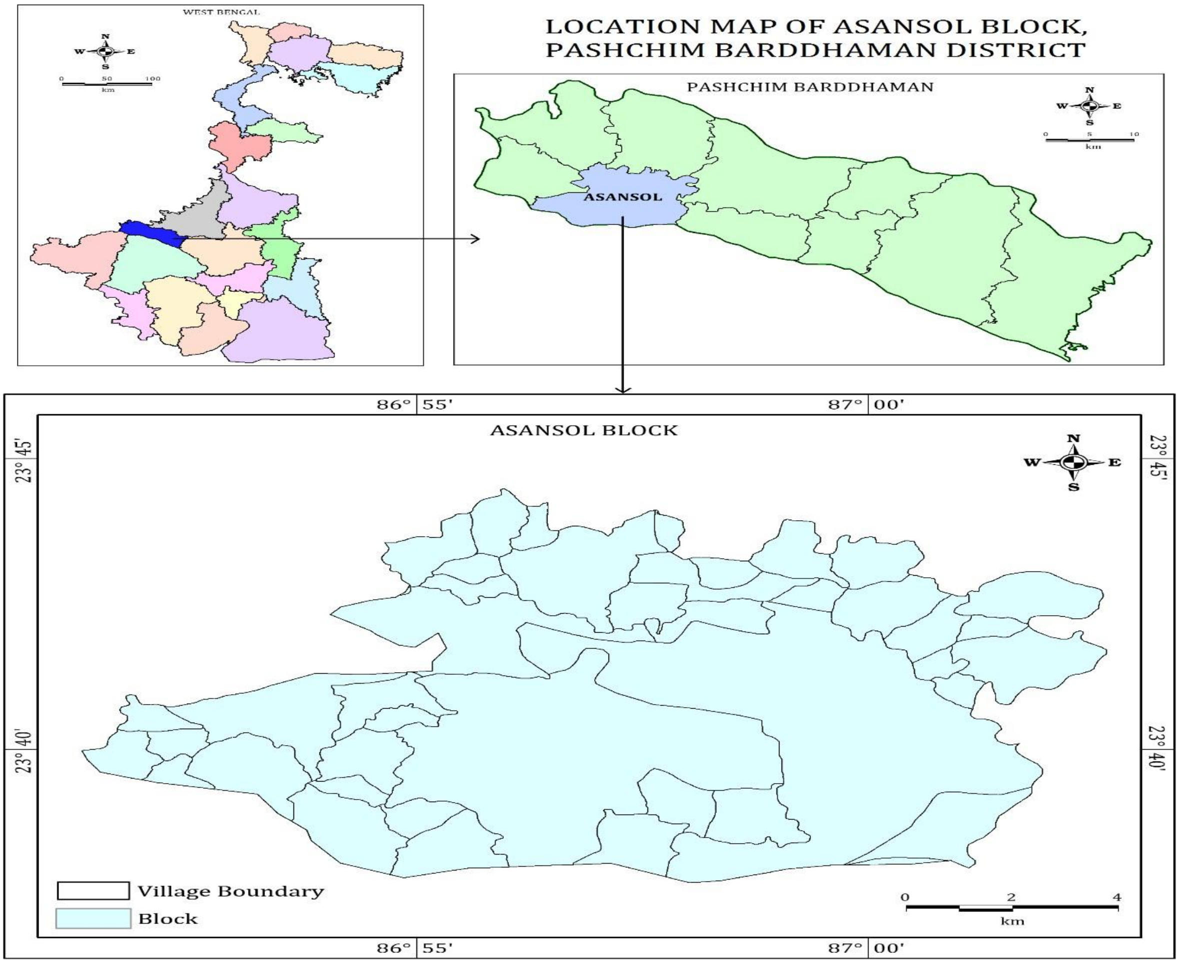


Figure *11.12*.1: Location Map of *Asansol* Block

Population (as on 2011):

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

Rural	Urban	Total	Population Density per Sqkm
--	563917	563917	4410

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 *Asansol* block.

Block Name	Normal Rainfall	Rain Fall									
		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Asansol	1381.1	1052.88	654.09	1486.79	1155.98	1694.82	1364.43	1375.7	938.3	1186.06	1266.74

Agriculture& Irrigation (area in ha):

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

Name of the block	Reporting area (Ha)	Forest area	Area under non-agriculture wastes	Area under Agriculture		Barren and un-culturable lands	Permanent pastures and grazing lands	Land under misc. tree crops	Culturable wastes	Fallow land Other than current fallow	Current fallow
				Gross cropped Area	Net Sown Area						
Asansol	-	-	-	-	-	-	-	-	-	-	-

Table *11.12*.3.1: Command area(ha) of *Asansol* block

Sl. No.	Block Name	Surface Lift	CCA	DW	CCA	STW	CCA	DTW	CCA	Total CCA
1	*ASANSOL*	-	-	-	-	-	-	-	-	-

Ground Water Resource:

Table *11.12*.4: Details of Ground Water Resource Availability and Utilization in *Asansol* .
(As on 31.03.2013)

BLOCK NAME	*ASANSOL*
Total Annual Ground Water Recharge (Ham)	1761.01
Total Natural Discharges (Ham)	88.05
Annual Extractable Ground Water Recharge (Ham)	1672.96
Total Extraction	138.5
Annual GW Allocation for Domestic and Industrial Use as on 2042	104.2
Net Ground Water Availability for future use	1522.59
Stage of Ground Water Extraction (%)	8.28
Categorization	Safe
In Storage (HaM)	---

Disposition of Aquifers:
The principal aquifer systems encountered in this block are panchet formation of Gondwana basin.

Two aquifers are encountered in this block.

The range of **Aquifer-I** is from 0-50 mbgl. This aquifer is fresh in nature.

The range of **Aquifer-II and** varies from50-150mbgl. This aquifer is also fresh in nature.

No of EW & OWs of CGWB. 9 EW 1 OW 0PZ

No of monitoring stations of CGWB. 7

No of Key well monitoring stations. 5

Table *11.12*.5: Details of aquifer disposition in *Asansol* Block

Block	No. of Aquifers	Water bearing zone	Aquifer Thickness (m)		Discharge (lpm)	T (m^2/day)	SWL (mbgl)	Drawdown (mbgl)	S
			Aquifer-I (within 50 mbgl)	Aquifer-II (Below 50 mbgl)					
Asansol	2	26-30, 43-46 67-68.5	12	-	433	63.66	15.43	18.295	-

Table *11.12*.6: Details of Aquifer Wise Water Level Ranges & seasonal long term water level trends.

Block	**Aquifer**	**Pre-monsoon Trend**			**Post-monsoon Trend**		
		WL Range (mbgl)	**Rise (m/year)**	**Fall (m/year)**	**WL Range (mbgl)**	**Rise (m/year)**	**Fall (m/year)**
Asansol	I	2.95-6.73			0.67-1.78		
	II	8.04-10.71	-	-	3.32-6.67	-	-

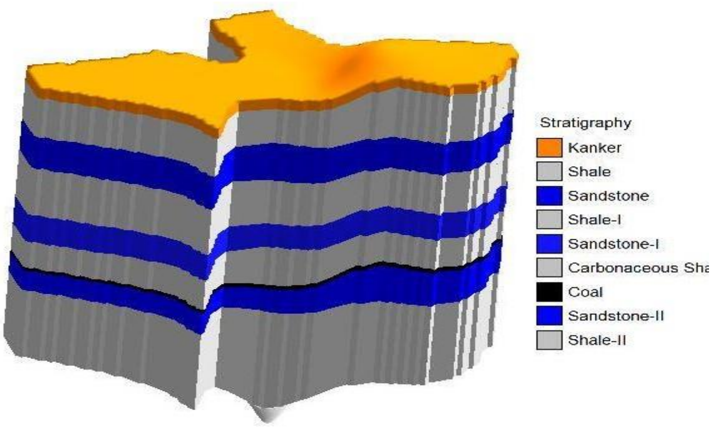


Figure*11.12*.2: 3-DimensionalAquifer disposition in *Asansol* Block

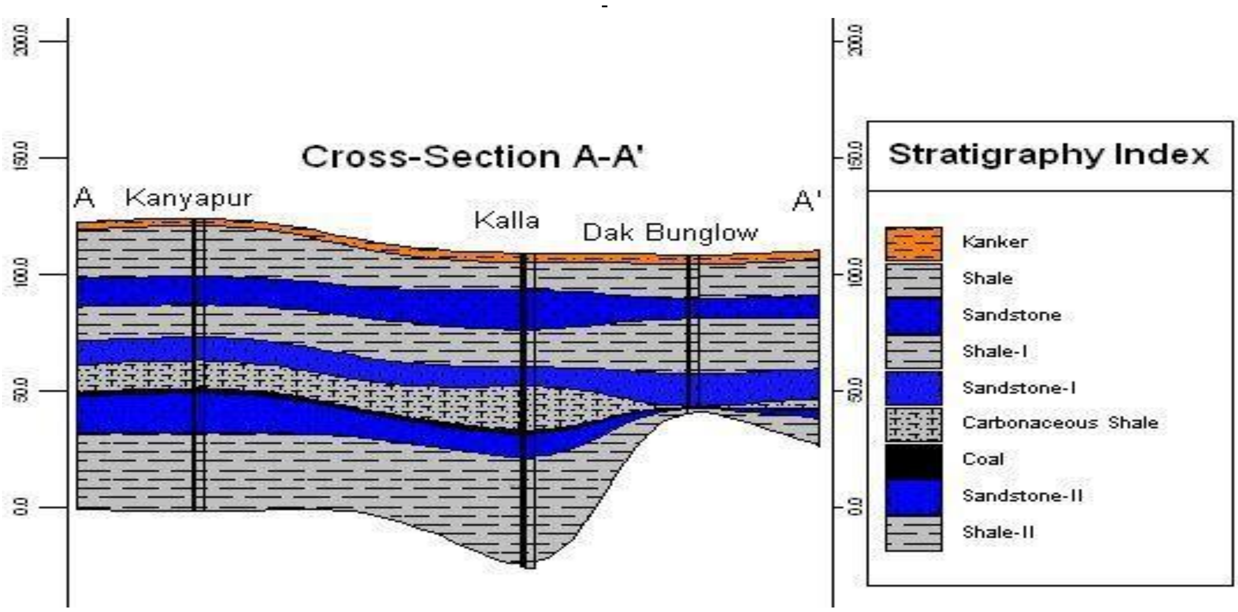


Figure*11.12*.3: 2-Dimensional Section in *Asansol* Block

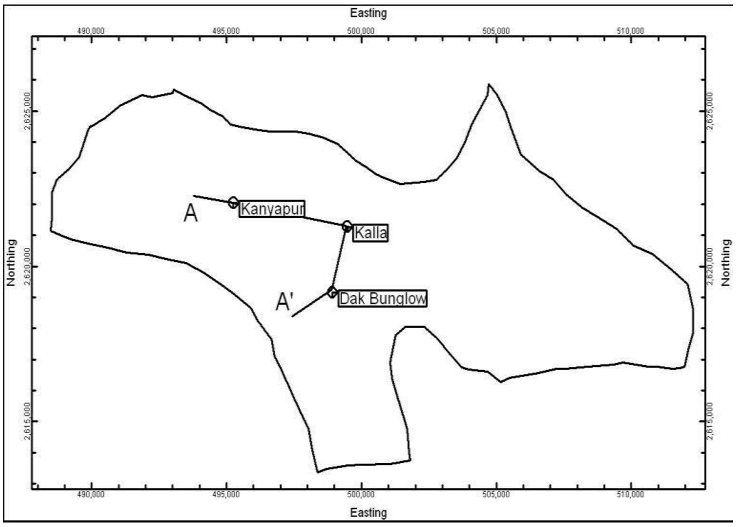


Figure*11.12*.3.1: 2-Dimensional Section profile Map in *Asansol* Block

Ground water quality and issues:

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

Table 11.12.7 Range of chemical parametersin*Asansol* Block

Asansol	pH	EC	TH	Ca	Mg	Na	K	HCO3	TA	Cl	NO3	F	TDS	U
AQ-II	7.8	759-.1-897	285-305	26-54	36.4-58.3	62.3-76.1	1.38-3.35	402.6-518.5	330-425	42.54-56.72	1.0-89.5	0.65	532.6-538.4	1.209-3.50
AQ-I	7.8	980.1-1366	160-420	22-100	25.48-41.26	75.24-294.3	6.2-14.2	378.2-701.5	310-575	74.44-159.52	0.49-0.98	0.39-1.23	477.29-897.49	3.40-6.25

Issues and problems in Asansol Area

Problems related to surface Water

- Damodar river serves as the life-line in Asansol Sub-division. Since ground water is scanty and difficult to reach, the sole source of water for catering the complete industrial, commercial and domestic demand is dependent upon Damodar River.
- Unchecked industrialization and urbanization in this belt along the banks of the Damodar river has affected its water quality. Every day large volumes of BOD is being released into the river due to the domestic and diverse industrial activities.
- Damodar river mainly receives industrial pollutants through storm water drains i.e. Nunia Nalah in Asansol, in addition to the discharge through some drains from Iron and Steel Co (Burnpur) and other polluting industrial plants.
- Due to the absence of proper sewage system and treatment plants, the domestic wastes from almost all places find their way to the Damodar River.
- Apart from mining and mineral processing units, coke oven plants and collieries which are concentrated in close proximity to the river are also discharging their effluents into it. The water in the collieries often contains large quantities of coal fines in the form of suspended solids with very high COD and TSS. The TSS and BOD in the effluents of the thermal power stations, coal washeries, paper mills and distillery is very high.
- The river stretch in the Asansol receives discharge from the thermal power stations in Santaldih and Dishergarh. The river stretch has two major steel plants namely Indian Iron and Steel Company (IISCO) and Hindustan steels. It has been established that the iron and steel industry contributes more than half of the particulate matter load.
- The effluent discharge from these diverse industries adds much to the deteriorating quality of the surface water resources of this region. The quality of river water in Damodar, along the southern boundary of ADPA is also found contaminated with chemicals and heavy metals including the conventional polluting parameters.
- In the entire stretch of the river, heavy metals such as Chromium, Lead and Cadmium have been found consistently higher than USEPA Aquatic Life Standard by about 5-40 times. It is reported that the BOD level of river water is 2-3 times higher than the Indian Standards to be maintained for using river water for drinking purposes with conventional water treatment facilities.

Problems related to groundwater

It is observed from the ground water level monitoring in April 2022 of Barddhaman district, that the average depth of water level in alluvium area lies in the depth of 9-12 m below ground level. The water level was too deep to reach, but still not lowered to an alarming level.

As the surface water sources are polluted in this area (Damodar River), many are forced to rely on ground water sources. In many areas, the ground water quality is not within the acceptable limits making even water from well unfit for drinking. A large section of the population is reported to rely on contaminated water from well (around 13 percent in Asansol) - mostly due to lack of adequate water supply. A status of distribution of households according to access to source of water is given fig11.12.7

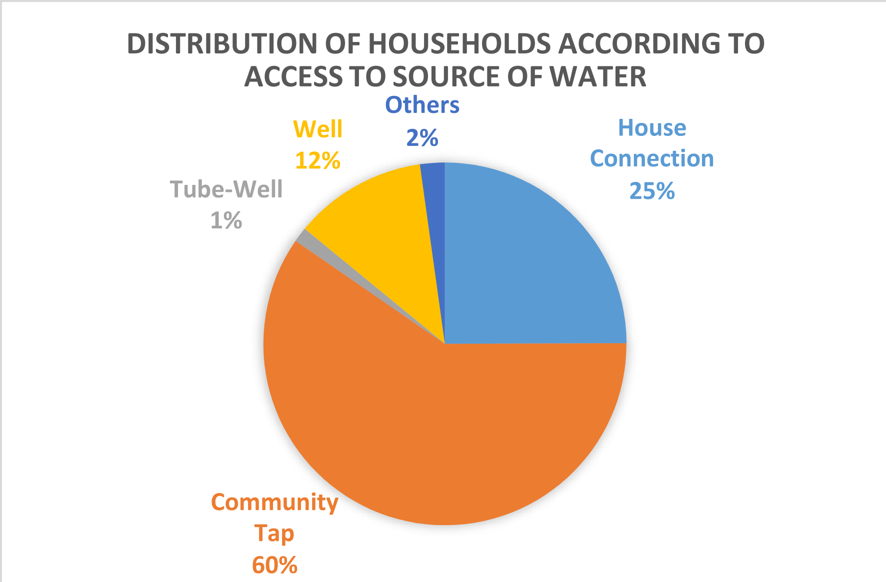


Figure11.12.4: Distribution of Households according to Access to source of water in Asansol block

Aquifer Management Plan:

Management Intervention through Harvesting of Surface Runoff and Artificial Recharge:

It has been estimated that the utilizable surface runoff produced in the block is 2.5 MCM. This surface runoff is proposed to be utilized to recharge the depleted aquifers in the block. As per the available storage space, for Artificial recharge structures like percolation tank, Check Dam, sub Surface Dyke and Dug Well recharge is given in **Table 11.8.6.**Therefore, 26 Contour Band, 10 Check Dam and 13 Sub Surface Dykes are recommended in the block. The roof top rainwater harvesting structures with suitably design may be proposed to construct in the census towns areas in primary phases and subsequently may be extended to the rural areas.

Table 11.12.8: Proposed Artificial Recharge Structures, allocation and cost of construction in Asansol block

Block	Formation	Utilizable Surface Run Off	Allocation of Utilizable Recource(MCM)					Structures Feasible					Cost of Structures					TOTAL
			Percolation Tank	Check Dam	Gabion/ Contour Bund	Sub-Surface Dyke	Dug Well Recharge	Percolation Tank	Check Dam	Gabion/ Contour Bund	Sub-Surface Dyke	Dug Well Recharge	Percolation Tank	Check Dam	Gabion/ Contour Bund	Sub-Surface Dyke	Dug Well Recharge	
Asansol	Hard Rock	2.596	1.69	0.52	0.13	0.1	0.1	3	10	26	13	3	36	15	13	13	3.3	80.30

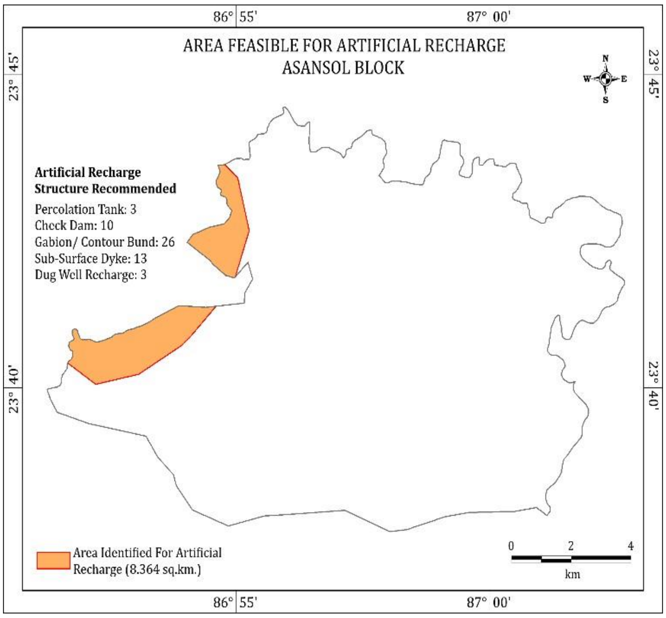


Figure11.12.5: Area Feasible for Artificial Recharge of groundwater for *Assansol*

Management Plan for Industrial/Mining Purpose:

I. All industries, whether existing/ new/ under expansion and drawing/ proposing to withdraw ground water need to obtain NOC for ground water withdrawal from the State Ground water Authority.
II. All industries abstracting ground water > 500 m^3/day should mandatorily implement artificial recharge measures as per norms and these units are required to make 90 % quantum of recharge to that of ground water withdrawal by them.
III. The competent authority should issue NOC and monitor its compliance.
IV. Regular Field monitoring is necessary for potential chemical presence in tube wells.

SALIENT INFORMATION

Block Name: *Kanksa*

Geographical area (sq. km): 283

Mappable area (sq. km): 269

District: Paschim Bardhaman

State: West Bengal

Basin: Ajay basin

Sub Basin:

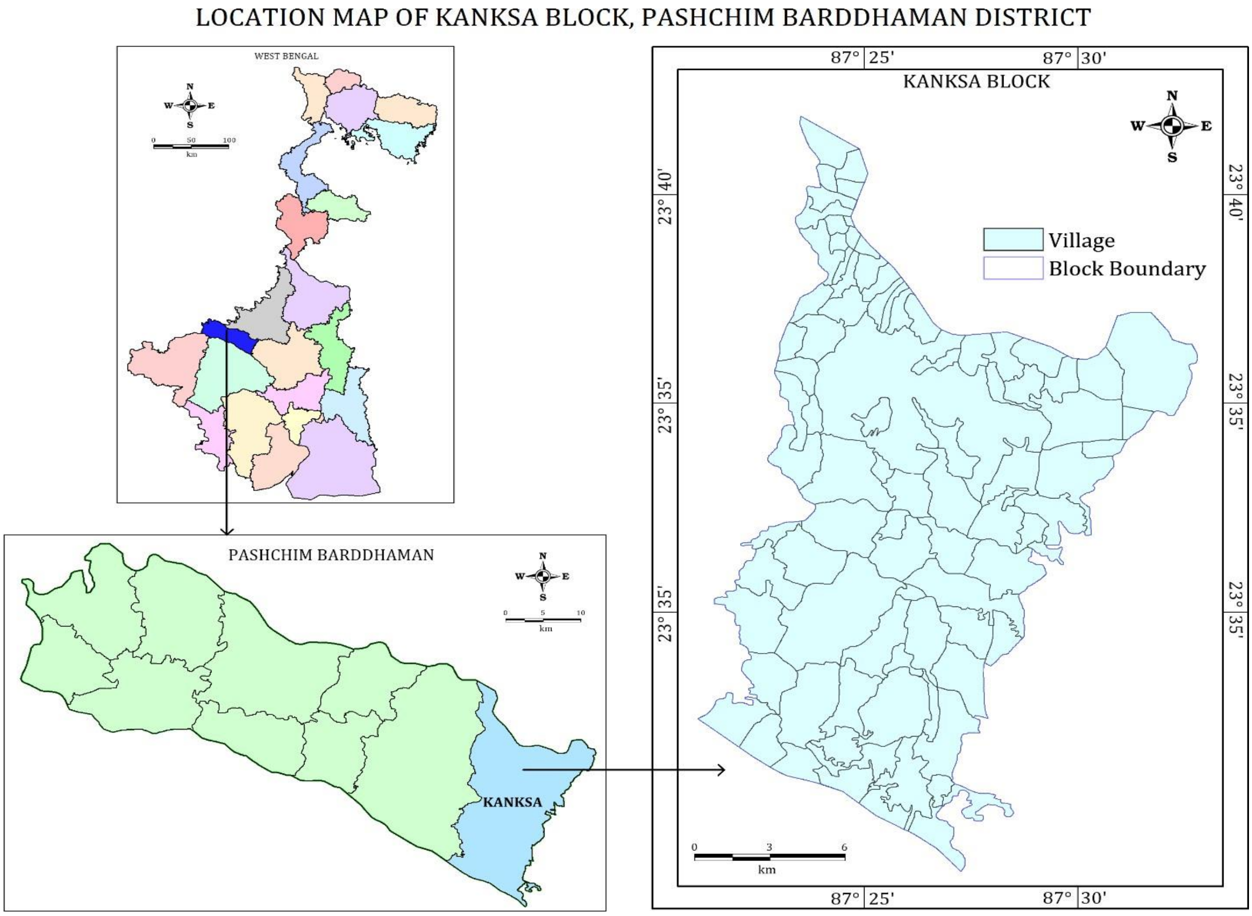


Figure *11.13*.1: Location Map of *Kanksa* Block

Population (as on 2011):

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

Rural	Urban	Total	Population Density per Sqkm
103594	74531	178125	637

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 ten years in *Kanksa* block.

Block Name	Normal Rainfall	Rain Fall									
		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Kanksa	1381.1	1052.88	654.09	1486.79	1155.98	1694.82	1364.43	1375.7	938.3	1186.06	1266.74

Agriculture& Irrigation (area in ha):

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

Name of the block	Reporting area (Ha)	Forest area	Area under non-agriculture wastes	Area under Agriculture		Barren and un-culturable lands	Permanent pastures and grazing lands	Land under misc. tree crops	Culturable wastes	Fallow land Other than current fallow	Current fallow
				Gross cropped Area	Net Sown Area						
Kanksa	27582	8249	9675	17187	9460	18	-	5	155	20	-

Table *11.13*.3.1: Command area(ha) of *Kanksa* block

Sl. No.	Block Name	Surface Lift	CCA	DW	CCA	STW	CCA	DTW	CCA	Total CCA
1	*KANKSA*	90	1689.70	1	2.00	680	2024.22	41	1640.00	5355.92

Ground Water Resource:

Table *11.13*.4: Details of Ground Water Resource Availability and Utilization in *Kanksa* Block.
(As on 31.03.2013)

BLOCK NAME	*KANKSA*
Total Annual Ground Water Recharge (Ham)	15101.36
Total Natural Discharges (Ham)	755.07
Annual Extractable Ground Water Recharge (Ham)	14346.29
Total Extraction	2758.8
Annual GW Allocation for Domestic and Industrial Use as on 2042	204.06
Net Ground Water Availability for future use	11560.76
Stage of Ground Water Extraction (%)	19.23
Categorization	Safe
In Storage (Ham)	99753

Disposition of Aquifers:
The principal aquifer systems encountered in this block are alluvial formation

Two aquifers are encountered in this block.

The range of **Aquifer-I** is from 0-50 mbgl. This aquifer is fresh in nature.

The range of **Aquifer-II and IIA** varies from50-150mbgl. This aquifer is also fresh in nature.
No of EW & OWs of CGWB. 2 EW 1 OW 7PZ

No of monitoring stations of CGWB. 3

No of Key well monitoring stations. 9

Table *11.13*.5: Details of aquifer disposition in *Kanksa* Block

Block	No. of Aquifers	Water bearing zone	Aquifer Thickness (m)		Discharge (lps)	T (m^2/day)	SWL (mbgl)	Drawdown (mbgl)	S
			Aquifer-I (within 50 mbgl)	Aquifer-II (Below 50 mbgl)					
Kanksa	2	45-63 130-136	19	30	11.25	-	5.0	-	-

Table *11.13*.6: Details of Aquifer Wise Water Level Ranges & seasonal long term water level trends.

Block	Aquifer	Pre-monsoon Trend			Post-monsoon Trend		
		WL Range (mbgl)	**Rise (m/year)**	**Fall (m/year)**	**WL Range (mbgl)**	**Rise (m/year)**	**Fall (m/year)**
Kanksa	I	3-14.14			2.68-9.26		
	II	9.47-17.71	-	-	6.47-13.43	-	-

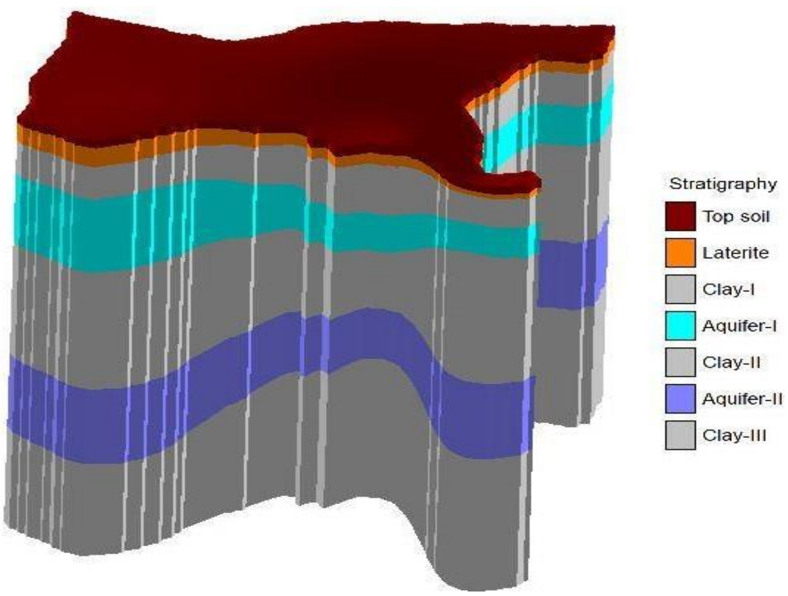


Figure*11.13*.2: 3-DimensionalAquifer disposition in *Kanksa* Block

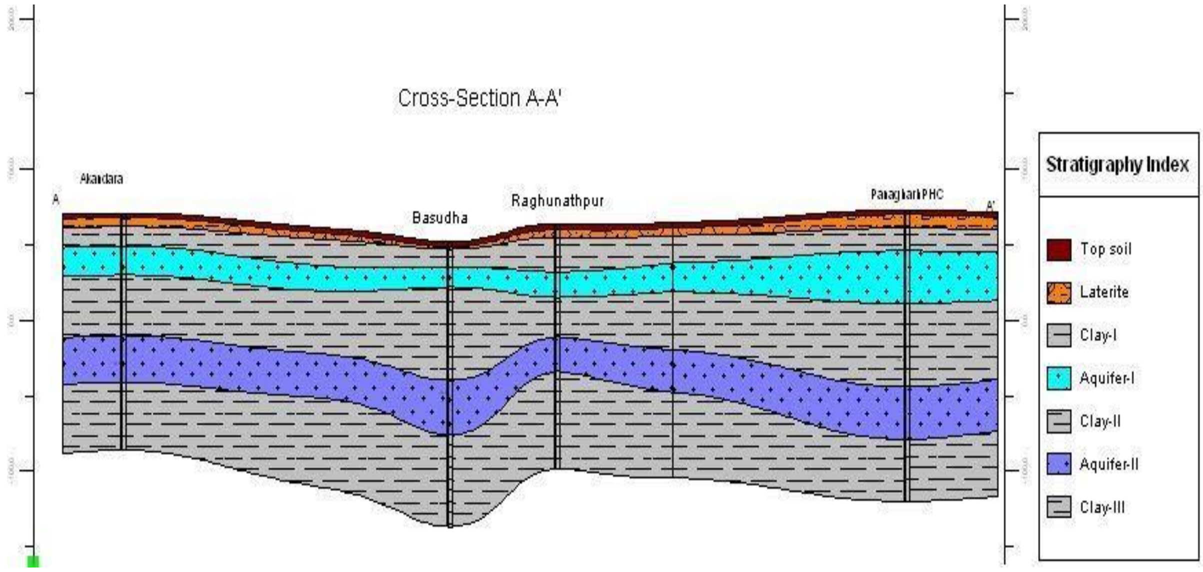


Figure*11.13*.3: 2-Dimensional Section in *Kanksa* Block

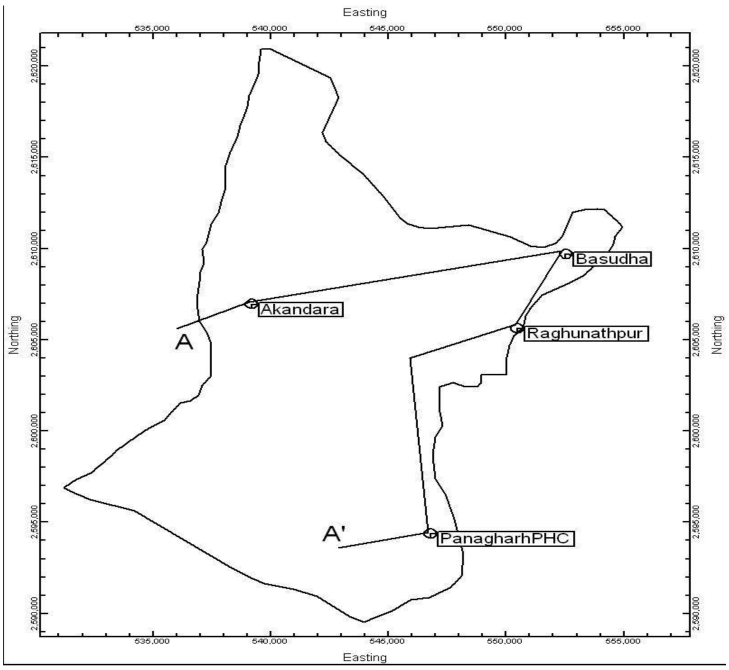


Figure*11.13*.3.1: 2-Dimensional Section profile Map in *Kanksa* Block

Ground water quality and issues:

Based on 12 Monitoring well , three exploratory wells and one observation wells, the range of chemical parameter for the block is given below.

Table 11.13.7 Range of chemical parameters in *Kanksa* Block

Kanksa	pH	EC	TH	Ca	Mg	Na	K	HCO3	TA	Cl	NO3	F	TDS	U
AQ-II	5.8-7.16	39.4-138	55-95	0 8 - 22	3.6-9.7	3.95-9.36	1.43-3.33	61-103.7	50-85	14.18-21.27	0.2-0.5	0.03-0.8	75-123.8	<0.8009
AQ-I	6.33-7.59	102.4-841.2	65-290	18-32	4.9-51	2.86-56.7	0.7-3.52	91.5-439.2	75-360	17.72-67.35	0.1-1.2	0.04-0.47	126.1-477.3	10.5

Aquifer Management Plan:

Ground Water Management Plan for irrigation purposes:

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 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, rainwater-harvesting may also considered

i. Although ground water development in the block is average with stage of ground water development at 19%, further development should done in planned manner to harness the additional available resource for site-specific sustainable development.
ii. Modern methods of irrigation like sprinkler and drip irrigation methods are encouraged.
iii. Crops with low water requirement should be preferred

Management Intervention through Harvesting of Surface Runoff and Artificial Recharge:

It has been estimated that the utilizable surface runoff produced in the block is 44.23 MCM. This surface runoff is proposed to be utilized to recharge the depleted aquifers in the block. As per the available storage space, 13.3 MCM water is required to fill the deeper aquifers in block. Therefore, 44 injection wells with roof top rain water harvesting structures are recommended in the block. The remaining surface runoff, 31.03 MCM is recommended to be utilized in storage tanks for generation of irrigation potential and thus, 44 storage tanks have been proposed. The roof top rain water harvesting structures with suitably design injection wells may be proposed to construct in the census towns areas in primary phases and subsequently may be extended to the rural areas.

Table 11.13.8: Proposed Artificial Recharge Structures, allocation and cost of construction in Kanksa block

Block	Formation	Utilizable Surface Run Off	Allocation of Utilizable Recource(MCM)			Structures Feasible			Cost of Structures			TOTAL
			Percolation Tank	REET with RS	Injection Well	Percolation Tank	REET with RS	Injection Well	Percolation Tank	REET with RS	Injection Well	
Kanksa	Alluvium	44.33	22.17	8.866	13.3	44	89	44	352	356	132	840

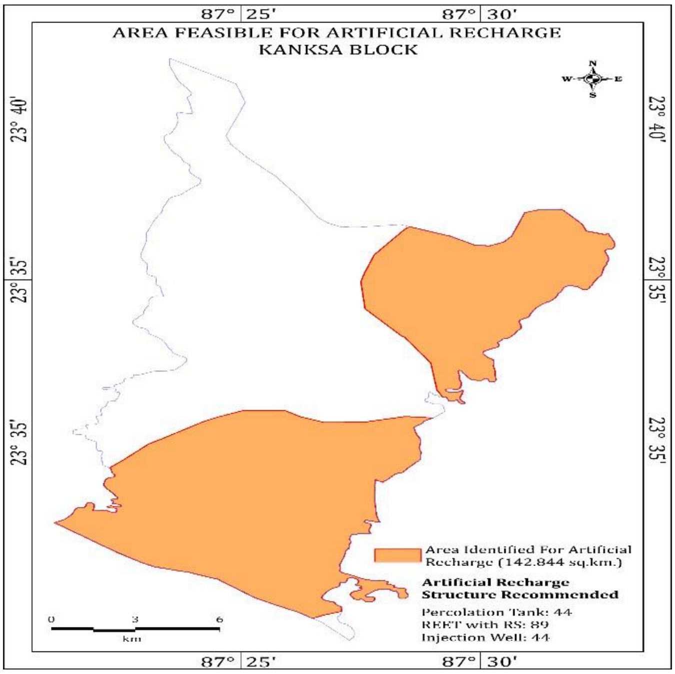


Figure11.13.4: Area Feasible for Artificial Recharge of groundwater for *Kanksa*

Ground Water Management Plan for drinking purpose:

i. As per Functional Household tap water connection (FHTC) inception in Kansa block, only 30162 households connected to tap water connection out of total 48086 households. The block has ten ground water Based, commissioned public water supply schemes by PHED. Considering an adequate normal monsoon rainfall of 1381 mm, which the block receives, practice of the rainwater conservation through roof top harvesting is highly recommended. 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.

ii. The block shows a falling trend of 0.193 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.

iii. Regular field monitoring is necessary from time to time for any potential chemical presence.

PART – III

DATA GAP ANALYSIS

DATA GAP ANALYSIS FOR AQUIFER MAPPING PROGRAMME IN PURBA & PASCHIM BARDHAMAN

The study area comprises of 13 blocks of Purba and Paschim Bardhaman districts. The present study area covers a total of 3972 sq. km. geographical area. It is bounded within the north latitudes 23°27'18" N to 24°07'44" &east longitudes of 86°47'24" E to 87°50'46" E in Survey of India toposheet no. s73M/1, 73M/2, 73M/6, 73M/7, 73M/10, 73M/11, 73M/12, 73M/15, 73M/16, 73I/13, 73I/14, 79A/4. 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.

A. Data Gap for Exploratory Wells

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 20 Exploratory wells (EW) and11 Observation wells (OW) are required in the study area.

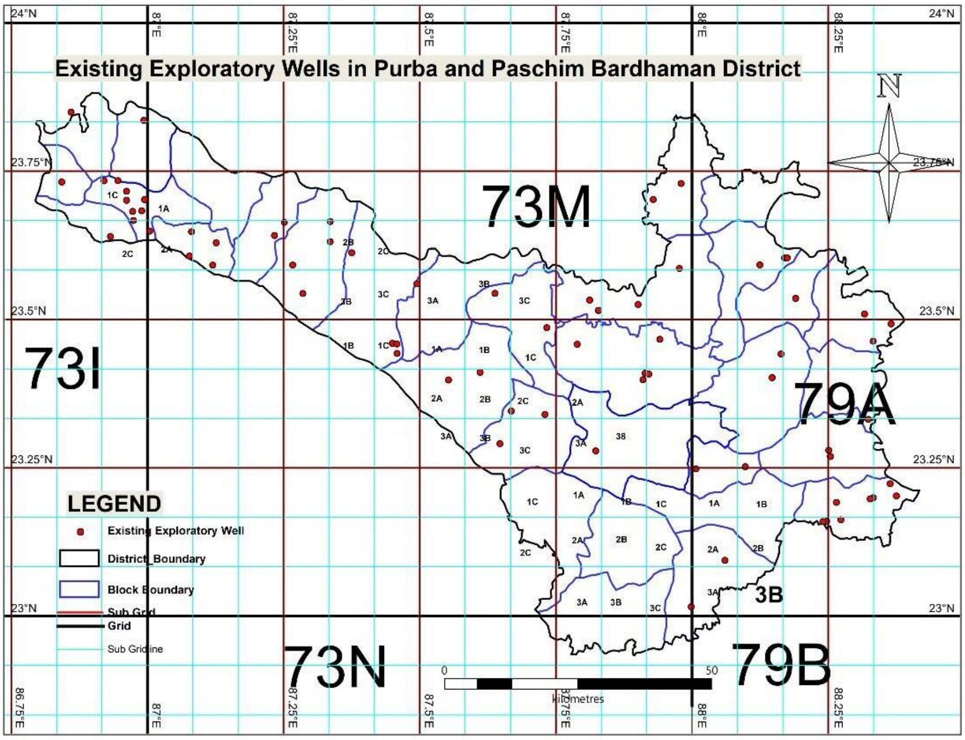


Fig 12.1: Map of existing exploratory wells in Purba and Paschim Bardhaman district.

Table 12.1: Table suggesting extra Exploratory wells and their depths for the study area

Toposheet No.	Quadrant	No. of Additional EW/OW required	Depth of Drilling (Meters)
73M/2	1A	1 EW 1 OW	200
73M/6	2B	1 EW 1 OW	200
73M/10	3A	1 EW 1 OW	200
	3C	1 EW	200, 300
73M/11	1A	1EW 1 OW	200, 300
	2B	1 EW 2 OW	300
	3A	1 EW	200
	3C	1 EW	200
73M/12	1C	1 EW	200
73M/15	3C	1 EW	200, 300
73M/16	1A	1EW 1 OW	200, 300
	1C	1 EW	300
	2B	2 EW 2OW	200
	3A	1 EW	200
	3C	1 EW	200
79A/4	1A	0 EW 1 OW	200
	1C	1 EW	200
	2B	2 EW 2 OW	200, 300
	3A	1EW	200

B. 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 43 wells tapping Aquifer- I, 38 wells tapping Aquifer-II and 10 wells tapping Aquifer-III are required for future monitoring.

Table 12.2: Table suggesting aquifer wise extra key-wells for the study area

Toposheet No.	Quadrant	No. of Additional Key Wells required Aquifer wise
73I/13	1C	Aquifer I: 0, Aquifer II: 1, Aquifer III: 0
	2C	Aquifer I: 2, Aquifer II: 1, Aquifer III: 0
73M/2	1A	Aquifer I: 1, Aquifer II: 1, Aquifer III: 0
73M/6	2B	Aquifer I: 1, Aquifer II: 1, Aquifer III: 0
	2C	Aquifer I: 1, Aquifer II: 1, Aquifer III: 1
	3B	Aquifer I: 0, Aquifer II: 1, Aquifer III: 0
	3C	Aquifer I: 2, Aquifer II: 1, Aquifer III: 0
73M/7	1B	Aquifer I: 0, Aquifer II: 1, Aquifer III: 0
	1C	Aquifer I: 2, Aquifer II: 1, Aquifer III: 1
73M/10	3A	Aquifer I: 2, Aquifer II: 1, Aquifer III: 0
	3B	Aquifer I: 0, Aquifer II: 1, Aquifer III: 1
	3C	Aquifer I: 2, Aquifer II: 1, Aquifer III: 0
73M/11	1A	Aquifer I: 2, Aquifer II: 1, Aquifer III: 0

	1B	Aquifer I: 0, Aquifer II: 1, Aquifer III: 1
	1C	Aquifer I: 2, Aquifer II: 1, Aquifer III: 0
	2A	Aquifer I: 0, Aquifer II: 0, Aquifer III: 0
	2B	Aquifer I: 0, Aquifer II: 1, Aquifer III: 1
	2C	Aquifer I: 0, Aquifer II: 1, Aquifer III: 0
	3A	Aquifer I: 0, Aquifer II: 1, Aquifer III: 0
	3B	Aquifer I: 0, Aquifer II: 1, Aquifer III: 0
	3C	Aquifer I: 2, Aquifer II: 1, Aquifer III: 0
73M/12	1C	Aquifer I: 1, Aquifer II: 1, Aquifer III: 0
	2C	Aquifer I: 0, Aquifer II: 1, Aquifer III: 0
73M/15	2A	Aquifer I: 1, Aquifer II: 1, Aquifer III: 0
	3A	Aquifer I: 1, Aquifer II: 1, Aquifer III: 0
	3B	Aquifer I: 0, Aquifer II: 1, Aquifer III: 1
	3C	Aquifer I: 1, Aquifer II: 1, Aquifer III: 0
73M/16	1A	Aquifer I: 1, Aquifer II: 1, Aquifer III: 0
	1B	Aquifer I: 0, Aquifer II: 1, Aquifer III: 0
	1C	Aquifer I: 0, Aquifer II: 1, Aquifer III: 0
	2A	Aquifer I: 0, Aquifer II: 1, Aquifer III: 0
	2B	Aquifer I: 1, Aquifer II: 1, Aquifer III: 1
	2C	Aquifer I: 0, Aquifer II: 1, Aquifer III: 0
	3A	Aquifer I: 1, Aquifer II: 1, Aquifer III: 0
	3B	Aquifer I: 0, Aquifer II: 1, Aquifer III: 0
73N/13	1A	Aquifer I: 1, Aquifer II: 1, Aquifer III: 0
	1B	Aquifer I: 0, Aquifer II: 1, Aquifer III: 0
79A/4	1A	Aquifer I: 1, Aquifer II: 1, Aquifer III: 0
	1B	Aquifer I: 0, Aquifer II: 1, Aquifer III: 0
	2A	Aquifer I: 1, Aquifer II: 1, Aquifer III: 1
	2B	Aquifer I: 2, Aquifer II: 1, Aquifer III: 1
	3A	Aquifer I: 2, Aquifer II: 1, Aquifer III: 0

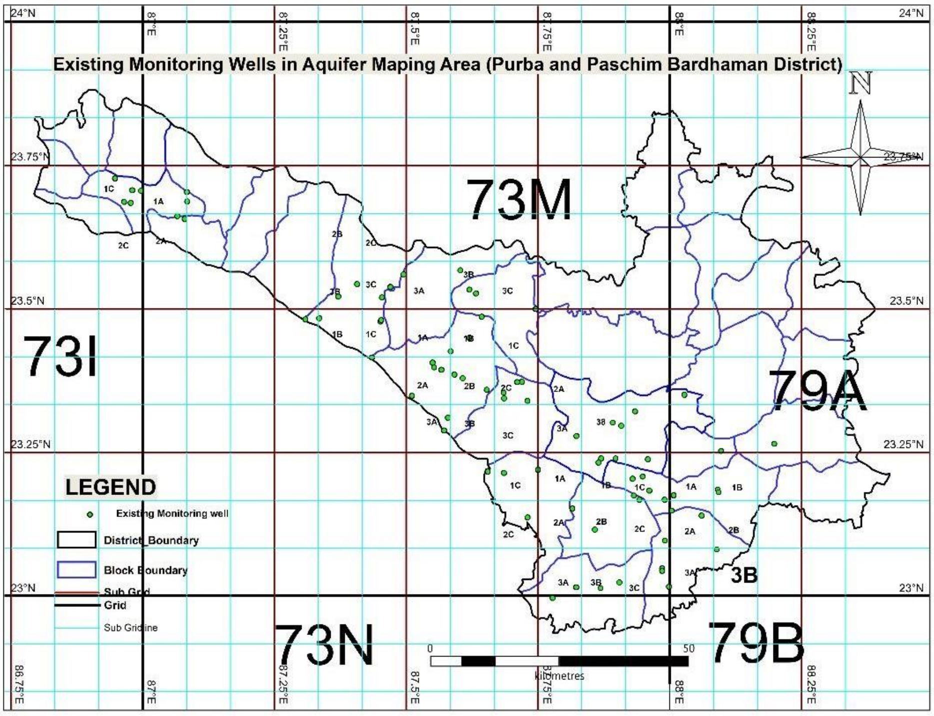


Fig 12.2: Map of existing Key Wells in the study area.

C. 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 43 wells tapping Aquifer- I, 38 wells tapping Aquifer-II and 10 wells tapping Aquifer-III are required for future monitoring.

Table 12.3: Table suggesting aquifer wise extra water quality monitoring stations for the study area

Toposheet No.	Quadrant	No. of Additional Key Wells required Aquifer wise
73I/13	1C	Aquifer I: 0, Aquifer II: 1, Aquifer III: 0
	2C	Aquifer I: 2, Aquifer II: 1, Aquifer III: 0
73M/2	1A	Aquifer I: 1, Aquifer II: 1, Aquifer III: 0
73M/6	2B	Aquifer I: 1, Aquifer II: 1, Aquifer III: 0
	2C	Aquifer I: 1, Aquifer II: 1, Aquifer III: 1
	3B	Aquifer I: 0, Aquifer II: 1, Aquifer III: 0
	3C	Aquifer I: 2, Aquifer II: 1, Aquifer III: 0
73M/7	1B	Aquifer I: 0, Aquifer II: 1, Aquifer III: 0
	1C	Aquifer I: 2, Aquifer II: 1, Aquifer III: 1
73M/10	3A	Aquifer I: 2, Aquifer II: 1, Aquifer III: 0
	3B	Aquifer I: 0, Aquifer II: 1, Aquifer III: 1
	3C	Aquifer I: 2, Aquifer II: 1, Aquifer III: 0
73M/11	1A	Aquifer I: 2, Aquifer II: 1, Aquifer III: 0
	1B	Aquifer I: 0, Aquifer II: 1, Aquifer III: 1

	1C	Aquifer I: 2, Aquifer II: 1, Aquifer III: 0
	2A	Aquifer I: 0, Aquifer II: 0, Aquifer III: 0
	2B	Aquifer I: 0, Aquifer II: 1, Aquifer III: 1
	2C	Aquifer I: 0, Aquifer II: 1, Aquifer III: 0
	3A	Aquifer I: 0, Aquifer II: 1, Aquifer III: 0
	3B	Aquifer I: 0, Aquifer II: 1, Aquifer III: 0
	3C	Aquifer I: 2, Aquifer II: 1, Aquifer III: 0
73M/12	1C	Aquifer I: 1, Aquifer II: 1, Aquifer III: 0
	2C	Aquifer I: 0, Aquifer II: 1, Aquifer III: 0
73M/15	2A	Aquifer I: 1, Aquifer II: 1, Aquifer III: 0
	3A	Aquifer I: 1, Aquifer II: 1, Aquifer III: 0
	3B	Aquifer I: 0, Aquifer II: 1, Aquifer III: 1
	3C	Aquifer I: 1, Aquifer II: 1, Aquifer III: 0
73M/16	1A	Aquifer I: 1, Aquifer II: 1, Aquifer III: 0
	1B	Aquifer I: 0, Aquifer II: 1, Aquifer III: 0
	1C	Aquifer I: 0, Aquifer II: 1, Aquifer III: 0
	2A	Aquifer I: 0, Aquifer II: 1, Aquifer III: 0
	2B	Aquifer I: 1, Aquifer II: 1, Aquifer III: 1
	2C	Aquifer I: 0, Aquifer II: 1, Aquifer III: 0
	3A	Aquifer I: 1, Aquifer II: 1, Aquifer III: 0
	3B	Aquifer I: 0, Aquifer II: 1, Aquifer III: 0
73N/13	1A	Aquifer I: 1, Aquifer II: 1, Aquifer III: 0
	1B	Aquifer I: 0, Aquifer II: 1, Aquifer III: 0
79A/4	1A	Aquifer I: 1, Aquifer II: 1, Aquifer III: 0
	1B	Aquifer I: 0, Aquifer II: 1, Aquifer III: 0
	2A	Aquifer I: 1, Aquifer II: 1, Aquifer III: 1
	2B	Aquifer I: 2, Aquifer II: 1, Aquifer III: 1
	3A	Aquifer I: 2, Aquifer II: 1, Aquifer III: 0

D. Data Gap for Geophysical studies (VES)

CGWB has not carried out any VES in the study area. A total of 126 no. of VES is suggested to carry out in the study area. The details of numbers of VES required is explained quadrant wise in the following table.

Table 12.4: Table suggesting no. of VES stations for the study area

Toposheet No.	Quadrant	No. of Additional VES required Quadrant wise
73I/13	1C	3
	2C	3
73M/2	1A	3
73M/6	2B	3
	2C	3
	3B	3
	3C	3
73M/7	1B	3
	1C	3

73M/10	3A	3
	3B	3
	3C	3
73M/11	1A	3
	1B	3
	1C	3
	2A	3
	2B	3
	2C	3
	3A	3
	3B	3
	3C	3
73M/12	1C	3
	2C	3
73M/15	2A	3
	3A	3
	3B	3
	3C	3
73M/16	1A	3
	1B	3
	1C	3
	2A	3
	2B	3
	2C	3
	3A	3
	3B	3
73N/13	1A	3
	1B	3
79A/4	1A	3
	1B	3
	2A	3
	2B	3
	3A	3

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APENDIX-I

Key Wells Used for NAQUIM Studies in parts of Purba and Paschim Bardhaman district.

Sl.No.	LOCATION	block	TYPE	MP	JAN WL	APR WL	LAT	LONG
1	PANCHRA	jamalpur	DTW	0.59	8.64	13.59	23.114538	88.029515
2	Masagram	jamalpur	CTW	0.24	8.07	10.8	23.120855	88.028428
3	Dhuluk	jamalpur	CTW	0.28	7.32	11.46	23.087945	88.04568
4	Kalapahar	jamalpur	CTW	0.33	7.94	12.31	23.055392	88.035498
5	Kalapahar	jamalpur	Dug Well	0.87	2.55	1.65	23.055392	88.035498
6	Dhap dhara	jamalpur	DTW	0.58	5.48	12.66	23.009477	87.972907
7	Sonagaria	jamalpur	CTW	0.25	7.28	11.19	23.001952	87.968987
8	Basantpur	jamalpur	Mark-II	0.66	6.64	10.19	23.059738	88.014535
9	Hanumandanga	jamalpur	CTW	0.31	5.26	9.7	23.036687	88.01788
10	Amarpur	jamalpur	DTW	0.25	8.66	14.52	22.978007	87.97447
11	Abujhati	jamalpur	DTW	0.4	10.7	15.97	23.067177	88.102693
12	Abujhati	jamalpur	CTW	0.33	10.88	----	23.066325	88.101637
13	Sriram Rajpur	memari-I	CTW	0.23	12.77	13.79	23.19868	88.050802
14	Rasulpur	memari-I	DTW	0.12	12.33	13.83	23.193118	88.046807
15	Shankarpur	memari-I	Mark-II	0.56	17.32	17.98	23.209932	88.132317
16	Magra	memari-I	CTW	0.24	18.24	18.96	23.217568	88.134317
17	Gobindpur	memari-I	DTW	1.02	18.19	22.72	23.202412	88.182993
18	Ram debipur	memari-I	CTW	0.16	16.49	18.4	23.175564	88.173101
19	Kantapur	memari-I	SUb-TW	0.34	14.63	16.85	23.119037	88.13702
20	Shimla	memari-I	CTW	0.24	14.32	6.15	23.1445	88.124865
21	Township*	bardhamn	DTW	0.62	5.78	7.38	23.220867	87.899504
22	Machkhanda	Rayna-i	CTW	0.38	5.77	-0.38	23.191627	87.84994
23	Sandeshghati	Rayna-i	Mark-II	0.68	6.98	14.69	23.135765	87.871722
24	Kulia	Rayna-i	DTW	0.58	6.39	14.25	23.135447	87.889635
25	Balla	Rayna-i	CTW	0.31	5.49	11.74	23.140925	87.899842
26	Balla	Rayna-i	Mark-II	0.46	---	---	23.140925	87.899842
27	Boro-balaram	Rayna-i	CTW	0.27	4.71	10.49	23.130492	87.95675
28	Meral	Rayna-i	CTW	0.24	6.18	12.53	23.116007	87.915677
29	Shayamsundar	Rayna-i	CTW	0.26	7.32	15.11	23.096928	87.87297
30	Rayna	Rayna-i	CTW	0.32	7.88	14.15	23.06917	87.894945
31	Adampur	Rayna-ii	CTW	0.18	5.06	11.69	23.049092	87.948187
32	Shankari	kahandaghosh	DTW	0.18	11.32	14.62	23.192792	87.785535
33	Shankari	kahandaghosh	CTW	0.26	6.95	10.81	23.192792	87.785535

34	Khejurhati	kahandaghosh	CTW	0.25	5.9	8.62	23.219263	87.726863
35	Berugram	kahandaghosh	CTW	0.12	7.07	15.43	23.1746	87.692922
36	Saranga	kahandaghosh	CTW	0.23	2.34	6.54	23.147933	87.76138
37	Narugram	kahandaghosh	Mark-II	0.51	6.02	15.46	23.146267	87.837538
38	Balabati	kahandaghosh	CTW	0.14	8.67	17.44	23.09574	87.76719
39	Gopalbere	kahandaghosh	CTW	0.15	11.57	19.65	23.051008	87.751322
40	Chakchandanpur	Rayna-ii	Sub-Tw	0.2	14.57	18.97	23.048525	87.80931
41	Chakchandanpu	Rayna-ii	Mark-II	0.48	14.17	21.39	23.04814	87.809792
42	Nandanpur	Rayna-ii	CTW	0.23	10.38	14.34	23.011613	87.767057
43	Belar	Rayna-ii	CTW	0.38	10.8	13.68	22.965722	87.805478
44	Sherpur	Rayna-ii	DTW	0.61	11.31	14.49	22.972323	87.811912
45	Mohanpur	Rayna-ii	Mark-II	0.54	14.57	-0.54	22.964213	87.857838
46	Chotobynan	Rayna-ii	DTW	0	17.08	23.76	22.967267	87.856867
47	Kumarhati	Rayna-ii	CTW	0.16	12.15	11.16	22.981172	87.883258
48	Gotan	Rayna-ii	CTW	0.17	7.77	12.25	22.968182	87.918613
49	Bansa	Rayna-ii	CTW	0.16	10.84	16.02	23.042202	87.871163
50	Alampur	Bardhaman	CTW	0.42	11.31	12.97	23.321763	87.80987
51	Mahinagar	Bardhaman	Mark-II	0.53	11.95	13.34	23.355369	87.79768
52	Karanji	Ausgram-I	CTW	0.23	8.92	10.18	23.377158	87.766887
53	Karanji	Ausgram-I	DTW	0.93	9.37	10.15	23.376765	87.76905
54	Alutia	Ausgram-I	Mark-II	0.43	8.24	12.88	23.49569	87.721053
55	Gonna	Ausgram-I	CTW	0.21	5.77	-0.21	23.456012	87.658472
56	Laxmiganj	Ausgram-I	CTW	0.31	8.98	13.54	23.480702	87.717243
57	Gangarampur	Ausgram-I	CTW	0.29	5.2	12.38	23.557832	87.734151
58	Kantatikudi	Ausgram-I	Mark-II	0.45	4.94	11.99	23.58628	87.694817
59	Kantatikudi	Ausgram-I	CTW	0.17	3.7	-----	23.58628	87.694817
60	Bijayapur	Ausgram-I	CTW		3.23	12.55	23.554318	87.687723
61	Billagram	Ausgram-I	CTW	0.33	11.47	12.95	23.400275	87.74543
62	Sapen	Bardhaman	Mark-II	0.66	12.63	14.11	23.290095	87.940292
63	Hatgobindpur	Bardhaman	CTW	0.32	13.04	10.96	23.257098	87.981987
64	Debgram	Bardhaman	CTW	0.15	17.84	17.41	23.31425	87.979067
65	Bakalsa	Bardhaman	CTW	0.13	21.57	22.05	23.318832	88.035957
66	Gangpur	Bardhaman	CTW	0.14	5.48	6.66	23.22038	87.905382
67	Belkash	Bardhaman	CTW	0.11	6.26	6.09	23.262605	87.793153
68	Syamsunder	Galsi-II	CTW	0.16	5.64	6.04	23.273993	87.765373
69	Dalimgarya	Galsi-II	Sub-TW	0.26	5.82	8.12	23.302818	87.71522
70	Itaru	Galsi-II	DTW	0.11	5.69	12.55	23.279162	87.703282
71	Itaru	Galsi-II	CTW	0.16	4.16	7.31	23.27776	87.70388

72	Dighirpara	Galsi-II	Sub-Tw	0.58	5.73	8.3	23.286993	87.629533
73	Serrorai	Galsi-II	Mark-II	0.45	6.34	8.18	23.313222	87.615982
74	Bondutia	Galsi-I	CTW	0.38	6.2	----	23.31664	87.658717
75	Garibati	Galsi-I	CTW	0.12	5.67	6.02	23.346592	87.557925
76	Pandudaha	Galsi-I	CTW	0.37	4.19	3.98	23.366168	87.52444
77	Udayapally	bardhaman	CTW	0.43	8.27	8.25	23.238142	87.815878
78	Sankuri	Galsi-I	Sub-TW	0.18	8.6	7.68	23.399703	87.45741
79	Nigha	Assansol	Dug	0.73	2.14	2.95	23.6744	87.036172
80	Kankhaya	Assansol	Mark-II	0.53	7.23	10.71	23.703157	87.019712
81	Pariharpur	Assansol	Dug	0.67	4.35	6.73	23.707907	87.039778
82	Assansol	Assansol	Dug	1.78	2.4	1.5	23.713845	86.949182
83	Sitarampur	Assansol	Mark-II	0.43	3.75	8.04	23.707985	86.909115
84	Indraprastha	Assansol	Dug	0.6	2.33	2.18	23.672207	86.966478
85	Akandara	kanksa	Mark-II	0.48	6.47	9.47	23.672207	86.966478
86	Kataberia	kanksa	Dug	0.45	2.68	3	23.613248	87.37367
87	Jhatgoria	kanksa	Sub-TW	0.16	13.21	14.14	23.617807	87.391598
88	Jamadaha	kanksa	Sub-Tw	0.26	10.03	5.14	23.648088	87.406162
89	Khalabati	kanksa	CTW	0.31	9.18	8.25	23.609478	87.443935
90	Rakshitpur	kanksa	Sub-TW	0.18	5.62	6.19	23.56292	87.429948
91	Debsala	kanksa	DTW	0.45	8.91	9.67	23.510257	87.491997
92	Sonai	kanksa	Dug	0.8	4.01	3.7	23.47091	87.484362
93	Kanksa	kanksa	Mark-II	0.43	13.86	17.71	23.45919	87.449747
94	Rajbandh	kanksa	CTW	0.12	9.26	10.95	23.474623	87.393632
95	Mankar	Galsi-II	Sub-TW	0	11.82	15.78	23.425688	87.555648
96	Mankar	Galsi-II	Mark-II	0.45	14.21	15.58	23.43305	87.550553
97	Gopalmath	Ausgram-II	Dug	0.7	2.97	3.09	23.46334	87.536438
98	Gopalmath	Ausgram-II	Sub-tw	0.52	6.89	9.71	23.46334	87.536438
99	Bhatkunda	Ausgram-II	Dug	0.6	3.04	3.33	23.505892	87.557133
100	Rangakhila	Ausgram-II	Mark-II	0.51	6.65	8.17	23.52876	87.522727
101	Amarpur	Ausgram-II	Dug	0.55	2.71	3.47	23.563927	87.520767
102	Babuisol	Ausgram-II	DTW	0.46	10.2	17.86	23.489518	87.56926
103	Babuisol	Ausgram-II	Dug	0.2	1.97	6.17	23.489693	87.570262
104	Bhalki	Ausgram-II	DTW	0.49	7.65	12.67	23.456028	87.625525
105	Malidapara	Ausgram-II	CTW	0.16	8.57	11.48	23.420878	87.681817

APENDIX-II

Location wise Chemical Parameters

Sl. no.	Village	pH	EC	TH	Ca	Mg	Na	K	HCO3	TA	Cl	NO3	F	TDS	U
1	PANCHRA	7.47	385.3	165	40	15.8	35.2	1.19	262.3	215	31.905	7.7	0.66	292.4	0.9378
2	Masagram	7.62	322.5	140	36	12.1	30.5	1.54	225.7	185	21.27	7.8	0.48	247.4	0.0663
3	Dhuluk	7.64	350.2	165	42	14.6	20	0.81	207.4	170	31.905	8.0	0.48	244.3	0.2664
4	Kalapahar	7.48	237.8	95	24	8.5	20.64	1.68	158.6	130	14.18	7.7	0.22	173.6	0.0774
5	Kalapahar	7.28	707.2	195	54	14.6	68.58	32.76	274.5	225	77.99	7.5	0.48	433.8	0.3203
6	Dhapdhara	7.63	636.9	240	36	36.4	64.5	2.43	427	350	17.725	8.4	0.4	426.3	1.8822
7	Sonagaria	7.76	577.1	225	18	43.7	60.2	1.72	408.7	335	17.725	8.0	0.6	399.2	3.5967
8	Basantpur	7.62	267.8	125	54	-2.4	26.3	1.08	183	150	21.27	4.8	0.63	217.3	0.3326
9	Hanumandanga	7.79	508.4	215	40	27.9	27.35	0.92	250.1	205	31.905	8.0	0.61	289.3	1.7513
10	Amarpur	7.8	453.8	225	40	30.3	34.5	1.16	341.6	280	24.815	7.5	0.44	347.2	1.6010
11	Abujhati	7.8	527.9	225	52	23.1	32.24	2.48	311.1	255	28.36	7.7	0.38	336.0	BDL
12	Abujhati	7.77	481.1	225	38	31.6	40.2	1.12	335.5	275	24.815	7.8	0.42	348.6	1.7844
13	SriramRajpur	7.81	254.6	100	32	4.9	30.5	1.46	183	150	14.18	7.7	0.39	202.7	0.2315
14	Rasulpur	7.65	266.7	45	36	16.0	18.95	2.02	183	150	14.18	7.6	0.3	206.7	0.1110
15	Shankarpur	7.76	426.3	285	40	44.9	24.32	1.14	274.5	225	42.54	7.9	0.44	349.1	1.1408
16	Magra	7.78	452.5	200	44	21.8	36.5	1.67	292.8	240	28.36	7.9	0.42	319.3	1.9023
17	Gobindpur	7.8	507.1	200	36	26.7	39.6	2.51	317.2	260	24.815	7.8	0.3	331.2	0.6888
18	Ram debipur	7.82	473.4	190	52	14.6	35.1	1.87	292.8	240	24.815	7.4	0.4	314.8	2.5389
19	Kantapur	7.9	331.1	155	16	27.9	33.9	2.1	237.9	195	21.27	7.7	0.2	254.2	0.8322
20	Shimla	7.23	352.6	140	44	7.3	16.31	1.35	146.4	120	42.54	0.0	0.18	201.0	BDL
21	Machkhanda	7.68	415.6	210	32	31.6	31.14	1.24	256.2	210	17.725	0.5	0.39	290.4	1.4985
22	Sandeshghati	7.76	604.3	265	30	46.1	39.2	1.41	414.8	340	24.815	0.1	0.62	395.3	2.8924
23	Balla	7.64	584.7	240	28	41.3	26.9	1.35	372.1	305	17.725	0.6	0.64	343.5	3.0191
24	Boro-balaram	7.66	397.3	170	26	25.5	30.33	1.4	268.4	220	21.27	0.4	0.34	269.0	0.8264

25	Meral	7.72	542.2	245	28	42.5	34.32	1.21	366	300	14.18	0.1	0.58	344.1	4.1368
26	Shayamsundar	7.76	779.6	295	32	52.2	40.5	1.05	366	300	85.08	0.4	0.52	435.0	5.9164
27	Rayna	7.83	574.3	250	44	34.0	28.91	0.87	353.8	290	21.27	0.1	0.6	345.6	2.4385
28	Adampur	7.77	581.4	230	40	31.6	29.6	2.7	323.3	265	38.995	0.4	0.44	340.9	4.1999
29	Shankari	7.58	491.6	230	36	34.0	24.06	1.14	347.7	285	14.18	6.2	0.56	328.3	4.2255
30	Khejurhati	7.64	491.4	210	52	19.4	27.24	11.21	268.4	220	38.995	0.2	0.47	313.3	1.4105
31	Berugram	7.5	996.6	390	56	60.0	24	2.62	335.5	275	138.255	10.0	0.4	496.0	0.8316
32	Saranga	7.71	510.9	230	40	31.6	42.9	1.44	366	300	24.815	15.8	0.48	380.2	1.3363
33	Narugram	7.7	543.9	260	46	35.2	15.61	0.8	317.2	260	35.45	0.1	0.61	327.2	2.4438
34	Balabati	7.67	667.3	290	46	42.5	19.56	1.11	317.2	260	53.175	0.1	0.41	356.3	4.3497
35	Gopalbere	7.74	444.6	200	50	18.2	30.1	0.83	298.9	245	21.27	5.3	0.75	308.8	1.7898
36	Chakchandanpur	7.76	576.9	230	50	25.5	20.62	1.58	286.7	235	35.45	1.9	0.6	310.6	0.9511
37	Nandanpur	7.75	487.6	260	40	38.8	16.76	1.38	347.7	285	24.815	1.7	0.62	336.2	3.8256
38	Belar	7.67	506.3	235	40	32.8	23.93	2.15	323.3	265	21.27	0.3	0.57	318.2	2.8726
39	Chotobynan	7.64	436.1	205	42	24.3	26.1	1.04	317.2	260	14.18	0.1	0.46	301.6	BDL
40	Kumarhati	7.64	474	200	46	20.6	29.7	1.67	292.8	240	17.725	0.3	0.6	295.2	1.1950
41	Gotan	7.39	521.4	230	46	27.9	11.33	0.86	244	200	24.815	2.6	0.62	263.0	2.5782
42	Bansa	7.66	472	240	56	24.3	17.37	1.19	244	200	56.72	2.5	0.4	307.2	1.5388
43	Alampur	7.53	544	230	40	31.6	15.11	1.12	311.1	255	17.725	2.7	0.49	298.5	1.7187
44	Mahinagar	7.36	443.5	260	48	34.0	17.35	0.75	298.9	245	35.45	1.6	0.43	319.9	2.7483
45	Karanji	7.2	196.9	170	48	12.1	22.4	1.46	201.3	165	46.085	0.3	0.23	253.4	0.4912
46	Alutia	7.18	416.9	190	28	29.1	13.37	1.17	164.7	135	53.6	2.3	0.21	228.3	BDL
47	Gonna	6.88	179.7	80	28	2.4	15.9	1.84	98	160	31.9	0.5	0.25	140.6	0.1688
48	Laxmiganj	7.62	648.9	70	18	6.1	28.82	1.04	97.6	80	35.45	0.6	0.12	149.6	BDL
49	Gangarampur	7.58	643.4	240	40	34.0	31.92	1.14	347.7	285	28.36	1.1	0.46	349.1	2.3068
50	Kantatikudi	7.49	354.4	155	40	13.3	28.4	1.41	244	200	21.27	0.6	0.5	254.4	0.4170
51	Bijayapur	7.72	603.2	235	30	38.8	29.53	3.24	372.1	305	17.725	0.1	0.36	346.7	0.6303
52	Billagram	7.65	427.3	200	42	23.1	19.5	1.16	298.9	245	14.18	1.0	0.57	283.8	1.3692
53	Sapen	7.54	514.9	230	38	32.8	21.93	1.25	317.2	260	28.36	2.1	0.42	318.3	2.5573

54	Hatgobindpur	7.55	491.2	210	44	24.3	38.9	1.59	292.8	240	49.63	1.6	0.29	338.8	2.4260
55	Debgram	7.58	490.1	230	40	31.6	19.79	1.08	317.2	260	24.815	0.1	0.44	311.3	3.3990
56	Bakalsa	7.77	492.5	215	46	24.3	38.2	1.12	317.2	260	38.995	2.0	0.51	344.6	0.7770
57	Gangpur	7.47	224	95	30	4.9	28.1	2.09	140.3	115	24.815	0.4	0.62	176.5	0.3794
58	Belkash	7.56	251.5	120	30	10.9	24.6	1.19	189.1	155	24.815	0.2	0.53	207.6	0.2123
59	Syamsunder	7.51	466.9	205	30	31.6	35.1	2.14	268.4	220	42.54	0.5	0.36	305.9	1.1790
60	Dalimgarya	7.4	360.8	170	38	18.2	11.02	0.75	189.1	155	28.36	0.2	0.26	212.1	0.6664
61	Itaru	7.25	179.2	115	40	3.6	13.54	1.02	122	100	17.725	2.5	0.28	169.6	BDL
62	Dighirpara	7.59	440.5	220	46	25.5	15.13	1.29	280.6	230	35.45	1.0	0.42	296.0	1.5646
63	Serrorai	7.72	556.3	255	52	30.3	16.07	0.92	305	250	31.905	0.5	0.58	318.4	0.3683
64	Bondutia	7.71	583.2	210	52	19.4	34.5	0.99	292.8	240	35.45	1.9	0.52	323.4	3.4799
65	Garibati	7.66	1010	265	64	25.5	92.4	1.14	384.3	315	120.53	3.2	0.47	541.7	6.5535
66	Pandudaha	7.6	391.7	225	44	27.9	11.24	0.94	286.7	235	21.27	2.3	0.44	283.0	0.7859
67	Udayapally	7.62	242.6	130	32	12.1	9.03	1.75	122	100	24.815	0.5	0.29	171.2	BDL
68	Sankuri	7.51	407.2	195	46	19.4	14.11	1.11	213.5	175	28.36	0.3	0.42	239.9	1.9830
69	Nigha	7.87	1366	160	22	25.5	294.3	9.8	701.5	575	92.17	0.5	1.23	897.5	4.1924
70	Kankhaya	7.88	897	305	26	58.3	76.1	3.35	518.5	425	56.72	1.0	0.65	538.4	3.5050
71	Pariharpur	7.84	1315	420	100	41.3	91.65	6.16	384.3	315	159.525	0.6	0.39	669.1	6.2578
72	Sitarampur	7.8	759.1	285	54	36.4	62.5	1.38	402.6	330	42.54	89.5	0.62	532.6	1.2094
73	Indraprastha	7.84	980.1	265	42	38.8	75.24	14.2	378.2	310	74.445	1.0	0.89	477.3	3.4029
74	Akandara	6.29	39.4	60	8	9.7	3.95	1.43	61	50	14.18	0.5	0.05	75.0	0.8009
75	Kataberia	6.33	102.4	65	18	4.9	21.6	0.7	91.5	75	24.815	0.3	0.04	126.1	BDL
76	Jhatgoria	6.51	102.7	75	24	3.6	4.12	1.5	67.1	55	21.27	1.7	0.06	97.3	BDL
77	Jamadaha	7.33	437.5	185	44	18.2	29.4	1.16	225.7	185	56.72	1.4	0.4	288.9	0.2719
78	Khalabati	6.82	189.6	135	22	19.4	2.86	3.52	152.5	125	17.725	1.2	0.24	160.0	BDL
79	Rakshitpur	6.12	54.4	60	20	2.4	2.96	2.16	61	50	17.725	0.3	0.05	82.9	BDL
80	Debsala	5.8	120.4	55	16	3.6	9.36	3.33	67.1	55	14.18	0.2	0.03	87.7	BDL
81	Kanksa	7.16	138	95	22	9.7	5.04	2.24	103.7	85	21.27	0.2	0.08	123.8	BDL
82	Rajbandh	7.59	841.2	290	32	51.0	56.7	1.8	439.2	360	67.355	0.1	0.47	477.3	10.5051

83	Mankar	6.84	174.3	50	12	4.9	10.75	2.9	61	75	17.7	0.2	0.07	85.6	0.0790
84	Mankar	6.55	93.3	60	18	3.6	6.77	2.51	54.9	45	24.815	2.2	0.04	91.5	BDL
85	Gopalmath	6.87	232.8	40	18	-1.2	7.1	1.66	49	55	14.18	0.5	0.08	70.2	BDL
86	Bhatkunda	7	232.5	145	30	17.0	15.6	2.44	170.8	140	28.36	0.6	0.19	198.4	BDL
87	Rangakhila	6.43	195.6	70	20	4.9	20.4	4.14	48.8	40	42.5	9.7	0.04	134.5	BDL
88	Amarpur	7.34	271.4	145	30	17.0	15.2	3.76	195.2	160	17.725	0.2	0.3	203.3	BDL
89	Babuisol	7.81	532.2	160.5	34	18.3	42.1	9.63	298.9	245	24.815	0.4	0.36	312.0	BDL
90	Bhalki	6.86	114.5	60	16	4.9	21.4	1.58	97.6	80	21.27	0.6	0.13	125.4	BDL
91	Malidapara	7.48	219.5	105	28	8.5	16.2	1.61	134.2	110	17.725	0.0	0.22	154.2	0.0030