केंद्रीय भूमि जल बोर्ड

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भारत सरकार

Central Ground Water Board

Department of Water Resources, River Development and Ganga Rejuvenation,

Ministry of Jal Shakti

Government of India

AQUIFER MAPPING AND MANAGEMENT OF GROUND WATER RESOURCES

MURSHIDABAD, BIRBHUM & BARDDHAMAN DISTRICT, WEST BENGAL

पूर्वी क्षेत्र, कोलकाता

Eastern Region, Kolkata

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MINISTRY OF JAL SHAKTI, DEPARTMENT OF WATER RESOURCES, RIVER DEVELOPMENT & GANGA REJUVENATION

REPORT ON

AQUIFER MAPPING AND MANAGEMENT PLAN IN PARTS OF MURSHIDABAD, BIRBHUM & BARDDHAMAN DISTRICT, WEST BENGAL

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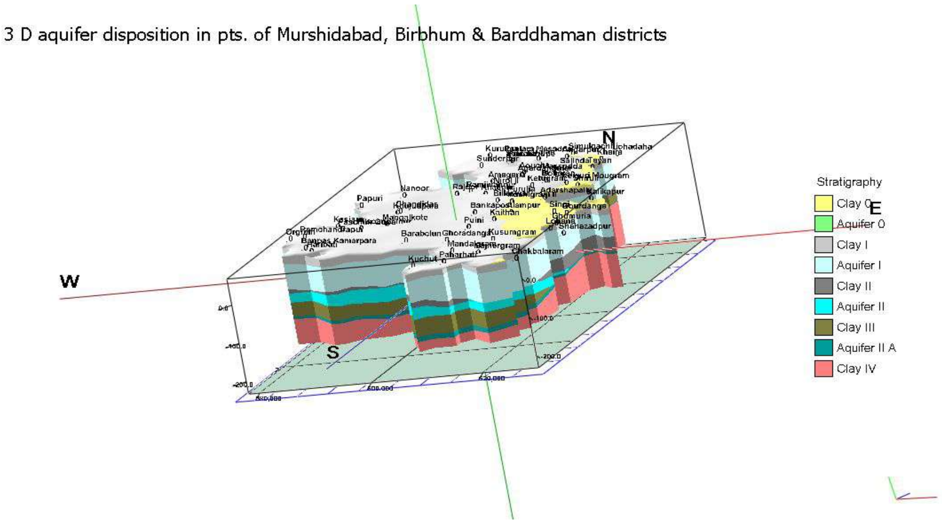

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Contents

1. INTRODUCTION

Groundwater is one of the prime sources of fresh water contributing significantly for the survival of mankind. However, over-exploitation, surface runoff, subsurface groundwater discharge along with quality problem have depleted the fresh groundwater availability considerably. Assessing the groundwater potential zone is extremely important for the protection of water quantity & quality, and the management of groundwater system. In this context, the National Aquifer Mapping & Management Programme (NAQUIM) has been taken up by CGWB under XIIth Plan. As per the revised Action Plan under NAQUIM, ground water management studies in 46 blocks of seven districts namely Murshidabad (3 blocks), Barddhaman (8 blocks), Birbhum (1 block), Nadia (9 blocks), North 24 Parganas (13 blocks), South 24 Parganas (9 blocks) and Howrah (3 blocks) district in West Bengal, covering an area of approximately 8904 sq. km. was taken up by CGWB, ER, Kolkata. In this report, aquifer mapping studies in above mentioned blocks of Barddhaman, Murshidabad and Birbhum districts, together grouped under Sub-Area C for office convenience, have been dealt. Here, the salient features of aquifer geometry, characteristics, ground water occurrences, availability, resource vis-a-vis quality, development & block-wise aquifer management plan scope of ground water etc. have been discussed.

1.1 Objective

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

1.2 Scope of Study

The scope of the present study is broadly within the framework of National Aquifer Mapping & Management Programme (NAQUIM) being implemented by CGWB. There are four major activity components viz.: (i) data collection / compilation (ii) Data gap analysis (iii) Data generation and (vi) Preparation of aquifer maps and block wise management plan to achieve the primary objective. Data compilation includes collection, and wherever required procurement, of all maps from concerned Agencies, such as the Survey of India, Geological Survey of India, Indian Meteorological Dept. (IMD), State Government Dept. Viz. Public Health engineering Deptt., Agri – Irrigation Dep., State Water Investigation Directorate, Dept. of Science & Technology, Bureau of Economics & Statistics, Agriculture Dept., etc., Identification of Data Gap is aimed to ascertain requirement for further data generation in respect of hydro-geological, geophysical, chemical, hydrological, hydro-meteorological studies, etc. Generation of data means collection of data in respect of hydrogeology including litho-logs and aquifer parameters, hydrometeorology, chemical quality of ground water.

Generation of ground water quality data is accomplished by collection of water samples from the field and their laboratory analyses for all major parameters, and some of the heavy metals. Additional data pertaining to sub-surface lithologyand aquifer parameters were obtained through drilling of additionalexploratory wells and slim holes, pumping tests at the drilling sites, etc.

1.3 Approach and Methodology

An approach and methodology adopted to achieve the major objective have been shown below stepwise.

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 acquired data from different sources and preparation of Block-wise Aquifer Maps and Management Plan

1.4 Location, Extent and Accessibility of the study area

The study area (Plate 1) comprises a total of 12 blocksof three districts, e.g., 3 blocks in Murshidabad,8 blocks in Barddhaman and 1 block in Birbhum district of West Bengal have been covered. The study area under Sub Area C in Murshidabad, Barddhaman,Birbhum districts is 2807.7 sq kms. This area is located in parts of Birbhum, Murshidabad and Barddhaman districts covering 12 blocks (Murshidabad -3 blocks, Barddhaman- 8 blocks,Birbhum - 1 block) covering an area of 2807.7 sq km and mainly located in the Western parts of Bhagirathi river. The area extends between North latitudes 23° 11' 34.8” and 24° 3' 57.6” and East longitudes 87° 43' 26.4” and 88° 16' 48”.The study area partly falls in the Survey of India Degree Sheet no. 72P, 73 M, 78 D and 79A. The study areaforms part of upper deltaic region of Bengal Basin. The study area is well connected by road and rail.

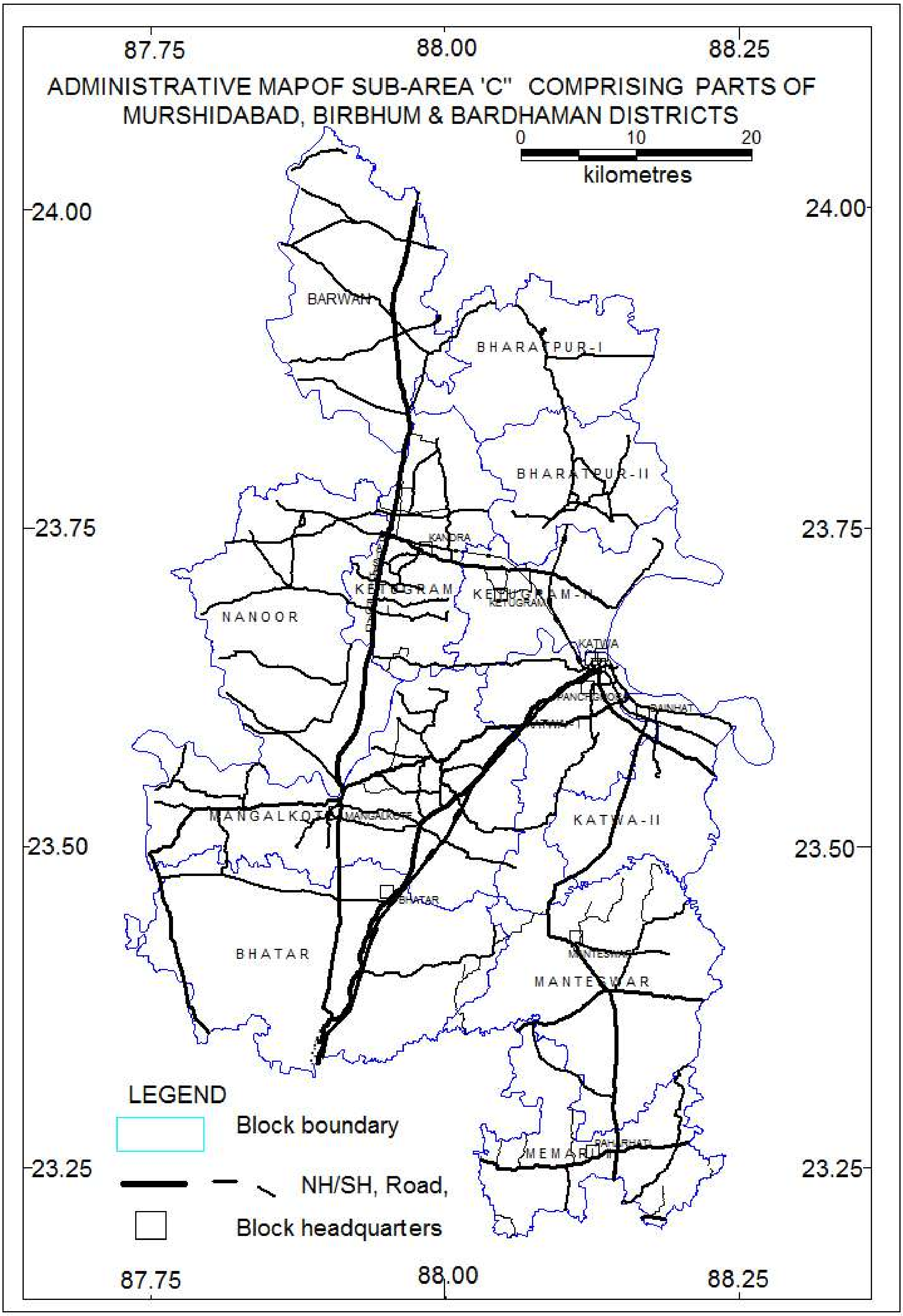


Plate 1: Administrative map of study area (Sub-Area 'C', AAP 2016-17)

1. 5Administrative Divisions

This area covers 12 blocks (Murshidabad -3 blocks, Barddhaman - 8 blocks and Birbhum - 1 block)over an area of 2807.70 sq km. Details of administrative divisions are summarized in Table1.5.1.

Table 1.5.1: Details of administrative divisions

Sr. No.	District	Block	Area* (sq km)	Name of Sub-division	Number of Panchayat samity	Number of Gram Panchayat	Gram Samsad
1	Murshidabad	Bharatpur I	178.00	Kandi	1	8	121
2	Murshidabad	Burwan	280.00	Kandi	1	13	185
3	Murshidabad	Bharatpur II	162.00	Kandi	1	7	123
Murshidabad			**620**		**3**	**28**	**429**
1	Barddhaman	Ketugram I	200.00	Katwa	1	8	117
2	Barddhaman	Ketugram II	142.00	Katwa	1	7	90
3	Barddhaman	Katwa I	182.99	Katwa	1	9	129
4	Barddhaman	Mangolkote	360.00	Katwa	1	15	198
5	Barddhaman	Memari II	106.00	Barddhaman (South)	1	9	115
6	Barddhaman	Bhatar	393.00	Barddhaman (north)	1	14	201
7	Barddhaman	Manteswar	319.00	Kalna	1	13	176
8	Barddhaman	Katwa II	168.71	Katwa	1	7	101
Barddhaman			**1871.7**		**8**	**82**	**1127**
1	Birbhum	Nanoor	316.00	Bolpur	1	11	168
Birbhum			**316.00**	**Bolpur**	**1**	**11**	**168**
TotalSub-Area C (AAP 2016-17)			**2807.7***		**12**	**121**	**1724**

* - as assigned

In the present area, there are 12 panchyat Samity, 121 Gram Panchyat and 1724 Gram Samsads.

The Total population of the Study Sub-area C (Parts of Murshidabad, Barddhaman and Birbhum districts) are presented in Table 1.5.2 a (Murshidabad district), Table 1.5.2 b (Barddhaman district), Table 1.5.2 c (Birbhum district) and 1.5.2 d (district wise).

Table 1.5.2 a: Distribution of population in parts of Murshidabad district

Distribution of Rural and Urban Population by sex in the Study area of Murshidabad district (Census 2011)

Sub-Division / C.D.Block / M.C./ M	Rural Population			Urban Population			Total Population		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Burwan	132439	125027	257466	-	-	-	132439	125027	257466
BharatpurI	89088	83614	172702	-	-	-	89088	83614	172702
BharatpurII	78380	75094	153474	11651	11243	22894	90031	86337	176368
BharatpurI	89088	83614	172702	-	-	-	89088	83614	172702
Kandi Sub - Division	**299907**	**283735**	**583642**	**11651**	**11243**	**22894**	**311558**	**294978**	**606536**

Table 1.5.2 b: Distribution of population in parts of Barddhaman district

Distribution of Rural and Urban Population by sex in the Study area of Barddhaman district (Census 2011)

Sub-Division / C.D.Block / M.C./ M	Rural Population			Urban Population			Total Population		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Burdwan (N) Sub-Division	**134096**	**128968**	**263064**	**0**	**0**	**-**	**134096**	**128968**	**263064**
Bhatar	134096	128968	263064	-	-	-	134096	128968	263064
Burdwan (S) Sub-Division	**76500**	**73752**	**150252**	**0**	**0**	**-**	**76500**	**73752**	**150252**
MemariII	76500	73752	150252	-	-	-	76500	73752	150252
Katwa Sub-Division	**437393**	**413144**	**850537**	**44704**	**43384**	**88088**	**482097**	**456528**	**938625**
Mongalkote	134693	128547	263240	-	-	-	134693	128547	263240

KetugramI	84966	80442	165408	-	-	-	84966	80442	165408
KetugramII	61413	57154	118567	-	-	-	61413	57154	118567
KatwaI	85733	80881	166614	3354	3119	6473	89087	84000	173087
KatwaII	70588	66120	136708	-	-	-	70588	66120	136708
Katwa(M)	-	-	-	41350	40265	81615	41350	40265	81615
Kalna Sub-Division	**120940**	**116458**	**237398**	**0**	**0**	**-**	**120940**	**116458**	**237398**
Monteswar	120940	116458	237398	-	-	-	120940	116458	237398
Part of district Total	**768929**	**732322**	**1501251**	**44704**	**43384**	**88088**	**813633**	**775706**	**1589339**

Table 1.5.2 c: Distribution of population in parts of Birbhum district

Distribution of Rural and Urban Population by sex in the Study area of Barddhaman district (Census 2011)									
Sub-Division / C.D.Block / M.C./ M	Rural Population			Urban Population			Total Population		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Bolpur subdivision/ Nanoor	109495	103892	213387	2690	2577	5267	112185	106469	218654
Part of district Total	**109495**	**103892**	**213387**	**2690**	**2577**	**5267**	**112185**	**106469**	**218654**

Table 1.5.2 d: Total distribution of rural & urban population in study area

Distribution of Rural and Urban Population by sex District wise in the Study area (Census 2011)									
District	Rural Population			Urban Population			Total Population		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Murshidabad	299907	283735	583642	11651	11243	22894	311558	294978	606536
Birbhum	109495	103892	213387	2690	2577	5267	112185	106469	218654
Barddhaman	768929	732322	1501251	44704	43384	88088	813633	775706	1589339
Total in the Study area	**1178331**	**1119949**	**2298280**	**59045**	**57204**	**116249**	**1237376**	**1177153**	**2414529**

1.6 Landuse and irrigation

Out of the total area concernedabout 79.87 % areais occupied by cultivable land, about1.58 % area is occupied by cultivable waste land and almost negligiblearea is under forest land. The land use categories have been compiled from data including those of Agriculture dept. and Land &Land Reforms Dept., Govt. of West Bengal, in each block is shown in Table-1.6.1.

Irrigation plays an important role for crop production and intensity of crops. The cultivable land in the study area, about 60% is rain-fed, andin the rest area crop production is solely dependent of surface water and ground water irrigation systems. About 40% of cultivable area has been irrigated through ground water & surface water. Ground water irrigation is created by deep tube well and shallow' tube wells. Irrigation by surface water is done through River lift irrigation,whereas irrigation by water conservation structures (tanks etc.) is covering a substantial part of study area. Block wise details of irrigation in respect of blocks of Birbhum, Murshidabad and Barddhaman districts have been tabulated in Table-1.6.2a, Table-1.6.2b and Table-1.6.2c.

The majority of the study area is covered under “Rarh” area which is located in the western part of Bhagirathi River. Rice including ‘Boro’ forms the principal crop of the study area. Other crops with a substantial production include wheat,jute, pulses, oil seeds, vegetables including potato and sugar cane.

Table-1.6.1: Block-wise landuse category (in ha)

SI. No (1)	Name of the Block (2)	Reported area (3)	Cultivable Area (4)	Area under pasture & orchard (5)	Cultivable Waste Land (6)	Forest Land (7)	River (+canal, +wet land) (8)	Reservoirs, lakes, ponds, tanks
1	Bharatpur I	17800	15414	325	180	0	429.64 (wet land-322.01)	237.75
2	Bharatpur II	16200	13683	245	140	0	115.44	146.99
3	Burwan	28000	25569	375	72.08	0	670.20	140.48
4	Nanoor	31600	26892	10.08	3.53	15.85	1142.56 (canal-58.93)	471.12
5	Ketugram I	20000	15032	-	1022	0	314.18 (wet land-3.70)	132.03
6	Ketugram II	16230	12542	6	385	0	1322.46	174.03
7	Katwa I	18299	12400	7	144	0	726.18	287.06
8	Katwa II	16871	11700	21	64	0	938.46 (wet land-106.77)	99.80
9	Mangalkote	36000	28600	2	1609	0	1491.82 (wet land-50.01)	254.48
10	Memari II	18664	14508	11	-	0	169.77	74.12
11	Bhatar	39300	31387	1	760	301	60.41 (canal-83.22)	239.86
12	Manteswar	31900	24606	-	228	0	347.63	158.47

Table-1.6.2a: Block wise details of Irrigation in part of Birbhum district

Sl No	Block	Dug well		Shallow tube well		Deep tube well		Surface flow		Surface lift		CCA in ha	
		No.	CCA in ha	No.	CCA in ha	No.	CCA in ha	No.	CCA in ha	No.	CCA in ha	Surface Water	Ground water
1	Nanoor	0	0	1253	5884.65	0	0	17	149.36	508	1170.78	1320.14	5884.65

Table-1.6.2b: Block wise details of Irrigation in Murshidabad district

Sl No.	Block	Dug well		Shallow tube well		Deep tube well		Surface flow		Surface lift		CCA in ha		Total CCA in ha
		No.	CCA in ha	No.	CCA in ha	No.	CCA in ha	No.	CCA in ha	No.	CCA in ha	Surface water	Ground water	
1	Burwan	0	0	2023	7296.13	13	500.00	54	1361.32	267	1417.00	2778.32	7796.13	10574.45
2	Bharatpur-I	0	0	974	6320.79	8	320	7	129.53	51	998.87	1128.40	6640.79	7769.19
3	Bharatpur-II	0	0	934	4582.75	16	640.48	0	0	15	740.18	740.18	5223.23	5963.41

Table-1.6.2c: Block wise details of Irrigation in Barddhaman district

Sl No.	Block	Dug well		Shallow tube well		Deep tube well		Surface flow		Surface lift		CCA in ha		Total CCA in ha
		No.	CCA in ha	No.	CCA in ha	No.	CCA in ha	No.	CCA in ha	No.	CCA in ha	Surface water	Ground water	
1	Bhatar	1	13.49	2078	11748.95	3	120.00	1	14.00	72	537.43	551.43	11882.44	12433.87
2	Katwa I	0	0	872	4402.26	37	1440.00	1	2.66	24	223.56	226.22	5842.26	6068.48
3	Katwa II	2	45.26	654	3311.28	55	2160.00	7	18.84	31	706.89	725.73	5516.54	6242.27
4	Ketugram I	39	204.33	924	4819.09	14	560.00	3	50.75	96	361.05	411.80	5583.42	5995.22
5	Ketugram II	15	86.73	800	3212.89	29	1110.60	1	2.69	112	1283.32	1286.01	4410.22	5696.23
6	Mangalkote	1	6.07	1715	8677.51	13	521.00	7	11.31	142	481.81	493.12	9204.58	9697.70
7	Manteswar	3	11	2061	10726.74	52	2121.00	43	5171.88	39	1211.34	6383.22	12858.74	19241.96
8	Memari II	0	0	1199	6370.60	29	1160.26	0	0	6	258.47	258.47	7530.86	7789.33

1.7 Urban areas, Industries and Mining activities

Urban areas in the study area include one municipality in the study area i.e., Katwa in Barddhaman district. A few small industries are set up in the study area, registered with the Directorate of Cottage and Small-Scale Industries. Mining activities are virtually absent in this area. Nearby National Thermal Power Corporation has already acquired vast land to set up a thermal power plant in the area.

2. CLIMATE

The climate of the area is characterized by hot and humid climate with adequate rainfall mainly derived from south-west monsoon, which starts from mid-June and continue upto September. Generally, 85 percent of the rainfall is received during the monsoon period. Pre-monsoon showers are occasionally received in the month of March, April and May.

2.1 Rainfall

Month wise average rainfall for the year 2012 – 2016of the present area hasbeen tabulated and presented in Table-2.1.1 below.

2.2 Temperature

The winter season sets in around middle of November when both maximum and minimum temperaturebegins to drop steadily and attain their respective lowest values in the month of January. The temperature starts rising in the month of February. May is the hottest month of the year.

Table-2.2.1 Average annual rainfall in study area for the period 2012 -16 (in mm)

Districts	year	January	February	March	April	May	June	July	August	September	October	November	December
Murshidabad													
	2012	15.7	0.5	10.1	56.4	35	103.5	292.9	110.3	173.9	109.1	68	4.1
	2013	0	1	0.5	33.6	192.7	174.5	115.4	311.3	195.2	204	0	0
	2014	0.3	30.7	4.4	0	138.9	183.6	280.1	239.7	282.3	15.6	0	0
	2015	7.1	7	12	50	88	341.5	640.4	274.6	193.2	49.9	7.8	2
	2016	41	7.5	7	24	89	141.7	304.3	171	203.4	57.3	0	0
Average 5 yrs		**12.82**	**9.34**	**6.8**	**32.8**	**108.72**	**188.96**	**326.62**	**221.38**	**209.6**	**87.18**	**15.16**	**1.22**
Birbhum													
Districts	**year**	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**
	2012	17.2	5.5	7.7	29.9	46.9	122.9	324.5	197.4	139.2	84.6	71	6
	2013	1.8	14.5	0.9	46.2	152.3	164.9	170.6	345.7	149.9	327.5	0	0
	2014	3.8	35.4	28.5	0.2	80.9	177.3	391.6	285.7	130.2	10.2	0	0.6
	2015	9.1	4.3	35.5	69.4	54.4	321.5	698.5	296.8	144.2	21.1	4.2	0.2
	2016	24.3	14	12.7	2.7	94.9	214.6	346.6	308.4	242.4	35.2	0	0
Average 5 yrs		**11.24**	**14.74**	**17.06**	**29.68**	**85.88**	**200.24**	**386.36**	**286.8**	**161.18**	**95.72**	**15.04**	**1.36**

Bardhaman													
Districts	**year**	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**
	2012	31.1	7.8	3.2	63.3	39.4	133.9	424.5	277.9	194.6	57.2	37.5	6.2
	2013	6.8	17.5	4.6	41.5	175.1	210.2	145.5	341.1	250.7	342.5	0	0
	2014	1.1	35.1	32	0.7	74.6	233.9	280.6	256.5	195.3	23.9	0	0.7
	2015	8.5	10.1	29.4	76.3	64.2	338.1	587.3	285.8	111.8	34.1	0	0.9
	2016	13.5	29.3	15	0	120	182.5	263.9	463.5	274.5	44.3	1.9	0
Average 5 yrs		**12.2**	**19.96**	**16.84**	**36.36**	**94.66**	**219.72**	**340.36**	**324.96**	**205.38**	**100.4**	**7.88**	**1.56**

(Source: IMD)

3. PHYSIOGRAPHY

3.1 Geomorphology

Overall, the study area belongs to alluvial plain topography. The area under study is generally flat with surface elevation ranging from 57m above MSL in the West (Bhatar block) to 8 m above mean sea level (MSL) towards East (Manteswar block); the average slope of the area is 0.692 m /Km. Geo-morphology of the study area has been shown in Plate-3.1.1below. Elevation in study area has been presented by Plate-3.1.2.

Geo-morphologically, the gentle dipping flattish interfluves area between Damodar and Ajoy rivers constitute an upper delta regime of Hugli-Bhagirathi River basin. In certain span of this river system, there is a tendency of shifting meandering courses, which has left scars of numerous abandoned palaeo channels. The broad geomorphic divisions are: i) Paradeltaic fan surface in small upland area in Burwan block of Murshidabad district, ii) Upper mature deltaic plain & paradeltaic flood surface of parts of Barddhaman & Birbhum districts and are encountered on relatively lower elevation than fan surface and iii) small portion of flood plain around banks of major rivers of the area, viz. Bhagirathi and Ajoy.

3.2 Drainage

The whole area is drained by the rivers and tributaries of Bhagirathi/Hugly/Ganga/Padma drainage system. All rivers and tributaries are perennial in nature. The major river Bhagirathi/ Hugli flows along the central portion of the area from almost north to south/southeast direction. The major tributaries of Hugly/Bhagirathi River system of study area are Mayurakshi and Ajoy Rivers, flowing from west to east to join River Bhagirathi in Murshidabad district and near Katwa in Barddhaman district respectively. The Drainage in the study area is shown in Plate-3.2.1. Water bodies in study area has been shown in Plate-3.2.2.

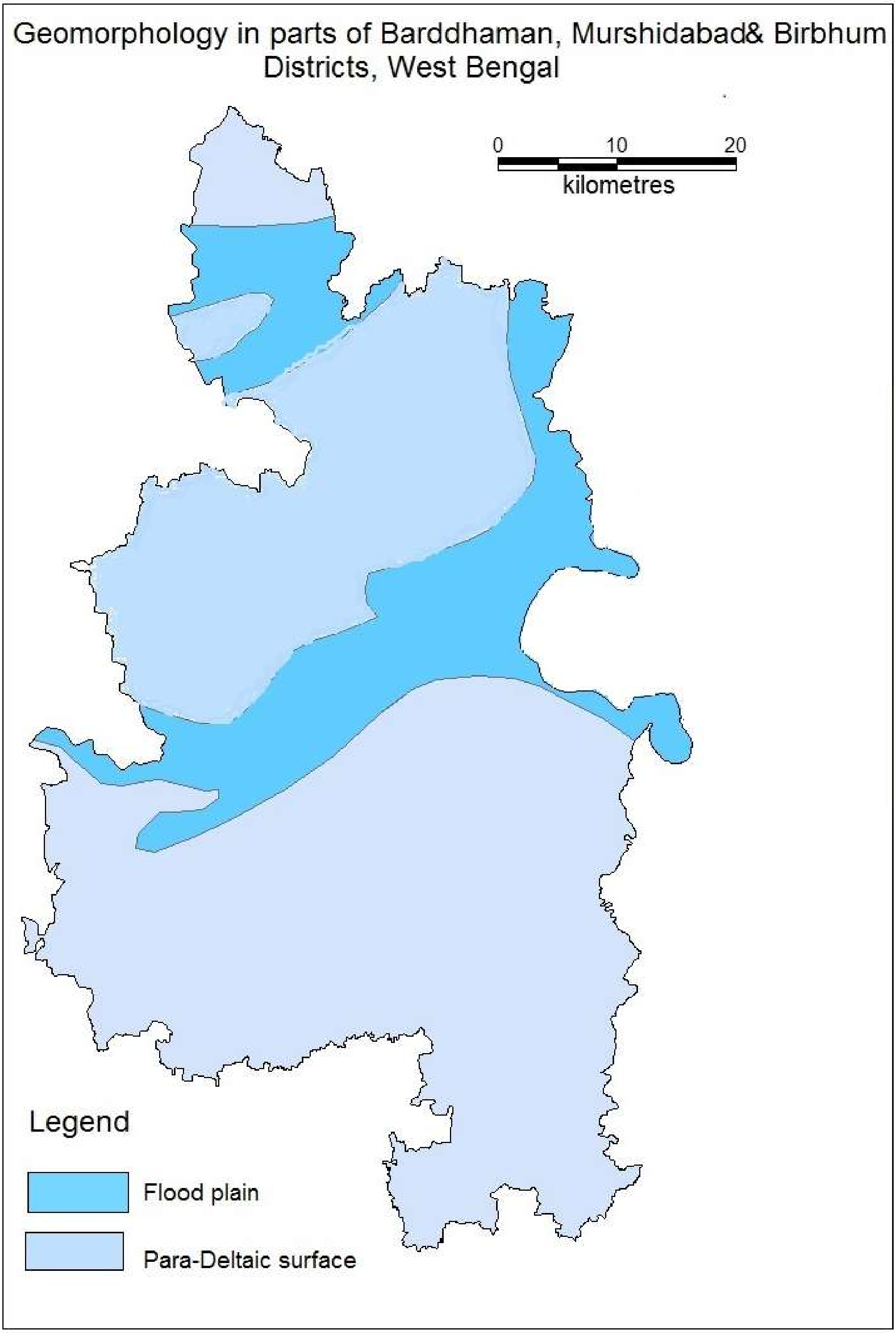


Plate-3.1.1: Geo-morphology in the study area

Plate 3.1.2: Elevation in study area

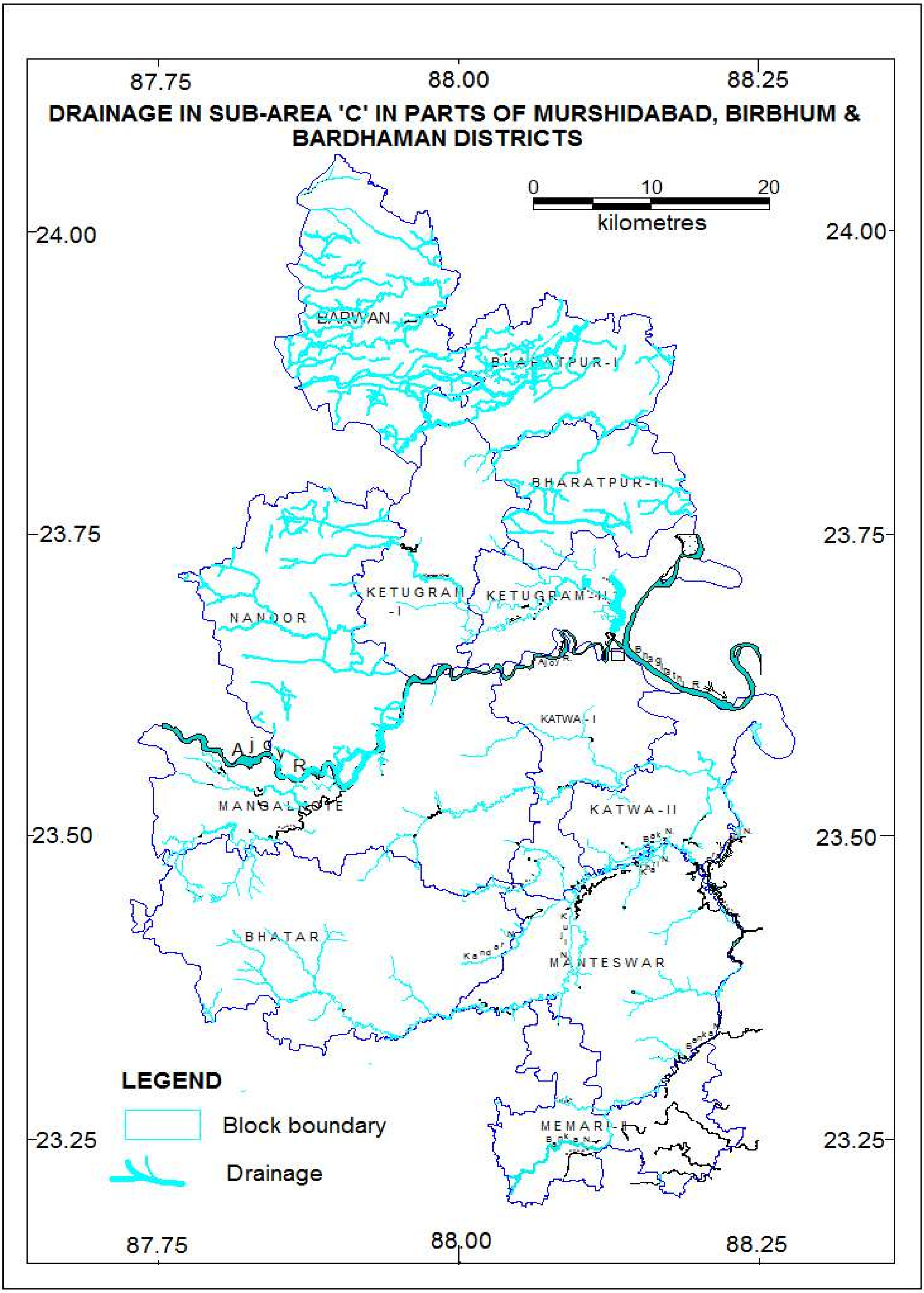


Plate-3.2.1: Drainage Map of the study area

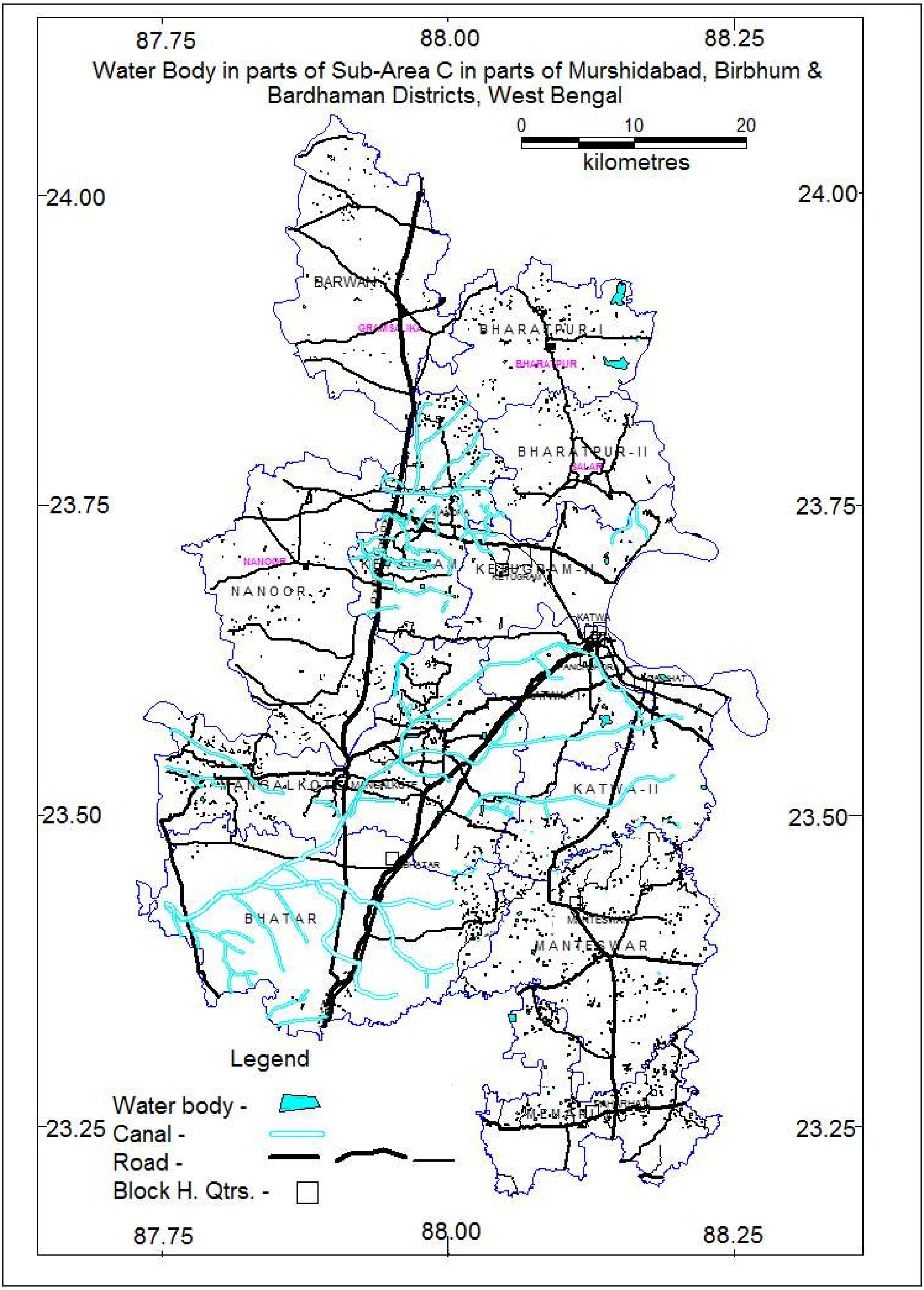


Plate-3.2.2: Water bodies in study area

3.3 Soil characteristics

Main types of soil in the study area are poorly drained, fine loamy soils (fine loam), imperfectly drained, fine loamy soils and moderately well drained, sandy soils (coarse loam)**.**Block-wise major soil types are described in Table 3.3.1. However, the detailed Soil Map of this area is shown in Plate-3.3.1 (Source – NBSS & LUP).

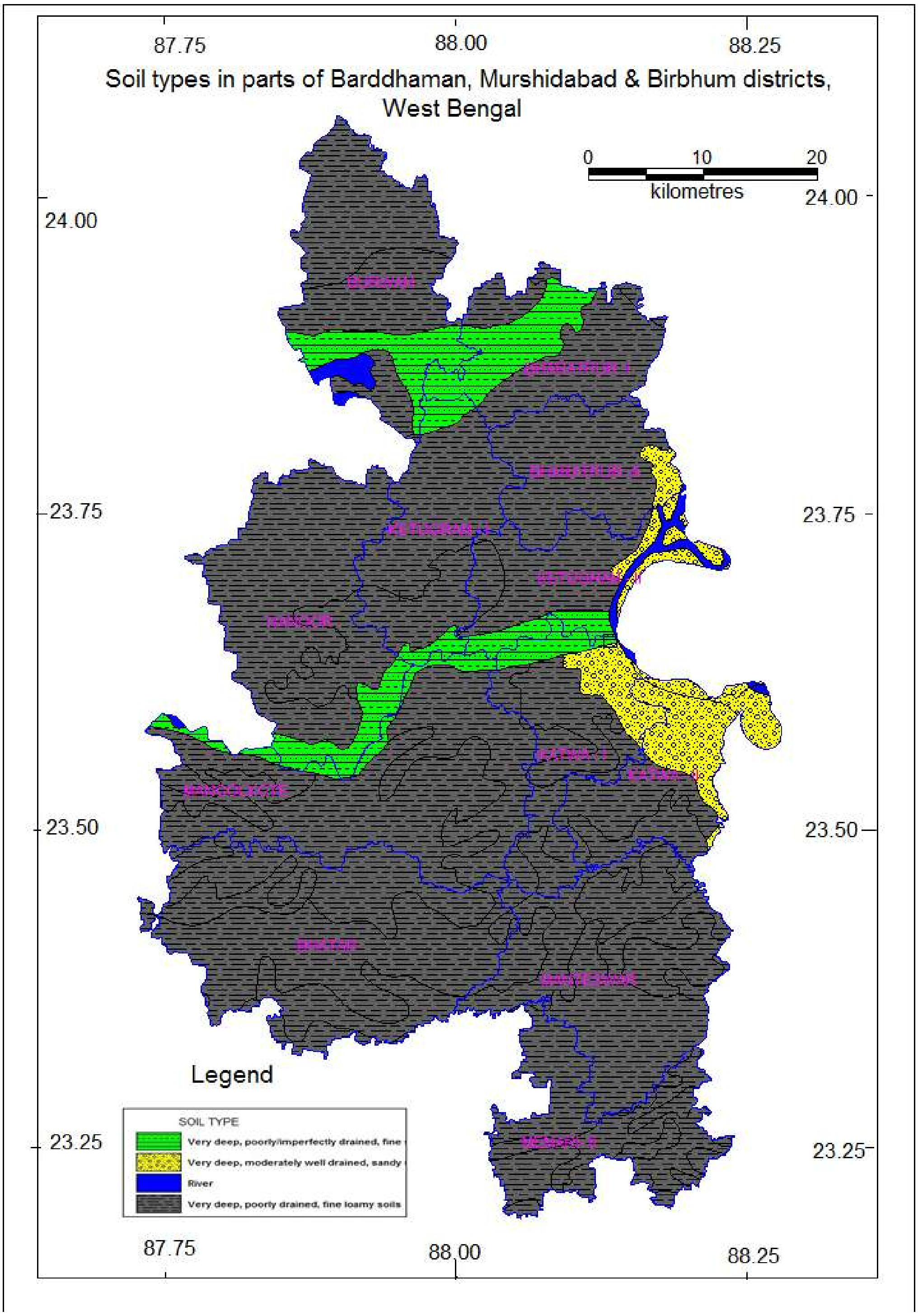


Plate-3.3.1: Soil map in study area

Table 3.3.1: Mmajorsoil types (with area in sq.km) in study area

Sl. No.	Block	Poorly drained, fine loamy soils (fine loam)		Imperfectly drained, fine loamy soils		Moderately well drained, sandy soils (coarse loam)	
		Area	%	Area	%	Area	%
1	Bhatar	416.30	100	0	0	0	0
2	Katwa I	129.15	70.93	18.90	10.38	34.03	18.69
3	Katwa II	91.34	54.53	0	0	76.15	45.47
4	Ketugram I	172.05	89.84	19.46	10.16	0	0
5	Ketugram II	102.18	69.88	22.75	15.56	21.28	14.55
6	Mangalkote	353.28	93.05	26.80	7.06	0	0
7	Manteswar	312.05	99.99	0	0	0	0
8	Nanoor	284.43	88.92	35.46	11.08	0	0
9	Burwan	215.30	81.54	48.75	18.46	0	0
10	Bharatpur I	119.33	65.06579	64.07	34.93	0	0
11	Bharatpur II	142.59	92.69	0	0	11.24	7.31
12	Memari II	215.30	78.02	48.75	17.66	0	0

4. GEOLOGY

4.1 General geology

The area under study is mostly covered by a huge thickness of Quaternary deposits, which overlies Tertiaries. Tertiaries, which are represented by finer fractions of sediments are generally encountered during exploration in parts of western part of Murshidabad, Barddhaman and Birbhum districts. Quaternaries of Hugli-Bhagirathi River system are represented by Older Alluvium and Recent alluvium. Older Alluvium are mainly yellow to brown in colour, oxidised, and mostly developed in upland areas of parts of study area of Bardhaman, Birbhum and Murshidabad districts. Sometimes, these are reportedly capped by laterite deposits and are encountered just in the far west, outside study area. Recent to Sub-Recent Alluvium of the Ganga River system consists of clay, silt, sand, and gravel; these deposits are characteristically grey, fine to coarse, and very often micaceous and their composition is mainly quartzo-feldspathic.

The geology of the whole study area has been shown in Plate -4.1.1.

The surfacial Quaternary deposits constitute three litho-stratigraphic units: i) wide area including parts of Bardhaman, Birbhum and Murshidabad districts, is covered by Sijua Formation of Upper Pleistocene to Middle Holocene, comprised of unconsolidated oxidized sediments, viz. clay with caliche concretions, ii) some part of Katwa - Ketugram area along adjoining areas of major drainage channels is occupied by Panskura Formation, which is also unconsolidated oxidized sediments clay alternating with silt and sand of Middle to Late Holocene (= Chinsura/Katawa Formation) and iii) small lensoid area along major drainage channel of River Bhagirathi of parts of Murshidabad and Barddhaman districts is covered by Diara Formation represented by unconsolidated un-oxidized sediments formed by sand, silt, clay and gravel of Upper Holocene to Recent.

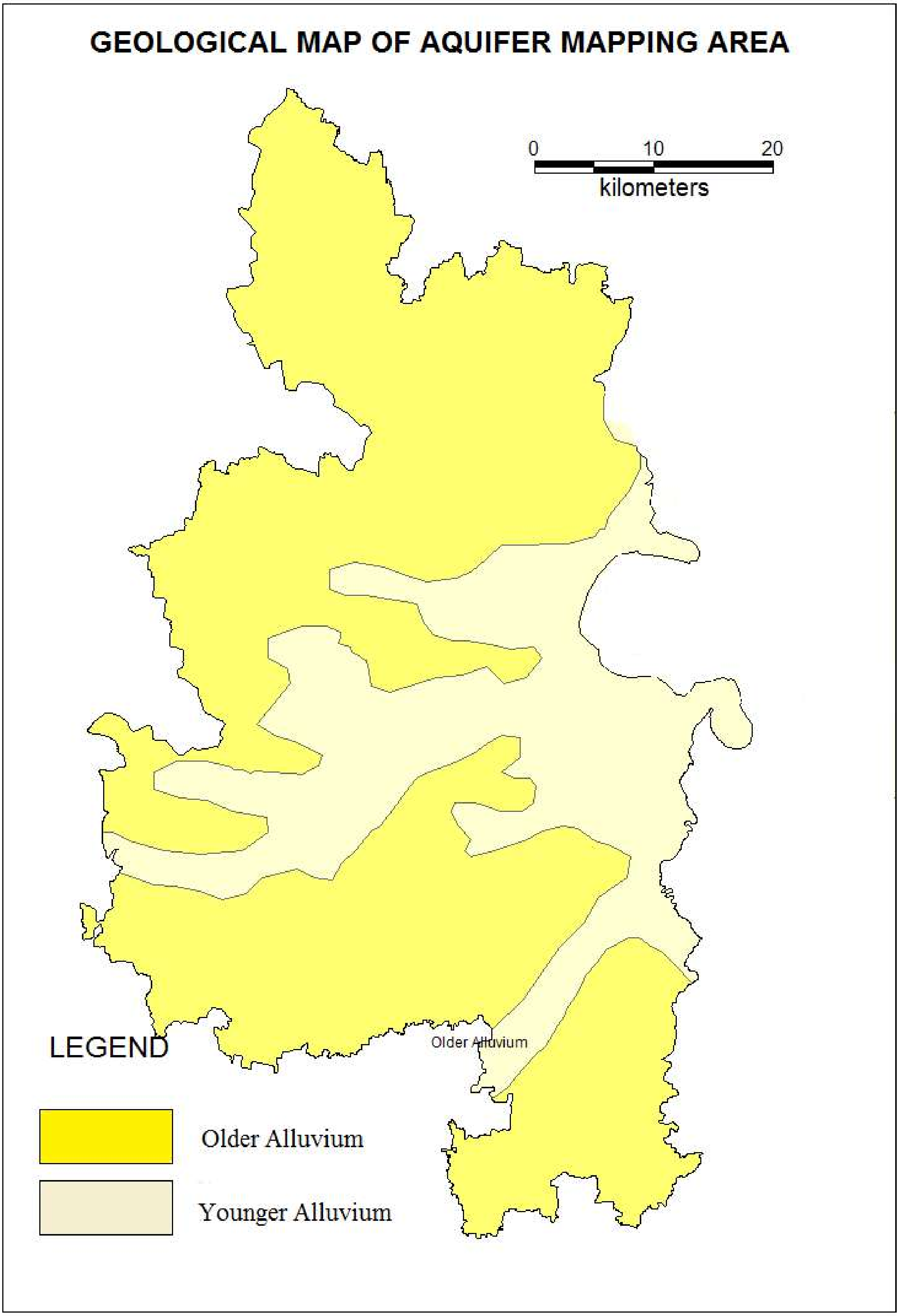


Plate-4.1.1: Geology in study area

5.SUBSURFACE AQUIFER DISPOSITION

In study area, exploratory drilling reveals the presence of more than 350 m thick sediments.Generally, finer sediments, sometimes mixed with clay, occur at or near the surface up to a maximum depth of about 12 mbelow ground level (m bgl). In this area, there are two main groups of aquifers: Aquifer I Group and Aquifer II Group, besides, there are two other aquifer groups, viz. Aquifer '0' Group and Aquifer III Group, which are localised in nature.

Aquifer '0' Group: this aquifer has developed very much locally within a very shallow depth range between 25 m and 40 m within Younger Alluvium deposits, which is very restricted in occurrence. The aquifer has been encountered only in eastern periphery of three blocks, viz. Katwa I, Katwa II and Ketugram II, contiguously located at the proximity to the course of Bhagirathi River.

Aquifer I group: the shallow aquifer includes one or two layers of total thickness ranging generally between 20.5 m and 125 m; but, in blocks of Mangalkote and Manteswar, two top aquifer groups coalesce two form a single continuous aquifer, thickness of which ranges up to about 135 m. This aquifer consists of granular zone comprising of coarse sand and gravel with or without intervening clay lenses/ beds, within a depth of 145mbgl. This group occurs throughout the study area, although clay layers have been encountered within the aquifers of this group. This aquifer is mostly underlain by clay layer, which is sometimes sandy in nature, of thickness ranging up to 34 m. This aquifer is unconfined to semi-confined in nature. But, in parts of blocks of Burwan, Bharatpur I, Bharatpur II, Nanoor, Katwa II and Ketugram II, particularly in adjoining flood plains of Bhagirathi River, the aquifer is mostly semi-confined to confined in nature.

Aquifer II: thisdeeper aquifer has been encountered mainly in blocks of Bharatpur I, Nanoor, Ketugram I, Katwa I, Bhatar and Memari II. This aquifer is relatively thinner and less potential as compared to Aquifer I Group. This group also includes one or more layers of total thickness ranging from 17 to about 51 m of granular zone comprising of fine to medium sand with or without intervening clay layers, within 80.5-240 mbgl. Aquifer II is separated from the upper Aquifer I by a distinguished very thick clay layer, which is generally characteristically dark grey in colour, excepting in parts of Manteswar and Mangalkote blocks. Aquifer II occurs mostly under semi-confined to condition.

Aquifer III: thesisencountered only in Nanoor block in Birbhum district; in this part this aquifer has been tapped within 247- 336during exploration up to 350 m bgl.and is found separated from upper Aquifer II Group by a distinct clay layer of copious thickness of 125 mat Nanoor. The thickness of this aquifer varies within 25 m.It has been tried to visualise the aquifers of the study area in 3 D and 2 D views. The Aquifer III has been encountered beyond 200 m only in the sub-surface of Nanoor block. The occurrence of aquifer III is a very much localized phenomenon; so, for showing aquifers in 3 D and 2 D views, the data of this aquifer in lithologs of tube wells in Nanoor block have not been considered. Fig. 5.0.1 to Fig. 5.0.6, stratigraphic logs, 3 D aquifer disposition from south-eastern side, one N-S section index line & respective section, and one W-E section index line & section of the whole study area have been shown. From the said figs., it is evident that in the southwestern part of study area there are two distinct aquifers: Aquifer I & Aquifer II, which tend to coalesce to form single aquifer in the south-eastern part and again separates in the eastern part of Memari block. Also, it is interpretated that Aquifer I ismore or less persistent and quite thick and major aquifer of the area. Aquifer II has been developed at placesin Nanoor, Memari II, Bhatar and Katwa I; it is thin and inconsistent in nature, and found to coalesce with Aquifer I at places, viz. Manteswar, Mangalkote and even at Memari II.The nature of Aquifer IIA is similar to that of Aquifer II, and that is why it has been grouped under Aquifer II Group itself.

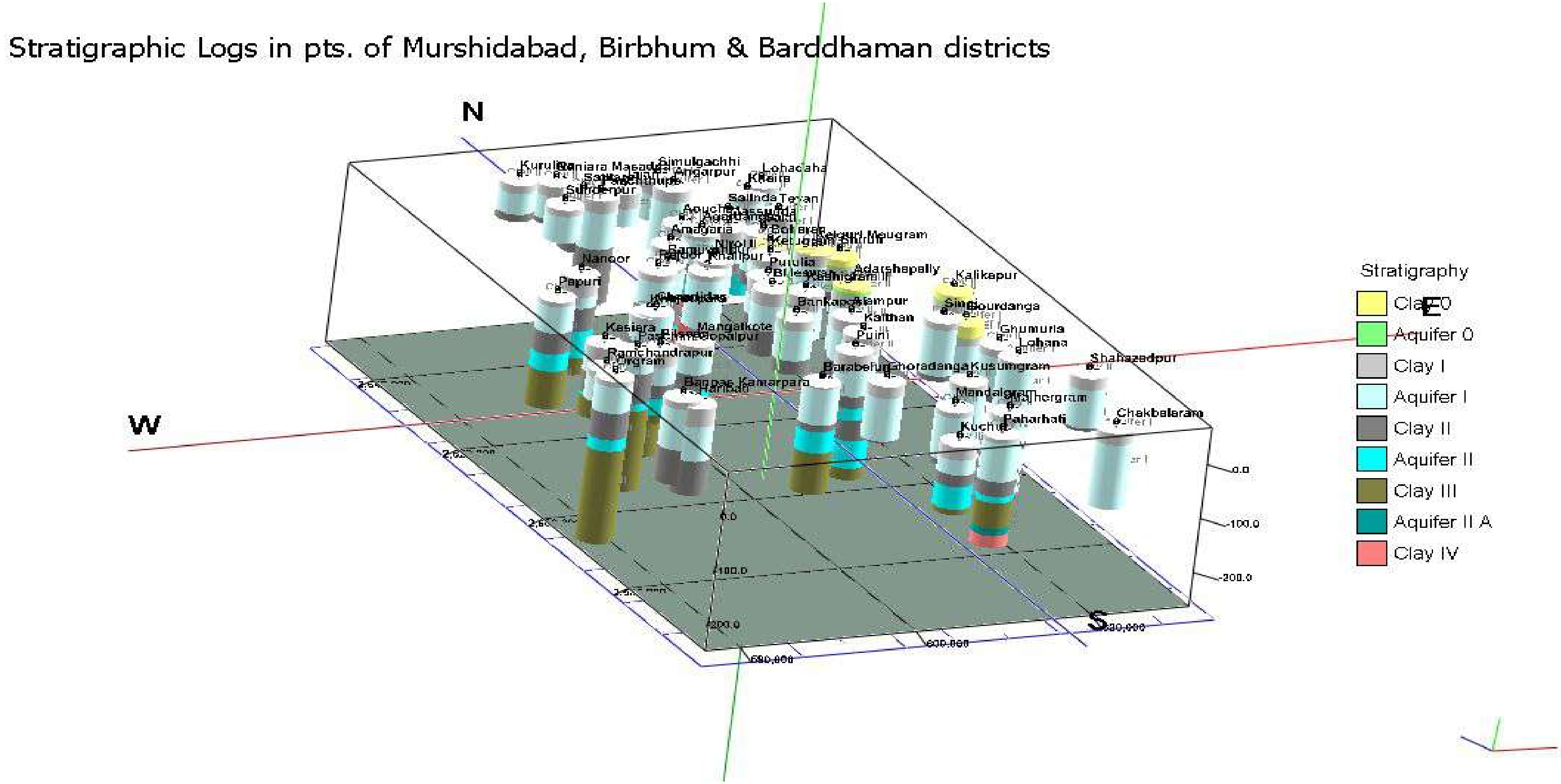


Fig. 5.0.1: Stratigraphic logs in study area

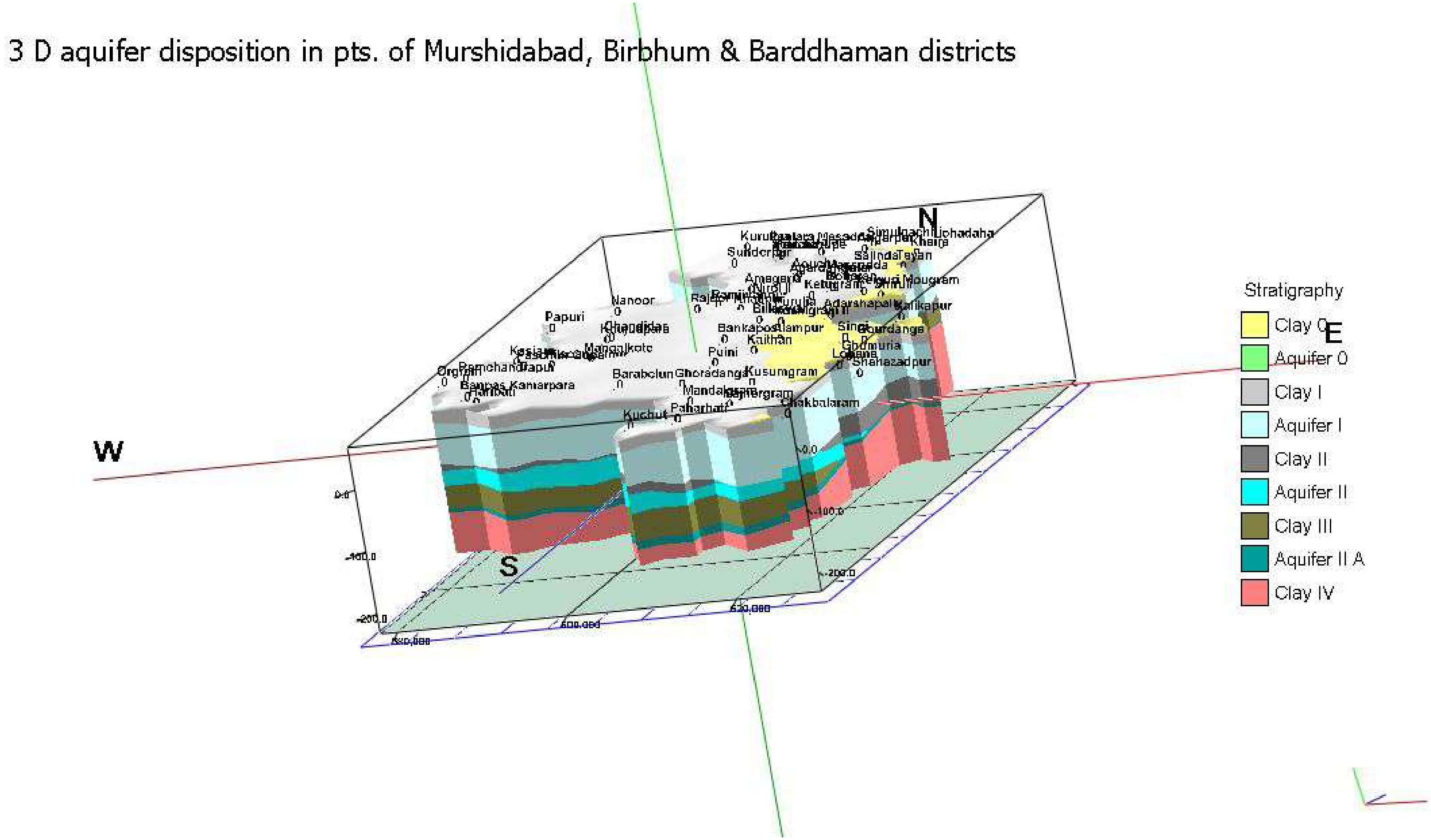


Plate 5.0.2: 3 D aquifer disposition in study area from south-eastern side

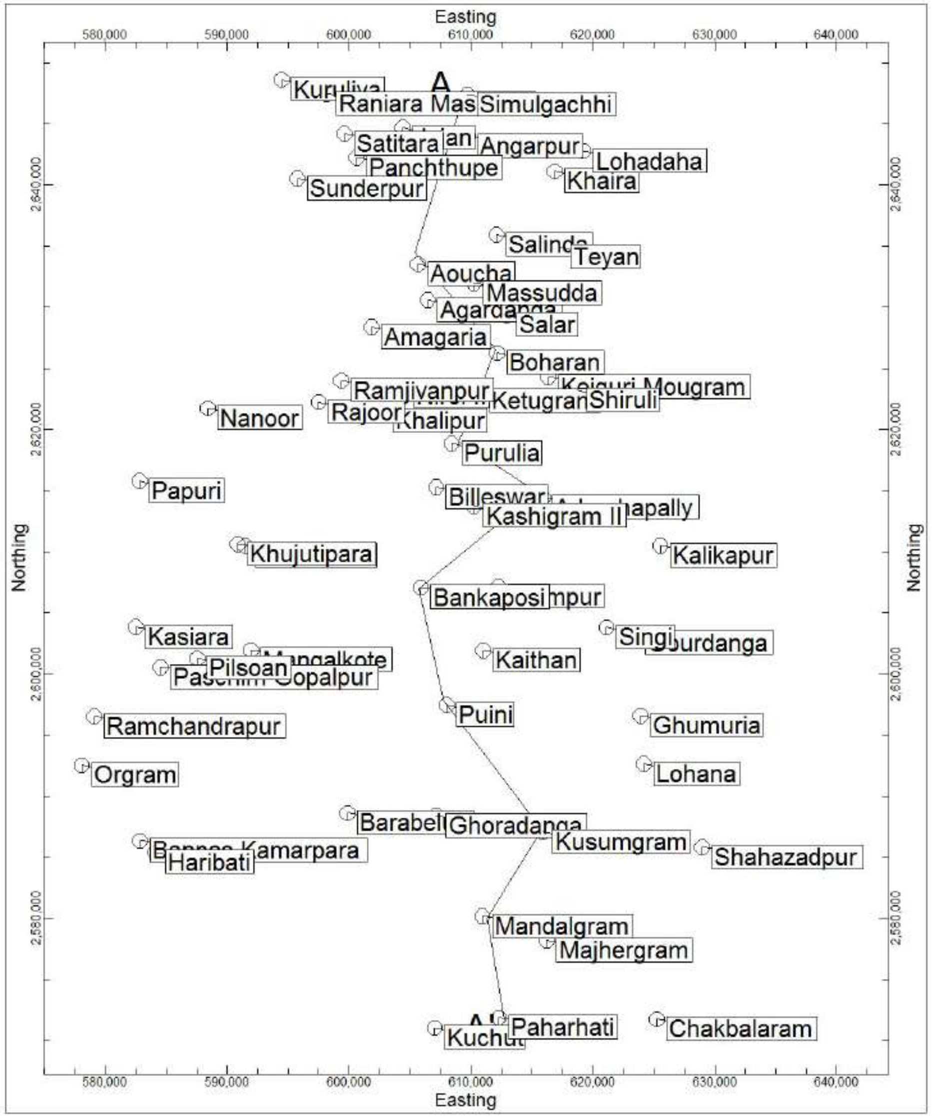


Fig. 5.0.3: N-S Section index line - 1

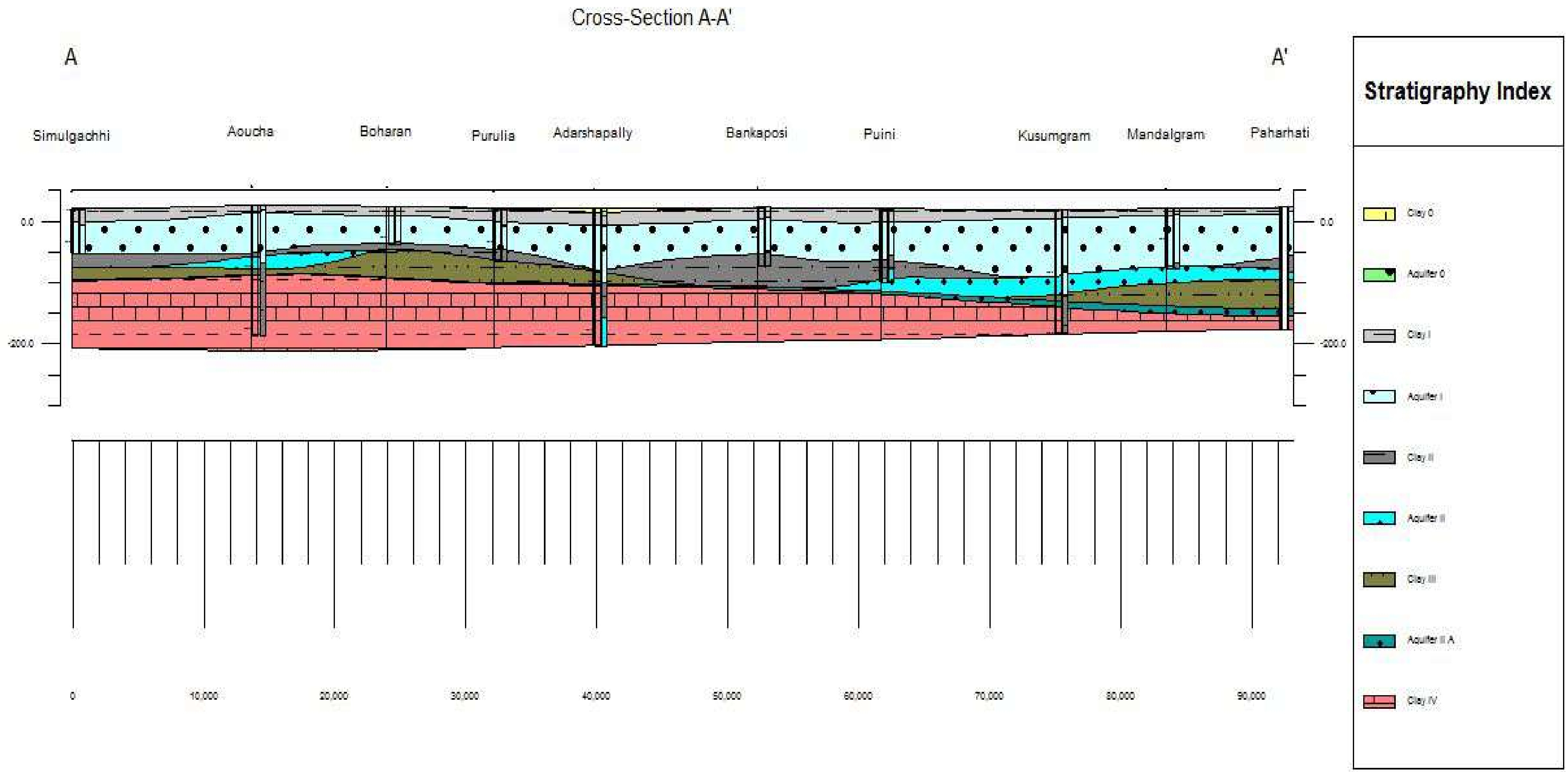


Fig. 5.0.4: N-S Section

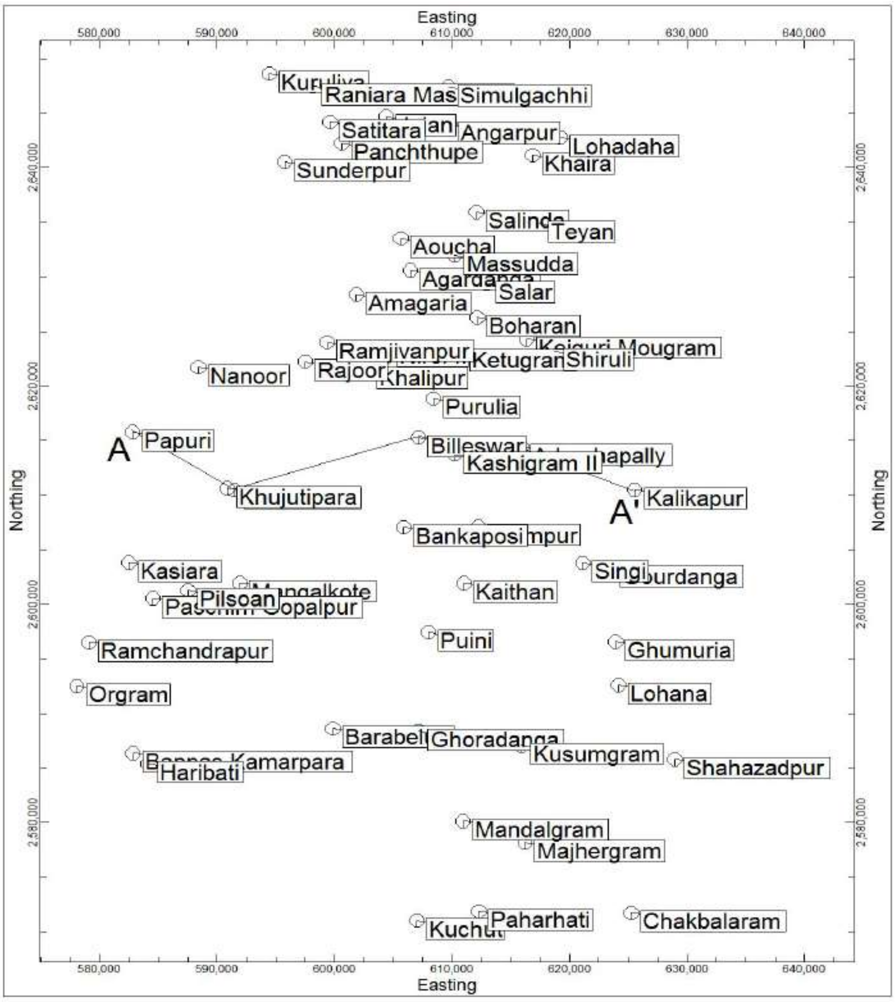


Fig. 5.0.5: W-E Section index line - 1

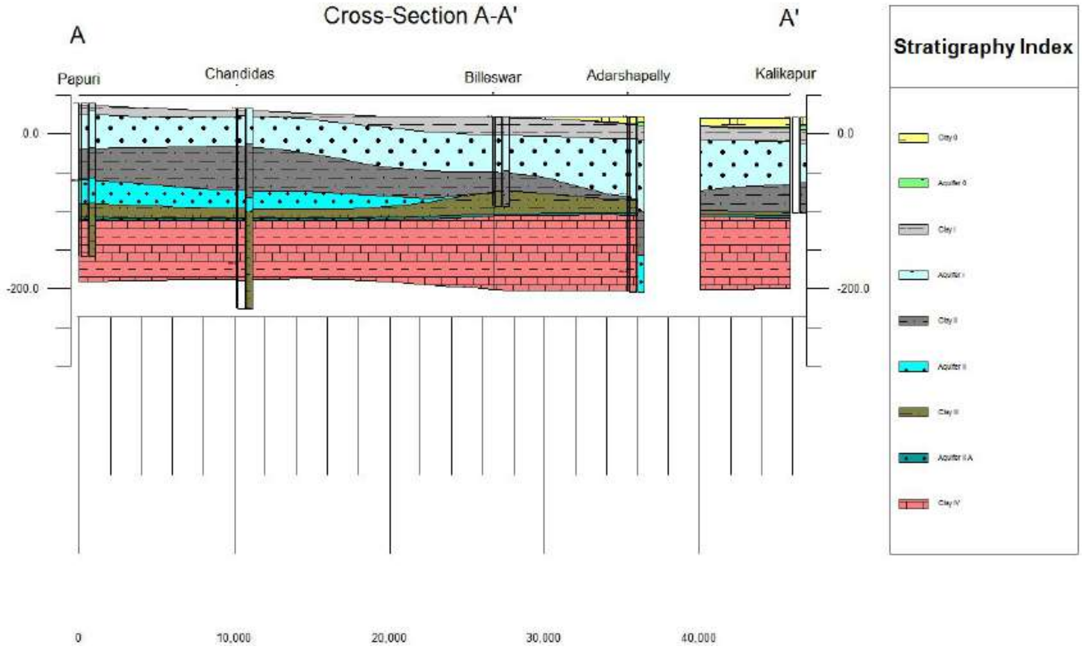


Fig. 5.0.6: W-E Section - 1

6. HYDROGEOLOGY

6.1 Water bearing Formation and Aquifer groups:

The area under study isoccupied mainly by Older Alluvium, overlying the Tertiaries and underlain by a thin veneer of Younger Alluvium in the eastern part of Ketugram II, Katwa I and Katwa II blocks. Tertiaries are encountered at deeper levels. After analysing exploratory data of CGWB up to a maximum depth of about 350 m bgl and tube well data collected from State Govt. Departments, it is suggested that in the study area, there are mainly two aquifer groups, i.e., Aquifer I and Aquifer II; besides there are two other aquifer groups: Aquifer '0' and Aquifer III. Aquifer I have been encountered in all the 12 blocks, Aquifer II has been encountered in 7 blocks and not encountered in Burwan, Bharatpur II, Ketugram II, Katwa II, and Manteswar blocks.

The aquifer groups comprise a single or more aquifers with intervening thin clay lenses/ beds. In blocks of Burwan, Manteswar, Bharatpur II, Katwa II and Manteswar,only single aquifer, Aquifer I is encountered up to the exploration depth of 200 m. In Bharatpur I , Ketugram I and Mangalkote blocks, there are two aquifers in Aquifer I. Similarly, in Ketugram I, Memari II, there are two aquifers in Aquifer II. Aquifer 0 is encountered within a depth of 40 m bgl in very limited area in three blocks, viz. Ketugram II, Katwa I and Katwa II. Aquifer III is encountered only in Nanoor block, which shows two aquifers in this group; also, it appears that in this block Aquifer II and Aquifer III tends to merge together in the east/ north-east.

Out of two main aquifer groups, i.e., Aquifer I & Aquifer II, the first one i.e. Aquifer I is the major one. Aquifer I is prolific and regionally extensive; this aquifer is encountered generally within Older Alluvium but found to be extended up to 145 m in the Tertiaries from ground surface. Thick aquifer I has been encountered in Manteswar, Bharatpur I, Mangalkote, Burwan and Memari II blocks. Maximum thickness of 135 m of Aquifer I has been encountered at Kusumgram in Manteswar block. In Older Alluvium, it is mainly greyish brown to yellowish brown to golden brown in colour, fine to very coarse sand and even sometimes gravel sized in nature; but, when it extends in the lower Tertiaries, it is grey/blackish grey and generally finer in nature.

Layers of second aquifer, i.e. Aquifer II, is thin in nature and is encountered within the depth range of 83-240 m in the Tertiaries. Cumulative thickness of this aquifer varies between 17 m in Ketugram I and 51 m in Katwa I block; data from state agency shows that thickness of this aquifer in Bhatar block is about 75 m. Sediments in Aquifer II is mainly greyish, very often becomes dark in nature and generally finer grained.

Between Aquifer I and aquifer II, there is a thick clay layer, the thickness of which varies from block to block; maximum thickness of this clay (Clay II) has been encountered 26.51 m in Memari II and 73.73 m in Katwa I. Clay II, Clay III and Clay IV are of same type belonging to the Tertiaries. Parting and coalescence of aquifers and presence of sticky clay layers is very common in Aquifer II.

The third aquifer or Aquifer III of cumulative thickness of 25 m comprising two layers has been encountered at depth in the Tertiaries only in Nanoor block, where exploration by CGWB was carried out up to a much higher depth and encountered this aquifer within 247-336 m. This aquifer could not be studied in detail due to paucity of data & its occurrence at greater depth. This is obviously fine grained, dark coloured.

In study area, the top most aquifer i.e. Aquifer ‘0’ has been sparsely encountered in patches as thin veneers of Younger Alluvium in Ketugram II, Katwa I and Katwa II blocks within a depth of 40 m. The thickness of this aquifer ranges between 3.05 m to 6 m in the present area. It is characteristically light coloured, sometimes variegated in nature and comprised of sand, silt and clay.

The 2D/3D views of the aquifer system in the subsurface of study area have been shown inFig. 6.1.1 to Fig. 6.1.7.

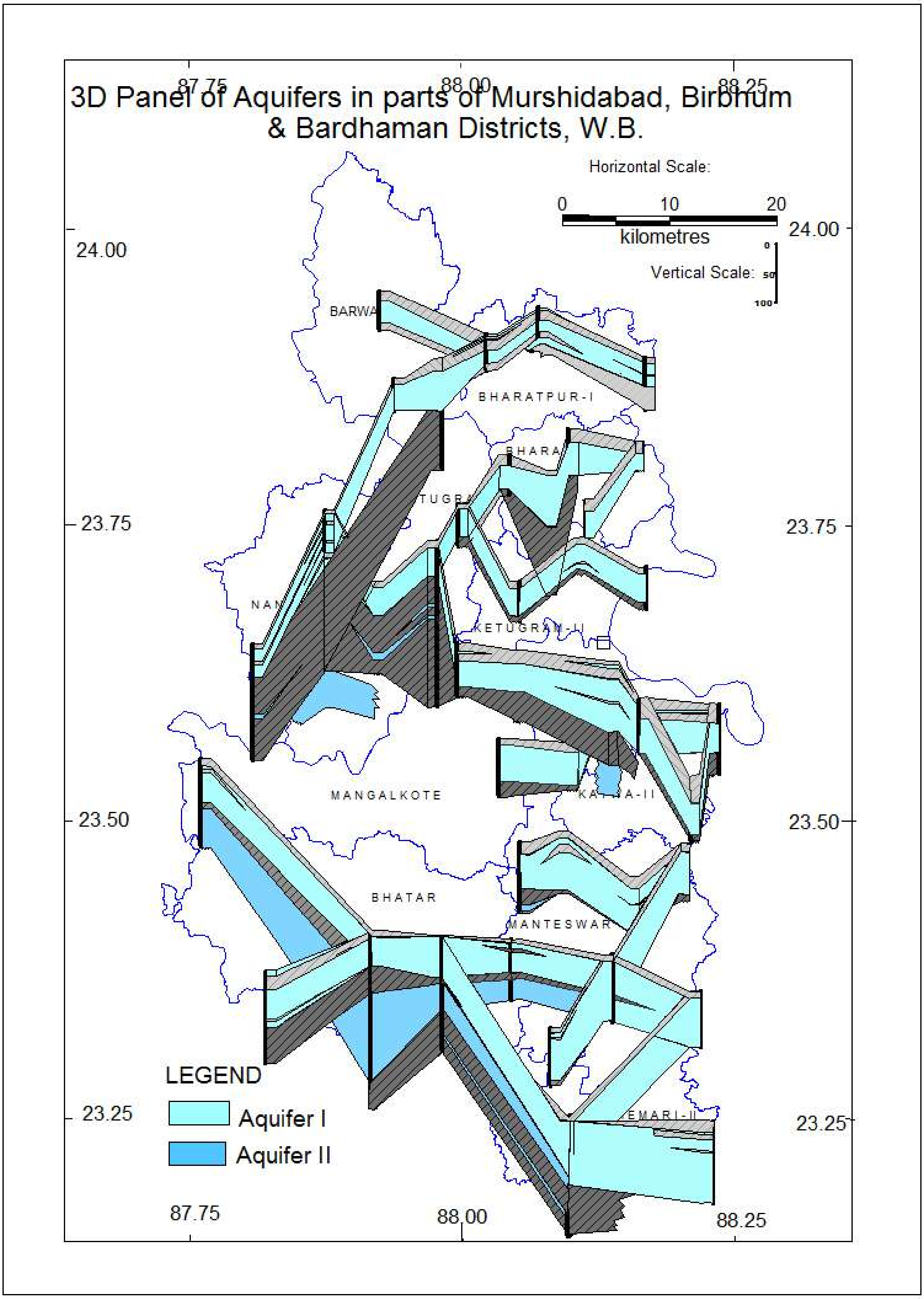


Fig. 6.1.1: Aquifer disposition of Aquifer I, Aquifer II& Aquifer III in study area.

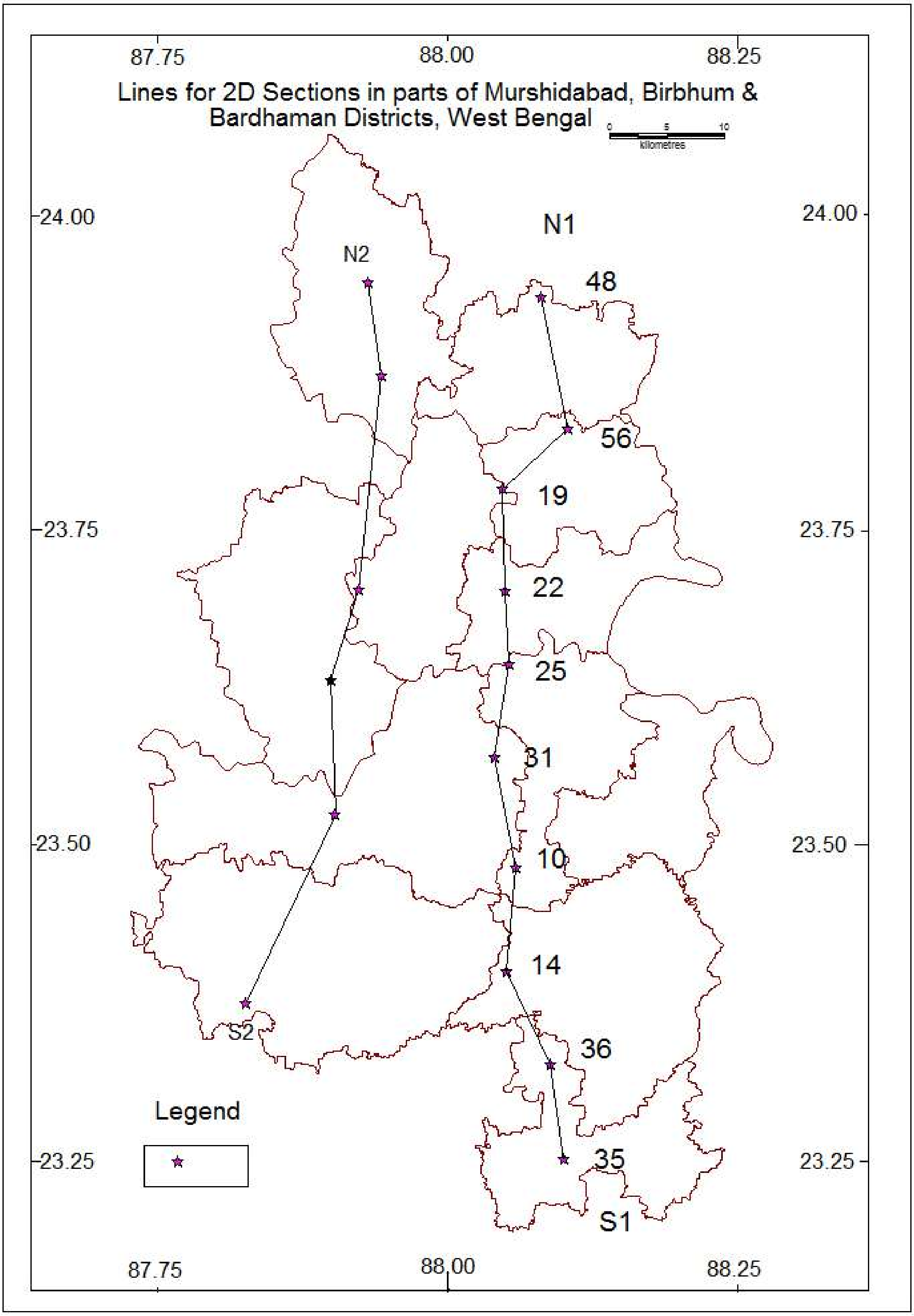


Fig. 6.1.2: Section lines (north-south): N1-S1, N2-S2 study area

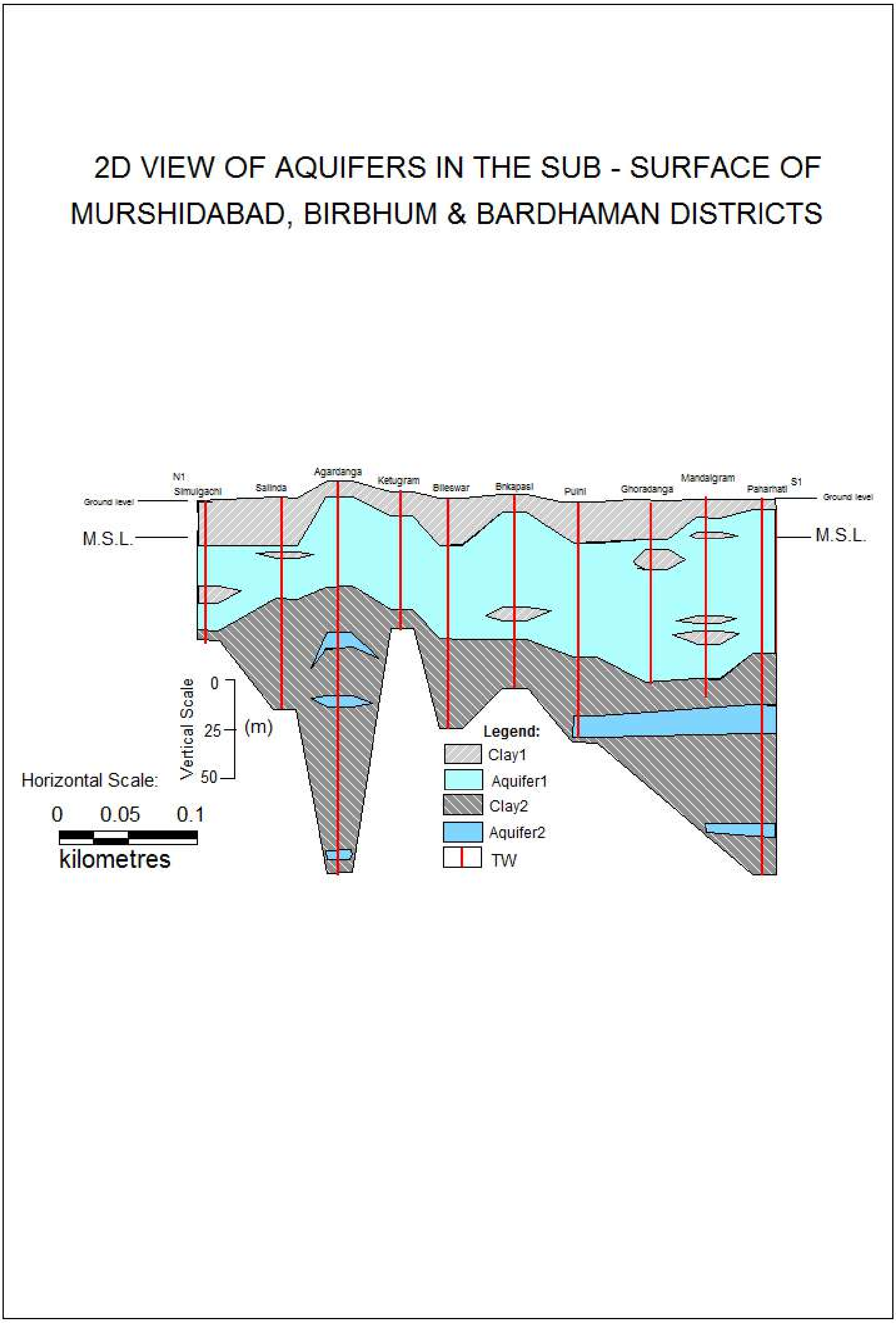


Fig. 6.1.3: 2D section of aquifers along N1-S1 section line

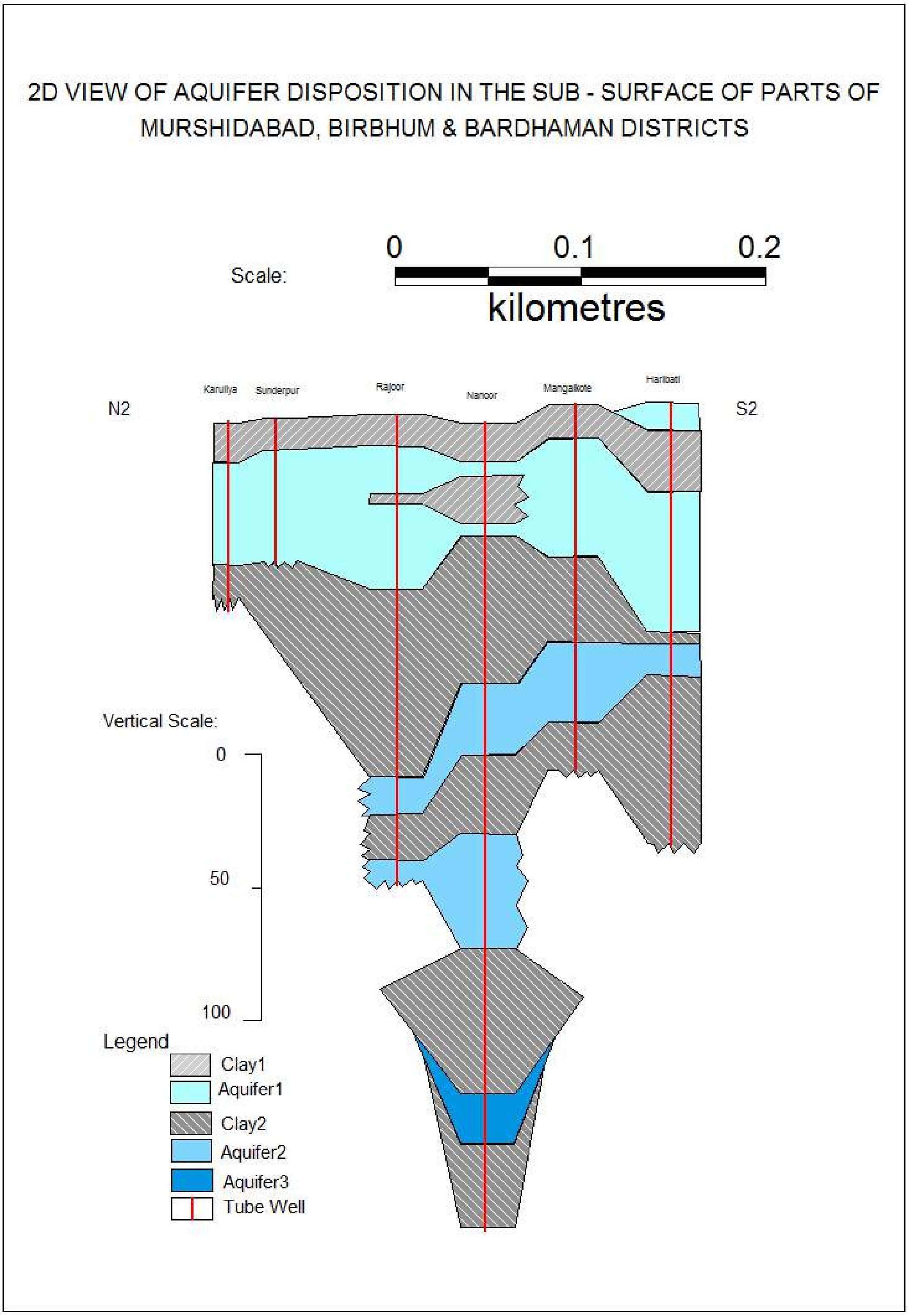


Fig. 6.1.4: 2D section of aquifers along N2-S2 section line

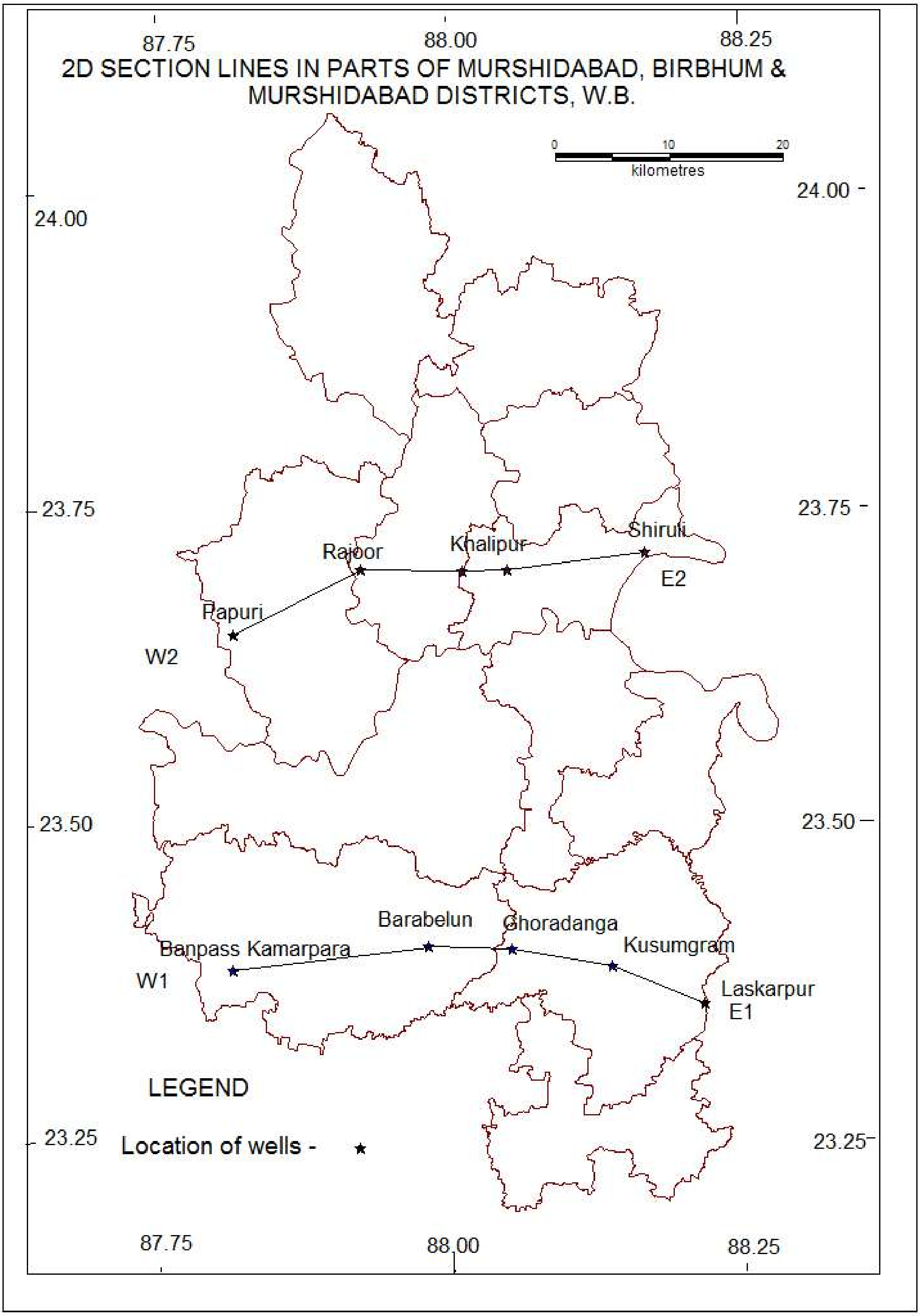


Fig. 6.1.5: Section lines (north-south): W1-E1, W2-E2 in 12 blocks

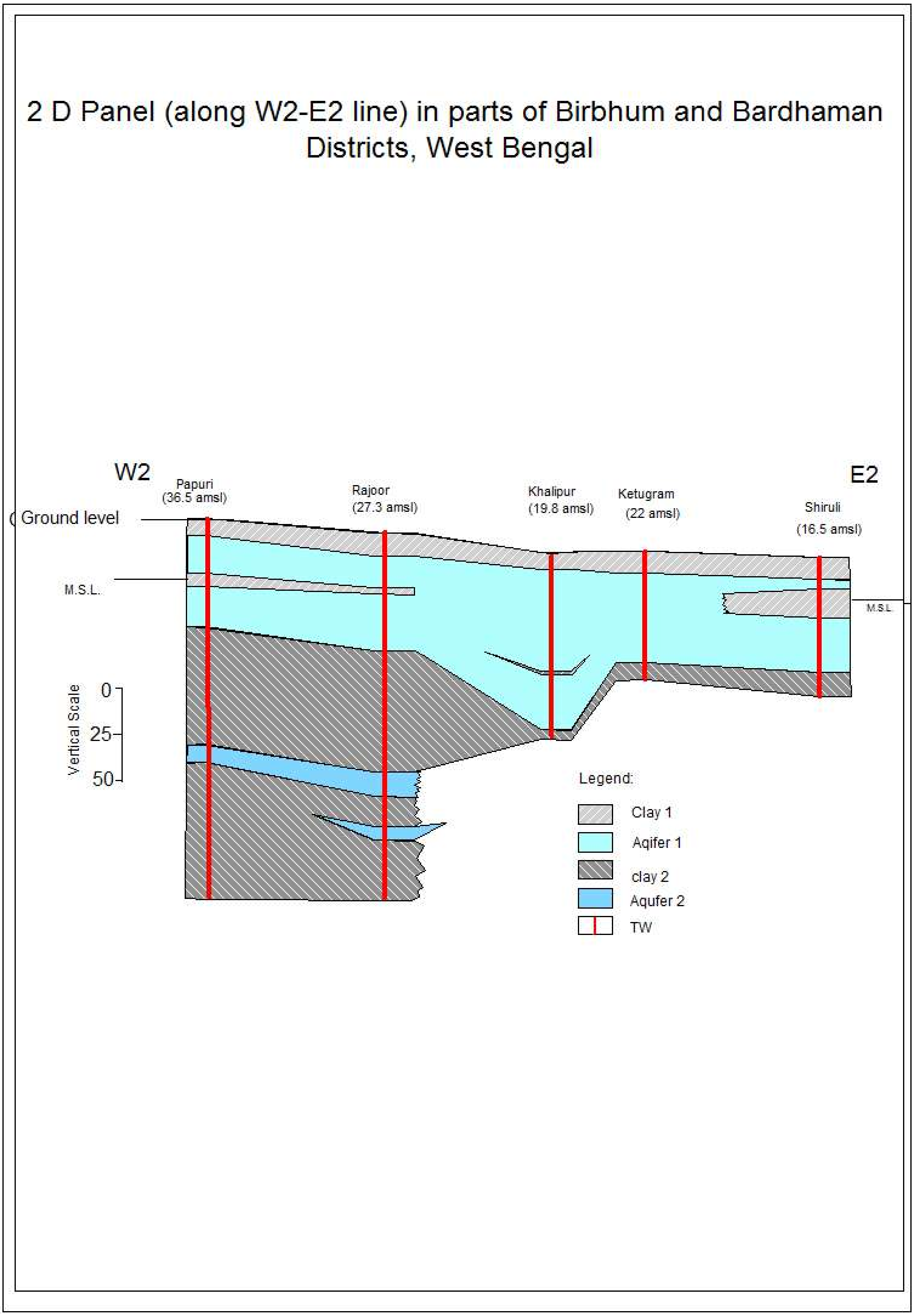


Fig. 6.1.6: 2D section of aquifers along W2-E2 section line

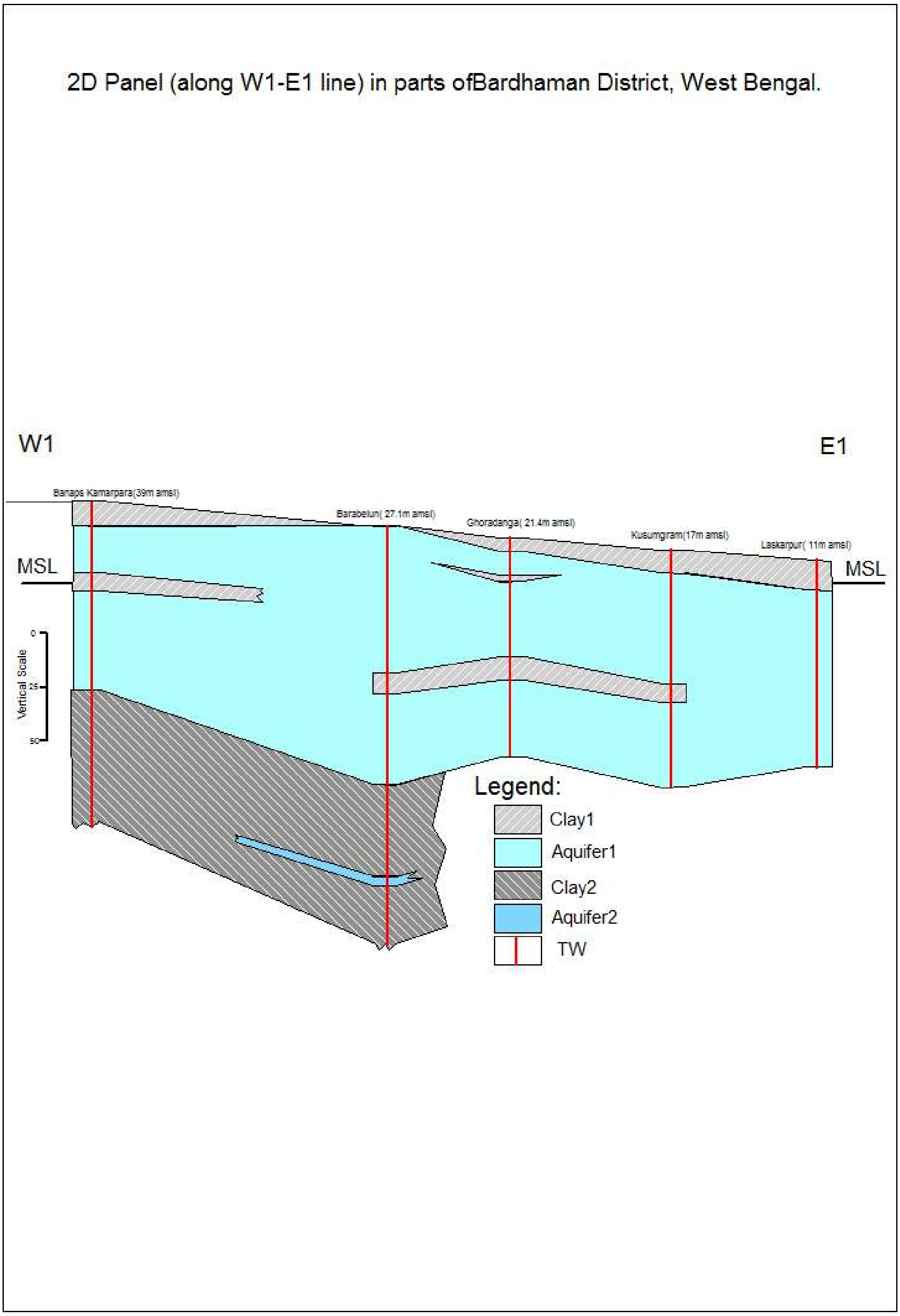


Fig. 6.1.7: 2D section of aquifers along W1-E1 section line

Lithologs in respect of exploratory tube wells of CGWB and selected tube wells of Agri-Irrigation Department and Public Health Engineering Department have been collected and compiled. A total of four aquifer groups have been deciphered: Aquifer I encountered in 12 blocks and prolific in nature, Aquifer II encountered in 7 blocks, Aquifer '0' in 3 blocks and Aquifer III in 1 block.Aquifer wise depth characteristics of different aquifers in study area have been enumerated in Table 6.1.1.

Table 6.1.1: Blockwise depth range of aquifers

Blocks	Area (ha)	Aquifer 0	Aquifer I	Aquifer II	Aquifer III
Burwan	28000	-	8-90	-	-
Bharatpur I	17800	-	10-114.5	132-145	-
Bharatpur II	*16200*	-	8-94	-	-
Nanoor	*31600*	-	10-55	83-134	247-261, 315, 336
Ketugram I	*20000*	-	8-70 (two layers)	122-134, 150-155	-
Ketugram II	*14200*	12.19-15.24	8-70	-	-
Katwa I	*18299*	6.5-12.5	21-121	180-220	
Katwa II	*16871*	11.75-24.4	12-98	-	-
Manteswar	31900	-	11.55-137, 103.63-141.73		-
Mangalkote	*36000*	-	5-72	*80.5-112	-
Bhatar	*39300*	-	10 - 88	82-122 107-130	-
Memari II	*10600*	-	7.5-80	105-118, 165-178	-

.* joins with Aquifer I in the north-east

6.2 Aquifer wise groundwater regime, depth to water level, etc.

During detailed survey 143 numbers of key observation wells have been established in the study area including existing Network Hydrograph Stationsof CGWB, for water level monitoring and water sample collection. These are mostly tube-wells; out of these stations, 106 nos. of stations within 7.28 – 121.92 m bgl representI^{st} aquifer, 23 nos. of key wells represent 2^{nd} aquifer with depth range between 91.44 and 294 mbgl, and 4 stations sparsely situated within 0-40 m bgl in Ketugram II, Katwa I and Katwa II blocks representingAquifer ‘0’; there is no representative of key well of Aquifer III. However, CGWB has constructed one expl. well tapping Aquifer III. Pre-monsoon and post-monsoon depth to water levels including 106 wells representing Aquifer I and 4 wells representing Aquifer ‘0’ have been tabulated and given in Annexure Ia and pre-monsoon and post-monsoon depth to water levels of 23 wells of Aquifer II have been tabulated and given in Annexure Ib. Graphical representation of key wells representing Aquifer I and Aquifer II have been shown in Plate 6.2.1 and Plate 6.2.2.

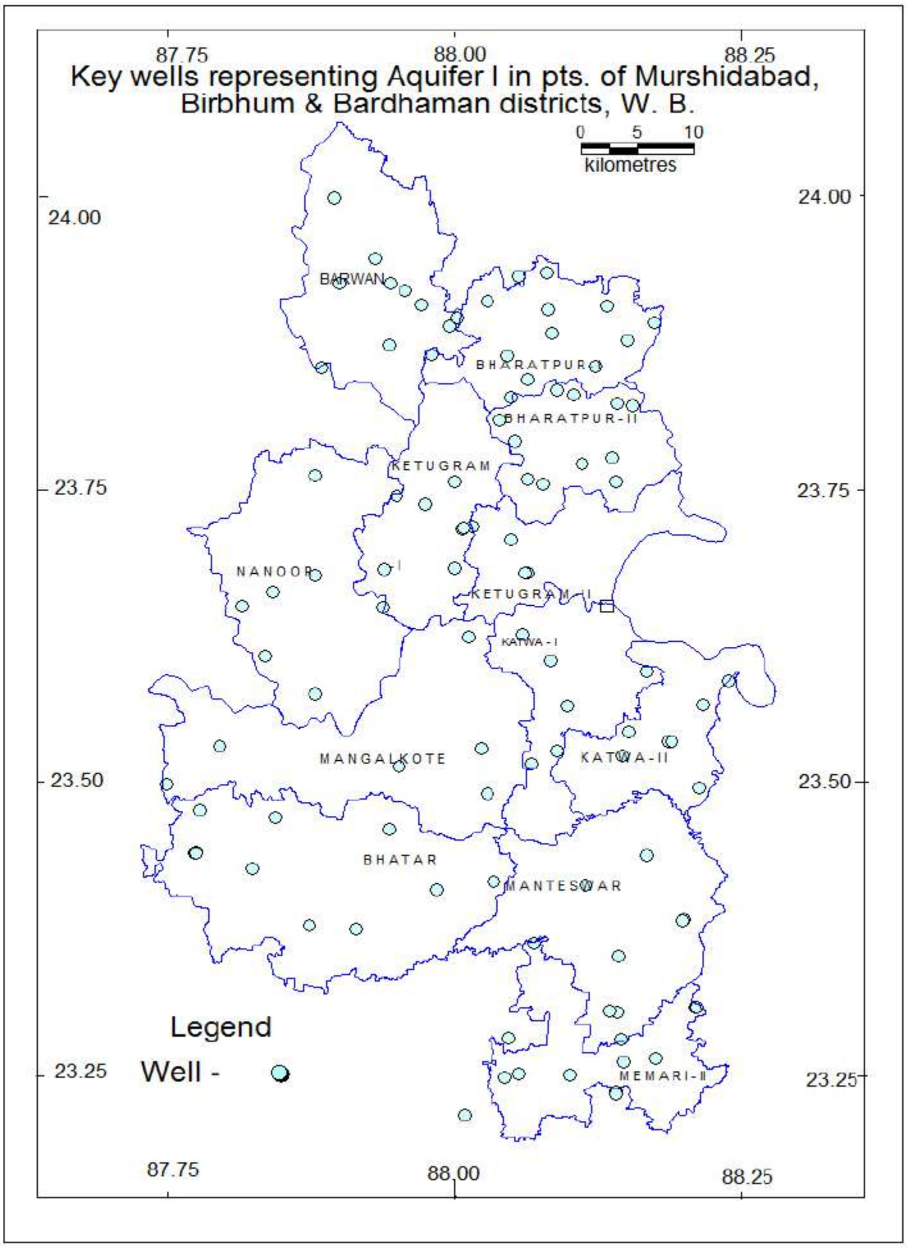


Plate 6.2.1:Key wells representing Aquifer I in study area

6.2.1Aquifer I

The Pre-monsoon depth to water level in Aquifer I in present area has been graphically presented in Plate 6.2.1a, what reveals that in the major part the water level is deep, ranging within 10-20 m bgl; but, zones of deeper water level within 20-40 m bgl are mainly encountered in i) southern part covering adjoining parts of blocks of Manteswar, Mangalkote, Katwa II and Bhatar, ii) northern part covering blocks of Ketugram I, Ketugram II, Bharatpur Iand Bharatpur II, iii) southeast part of Burwan block and iv) northern part of Nanoor block.

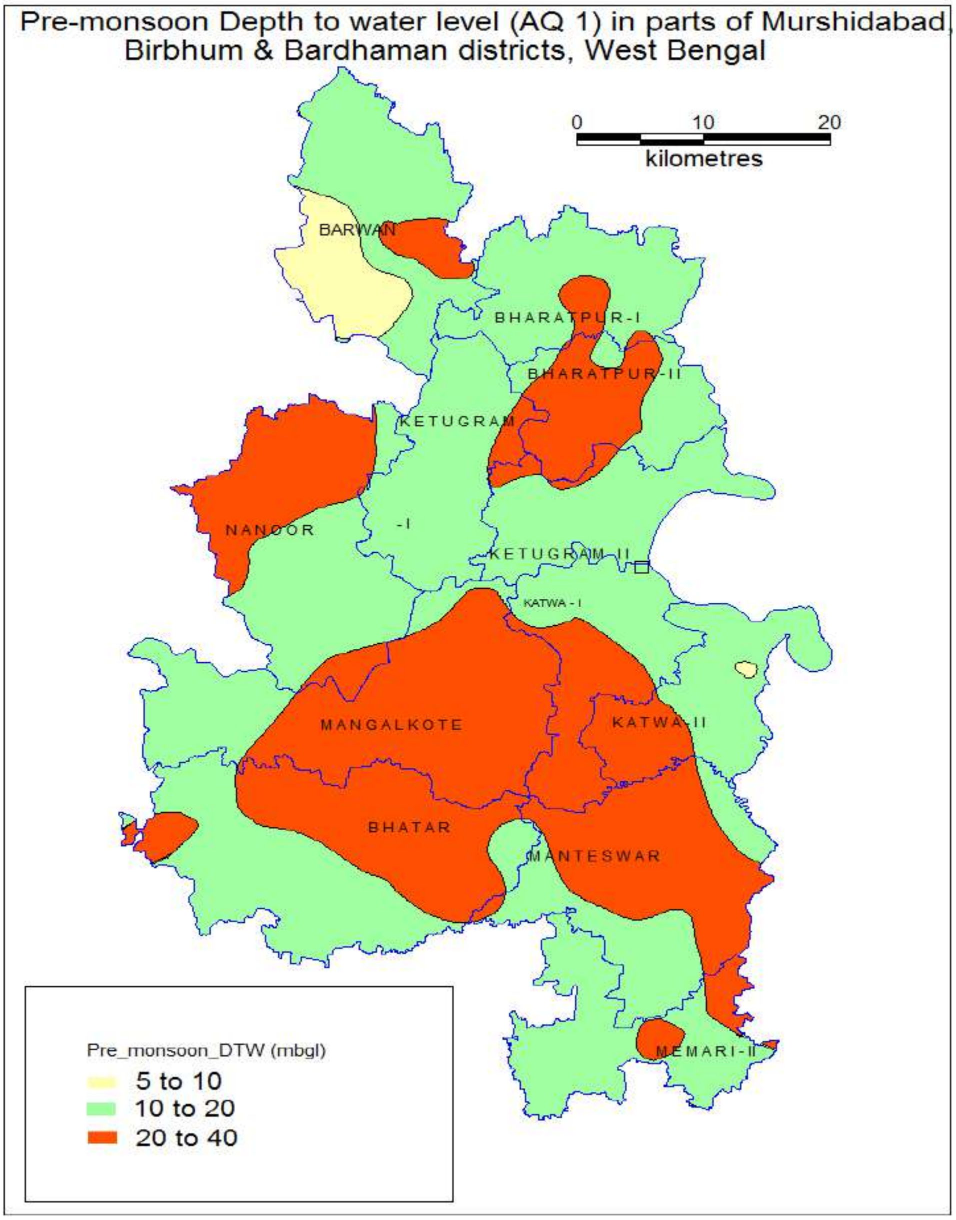


Plate 6.2.1a: pre-monsoon depth to water level in Aquifer I

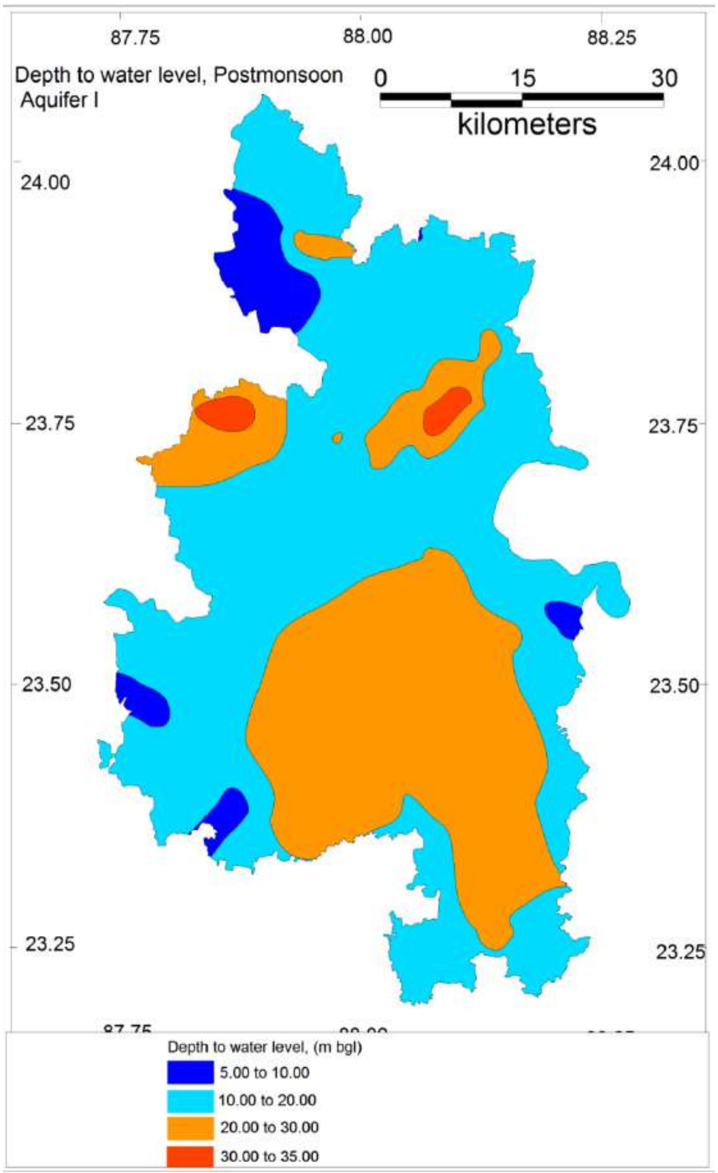


Plate 6.2.1b: post-monsoon depth to water level in Aquifer I

Shallow water level within 5-10 m bgl is very much restricted in a narrow portion at the extreme north-eastern part of Katwa II blocks and in southwestern part of Burwan block

The post-monsoon depth to water level mapof Aquifer I, shown in Plate 6.2.1b,reveals almost the same water level character as that of pre-monsoon, i.e. in major part of the area, water level within 10-20 m bgl has been observed; besides, zones within 20-30 m bgl are mainly encountered in patches in i) southern part covering adjoining parts of blocks of Manteswar, Mangalkote, Bhatar & Memari II, ii) northern part covering blocks of Ketugram II and Bharatpur II, iii) small southeast part of Burwan block and iv) northern part of Nanoor block of study area.Shallow water level within 5-10 m bgl is very much restricted in parts of Katwa II blocks, in small south-western part of Burwan block, and western patches of both Mangalkote & Bhatar block.Both pre and post depth to water level maps show creation of local deep water level, which might be due to heavy irrigation practices in those parts.

6.2.2Aquifer II

On the basis of available data, pre-monsoon depth to water level for Aquifer IIhas been drawn in concerned 7 blocks of study area only and it has been shown in Plate-6.2.2a,whichrevealsthat thedepth to water level is mostly deep ranging between 20-30 m in the south- southwestern sector and in the northeastern part covering parts of Mangalkote, Memari II, Bharatpur I and Bhatar; water level within 10-20 m is encountered along NW-SE stretch in the northern part covering part of Ketugram I and Katwa I and in a small part in the west; however, eastern part of Memari II, northern part of Nanoor and border of Bhatar &Mangalkote show water level of more than 30 m. (vide Plate 6.2.2 a).

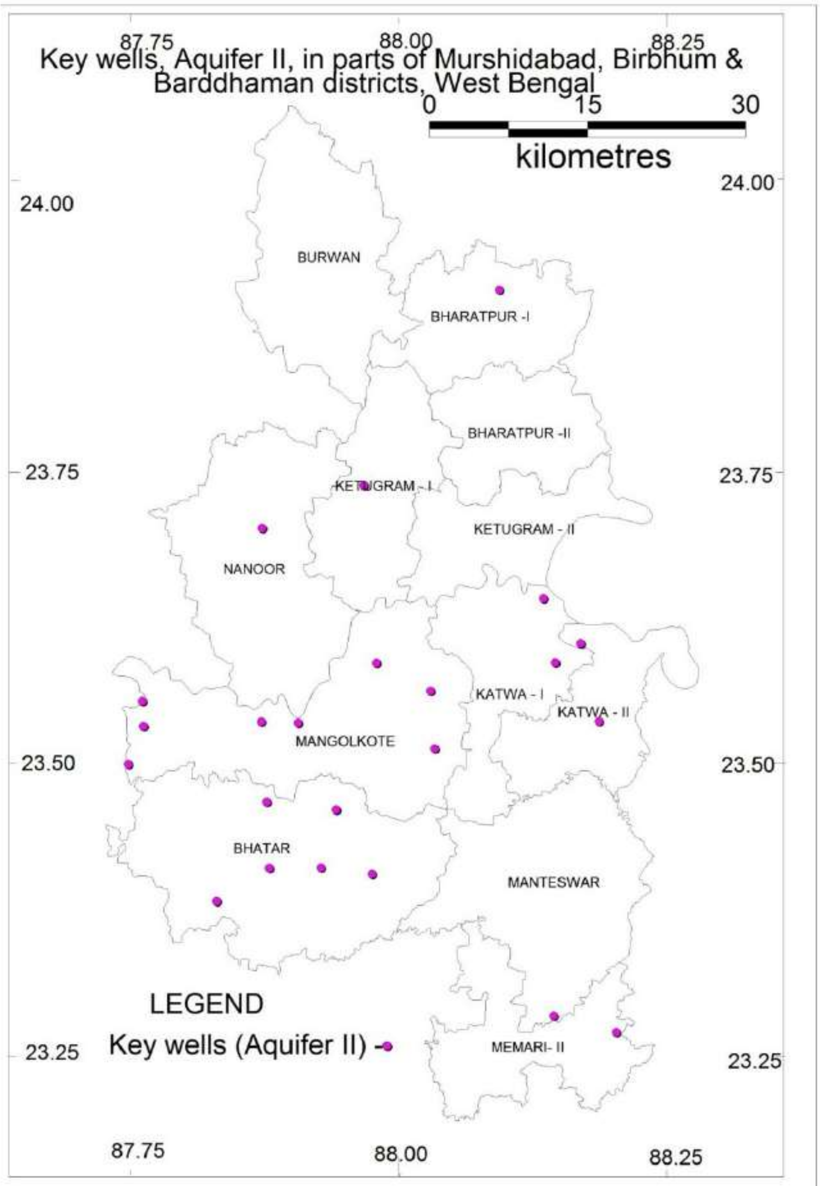


Plate 6.2.2: key wells representing Aquifer II

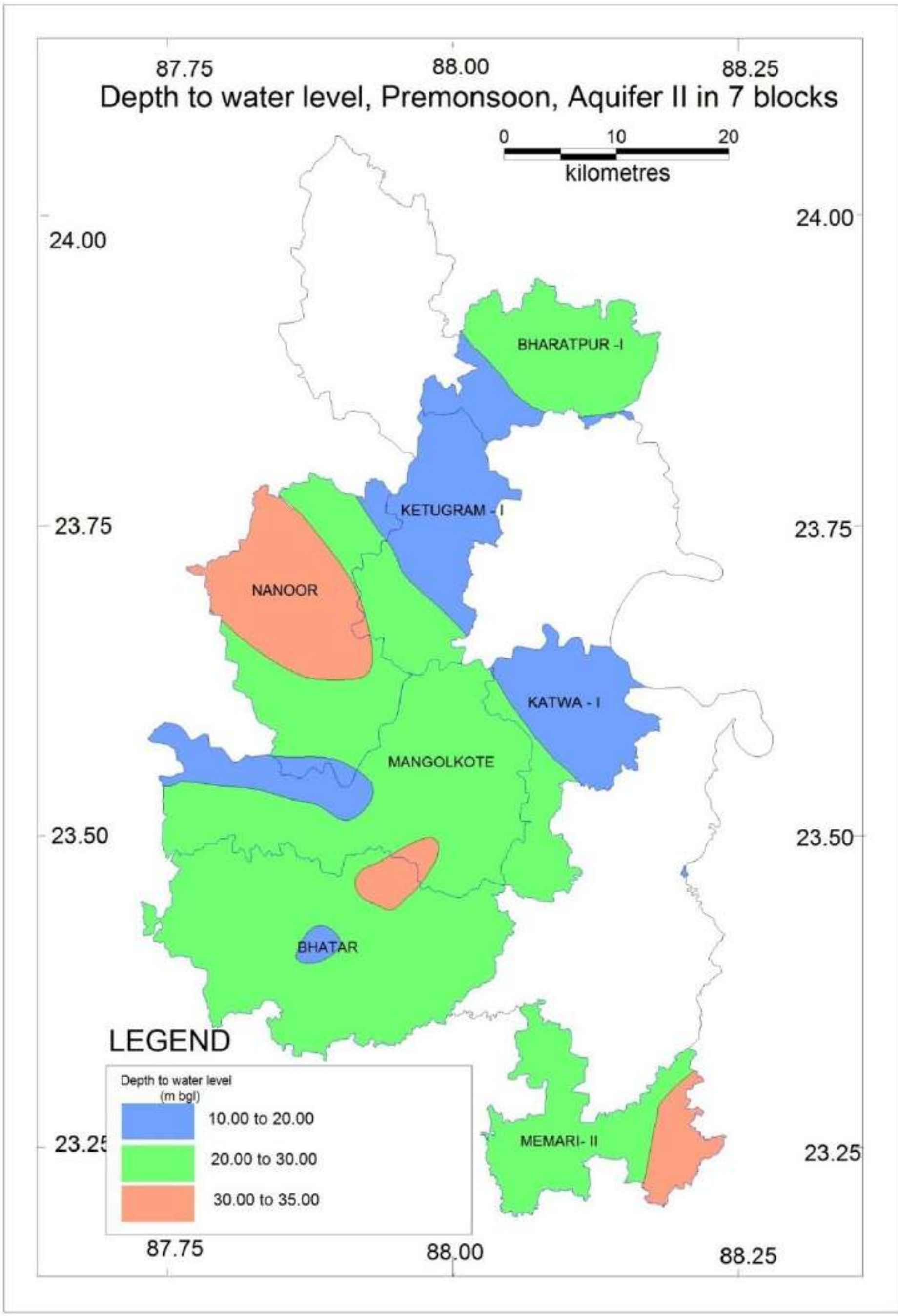


Plate 6.2.2 a: pre-monsoon depth to water level representing Aquifer II

Likewise, post-monsoon depth to water level map (vide Plate-6.2.2 b) for Aquifer II of the concerned 7 blocks has also been drawn and the same reveals that shallow water level within 10-18 m bgl mainly in the north along NW-SE stretch covering Ketugram I and Katwa I and in the west covering part of Mangalkote, water level between 18-25 m has been encountered mainly in parts of Memari II, Mangalkote and Bharatpur I, and water level within 25-33 m has been found in narrow NW-SE stretch in the central part covering parts of mainly parts of Nanoor and Mangalkote.

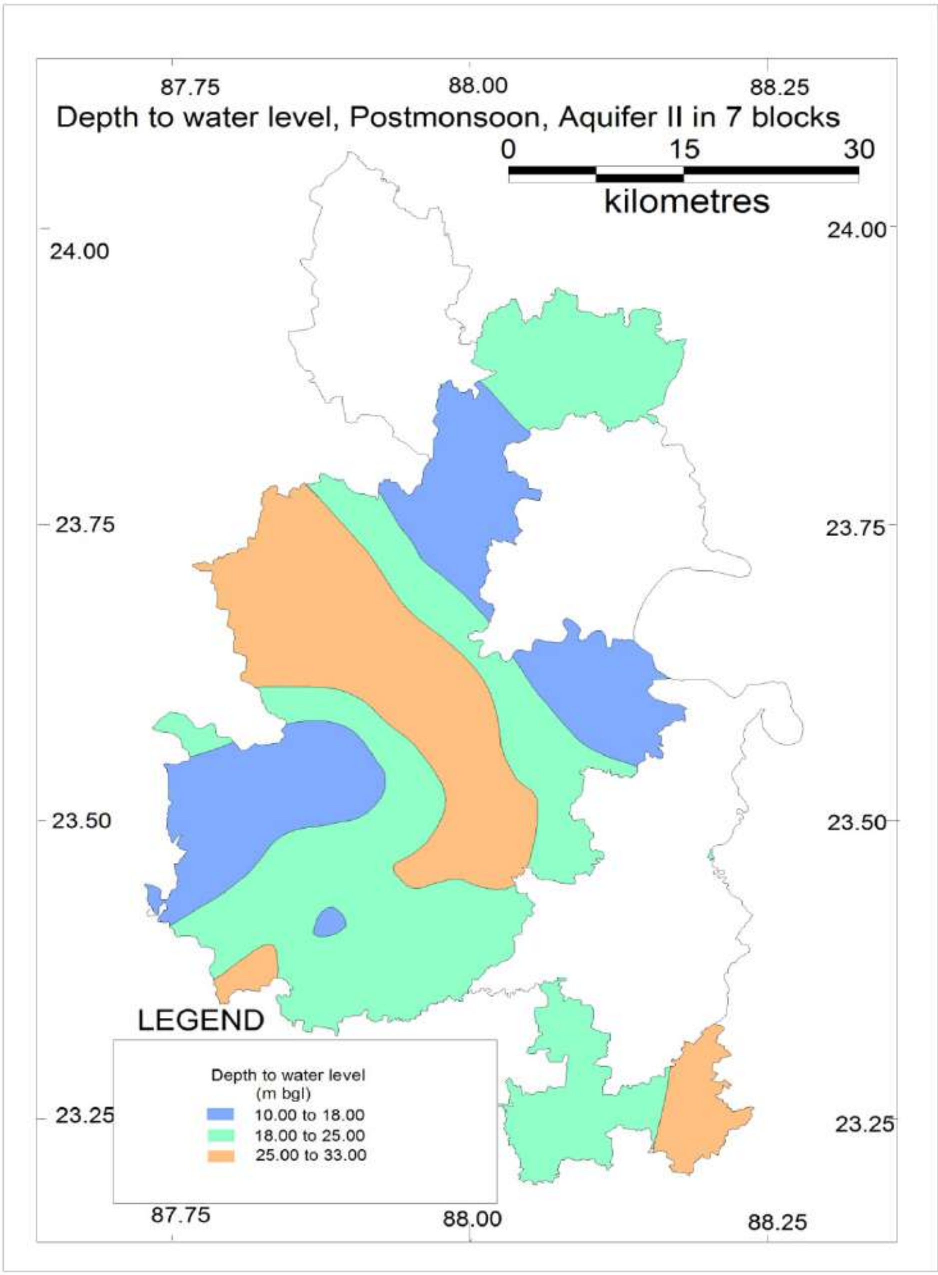


Plate 6.2.2 a: post-monsoon depth to water level representing Aquifer II

Available aquifer characteristics of Aquifer I and Aquifer II have been shown in Table 6.6.

6.2.3 Aquifer'0'

Aquifer '0' has been encountered in a small part within flood plain area of blocks of Ketugram II, Katwa I and Katwa II in the proximity areas beside Bhagirathi River. 4 nos. of wells are established to represent this aquifer. The details of these wells have been tabulated in Annexure 1a. Depth to water level in this aquifer ranges between 1.87 and 11.65 in pre-monsoon, and between 5.11 and 9.59 during post-monsoon.

6.2.4 Aquifer III

This aquifer has been encountered in Nanoor block in Birbhum district during exploration by CGWB by deep drilling up to 350 m. However, from nowhere else in the study area data of deep exploration for ground water is available. Depth to water level varies between 1.2 to 4.07 m bgl. Transmissivity of this aquifer is found to vary from 0.83 to 17.91 m^2/day. Discharge has been reported to be 1.66 lps.

6.3 Occurrence and movement of ground water:

In study area, ground water occurs mostly under water table conditions in Aquifer I and semi-confined to confined condition in Aquifer II; both of these aquifers is distributed all over the study area. Aquifer '0', very much restricted in a narrow patch in flood plain of Ketugram II, Katwa I and Katwa II blocks, occurs under phreatic condition in the dug well zone up to about 30 m depth. Aquifer III,encountered in exploration by CGWB in Nanoor block at depths of 247-261 & 315-336 exist under confined condition.

In study area, Aquifer I and Aquifer II are two major aquifers and data of these aquifers are available. Therefore, discussion has been made regarding these aquifers only. Data of Aquifer '0' and Aquifer III are very few.

6.3.1 Aquifer I

From the Water Table Map, Plate 6.3.1a, representing Aquifer I showswater table contours (May-2016). It is observed that, ground water table ranges from less than (-) 10.15 m below msl(meter below mean sea level) in Memari II block in southeast to more than 42 m amslin Burwan block in the northwestduring pre-monsoon period.There is no fixed direction of ground water flow; it may be due to haphazard development of ground water resources due to unplanned withdrawal. Groundwater.This map also shows that locally pockets of ground water surface below mean sea level has been encountered in the subsurface at many places, particularly in and around Memari II block, in the adjoining parts of Bhatar & Mangalkote blocks, in Manteswar block, in Ketugram-katwa sector, etc.Ground water trough like situation has been visualized in Memari II block and this might be due to excessive irrigation for cultivation of 'boro' rice. Ground water of higher elevations has been observed in north western part in Burwan.

From the post-monsoon water table contour map (Plate 6.3.1 b: November - December, 2016), i.e., during post-monsoon period, almost same situation is observed as above. Ground water table ranges from less than (-) 10.15 m below msl(meter below mean sea level) in Memari II block in southeast to more than 45 m amsl in Burwan block in the northwestduring pre-monsoon period; elevation of water table up to about 30 m above mean sea level has also encountered in the southeast of present area i.e. in Memari II block.Pockets of ground water surface below mean sea level has been encountered in the subsurface at many places, particularly in and around Memari II block, in the adjoining parts of Bhatar & Mangalkote blocks, in Manteswar block, in Ketugram-Katwa sector, etc; these pockets of more and haphazard ground water withdrawal are more pronounced in this season. Formation of ground water trough has been clearly depicted in Memari II block too. In this season also, there is no particular direction of ground water flow.

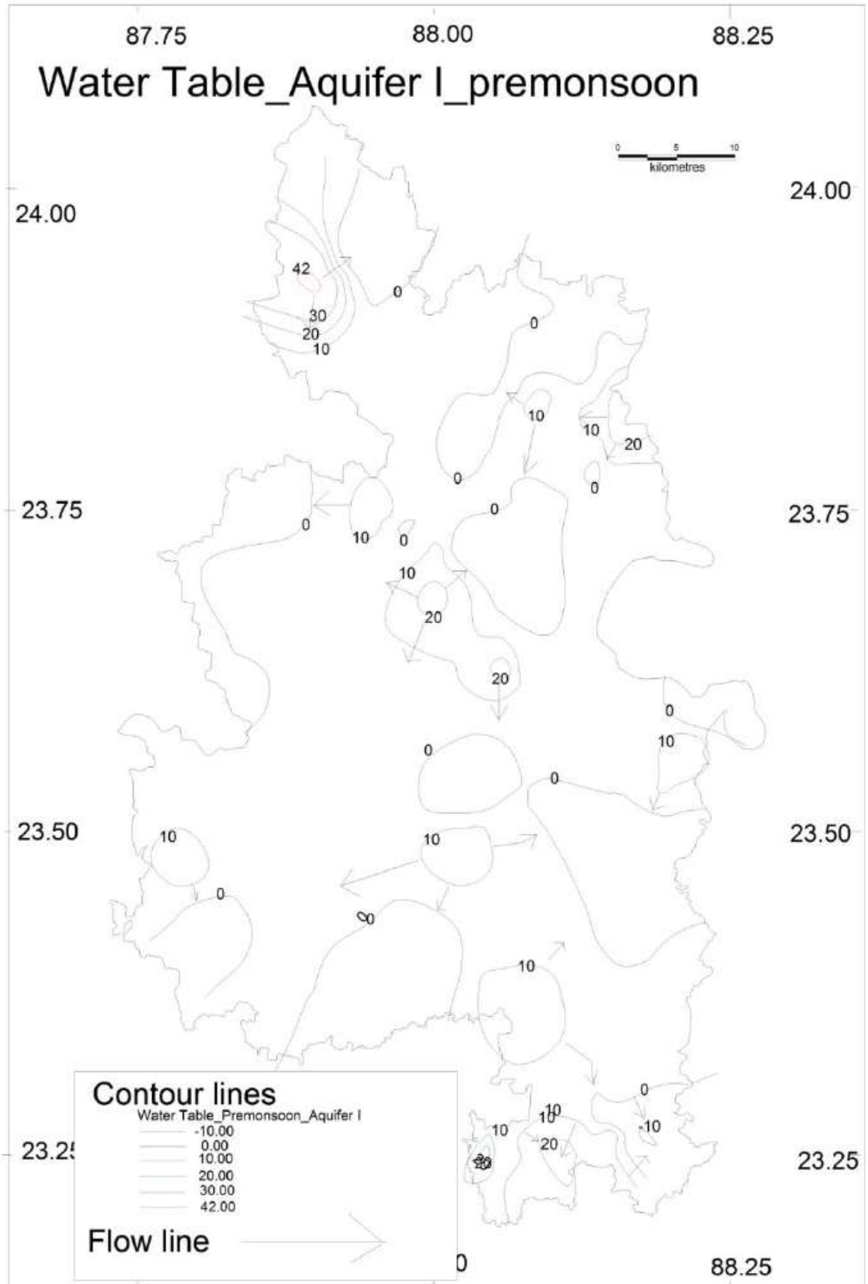


Plate 6.3.1 a: Water table (Aquifer I)

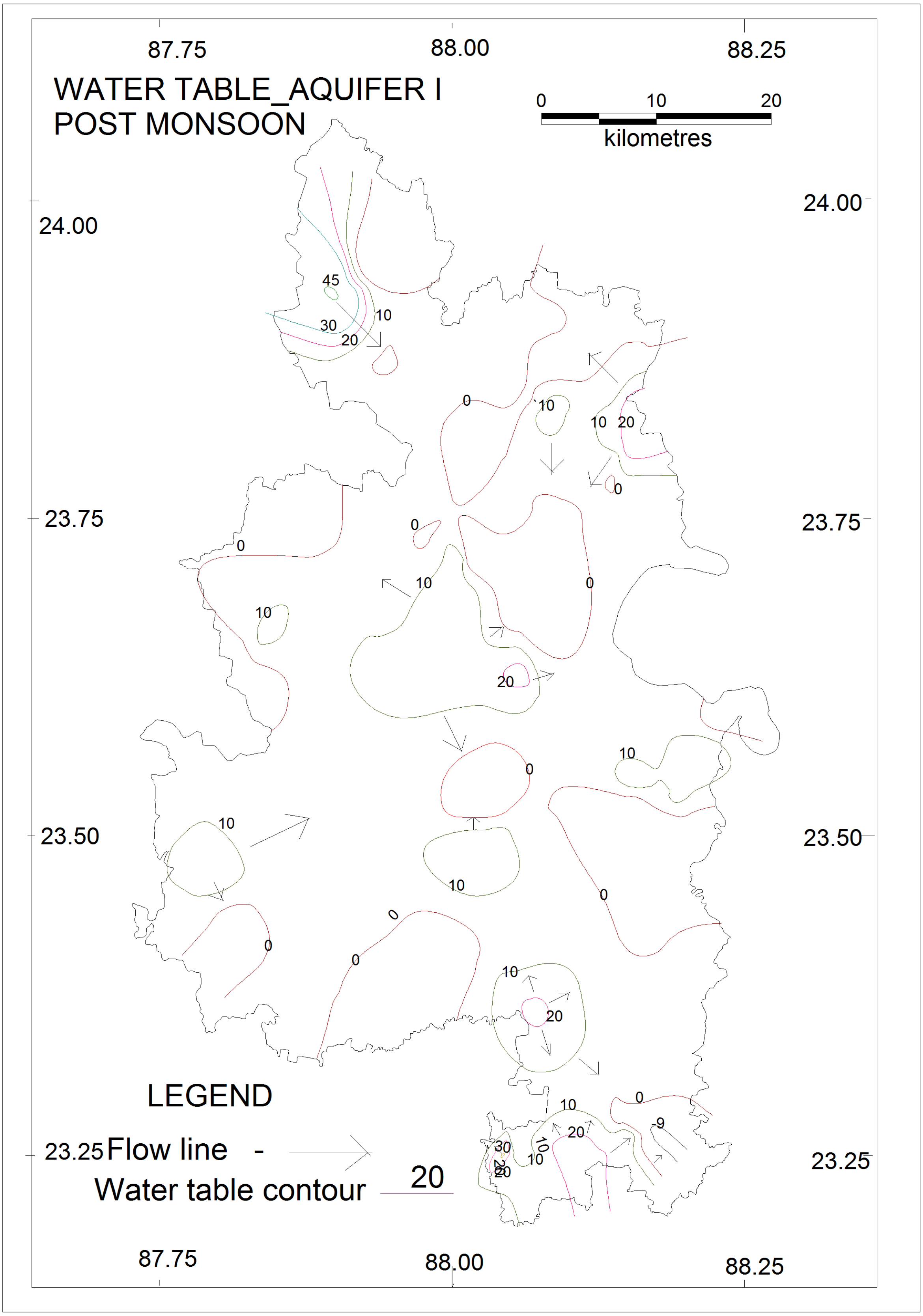

87.75
88.00
88.25
WATER TABLE_AQUIFER I
POST MONSOON
0
10
20
kilometres
24.00
24.00
23.75
23.75
23.50
23.50
23.25
23.25
LEGEND
Flow line -
Water table contour
20
87.75
88.00
88.25

Plate 6.3.1 b: Post-monsoon water table (Aquifer I)

6.3.2 Aquifer II

Aquifer II has been encountered only in 7 blocks as envisaged from the exploration data. So, piezometric surface has been drawn for premonsoon and postmonsoon only. From the piezo-metric surface map (Plate-6.3.2a)drawn based on data of premonsoon (May, 2016), it is observed that maximum elevation of piezometric surface of about 15 m above msl is restricted in and around Bhatar and Mangalkote blocks in southwest and less than – 15 m below msl in the southeast, especially in Memari II block; in the northern part of study area elevation of this surface is restricted within 0-5 m above msl. In the southern part, ground water generally flows from northwest to southeast, whereas in the north it flows northeasterly. Study of this map shows formation of one ground water depression in the central part of study area; lowest elevation of the same is about 5 m below msl. in and around Mangalkote block.

From the piezometric line map (**Plate-6.4.2b)**for post-monsoon period (November-December, 2016), it is observed that it is almost the replica of the water table map of pre-monsoon. Maximum elevation of water table more than 20 m above msl is restricted in south west in and around Bhatar block& minimum elevation of – 9 m below msl and less in the south east in and around Memari II block. In the southern part ground water flows generally in SW-NE direction. Like premonsoon period, post monsoon piezometric map also reveals formation of very shallow ground water depression in and around Bhatar area. This may be due to excessive irrigation for boro cultivation.

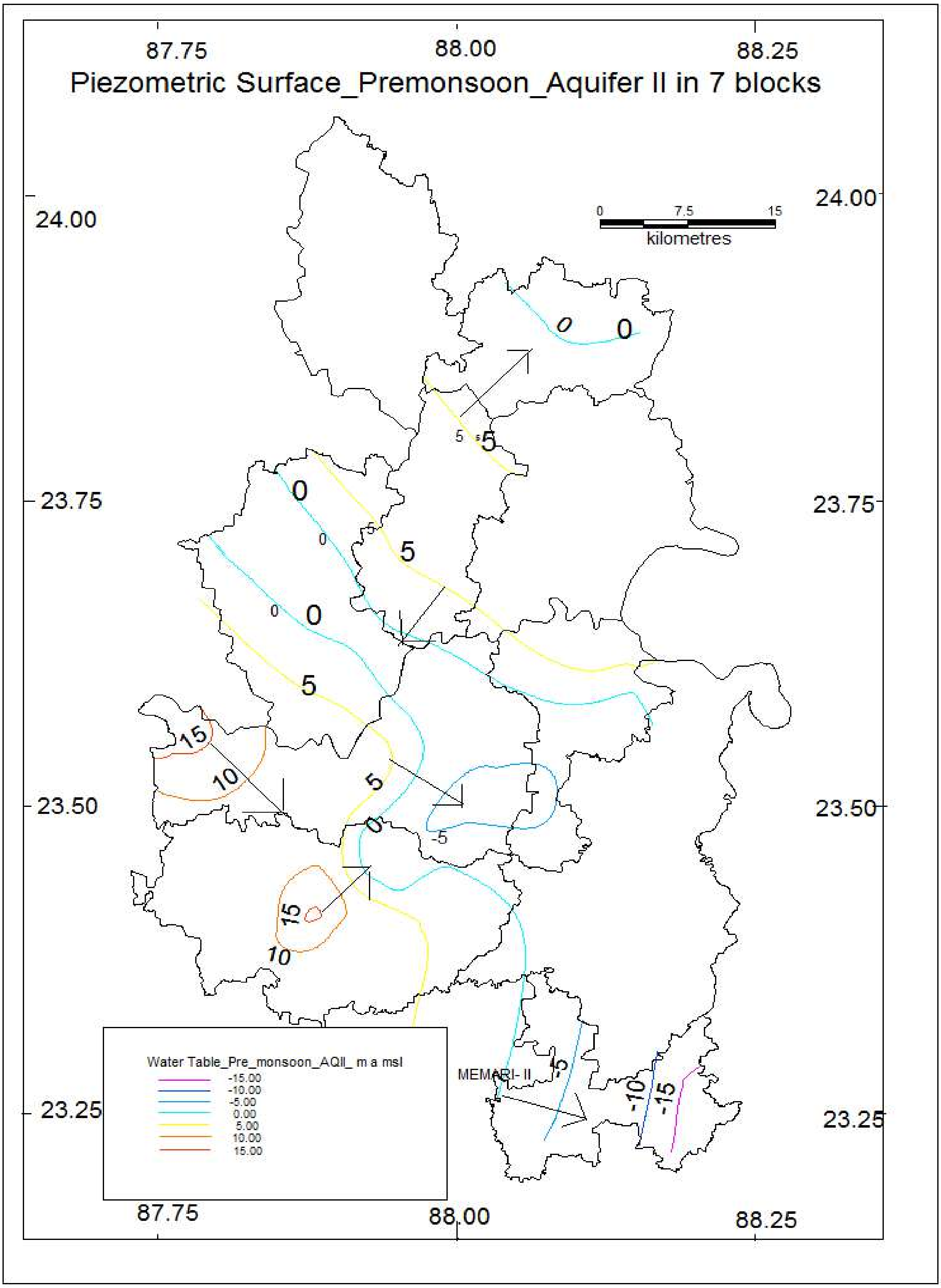


Plate 6.3.2 a: Pre-monsoon piezometric surface (Aquifer II)

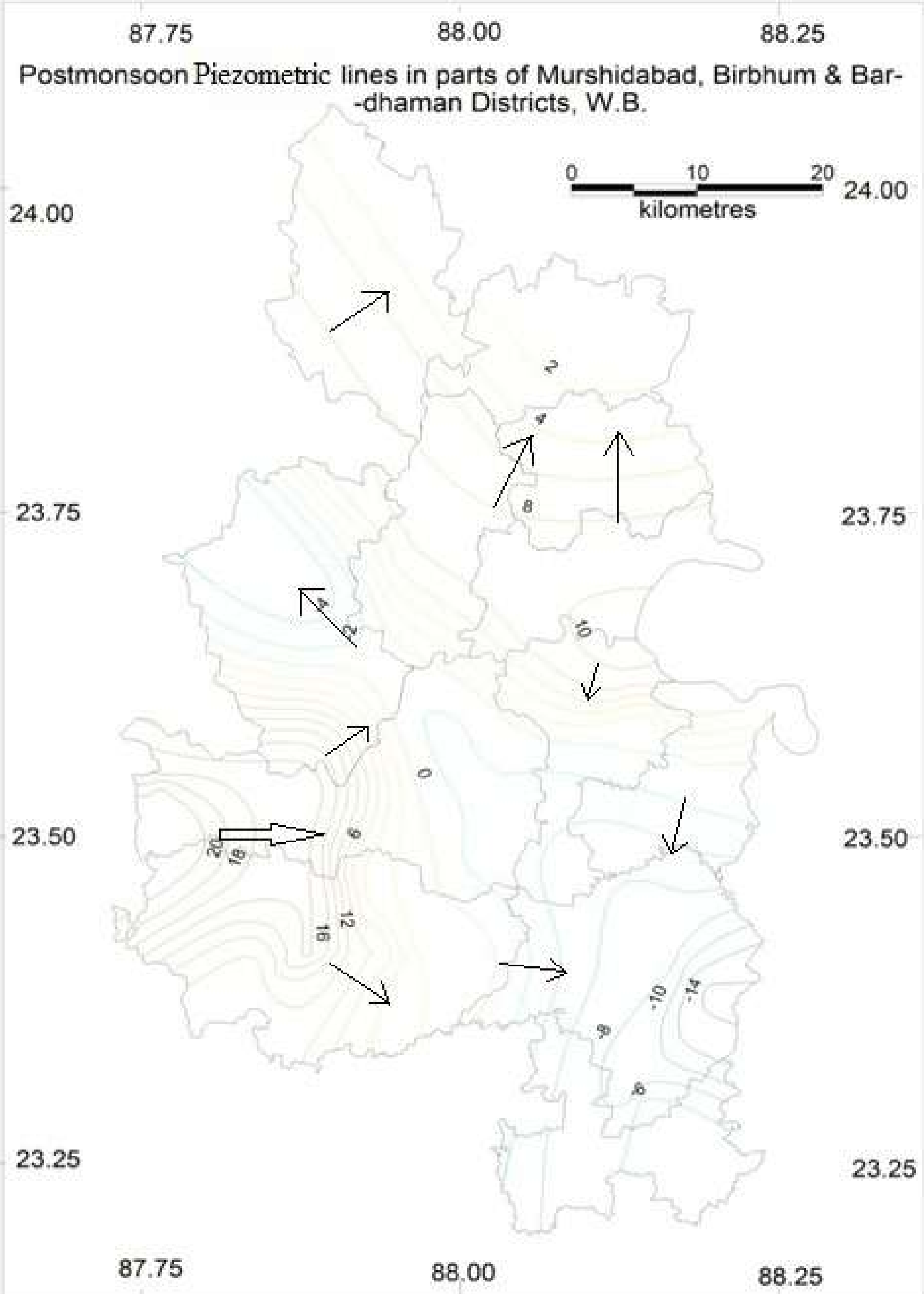


Plate 6.3.2 b: Post-monsoon piezometric surface (Aquifer II)

6.4 Ground Water Flow through the Aquifers:

6.4.1: Aquifer I

From the Water Table map (**Plate-6.3.1 a),** for Aquifer I showing water table contours (May 2016), it is observed that, a depression like situation has developed in the sub-surface mainly in the eastern part of study area. There is no specific direction of flow. It may be due unplanned withdrawal of ground water. Overall, the elevation of water table ranges from more than 42 m above msl in Burwan block in NW to -10 m below msl in Memari II in SE. Depression in water table has been developed in the central and eastern parts of study area. In post-monsoon, the elevation of water table ranges from more than 45 m above msl in Burwan block in NW to -9 m below msl in Memari II in SE. Similar types of depression of water table is also witnessed in this season.

6.4.2: Aquifer II

In Plate 6.3.2 a, premonsoon piezometric surface of Aquifer II has been shown. The elevation of this surface ranges between 15m above msl in SW to -15 m below msl. Ground water flow direction is from NW to SE in southern part and SW-NE in northern part of study area. Depression of piezometric surface has been witnessed in the central part.

In Plate 6.3.2 b, postmonsoon piezometric surface of Aquifer II has been shown. The elevation of this surface ranges between 20 m above msl in SW to -14 m below msl. Generally, ground water flow direction is towards east in southern part and towards northeast in northern part.

Ground water flow has been calculated by Darcy's law using Q= TIL where Q is quantity of ground water flowing through the area, T is Transmissivity of the Aquifer, I is Hydraulic Gradient and L is maximum length of flow path perpendicular to flow direction.

In general, in post monsoon period, ground water flow has been estimated as follows:

1. Mangalkote - maximum length of flow path across the area in NW-SE direction is about 9 km, i.e.,9000 m with hydraulic gradient of 1: 952.5 (as 21 m drop for distance of 20 km or 20000 m). Length (L) – 9 km. Average Transmissivity (T) of the 2nd aquifer is considered as200m^2/day. The quantity of Ground Water flow through the 2nd deeper Aquifer-II is calculated as 1889.76 m^3/day.
2. Bharatpur I - maximum length of flow path across the area in SW-NNE direction is about 12.6 km, i.e. 12600 m with hydraulic gradient of 1: 2630 (as 3 m drop for distance of 7.89 km or 7890 m).Average Transmissivity (T) of the 2nd aquifer is considered as200m^2/day.

The quantity of Ground Water flow through the 2nd deeper Aquifer-II is calculated as 958.17 m^3/**day**.

3. Ketugram I–ground water flow in two opposite directions:

    1) maximum length of flow path across the area in SW-NNE direction is about 9.5 km, i.e.,9500 m with hydraulic gradient of 1: 2980 (as 3 m drop for distance of 8.94 km or 8940 m). Average Transmissivity (T) of the 2nd aquifer is considered as 200 m^2/day. The quantity of Ground Water flow through the 2nd deeper Aquifer-II is calculated as 637.58 m^3/**day**.

    2)maximum length of flow path across the area in NE-SW direction is about 11.5 km, i.e.,11500 m with hydraulic gradient of 1: 1051.67 (as 6 m drop for distance of 6.31 km or 6310 m). Average Transmissivity (T) of the 2nd aquifer is considered as 200 m^2/day. The quantity of Ground Water flow through the 2nd deeper Aquifer-II is calculated as 2186.99 m^3/**day**.

4. Nanoor - maximum length of flow path across the area in SE - NW direction (length L) is about 13.68 km, i.e., 13680 m with hydraulic gradient of 1: 1368 (as 5 m drop for distance of 6.84 km or 6840 m). Average Transmissivity (T) of the 2nd aquifer is considered as 200 m^2/day. The quantity of Ground Water flow through the 2nd deeper Aquifer-II is calculated as 2000 m^3/day.

5. Katwa I - maximum length of flow path across the area in NNE-SSW direction (length L) is about 15.78 km, i.e., 15780 m with hydraulic gradient of 1: 1009.17 (as 12 m drop for distance of 12.11 km or 12110 m). Average Transmissivity (T) of the 2nd aquifer is considered as200 m^2/day. The quantity of Ground Water flow through the 2nd deeper Aquifer-II is calculated as 3127.32 m^3/**day**.

6. Bhatar – maximum length of flow path across the area in NNW-SSE direction (length L) is about 18.94 km, i.e., 18940 m with hydraulic gradient of 1: 1148.18 (as 11 m drop for distance of 12.63 km or 12630 m). Average Transmissivity (T) of the 2nd aquifer is considered as 200 m^2/day. The quantity of Ground Water flow through the 2nd deeper Aquifer-II is calculated as 3299.13 m^3/**day**.

7. Memari II - maximum length of flow path across the area in W-E direction (length L) is about 18.95 km, i.e. 18950 m with hydraulic gradient of 1:1104 (as 5 m drop for distance of 5.52 km or 5520 m). Average Transmissivity (T) of the 2nd aquifer is considered as 200

m^2/day. The quantity of Ground Water flow through the 2nd deeper Aquifer-II is calculated as 3432.97 m^3**/day**.

6.5Pre-monsoon&Post-monsoon long term trend analysis :

Thelong-term trend analysis during 2006-2016 reveals that in both the Aquifer I and aquifer II, generally there is a falling trend in all the Blocks both during Pre-monsoon and Post-monsoon periods.

In Aquifer I, the Pre-monsoon trend varies from 155.1 cm/year (in Manteswar Block) to 25.8 cm/year (in Nanoor Block). The Post-monsoon trend varies from 375.8 cm/year (in Bharatpur II Block) to 28.5 cm/year (in Burwan Block) Details of pre-monsoon and post-monsoon water level trend (from 2006 to 2016) in cm/year for individual Block is given in Table-VI A and Table-VI B respectively.

In Aquifer II, the Pre-monsoon falling trend varies from 110.7 cm/year (in Bhatar Block) to 25 cm/year (in Katwa II Block). The Post-monsoon falling trend varies from 154.5 cm/year (in Bhatar Block) to 7.1 cm/year (in Ketugram II Block) Details of pre-monsoon and post-monsoon water level trend (from 2006 to 2016) in cm/year for individual Block is given in Table-VI A and Table-VI B respectively.

Table 6.5 a: Block-wise Pre- and Post-monsoon long term water level trend for during 2006-2016 in Aquifer I

SI. No.	Block	Pre_Aq 'o'		Post_Aq'o' 'o"		Pre-monsoon_Aq I		Post-monsoon_Aq I	
		Rise	Fall	Rise	Fall	Rise (cm/year)	Fall (cm/year)	Rise (cm/yea	Fall (cm/year)
1	2	3	4	5	6	7	8	9	10
1.	Burwan					30.3	24.0 -26	-	28.5 - 144.5
2.	*Bharatpur I*					6.6	15.6 – 86.5		9.0 - 439.3
3.	*Bharatpur II*					3.9-47.1	55.5 - 76.91		102.7- 168.4
4.	*Nanoor*						25.8		263.8
5.	*Ketugram I*						34.5-73.2		76-102.7
6.	*Ketugram II*						52		16.5
7.	*Katwa I*	12.9	*17.5*		5.3-10.8	12.9	55.5-268.6		57.9
8.	*Katwa II*						73.2-121.8		94.6 - 121.5
9.	*Manteswar*						9.9 - 247		91.6 - 277.0
10.	*Mangalkote*						47.4-153.5		36.4 - 176.3
11.	Bhatar		35.1		13.8	88.4	14.8 - 392.5		39.0-135
12.	*Memari II*						100.4		94.6

Table 6.5b: Block-wise Pre- and Post-monsoon long term water level trend for during 2006-2016 in Aquifer II

Sl. No.	Block	Pre-monsoon		Post-monsoon	
		Rise (cm/year)	Fall (cm/year)	Rise (cm/year)	Fall (cm/year)
1	2	3	4	5	6
1.	Burwan	-	-	-	-
2.	*Bharatpur I*	-	-	-	-
3.	*Bharatpur II*				-
4.	*Nanoor*	-	-	-	-
5.	*Ketugram I*	0.2			7.1
6.	*Ketugram II*	-			
7.	*Katwa I*				
8.	*Katwa II*		25		
9.	*Manteswar*				
10.	*Mangalkote*				
11.	Bhatar		110.7		154.5
12.	*Memari II*				

6.6 Aquifers with yield prospects :

From the exploration data of CGWB & the litho charts of state-owned tube wells, two major aquifer groups could be delineated down to the drilled depth of 250 mbgl in the area under study. The first aquifer exists within a depth span of 47-142 mbgl with yield potential to the tune of 50-210 m^3/hr. The Transmissivity of the first aquifer system varies from 1000-5300 m^3/hr. The second aquifer groups in the depth span of 83-240mbgl, are found to occur in the blocks, namely, Nanoor, Ketugram I, KatwaI, Bhatar and Memari II. The yield of the tube wells, constructed by tapping the granular zones in the above depth span, ranges from 10-56 m^3/hr. Aquifer wise parameters in the study area is given in the followingTable-6.6.

Aquifer 0 has been found in three blocks, viz. Ketugram II, Katwa I and Katwa II. This aquifer is mostly tapped by dug wells, hand pumps (Mark I) and shallow wells. Depth to water level in this aquifer ranges between 1.87 and 11.65 in pre-monsoon, and between 5.11 and 9.59 during post-monsoon.

Aquifer properties i.e., Transmissivity, Storativity of Aquifer I and Aquifer II have been tabulated in Table 6.6.

7. GROUND WATER RESOURCES, DRAFT, SOD & CATEGORY

Dynamic Ground water resources of the area under study have been calculated on the basis of GEC (1997) methodology by CGWB and State Water Investigation Department (SWID) for the year as on 31.03. 2013.The block wise computed data of dynamic ground water resources, as on 31^{st} March 2013 is given in Table 7.0.1. The Static Ground Water Resources (block-wise) have been presented in Table 7.0.2. All 12 blocks have been categorized as Semi-critical blocks.

On the basis of ground water resource calculation (2013) and water level trend, all 12 blocks of present area i.e. Burwan, Katwa II, Manteswar, Bhatar, Memari II, Bharatpur I, Bharatpur II, Nanoor, Ketugram I, Ketugram II, Katwa I and Mangalkote, have been categorized as Semi-Critical blocks. Incidentally, out of 12, 2 blocks have been declared by the Arsenic Task Force, Govt. of West Bengal as arsenic infested. The map showing the category of blocks is shown in Plate-7.0.

Table- 6.6: (Major) Aquifer-wise aquifer parameters in the study area

Sl. No.	Name of Block	Depth range of 1st Aquifer (in m bgl)			Depth range of 2nd Aquifer (in m bgl)		
		Depth Range (mbgl)	**Discharge (m^3/hr)**	**T, m^2/day, (S)**	**Depth range**	**Discharge (m^3/hr)**	T, m^2/day, (S)
1	Burwan, Bharatpur I &*Bharatpur I*	8-114.5	5.97 - 59.76	59.30 - 601	132-145	5.97 – 17.57	97.58; ($7.503x10^{-3)}$)
2	*Nanoor*	8-47	5.97- 72.29	499.01 -681	83-120		($3.54x10^{-3}$)
3	*Ketugram I & Ketugram II*	8-70	31-128.30	31 – 1700	120-135, 150-155	34.2	($2.5x10^{-4)}$
4	*Katwa I & Katwa II*	8-121	14.4 - 47.7	11.4- 1254	180-220	14.4 – 122.40	172-216; **($3.1x10^{-5}$** - $7.09x10^{-4}$ **)**
5	*Manteswar*	3-142	7.92 - 126	91- 619 ($0.81X10^{-4}$ - $4.3X10^{-4}$)	-	-	-
6	*Mangalkote*	5-72	42.98 – 117.28	425 – 1128, ($4.56 X 10^{-1}$)	80.5-112	31.32	80 ($2.8X10^{-4}$ - **$1.03X10^{-3}$)**
7	Bhatar	10-125	42.44 - 126	619	165-240	7.92 - 22.75	91 ($0.81X10^{-4}$ - **$4.3X10^{-4}$**)
8	*Memari II*	7.5-80	36	40.44 - 41.40	105-118, 165-178	14.40	($0.81X10^{-4}$ - **$4.3X10^{-4}$**)

Table-7.0.1:Block wise dynamic ground water resources (Aquifer I)as on 31st March'13

SI. No.	Blocks	Net ground water availability (MCM)	Gross ground water draft (MCM)	Stage of development (%)	Category	Provision for domestic and industrial requirement supply upto next 25 years(MCM)
1.	Burwan	89.2039	54.1335	62.31	Semi-critical	6.6264
2.	*Bharatpur I*	49.0552	27.1777	57.39	Semi-critical	4.45.59
3.	*Bharatpur II*	48.8767	30.7959	64.99	Semi-critical	4.4307
4.	*Nanoor*	104.5008	47.2845	46.38	Semi-critical	4.9998
5.	*Ketugram I*	52.3863	32.4439	62.66	Semi-critical	5.8207
6.	*Ketugram II*	60.3103	27.9406	46.82	Semi-critical	6.7011
7.	*Katwa I*	61.6064	30.2022	51.15	Semi-critical	3.2424
8.	*Katwa II*	69.3776	30.0733	44.55	Semi-critical	7.7086
9.	*Manteswar*	96.9411	64.0124	66.85	Semi-critical	3.1018
10.	*Mangalkote*	123.94	47.6767	39.48	Semi-critical	13.7711
11.	Bhatar	130.2567	57.2361	45.01	Semi-critical	5.4066
12.	*Memari II*	55.6745	35.0025	65.33	Semi-critical	5.3490

Table 7.0.2: Block wise In-Storage Ground Water Resources (ham) in Aquifer I

Sr. No.	Block	Area in ha	Bottom of the unconfined aquifer (mbgl)	Average Pre-monsoon Water Level (mbgl)	Average specific yield	Thickness of the Saturated Zone of the Un-Confined aquifer below WLF zone (m)	Volume of Saturated Zone of the Unconfined aquifer below WLF zone (ham)	Static / In-Storage Ground Water Resources (ham)
1	**Bharatpur I**	17800	95	16.27	0.12	78.73	1401394	168167.28
2	**Burwan**	28000	64	16.92	0.12	47.08	1318240	158188.80
3	**Bharatpur II**	16200	70	23.09	0.12	46.91	759942	91193.04
4	**Ketugram I**	20000	59	17.65	0.16	41.35	827000	132320
5	**Ketugram I I**	14200	62	13.85	0.16	48.15	683730	109396.80
6	**Katwa I**	18299	99	20.21	0.2	78.79	1441778	288355.64
7	**Mangolkote**	36000	53	19.53	0.16	33.47	1204920	192787.2
8	**Memari II**	10600	90	19.14	0.2	70.86	751116	150223.2
9	**Bhatar**	39300	79	20.43	0.12	58.57	2301801	276216.12
10	**Manteswar**	31900	114	21.06	0.16	92.94	2964786	474365.76
11	**Katwa II**	16871	91	15.68	0.2	75.32	1270724	254144.74
12	**Nanoor**	31600	50	19.15	0.12	30.85	974860	116983.2
							Total	2412341.786
							in MCM	24123.42

Table 7.0.3: Block wise dynamic ground water resources (ham) in Aquifer II

Sl. No.	Block	Area (Ha)	Seasonal fluctuation (m)	Storage co-efficient	Ground water resource (Ham)
1	Bharatpur I	17800	**0.9**	**0.0075**	**120.15**
2	Ketugram I	20000	**1.44**	**0.0025**	**72**
3	Katwa I	18299	**1.39**	**0.0004**	**10.17**
4	Mangalkote	36000	**3.78**	**0.0007**	**95.26**
5	Bhatar	39300	**2.10**	**0.0003**	**24.76**
6	Memari II	10600	**3.13**	**0.0003**	**9.95**
7	Nanoor	31600	**1.5**	**0.0035**	**165.9**

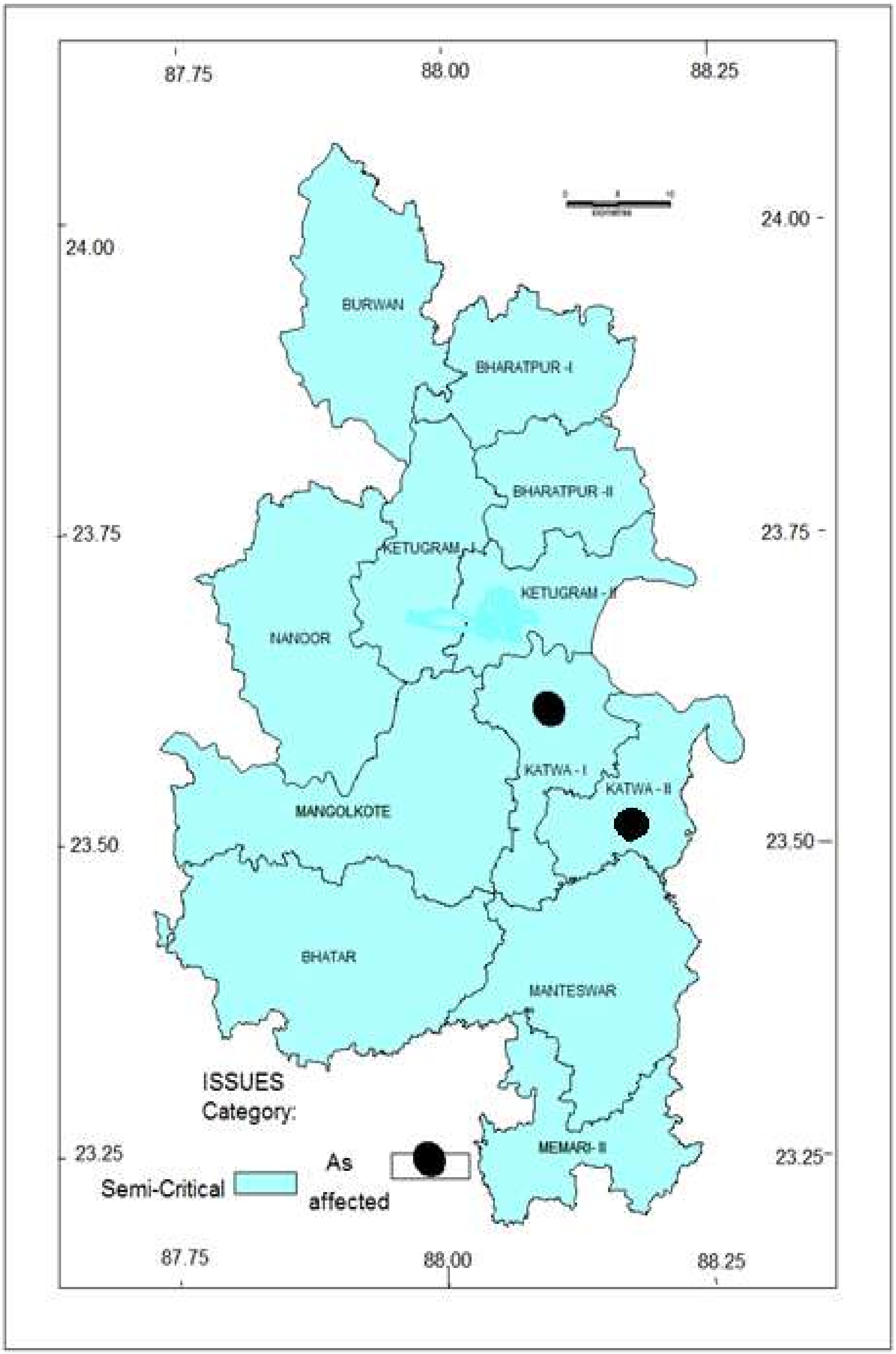


Plate 7.0: Categorisation of blocks in study area

8. HYDROCHEMISTRY

8.1 Quality of Shallow and Deeper Aquifer Water:

Ground water samples were collected during pre-monsoon period from the 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. Ground water of Aquifer I and Aquifer II is mainly HCO_3type in 3 districts of study area. However, in parts of the area, Cl- type ground water has also been encountered (vide Fig.-8.1).

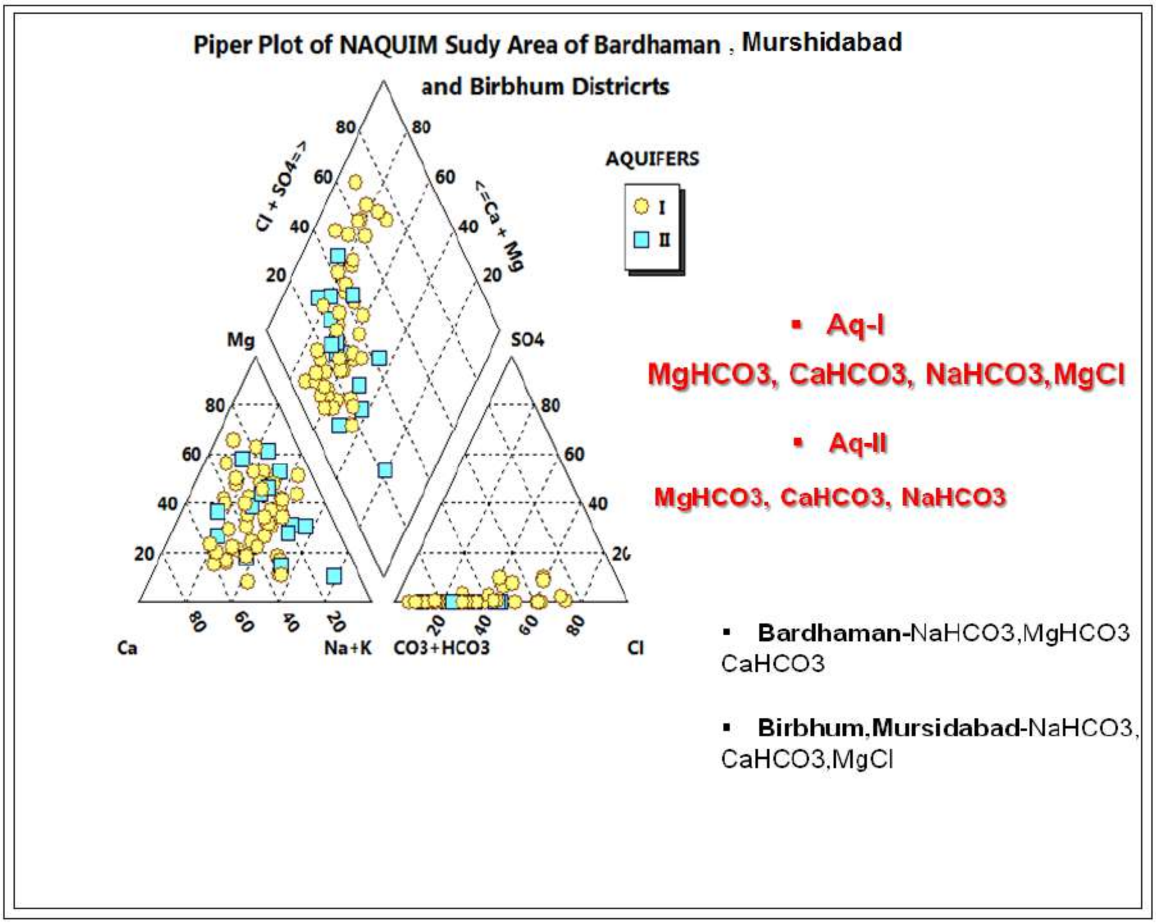


Fig. 8.1: Ground water type (Piper plot) of Aquifer I & Aquifer II in study area

8.2 General range of chemical parameter in the area:

From the analytical results as available so far from the laboratory on the basis of analysis of limited nos. of samples,it is found that, pH of water, in general, varies between6.13 and8.13and, EC between147 and 686 µS/cm (vide Table 8.2.1). TDS ranges from 95 mg/1 to 446 mg/1. Concentrations of Na and K ranges from 10 to 45 mg/1 and from 0.88 to 6.18 mg/1, respectively.Fe content is also available sporadically from less than0.1to more than 2.5mg/1(vide Table 8.2.1). Mg is available sporadicallyfrom less than 4.86 to 36.45 mg/1. CO_3 is absent. HCO_3 present in the range of30.5-298.9 mg/1and Cl is mostly in the range of7.11-67.545 mg/1.F ranges from0.93-1.62 mg/1.SO_4concentrations are varying frombdl to 16.Total Hardness as per $CaCO_3$ ranges from35-195 mg/1,whereas Ca varies from12 to 38 mg/1.Nitrate concentration ranges frombdl to 9.3 mg/1.As a whole, it can be said that the water of the area is generally potable.

Table 8.2.1: Range of chemical Parameters (routine) in ground water

Sl. No.	Block	Location	pH	EC	HCO_3	CO_3	Cl	TH	Ca	Mg	Na	K	SiO_2	PO_4	F	NO_3	SO_4	Fe	SAR
1	Katwa I	Churpani	7.48	510	231.8	Nil	60.435	105	20	13.365	34	1.06	bdl	bdl	1.13	bdl	5.6	0.1	1.438614
2	Katwa I	Shrikhanda	7.64	523	176.9	Nil	35.55	120	22	15.795	31	2.49	bdl	47	1.35	bdl	11	0.2	1.226804
3	Katwa I	Jogeswardih	7.51	388	219.6	Nil	21.33	95	18	12.15	26	2.07	bdl	bdl	1.44	bdl	1.7	0.1	1.156548
4	Bhatar	Amarun	6.13	359	91.5	Nil	24.885	90	28	4.86	17	0.88	bdl	bdl	1.29	bdl	16	0.2	0.778635
5	Bhatar	Devpur	6.91	147	61	Nil	14.22	35	12	1.215	10	3.49	bdl	bdl	1.15	2.3	bdl	0.2	0.734889
6	Bhatar	Orgram	7.53	404	30.5	Nil	49.77	125	38	7.29	20	6.18	bdl	bdl	1.62	0.31	12	2.5	0.777187
7	Ketugram II	Naihati	7.64	378	195.2	Nil	17.775	105	26	9.72	27	1.1	bdl	bdl	0.93	bdl	4.5	0.2	1.143607
8	Ketugram II	Ketugram	7.36	438	207.4	Nil	17.775	105	20	13.365	31	2.21	bdl	bdl	1.48	bdl	bdl	0.1	1.311678
9	Ketugram I	Ratanpurpirtala	7.52	486	244	Nil	21.33	105	16	15.795	38	1.48	bdl	bdl	1.18	bdl	6	0.1	1.606761
10	Ketugram I	Bhulkuri	8.03	515	183	Nil	21.33	60	18	3.645	32	2.18	bdl	bdl	1.2	bdl	bdl	0.5	1.794706
11	Ketugram I	hat Moregram	7.24	614	73.2	Nil	67.545	190	30	27.945	17	1.38	bdl	bdl	1.04	bdl	16.2	1.3	0.534414
12	Ketugram I	Kandra	7.54	324	256.2	Nil	17.775	90	20	9.72	18	1.24	bdl	bdl	1.13	bdl	bdl	0.3	0.823114
13	Mangalkote	Royramchandrapur	7.39	271	61	Nil	28.44	95	28	6.075	12	2.48	bdl	bdl	0.98	9.4	bdl	0.1	0.534807
14	Mangalkote	Sinut/bhatpara	7.43	329	183	Nil	10.665	100	12	17.01	31	1.3	bdl	bdl	1.81	bdl	bdl	0.4	1.342366
15	Mangalkote	Mazhigram	7.29	383	213.5	Nil	14.22	85	24	6.075	22	1.26	bdl	19	1.46	bdl	bdl	0.2	1.036319
16	Memari II	Kuchut	7.26	475	213.5	Nil	17.775	80	22	6.075	15	0.79	bdl	0.1	1.21	bdl	4.07	1.3	0.728231
17	Memari II	Bohar	7.14	413	176.9	Nil	7.11	165	18	29.16	27	2.06	bdl	bdl	1.44	bdl	bdl	0.2	0.91001

18	Katwa II	Gazipur	7.01	686	298.9	Nil	35.55	195	18	36.45	42	5.39	bdl	bdl	1.44	bdl	16	-	1.301743
19	Katwa II	Amul	7.27	499	219.6	Nil	24.885	120	18	18.225	43	1.85	bdl	bdl	1.19	bdl	8.1	-	1.700676
20	Monteswar	Maldanga	7.43	465	207.4	Nil	24.885	110	22	13.365	20	1.36	bdl	bdl	1.24	bdl	7.4	0.1	0.826929
21	Monteswar	Madhyamgram	7.48	496	164.7	Nil	46.215	115	16	18.225	36	2.64	bdl	bdl	1.06	bdl	13	0.2	1.45416
22	Monteswar	Raigram	7.42	442	176.9	Nil	31.995	95	24	8.505	28	1.86	bdl	bdl	1.75	bdl	bdl	0.5	1.246934
23	Monteswar	Monteswar	7.83	508	244	Nil	46.215	100	22	10.935	31	1.27	bdl	bdl	1.22	bdl	bdl	0.1	1.344785
24	Katwa II	Kurchi	7.62	429	231.8	Nil	17.775	100	4	21.87	34	1.08	bdl	bdl	1.53	bdl	0.8	0.1	1.47016
25	Katwa II	Dainhat	7.82	562	67.1	Nil	24.885	150	18	25.515	45	2.48	bdl	bdl	1.39	bdl	3.9	0.1	1.591022

Table 8.2.2: As concentration in ground water in study area

Sl. No.	Location	Lat.	Long.	Aquifer type	Block	As (mg/l)	Source
1	Natungram (Mougram)	23.74	88.19	I	Ketugram II	0.212 (Average)	PHED
2	Char Sujapur (Mougram)	23.72	88.22	I	Ketugram II	0.023 (Average)	PHED
3	Sujapur (Mougram)	23.72	88.21	I	Ketugram II	0.0725 (Average)	PHED
4	Kamalbari (Mougram)	23.72	88.20	I	Ketugram II	0.07 (Average)	PHED
5	Narayanpur (Mougram)	23.72	88.18	I	Ketugram II	0.0433 (Average)	PHED
6	Raghupur (Mougram)	23.72	88.18	I	Ketugram II	0.04	PHED
7	Singi	23.54	88.19	II	Katwa II	0	CGWB *
8	Singi	23.54	88.19	II	Katwa II	0	CGWB *
9	Singi	23.54	88.19	I	Katwa II	0	CGWB *
10	Karule	23.52	88.07	I	Katwa I	0	CGWB *
11	Karule	23.52	88.06	I	Katwa I	0	CGWB *
12	Mejiari	23.51	88.14	I	Katwa II	0	CGWB *
13	Kuara	22.48	88.12	I	Manteswar	0	CGWB *
14	Choardanga	23.45	88.19	I	Manteswar	0	CGWB *
15	Choardanga	23.45	88.19	I	Manteswar	0	CGWB *
16	Dainhat	23.61	88.17	I	Dainhat Municipality	0.00667	CGWB *

17	Dainhat	23.61	88.17	I	Dainhat Municipality	0.00127	CGWB *
18	Dainhat	23.61	88.17	I	Dainhat Municipality	0	CGWB *
19	Angarpur	23.65	88.07	I		0	CGWB *
20	Guskara	23.50	87.75	I	Ausgram I	0	CGWB
21	Amarun	23.36	87.94	I	Bhatar	0.001	CGWB
22	Barabelun	23.41	87.98	I	Bhatar	0.0003	CGWB
23	Bolgona	23.46	87.94	I	Bhatar	Nil	CGWB
24	Kubajpur	23.36	87.98	I	Bhatar	0.001	CGWB
25	Orgram	23.44	87.77	I	Bhatar	Nil	CGWB
26	Kaithan	23.53	88.08	I	Katwa I	0.0003	CGWB
27	Katwa	23.64	88.14	I	Katwa I	0.001	CGWB
28	Dainhat	23.61	88.17	I	Katwa II	Nil	CGWB
29	Nandigram	23.54	88.15	I	Katwa II	0.001	CGWB
30	Singi	23.54	88.19	I	Katwa II	0.0003	CGWB
31	Hat Moregram	23.75	88.03	I	Ketugram I	0.0001	CGWB
32	Khalipur (Kamarpur)	23.72	88.01	I	Ketugram I	0.0002	CGWB
33	Ramjibanpur (Kandra)	23.74	87.97	I	Ketugram I	Nil	CGWB
34	Ketugram	23.69	88.04	I	Ketugram II	0.0002	CGWB
35	Charnak	23.53	87.79	I	Mangalkot	Nil	CGWB
36	Koichor	23.53	88.02	I	Mangalkot	0.0002	CGWB
37	Natunhat	23.53	87.90	I	Mangalkot	0.001	CGWB
38	Denur	23.45	88.14	I	Manteswar	Nil	CGWB
39	Jamna	23.36	88.16	I	Manteswar	0.0001	CGWB
40	Kusumgram	23.39	88.13	I	Manteswar	Nil	CGWB
41	Madhyamgram	23.31	88.13	I	Manteswar	0.0001	CGWB
42	Maladanga	23.42	88.08	I	Manteswar	0.0001	CGWB
43	Bohar	23.25	88.09	I	Memari II	Nil	CGWB
44	Paharhati	23.25	88.09	I	Memari II	Nil	CGWB
45	Golte	23.67	87.71	I	Nanoor	NIL	CGWB

46	Kakunia	23.60	87.92	I	Nanoor	0.0001	CGWB
47	Kankunia	23.60	87.92	I	Nanoor	0.0002	CGWB
48	Kirnahar	23.76	87.86	I	Nanoor	0.0002	CGWB
49	Kurchandi	23.67	87.80	I	Nanoor	NIL	CGWB
50	Nanoor	23.70	87.87	I	Nanoor	0.0002	CGWB
51	Bharatpur	23.89	88.08	I	Bharatpur I	0.0004	CGWB
52	Gangedda	23.92	88.05	I	Bharatpur I	0.012	CGWB
53	Geetgram	23.83	88.01	I	Bharatpur I	0.002	CGWB
54	Lohadaha	23.88	88.17	I	Bharatpur I	0.001	CGWB
55	Dakshin Khandagram	23.75	88.07	I	Bharatpur II	0.023	CGWB
56	Kagram	23.75	88.13	I	Bharatpur II	0.015	CGWB
57	Salar	23.77	88.10	I	Bharatpur II	0.002	CGWB
58	Salar	23.77	88.10	I	Bharatpur II	0.022	CGWB
59	Salar	23.90	88.10	I	Bharatpur II	0.002	CGWB
60	Salinda-Nabapally	23.84	88.09	I	Bharatpur II	0.094	CGWB
61	Tenya	23.82	88.15	I	Bharatpur II	0.001	CGWB
62	Barwan	23.90	87.96	I	Burwan	0.001	CGWB
63	Kuli	23.97	87.96	I	Burwan	0.0004	CGWB
64	Narayanpur	23.88	87.91	I	Burwan	0.01	CGWB
65	Adarsha Pally High School	23.63	88.13	II	Katwa-I	0.006	CGWB Expl. Data
66	Adarsha Pally High School	23.63	88.13	I	Katwa-I	BDL	CGWB Expl. Data
67	Adarsha Pally High School	23.63	88.13	II	Katwa-I	BDL	CGWB Expl. Data

CGWB* - CGWB sample, analysed in CCL, GSI, Kolkata

In Table 8.2.2, As concentration in ground water of the study area have been shown. The data have been collected during special drive-in respect of samples from hydrograph stations in the area and surrounding wells in concerned blocks in year 2015-16; also some samples from the area were collected during surveys of earlier year and the same were analysed by GSI, Kolkata, and some data were directly collected from PHED, Govt. of West Bengal.

8.3 Ground water pollution:

Generally, all chemical parameters in collected water samples show values within permissible limit.All the water samples analysed in the laboratory show pH values withinthe permissible limit of 6.5 and 8.5.EC of these samples indicate that ground water is, in general, potable.Other parameters of routine analysis are also very much within their respective permissible limits, excepting fluoride, which shows slightly higher concentration than its permissible limit of 1.5 mg/l at a very few places. As per Arsenic Task Force, Govt. of West Bengal, ground water in all the blocks of the study area is arsenic free, excepting Katwa I and Katwa II. As per the report of the PHED, Govt. of West Bengal, so far the arsenic contamination in ground water in tube wells is concerned, different level of arsenic contamination in wells are given (Table 8.3.1)as follows:

Table 8.3.1: Nos. of Tube wells showing arsenic in ground water in Katwa I and katwa II blocks

(Source –PHED, Govt. of West Bengal)

Sl. No.	**Name of arsenic affected block**	**No. of Tube well analysed**	**Arsenic Concentration (in mg/l)**						
			<& =0.01		**>0.01 &<=0.05**		**>0.05**		**Max.concentration**
			%	**No.**	**%**	**No.**	**%**	**No.**	
1	Katwa I	1,332	95.27	1,269	4.35	58	0.38	5	0.10
2	Katwa II	1079	90.08	972	7.78	84	2.13	23	0.84

Details of arsenic free deep tube wells constructed by CGWB are given in Table-8.3.2. Point concentration of arsenic in ground water of aquifer I has been shown in Plate 8.3.

Table-8.3.2: Details of tube well with potable concentration of arsenic by CGWB

Block	Location	Depth of tube well	Zone tapped (m)	Arsenic concentration (mg/I)
Katwa I	Adarsha Pally High School	223.5	206-218 (cement sealing: 197.5- 199.5)	0.006

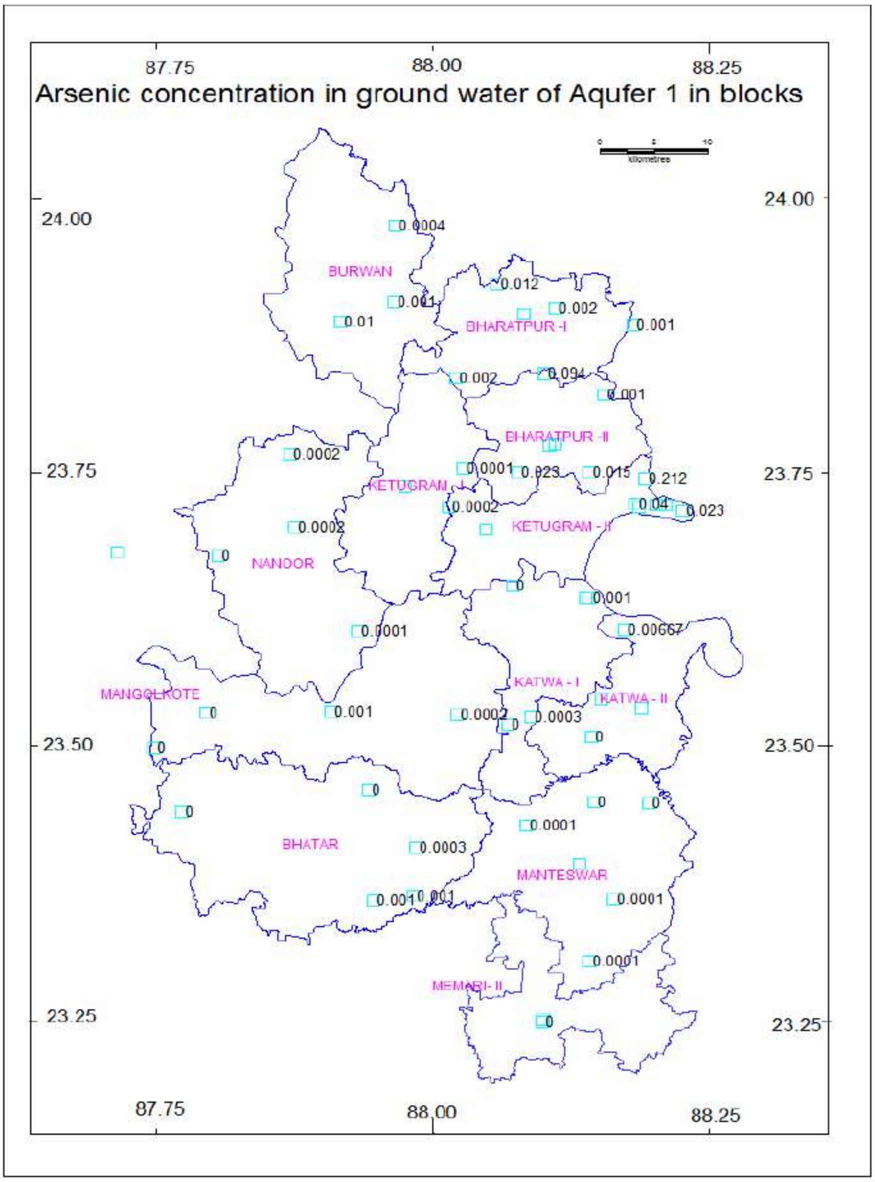


Plate 8.3: point data of arsenic concentration in ground water of Aquifer I

Analysis of ground water samples by PHED (communicated to CGWB personnel while studying in field) shows presence of higher concentration of arsenic in ground water in some tube wells in Ketugram II block (vide Table 8.3.2). Some ground water samples of National Hydrograph Stations in different blocks of the area were analysed under Special Drive in 15-16, which shows presence of neglisible amount of arsenic (<0.01 mg/l) at some stations in many blocks other than Katwa I and Katwa II. These data have also been given in Table 8.3.2. For some other hydrogeological investigation, samples have also been analysed in the laboratory of Geological survey of India and found alarming quantity of arsenic in ground water in shallow tube wells of Katwa I and Katwa II blocks. These data are also given in Table 8.3.2 and these data have also been shown in Plate 8.3.

SOES, Jadavpur has done detailed study on arsenic infestation in ground water and reported their observation, which have been shown in following tables district-wise:

Table – 8.3.3: Status of As concentration in ground water in Murshidabad district

Block	Total samples analysed	Samples with different As concentration (µg/L)			
		<=3 µg/L	% of samples with As > 10 µg/L	% of samples with As > 50 µg/L	Maximum concentration of As , µg/L (Nos. of Samples with > 1000 µg/L)
Bharatpur I	616	533	5.8	0.3	82
Bharatpur II	625	625	-	0	<3
Burwan	702	684	1.1	0.3	64

(Source- SOES, Jadavpur)

Table – 8.3.4: As concentration in ground water in Barddhaman district

Block	Total samples analysed	Samples with different As concentration (µg/L)			
		<=3 µg/L	% of samples with As > 10 µg/L	% of samples with As > 50 µg/L	Maximum concentration of As , µg/L (Nos. of Samples with > 1000 µg/L)
Bhatar	74	72	-	-	9
Katwa I	313	292	5.4	1.3	2230 (1)
Katwa II	143	138	-	-	5
Ketugram I	120	114	-	-	8
Ketugram II	134	125	3	-	22
Mangalkote	73	69	-	-	4
Manteswar	47	47	-	-	3
Mamari II	90	85	5.6	1.1	170

(Source – PHED, Govt. of West Bengal)

Table-8.3.5: Arsenic affected Blocks and Risk Population

(Source – PHED, Govt. of West Bengal)

District	**Block (As affected)**	**No. of habitations in the risk zone where As conc. >0.05 mg/l**	**No. of habitations in the risk zone where As conc. 0.01 to 0.05 mg/l**	**Risk Population (2011) where As conc. >0.05 mg/l**
Bardhaman	*Katwa I*	2	13	166614
Bardhaman	*Katwa II*	9	14	136708

8.4 Ground Water Suitability for irrigation:

The Sodium Adsorption Ratio (SAR) of water in the study area ranges from0.535 to1.794.Therefore, 100% of samples having SAR value < 18 indicate well to permissible suitability of ground water for irrigational use. Piper-Trilinear Diagram and Salinity Hazardbased on samples of study area have been presented in Fig. 8.1 and Fig. 8.4 respectively**.** The ground water has low EC values which implies that salinity hazards is nil in the area. However, the water from deeper aquifer (Aquifer II) is generally suitable for domestic, agriculture and industrial uses except in some pockets where a little higher concentration of Fe has been found which can be reduced by simple aeration and filtration method.

8.4.1 Ground Water Availability for future irrigation

By the estimation of Dynamic Ground water resources for West Bengal on the basis of GEC (1997) methodology by CGWB and State Water Investigation Department (SWID) for the year as on 31.03.2013, the block-wise cultivable area, net irrigated area & ground wateravailability for future irrigation have been presented in Table 8.4.1.1.

Table- 8.4.1.1: Block-wise cultivable area, net irrigated area & ground water availability

Sr. No.	Block	Geographical area in ha	Cultivable area in ha	Net irrigated Command area (GW) in ha	Net irrigated Command area (SW) in ha	Net irrigated Command area (GW +SW) in ha	Net area available for Irrigation	GW available for Future irrigation (ham)
1	Bharatpur I	17800	15414	6640.79	1128.4	7769.19	7644.81	1936.73
2	Burwan	28000	25569	7796.13	2778.32	10574.45	14994.55	3133.75
3	Bharatpur II	16200	13683	5223.23	740.18	5963.41	7719.59	1558.33
Murshidabad Total		**62000**	**54666**	**19660**	**4646.9**	**24307.1**	**30358.9**	**6628.81**
4	Ketugram I	20000	15032	5583.42	411.8	5995.22	9036.78	1879.55
5	Ketugram II	14200	12542	4410.22	1286.01	5696.23	6845.77	3151.27
6	Katwa I	18299	12400	5842.26	226.22	6068.48	6331.52	2891.22
7	Mangolkote	36000	28600	9204.58	493.12	9697.7	18902.3	7388.48
8	Memari II	10600	14508	7530.86	258.47	7789.33	6718.67	1806.55
9	Bhatar	39300	31387	11882.44	551.43	12433.87	18953.13	7038.61
10	Manteswar	31900	24606	12858.74	6383.22	19241.96	5364.04	3141.73
11	Katwa II	16871	11700	5516.54	725.73	6242.27	5457.73	3771.21
	Barddhaman Total	**187170**	**150775**	**62829.1**	**10336**	**73165.1**	**77609.9**	**31068.62**
12	Nanoor	31600	26892	5884.65	1320.14	7204.79	19687.21	5459.1
	Birbhum Total	**31600**	**26892**	**5884.65**	**1320.14**	**7204.79**	**19687.21**	**5459.1**

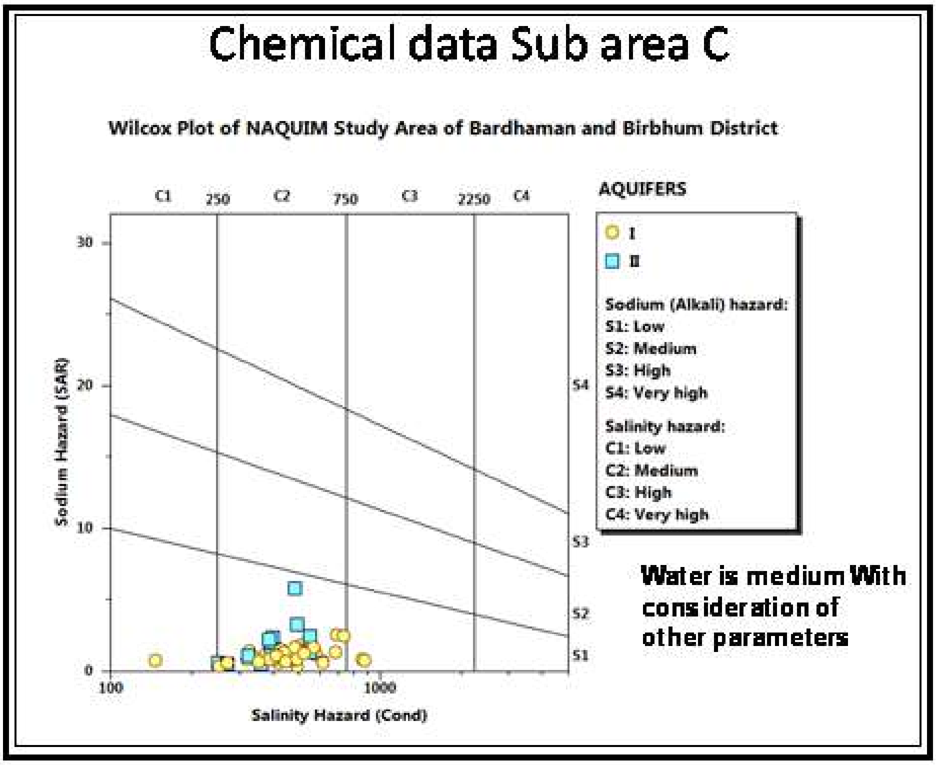


Fig. 8.4: Salinity Hazard plots of samples in study area

Table-8.4.1.2: Block wise ground water Resources, Draft, SOD and Category

Sr. No.	Name of Block	Net Available GW Resources (MCM)	Gross GW Draft (MCM)	SOD (%)	Category
1	Burwan	89.2039	54.1335	62.31	Semi-Critical
2	*Bharatpur I*	49.0552	27.1777	57.39	Semi-Critical
3	*Bharatpur II*	48.8767	30.7959	64.99	Semi-Critical
4	*Nanoor*	104.5008	47.2845	46.38	Semi-Critical
5	*Ketugram I*	52.3863	32.4439	62.66	Semi-Critical
6	*Ketugram II*	60.3103	27.9406	46.82	Semi-Critical
7	*Katwa I*	61.6064	30.2022	51.15	Semi-Critical
8	*Katwa II*	69.3776	30.0733	44.55	Semi-Critical
9	*Manteswar*	96.9411	64.0124	66.85	Semi-Critical
10	*Mangalkote*	123.94	47.6767	39.48	Semi-Critical
11	Bhatar	130.2567	57.2361	45.01	Semi-Critical
12	*Memari II*	55.6745	35.0025	65.33	Semi-Critical

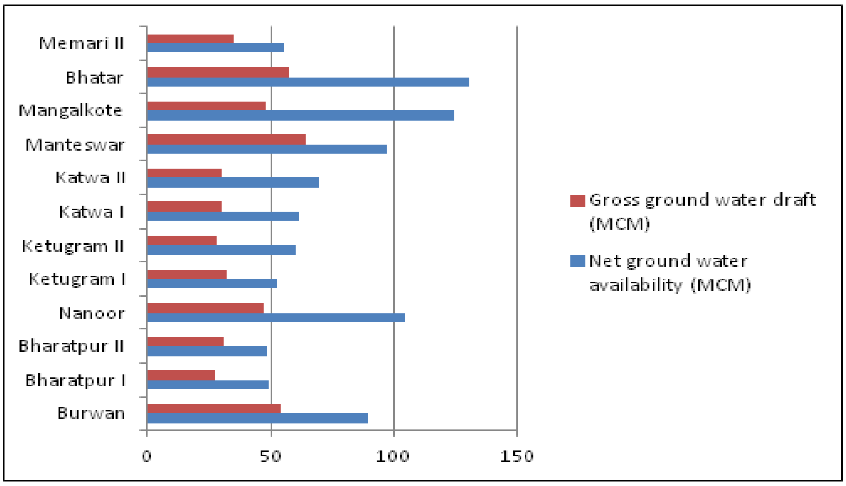


Fig. 8.4.1: Available ground water resources in different blocks of study area in aquifer I

It is observed that in all the blocks, the stage of development is between 40 % and 67 % and the long term trend of water level. However, 2006-2016 reveals that there is a remarkable falling trend in Aquifer I in all the blocks both during Pre-monsoon and Post-monsoon periods. In Aquifer I, as a whole the Pre-monsoon water level long term trend varies from 118.7 cm/year (Manteswar Block) to 6.6 cm/year (Burwan Block). In the post-monsoon trend varies from 325.53 cm/year (in Bharatpur II Block) to 16.5 cm/year (Ketugram II Block). Based on the ground water resources estimation, it is recommended to use of ground water resources for irrigation purposes, but regular monitoring of ground water regime is essential.

Change in storage in Aquifer II

In present area, Aquifer II, which occurs under semi-confined to confined condition, has been encountered mainly in Katwa I, Ketugram I, Bhatar, Memari II and Nanoor. In Mangalkote block, actually there are two aquifers, which coalesce in to one aquifer in the north-east. However, adjoining area of Aquifer II has also been traced up to a certain extent in areas of adjoining blocks/ municipalities. Change in storage has been calculated based on fluctuation data in depth to water level between Pre and Post monsoon 2016 in year 2016 and the same has been presented in Table-8.4.1.3.

. ***Table-8.4.1.3: Block wise change in storage (MCM) in Aquifer II***

Sr. no.	District	Block	Area in ha	Fluctuation of Water level (Pre to post) in metre	Average Storativity of confined aquifer	Change in Storage in Ham	Change in Storage in MCM
1	Barddhaman	Ketugram I	20000	1.44	0.0025	72	0.72
2	Barddhaman	Katwa I	18299	1.39	0.0004	10.17	0.10
3	Barddhaman	Mangolkote	36000	3.78	0.0007	95.26	0.95
4	Barddhaman	Memari II	10600	3.13	0.0003	9.95	0.10
5	Barddhaman	Bhatar	39300	2.10	0.0003	24.76	0.25
Barddhaman Total			124199	-	-	212.14	2.12
6	Birbhum	Nanoor	31600	1.5	**0.0035**	**165.9**	1.66
Birbhum Total			31600			165.9	1.66
7	Murshidabad	Bharatpur I	17800	0.9	0.0075	120.15	1.21
Murshidabad Total			17800			120.15	1.21

Table: 8.4.1.4: Block wise Calculation of Ground Water Flow in Aquifer II during post-monsoon 2016

Sr no.	District	Block	Major flow path's lengths (m)	Hydraulic Gradient (I)	Average T (Aquifer II)	Quantity of Ground water Flow in (m^3/day)
1	Barddhaman	Ketugram I	a. 11500 b. 9500	1:1051.67, NE-SW 1:2980 SSW-NNE	200	2186.99 637.58
2	Barddhaman	Katwa I	a. 15780	1:1009.17NNE-SSW	200	3127.32
3	Barddhaman	Mangolkote	a. 9000	1:952.5 NW-SE	200	1889.76
4	Barddhaman	Memari II	a. 18950	1:1104 W-E	200	3432.97
5	Barddhaman	Bhatar	a. 18940	1:1148.18 NNW - SSE	200	3299.13
6	Birbhum	Nanoor	a. 13680	1:1368 SE-NW	200	2000
7	Murshidabad	Bharatpur I	a. 12600	1:2630	200	958.17

Annexure Ia: Details of key wells in Aquifer I in the districts of Bardhaman, Murshidabad and Birbhum, West Bengal

ID No.	Village	Block	Location details	Type of structure	Owner	M.P. (magl)	Diam. (m)	Depth (mbgl)	Pre-monsoon DTW (mbgl)	Post-monsoon DTW (mbgl)	Lat	Long
1	ORGRAM	Bhatar	Within Seed Farm premises	Dug	Seed Farm	0.9	2.85	23.95	9.5	6.91	23.44111	87.77083
2	KURUMBA	Bhatar	In the land of Shri Narayan Chandra Ghosh	Mini Tube well	Private	0.6	0.152	26.83	11.58	8.2	23.37944	87.87056
3	RAIGRAM	Monteswar	In the agricultural land of Shri Saukat Ali Mandal	Mini Tube well	Private	0.62	0.152	35.96	21.4	18.55	23.38442	88.19808
4	SWARNACH ALIDA	Bhatar	Near land of Shri Debabrata Yash	Mini Tube well	Private	0.4	0.152	36.17	18.59	16.43	23.42839	87.8205
5	FAKIRDANG A	Bhatar	In Sri Kiran Sankar Roy's land	Mini Tube well	Private	0.5	0.152	36.57	17.4	20.17	23.41653	88.03103
6	CHURPUNI	Katwa I	New Market	Cydrical H P	Panchayet	0.1	0.076	36.58	17.65	19.4	23.62625	88.05714
7	BARAPURUL IA	Ketugram II	Inside SSK	Mark I tube well	Panchayet	0.3	0.076	36.58	15.76	14.87	23.67928	88.06175
8	FUNTISANK O	Ketugram II	Beside Asha Pharmacy	Cydrical T W with H P	Panchayet	0.45	0.152	38.1	15.08	15.54	23.74434	87.94636
9	AMARUN	Bhatar	On Katowa Road in Sri Sankar Ghosh's land beside Netaji weigh Bridge	Mini Tube well	Private	1.33	0.152	38.29	19.25	19.1	23.37633	87.91133

10	KHANRGRA M	Bardhaman II (at border of Memari II Block)	Beside boundary of Memari II Block in agricultural land of Shri basudev Bagh	Mini Tube well	Private	0.4	0.152	39.62	11.82	8.08	23.21847	88.00647
11	KHATUNDI	Ketugram I	Beside Khalipur-Pandugram main road	Mini Tube well	Private	2.35	0.152	39.62	15.68	14.87	23.68283	87.99722
12	JAJAN	BHARATPUR-I	In village	PZ	SWID	0.65	0.101	40	18	19.5	23.91028	88.02583
13	SAHAPUR	BHARATPUR-I	In village	Mark-II	Panchayet	0.78	0.152	40	18.05	16.7	23.855	88.12056
14	KHARERA (Paschimpura)	BHARATPUR-II	In village	Mark-II	Panchayet	0.85	0.152	40	21.78	18.6	23.79139	88.05056
15	ROY RAMCHAND RAPUR	Mangalkote	In the land of Shri Gadadhar Saha near Manasa tala on the way to Primary school	Mini Tube well	Private	0.4	0.152	42.27	12.95	6.49	23.47692	87.77458
16	PIPLAN	Monteswar	Inside house of Sri Prasanta Samanta	Mini Tube well	Private	0.3	0.152	42.37	19.7	22.54	23.35322	88.14072
17	SINGI	Katwa II	Beside main road in the agricultural land of Shri Wagul Haque	Mini Tube well	Private	0.5	0.152	42.67	16.75	16.39	23.53606	88.18347
18	RATANPUR PIRTALA	Ketugram I	Opposite to Mobile Tower, in owner's agricultural land	Mini Tube well	Private	0.45	0.152	42.67	18.25	15.97	23.68178	87.93533
19	DEVPUR	Bhatar	In front of Srikrishna Lottery Agency	Mark I Tube well	Panchayet	0.35	0.076	42.67	23.43	16.7	23.47105	87.84063
20	JABAGRAM	Mangalkote	In agricultural land of Shri Tapas Paul on way to Maldanga	Mini Tube well	Private	1	0.152	42.67	25.49	23.33	23.49186	88.0265
21	ORGRAM	Bhatar	Beside office inside premises	Shallow Tube Well	Govt.	0.45	0.152	42.67	27.43	23.58	23.44197	87.77181

22	KUCHUT	Memari II	In agricultural land of Sri Debu, beside Kalna-Bardhaman road	Mini Tube well	Private	0.87	0.152	44.85	14.96	12.1	23.25075	88.04097
23	TALGRAM	BHARATPUR-I	In village	Mark-II	Panchayet	0.73	0.152	45	17.8	16	23.86361	88.04306
24	KARULE	Katwa I	In agricultural land of Shri Asit Ray	Mini Tube well	Private	0.92	0.152	45.42	24.93	21.88	23.51708	88.06461
25	UTTAR GOPAlPUR	Ketugram I	Inside Uttar Gopalpur Primary School	Mark II Tube well	Private	0.65	0.076	45.72	18.35	22.16	23.75681	87.99681
26	JHIKRA GHAT	Memari II	Opposite to Bardhaman Jagabandhu Machinaries	Mini Tube well	Jhikra Bamunpukur Society	0.7	0.152	48.06	19.75	21.47	23.28306	88.14242
27	GAZIPUR	Katwa II	Beside main road	Mark I Tube well	Panchayet	0.2	0.152	48.16	15.56	14.05	23.58787	88.23673
28	MALAMBA	Memari II	On Nabadwip road in agriculturalland of Sri Sailen Mandal	Mini Tube well	Private	0.5	0.152	48.26	18.4	19.3	23.36439	88.06642
29	PUTSURI	Monteswar	In front of house of Sri Bhagirath Mandal	Cydrical T W with H P	Panchayet	0.35	0.076	48.41	22	21.98	23.4395	88.16458
30	AMUL	Katwa II	Beside main road	Mini Tube well	Private	1.7	0.152	48.76	16.23	15.24	23.49617	88.21067
31	RAMJIBANPUR	Ketugram I	Within Block Office of Ketugram I	PZ	SWID	0.55	0.05	50	18.7	20.2	23.7375	87.97222
32	MADHYAMGRAM	Monteswar	Within Nion co-operative Store premises	PZ	SWID	0.43	0.05	50	16.57	24.22	23.30556	88.13917

33	CHANAK	Mangalkote	Beside Guskara-Mangalkote Rd.	PZ	SWID	0.67	0.05	50	12.8	17.64	23.53222	87.7925
34	NANDIGRAM	Katwa II	Within primary school, on Manteswar Rd.	PZ	SWID	0.25	0.05	50	19.6	23.27	23.54389	88.14972
35	BARABELUN	Bhatar	Beside Bhatar-Manteswar Rd.	PZ	SWID	0.65	0.05	50	24.2	24.55	23.40927	87.9818
36	KAICHOR	Mangalkote	Beside Police outpost	PZ	Panchayet	0.6	0.05	50	21.55	26.93	23.53	88.02
37	KAITHON	Katwa I	Hattala Bazar, opposite 'Abarani', near transformer	PZ	SWID	0.6	0.05	50	21.7	25.68	23.5275	88.08639
38	KHALIPUR	Ketugram I	Within Sr. Madrasa Compound	PZ	SWID	0.6	0.05	50	20	24.24	23.71861	88.0125
39	SINGI	Katwa II	Kashiram Das Pathagar premises	PZ	SWID	0.53	0.05	50	17.9	16.29	23.5358	88.18675
40	AMARUN	Bhatar	Beside Katwa Road & near Weigh Bridge	PZ	SWID	0.4	0.05	50	17.6	22.85	23.37637	87.91133
41	GUSKARA	Ausgram I	Within Seed Farm premises	PZ	SWID	0.26	0.05	50	14.4	8.53	23.5	87.74558
42	SHYAMBAZAR	Katwa II	Inside owner's agricultural land premises (owner-Shri Aditya Ghosh)	Mini Tube well	Private	0.7	0.152	51.82	20.47	19.44	23.62433	88.00975
43	KHAIRA	BHARATPUR-I	In village	Mark-II	Panchayet	0.7	0.152	53	11.54	10.5	23.8775	88.14778
44	UTTAR GOPAlPUR	Ketugram I	In the agricultural land, west of Ketugram-Gopalpur Road	Mini Tube well	Private	1.2	0.152	53.66	18.3	14.98	23.75653	87.99694
45	KURULIYA	Burwan	In village	STW (AI)	AI	0.5	0.2032	54	15	12.1	23.94639	87.92833

46	BITRA	Memari II	Opposite to M/S Utsav Decorators	Mini Tube well	Private	0.7	0.152	54.16	21.27	20.33	23.30977	88.20815
47	MONTESWA R	Monteswar	In the agricultural land of Shri Nayan Garai, beside Monteswar-Satgachhia road	Mini Tube well	Private	0.6	0.152	54.26	26.75	26.1	23.41408	88.11222
48	SHIBPUR	Memari II	Near Primary SchoolOn the road to Melna	Mark I Tube well	Panchayet	0.15	0.076	54.71	15.56	13.45	23.25294	88.054
49	BITRA	Memari II	Inside Health Centre	Mark II Tube well	Private	0.7	0.152	54.86	20.88	19.68	23.30977	88.20917
50	BALGONA	Bhatar	Within Nityanandapur Primary school	PZ	CGWB	0.5	0.101	55	30.87	29.13	23.46111	87.93972
51	GADDA	BHARATPUR-I	In village	Mark-II	Panchayet	0.5	0.152	55	18	15.4	23.86528	87.97722
52	ORGRAM	Bhatar	Within Seed Farm premises	PZ 2	CGWB	0.6	0.3	55.51	24.9	22.85	23.44111	87.77111
53	AMLAI	BHARATPUR-I	In village	MARK-II	Panchayet	0.35	0.152	60	16.2	15.05	23.90667	88.13028
54	KHARINDA	BHARATPUR-I	In village	Mark-II	Panchayet	0.75	0.152	60	14.2	13	23.84333	88.06083
55	SUNUTI	BHARATPUR-I	In village	Mark-II	Panchayet	0.7	0.152	60	14.9	12.5	23.82889	88.04722
56	TALIBPUR	BHARATPUR-II	In village	Mark-II	Panchayet	0.85	0.152	60	17.9	14.6	23.77694	88.13472
57	SIMULIYA	BHARATPUR-II	In village	STW (PHED)	PHED	0.5	0.2032	60	31.4	29.25	23.75917	88.06167
58	MASSUDDA	BHARATPUR-II	In village	Mark-II	Panchayet	0.75	0.152	60	18.5	16.3	23.80944	88.03722
59	PANCHTHUP E	Burwan	In village	STW (PHED)	PHED	0.5	0.2032	60	20	17.75	23.88917	87.99306

60	SATITARA	Burwan	In village	STW (PHED)	PHED	0.5	0.2032	60	22	19.9	23.9075	87.96917
61	SHRIHATA	Burwan	In village	STW (AI)	AI	0.5	0.2032	60	27	24.2	23.91944	87.95417
62	SWAMANTR I	Burwan	In village	Mark-II	Panchayet	0.7	0.152	60	7.7	6.15	23.92528	87.89722
63	BURWAN	Burwan	In village	STW (PHED)	PHED	0.5	0.2032	60	26	24.7	23.92556	87.94083
64	SUNDERPUR	Burwan	In village	Mark-II	Panchayet	0.7	0.152	60	8	7.15	23.87333	87.94056
65	MANDRA	Burwan	In village	Mark-II	Panchayet	0.75	0.152	60	8.5	7.3	23.85389	87.88111
66	CHARKALG RAM	Nanoor	In village	Mark-II	Panchayet	0.7	0.152	60	18.5	16.2	23.66278	87.83861
67	BASAPARA	Nanoor	In village	Mark-II	Panchayet	0.7	0.152	60	19.8	17.4	23.57583	87.87611
68	RAMDASPU R	Katwa II	Beside main road, at bus stop	Mark I Tube well	Panchayet	0.4	0.152	60.96	9.29	8.51	23.56724	88.2143
69	BHULKURI	Ketugram I	On the way to Bara Purulia	Mini Tube well	Private	0.58	0.152	60.96	15.16	14.12	23.67911	88.05931
70	PALITA MORE	Kandra Block (at border of KetugramII)	In the agricultural land of Shri Hasil Sekh	Mini Tube well	Private	0.6	0.152	60.96	16.02	13.23	23.65033	87.9345
71	KASTOKUR UMBA	Bardhaman II block (at border of Memari II Block)	In agricultural land of Shri madan Mohan Ghol on way to main villlage locality	Mini Tube well	Private	1.33	0.152	60.96	18.3	14.15	23.28375	88.04489
72	HAT MOREGRAM MORE	Ketugram II	On the road to Hat Moregram	Mini Tube well	Private	1.12	0.152	60.96	18.51	18.49	23.71706	88.00361

73	PAHARHATI	Memari II	Within Block premises of Memari II	Tube Well	Block	0.4	0.305	60.96	18.75	19.1	23.25239	88.09758
74	MALLIKPUR	Memari II	In agricultural land beside Memari-Satgachhia main road	Mini Tube well	Private	0.7	0.152	60.96	19.29	19.8	23.23775	88.1388
75	BUNOPARA	Memari II	Inside ICDS school premises	Mark II Tube well	Panchayet	0.6	0.076	60.96	19.67	16.34	23.26675	88.17299
76	MADHYAMGRAM	Monteswar	Beside main road	Mark I Tube well	Panchayet	0.2	0.076	60.96	19.79	23.05	23.30694	88.13306
77	KURCHI	Katwa II	Near Road Junction, opposite to Radhagovinde Traders	Mark II Tube well	Panchayet	0.25	0.076	60.96	21.45	20.63	23.52353	88.14368
78	SINUT/BHATPARA	Mangalkote	In agricultural land of Shri Tafiq Sekh	Mini Tube well	Private	0.4	0.152	60.96	24.89	22.75	23.51483	87.94844
79	GAPHULIA	Katwa I	Inside owner's agricultural land premises	Mini Tube well	Private	0.7	0.152	60.96	25.09	23.78	23.56614	88.09547
80	HAT MOREGRAM	Ketugram I	Inside school	Cydrical T W with H P	Private	0.45	0.076	60.96	16.78	15.88	23.71739	88.00475
81	SALINDA	BHARATPUR-II	In village	STW (AI)	AI	0.5	0.2032	62	16	14.6	23.83083	88.10056
82	ANGARPUR	BHARATPUR-I	In village	DTW(AI)	AI	1.4	0.254	65	15	12.6	23.90361	88.07833
83	NAWAPARA	BHARATPUR-II	In village	STW (PHED)	PHED	0.5	0.2032	67	26	23.3	23.82333	88.13917
84	RAMDASPUR	Katwa II	Near Bus Stand	Mini Tube Well	Private	1.4	0.152	67.06	9.5	7.07	23.56724	88.21445

85	BHARATPUR	BHARATPUR-I	In village	Mark-II	Panchayet	0.75	0.152	70	21.94	19.1	23.88306	88.08194
86	BADAKAPSA	Burwan	In village	Mark-II	Panchayet	0.7	0.152	70	15	12.9	23.99861	87.89222
87	UCHKATAN	Nanoor	In village	Mark-II	Panchayet	0.7	0.152	70	16	14.1	23.67694	87.87639
88	PAPURIA	Nanoor	In village	Mark-II	Panchayet	0.7	0.152	70	21.75	18.15	23.65056	87.81194
89	BANGACHA TRA	Nanoor	In village	Mark-II	Panchayet	0.7	0.152	70	18	15. 30	23.60833	87.83167
90	RASARA	Bharatpur-I	In village	Mark-II	Panchayet	0.7	0.152	70	12.8	9.2	23.93194	88.05389
91	MUNIADIH	Burwan	In village	Mark-II	Panchayet	0.75	0.152	70.6	20	17.25	23.89611	87.99972
92	GOPKHANJI	Dainhat Municipality	Inside owner's hatchery premises	Mini Tube well	Private	1.08	0.152	72.07	11.74	11.35	23.59503	88.16503
93	MALLIKPUR	Memari II	Beside main road	Mark II Tube well	Panchayet	1.1	0.076	73.15	20.1	16.9	23.23646	88.1388
94	KETUGRAM	Ketugram II	PHED Pump House	PHED No. 2	PHED	0.45	0.203	75	14.98	14.58	23.70714	88.04678
95	SHRIKHAND A	Katwa I	Near Panchayet Office	Deep Tube Well	PHED	0.65	0.3048	86.87	20.19	23.75	23.60458	88.08061
96	SALAR	BHARATPUR-II	In village	SDT (PHED)	PHED	0.8	0.2032	90	34.2	31.2	23.77167	88.10833
97	LOHADAHA	BHARATPUR-I	In village	DTW (PHED)	PHED	1.5	0.254	100	18	15.5	23.89194	88.17111
98	KINARHAR	Nanoor	In village	DTW (PHE)	PHED	0.5	0.254	103	36	33. 55	23.76194	87.87667

99	KAGRAM	BHARATPUR-II	In village	DTW (PHED)	PHED	0.5	0.254	107	17	15	23.75694	88.13778
100	DAKHIN KHAND	BHARATPUR-II	In village	DTW (PHED)	PHED	0.6	0.254	107	40.9	36	23.755	88.07417
101	RAMDASPU R	Katwa II	Near Bus Stand	Deep Tube Well	AI	0.4	0.36	109.7 2	10.02	8.38	23.56724	88.21445
102	SIMULGACC HI	BHARATPUR-I	In village	DTW(A I)	AI	0.7	0.254	110	16.75	14.2	23.93444	88.07778
103	SATGACHHI A	Memari II	Kalapukur behind Bharat Show Room	Deep Tube Well	PHED	0.6	0.305	115.8 2	21.87	23.15	23.26369	88.145
104	TEYAN	BHARATPUR-II	In village	DTW (PHED)	PHED	0.5	0.254	117	15	13.2	23.82111	88.1525
105	RAIGRAM	BHARATPUR-II	In village	DTW (AI)	AI	0.5	0.254	120	23.3	19.4	23.83444	88.08611
106	RAIGRAM	Monteswar	Near Mini T W of Raigram	Deep Tube Well	AI	0.6	0.356	121.9 2	19.52	19.85	23.38358	88.19653

Annexure Ib: Details of key wells in Aquifer II in the districts of Bardhaman, Murshidabad and Birbhum, West Bengal

I.D. No.	Village	Block	Location details	Type of structure	Owner	M.P. (magl)	Diam. (m)	Depth (mbgl)	Pre-monsoon DTW (mbgl)	Post-monsoon DTW (mbgl)	Lat	Long	Type of aquifer	RL (mamsl)
1	ATGARA	Mangalkote	In the agricultural land of Shri Ashok Sarkar	Mini Tube well	Private	0.75	0.152	91.44	19.45	11.05	23.5362	87.87008	II	28.2
2	PANOA	Bhatar	Newly constructed PWSS well	Deep Tube Well	PHED	0.6	0.305	170	17.05	16.4	23.4111	87.87719	II	32.5
3	UNIA	Mangalkote	In the agricultural land of Shri	Deep Tube Well	Private	0.36	0.356	91.44	18.29	17.67	23.5538	87.75892	II	35
4	DAINHAT (at the proximity to Katwa I block)	Dainhat Municipality	Opposite to M/S Tapas Bag near Rly. Stn.	Deep Tube Well	PHED	0.6	0.304	190	15.31	12.52	23.603	88.16786	II	19
5	SINGI (at the proximity to boundary of Katwa I block)	Katwa II	Beside main road (PWSS well)	Deep Tube Well	PHED	0.8	0.3048	106.68	15.2	16.89	23.5364	88.18489	II	15.4
6	GUSKARA	Ausgram (at the boundary of Mangalkote block)	In Seed Farm	Deep Tube Well	Govt.	0.75	0.304	106.68	25.67	10.3	23.4996	87.74558	II	35
7	KATWA (at the proximity to Katwa I block)	Katwa Municipality	Beside Rly. Stn.	Deep Tube Well	Rly. Dppt.	0.35	0.355	115.47	13.03	10.34	23.6414	88.13307	II	20.8

8	SONADANGA (IBRAMBAD)	Monteswar	In the agricultural land of Shri Jabbar Sekh	Deep Tube Well	AI	0.25	0.356	115.82	22.45	21.64	23.4257	88.16017	II	14.8
9	BHATAR	Bhatar	Panchayet office premises	Deep Tube Well	PHED	0.77	0.305	115.82	23.49	22.23	23.4114	87.92528	II	30.3
10	MAHARA	Bhatar	In the agricultural land of Shri Chandrasekhar Ghosh	Deep Tube Well	Private	0.1	0.36	115.82	26.15	25.65	23.3826	87.82828	II	34.3
11	MAJHIGRAM	Mangalkote	PHED T W No. 1	Deep Tube Well	PHED	0.5	0.304	115.82	28.82	29.2	23.5862	87.97747	II	27
12	BALGONA	Bhatar	In office premises of Nityananda Panchayet primises	Deep Tube Well	Panchayet	0.45	0.203	115.82	31.87	25.38	23.4607	87.93961	II	27.5
13	NARAYANPUR	Katwa I	Beside village road	Deep Tube Well	AI	0.2	0.304	115.82	16.02	14.27	23.5867	88.14431	II	15.6
14	KANDRA	Ketugram I	In the agricultural land of Late Shivsankar Biswas	Deep Tube Well	AI	0.2	0.0365	115.82	17.89	16.45	23.7384	87.96564	II	24.9
15	MADHYAMGRAM	Memari II	On Madhyamgram-Malamba road	Deep Tube Well	PHED	0.9	0.203	115.82	24.36	24.7	23.3077	88.13033	II	16.2
16	ERUAR	Bhatar	PHED T W No. 3	Deep Tube Well	PHED	0.7	0.3048	180	28	21.12	23.4675	87.87489	II	37.3

17	KASHEMNA GAR	Mangalkote	Opposite to Kusumita Jewellers, PWSS well	Deep Tube Well	Govt.	0.35	0.304	120	23.48	12.96	23.5324	87.759 81	II	35.6
18	JOGESWARD IH	Mangalkote	PHED Pump House	Deep Tube Well	PHED	0.5	0.305	121.9	26.07	24.9	23.5624	88.027 94	II	23.3
19	KHIRGRAM	Mangalkote	Near Jugadya Temple	Deep Tube Well	Pancha yet	0.5	0.152	140.21	28.38	25.65	23.5132	88.031 53	II	22.5
20	JHIKRA (just at the proximity to Memari II block)	Monteswar	Near road pool at the border with Memari II Block	Deep Tube Well	AI	0.5	0.356	143.26	21.33	20.88	23.2871	88.140 81	II	15.9
21	BARABELUN	Bhatar	Near Girls'High School	Deep Tube Well	PHED	0.6	0.356	146.3	21.58	24.79	23.4057	87.973 19	II	26.5
22	BOHAR	Memari II	Within pump house on way to NHS	Deep Tube Well	PHED	0.4	0.036	201.17	33.13	26.54	23.3826	88.196 49	II	12.3
23	NANOOR	Nanoor	In village	DTW (PHE)	PHED	0.5	0.254	180	34	32.5	23.7017	87.870 83	II	32.5

Annexure Ic: Details of key wells in Aquifer '0' in the districts of Bardhaman, Murshidabad and Birbhum, West Bengal

I.D. No.	Village	Block	Location details	Type of structure	Owner	M.P. (magl)	Diam. (m)	Depth (mbgl)	Pre-monsoon DTW (mbgl)	Post-monsoon DTW (mbgl)	Lat	Long
1	NAIHATI	Ketugram II	Beside road	Cydrical TW with H P	Panchayet	0.3	0.076	39.62	7.14	6.89	23.69233	88.14042
2	GANGATIKURI	Ketugram II	Near house of Sri Jiten Mandal, beside main road	Mark I tube well	Panchayet	0.35	0.0762	36.58	11.65	9.59	23.711	88.09486
3	KATWA TOWN	Katwa I	Within Masjid	Dug	Private	0.23	0.55	7.28	3.47	5.11	23.64833	88.12888
4	DAINHAT	Katwa II	Just S of old BDO office on Katwa Rd.	Dug	Private	0.83	0.72	14.8	1.87	5.71	23.60687	88.17115

9. Ground Water Management Plan

It is observed that in most of the blocks, 50 % and more of the total cultivable area is yet to be brought to be under irrigation. In the study area out of cultivable area of 232333 ha, only 104676.99 ha has been covered by irrigation facilities.Therefore, still 127656.01 ha of land need to be irrigated.Throughout the area, the major and the pre-dominant aquifer shows a remarkable falling trend of both the pre-monsoon and the post-monsoon water level. as a whole the Pre-monsoon water level long term trend varies from 118.7 cm/year (Manteswar block) to 6.6 cm/year (Burwan block). In the post-monsoon trend varies from 325.53 cm/year (in Bharatpur II block) to 16.5 cm/year (Ketugram II block)..However, locally rise in water level at a few places in Burwan, Bharatpur I, Bharatpur II, Katwa I & Bhatar has been encountered (vide Table - 6.5b). Of course, stage of Ground Water development in the area varies between 39.48 % and 66.85 %.The reason for moderate SOD, but significant declining rate in water level in post-monsoon compared to pre-monsoon may be due to massive irrigation in former season and the impact of pumping water level in one well with the others and vice versa. Aclose monitoring of water level as well as water quality is required to adopt time to time change in ground water management scenario of the area.

Management Strategy for use of irrigation water & modification in cropping pattern

- Change in cropping pattern is need of the hour.
- Cultivation of low water requiring crops and change in cropping pattern suitable for the area.
- Boro cultivationneeds 1.2 to 1.4 m of water column, grown during summer and heavily depends on ground water. Phasewise lessening of area for its cultivation is strongly suggested for experimentation. The cultivation of 'boro' is initially proposed to be reduced by about 10 %. The total annual paddy production could be balanced by increasing cultivation of Aus, which is grown in Kharif season, by the same area. The reduced area of boro cultivation may be substituted by 1:1:1 area of cultivation of Til, Mung and ground nut. Besides, cash crops like sugar cane, flowers, oil seeds, etc. may also be tried in larger areas than being done now. Flowers are nowadays a good cash crop.
- For encouragement of cultivation of other crops instead of Boro, incentives should be provided by the govt. to the farmers.

- Boro cultivation is permissible in summer, if done by the surface water sources, viz. pond, tank, other surface water sources and conservation pond, to be constructed to store harvested rain water.
- Very recently, wheat cultivation has been discouraged because of reported damages by pests; however, increase in area of wheat cultivation may be a suitable option in parts of the study area under normal condition. Wheat needs about 0.35 m of water column and it's cultivation should be encouraged.
- Rain water harvesting and artificial recharge may be introduced in a big way to eliminate the problem of both declining water level and arsenic contamination.
- To improve the ground water scenario in shallow aquifer, implementation of modern irrigation practices like drip water irrigation system, sprinklers can be made.
- Water column suggested are rice (0.8) wheat (0.2-0.35), mustard (0.2), pulse (0.08-0.12), vegetable (0.12-0.16) following micro-irrigation system.

Benefits from implementation of above management strategy

- By decreasing area of Boro cultivation in summer and implementing micro-irrigation techniques, huge draft of ground water could be avoided.
- Fish farming can be done in conserved water ponds, tanks, etc.
- Income of the farmers and the inclusive growth of the society is assured.

Scope for Rainwater Harvesting and Artificial Recharge in Study Area:

Considering the details of post-monsoon depth to water level, which is generally very high throughout the area andlong-term trend of ground water level, almost the whole study area is suitable for artificial recharge. Also, the area is suitable for water conservation too. It is observed that in the whole study area of 2808.08 sq km is suitable for artificial recharge to ground water aquifers and water conservation.

Using method of Dhruvanarayana,1993 detailed water budgeting for individual blocks has been made based on data of Normal Rainfall, soil type and land slope, etc.: in this method run-off component for recharge and conservation has been determined, followed by proposal of different types of artificial recharge and conservation structures in different blocks, and total cost estimate for different blocks has been assessed for implementation ofdevelopment of water resources as a whole. As a result, the economy of the area will be improved. The stepsfor estimation of run- off, determination of proposal of nos. of structures, cost estimation, etc. are given below:

i. Determination of Total volume of surface runoff available Annually 'Vt'(RnXAXC) Ham
ii. Determination of 75% of 'Vt' = V Ham
iii. Determination of 50% of ‘V’(Non committed)= Vnc Ham
iv. Considering 60% of ‘Vnc’ to be harvested = Vf Ham
v. Source water allocation for artificial recharge for Irrigation Cum Recharge Tank, Re-excavation of Existing Tank (REET) with Recharge Shaft, Injection Well, conservation structure, viz. Farm Pond, etc.
vi. Finally, nos. of different structures possible in different blocks depending upon soil characteristics and other aspects, along with their size specifications and cost estimate have also been made.

Considering the higher ground water development, categorization of the block as per the Ground Water Resource Assessment, 2013 and block/municipal level suitable area for recharge, priority may be assessed for implementation of artificial recharge projects in the study area. Percolation Tanks and Re-excavation of Existing Tanks with Recharge Shafts in the rural area, and Injection Wells in the municipal and urban area may be constructed as per the feasibility study.

The number and types of artificial recharge and conservation structuresproposed to be constructed for harvesting rainwater and the estimated cost involved fordoing this, have been shown in Table 9.1& Table 9.2

Table 9.1: Estimation of run-off component of rain fall for harvesting

Sl. No.	District	Normal monsoon rainfall in m(50 yrs data from data.gov.in) 'Rn'	Block	Area(Ha) 'A'	Annual total volume of rain fall in Ham=(Rn X A)	Run off co-efficient from Dhruvanarayana,1993(Land slope, type of land and soil type) 'C' land slope 0-5%	Major type of soil available in that block	Total volume of surface runoff available Annually 'Vt' (RnXAXC) Ham	75% of 'Vt' = V Ham	50% of V (Non committed) = Vnc Ham	60% of Vnc= Vf Ham
1	Bardhaman	1.029	Ketugram I	20000	20580	0.45	50 % silty clay & 50% silty loam	9261	6945.75	3472.88	2083.725
2	Bardhaman	1.029	Ketugram II	14200	14611.8	0.525	75 % silty clay & 25 % silty loam	7671.195	5753.396	2876.7	1726.018875
3	Bardhaman	1.029	Katwa I	18299	18829.67	0.45	25 % clay, 75 % sandy/silty loam	8473.352	6355.014	3177.51	1906.504189
4	Bardhaman	1.029	Katwa II	16871	17360.26	0.65	90 % clay, 10 % loam	11284.17	8463.126	4231.56	2538.937879
5	Bardhaman	1.029	Mangalkote	36000	37044	0.51	30 % loam & 70 % silty clay	18892.44	14169.33	7084.67	4250.799
6	Bardhaman	1.029	Memari II	10600	10907.4	0.39	70 % loam &30 % silty clay	4253.886	3190.415	1595.21	957.12435

7	Bardhaman	1.029	Bhatar	39300	40439.7	0.3	100 sandy/silty loam	12131.91	9098.933	4549.47	2729.67975
8	Bardhaman	1.029	Monteswar	31900	32825.1	0.45	50 % loam & 50 % silty clay	14771.3	11078.47	5539.24	3323.541375
9	Murshidabad	1.079	Bharatpur I	17800	19206.2	0.52	50% fine loam, 10% coarse loam & 40% clay	9987.224	7490.418	3745.21	2247.1254
10	Murshidabad	1.079	Bharatpur II	16200	17479.8	0.52	50% fine loam, 10% coarse loam & 40% clay	9089.496	6817.122	3408.56	2045.1366
11	Murshidabad	1.079	Burwan	28000	30212	0.4875	60% fine loam, 20% coarse loam & 20% clay	14728.35	11046.26	5523.13	3313.87875
12	Birbhum	1.106	Nanoor	31600	34949.6	0.49	30 % Sandy loam, 20 % silty clay & 50 % clay	17125.3	12843.98	6421.99	3853.1934

- ***REET – Re-excavation of existing tanks, size 100m*100m*5m, Filling -2 times, capacity – 10 Ham, for recharge and irrigation
- Irrigation cum recharge tank – size 100m*100m*5m, Filling -10 times, capacity – 50 Ham; for recharge and irrigation
- Farm pond- size 100m*100m*5m, Filling -2 times, capacity – 10 Ham; for fishing only
- Injection wells - dia. -10"*6"; Depth - 300 m / 200m / 100m, Capacity -30 Ham, for recharge into deeper zones as well as for pumping

II. BLOCK WISE MANAGEMENT PLAN

10. BLOCK WISE MANAGEMENT PLAN MURSHIDABAD DISTRICT (PT.)

Block wise management Plan

10.1 BURWAN BLOCK

Salient Information

Area (in Km^2): 280.00

District: Murshidabad

State: West Bengal

Population (as on 2011):

Rural	Urban	Total
257466	-	257466

Approximate Decadal Growth Rate from 2001-2011: 14.74%

Rainfall:

Average annual rainfall (Murshidabad district) for the period 2012 -16 (in mm): **1220.6**

District	Normal	Actual (Annual)				
		2012	2013	2014	2015	2016
Murshidabad	1391.1	979.5	1228.2	1175.6	1673.5	1046.2

Agriculture & Irrigation (area in sq. Km):

SI. No	Name of the Block	Geographic Area	Cultivable Area	Area under pasture & orchard	Cultivable Waste Land	Forest Land
1.	Burwan	280	255.69	3.75	72.08	Nil

Aquifer Wise Ground Water Resource Availability & Extraction(in MCM):

Resource Availability	Aquifer I	Aquifer II	Extraction (for Aquifer I)
Dynamic Resource	89.2039	-	54.1335
Static Resource	**1285.20**	-	-

10.1.1Disposition of Aquifer:

Block	Depth range of Aquifer in m bgl	
	Aquifer I	Aquifer II
Burwan	8-90	-

Aquifer I occurs under semi-confined to confined condition**.**

Aquifer Wise Water Level & Pre-monsoon and Post-monsoon water level trends (2006 to 2016)

SI. No.	Block	Aquifer	Pre-monsoon Trend			Post-monsoon Trend		
			Water Level Range(m bgl)	Rise (cm/year)	Fall (cm/year)	Water Level Range(m bgl)	Rise (cm/year)	Fall (cm/year)
1.	Burwan	I	7.7-27	-	Average Fall 6.6	6.15-24.7	-	Average Fall 71.2

Thickness of granular zone (Average): 48.98 m (Aquifer I)Aquifer-wise Statement

Name of Block	Aquifer I			Aquifer II		
	Depth Range (m bgl)	**Discharge (m^3/hr)**	**T (m^2/day)**	**Depth Range (m bgl)**	**Discharge (m^3/hr)**	**T (m^2/day)**
Burwan	8-90	17.57 - 59.76	59.30 - 601	-	-	-

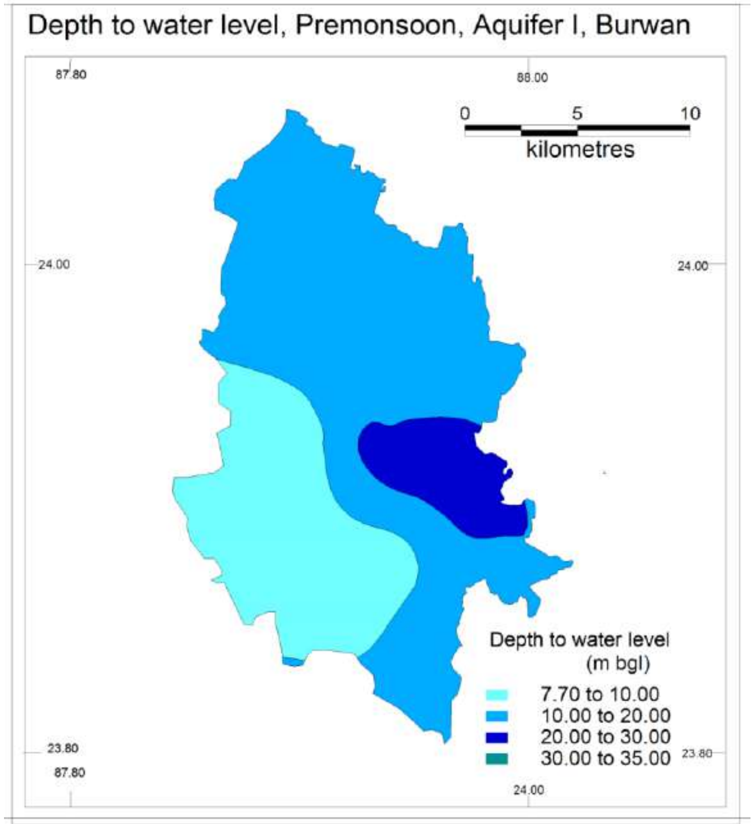


Fig. Depth to water level, Aquifer I, Pre monsoon

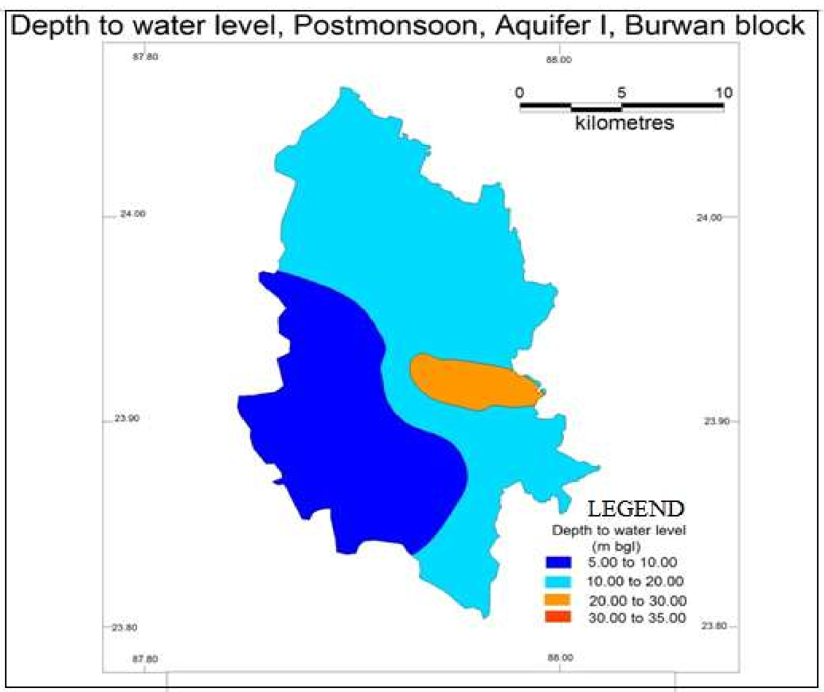


Fig. Depth to water level, Aquifer I, Post monsoon

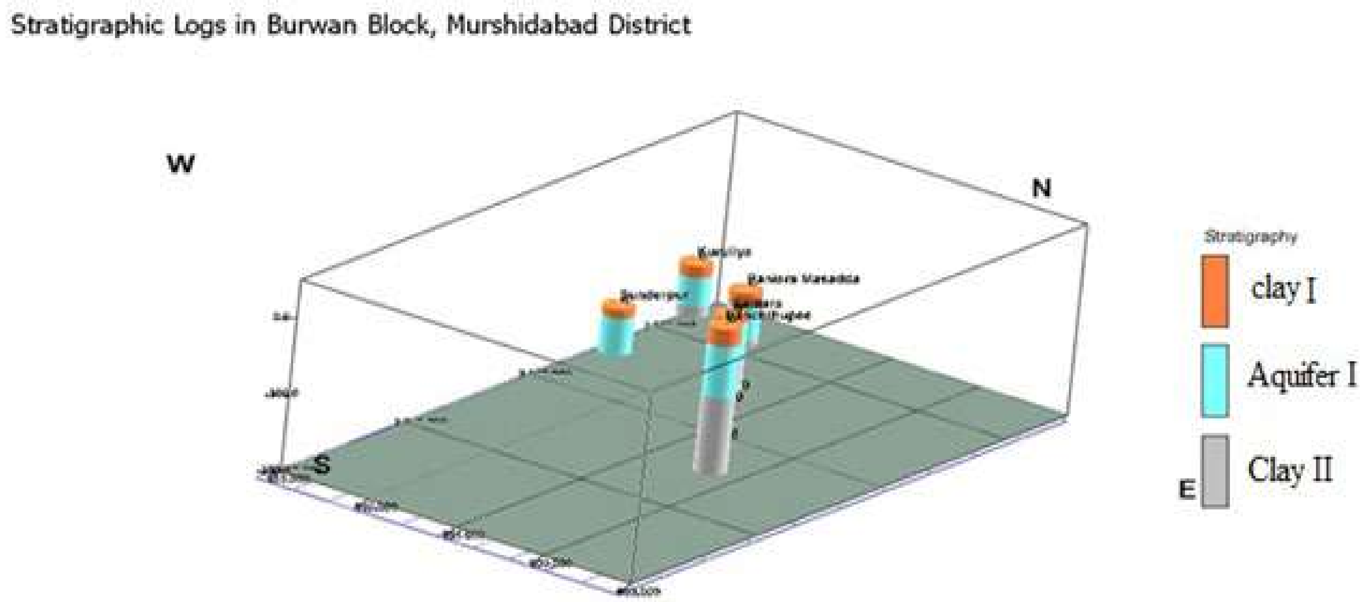


Plate 9.1.2.1: Stratigraphic logs in Burwan block, Murshidabad district

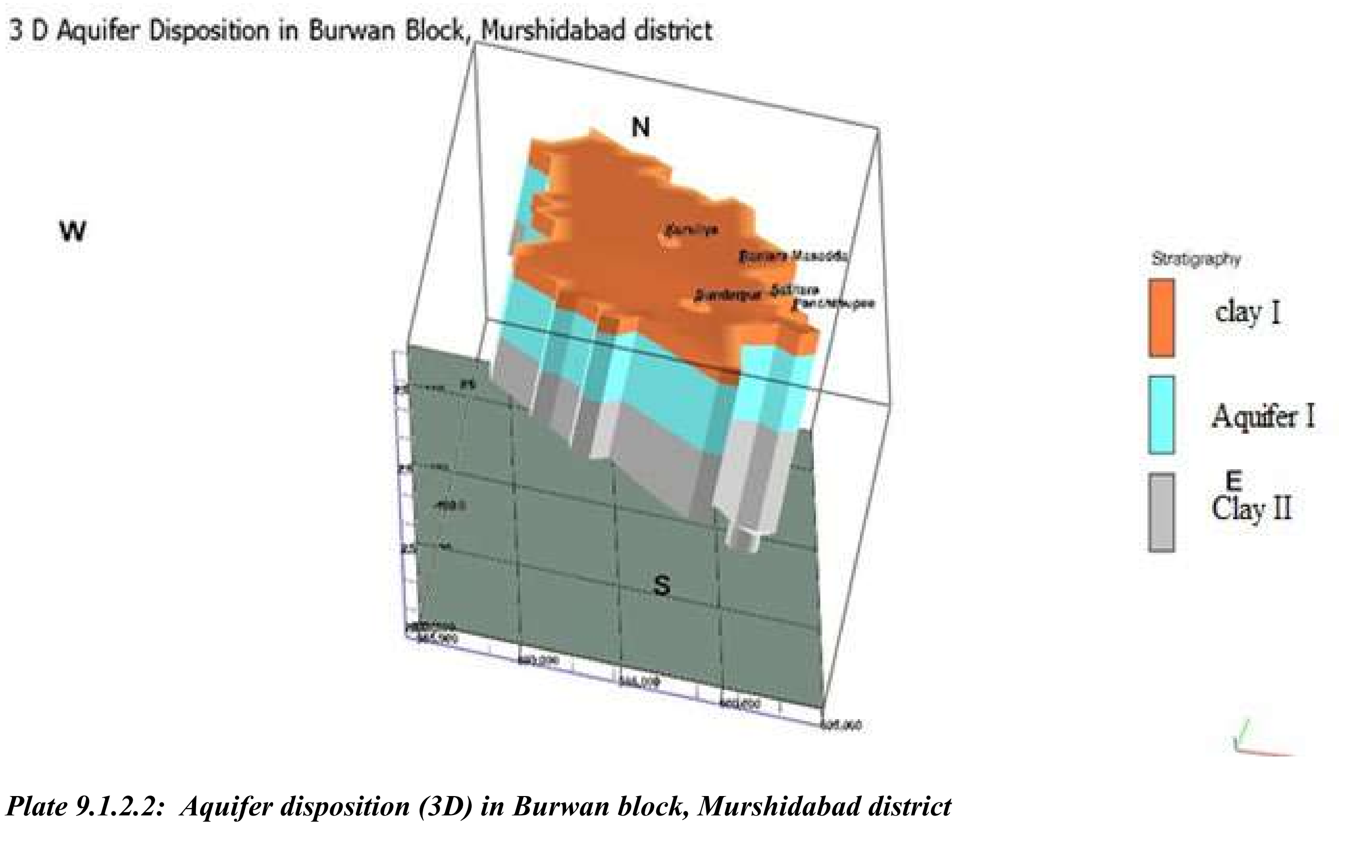


Plate 9.1.2.2: Aquifer disposition (3D) in Burwan block, Murshidabad district

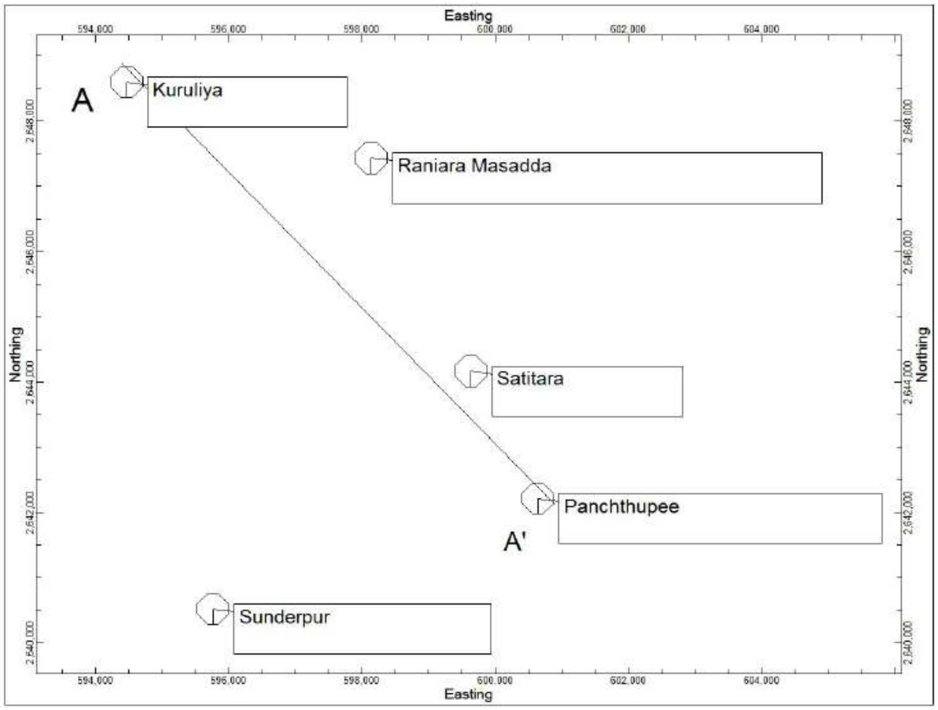


Plate 9.1.2.3: NW-SE section index line in Burwan block, Murshidabad district

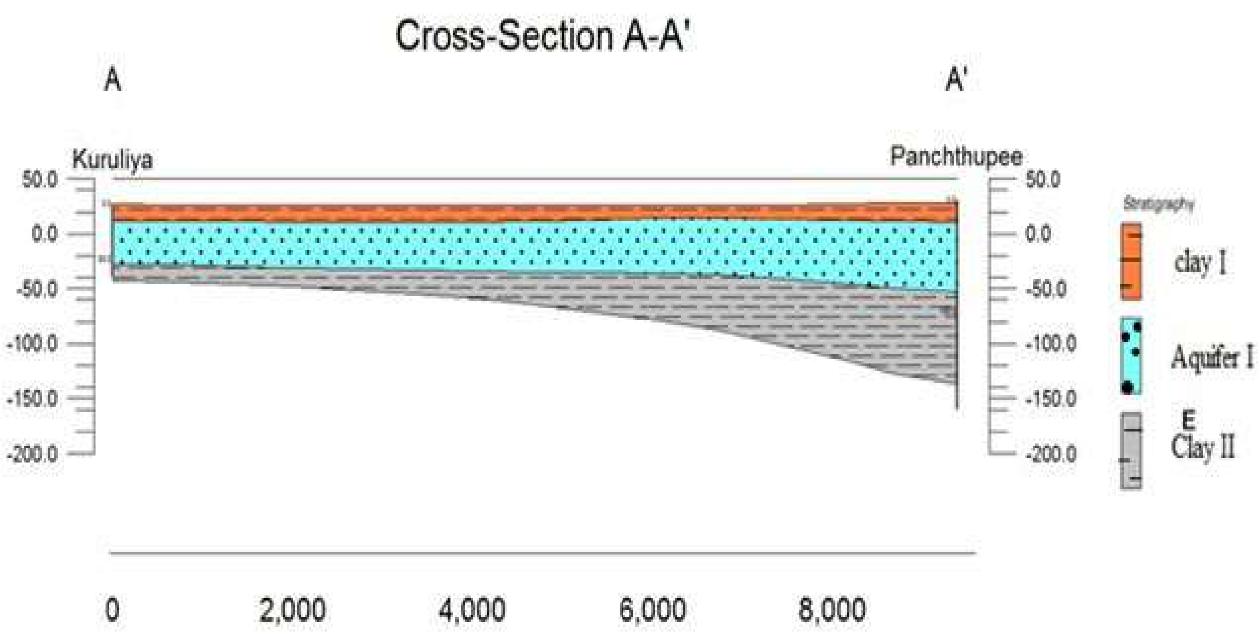


Plate 9.1.2.4: NW-SE section in Burwan block, Murshidabad district

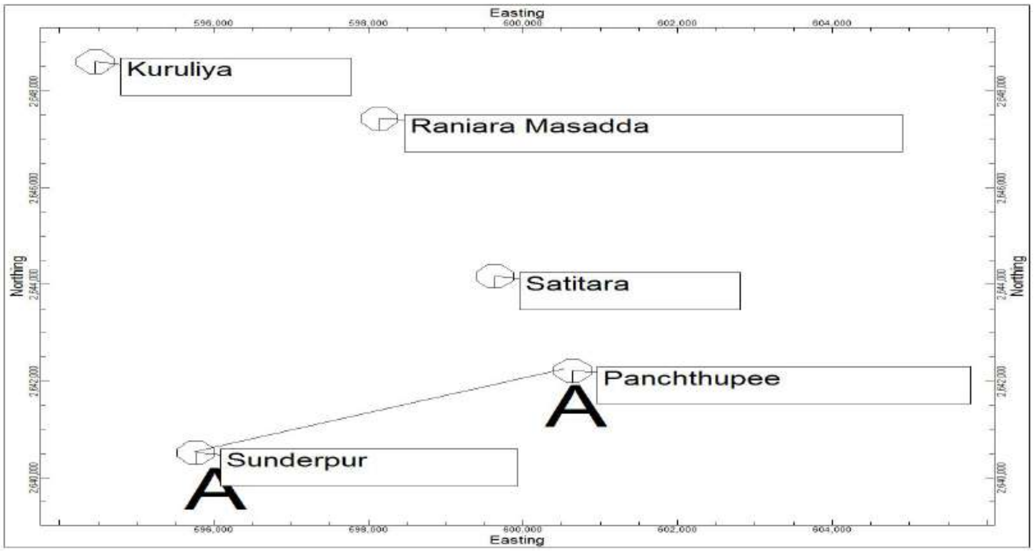


Plate 9.1.2.5: ENE-WSW section index line in Burwan block, Murshidabad district

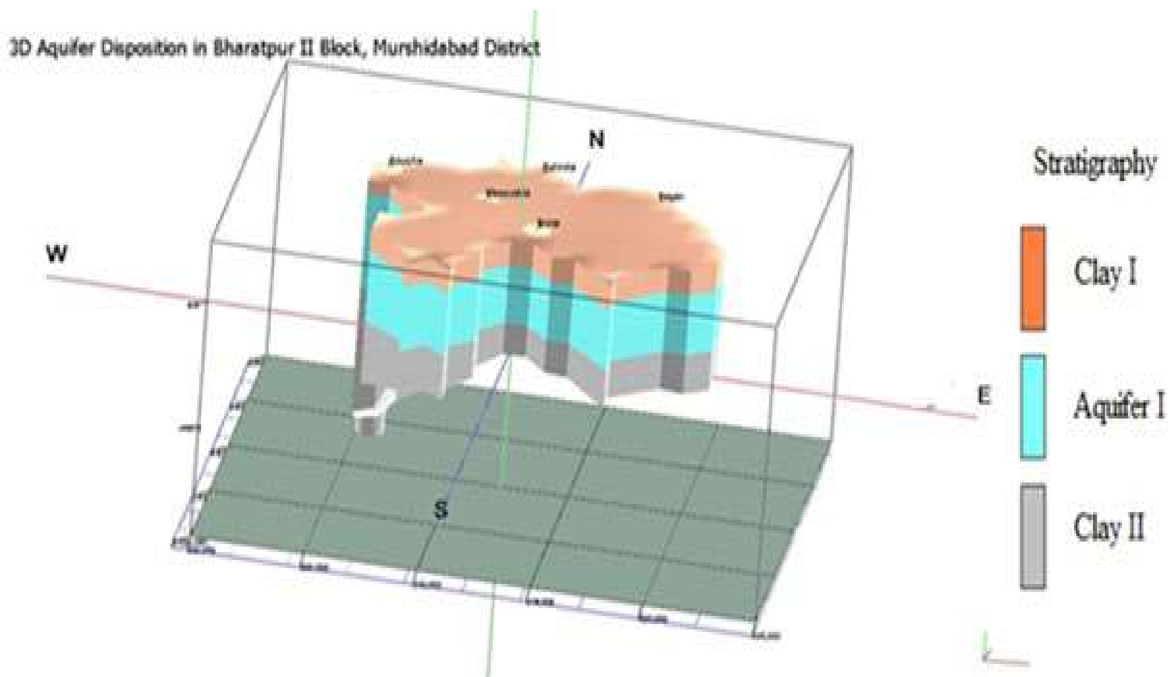


Plate 9.1.2.6: ENE-WSW section in Burwan block, Murshidabad district

10.1.2Ground Water Resource, Extraction, Contamination & Other Issues:
Aquifer Wise Resource Availability & Extraction:

Dynamic ground water resources in Aquifer I as on 31st March'13

Block	Net ground water availability (MCM)	Gross ground water draft (MCM)	Stage of development (%)	Category	Provision for domestic and industrial requirement supply up to next 25 years (MCM)
Burwan	89.2039	54.1335	62.31	Semi-critical	6.6264

Static (in-storage) Resources (Aquifer I): 158188.80 Ham

10.1.3 Chemical Quality of Ground Water & Contamination:
Range of important Chemical Parameters:

As -data based on3 samples of spl. Drive' 15-16 & other parameters based on limited samples of 16-17. As = 0.01 mg/l has been reported in 1 out of 3 tube wells, eg. at Narayanpur.

Block	As(mg/l)	TH (mg/l)	EC (µS/cm)	F(mg/l)	NO_3(mg/l)
Burwan	**0.0004 – 0.01**	**155-240**	**390.2-692.1**	**0.29-1.05**	**0-0.7**

Percentage of tube wells having arsenic content in the block (based on SOES data):

Arsenic (<0.01 ing/1) %	Arsenic (>0.01-<0.05 mg/1) %	Arsenic (> 0.05 mg/1) %	Total Tube well (max. concentration based on samples with As> 1 mg/l)
NA	1.1	0.3	702 (0.064 mg/l)

Arsenic affected Risk Population:

There is no record of severe arsenic contamination of ground water in this block. Also, no govt. agency & organisation has so far estimated Risk population in this block.

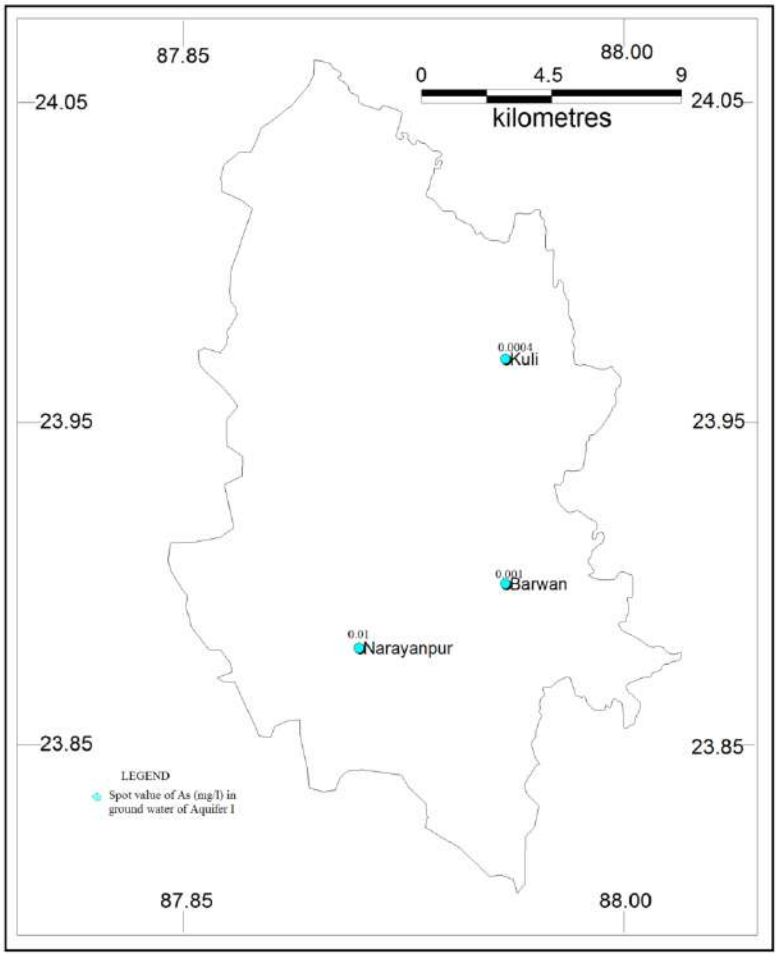


Fig. Arsenic concentration in ground water, Aquifer I

10.1.4Issues:

a) Deep water level
b) Falling trend of depth to water level in post-monsoon season
c) Marginal arsenic infestation in ground water as reported by SOES, Jadavpur; not declared as As-infested by Arsenic Task Force, Govt. of West Bengal

10.1.5Ground Water Resource Enhancement& Management Plan:

Ground Water Management Plan for drinking purposes

Table 9.1.6.1: Status of existing water supply schemes

(Source- Govt. of West Bengal)

Sl. No.	Block	Ongoing PWSS schemes		New PWSS		Augmented PWSS	
		Nos.	Population covered	Nos.	Population covered	Nos.	Population covered
2	Burwan	3	67555	-	-	-	-

Proposed interventions:

Potential aquifers are encountered within 100 m bgl; ground water in it is potable. Beyond this depth, no potential aquifer has been encountered by exploration up to a depth of about 250 m bgl.

To provide drinking water, exploration based drilling down to about 600 m bgl will provide information about both potential zones and presence of arsenic, if any, in ground water in the area.

In future, tube wells tapping the fresh deeper aquifer with proper cement sealing against clay bed has been proved to supply arsenic free fresh ground water to villages, yet to be covered by water supply scheme.

Surface water may be an alternative source for drinking.

Ground Water Management Plan for Irrigation purpose

Table 9.1.6.2: Irrigation Scenario in Burwan block

Cultivable area in ha	Net irrigated area in Ha	Area to be irrigated in Ha	SOD in %	Pre monsoon WL Trend 2016 in cm/yr	Post monsoon WL Trend 2016 in cm/yr	Average Pre monsoon WL in m bgl	Average Post monsoon WL in m bgl	Remarks for GW Management Plan
25569	10574.45	14994.55	62.31	Average Fall 6.6	Average Fall 71.2	16.92	14.94	Given below

Data of 4th M.I. Census shows:

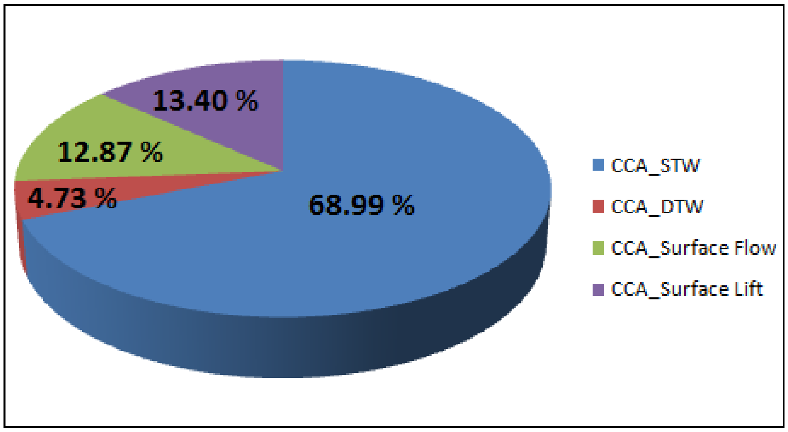


Fig. 9.1.6.1: Per Cent contribution of different sources in irrigation

Table – 9.1.6.3: CCA and sources of irrigation

Block		**Shallow Tube well**		**Deep Tube well**		**Surface Flow**		**Surface Lift**		**CCA (Ha)**	
	Total CCA (Ha)	**Nos.**	**CCA (Ha)**	**Nos.**	**CCA (Ha)**	**Nos.**	**CCA (Ha)**	**Nos.**	**CCA (Ha)**	**Ground water**	**Surface water**
Burwan	10574.45	2023	7296.13	13	500.00	54	1361.32	267	1417.00	7796.13	2778.32

(Source – Dept. of M. I., Govt. of West Bengal)

Table 9.1.6.3 and Fig. 9.1.6.1 indicate that almost 68.99 % and 4.73 % of the cultivable area is irrigated by shallow tube well and deep tube wells respectively. These tube wells are mostly used for Rabi crops, boro paddy, etc.

Data show that the post monsoon water level trend of this block is falling at an average rate of 71.2 cm/ year. Depth to water level is also deep in nature. To improve this ground water scenario, rain water harvesting and artificial recharge may be implemented which might restrict the declining trend.

Table 9.1.6.4: Area suitable for recharge in the study area:

District	Block Name	Area (in sq. km)	Total Area suitable for recharge (sq. km.)
MURSHIDABAD	Burwan	280.00	280

Ground Water Management Plan for Irrigation

Proposed Interventions:

Ground Water Resource Estimation shows that 14994.55 Ha of cultivable area are still not being covered by any irrigation schemes; it also indicates that ground water resource available for future irrigation is 3133.75 Ham. Considering Unit Draft of STW 0.022 MCM & Command Area of STW of 6 Ha (0.06 sq. km), additional 8544 Ha area can be made irrigable (vide Table 9.1.6.4).

Table – 9.1.6.5: Additional Irrigation Potential created by Available Ground Water Resource

Net Ground Water Resource (MCM)	**SOD (%)**	**Ground Water Resource available (Ham)**	**Available area to be irrigated (Ha)**	**Additional Nos. of STWs feasible**	**Additional Irrigation Potential Created (Ha)**
89.2039	62.31	3133.75	14994.55	1424	8544

Still cultivable area 6450.55 Ha i.e.14994.55-8544 Ha is remaining to be covered by irrigation facility. This is possible only when rain water is harvested.

Management for Irrigation water

- Boro cultivation should be reduced. Wheat cultivation can be encouraged. Boro needs 1.2 to 1.4 m, and wheat needs about 0.35 m of water column.
- Rain water harvesting and artificial recharge may be implemented to eliminate the problem of both declining water level and arsenic contamination.
- Cultivation of low water requiring crops and change in cropping pattern suitable for the area.

- To improve the ground water scenario in shallow aquifer, implementation of modern irrigation practices like drip water irrigation system, sprinklers can be made.
- Change in cropping pattern is also needed.

Water column recommended for crops in consultation with expert of Vidhan Chandra Krishi Vidyalaya, Kalyani

District	Block	Major crops/vegetables/ fruits/flowers currently in practice	Water column depth(m)	Crops suggested for better management(considering ground water quality & quantity)	Water column depth(m) recommended	Remarks e.g. Irrigation techniques etc
Murshidabad	Burwan	Rice,wheat, mustard,jute,vegetables	Rice(1.2-1.4),oilseed(0.2-0.25),jute(rain-fed),vegetable (0.15-0.2)	Wheat,mustard,pulses,vegetables,jute	Wheat(0.2-0.25),mustard (0.2),pulse(0.08-0.12),vegetable(0.12-0.16)	Based on crop physiology (soil moisture depletion),drip for vegetables

Scope for Rain Water Harvesting and Artificial Recharge in Study Area:

Using method of Dhruvanarayana, 1993, in Burwan block the number and types of artificial recharge and conservation structures proposed to be constructed for harvesting rain water and the estimated cost involved for doing this, have been shown in Table 9.1.6.6a & Table 9.1.6.6 b. 33.14 MCM of rain water has been calculated to be harvested. This harvested water can be utilized for construction of suitable structures for artificial recharge and conservation of water. In study area, harvested water has been utilized in 45:45:10 ratio for construction of Irrigation cum recharge Tank, Re-excavation of existing tanks & Farm Pond. By doing so, ground water scenario can be improved as well as the inclusive economic growth can be achieved.

Table 9.1.6.6a: Calculation of harvested rain water in Burwan block

Normal monsoon rainfall in m	Area(Ha) 'A'	Annual total volume of rain fall in Ham=(Rn X A)	Run off co-efficient from Dhruvanarayana,1993(Land slope, type of land and soil type) 'C' land slope 0-5%	Major type of soil available in that block	Total volume of surface runoff available Annually 'Vt' (RnXAXC) Ham	75% of 'Vt' = V Ham	50% of V (Non committed)= Vnc Ham	Considering 60% of Vnc, to be harvested = Vf Ham
1.079	28000	30212	0.4875	60% fine loam, 20% coarse loam & 20% clay	14728.35	11046.26	5523.13	3313.87875

Table 9.1.6.6.b: Proposed Artificial Recharge & Conservation structures (specification of structures given in Part II Section)

Net run -off water availability for recharge and conservation in MCM	Source Water Allocation (MCM)				Number of Structures				Structure-wise Cost Estimate (lakh Rs.)				Cost estimated (lakh Rs.)
(1)	Irrigation cum recharge Tank (45 % of 1) (2)	Re-excavation of existing tanks (45 % of 1) (3)	Injection Well (4)	Farm Pond ((10 % of 1) (5)	Irrigation cum recharge Tank (6)	REET (7)	Injection Well (8)	Farm Pond (9)	Injection Well (10)	Irrigation cum recharge Tank @ Rs 8 lakh (11)	REET @ Rs 8 lakh (12)	Farm Pond (13)	(14)
33.14	14.91	14.91	0	3.31	30	149	0	33	0	240	1192	264	1696

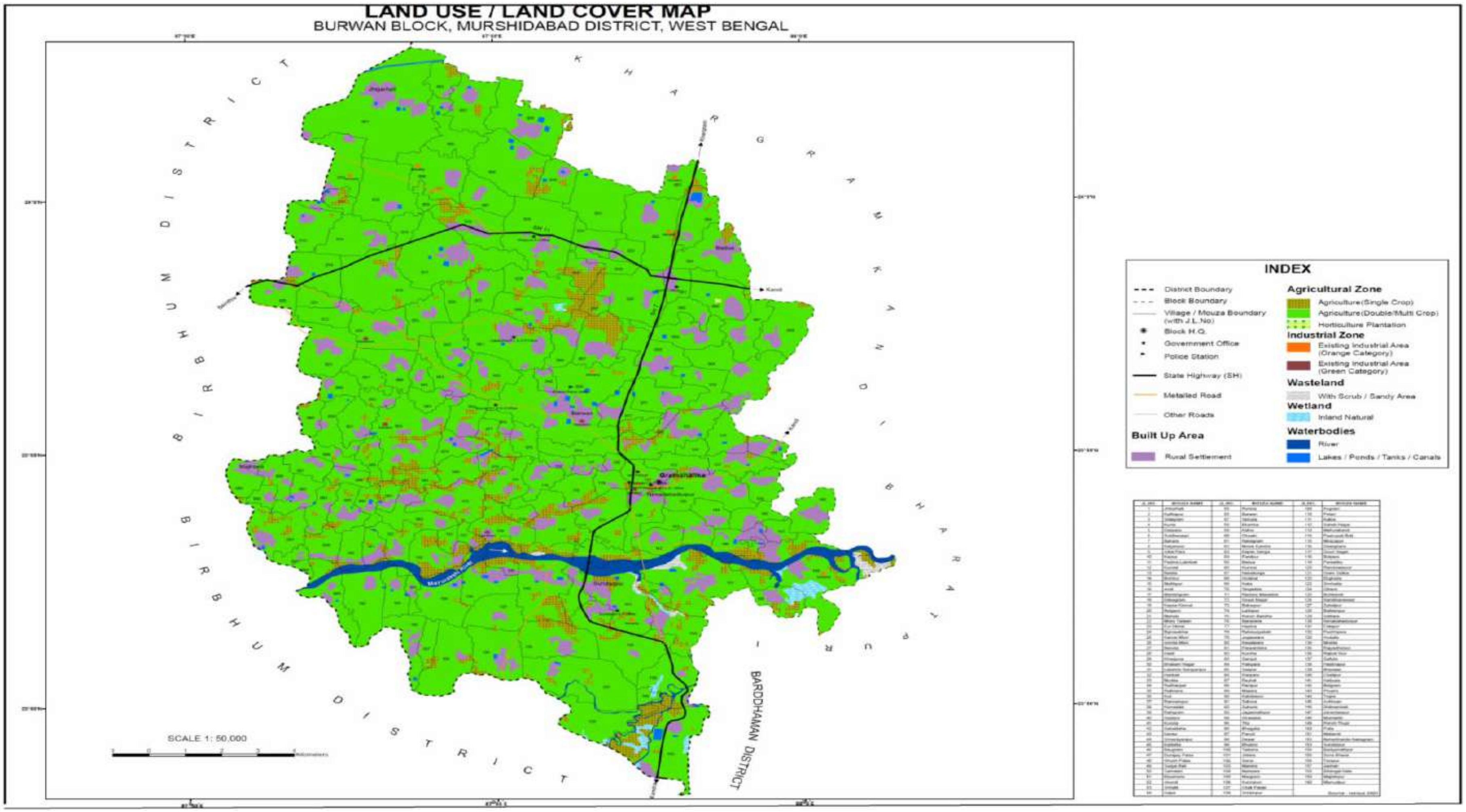


Plate 9.1.6: Land use/ land cover in Burwan block

(Source: Land and land Reforms Dept., Govt. of West Bengal)

Utilization of Harvested Rain Water: Table 9.1.6.6. b shows that 44.164575 Ham of rain water could be harvested in Burwan block. In Plate 9.1.6, land use & land cover in this block has been shown; from it it is visualized that the land is suitable for multi-crop cultivation. The amount of 33.14 MCM of rain water can be utilized for construction of different artificial recharge and conservation structures and estimated cost has been calculated to be Rupees 1696 lakh. At the same time, left out cultivable land can also be irrigated.

Table 9.1.7.a: Cropping pattern in Burwan block (area in Ha, production in '000 M Tons)

Aus (Area)	Aus (Production)	Aman (Area)	Aman (Production)	Boro (Area)	Boro (Production)	Jute (Area)	Jute (Production)	Wheat (Area)	Wheat (Production)
1640	1.529	20712	54.727	11553	35.186	3	0.019	2854	6.512

Table9.1.7. b: Cropping pattern in Burwan block(area in Ha, production in '000 M. Tons)

Potato (Area)	Potato (Production)	Masur (Area)	Musur (Production)	Mustard (Area)	Mustard (Production)	Til (Area)	Til (Production)	Gram (Area)	Gram (Production)
6068	133.912	3	0.016	4261	2.534	1422	1.195	0	0

Source: Agri. Marketing Board, Govt. of West Bengal)

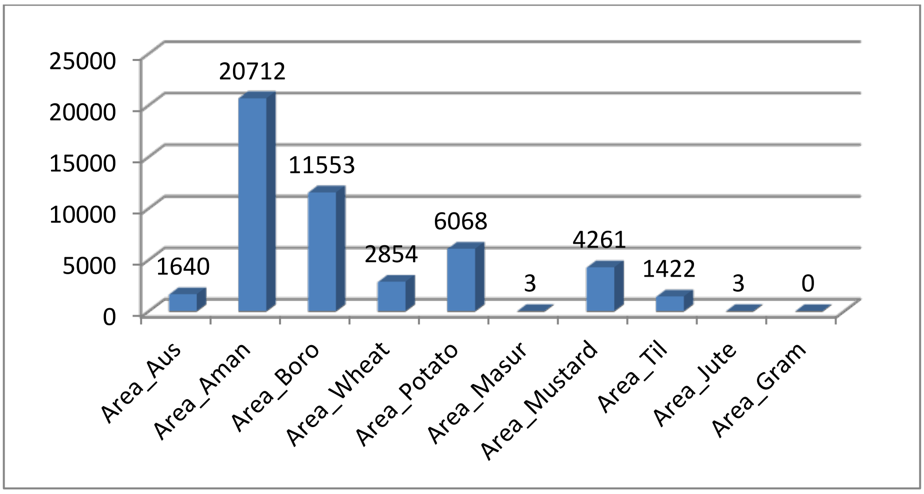


Fig. 9.1.7C: Graphical representation of area of cultivation (Ha) of major crops

Attempt has been made to modify cropping pattern as per the management strategy mentioned under section **Management Strategy of irrigation water & modification in cropping pattern.** In Table 9.1.7, it has been shown that by using this strategy production of cereals, pulses, oil seeds, etc. would be manifold. At the same time, due to restriction of Boro cultivation by 10% less than the present area of cultivation, a huge amount of vital ground water resources could be saved.

Table 9.1.7: Proposed Modification of cropping pattern in Burwan block, Murshidabad district

Past Area of Boro cultivation (Ha)	**Average Water column required (m) for Col. I**	**G W draft due to boro cultivation (MCM) for Col. I**	**Proposed 10 % reduction of area of boro cultivation (Ha)**	**Amount of ground water saved (MCM) as in Col. I**	**Loss (M. Ton) of Boro paddy) due to reduction in area of cultivation @ yield rate 3613.69 kg/ Ha**	**Proposed cropping in 1:1:1 ratio in Lost area of Boro cultivation as proposed in Col IV**	**Gain (M. Ton each) due to alternate cropping @ existing yield rate Til @:911.26 kg/hec, Mung @ 605.21 kg/Ha & Ground nut @ 2309.39 kg/Ha**	**Ground water draft (MCM) for cultivation of Til, Mung & Ground nut @ 0.15 m/Ha**	**Gain due to increase in area of Aus cultivation in Kharif (at least 10 % of existing area of Boro cultivation, i.e. 1155.3 Ha.) at yield rate 2577.46 kg/ Ha (M. Ton)**	**Ground water saved (MCM)**
(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)	(IX)	(X)	(XI)
11553	1.3 m	1501.89	1155.3	150.19	4174.896	Til, Mung & Ground nut in 385.1 Ha each	Til- 350.93, Mung-233.07 Ground nut-889.35	1.73	2977.74	148.46

10.2 BHARATPUR I BLOCK

Salient Information

Block Name: Bharatpur I

Area (in km^2):178.00

District: Murshidabad

State: West Bengal

Population(as on 2011):

Rural	Urban	Total
172702	----	172702

Approximate Decadal Growth Rate from 2001-2011: 14.45%

Rainfall:

Average annual rainfall (Murshidabad district)for the period 2012 -16 (in mm): **1220.6**

Block	Normal	Actual (Annual)				
		2012	2013	2014	2015	2016
Bharatpur I	1391.1	979.5	1228.2	1175.6	1673.5	1046.2

Agriculture & Irrigation (Area in sq.km) :

SI. No	Name of the Block	Geographic Area	Cultivable Area	Area under pasture & orchard	Cultivable Waste Land	Forest Land
1.	Bharatpur I	178	154.14	3.25	1.80	Nil

Aquifer Wise Ground Water Resource Availability & Extraction (in MCM):

Resource Availability	Aquifer I	Aquifer II*	Extraction (for Aquifer I)
Dynamic Resource	49.0552	**1.20**	27.1777
Static Resource	1681.6728	-	-

Ground water flow through Aquifer II towards NNE – 958.17 m^3/day

10.2.1 Disposition of Aquifer:

Block	Depth range of Aquifer in m bgl	
	Aquifer I	**Aquifer II**
Bharatpur I	10-114.5	132-145

Aquifer I under semi-confined to confined condition.

Aquifer II occurs under semi-confined to confined condition.

Aquifer Wise Water Level & Pre-monsoon and Post-monsoon water level trends (2006 to 2016)

SI. No.	Block	Aquifer	Pre-monsoon Trend			Post-monsoon Trend		
			Water Level Range(mbgl)	Rise (cm/year)	Fall (cm/year)	Water Level Range(mbgl)	Rise (cm/year)	Fall (cm/year)
1.	Bharatpur I	I	11.54-21.94	-	Average Fall 41.9	10.5-19.1	-	Average Fall 134.49

Aquifer-wise Statement

Name of Block	**Aquifer I**			**Aquifer II**		
	Depth Range (m bgl)	**Discharge (m^3/hr)**	**T (m^2/day)**	**Depth Range (m bgl)**	**Discharge (m^3/hr)**	**T (m^2/day)**
Bharatpur I	10-114.5	17.57 - 59.76	59.30 - 601	132-145	-	-

Thickness of Aquifer I (Avearge): 63.2

Thickness of Aquifer II (one datum): 46.2

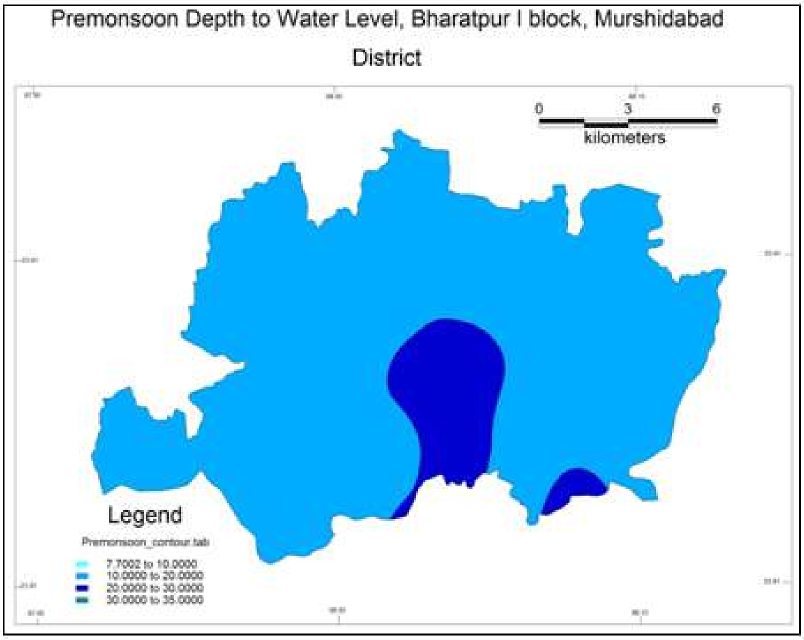


Fig. Depth to water level, Aquifer I, Pre monsoon

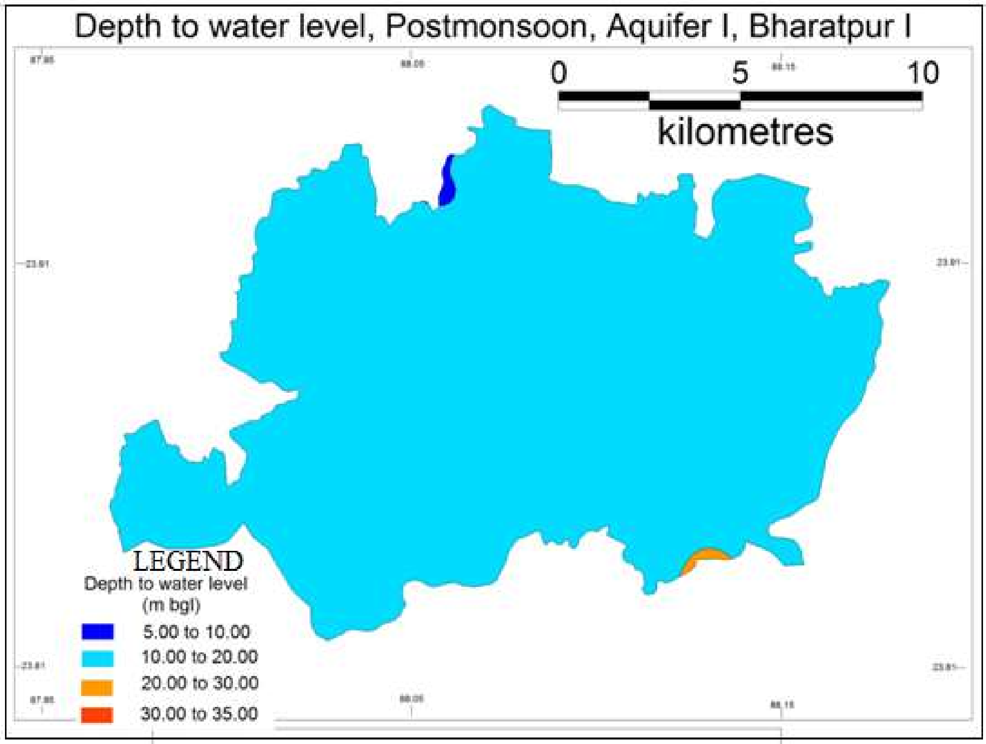


Fig. Depth to water level, Aquifer I, Post monsoon

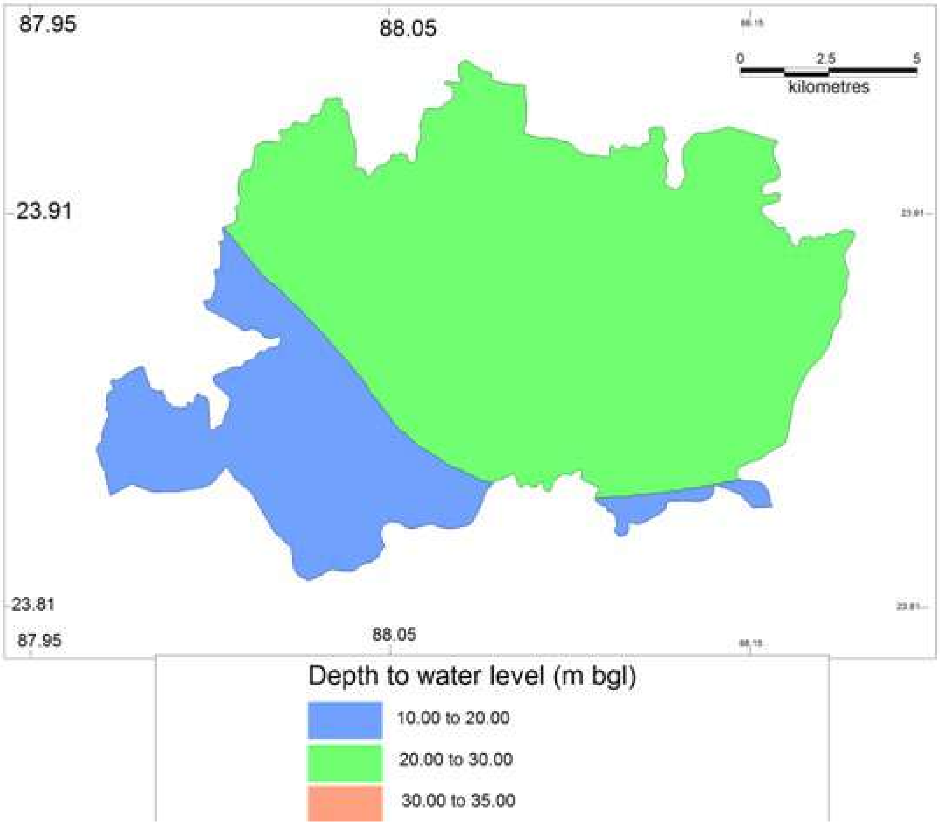


Fig. Depth to water level, Aquifer II, Pre monsoon

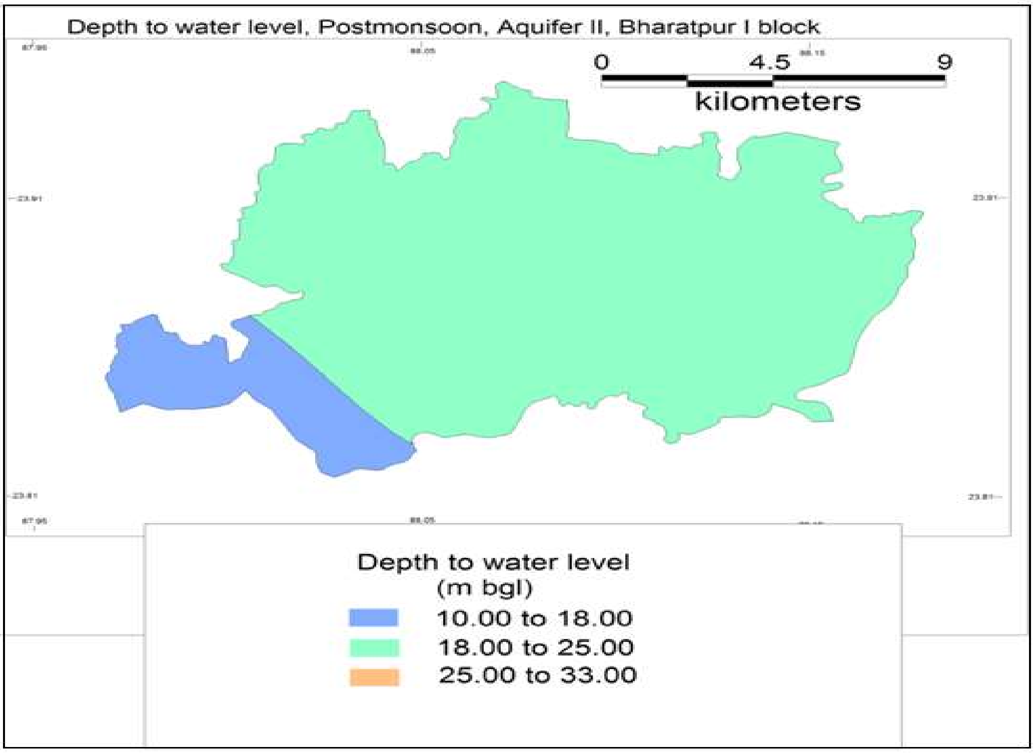


Fig. Depth to water level, Aquifer II, Post monsoon

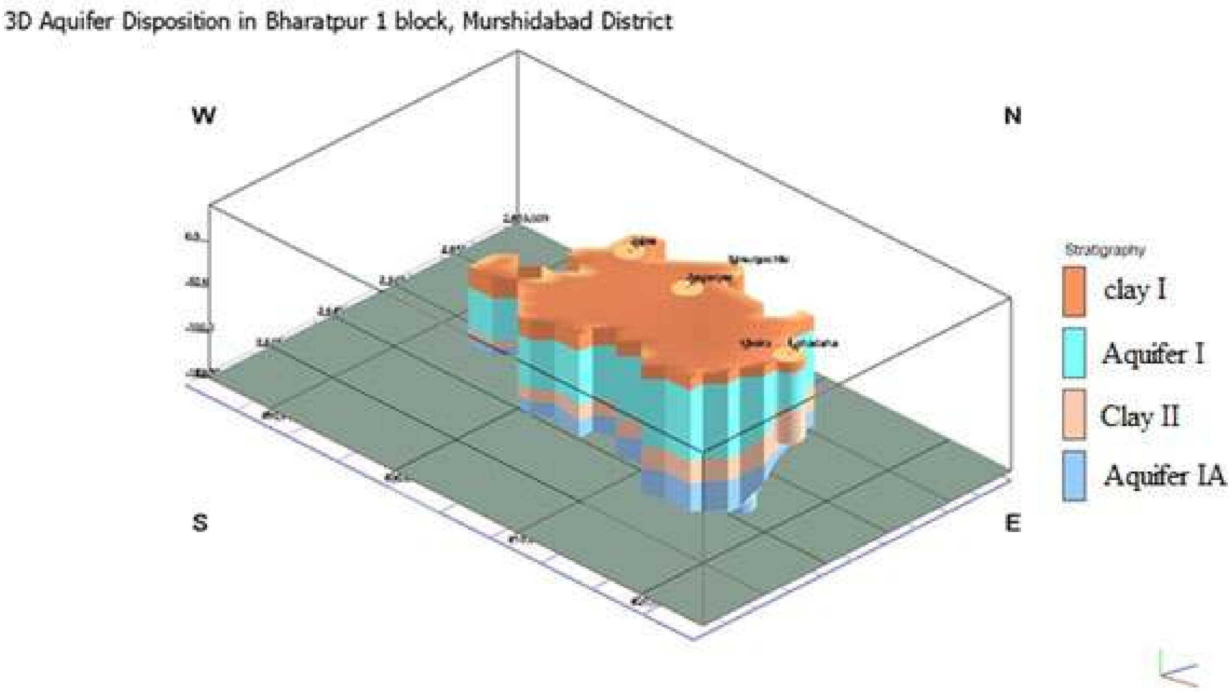


Plate 9.2.1: Aquifer disposition (3D) in Bharatpur I block, Murshidabad district

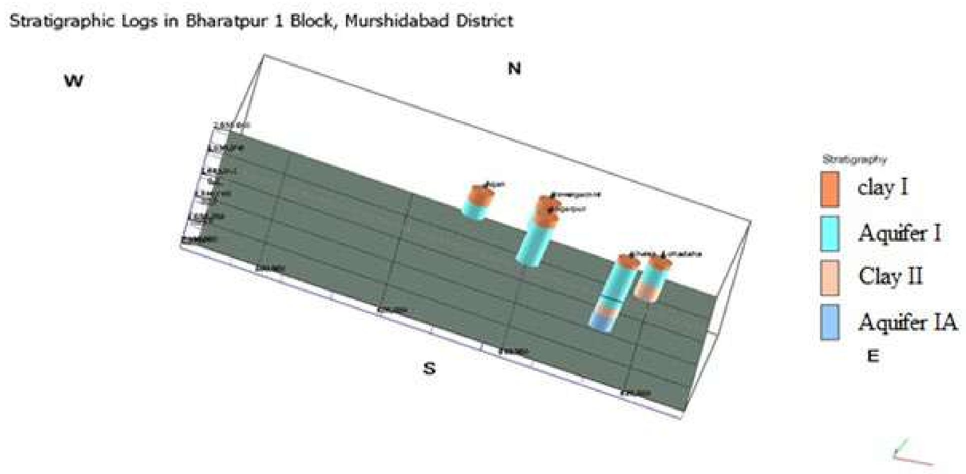


Plate 9.2.2: Stratigraphic Logs in Bharatpur I block, Murshidabad district

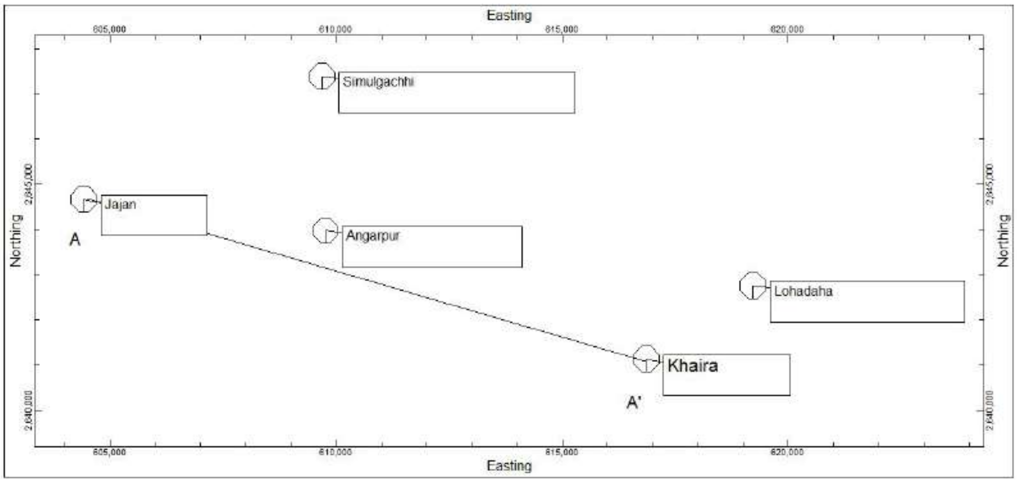


Plate 9.2.3: NW-SE Section line in Bharatpur I block

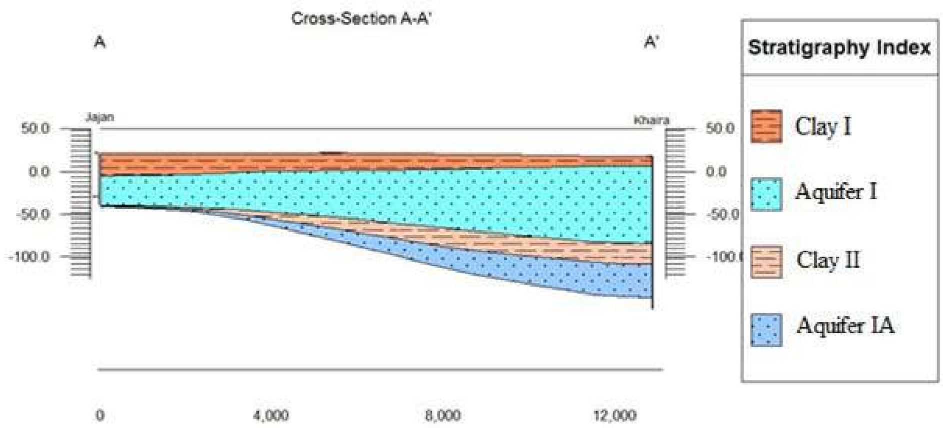


Plate 9.2.4: NW-SE Cross section in Bharatpur I block

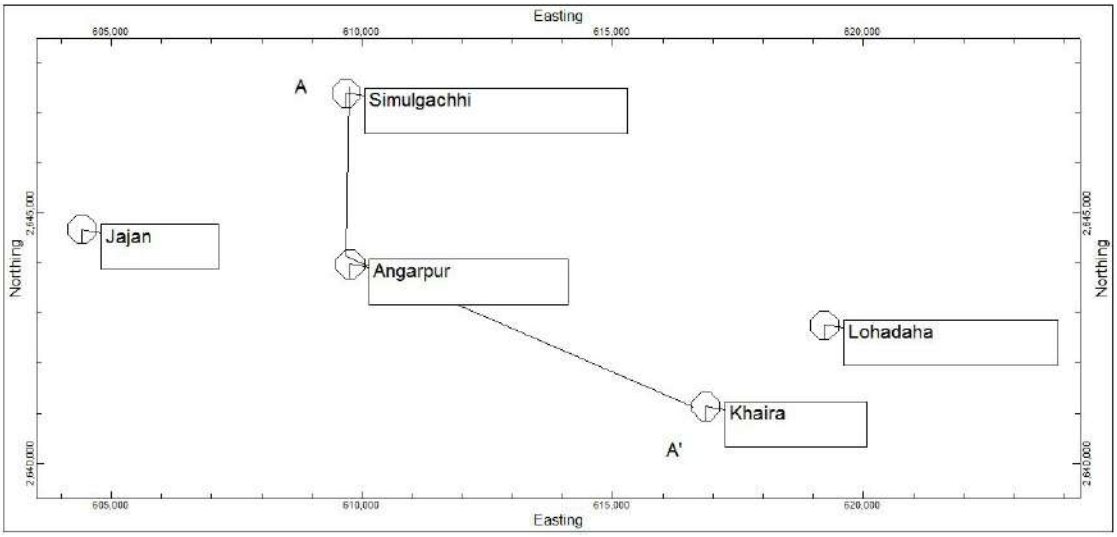


Plate 9.2.5: N-S_SE Section Line in Bharatpur I block

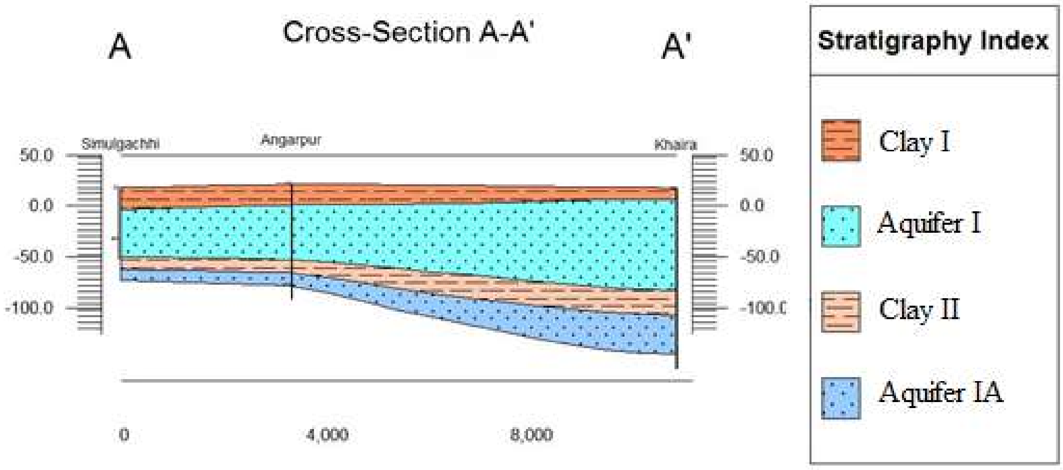


Plate 9.2.6:N-S_SE Section in Bharatpur I block

10.2.2 Ground Water Resource, Extraction, Contamination &other Issues:

Aquifer Wise Resource Availability & Extraction:

Dynamic ground water resources as on 31st March'13

Block	Net ground water availability (MCM)	Gross ground water draft (MCM)	Stage of development (%)	Category	Provision for domestic and industrial requirement supply up to next 25 years (MCM)
Bharatpur	49.0552	27.1777	57.39	Semi-	4.4559

Static (in-storage) Resources (Aquifer I): 168167.28 Ham.

10.2.3 Chemical Quality of Ground Water & Contamination:
Range of important chemical parameters:

As -data based on 4 samples of spl. Drive' 15-16 & other parameters based on limited samples of 16-17. As > 0.01 mg/l has been reported in dug well at Gangedda.

Block	As (mg/l)	TH (mg/l)	EC (µS/cm)	F(mg/l)	NO_3(mg/l)
Bharatpur I	**0.0004-0.012**	**95-255**	**406.2-864.8**	**0.48-1.48**	**0-1.6**

Percentage of tube wells having arsenic content in the block (based on SOES data):

Arsenic (<0.01mg/1)	Arsenic (>0.01- <0.05 mg/1)	Arsenic (> 0.05 mg/1)	Total Tube well (max. concentration based on samples with as> 1 mg/l)
NA	5.8	0.3	616 (0.082)

Arsenic affected Risk Population:

There is no record of severe arsenic contamination of ground water in this block so far by the competent authority. However, SOES, Jadavpur has reported As-contamination at a few places. Present study shows marginal As-contamination at a few places. Also, no govt. department & organisation has so far estimated Risk population in this block.

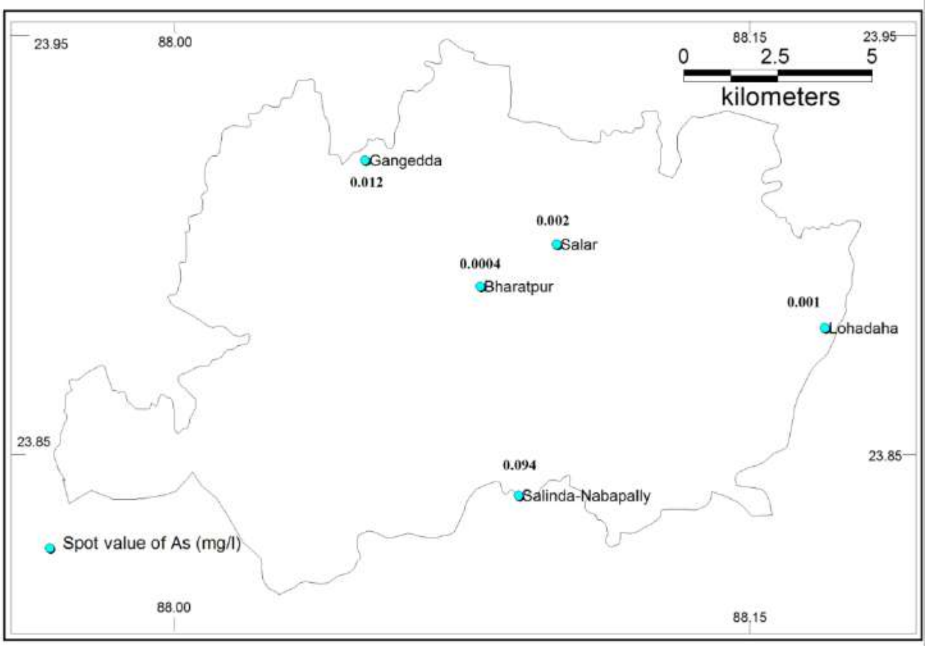


Fig. Arsenic concentration in ground water, Aquifer I

10.2.4 Issues:

a) Presence of single aquifer system
b) Deep water level
c) Abnormal falling trend of depth to water level both in pre-monsoon &post-monsoon seasons

d) Marginal arsenic reported in ground water reported by SOES, Jadavpur; though not declared as As-infested by Arsenic Task Force, Govt. of West Bengal

Arsenic affected Risk Population (based on PHED Hand Pump data):

Risk population has not been estimated

10.2.5 Ground Water Resource Enhancement & Management Plan:

Ground Water Management Plan for drinking purposes

Proposed interventions:

Potential aquifers are encountered within 145 m bgl, ground water in it is potable. Beyond this depth, no potential aquifer has been encountered by exploration up to a depth of about 250 m bgl. However, regular determination of quality of ground water is required for PWSS. To provide drinking water, exploration based drilling down to about 600 m bgl will provide information about both potential zones and presence of arsenic, if any, in ground water in the area. It is better to tap deeper aquifer for drinking purpose.

Surface water is an alternative source.

In future, tube wells tapping the fresh deeper aquifer with proper cement sealing against clay bed has been proved to supply arsenic free fresh ground water to villages, yet to be covered by water supply scheme.

Table 9.2.6.1: Status of existing water supply schemes

(Source – PHED, Govt. of west Bengal)Ground Water Management Plan for Irrigation purpose

Sl. No.	Block	Ongoing PWSS schemes		New PWSS		Augmented PWSS	
		Nos.	Population covered	Nos.	Population covered	Nos.	Population covered
2	Bharatpur I	1	30681	-	-	-	-

9.2.6.2: Irrigation Scenario in Bharatpur I block

Cultivable area in ha	Net irrigated area in Ha	Area to be irrigated in Ha	SOD (%)	Pre monsoon WL Trend 2016 in cm/yr	Post monsoon WL Trend 2016 in cm/yr	Average Pre monsoon WL in m bgl	Average Post monsoon WL in m bgl
15414	7769.19	7644.81	57.39	Average Fall 41.9	Average Fall 134.49	16.27	14.15

Data of 4th M.I. Census shows:

Table – 9.2.6.3: CCA and sources of irrigation

Source – Dept. of M. I., Govt. of West Bengal)

Block		Shallow Tube well		Deep Tube well		Surface Flow		Surface Lift		CCA (Ha)	
	Total CCA (Ha)	Nos.	CCA (Ha)	Nos.	CCA (Ha)	Nos.	CCA (Ha)	Nos.	CCA (Ha)	Ground water	Surface water
Bharatpur I	7769.19	974	6320.79	8	320	7	129.53	51	998.87	6640.79	1128.40

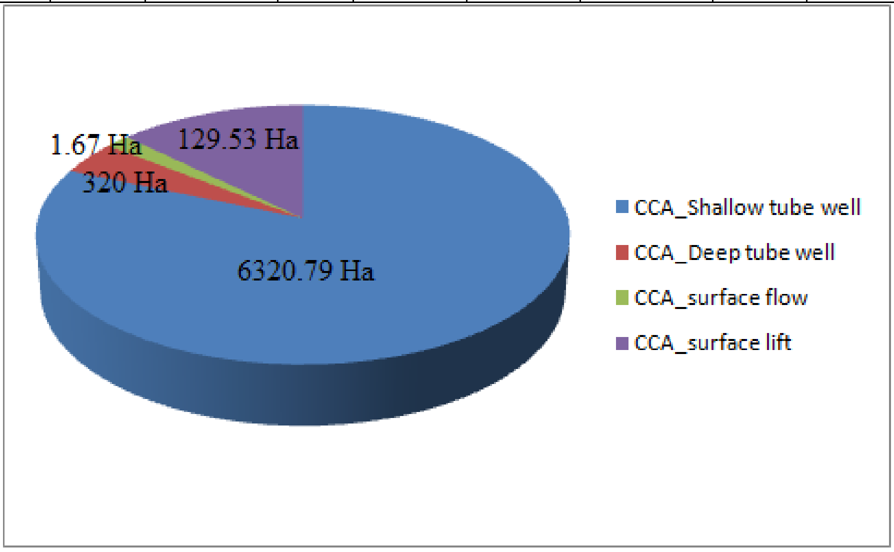


Fig. 9.2.6.1: Per Cent contribution of different sources in irrigation

Table 9.2.6.3 and Fig. 9.2.6.1 indicate that almost 81.35 % and 4.12 % of the cultivable area is irrigated by shallow tube well and deep tube wells respectively. These tube wells are mostly used for Rabi crops, boro paddy, etc. Other surface sources are contributing very less in irrigation.

Data indicate that both pre-monsoon and post –monsoon water level long term trends of this block show falling at a average rate of 41.9 cm/ year and 134.49 cm/ year respectively. Depth to water level is also deep in nature. To improve this ground water scenario, rain water harvesting and artificial recharge may be implemented which might restrict the declining trend.

Space Available For Recharge and Proposed Interventions:

Table 9.2.6.4: **Area suitable for recharge in the study area:**

District	Block Name	Area (in sq. km)	Total Area suitable for recharge (sq. km.)
MURSHIDABAD	Bharatpur-1	178	178

Ground Water Management Plan for Irrigation purposes

Proposed Interventions:

Ground Water Resource Estimation shows that 7644.81 Ha of cultivable area is still not being covered by any irrigation schemes; it also indicates that ground water resource available for future irrigation is 1936.73 Ham. Considering Unit Draft of STW 0.022 MCM & Command Area of STW 6 Ha (0.06 sq. km), additional 8544 Ha area can be made irrigable (vide Table 9.2.6.5).

Table – 9.2.6.5: Additional Irrigation Potential created by Available Ground Water Resource

Net Ground Water Resource (MCM)	**SOD (%)**	**Ground Water Resource available (MCM)**	**Available area to be irrigated (Ha)**	**Additional Nos. of STWs feasible**	**Additional Irrigation Potential Created(ha)**
49.0552	57.39	19.3673	7644.81	394	2364

Still cultivable area 5280.81 Ha i.e. 7644.81 - 2364 Ha is remaining to be covered by irrigation facility. This is possible only when rain water is harvested.

Management for Irrigation water

- Boro cultivation should be reduced. Though Boro cultivation has been restricted for some pest problem in recent times, however, Wheat cultivation can be encouraged. In normal condition. Boro needs 1.2 to 1.4 m, and wheat needs about 0.35 m of water column.
- Rain water harvesting and artificial recharge may be considered which will eliminate the problem of both declining water level and arsenic contamination.
- Cultivation of low water requiring crops and change in cropping pattern suitable for the area.
- To improve the ground water scenario in shallow aquifer, implementation of modern irrigation practices like drip water irrigation system, sprinklers can be made.

- Change in cropping pattern is also needed.

Water column recommended for crops in consultation with expert of Vidhan Chandra Krishi Vidyalaya, Kalyani

Scope for Rain Water Harvesting and Artificial Recharge in Study Area:

Using method of Dhruvanarayana, 1993, in Bharatpur I block, the number and types of artificial recharge and conservation structures proposed to be constructed for harvesting rain water and the estimated cost involved for doing this, have been shown in Table 9.2.6.6a

District	Block	Major crops/vegetables/ fruits/flowers currently in practice	Water column depth (m)	Crops suggested for better management(considering ground water quality & quantity)	Water column depth (m) recommended	Remarks e.g. Irrigation techniques etc
Murshidabad	Bharatpur I	Rice, wheat, mustard, jute, vegetables	Rice (1.2-1.4), oilseed (0.2-0.25), jute (rain-fed), vegetable (0.15-0.2)	Wheat, mustard, pulses, vegetables, jute	Wheat (0.2-0.25), mustard (0.2), pulse (0.08-0.12), vegetable (0.12-0.16)	Based on crop physiology (soil moisture depletion),drip for vegetables

& Table 9.2.6.6 b. 22.47 MCM of rain water has been calculated to be harvested. This harvested water can be utilized for construction of suitable structures for artificial recharge

and conservation of water. In this block, run off component of rainfall has been proposed to be harvested in 35: 35: 20: 10 ratio by construction of Irrigation cum Recharge Tank, Re-excavation of Existing Tank with Recharge Shaft, Injection Well and Farm Pond. This harvested water can also be utilized for irrigation of remaining cultivable land By doing this ground water scenario can be improved as well as the inclusive economic growth can be achieved.

Table 9.2.6.6.a: Calculation of harvested rain water in Bharatpur I block

Normal monsoon rainfall in m	Area(Ha) 'A'	Annual total volume of rain fall in Ham=(Rn X A)	Run off co-efficient from Dhruvanarayana,1993(Land slope, type of land and soil type) 'C' land slope 0-5%	Major type of soil available in that block	Total volume of surface runoff available Annually 'Vt' (RnXAXC) Ham	75% of 'Vt' = V Ham	50% of V (Non committed)= Vnc Ham	60% of Vnc to be harvested = Vf Ham
1.079	17800	19206.2	0.52	50% fine loam, 10% coarse loam & 40% clay	9987.224	7490.418	3745.21	2247.1254

Table 9.2.6.6.b: Proposed Artificial Recharge and conservation Structures (details of structures given in Part II Section):

Net run-off water availability for recharge & conservation (MCM)	Source Water Allocation (MCM)				Number of Structures				Structure-wise Cost Estimate (lakh Rs.)				Total Cost Estimate (lakh Rs.)
(1)	Irrigation cum recharge Tank (35 % of 1) (2)	Re-excavation of existing tanks with RS (35 % of 1) (3)	Injection Well for recharging deeper layer (20 % of 1) (4)	Farm Pond ((10 % of 1) (5)	Irrigation cum recharge Tank	REET with RS	Injection Well	Farm Pond	Irrigation cum recharge Tank @ Rs 8 lakh	REET with RS @ Rs 8 lakh	Injection Well	Farm Pond	
22.47	7.86	7.86	4.5	2.25	16	79	15	23	128	632	120	184	1064

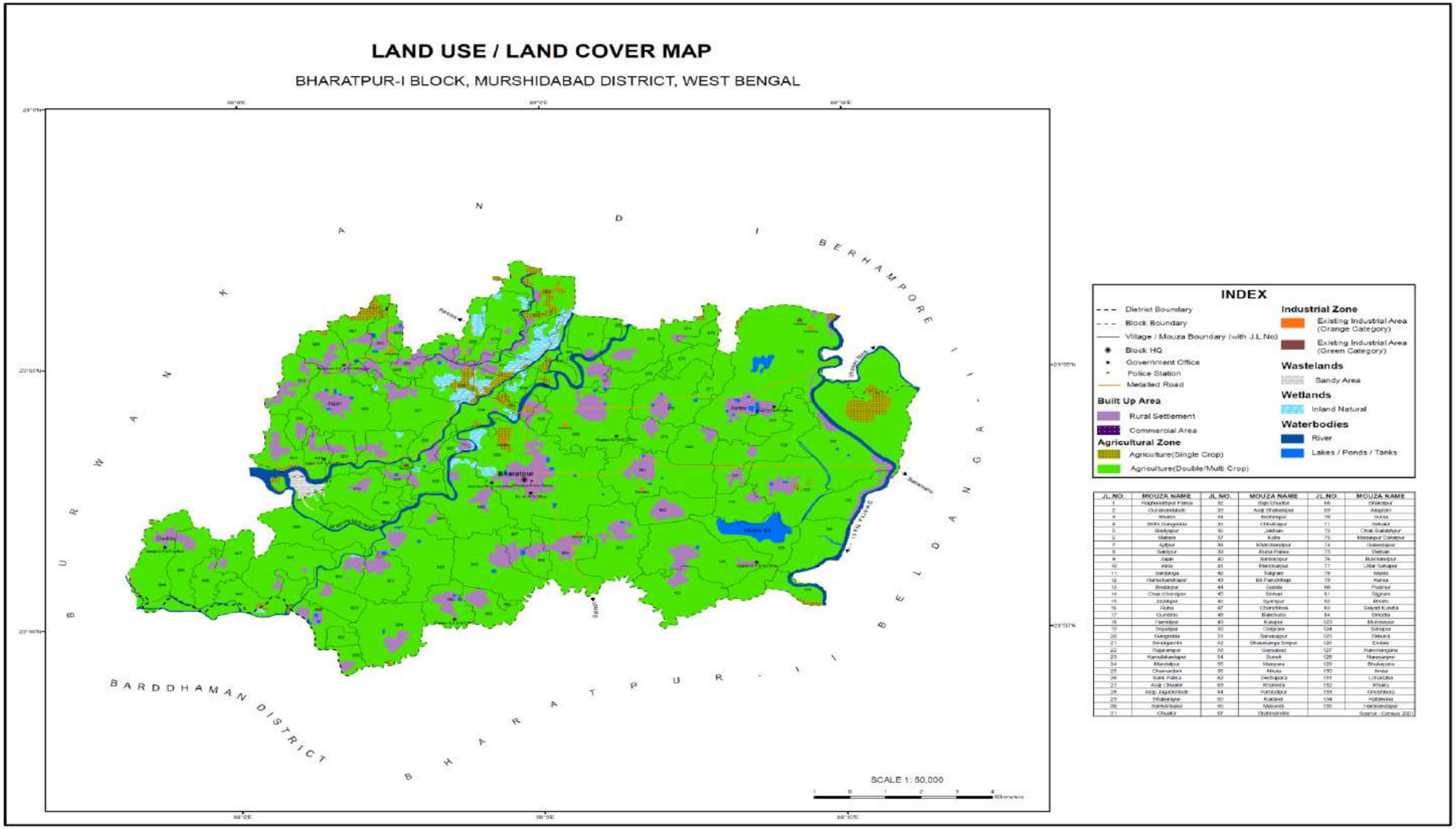


Plate 9.2.6: Land use/ land cover in Bharatpur I block

(Source: Land and land Reforms Dept., Govt. of West Bengal)

Utilization of Harvested Rain Water: Table 9.2.6.6. shows that 22.47 MCM of rain water could be harvested in Bharatpur I block. In Plate 9.2.6, land use & land cover in this block has been shown; from it is visualized that in this block mostly multi-crop cultivation is in practice. 22.47 MCM of rain water can be utilized for construction of different artificial and conservation structures and for this an estimated Rupees 1064 lakh is required.

Table 9.2.6.7 a: Cropping pattern of major crops (area in Ha, production in '000 M. Tons)

Aus (Area)	Aus (Production)	Aman (Area)	Aman (Production)	Boro (Area)	Boro (Production)	Jute (Area)	Jute (Production)	Wheat (Area)	Wheat (Production)
281	0.407	13893	22.181	10293	35.186	-	-	1467	3.597

Table – 9.2.6.7 b: Cropping pattern in Bharatpur I block (area in Ha, production in '000 M. Tons)

Potato (Area)	Potato (Production)	Masur (Area)	Musur (Production)	Mustard (Area)	Mustard (Production)	Til (Area)	Til (Production)	Gram (Area)	Gram (Production)
712	15.763	702	0.364	809	0.749	138	0.143	500	0.402

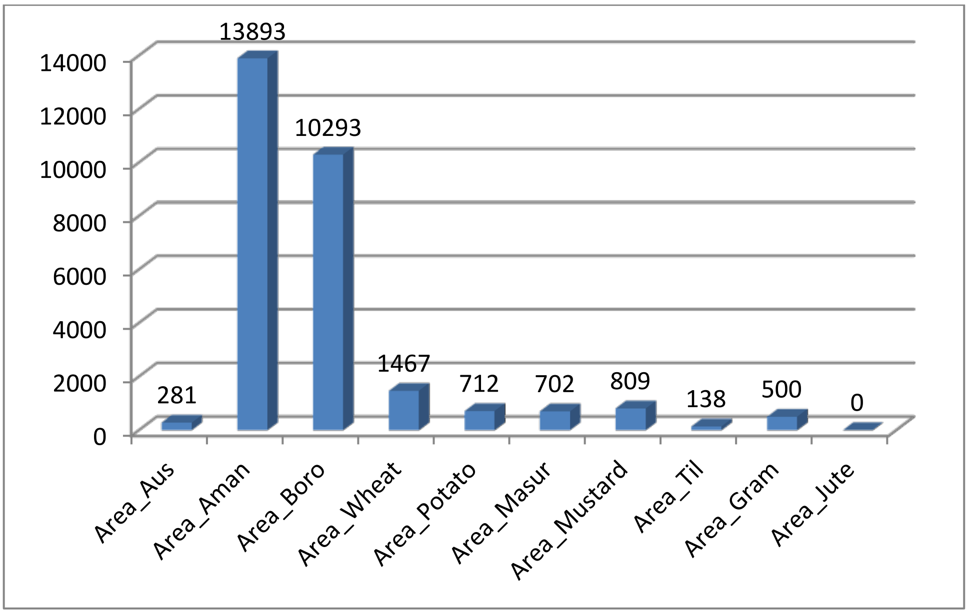


Fig. 9.2.6.7: Graphical representation of cultivation area (Ha) of major crops

Attempt has been made to modify cropping pattern as per the management strategy mentioned under section **Management Strategy of irrigation water & modification in cropping pattern.** In Table 9.2.7, it has been shown that by using this strategy production of cereals, pulses, oil seeds, etc. would be manifold. At the same time, due to restriction of Boro cultivation by 10% less than the present area of cultivation, a huge amount of vital ground water resources could be saved.

Table 9.2.7: Modification of cropping pattern in Bharatpur I block, Murshidabad district

Past Area of Boro cultivation (Ha)	**Average Water column required (m) for Col. I**	**G W draft due to boro cultivation (MCM) for Col. I**	**Proposed 10 % reduction of area of boro cultivation (Ha)**	**Amount of ground water saved (MCM) as in Col. I**	**Loss (M. Ton) of Boro paddy) due to reduction in area of cultivation @ yield rate of 3613.69 kg/ Ha**	**Proposed cropping in 1:1:1 ratio in Lost area of Boro cultivation as proposed in Col IV**	**Gain (M. Ton each) due to alternate cropping @ existing yield rate: Til @ 911.26 kg/hec, Mung @ 605.21 kg/Ha & Ground nut @ 2309.39 kg/Ha**	**G W draft (MCM) for cultivation of Til, Mung & Ground nut @ 0.15 m/ha**	**Gain due to increase in area of Aus cultivation in Kharif (at least 10% of existing area of Boro cultivation, i.e. 1029.3 Ha.) at yield rate 2577.46 kg/ Ha (M. Ton)**	**Ground water saved (MCM)**
(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)	IX	(X)	(XI)
10293	1.3 m	1338.09	1029.3	133.81	3719.57	Til, Mung & Ground nut in 343.1Ha each	Til- 312.65 , Mung- 207.65, Ground nut- 792.35	1.54	2652.98	132.27

10.3 BHARATPUR II BLOCK

Salient Information

Area (in Km^2):162.00

District: Murshidabad

State: West Bengal

Population(as on 2011):

Rural	Urban	Total
153474	22894	176368

Approximate Decadal Growth Rate from 2001-2011: 17.47%

Rainfall:

Average annual rainfall (Murshidabad district) for the period 2012 -16 (in mm): **1220.6**

Block	Normal	Actual (Annual)				
		2012	2013	2014	2015	2016
Bharatpur II	1391.1	979.5	1228.2	1175.6	1673.5	1046.2

Agriculture & Irrigation (Area in sq. Km) :

SI. No	Name of the Block	Geographic Area	Cultivable Area	Area under pasture & orchard	Cultivable Waste Land	Forest Land
1.	Bharatpur II	162	136.83	2.45	1.40	Nil

Aquifer Wise Ground Water Resource Availability & Extraction(in MCM):

Resource Availability	Aquifer I	Aquifer II	Extraction (for Aquifer I)
Dynamic Resource	48.88	-	30.80
Static Resource	911.9304	-	-

10.3.1 Disposition of Aquifer:

Depth range of Aquifer in m bgl	
Aquifer I	**Aquifer II**
8-94	-

Aquifer I occurs under semi-confined to confined condition.

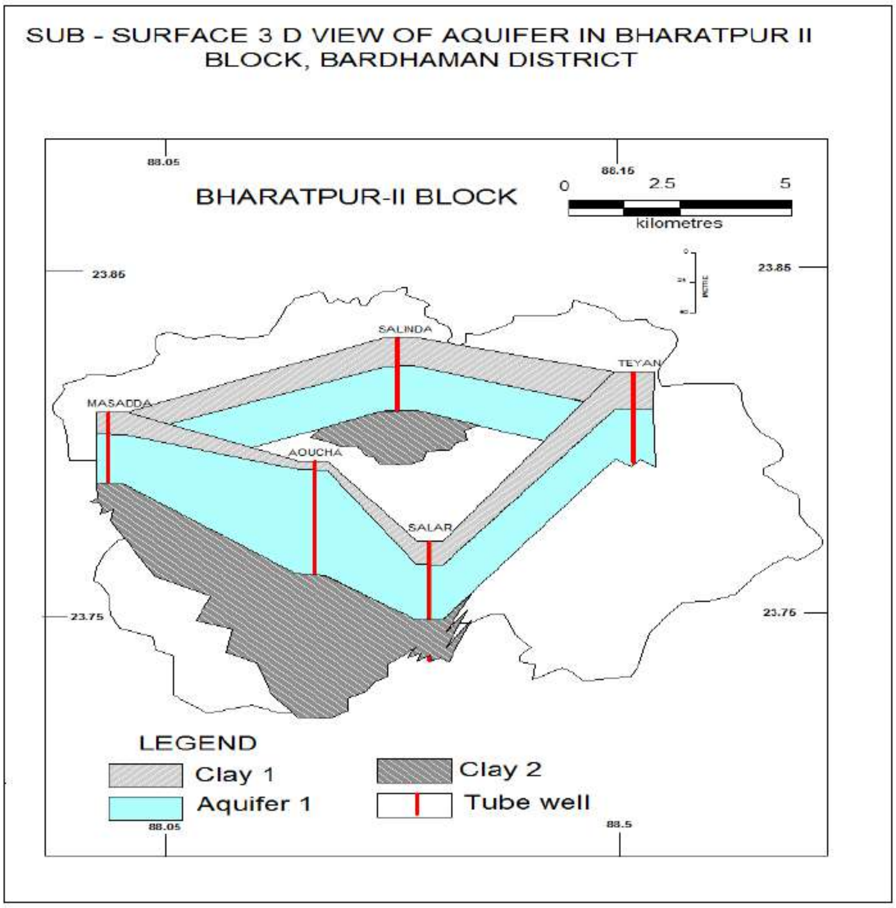


Plate 9.3.1: Aquifer disposition (3D) in Bharatpur II block, Murshidabad district

Aquifer Wise Water Level &Pre-monsoon & Post-monsoon water level trends (2006 to 2016)

SI. No.	Block	Aquifer	Pre-monsoon Trend			Post-monsoon Trend		
			Water Level Range(mbgl)	Rise (cm/year)	Fall (cm/year)	Water Level Range(mbgl)	Rise (cm/year)	Fall (cm/year)
1.	Bharatpur II	I	15-33	-	Average Fall 20.6	13.2-34	-	Average Fall 325.53

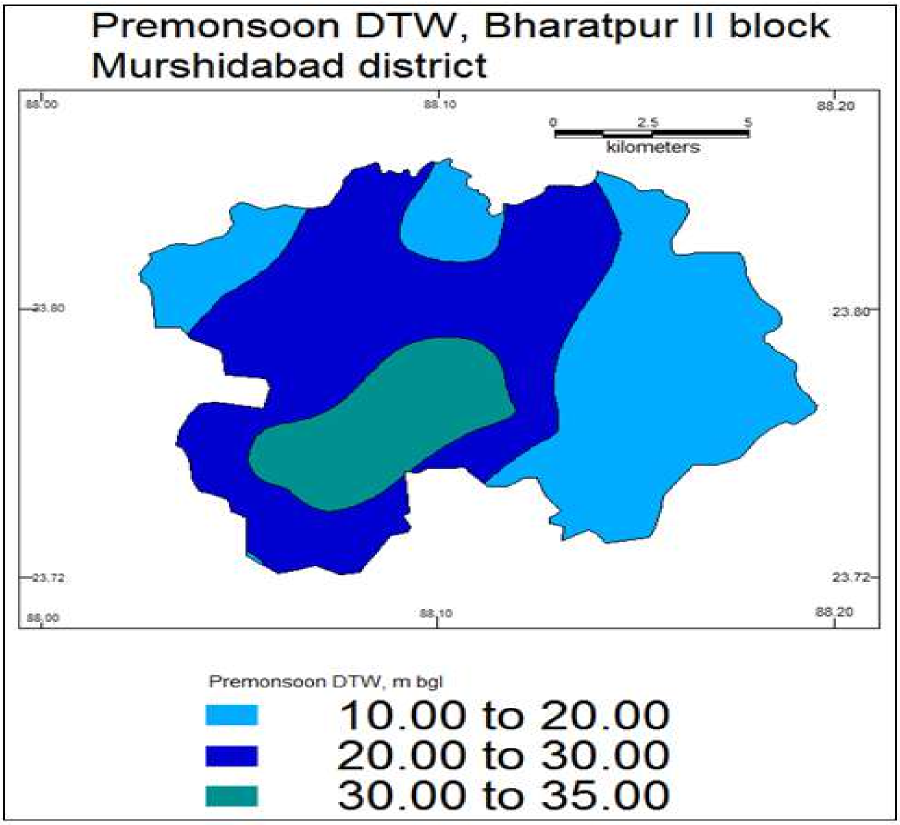


Fig. Depth to water level, Aquifer I, Pre monsoon

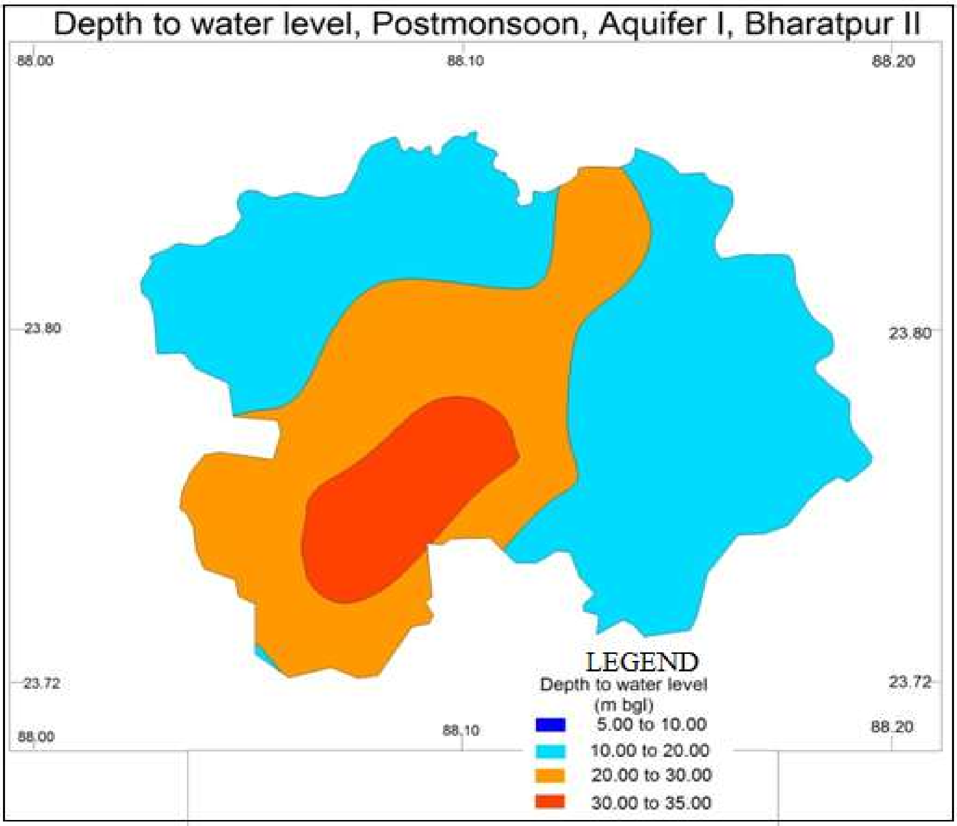


Fig. Depth to water level, Aquifer I, Post monsoon

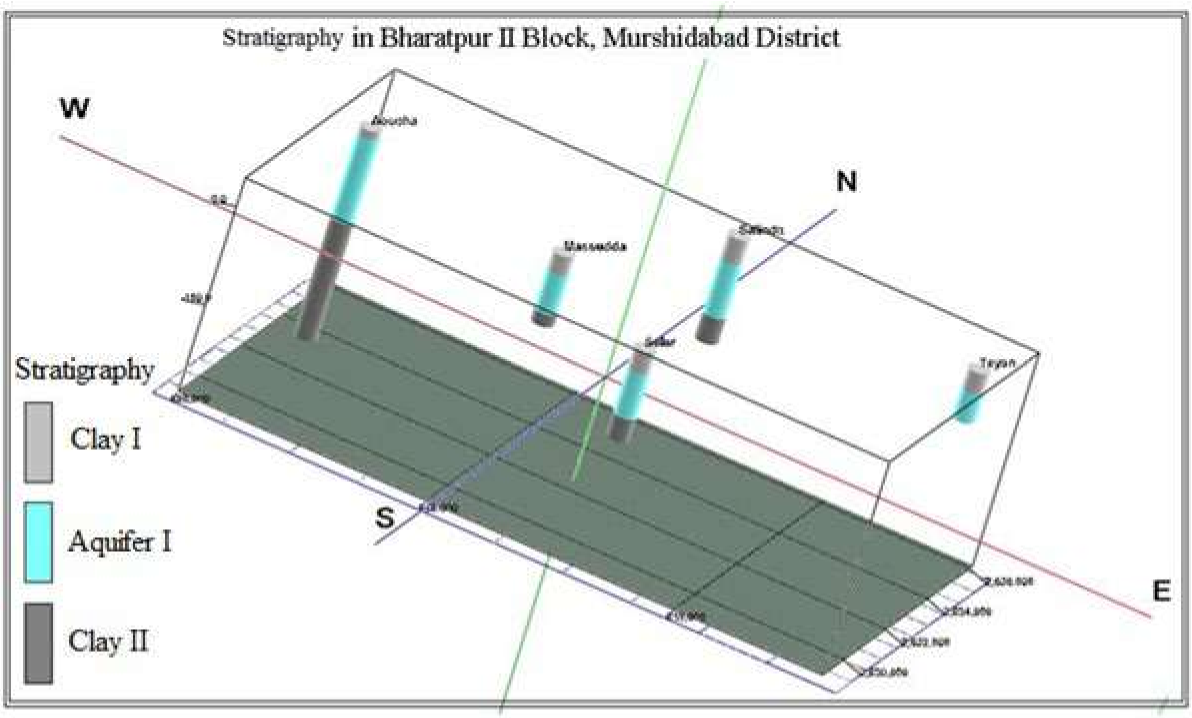


Plate 9.3.2: Stratigraphic logs in Bharatpur II block, Murshidabad district

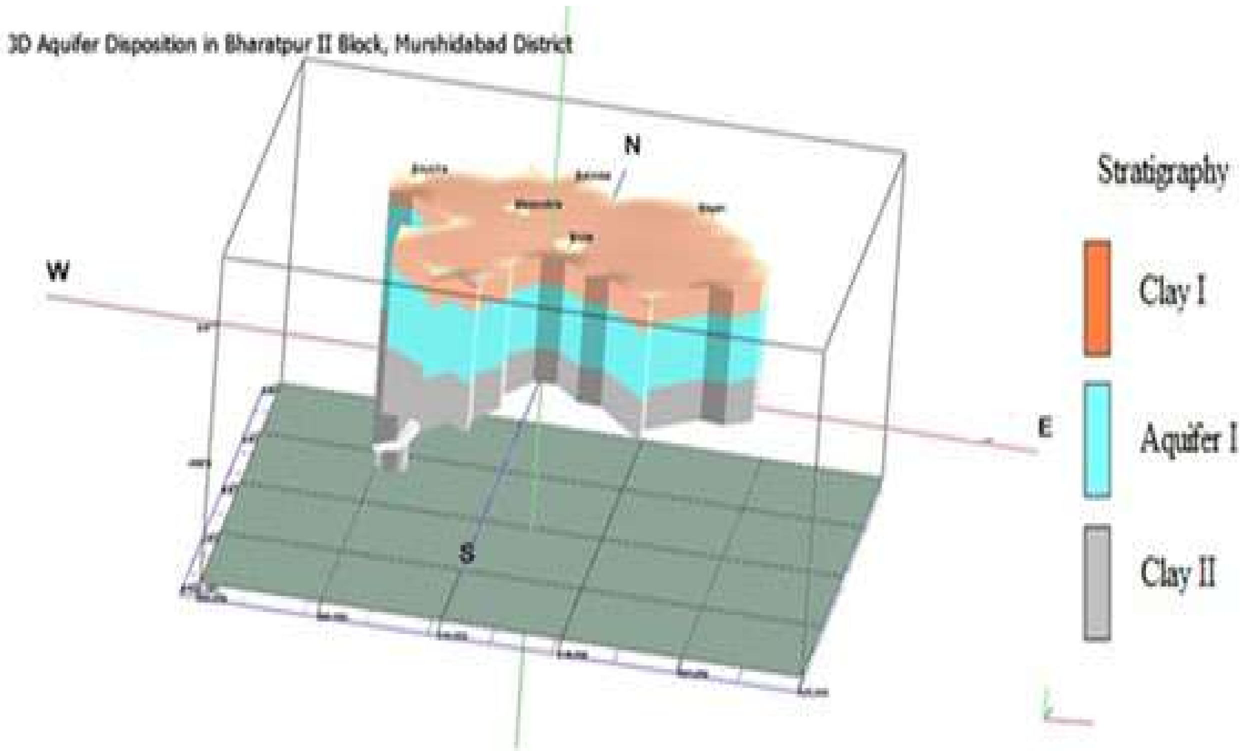


Plate 9.3.3: Aquifer disposition (3D) in Bharatpur II block, Murshidabad district

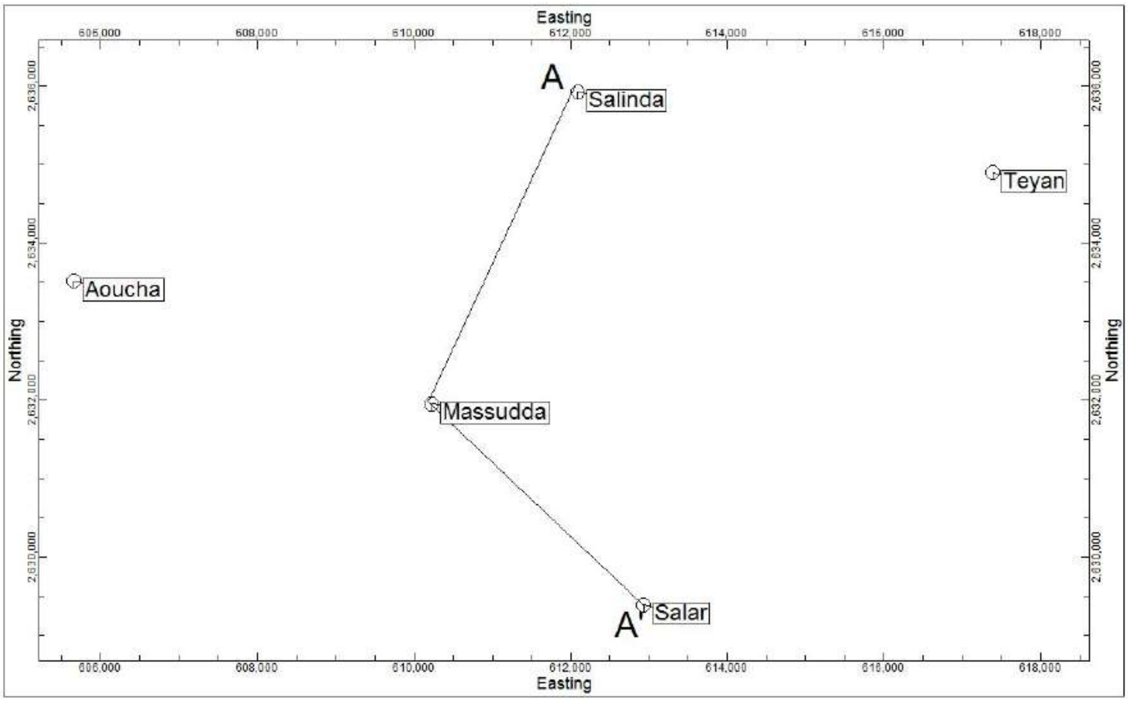


Plate 9.3.4: N-S section line in Bharatpur II block, Murshidabad district

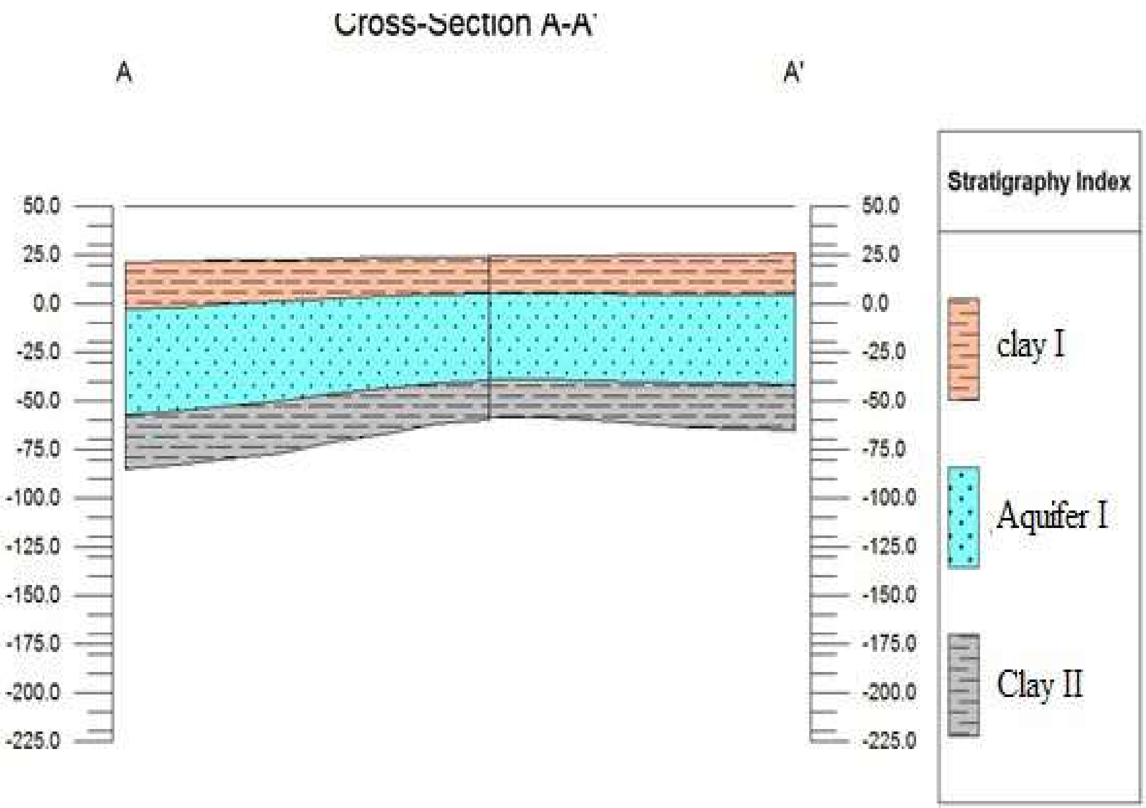


Plate 9.3.5: N-S section in Bharatpur II block, Murshidabad district

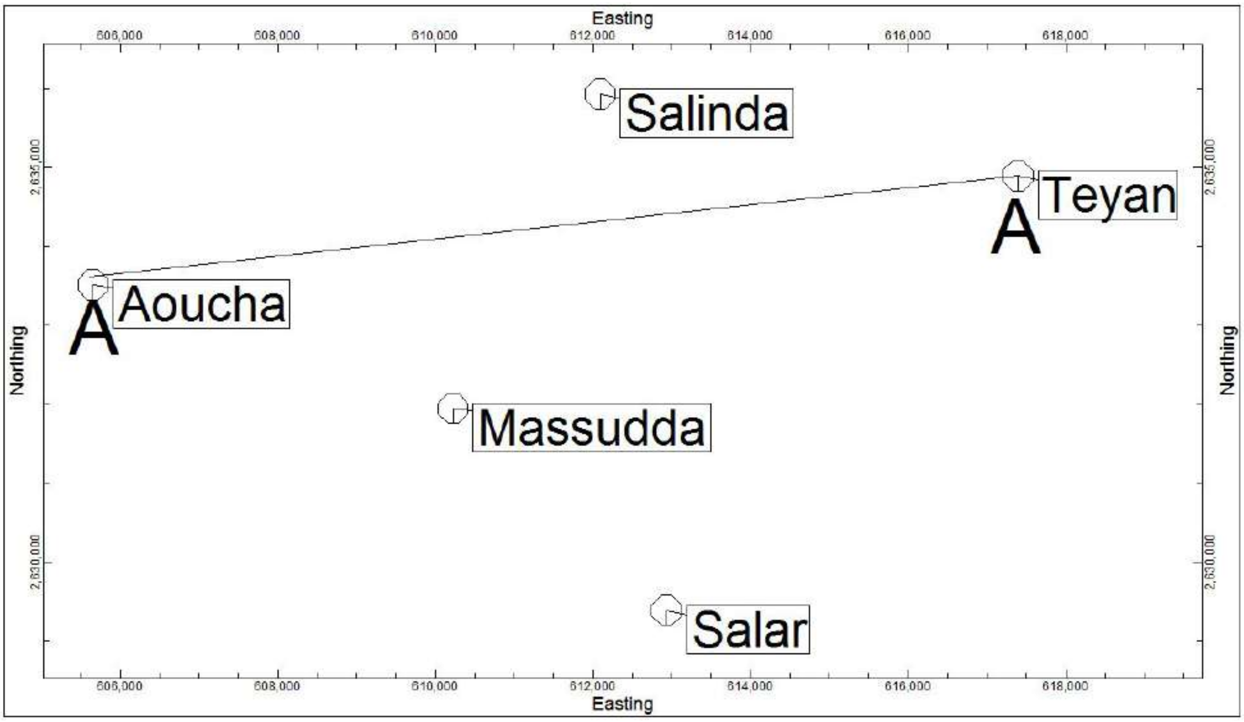


Plate 9.3.6: SW-NE section line in Bharatpur II block, Murshidabad district

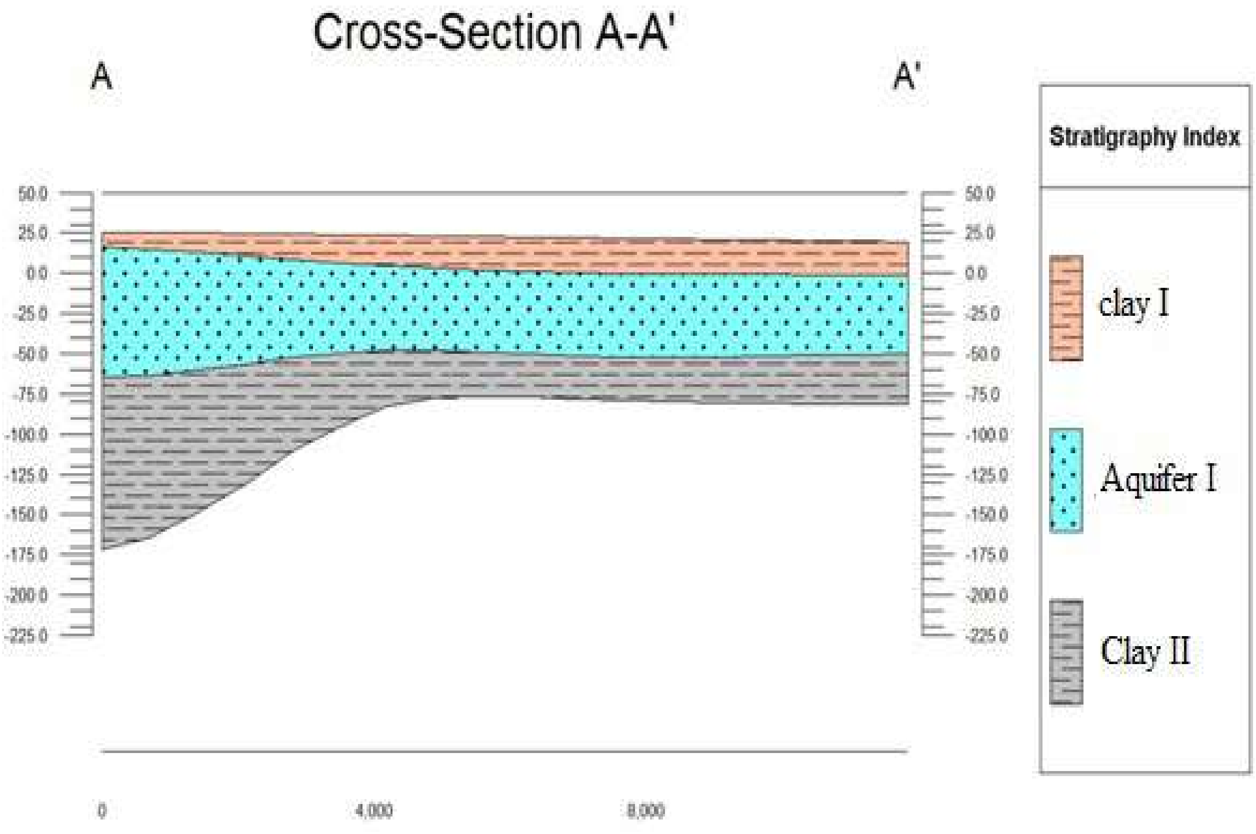


Plate 9.3.7: SW-NE section in Bharatpur II block, Murshidabad district

Thickness of Aquifer (Average): 51.33 m (Aquifer I)

Aquifer-wise Statement

Name of Block	**Aquifer I**			**Aquifer II**		
	Depth Range (m bgl)	Discharge (m^3/hr)	T (m^2/day)	Depth Range (m bgl)	Discharge (m^3/hr)	T (m^2/day)
Bharatpur II	8-94	17.57 - 59.76	59.30 - 601	-	-	-

10.3.2 Ground Water Resource, Extraction, Contamination & other Issues
Aquifer Wise Resource Availability & Extraction:

Dynamic ground water resources as on 31st March'13

Block	**Net ground water availability (MCM)**	**Gross ground water draft (MCM)**	**Stage of development (%)**	**Category**	**Provision for domestic and industrial requirement supply up to next 25 years(MCM)**
Bharatpur II	48.8767	30.7959	64.99	Semi-critical	4.4307

10.3.3 Chemical Quality of Ground water & Contamination:
Range of Chemical Pollutants:

As -data based on7 samples of spl. Drive' 15-16 & other parameters based on limited samples of 16-17. As > 0.01 mg/l has been reported in 4 out of 7 tube wells, eg. at Salinda-Nabapally, Salar, Kagram and Dakshin Khandagram.

As (mg/l)	TH (mg/l)	EC (µS/cm)	F (mg/l)	NO_3 (mg/l)
0.001-0.094	**130-260**	**353-493**	**0.05-1.3**	**0-17.9**

Percentage of tube wells having arsenic content in the block (based on data of SOES, Jadavpur):

SI. No.	Blocks	Arsenic (<0.01 ing/1)	Arsenic (>0.01-<0.05 mg/1)	Arsenic (> 0.05 mg/1)	Total Tube well (max. concentration based on samples with As> 1 mg/l)
1	Bharatpur II	NA	-	0	625 (0.03 mg/l)

Risk population not available. There is no record of severe arsenic contamination of ground water in this block. Also, no govt. department & organisation has so far estimated Risk population in this block. But, SOES, Jadavpur reported As-contamination at a few places. Present study also shows sporadic As-contamination at places.

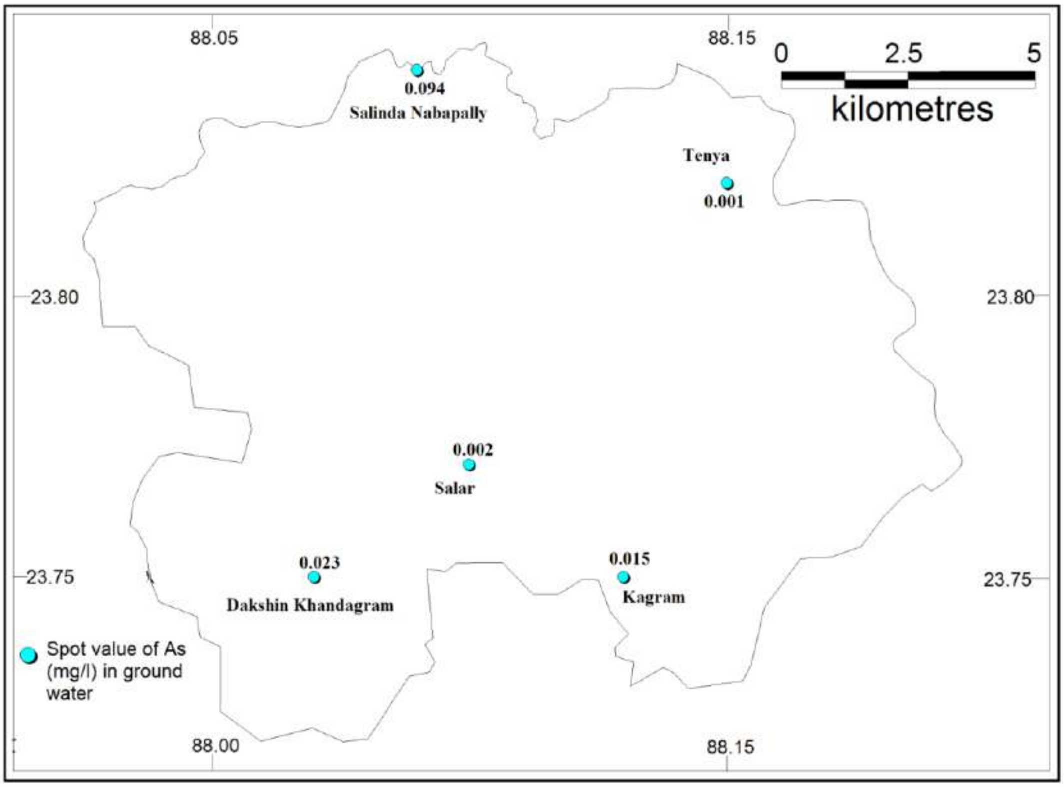


Fig. Arsenic concentration in ground water, Aquifer I

10.3.4 Issues:

a) Presence of single aquifer system
b) Deep water level
c) Very high falling trend of depth to water level both in pre-monsoon & post-monsoon seasons
d) Marginal arsenic reported in ground water reported by SOES, Jadavpur; though not declared as As infested by Arsenic Task Force, Govt. of West Bengal
e) Semi-critical category

10.3.5 Ground Water Resource Enhancement & Management Plan:

Ground Water Management Plan for drinking purposes

Table 9.3.6.1: Status of existing water supply schemes

Block	Nos. of ongoing PWSS scheme	Population covered	Nos. of new PWSS scheme	Population covered
Bharatpur II	4	75033	-	-

Source – PHED, Govt. of West Bengal)

Proposed interventions:

Potential aquifers are encountered within 94 m bgl. Present study shows that arsenic in ground water has been encountered at places. Therefore, extreme care has to be taken and regular monitoring of as content has to be determined. No potential aquifer has been encountered by exploration within depth span between 94 - 250 m.

To provide drinking water, exploration-based drilling down to about 600 m bgl will provide information about both potential zones and presence of arsenic, if any, in ground water in the area.

In future, tube wells tapping the fresh deeper aquifer with proper cement sealing against clay bed has been proved to supply arsenic free fresh ground water to villages, yet to be covered by water supply scheme.

Ground Water Management Plan for Irrigation purpose

9.3.6.2: Irrigation Scenario in Bharatpur II block

Sr No.	Name of Block	Cultivable area in Ha	Net irrigated area (Ha)	Area to be irrigated (Ha)	SOD in %	Pre monsoon WL Trend 2016 in cm/yr	Post monsoon WL Trend 2016 in cm/yr	Average Pre monsoon WL in m bgl	Average Post monsoon WL in m bgl
3	Bharatpur II	13683	5963.41	7719.59	64.99	Average Fall 20.6	Average Fall 325.53	23.09	20.86

Data of 4th M.I. Census shows:

Table – 9.3.6.3: CCA and sources of irrigation

Block		Shallow Tube well		Deep Tube well		Surface Flow		Surface Lift		CCA (Ha)	
	Total CCA (Ha)	Nos.	CCA (Ha)	Nos.	CCA (Ha)	Nos.	CCA (Ha)	Nos.	CCA (Ha)	Ground water	Surface water
Bharatpur II	5963.41	934	4582.75	16	640.48	0	0	15	740.18	5223.23	740.18

(Source- Dept. of M.I., Govt. of west Bengal)

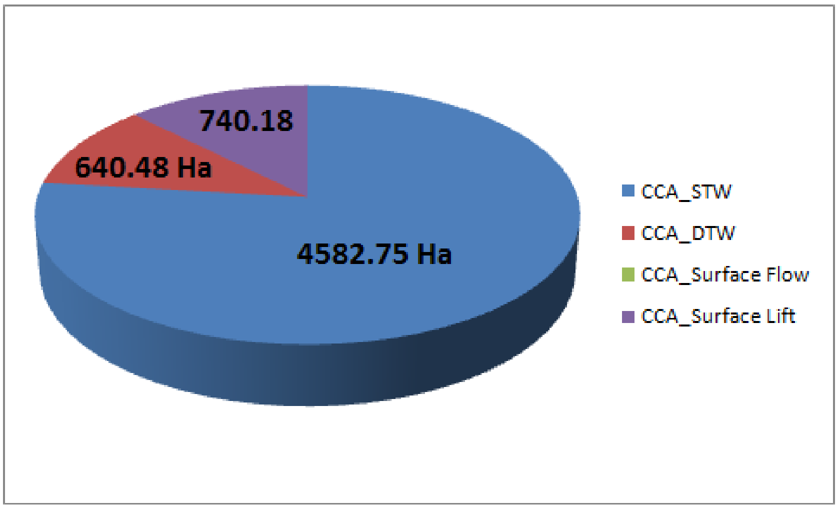


Fig. 9.3.6.1: Per Cent contribution of different sources in irrigation

Table 9.3.6.3 and Fig. 9.3.6.1 indicate that almost 76.85 % and 10.74 % of the cultivable area is irrigated by shallow tube well and deep tube wells respectively. These tube wells are mostly used for Rabi crops, boro paddy, etc. Other surface sources are contributing very less in irrigation.

Data indicate that both pre-monsoon and post –monsoon water level long term trends of this block show falling at average rate of 20.6 cm/ year and 325.53 cm/ year respectively. Depth to water level is also deep in nature. To improve this ground water scenario, rain water harvesting and artificial recharge may be implemented which might restrict the declining trend.

Space Available For Recharge and Proposed Interventions:

Table 9.3.6.4: Area suitable for recharge in the study area:

District	Block Name	Area (in sq. km)	Total Area suitable for recharge (sq. km.)
MURSHIDABAD	Bharatpur II	162	162.00

Proposed Interventions:

Ground Water Resource Estimation shows that 7719.59 ha of cultivable area is still not being covered by any irrigation schemes; it also indicates that ground water resource available for future irrigation is 1558.33Ham. Considering Unit Draft of STW 0.022 MCM & Command Area of STW 6 Ha (0.06 sq. km), additional Ha area can be made irrigable (vide Table 9.3.6.5).

Table – 9.3.6.5: Additional Irrigation Potential created by Available Ground Water Resource

Net Ground Water Resource (MCM)	**SOD (%)**	**Ground Water Resource available (MCM)**	**Available area to be irrigated (Ha)**	**Additional Nos. of STWs feasible**	**Additional Irrigation Potential Created (Ha)**
48.8767	64.99	15.5833	7719.59	708	4248

Still cultivable area 3471.59 Ha i.e. 7719.59 – 4248 Ha is remaining to be covered by irrigation facility. This is possible only when rain water is harvested.

Management for Irrigation water

- Boro cultivation should be reduced. Wheat cultivation can be encouraged. Boro needs 1.2 to 1.4 m, and wheat needs about 0.35 m of water column.
- Rain water harvesting and artificial recharge may be considered which will eliminate the problem of both declining water level and arsenic contamination.
- Cultivation of low water requiring crops and change in cropping pattern suitable for the area.
- To improve the ground water scenario in shallow aquifer, implementation of modern irrigation practices like drip water irrigation system, sprinklers can be made.
- Change in cropping pattern is also needed.

Water column recommendation for crops in consultation with expert of Bidhan Chandra Krishi VidyalayaScope for Rain Water Harvesting and Artificial Recharge in Study Area:

District	Block	Major crops/vegetables/ fruits/flowers currently in practice	Water column depth(m)	Crops suggested for better management(considering ground water quality & quantity)	Water column depth(m) recommended	Remarks e.g. Irrigation techniques etc
Murshidabad	Bharatpur II	Rice, wheat, mustard, jute, vegetables	Rice (1.2-1.4), oilseed (0.2-0.25), jute (rain-fed), vegetable (0.15-0.2)	Wheat, mustard, pulses, vegetables, jute	Wheat (0.2-0.25), mustard (0.2), pulse (0.08-0.12), vegetable (0.12-0.16)	Based on crop physiology (soil moisture depletion),drip for vegetables

Using method of Dhruvanarayana, 1993, in Bharatpur II block, the number and types of artificial recharge and conservation structures proposed to be constructed for harvesting rain water and the estimated cost involved for doing this, have been shown in Table 9.3.6.6a & Table 9.3.6.6 b. 20.45 MCM of rain water has been calculated to be harvested. This Run off component of rainfall can be utilized in 45:45:10 for construction of Irrigation cum Recharge Tank, Re-excavation of Existing Tank with Recharge Shaft and Farm Pond. Bydoing this ground water scenario can be improved as well as the inclusive economic growth can beachieved.

Table 9.3.6.6.a: Calculation of harvested rain water in Bharatpur II block

Normal monsoon rainfall in m(50 yrs data from data.gov.in) 'Rn'	Area(Ha) 'A'	Annual total volume of rain fall in Ham=(Rn X A)	Run off co-efficient from Dhruvanarayana,1993 (Land slope, type of land and soil type) 'C' land slope 0-5%	Major type of soil available in that block	Total volume of surface runoff available Annually 'Vt' (RnXAXC) Ham	75% of 'Vt' = V Ham	50% of V (Non committed)= Vnc Ham	60% of Vnc considered for harvesting = Vf Ham
1.079	16200	17479.8	0.52	50% fine loam, 10% coarse loam & 40% clay	9089.496	6817.122	3408.56	2045.1366

Table 9.3.6.6.b: Proposed Artificial Recharge Structures in Bharatpur II block (Details of structures given in Section II):

Net run-off water availability for recharge & conservation (MCM)	Source Water Allocation (MCM)				Number of Structures				Structure-wise Cost Estimate (lakh Rs.)				Total Cost Estimate (lakh Rs.)
(1)	Irrigation cum recharge Tank (45 % of 1) (2)	Re-excavation of existing tanks (45 % of 1) (3)	Injection Well for recharging deeper layer (0 % of 1) (4)	Farm Pond ((10 % of 1) (5)	Irrigation cum recharge Tank	Re-excavation of existing tanks	Injection Well for recharging deeper layer	Farm Pond	Irrigation cum recharge Tank @ Rs 8 lakh	REET with RS @ Rs 8 lakh	Injection Well	Farm Pond	
20.45	9.2	9.2	0	2.05	18	92	0	21	144	736	0	168	1048

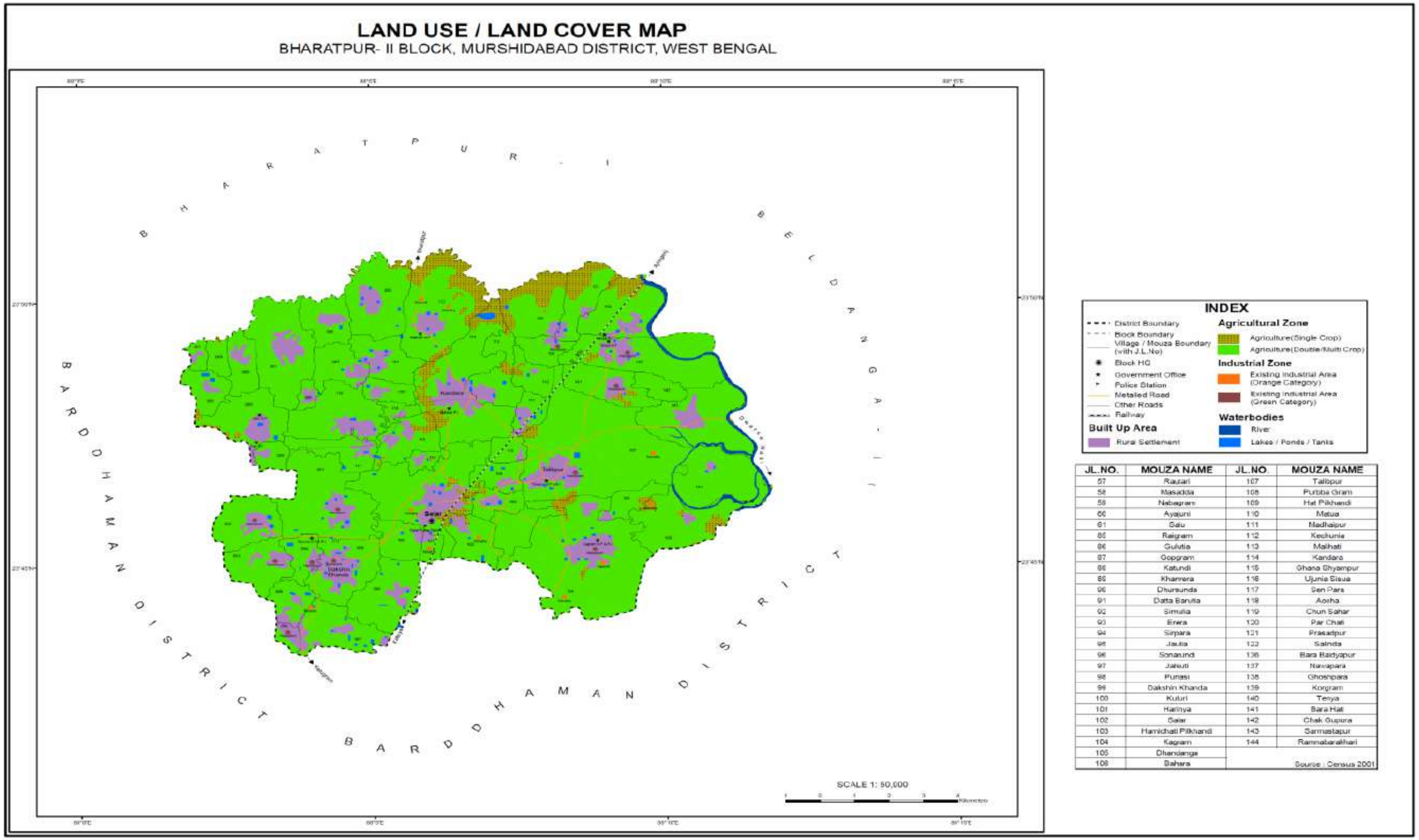


Plate 9.3.6: Land use/ land cover in Bharatpur II block

(Source: Land and land Reforms Dept., Govt. of West Bengal)

Utilization of Harvested Rain Water: Table 9.3.6.6. shows that 27.26 MCM of rain water could be harvested in Bharatpur II block. In Plate 9.3.6, land use & land cover in this block has been shown; from it it is visualized that in this block mostly double/ multi-crop cultivation is in practice. 20.45 MCM of rain water can be utilized for different artificial recharge and conservation structures and for this an estimated Rupees 1048 lakh is required. By harvested water, part of left out 3471.59 Ha of cultivable area can also be irrigated.

Table 9.3.6.7 a: Cropping pattern of major crops (area in Ha, production in '000 M. Tons)

Aus (Area)	Aus (Production)	Aman (Area)	Aman (Production)	Boro (Area)	Boro (Production)	Jute (Area)	Jute (Production)	Wheat (Area)	Wheat (Production)
845	2.261	13018	35.541	7751	30.098	1	0.014	1823	4.324

Table 9.3.6.7 b: Cropping pattern of major crops (area in Ha, production in '000 M. Tons)

Potato (Area)	Potato (Production)	Masur (Area)	Musur (Production)	Mustard (Area)	Mustard (Production)	Til (Area)	Til (Production)	Gram (Area)	Gram (Production)
802	10.433	1073	0.607	2566	1.94	99	0.1	1	0.001

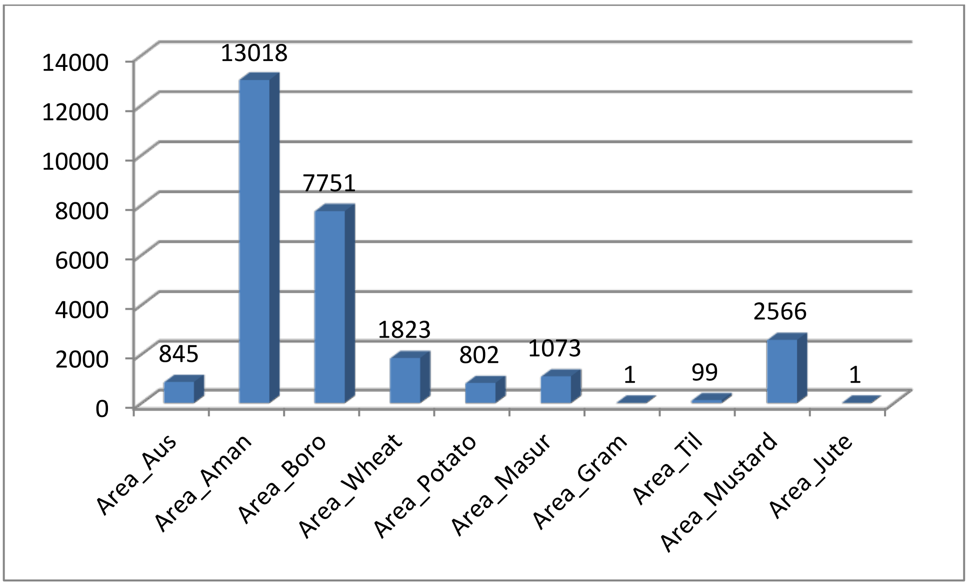


Fig. 9.3.7: Graphical representation of area (Ha) of cultivation of major crops

Attempt has also be been made to modify cropping pattern as per the management strategy mentioned under section **Management Strategy of irrigation water & modification in cropping pattern.** In Table 9.3.7, it has been shown that by using this strategy production of cereals, pulses, oil seeds, etc. would be manifold. At the same time, due to restriction of Boro cultivation by 10% less than the present area of cultivation, a huge amount of vital ground water resources could be saved.

Table 9.3.7: Proposed modification of cropping pattern in Bharatpur II block

Past Area of Boro cultivation (Ha)	Average Water column required (m) for Col. I	G W draft due to boro cultivation (MCM) for Col. I	Proposed 10 % reduction of area of boro cultivation (Ha)	Amount of ground water saved (MCM) as in Col. I	Loss (M. Ton) of Boro paddy due to reduction in area of cultivate@ yield rate of 3613.69 kg/ Ha	Proposed cropping in 1:1:1 ratio in Lost area of Boro cultivation as proposed in Col IV	Gain (M. Ton each) due to alternate cropping @ existing yield rate: Til @ 911.26 kg/hec, Mung @ 605.21 kg/Ha & Ground nut @ 2309.39 kg/Ha	Ground water draft (MCM) for cultivation of Til, Mung & Ground nut @ 0.15 m/Ha	Gain due to increase in area of Aus cultivation in Kharif (at least 10% of existing area of Boro cultivation, i.e. 775.1 Ha.) at yield rate 2577.46 kg/ Ha (M. Ton)	Ground water saved (MCM)
(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)	(IX)	(X)	(XI)
7751	1.3 m	100.76	775.1	10.08	2800.97	Til, Mung & Ground nut258.36 Ha each.	Til- 235.43 , Mung- 156.36 & Ground nut-596.65	1.16	1997.79	8.92

11. BLOCK WISE MANAGEMENT PLAN BIRBHUMDISTRICT(Parts)

11.1NANOOR

Salient Information

Block Name: Nanoor

Area(in Km^2): 316.00

District: Birbhum

State: West Bengal

Population(as on 2011):

Rural	Urban	Total
213387	5267	218654

Approximate Decadal Growth Rate from 2001-2011: 12.78%

Rainfall:

Average annual rainfall (Birbhum district)

for the period 2012 -16 (in mm): 1305.3

Block	Normal	Actual (Annual)				
		2012	2013	2014	2015	2016
Nanoor	1392.8	1052.8	1374.3	1144.4	1659.2	1295.8

Agriculture & Irrigation:(Area in sq. km)

SI. No	Name of the Block	Geographic Area	Cultivable Area	Area under pasture & orchard	Cultivable Waste Land	Forest Land
1.	Nanoor	316	268.92	0.11	--	--

Aquifer Wise Ground Water Resource Availability & Extraction (in MCM):

Resource Availability	Aquifer I	Aquifer II*	Extraction (for Aquifer I)
Dynamic Resource	104.5008	1.66	47.2845
Static Resource	1169.83	-	-

***Ground water flow through Aquifer II towards NW – 2000 m^3/day**

11.1.1Disposition of Aquifer:

Block	Depth range of Aquifer in m bgl		
	Aquifer I	Aquifer II	Aquifer III
Nanoor	10-55 (between 1st& 2nd aquifers sandy clay is there)	83-134	247-261, 315-336

Aquifer I & Aquifer II occur under semi-confined to confined condition, whereas Aquifer III occurs under confined condition.

Aquifer Wise Water Level & Pre-monsoon and Post-monsoon water level trends (2006 to 2016)

SI. No.	Block	Aquifer	Pre-monsoon Trend			Post-monsoon Trend		
			Water Level Range(m bgl)	Rise (cm/year)	Fall (cm/year)	Water Level Range(mbgl)	Rise (cm/year)	Fall (cm/year)
1.	Nanoor	I	16-33.75	-	Fall 25.8	14.1-31	-	Fall 263.8
2.	Nanoor	II	34 (1 datum)	-		32.5 (1 datum)	-	
3	Nanoor	III	-			-		

Thickness of Aquifer(Average):

Block	Area (sq km)	Average thickness of the Granular Zone in 1st aquifer (m)	Average thickness of the Granular Zone in 2nd aquifer (m)	Average thickness of the Granular Zone in 2nd aquifer (m)
Nanoor	316	36.58	31.44	52.13

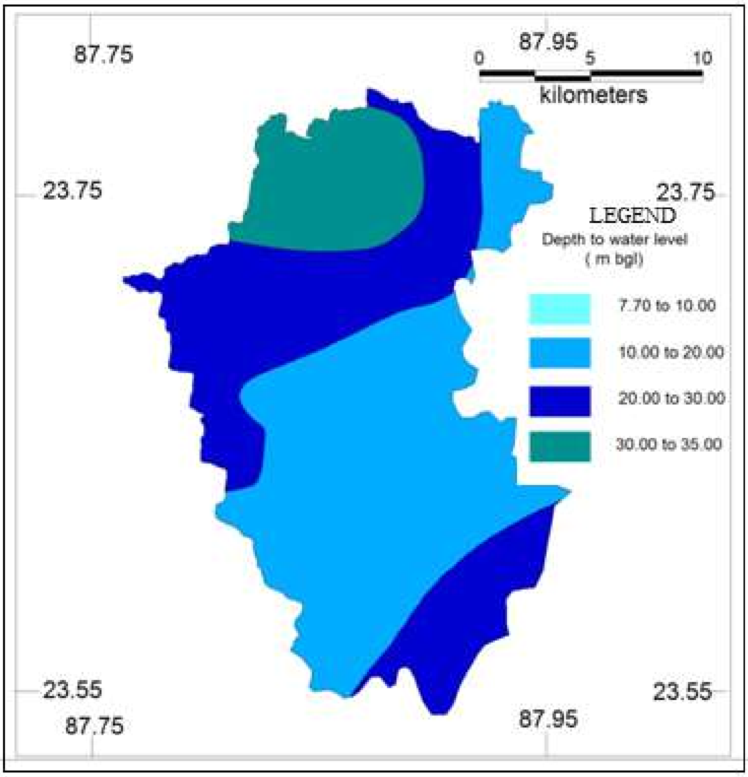


Fig. Depth to water level, Aquifer I, Pre monsoon

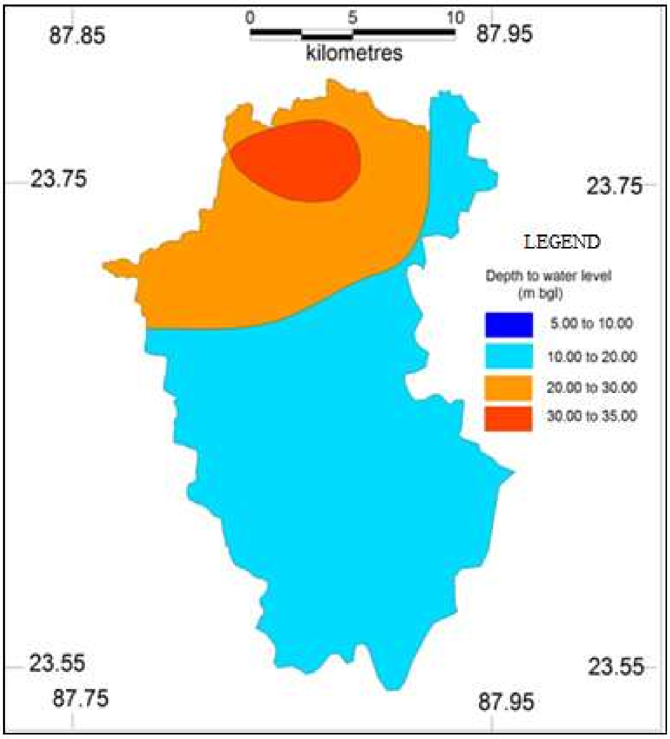


Fig. Depth to water level, Aquifer I, Post monsoon

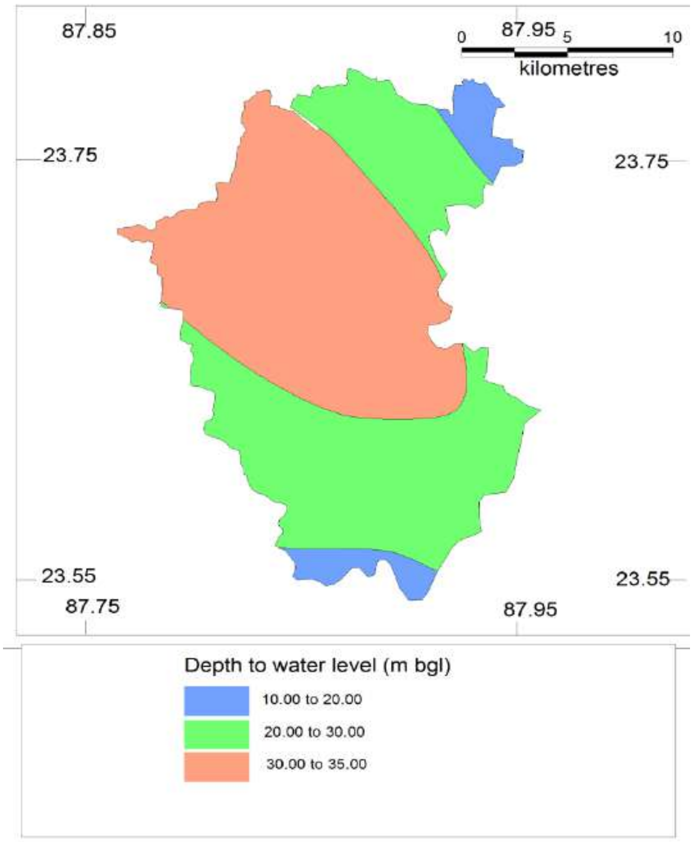


Fig. Depth to water level, Aquifer II, Pre monsoon

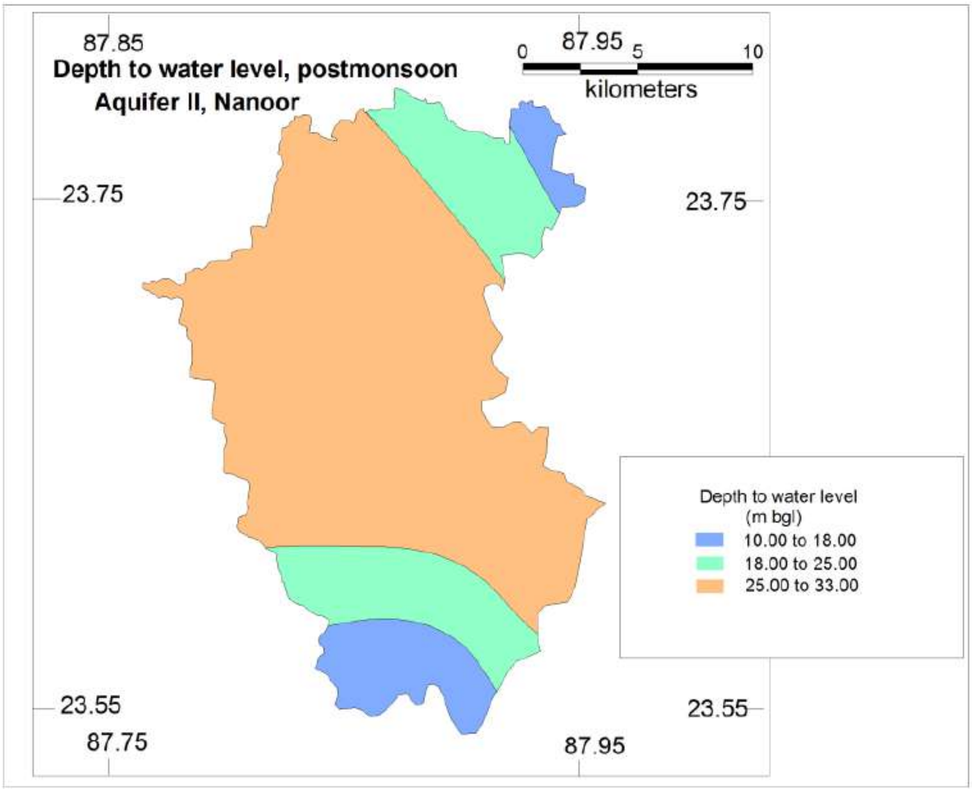


Fig. Depth to water level, Aquifer II, Post monsoon

3 D Aquifer disposition in NanoorBlock, Birbhum District

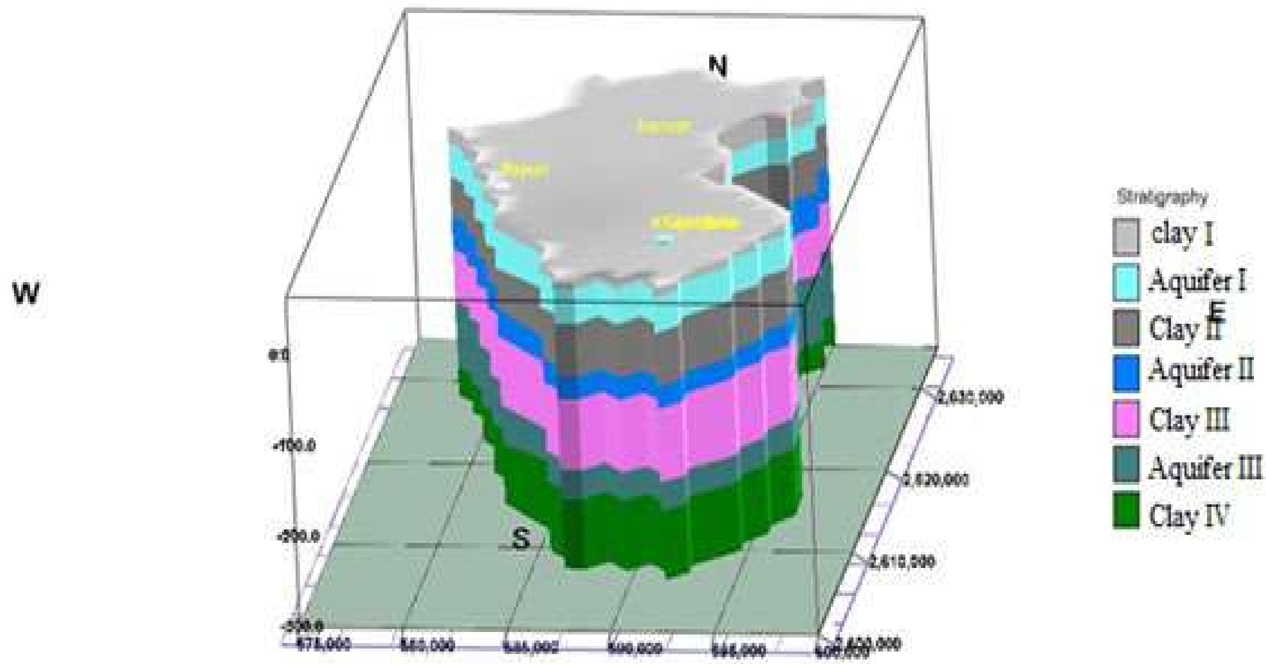


Plate 9.4.1: Aquifer disposition (3D) in Nanoor block, Birbhum district

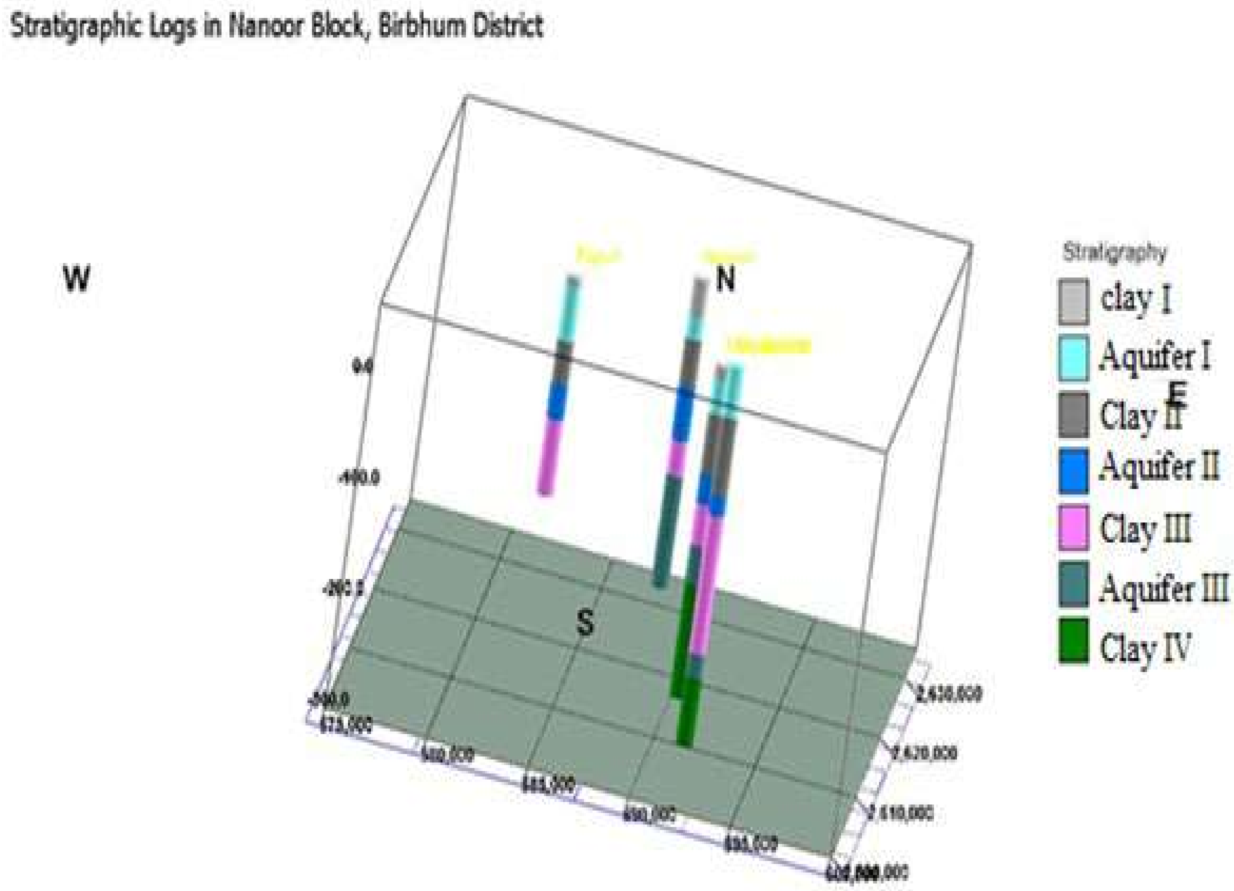


Plate 9.4.2: Stratigraphic Logs in Nanoor block, Birbhum district

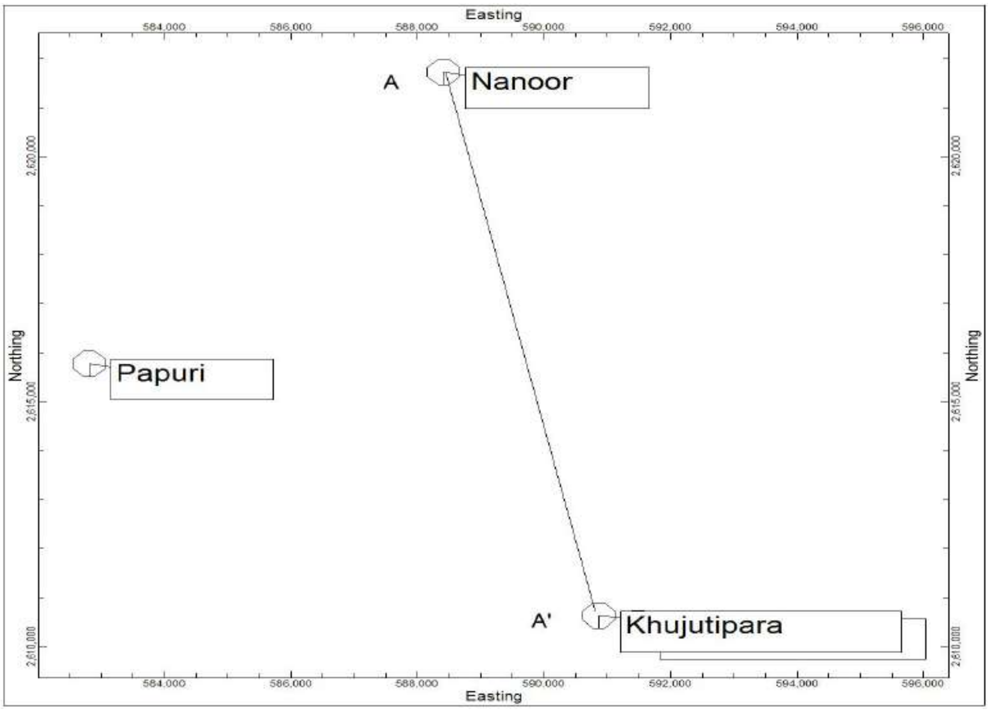


Plate 9.4.3: NNW-SSE Section Index line in Nanoor block, Birbhum district

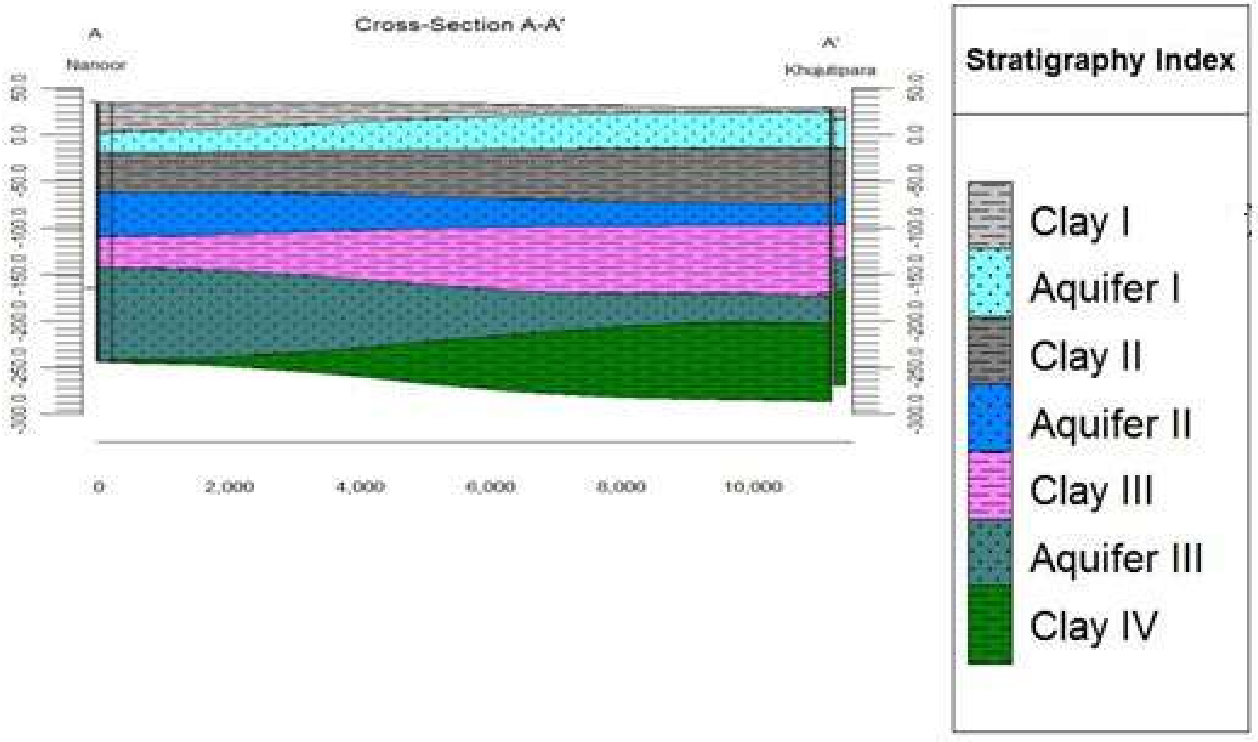


Plate 9.4.4: NNW-SSE Section in Nanoor block, Birbhum district

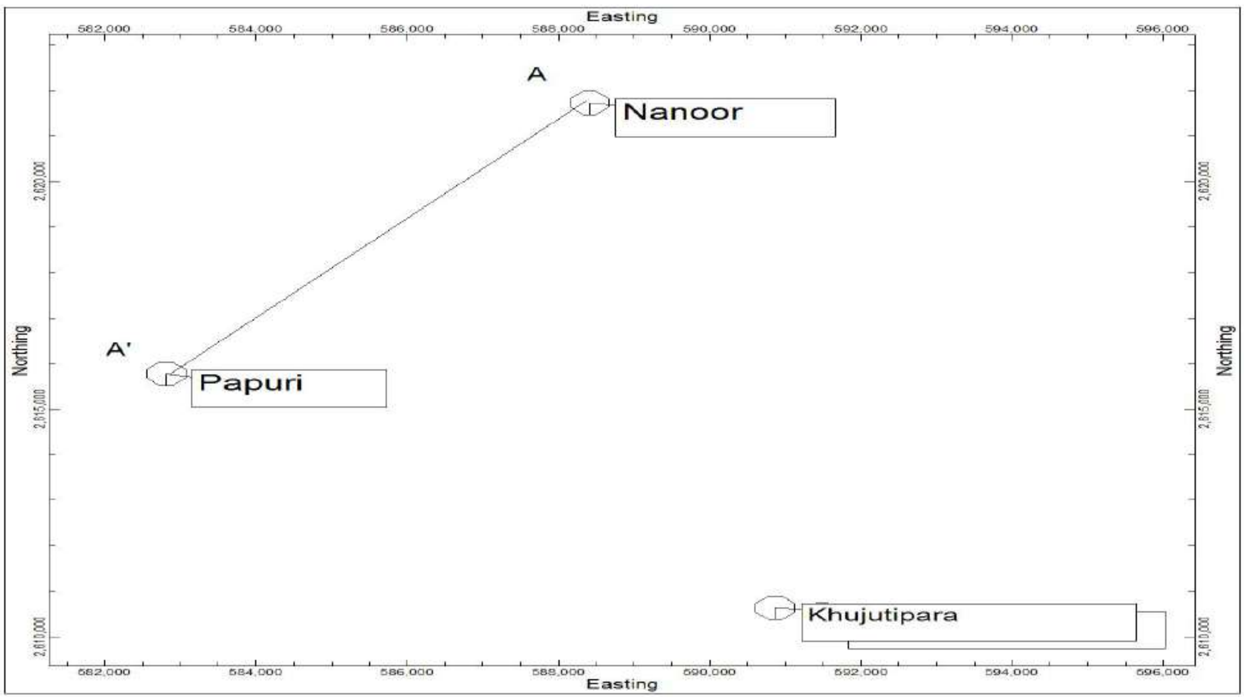


Plate 9.4.5: NE-SW Section Index line in Nanoor block, Birbhum district

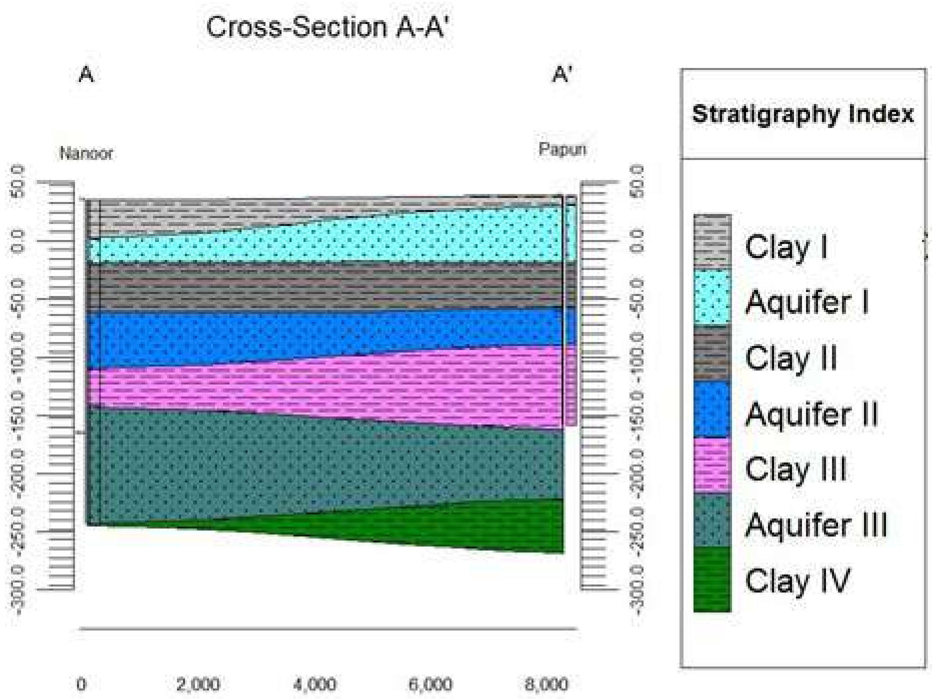


Plate 9.4.6: NE-SW Section in Nanoor block, Birbhum district

Aquifer-wise Statement

	Depth range of Aquifer I (m bgl)			Depth range of Aquifer II (m bgl)			Depth range of Aquifer III (m bgl)		
	Depth Range (m bgl)	**Discharge (m^3/hr)**	**T (m^2/day)**	**Depth Range (m bgl)**	**Discharge (m^3/hr)**	**T (m^2/day)**	**Depth Range (m bgl)**	**Discharge (m^3/hr)**	**T (m^2/day)**
Nanoor	0-55	40-65	1000-3417	83-134	10	-	247-261, 315-336	-	-

11.1.2 Ground Water Resource, Extraction, Contamination & other Issues:
Aquifer Wise Resource Availability & Extraction:

Dynamic ground water resources as on 31st March'13

Block	Net ground water availability (MCM)	Gross ground water draft (MCM)	Stage of development (%)	Category	Provision for domestic and industrial requirement supply up to next 25 years (MCM)
Nanoor	104.5008	47.2845	46.38	Semi-critical	4.9998

11.1.3 **Chemical Quality of GroundWater & Contamination:**

As -data based on 6 samples of spl. Drive' 15-16 & other parameters based on limited samples of 16-17. As in ground water has been found up to a maximum of 0.0002 mg/l in three tube wells, each one at Kankunia, Kirnahar and Nanoor

Range Of Chemical Pollutants:

Block	As(mg/l)	TH (mg/l)	EC(µS/cm)	F(mg/l)	NO_3(mg/l)
Nanoor	**Nil to 0.0002**	**90-165**	**253.6-877.2**	**0.34-0.7**	**0-26**

Arsenic affected Risk Population:

There is no record of risk population in this block.

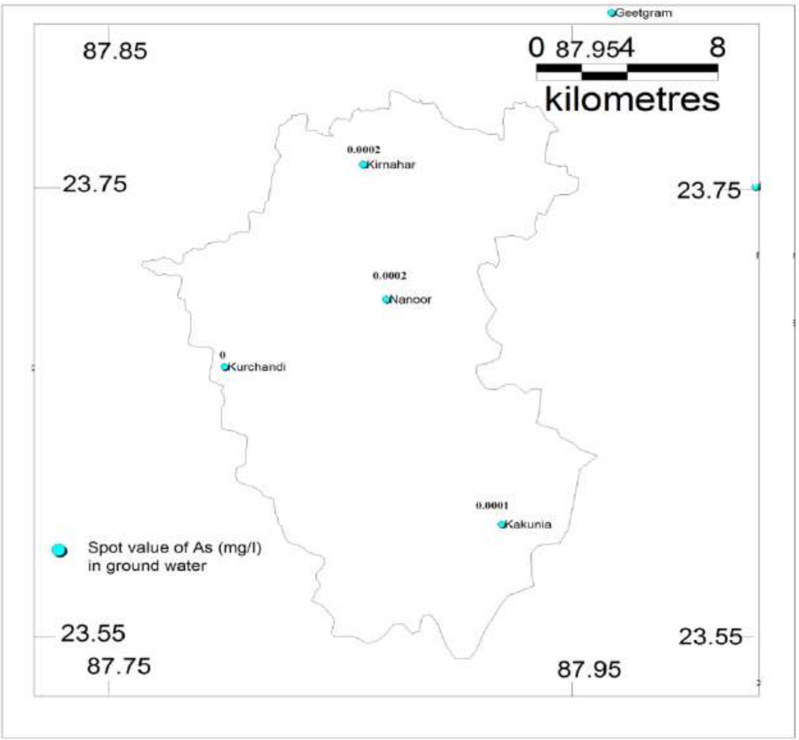


Fig. Arsenic in ground water in Aquifer I

11.1.4 Issues:

a) Deep water level
b) Abnormal falling trend of depth to water level both in pre-monsoon (25.8 cm/yr) & post-monsoon (263.8 cm/yr) seasons
c) Semi-critical category

11.1.5 Ground Water Resource Enhancement & Management Plan:

Ground Water Management Plan for drinking purposes

Table 9.4.6.1: Status of existing water supply schemes

(Source – PHED, Govt. of West Bengal)

Sr No.	Name of Block	Cultivable area in Ha	Net irrigated area (Ha)	Area to be irrigated (Ha)	SOD in %	Pre monsoon WL Trend 2016 in cm/yr	Post monsoon WL Trend 2016 in cm/yr	Average Pre monsoon WL in m bgl	Average Post monsoon WL in m bgl
1	Nanoor	26892	7204.79	19687.21	46.38	**Fall 25.8**	**Fall 263.8**	21.3	16.14

Proposed interventions:

Potential aquifers are encountered within 0-55 m and 83-120 m depth and beyond this depth less potential aquifers (discharge as low as 2.5 lps) within 247-261 & 315-336 m bgl have also been encountered. It is advisable to tap deeper aquifer for drinking purpose.

To provide drinking water, exploration based drilling down to about 600 m bgl will provide information about both potential zones and presence of arsenic, if any, in ground water in the area. In future, tube wells tapping the fresh deeper aquifer with proper cement sealing against clay bed (if arsenic is reported in future) has been proved to supply arsenic free fresh ground water to villages.

Ground Water Management Plan for Irrigation

9.4.6.2: Irrigation Scenario in Nanoor block

Data of 4th M.I. Census shows:

Table – 9.4.6.3: CCA and sources of irrigation

Block		**Shallow Tube well**		**Deep Tube well**		**Surface Flow**		**Surface Lift**		**CCA (Ha)**	
	Total CCA (Ha)	**Nos.**	**CCA (Ha)**	**Nos.**	**CCA (Ha)**	**Nos.**	**CCA (Ha)**	**Nos.**	**CCA (Ha)**	**Ground water**	**Surface water**
Nanoor	7204.79	1253	5884.65	0	0	17	149.36	508	1170.78	5884.65	1320.14

(Source -Dept. of M.I., Govt. of West Bengal)

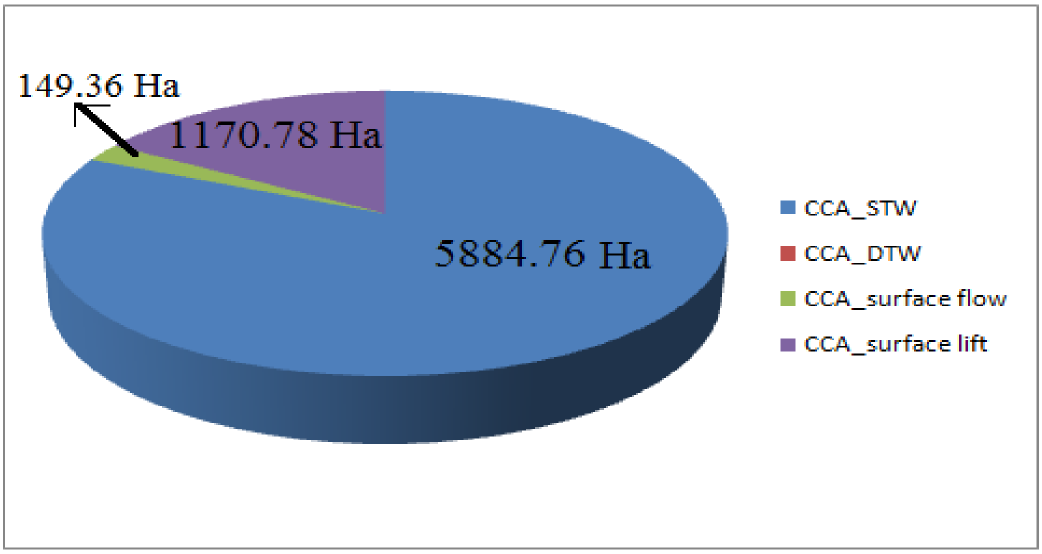


Fig. 9.4.6.1: Per Cent contribution of different sources in irrigation

Table 9.4.6.3 and Fig. 9.4.6.1 indicate that almost 81.67 % and 16.25 % of the cultivable area is irrigated by shallow tube wells and surface lift respectively. These sources are mostly used for rabi crops, boro paddy, etc. Surface flow source is contributing very less in irrigation.

Data indicate that both pre-monsoon and post –monsoon water level long term trends of this block show falling at a rate of 25.8 cm/ year and 263.8 cm/ year respectively. Depth to water level is also deep in nature. To improve this ground water scenario, rain water harvesting and artificial recharge may be implemented which might restrict the declining trend.

Space Available For Recharge and Proposed Interventions:

Table 9.4.6.4: **Area suitable for recharge in the study area:**

District	Block Name	Area (in sq. km)	Total Area suitable for recharge (sq. km.)
Birbhum	Nanoor	316	316

Proposed Interventions:

Ground Water Resource Estimation shows that 19687.21 Ha of cultivable area is still not being covered by any irrigation schemes; it also indicates that ground water resource available for future irrigation is 5459.1 Ham. Considering Unit Draft of STW 0.022 MCM & Command Area of STW 6 Ha (0.06 sq. km), additional 14886 Ha area can be made irrigable (vide Table 9.4.6.5).

Net Ground Water Resource (MCM)	SOD (%)	Ground Water Resource available (MCM)	Available area to be irrigated (Ha)	Additional Nos. of STWs feasible	Additional Irrigation Potential Created (Ha)
104.5008	46.38	54.591	19687.21	2481	14886

Table – 9.4.6.5: Additional Irrigation Potential created by Available Ground Water Resource

Still cultivable area 4801.21 Ha i.e.19687.21 – 14886 Ha is remaining to be covered by irrigation facility. This is possible only when rain water is harvested.

District	Block	Major crops/vegetables/ fruits/flowers currently in practice	Water column depth(m)	Crops suggested for better management(considering ground water quality & quantity)	Water column depth(m) recommended	Remarks e.g. Irrigation techniques etc
Birbhum	Nanoor	Rice, wheat, mustard	Rice (1.2-1.4), wheat (0.3-0.35), mustard (0.2-0.25)	Rice, wheat, mustard	Rice (0.75-0.85),wheat (0.2-0.25), mustard (0.2)	Alternate dry and wet method for rice, for others based on crop physiology

Management for Irrigation

- Boro cultivation should be reduced. Wheat cultivation can be encouraged. Boro needs 1.2 to 1.4 m, and wheat needs about 0.35 m of water column.
- Rain water harvesting and artificial recharge may be considered which will eliminate the problem of both declining water level and arsenic contamination.
- Cultivation of low water requiring crops and change in cropping pattern suitable for the area.
- To improve the ground water scenario in shallow aquifer, implementation of modern irrigation practices like drip water irrigation system, sprinklers can be made.
- Change in cropping pattern is also needed.

Water column recommended in consultation with expert of Bidhan Chandra Krishi Vidyalaya Kalyani, for different crops

Scope for Rain Water Harvesting and Artificial Recharge in Study Area:

Using method of Dhruvanarayana, 1993, in Nanoor block, the number and types of artificial recharge and conservation structures proposed to be constructed for harvesting rain water and the estimated cost involved for doing this, have been shown in Table 9.4.6.6a & Table 9.4.6.6 b. 38.53 MCM of rain water has been calculated to be harvested. This run off component of rainfall can be utilized in 35:35:20:10 ratio for construction of Irrigation cum Recharge Tank, Re-excavation of Existing Tank, Injection Well and Farm Pond; by doing this ground water scenario can be improved as well as the inclusive economic growth can be achieved.

Table 9.4.6.6.a: Calculation of harvested rain water in Nanoor block

Normal monsoon rainfall in m	Area(Ha) 'A'	Annual total volume of rain fall in Ham=(Rn X A)	Run off co-efficient from Dhruvanarayana,1993 (Land slope, type of land and soil type) 'C' land slope 0-5%	Major type of soil available in that block	Total volume of surface runoff available Annually 'Vt' (RnXAXC) Ham	75% of 'Vt' = V Ham	50% of V (Non committed) = Vnc Ham	60% of Vnc to be considered for harvesting = Vf Ham
1.106	31600	34949.6	0.49	30 % Sandy loam, 20 % silty clay & 50 % clay	17125.3	12843.98	6421.99	3853.1934

Table 9.4.6.6.b: Proposed Artificial Recharge Structures in Nanoor block (Details of structures given in Section II)

Block	Net surface water availability for recharge in MCM (1)	Source Water Allocation (MCM)				Number of Structures				Structure-wise Cost Estimate (lakh Rs.)				Total Cost Estimate (lakh Rs.)
		Irrigation cum recharge Tank (35 % of 1) (2)	Re-excavation of existing tanks with RS (35 % of 1) (3)	Injection Well for recharging deeper layer (20 % of 1) (4)	Farm Pond ((10 % of 1) (5)	Irrigation cum recharge Tank	Re-excavation of existing tanks with RS	Injection Well for recharging deeper layer	Farm Pond	Irrigation cum recharge Tank	Re-excavation of existing tanks with RS	Injection Well for recharging deeper layer	Farm Pond	
Nanoor	38.53	13.49	13.49	7.71	3.85	27	135	26	39	216	1080	208	312	1816

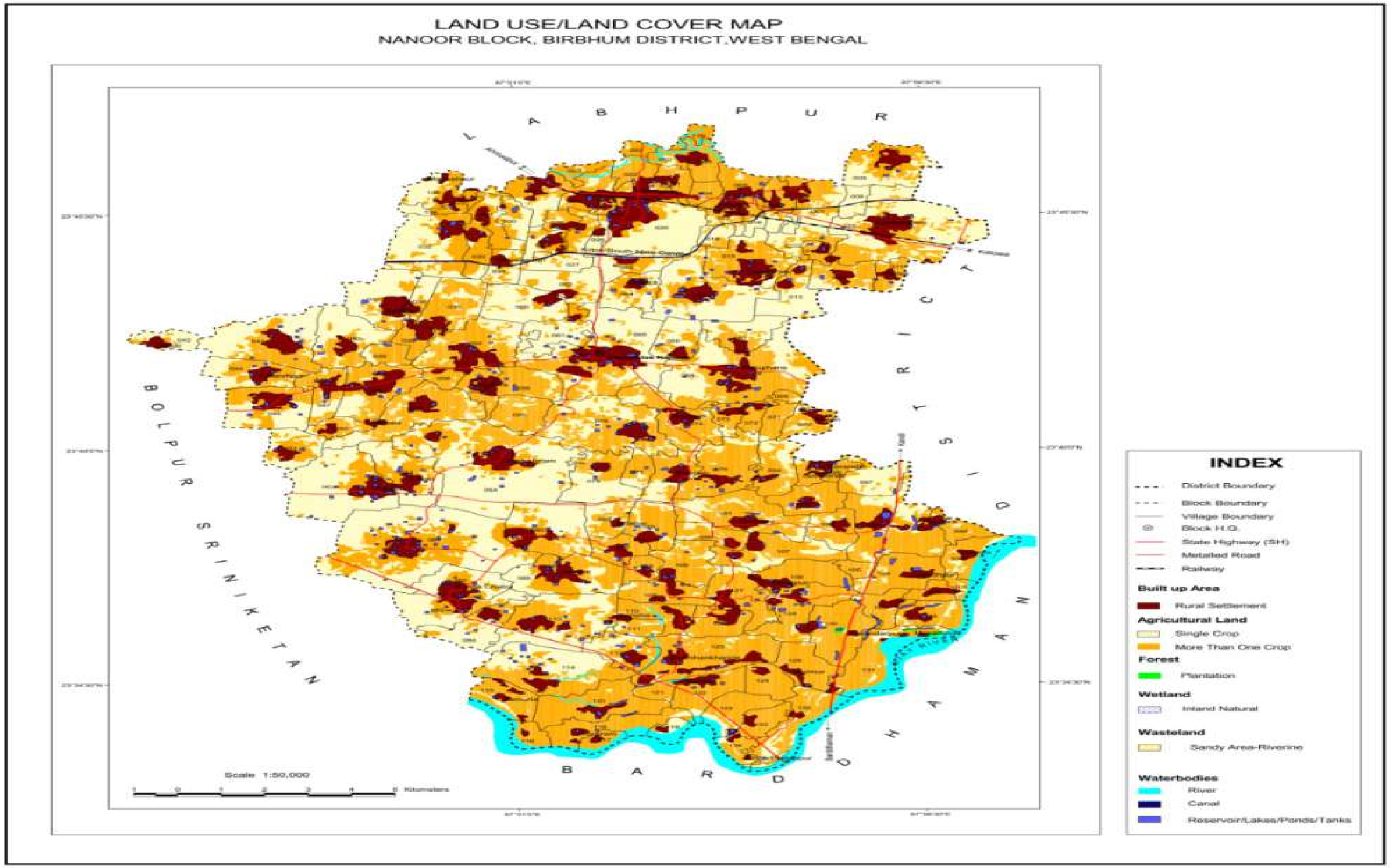


Plate 9.4.6: Land use/ land cover in Nanoor block

(Source: Land Use & Land Reforms Dept. , Govt. W. B.)

Table 9.4.6.7 a: Cropping pattern of major crops (area in Ha, production in '000 M. Tons)

Aus (Area)	Aus (Production)	Aman (Area)	Aman (Production)	Boro (Area)	Boro (Producti on)	Jute (Area)	Jute (Production)	Wheat (Area)	Wheat (Production)
18	0.013	460	0.401	3512	4.583	10	0.167	1418	3.827

Table – 9.4.6.7 b: Cropping pattern in Nanoor block (area in Ha, production in '000 M. Tons)

Potato (Area)	Potato (Production)	Masur (Area)	Musur (Production)	Mustard (Area)	Mustard (Production)	Til (Area)	Til (Production)	Gram (Area)	Gram (Production)
1023	27.183	294	0.238	-	-	-	-	410	0.63

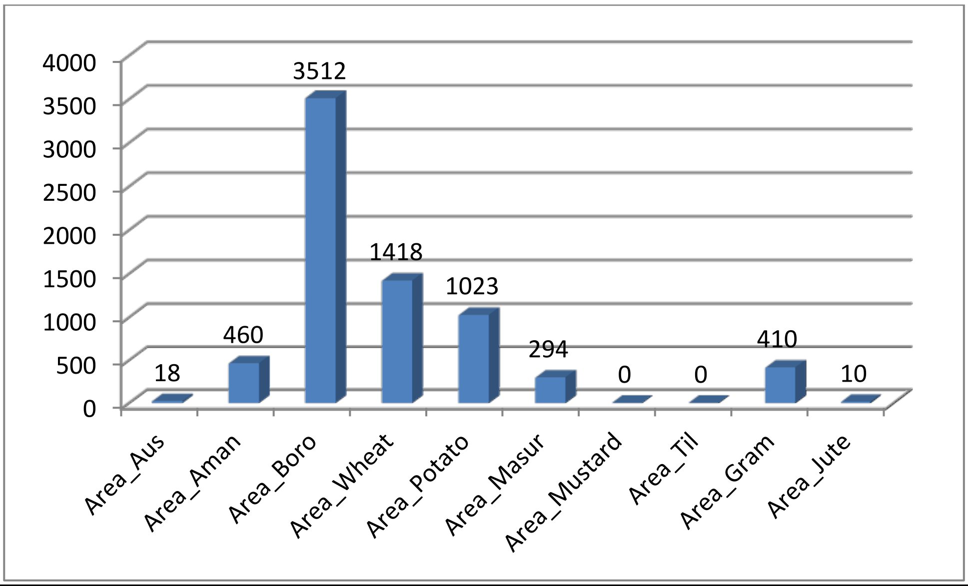


Table – 9.4.6.7 c: Graphical representation of cropping pattern (area in Ha)

Utilization of Harvested Rain Water: Table 9.4.6.6.b shows that 38.53 MCM of rain water could be harvested in Nanoor block. In Plate 9.4.6, land use & land cover in this block has been shown; from it it is visualized that in this block mostly multi-crop cultivation is in practice. The amount of water can be utilised in different artificial recharge and conservation structures and an estimated Rupees 1816 lakh will be incurred. Also, by harvested water part of left out 4801.21 Ha of cultivable land can be irrigated.

Attempt has also been made to modify cropping pattern as per the management strategy mentioned under section **Management Strategy of irrigation water & modification in cropping pattern.** In Table 9.4.7, it has been shown that by using this strategy production of cereals, pulses, oil seeds, etc. would be manifold. At the same time, due to restriction of Boro cultivation by 10% less than the present area of cultivation, a huge amount of vital ground water resources could be saved.

Table 9.4.7: Proposal for modification of cropping pattern in Nanoor block

Area of Boro cultivation (Ha)	**Average Water column required (m) for Col. I**	**G W draft due to boro cultivation (MCM) for Col. I**	**Proposed 10 % reduction of area of boro cultivation (Ha)**	**Amount of ground water saved (MCM) as in Col. I**	**Loss (M. Ton) of Boro due to reduction in area of cultivation @ yield rate 3391.19 kg/ Ha**	**Proposed cropping in lost area of Boro cultivation**	**Gain (M. Ton) due to alternate cropping @ existing yield rate: Mung @ 1678.55 kg/Ha**	**Ground water draft (MCM) for cultivation of Mung @ 0.15 m par Ha**	**Gain due to increase in area of Aus cultivation in Kharif (at least 10 % of existing area of Boro cultivation, i.e. 351.2 Ha.) at yield rate 2599.97 kg/ Ha (M. Ton)**	Ground water saved (MCM)
(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)	(IX)	(X)	(XI)
3512	1.3 m	45.66	351.2	4.57	1190.99	Mung in 351.2 Ha	Mung-589.51	0.53	913.11	4.04

12. BLOCK WISE MANAGEMENT PLAN OF DISTRICT BARDDHAMAN DISTRICT

12.1KETUGRAM I

Salient Information

Block Name: KETUGRAM I

Area (in Km^2): 200

District: Bardhaman

State: West Bengal

Population(as on 2011):

Rural	Urban	Total
165408	--	165408

Approximate Decadal Growth Rate from 2001-2011: 13.28%

Rainfall:

Average annual rainfall in Barddhaman district for the period 2012 -16 (in mm): 1380.28

Block	Normal	Actual (Annual)				
		2012	2013	2014	2015	2016
Ketugram I	1315.2	1276.6	1535.5	1134.4	1546.5	1408.4

Agriculture & Irrigation (Area in sq. Km):

SI. No	Name of the Block	Geographic Area	Cultivable Area	Area under pasture & orchard	Cultivable Waste Land	Forest Land
1.	Ketugram I	200	150.32	-	10.22	-

Aquifer Wise Ground Water Resource Availability & Extraction(in MCM):

Resource Availability	Aquifer I	Aquifer II*	Extraction (for Aquifer I)
Dynamic Resource	152.8305	0.72	32.4439
Static Resource	1323.20	-	-

*Ground water flow in Aquifer II towards SW: 2186.99 m^3/day; towards NNE: 637.58 m^3/day

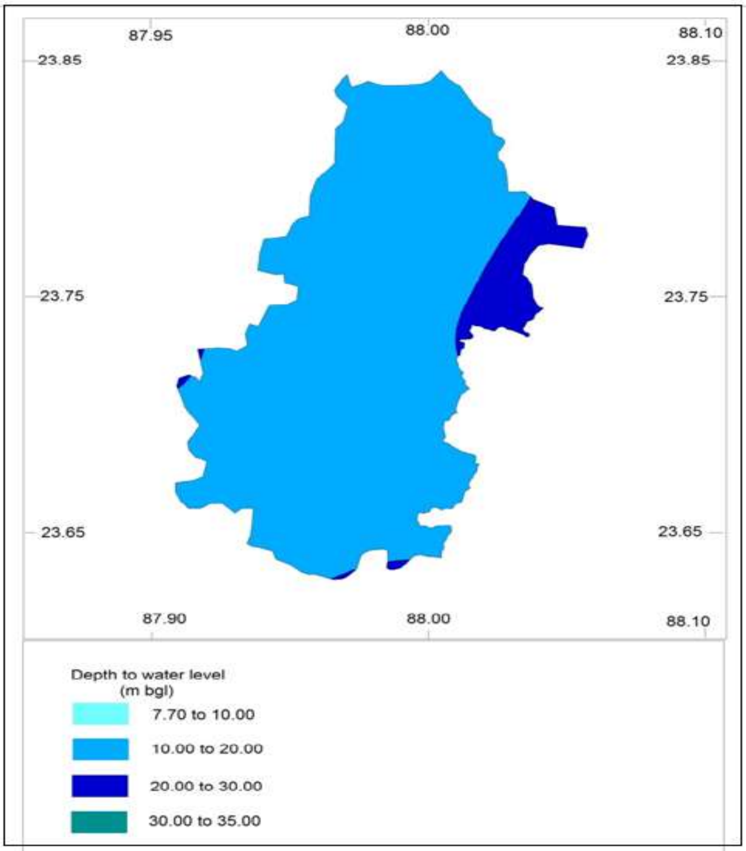


Fig. Depth to water level, Aquifer I, Pre monsoon

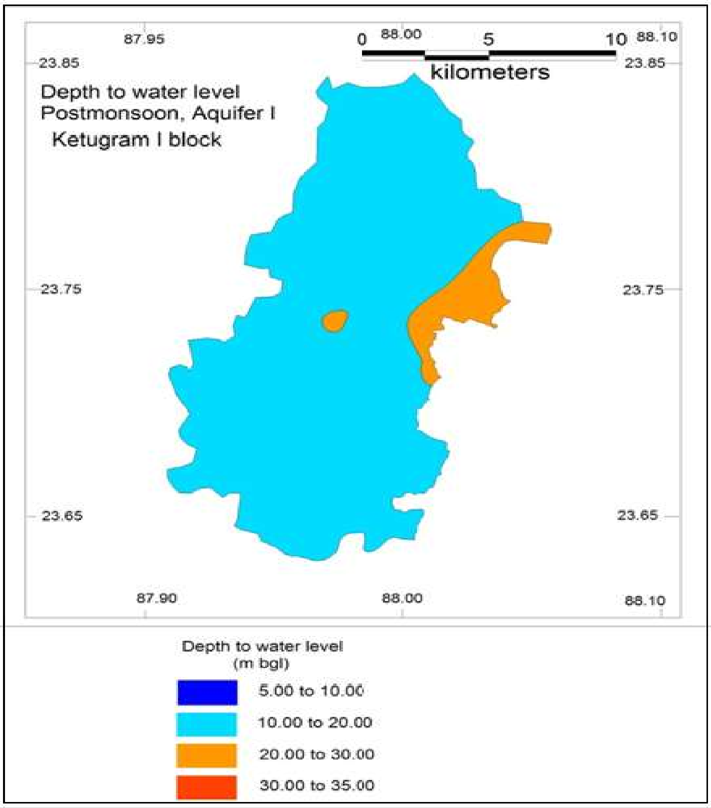


Fig. Depth to water level, Aquifer I, Post monsoon

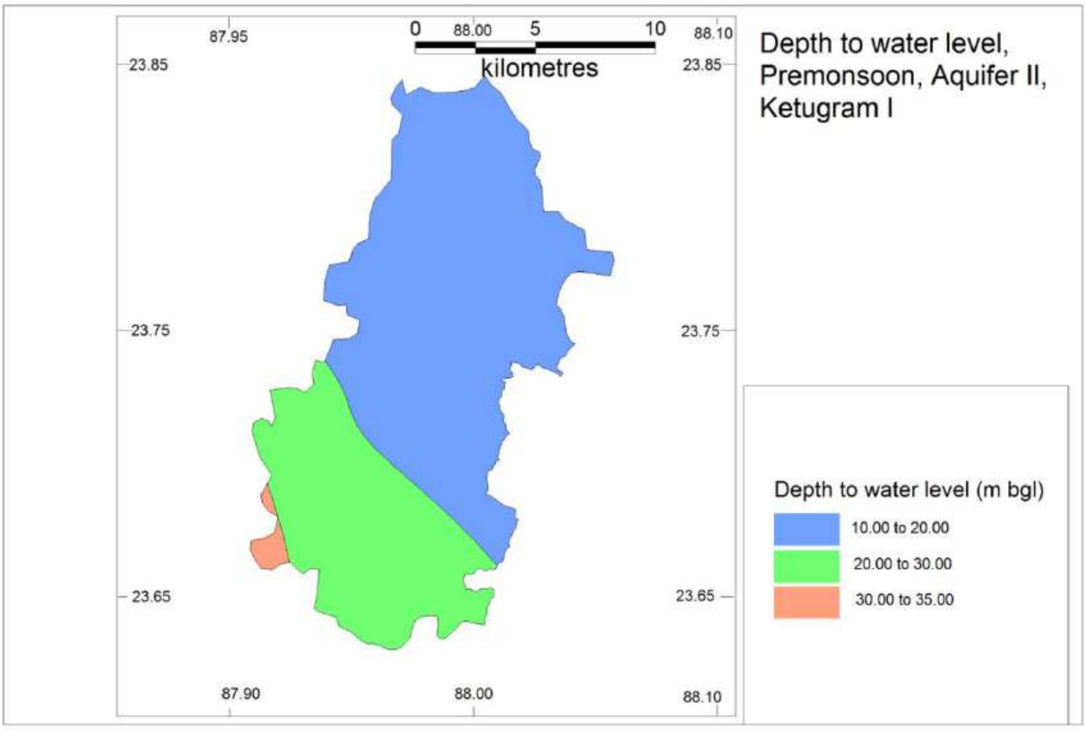


Fig. Depth to water level, Aquifer II, Pre monsoon

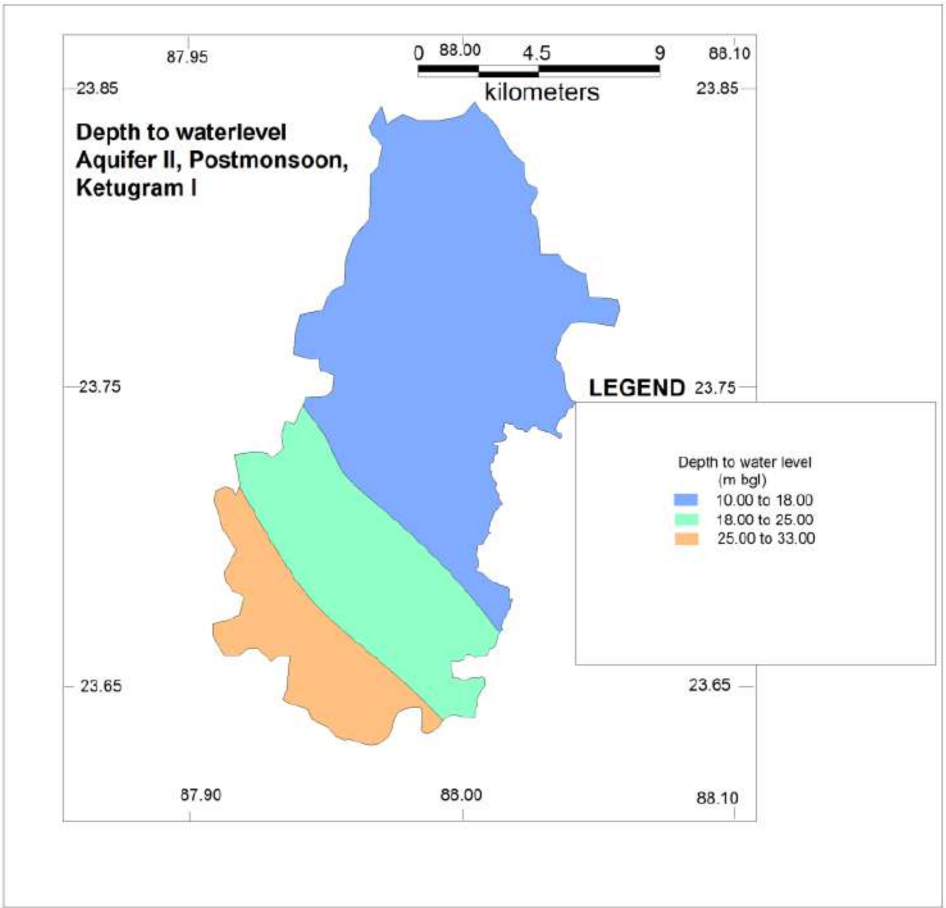


Fig. Depth to water level, Aquifer II, Post monsoon

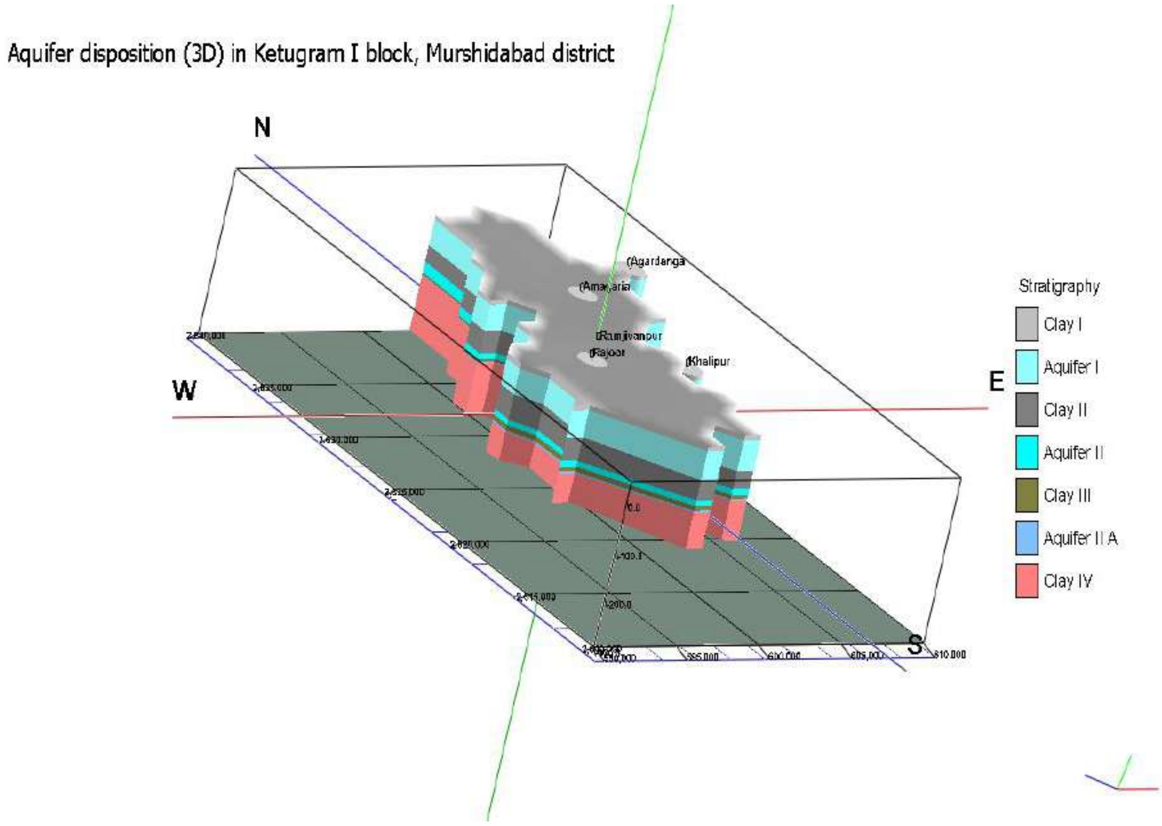


Plate 9.5.1: Aquifer disposition (3D) in Ketugram I block, Barddhaman district

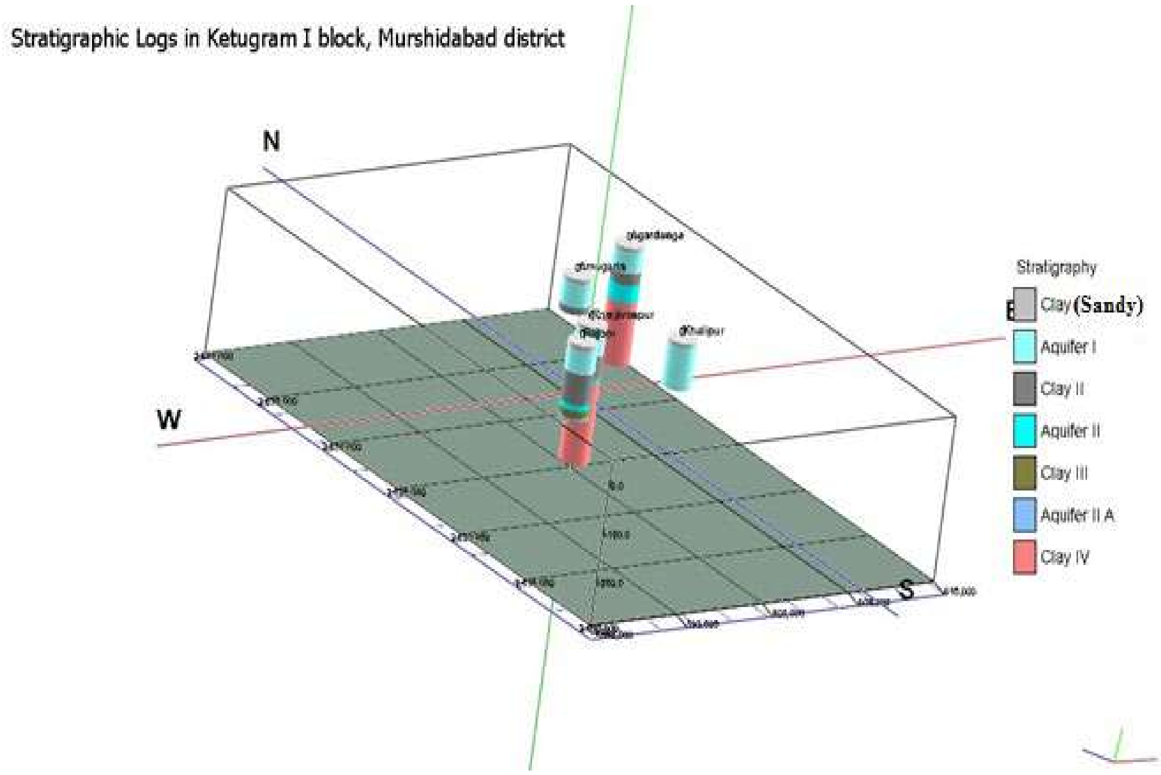


Plate 9.5.2: Stratigraphic logs in Ketugram I block, Barddhaman district

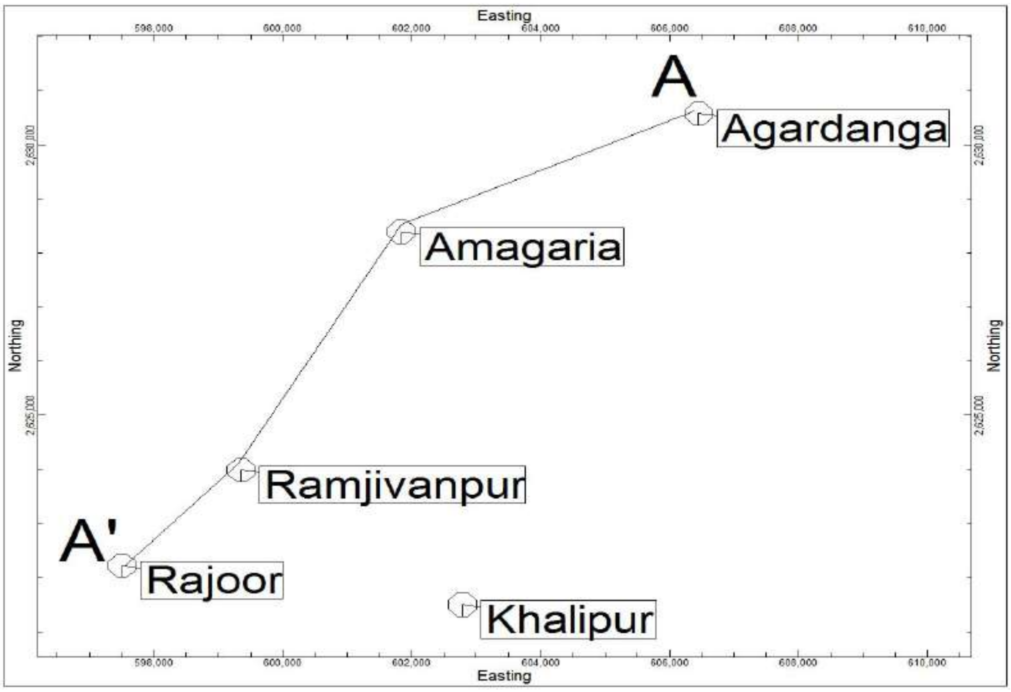


Plate 9.5.3: NE-SW Section Index line in Ketugram I block, Bardhaman district

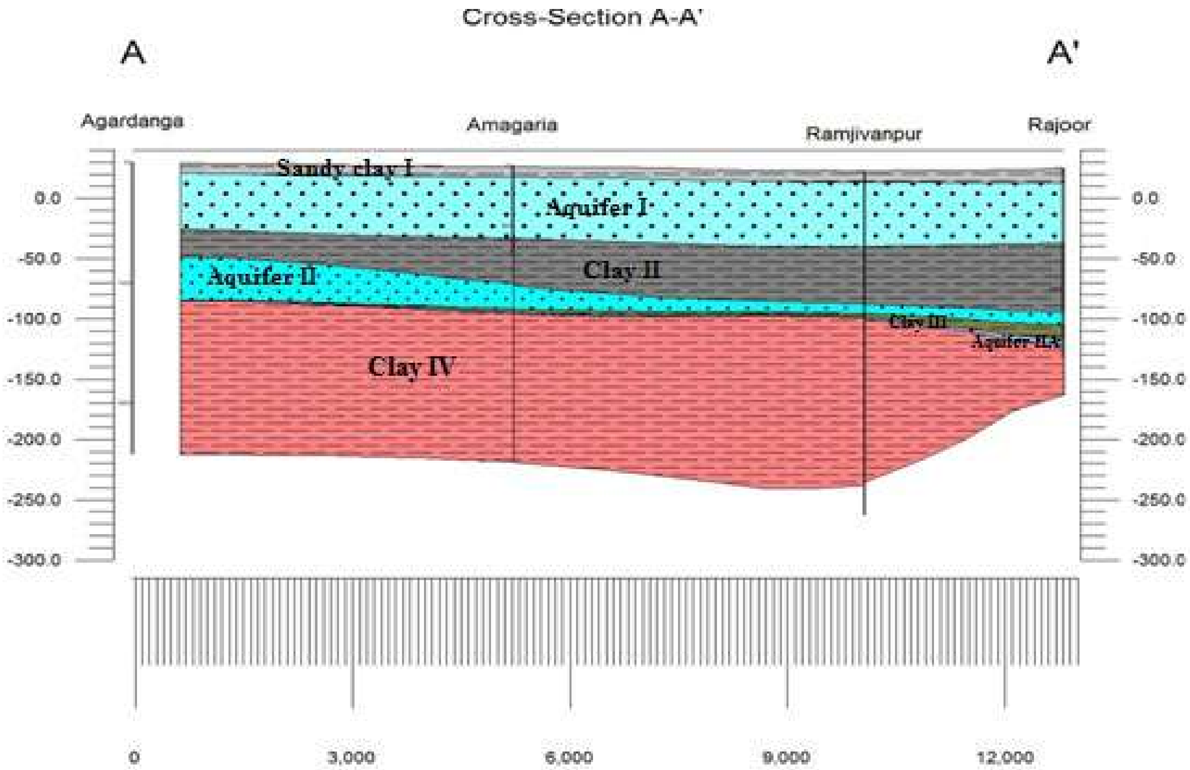


Plate 9.5.4: NE-SW Section in Ketugram I block, Bardhaman district

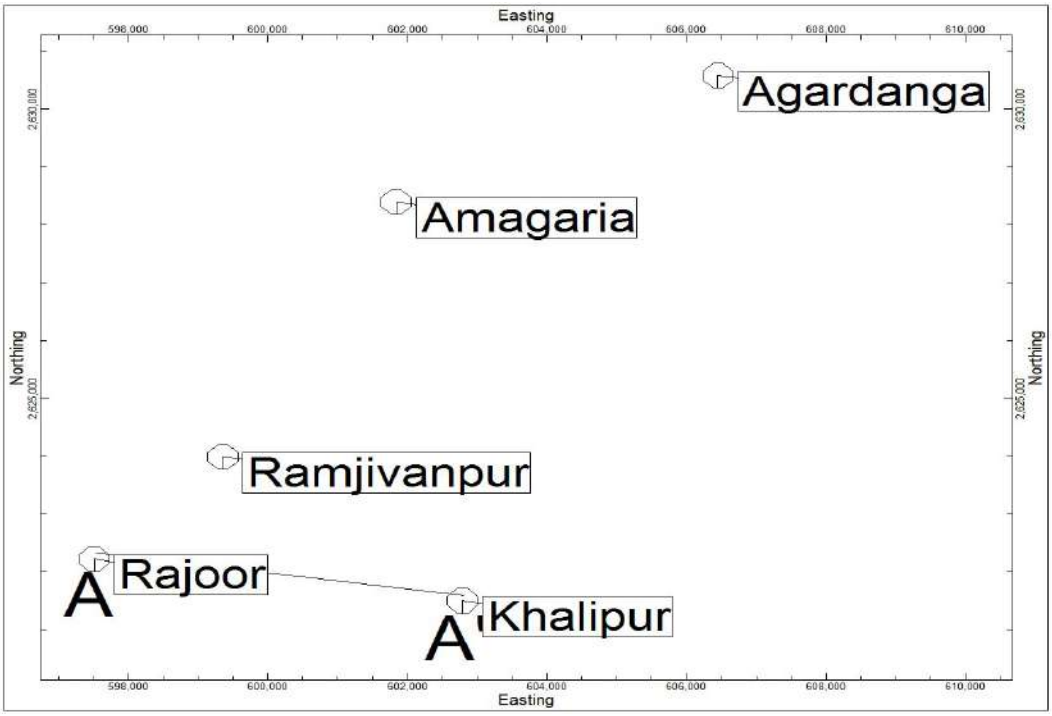


Plate 9.5.5:W-E Section Index Line in Ketugram I block, Bardhaman district

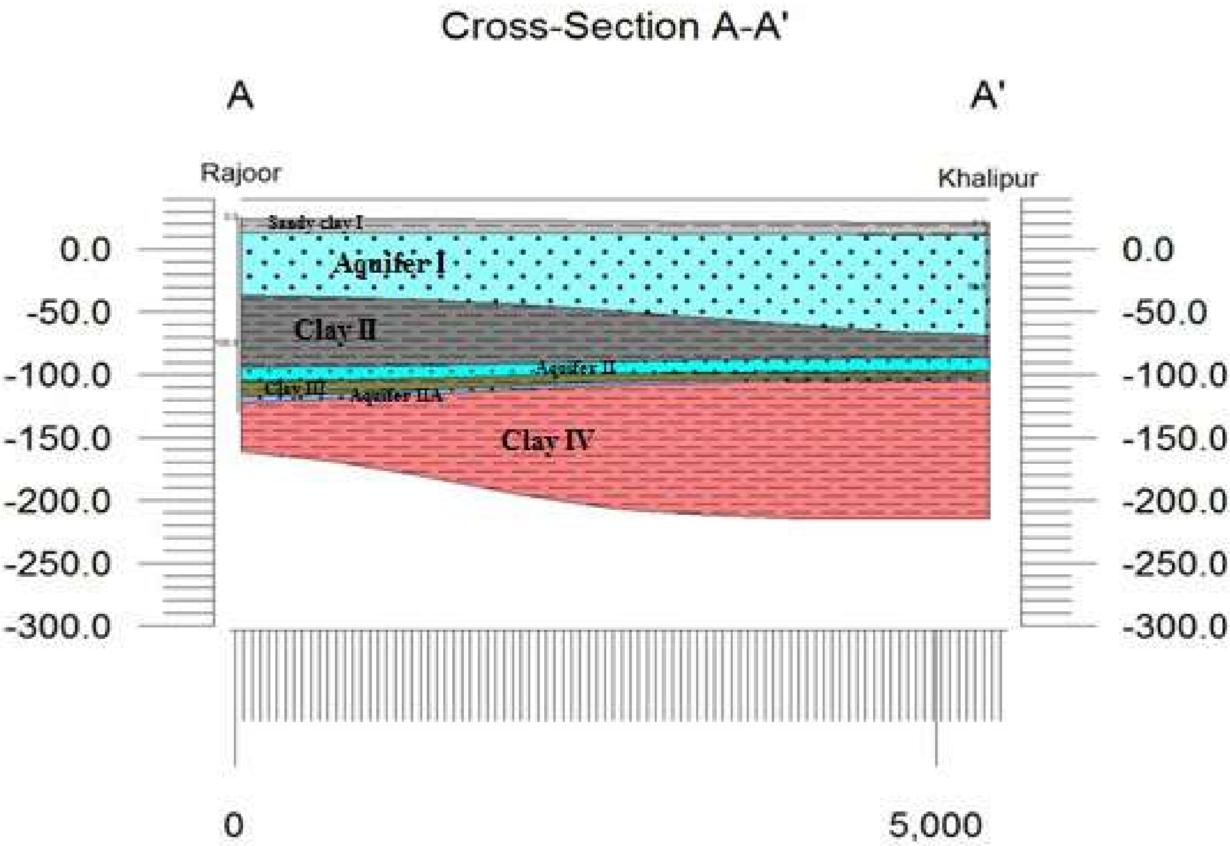


Plate 9.5.6:NE-SW Section in Ketugram I block, Bardhaman district

12.1.1 Disposition of Aquifer:

Block	Depth range of Aquifer in m bgl	
Ketugram-1	**Aquifer I**	**Aquifer II/ Aquifer 1 A**
	8-70	120-135, 150-155

Aquifer I and Aquifer II occur under semi-confined to confined condition.

Aquifer Wise Water Level Ranges &Pre-monsoon and Post-monsoon water level trends (2006 to 2016)

SI. No.	Block	Aquifer	Pre-monsoon Trend			Post-monsoon Trend		
			Water Level Range(mbgl)	Rise (cm/year)	Fall (cm/year)	Water Level Range(mbgl)	Rise (cm/year)	Fall (cm/year)
1.	Ketugram I	I	15.16-20.0	-	Fall 57.9	14.12-24.24	-	Fall 87.63
2	Ketugram I	II	24.9 (1 datum)	-	-	7.01(1 datum)	-	-

Thickness of Aquifer I (Average): 49.28 m

Thickness of Aquifer II (Average): 25.71 m

Aquifer-wise Statement

Name of Block	Aquifer I			Aquifer II/ Aquifer IA		
	Depth Range (m bgl)	**Discharge (m^3/hr)**	**T (m^2/day)**	**Depth Range (m bgl)**	**Discharge (m^3/hr)**	**T (m^2/day)**
Ketugram-1	8-70	31-128.30	31 – 1700,	120-135, 150-155	34.2	-

12.1.2 Aquifer Wise Resource Availability & Extraction:

Dynamic ground water resources as on 31st March'13

Block	Net ground water availability (MCM)	Gross ground water draft (MCM)	Stage of development (%)	Category	Provision for domestic and industrial requirement supply up to next 25 years (MCM)
Ketugram I	52.3863	32.4439	62.66	Semi-critical	5.8207

12.1.3 Chemical Quality of Ground Water & Contamination:

As -data based on 3 samples of spl. Drive' 15-16 & other parameters based on limited samples of 16-17. As in ground water has been found up to a maximum of 0.0002 mg/l in one tube well at Khalipur (Kamarpur Hat Tala).

Range of Chemical Pollutants:

Block	As(mg/l)	TH (mg/l)	EC (µS/cm)	F(mg/l)	NO_3(mg/l)
Ketugram I	**Nil to 0.0002**	**60-190**	**324-614**	**1.04-1.2**	**bdl**

Percentage of tube wells having arsenic content in the block based on SOES data:

Blocks	Arsenic (<0.01 ing/1)	Arsenic (>0.01-<0.05 mg/1)	Arsenic (> 0.05 mg/1)	Total Tube well (max. concentration based on samples with As> 1 mg/l)
Ketugram I	NA	-	-	120 (0.008)

Arsenic affected Risk Population:

Not record available

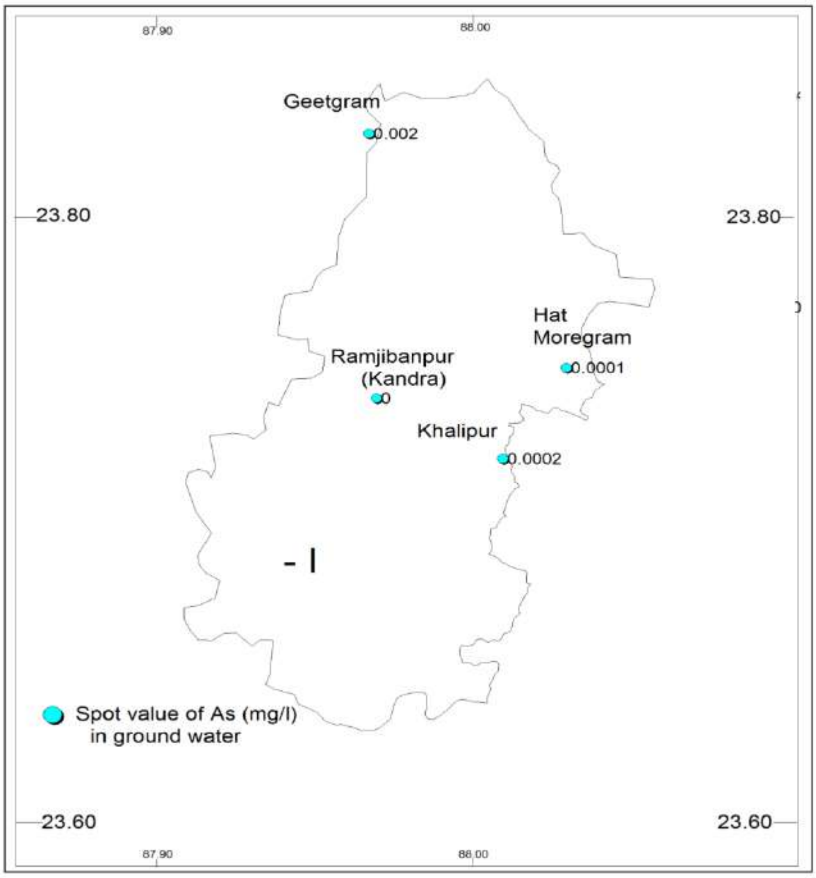


Fig. Arsenic in ground water in Aquifer I

12.1.4 Ground Water Resource Enhancement& Management Plan:

Ground Water Management Plan for drinking purposes

Table 9.5.6.1: Status of existing water supply schemes

Block	Nos. of ongoing PWSS scheme	Population covered	Nos. of new PWSS scheme	Population covered
Ketugram I & Ketugram II blocks (together)	5	100457	2	12607

(Source – PHED, Govt. of West Bengal)

Proposed interventions:

Potential aquifers are encountered within 8-70 m and beyond this depth less potential aquifers are encountered within 120-135, 150-155 m depth. These two aquifers join together to form a single aquifer at places. Ground water in aquifers is potable. However, it is advisable to tap deeper aquifer for drinking purpose.

To provide drinking water, exploration-based drilling down to about 600 m bgl will provide information about both potential zones and presence of arsenic, if any, in ground water in the area. In future, tube wells tapping the fresh deeper aquifer with proper cement sealing against clay bed (if arsenic is reported in future) has been proved to supply arsenic free fresh ground water to villages.

Ground Water Management Plan for Irrigation purposes

9.5.6.2: Irrigation Scenario in Ketugram I block

Name of Block	Cultivable area in ha	Net irrigated area (Ha)	Area to be irrigated (Ha)	SOD in %	Pre monsoon WL Trend 2016 in cm/yr	Post monsoon WL Trend 2016 in cm/yr	Average Pre monsoon WL in m bgl	Average Post monsoon WL in m bgl
Ketugram I	15032	5995.22	9036.78	62.66	**Fall 57.9**	**Fall 87.63**	17.65	17.78

Data of 4th M.I. Census shows:

Table – 9.4.6.3: CCA and sources of irrigation

(Source – Dept. of M.I., Govt. of West Bengal)

Total CCA (Ha)	Dug well		Shallow Tube well		Deep Tube well		Surface Flow		Surface Lift		CCA (Ha)	
	Nos.	CCA (Ha)	Nos.	CCA (Ha)	Nos.	CCA (Ha)	Nos.	CCA (Ha)	Nos.	CCA (Ha)	Ground water	Surface water
5995.22	39	204.33	924	4819.09	14	560.00	3	50.75	96	361.05	5583.42	411.80

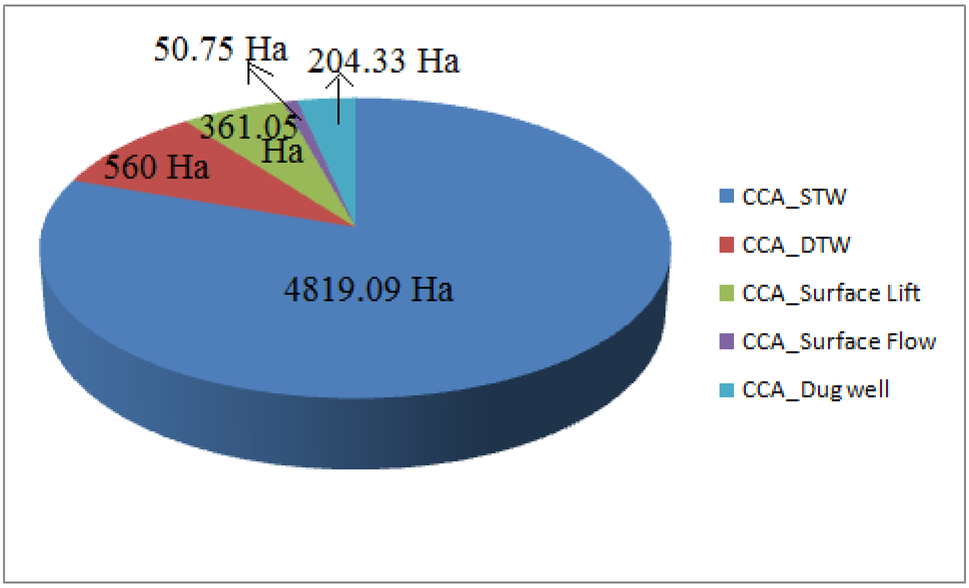


Fig. 9.5.6.1: Per Cent contribution of different sources in irrigation

Table 9.5.6.3 and Fig. 9.5.6.1indicate that almost 80.38% and 9.34 % of the cultivable area is irrigated by shallow tube wells and deep tube wells respectively. Dug well contributes 3.41 % of irrigation. These sources are mostly used for rabi crops, boro paddy, etc. Surface flow & surface lift source are contributing very less in irrigation.

Data indicate that both pre-monsoon and post –monsoon water level long term trends of this block show falling at a rate of 57.9 cm/ year and 87.63 cm/ year respectively. Depth to water level is also deep in nature. To improve this ground water scenario, rain water harvesting and artificial recharge may be implemented which might restrict the declining trend.

Space Available For Recharge and Proposed Interventions:

Table 9.5.6.4: Area suitable for recharge in the study area:

District	Block Name	Area (in sq. km)	Total Area suitable for recharge (sq. km.)
Bardhaman	Ketugram I	316	316

Proposed Interventions:

Ground Water Resource Estimation shows that 9036.78 Ha of cultivable area is still not being covered by any irrigation schemes; it also indicates that ground water resource available for future irrigation is 1879.55 Ham. Considering Unit Draft of STW 0.022 MCM & Command Area of STW 6 Ha (0.06 sq. km), additional 5124 Ha area can be made irrigable (vide Table 9.5.6.5).

Table – 9.5.6.5: Additional Irrigation Potential created by Available Ground Water Resource

Net Ground Water Resource (MCM)	SOD (%)	Ground Water Resource available (MCM)	Available area to be irrigated (Ha)	Additional Nos. of STWs feasible	Additional Irrigation Potential Created(Ha)
52.3863	62.66	18.7955	9036.78	854	5124

Still cultivable area 3912.78 Ha i.e.9036.78 - 5124 Ha is remaining to be covered by irrigation facility. This is possible only when rain water is harvested. Budgeting of rain water harvesting for this block has been discussed below.

Management for Irrigation water

- Boro cultivation should be reduced. Wheat cultivation can be encouraged. Boro needs 1.2 to 1.4 m, and wheat needs about 0.35 m of water column.
- Rain water harvesting and artificial recharge may be considered which will eliminate the problem of both declining water level and arsenic contamination.
- Cultivation of low water requiring crops and change in cropping pattern suitable for the area.
- To improve the ground water scenario in shallow aquifer, implementation of modern irrigation practices like drip water irrigation system, sprinklers can be made.
- Change in cropping pattern is also needed.

Water column recommended in consultation with expert of Bidhan Chandra Krishi Vidyalaya Kalyani, for crops

District	Block	Major crops/vegetables/ fruits/flowers currently in practice	Water column depth(m)	Crops suggested for better management(considering ground water quality & quantity)	Water column depth (m) recommended	Remarks e.g. Irrigation techniques etc
Barddhaman	Ketugram I	Rice, potato, mustard, gram	Rice (1.2-1.4), mustard (0.2-0.25), potato (0.2-0.25), gram (0.10-0.12)	Rice, mustard, potato, gram	Rice (0.75-0.85), mustard (0.2), potato (0.2), gram (0.08-0.12)	Alternate dry and wet method for rice, for others based on crop physiology

Scope for Rain Water Harvesting and Artificial Recharge in Study Area:

Using method of Dhruvanarayana, 1993, in Ketugram I block, the number and types of artificial recharge and conservation structures proposed to be constructed for harvesting rain water and the estimated cost involved for doing this, have been shown in Table 9.2.6.6a & Table 9.2.6.6 b. 20.84 MCM of rain water has been calculated to be harvested. This water can be utilized in 35:35:20:10 ratio for construction of Irrigation Cum Recharge Pond, Re-excavation of Existing Tank, Injection Well and Farm Pond. Also, by use of harvested water part of remaining cultivable land of 3912.78 Ha may be irrigated. By doing this, ground water scenario can be improved as well as the inclusive economic growth can be achieved. For construction of the above structures, an estimated Rupees 984 lakh is required.

Table 9.5.6.6.a: Budgeting rain fall run off availability in Ketugram I block

Normal monsoon rainfall in m	Area(Ha) 'A'	Annual total volume of rain fall in Ham=(Rn X A)	Run off co-efficient from Dhruvanarayana,1993 (Land slope, type of land and soil type) 'C' land slope 0-5%	Major type of soil available in that block	Total volume of surface runoff available Annually 'Vt' (RnXAXC) Ham	75% of 'Vt' = V Ham	50% of V (Non committed) = Vnc Ham	60% of Vnc considered for harvesting = Vf Ham
1.029	20000	20580	0.45	50 % silty clay & 50% silty loam	9261	6945.75	3472.88	2083.725

Table 9.5.6.6.b: Proposed Artificial Recharge Structures in Ketugram I block (Details of structures given in Section II):

Block	Net run off water availability for recharge in MCM (1)	Source Water Allocation (MCM)				Number of Structures				Structure-wise Cost Estimate (lakh Rs.)				Total Cost Estimate (lakh Rs.)
		Irrigation cum recharge Tank – 35% of Col. 1 (2)	Re-excavation of existing tanks with RS -35% of Col. 1 (3)	Injection Well for recharging deeper layer-20 % of Col. 1 (4)	Farm Pond - 10% of Col. 1 (5)	Irrigation cum recharge Tank	Re-excavation of existing tanks with RS	Injection Well for recharging deeper layer	Farm Pond	Irrigation cum recharge Tank	Re-excavation of existing tanks with RS	Injection Well for recharging deeper layer	Farm Pond	
Ketugram I	20.84	7.29	7.29	4.17	2.084	15	73	14	21	120	584	112	168	984

Table 9.5.6.7 a: Cropping pattern of major crops (area in Ha, production in '000 M. Tons)

Aus (Area)	Aus (Production)	Aman (Area)	Aman (Production)	Boro (Area)	Boro (Production)	Jute (Area)	Jute (Production)	Wheat (Area)	Wheat (Production)
333	0.865	9166	10.733	9382	32.518	1080	13.705	55	0.15

Table 9.5.6.7 b: Cropping pattern of major crops (area in Ha, production in '000 M.Tons)

Potato (Area)	Potato (Production)	Masur (Area)	Musur (Production)	Mustard (Area)	Mustard (Production)	Til (Area)	Til (Production)	Gram (Area)	Gram (Production)
165	1.731	199	0.06	-	-	26	0.02	-	-

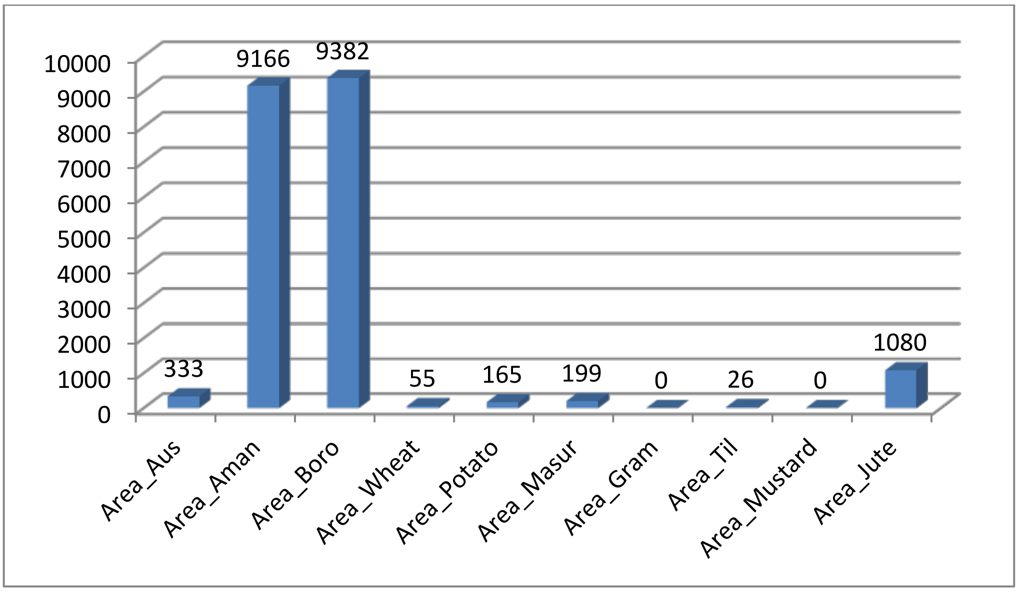


Fig. 9.5.6.7 c: Graphical representation of cropping pattern (area in Ha)

Attempt has also been made to modify cropping pattern as per the management strategy mentioned under section **Management Strategy of irrigation water & modification in cropping pattern.** In Table 9.5.7, it has been shown that by using this strategy production of cereals, pulses, oil seeds, etc. would be manifold. At the same time, due to restriction of Boro cultivation by 10% less than the present area of cultivation, a huge amount of vital ground water resources could be saved.

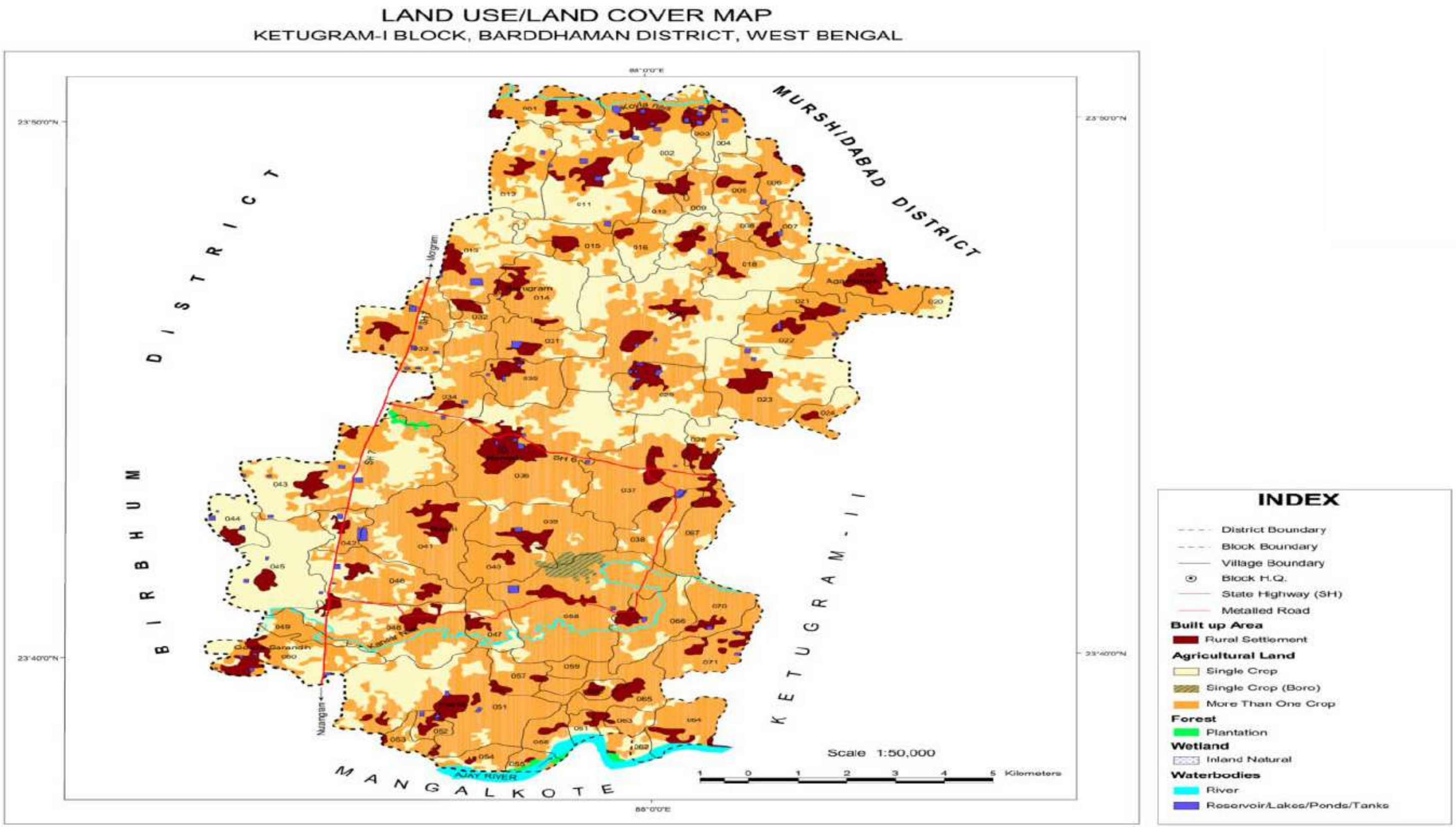


Plate 9.5.6: Land use/ land cover in Ketugram I block

(Source: Land and land Reforms Dept., Govt. of West Bengal)

Table 9.5.7: Proposed modification of cropping pattern in Ketugram I block

Area of Boro cultivation (Ha)	**Average Water column required (m) for Col. I**	**G W draft due to boro cultivation (MCM) for Col. I**	**Proposed 10 % reduction of area of boro cultivation (Ha)**	**Amount of ground water saved (MCM) as in Col. I**	**Loss (M. Ton) of Boro paddy due to reduction in area of cultivation @ yield rate of 3264.40 kg/ Ha**	**Proposed cropping in 1:1:1 ratio in lost area of Boro cultivation as proposed in Col IV**	**Gain (M. Ton each) due to alternate cropping @ existing yield rate Til @ 908.89 kg/hec, Ground nut @ 1770.45 kg/Ha & Mung @ 1182.23 kg/Ha**	**Ground water draft (MCM) for cultivation of Til, Ground nut & Mung @ 0.15 m per Ha**	**Gain due to increase in area of Aus cultivation in Kharif (at least 10 % of existing area of Boro cultivation, i.e. 938.2 Ha.) at yield rate 3361.24 kg/ Ha (M. Ton)**	**Ground water saved (MCM)**
(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)	(IX)	(X)	(XI)
9382	1.3	121.96	938.2	12.20	3062.66	Til, Ground nut & Mung 312.73 Ha each.	Til- 82.68 , Ground nut - 553.67 & Mung - 589.51	1.41	3153.52	10.79

12.2 KETUGRAM II

Salient Information

Block Name: KETUGRAM II

Area assigned (in km^2):142

District: Bardhaman

State:West Bengal

Population (as on 2011):

Rural	Urban	Total
118567	---	118567

Approximate Decadal Growth Rate from 2001-2011: 10.80%

Rainfall:

Average annual rainfall (as in the district)

for the period 2012 -16 (in mm):1380.28

Block	Normal	Actual (Annual)				
		2012	2013	2014	2015	2016
Ketugram II	1315.2	1276.6	1535.5	1134.4	1546.5	1408.4

Agriculture &Irrigation (area in sq. Km):

SI. No	Name of the Block	Area	Cultivable Area	Area under pasture & orchard	Cultivable Waste Land	Forest Land
1.	Ketugram II	142	125.42	0.06	3.85	-

Aquifer Wise Ground Water Resource Availability & Extraction: (in MCM)

Resource Availability	Aquifer I	Aquifer II	Extraction (for Aquifer I)
Dynamic Resource	60.3103	-	27.9406
Static Resource	3151.27		-

12.2.1 Disposition of Aquifer:

Block	Depth range of Aquifer in m bgl		
Ketugram II	'0' Aquifer	1st Aquifer	2nd aquifer
	12.19-15.24	8-70	-

Aquifer '0' occurs under unconfined condition; Aquifer I occurs under semi-confined to confined condition.

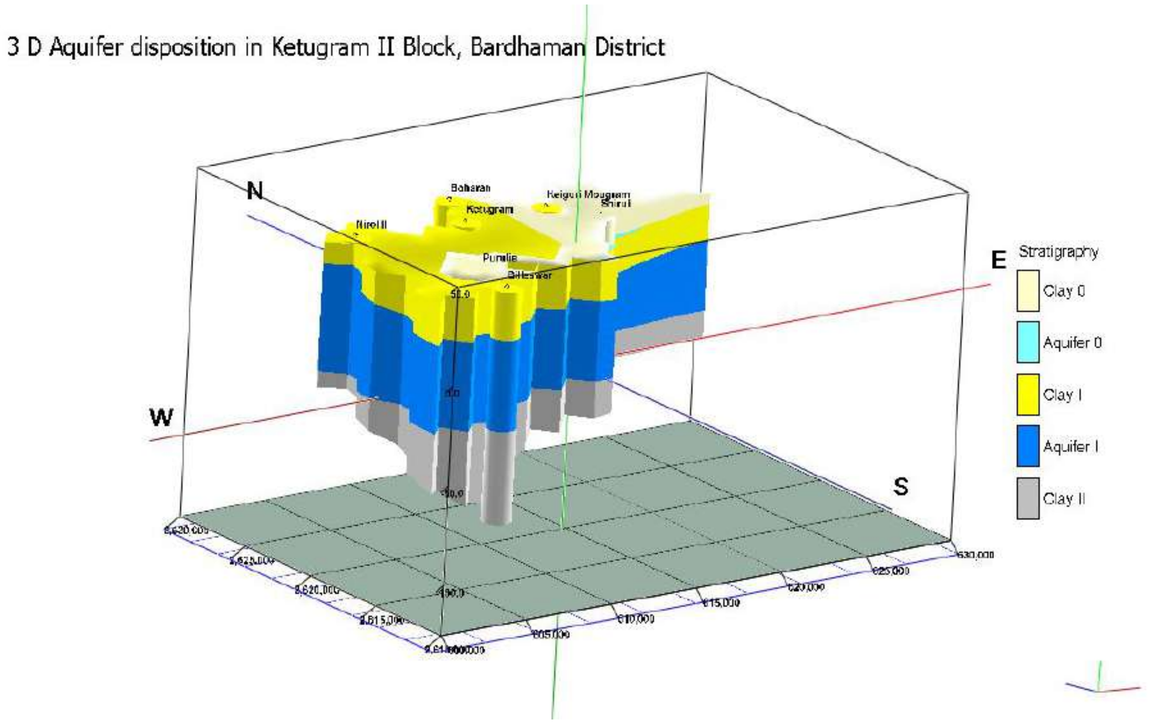


Plate 9.6.1: Aquifer disposition (3D) in Ketugram II block, Barddhaman district

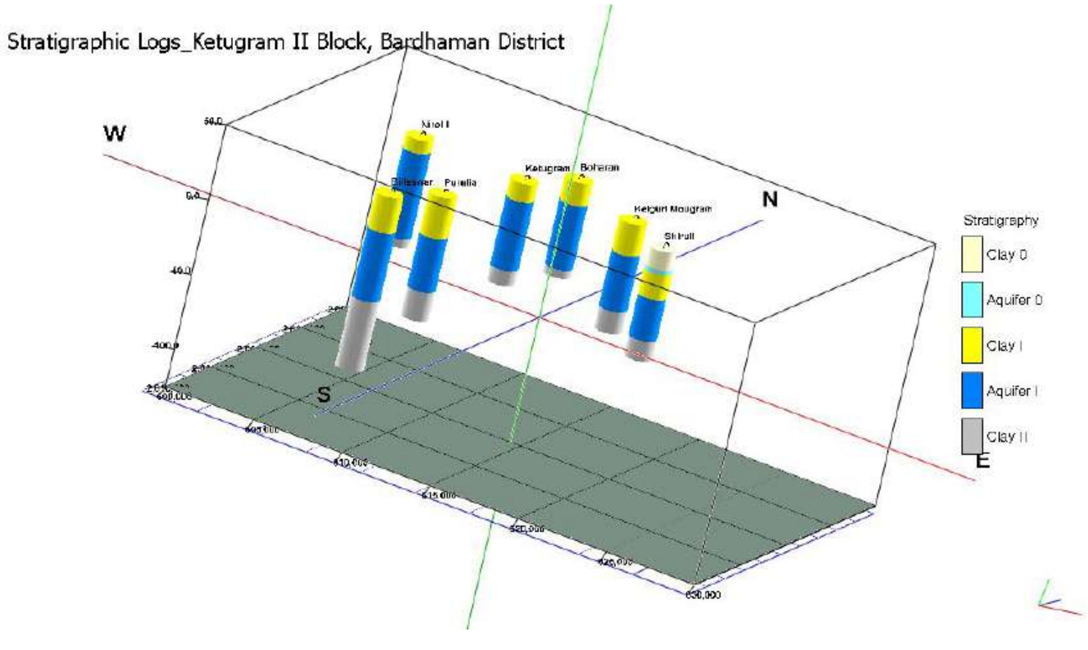


Plate 9.6.2: Stratigraphic Logs in Ketugram II block, Barddhaman district

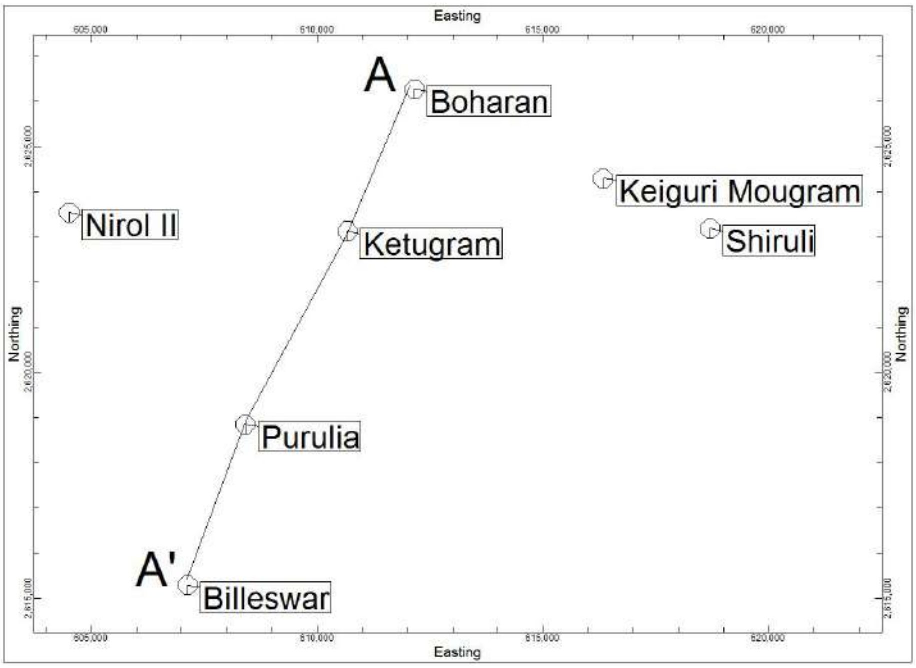


Plate 9.6.3: NNE-SSW Section line in Ketugram II block, Bardhaman district

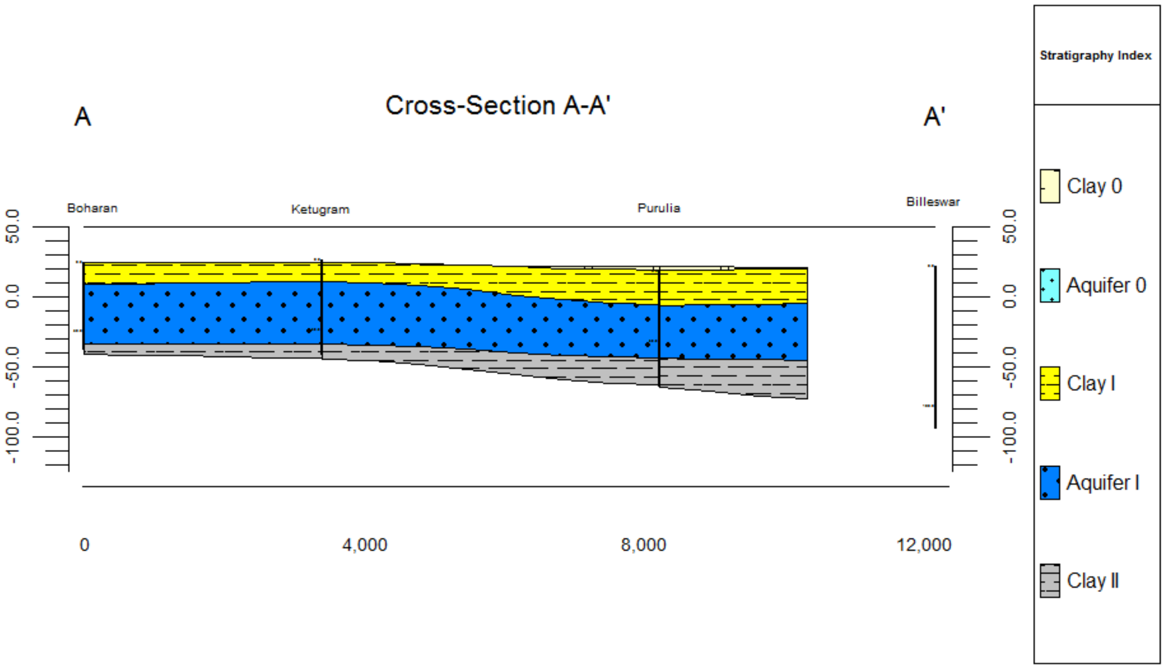


Plate 9.6.4: NNE-SSW Section in Ketugram II block, Bardhaman district

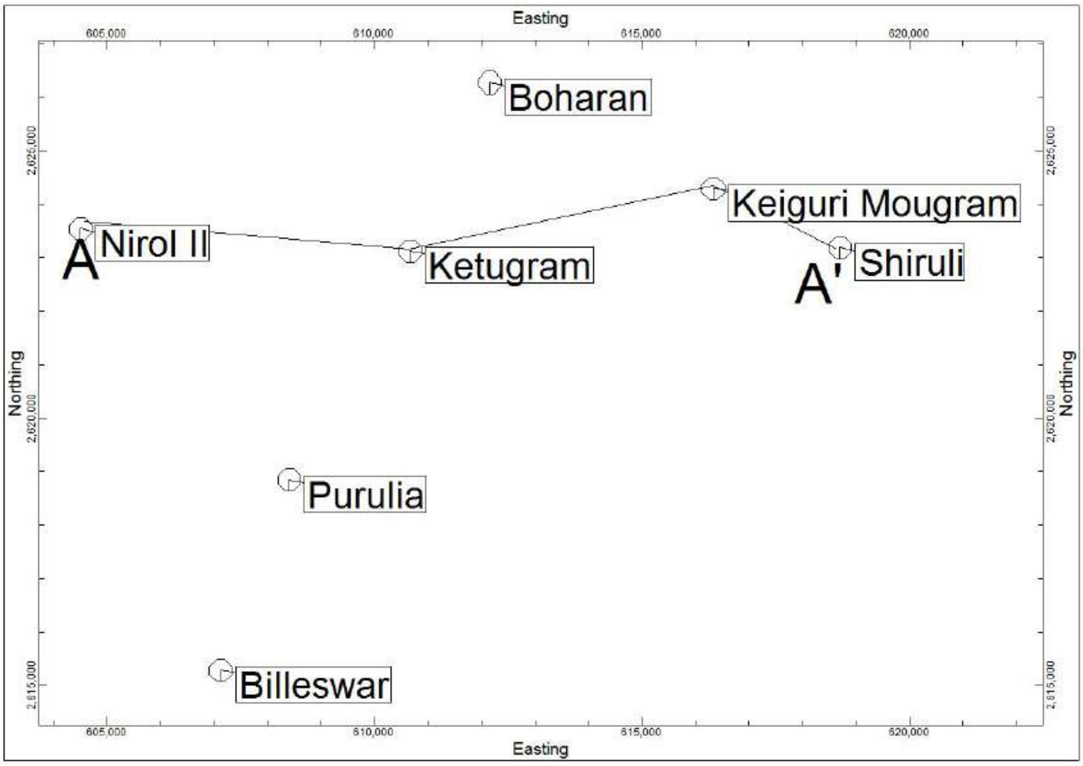


Plate 9.6.5:: W-E Section line in Ketugram II block, Bardhaman district

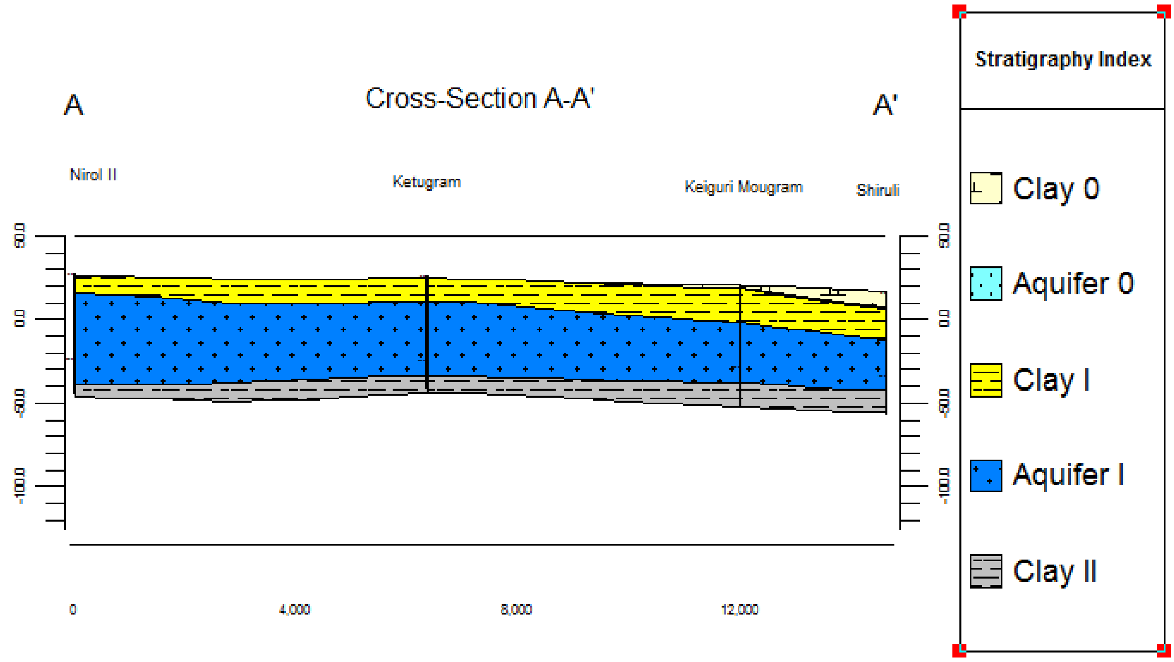


Plate 9.6.6: W-E Section in Ketugram II block, Bardhaman district

Aquifer Wise Water Level Ranges &Pre-monsoon and Post-monsoon water level trends (2006 to 2016)

SI. No.	Block	Aquifer	Pre-monsoon Trend			Post-monsoon Trend		
			Water Level Range(mbg	Rise (cm/year)	Fall (cm/year)	Water Level Range(mbgl)	Rise (cm/year)	Fall (cm/year)
1.	Ketugram II	'0'	7.14-11.65	-	-	6.89-9.59	-	-
1.	Ketugram II	I	14.98-		Fall 52	14.58-18.49		Fall 16.5

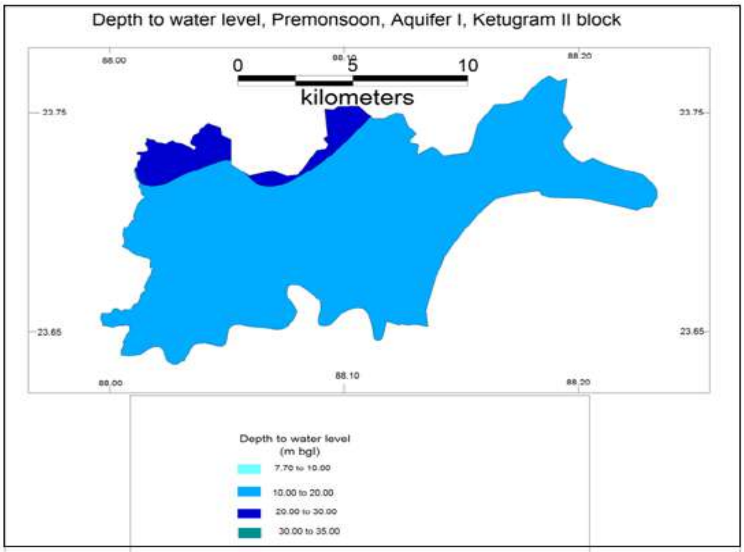


Fig. Depth to water level, Aquifer I, Pre monsoon

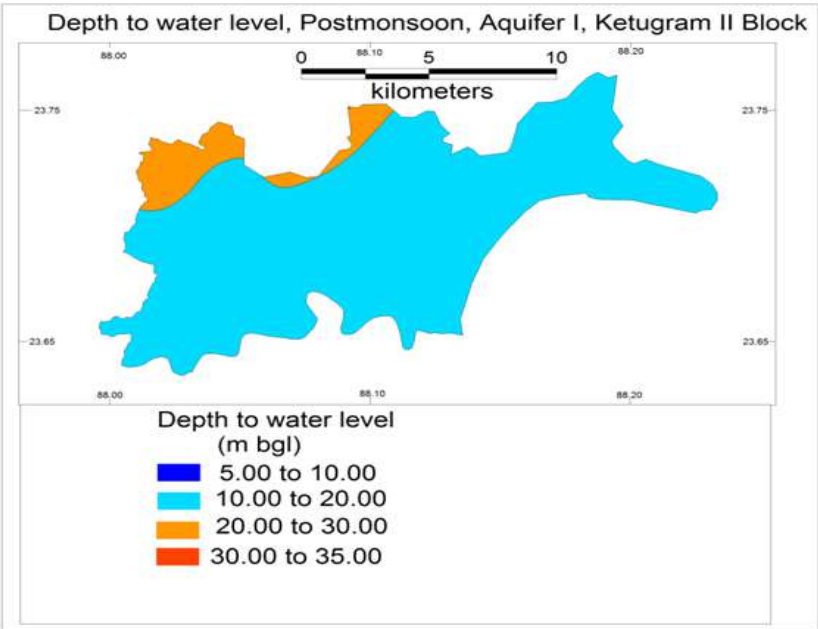


Fig. Depth to water level, Aquifer I, Post monsoon

Thickness of aquifer (average): 41.72 m (Aquifer I)

Aquifer-wise Statement

Name of Block	Aquifer I			Aquifer '0'		
	Depth Range (m bgl)	Discharge (m^3/hr)	T (m^2/day)	Depth range	Maximum Discharge (m^3/hr)	T (m^2/day)
Ketugram-II	8-70	34.2 - 128.30	31 – 1700,	12.19-15.24	50	-

12.2.2 Aquifer Wise Resource Availability & Extraction:

Dynamic ground water resources as on 31st March'13

Block	Net ground water availability (MCM)	Gross ground water draft (MCM)	Stage of development (%)	Category	Provision for domestic and industrial requirement supply up to next 25 years (MCM)
Ketugram II	60.3103	27.9406	46.82	Semi-critical	6.7011

12.2.3 Chemical Quality of Ground Water & Contamination:

As -data based on 6 set samples by local investigation by PHED & other parameters based on limited samples of 16-17. Average As in ground water has been found at some places and it has been encountered up to a maximum of 0.212 mg/l at Mougram (Natungram).

Table 9.6.1 Range of Chemical Pollutants:

Block	As(mg/l)	TH (mg/l)	EC (µS/cm)	F(mg/l)	NO_3(mg/l)
Ketugram II	**0.023 to 0.212**	**105**	**378-438**	**0.93-1.48**	**bdl**

Table 9.6.2 Percentage of tube wells having arsenic content in the block based on SOES data:

SI. No.	Blocks	Arsenic (<0.01 ing/1)	Arsenic (>0.01- <0.05 mg/1)	Arsenic (> 0.05 mg/1)	Total Tube well (max. concentration based on samples with As> 1 mg/l)
1	Ketugram II	NA	3	-	134 (0.022)

Arsenic affected Risk Population:

There is no record of risk population in this block. However, it has been noted that in a no. of hand pump arsenic in ground water is found to be present above permissible limit.

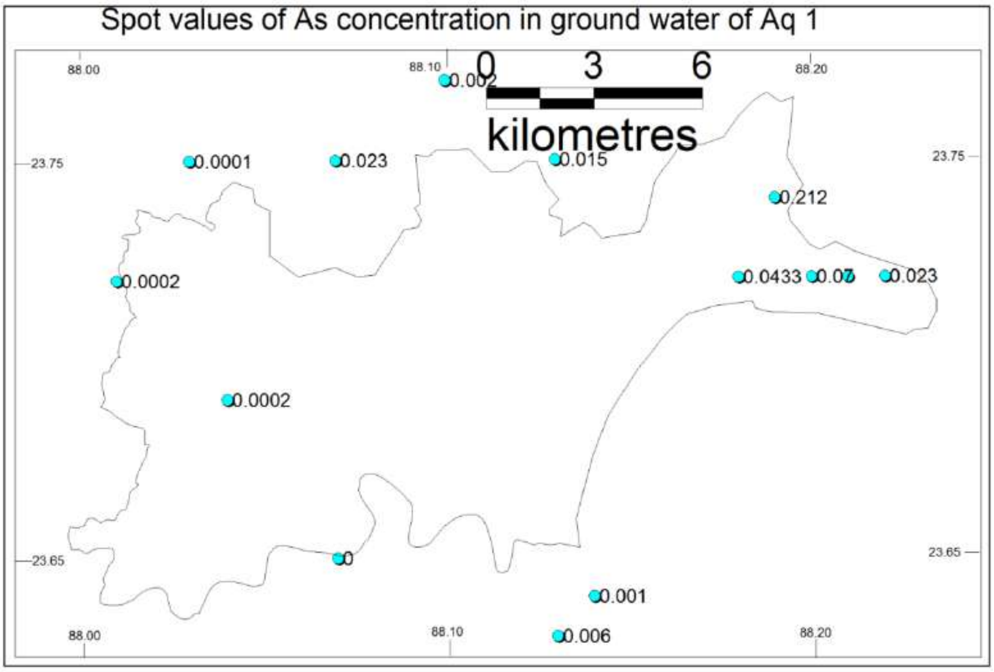


Fig. Arsenic in ground water in Aquifer I

12.2.4Ground Water Resource Enhancement & Management Plan:

Ground Water Management Plan for drinking purposes.

Table 9.6.5.1: Status of existing water supply schemes

Block	Nos. of ongoing PWSS scheme	Population covered	Nos. of new PWSS scheme	Population covered
Ketugram I Ketugram II blocks (together)	5	100457	2	12607

(Source – PHED, Govt. of West Bengal)

Proposed interventions:

Aquifer I is encountered within 8-70 m. This aquifer is found to be suitable for drinking purpose.

Apart from this, there is another aquifer up to a depth of about 40 m bgl i.e. Aquifer '0', in which sporadic arsenic contamination of ground water has been reported; this aquifer is encountered as outlier over Aquifer I in the extreme eastern extremity of the block. This aquifer can be used for irrigation purpose only. Regular determination of As in ground water is to be done if it is used for drinking purpose.

To provide drinking water, exploration-based drilling down to about 600 m bgl will provide information about both potential zones and presence of arsenic, if any, in ground water in the area. In future, tube wells tapping the fresh deeper aquifer with proper cement sealing against clay bed (if arsenic is reported in future) occurring above has been proved to supply arsenic free fresh ground water to villages.

Ground Water Management Plan for Irrigation

Name of Block	Cultivable area in ha	Net irrigated area (Ha)	Area to be irrigated (Ha)	SOD in %	Pre monsoon WL Trend 2016 in cm/yr	Post monsoon WL Trend 2016 in cm/yr	Average Pre monsoon WL in m bgl	Average Post monsoon WL in m bgl
Ketugram II (mainly done by ground water in Aquifer I)	12542	5696.23	6845.77	46.82	**Fall 52**	Fall 16.5	13.85	13.33

9.6.5.2: Irrigation Scenario in Ketugram II block

Data of 4th M.I. Census shows:

Total CCA (Ha)	Dug well		Shallow Tube well		Deep Tube well		Surface Flow		Surface Lift		CCA (Ha)	
	Nos.	CCA (Ha)	Nos.	CCA (Ha)	Nos.	CCA (Ha)	Nos.	CCA (Ha)	Nos.	CCA (Ha)	Ground water	Surface water
5696.23	15	86.73	800	3212.89	29	1110.60	1	2.69	112	1283.32	1286.01	4410.22

Table – 9.6.6.3: CCA and sources of irrigation in Ketugram II

(Source -Dept. of M.I., Govt. of West Bengal)

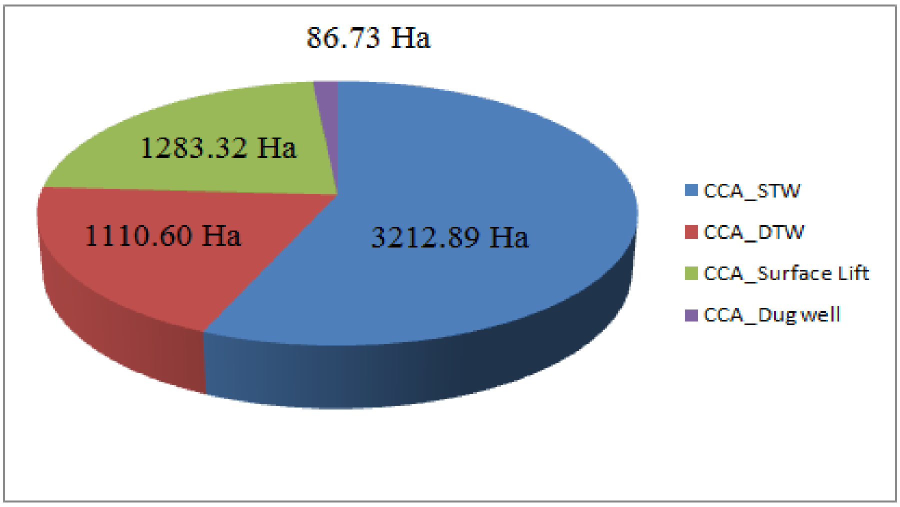


Fig. 9.6.6.1: Per Cent contribution of different sources in irrigation

Table 9.6.6.3 and Fig. 9.6.6.1 indicate that almost 56.4% and 19.5 % of the cultivable area is irrigated by shallow tube wells and deep tube wells respectively. These sources are mostly used for rabi crops, boro paddy, etc. Dug well contributes 1.52 %.Surface flow is contributing a very meagre amount in irrigation.

Data indicate that in post –monsoon water level long term trends of this block show falling at a rate of 7.1 cm/ year. Depth to water level is also deep in nature. To improve this ground water scenario, rain water harvesting and artificial recharge may be implemented which might restrict the declining trend.

Space Available For Recharge and Proposed Interventions:

Area suitable for recharge in the study area:

District	Block Name	Area (in sq. km)	Total Area suitable for recharge (sq. km.)
Bardhaman	Ketugram II	142	142

Proposed Interventions:

Ground Water Resource Estimation shows that 6845.77 Ha of cultivable area is still not being covered by any irrigation schemes; it also indicates that ground water resource available for future irrigation is 3151.27 Ham. Considering Unit Draft of STW 0.022 MCM & Command Area of STW 6 Ha (0.06 sq. km), additional 8592 Ha area can be made irrigable (vide Table 9.6.6.5).

Table – 9.6.6.5: Additional Irrigation Potential created by Available Ground Water Resource

Net Ground Water Resource (MCM)	SOD (%)	Ground Water Resource available (MCM)	Available area to be irrigated (Ha)	Additional Nos. of STWs feasible	Additional Irrigation Potential Created (Ha)
60.3103	27.94	31.5127	6845.77	1432	8592

District	Block	Major crops/vegetables/ fruits/flowers currently in practice	Water column depth(m)	Crops suggested for better management(considering ground water quality & quantity)	Water column depth(m) recommended	Remarks e.g. Irrigation techniques etc
Barddhaman	Ketugram II	Rice, potato, mustard, gram	Rice (1.2-1.4), mustard (0.2-0.25), potato (0.2-0.25), gram (0.10-0.12)	Rice, mustard, potato, gram	Rice (0.75-0.85), mustard (0.2), potato (0.2), gram (0.08-0.12)	Alternate dry and wet method for rice, for others based on crop physiology

Therefore, the whole area can be covered by the additional ground water resource available for irrigation, which has been estimated by the competent authority. However, if required, in near future during exigency rain water can be harvested.

Management for Irrigation water

- Aquifer ‘0’ is suggested for irrigation purpose.
- Boro cultivation should be reduced. Wheat cultivation can be encouraged. Boro needs 1.2 to 1.4 m, and wheat needs about 0.35 m of water column.
- Rain water harvesting and artificial recharge may be considered which will eliminate the problem of both declining water level and arsenic contamination.

- Cultivation of low water requiring crops and change in cropping pattern suitable for the area.
- To improve the ground water scenario in shallow aquifer, implementation of modern irrigation practices like drip water irrigation system, sprinklers can be made.
- Change in cropping pattern is also needed.

Water column recommended in consultation with expert of Bidhan Chandra Krishi Vidyalaya Kalyani, for crops

Scope for Rain Water Harvesting and Artificial Recharge in Study Area:

Using method of Dhruvanarayana, 1993, in Ketugram II block, the number and types of artificial recharge and conservation structures proposed to be constructed for harvesting rain water and the estimated cost involved for doing this, have been shown in Table 9.6.6.6a & Table 9.6.6.6 b. 17.26 MCM of rain water has been calculated to be harvested. This harvested water can be utilized in 45:45:10 ratio for construction of Irrigation Cum Recharge Pond, Re-excavation of Existing Tank and Farm Pond; For this, an estimated Rupees 922 lakh is required. By doing this ground water scenario can be improved as well as the inclusive economic growth can be achieved. By harvested water, irrigation can be done, if needed.

An attempt has also be been made to modify cropping pattern as per the management strategy mentioned under section **Management Strategy of irrigation water & modification in cropping pattern.** In Table 9.6.7, it has been shown that by using this strategy production of cereals, pulses, oil seeds, etc. would be manifold. At the same time, due to restriction of Boro cultivation by 10% less than the present area of cultivation, a huge amount of vital ground water resources could be saved.

Table 9.6.6.6.a: Budgeting rain fall run off availability in Ketugram II block

Normal monsoon rainfall in m (50 yrs data from data.gov.in) 'Rn'	Area(Ha) 'A'	Annual total volume of rain fall in Ham=(Rn X A)	Run off co-efficient from Dhruvanarayana,1993 (Land slope, type of land and soil type) 'C' land slope 0-5%	Major type of soil available in that block	Total volume of surface runoff available Annually 'Vt' (RnXAXC) Ham	75% of 'Vt' = V Ham	50% of V (Non committed) = Vnc Ham	60% of Vnc considered for harvesting = Vf Ham
1.029	14200	14611.8	0.525	75 % silty clay & 25 % silty loam	7671.195	5753.396	2876.7	1726.018875

Table 9.6.6.6.b: Proposal for artificial recharge and conservation structure (Details of structures given in Section II):

Block	Net run off water availability for recharge in MCM (1)	Source Water Allocation (MCM)				Number of Structures				Structure-wise Cost Estimate (lakh Rs.)				Total Cost Estimate (lakh Rs.)
		Irrigation cum recharge Tank – 45 % of Col. 1 (2)	Re-excavation of existing tanks - 45 % of Col. 1 (3)	Injection Well for recharging deeper layer- 0 % of Col. 1 (4)	Farm Pond - 10% of Col. 1 (5)	Irrigation cum recharge Tank	Re-excavation of existing tanks with RS	Injection Well for recharging deeper layer	Farm Pond	Irrigation cum recharge Tank	Re-excavation of existing tanks with RS	Injection Well for recharging deeper layer	Farm Pond	
Ketugram II	17.26	7.77	7.77	0	1.73	16	78	0	17	128	624	0	170	922

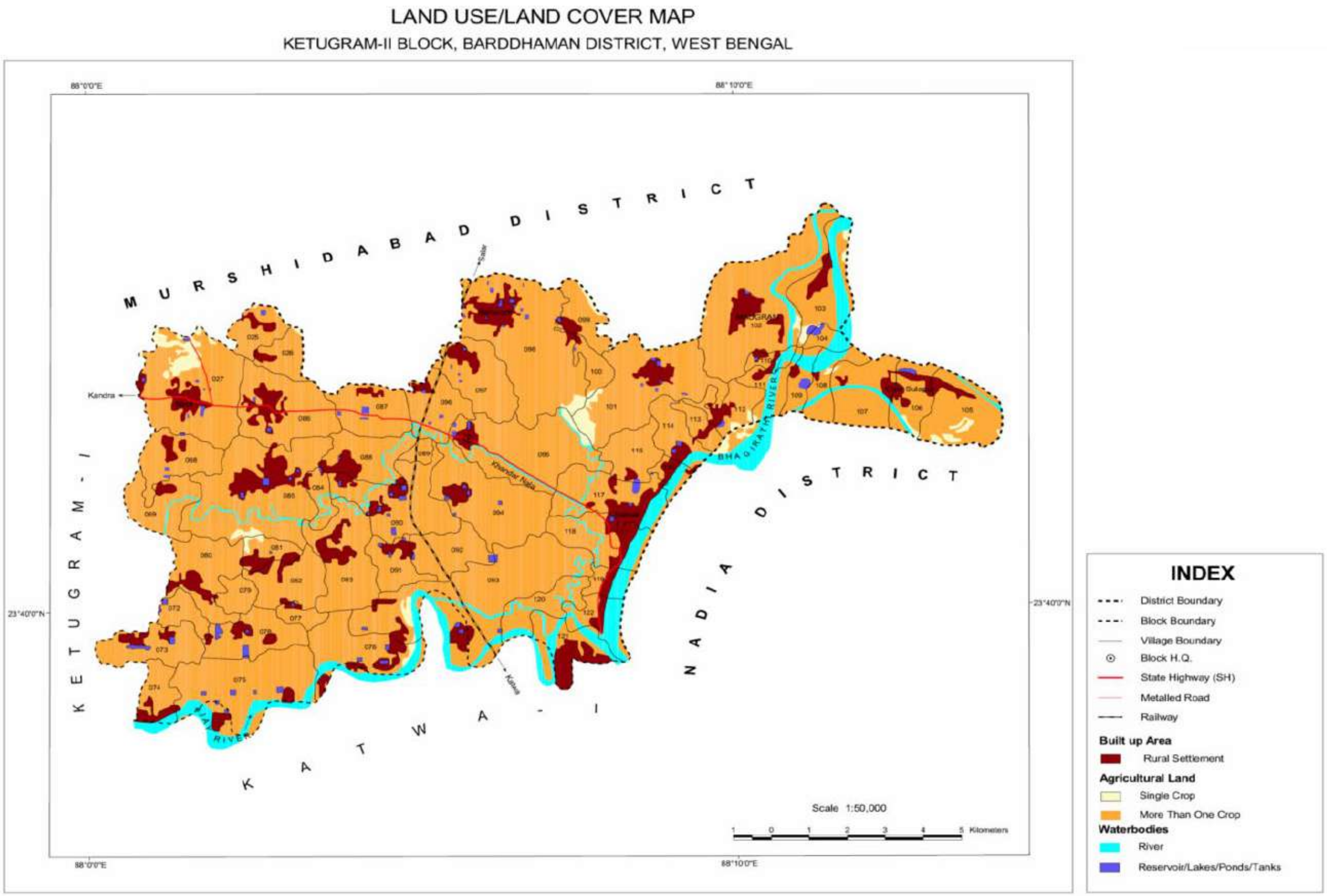


Plate 9.6.6: Land use/ land cover in Ketugram II block Source: Land Use & Land Reforms Dept., Govt. W. B.)

Table 9.6.6.7 a: Cropping pattern of major crops (area in Ha, production in '000 M. Tons)

Aus (Area)	Aus (Production)	Aman (Area)	Aman (Production)	Boro (Area)	Boro (Production)	Jute (Area)	Jute (Production)	Wheat (Area)	Wheat (Production)
-	-	16053	41.08	7637	23.642	-	-	35	0.092

Table 9.6.6.7 b: Cropping pattern of major crops (area in Ha, production in '000 M. Tons)

Potato (Area)	Potato (Production)	Masur (Area)	Musur (Production)	Mustard (Area)	Mustard (Production)	Til (Area)	Til (Production)	Gram (Area)	Gram (Production)
174	1.946	8	0.005	-	-	200	0.137	-	-

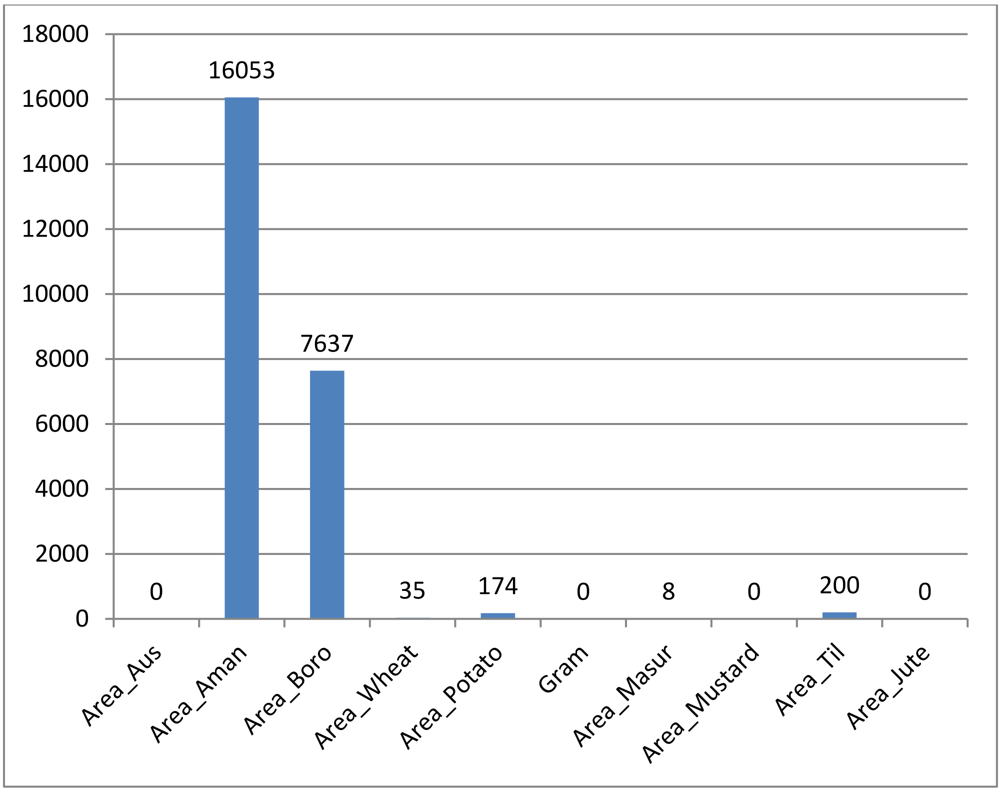


Table 9.6.6.7 c: Graphical representation of Cropping pattern of major crops (area in Ha)

Table 9.6.7: Proposed modification of cropping pattern in Ketugram II block, Barddhaman district

Area of Boro cultivation (Ha)	**Average Water column required (m) for Col. I**	**G W draft due to boro cultivation (MCM) for Col. I**	**Proposed 10 % reduction of area of boro cultivation (Ha)**	**Amount of ground water saved (MCM) as in Col. I**	**Loss (MCM) of Boro due to reduction in area of cultivation @ yield rate of 3264.40 kg/ Ha (in M. Ton)**	**Proposed cropping in 1:1:1 ratio in lost area of Boro cultivation as proposed in Col IV**	**Gain (M. Ton each) due to alternate cropping @ existing yield rate Til @ 908.89 kg/hec, Ground nut @ 1770.45 kg/Ha & Mung @ 1182.23 kg/Ha**	**Ground water draft (MCM) for cultivation of Til, Ground nut & Mung**	**Gain due to increase in area of Aus cultivation in Kharif (at least 10% of existing area of Boro cultivation, i.e. 763.7 Ha.) at yield rate 3361.24 kg/ Ha (M. Ton)**	Ground water saved (MCM)
(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)	(IX)	(X)	(XI)
7637	1.3	99.28	763.7	9.93	2493.022	Til, Ground nut & Mung254.57 Ha each.	Til- 231.38, Ground nut- 450.70 & Mung-300.96	1.15	2566.98	8.78

12.3 KATWA I

Salient Information

Block Name: Katwa-1

Area (in Km^2): 182.99

District: Bardhaman

State: West Bengal

Population (as on 2011):

Rural	Urban	Total
166614	6473	173089

Approximate Decadal Growth Rate from 2001-2011: 13.82%

Rainfall:

Average district annual rainfall for the period 2012 -16 (in mm): 1380.28

Block	Normal	Actual (Annual)				
		2012	2013	2014	2015	2016
Katwa I	1315.2	1276.6	1535.5	1134.4	1546.5	1408.4

Agriculture & Irrigation (area in sq. km.):

SI. No	Name of the Block	Geographic Area	Cultivable Area	Area under pasture & orchard	Cultivable Waste Land	Forest Land
1.	Katwa I	182.99	124	0.07	1.44	-

Aquifer Wise Ground Water Resource Availability & Extraction(in MCM):

Resource Availability	Aquifer I	Aquifer II*	Extraction (for Aquifer I)
Dynamic Resource	61.6064	0.1027	30.2022
Static Resource	2883.5564	-	-

***Ground water flow through Aquifer II towards SSW – 3127.32 m^3/day**

12.3.1 Disposition of Aquifer:

Block	Depth range of Aquifer in m bgl		
	Aquifer 0	Aquifer I	Aquifer II
Katwa I	6.5-12.5 (up to 40 m)	21-121	180-220

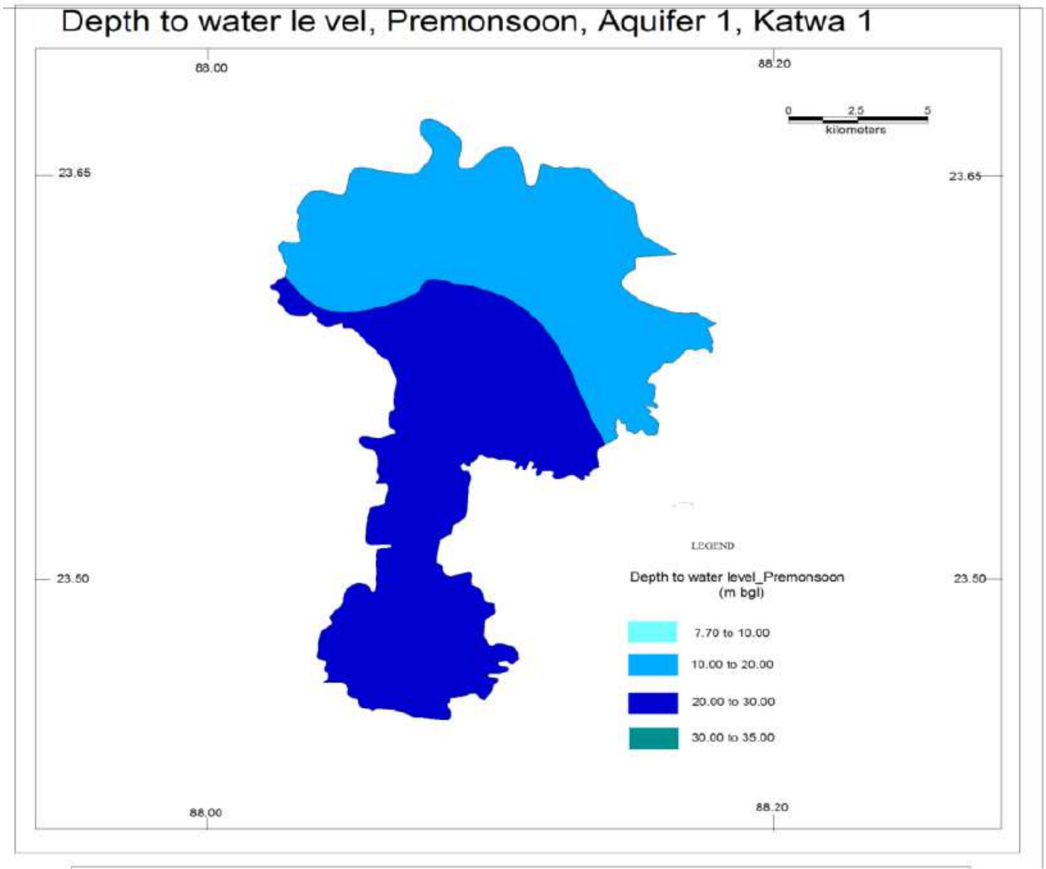
Aquifer '0' occurs under unconfined condition; Aquifer I occurs under unconfined to semi-confined condition; Aquifer II occurs under semi-confined to confined condition.

Aquifer Wise Water Level Ranges &Pre-monsoon and Post-monsoon water level trends (2006 to 2016):

SI. No.	Block	Aquifer	Pre-monsoon Trend			Post-monsoon Trend		
			Water Level Range (m bgl)	Rise (cm/year)	Fall (cm/year)	Water Level Range (m bgl)	Rise (cm/year)	Fall (cm/year)
1	Katwa I	‘0’	3.47	-	- Average Fall	5.11	-	Average Fall 10.7
2	Katwa I	I	17.65-25.09	-	Average Fall	10.34-25.68	-	Fall 57.9

Thickness of Aquifer(average): 61.29 (Aquifer I), 40.36 (Aquifer II)

Fig. Depth to water level, Aquifer I, Pre monsoon



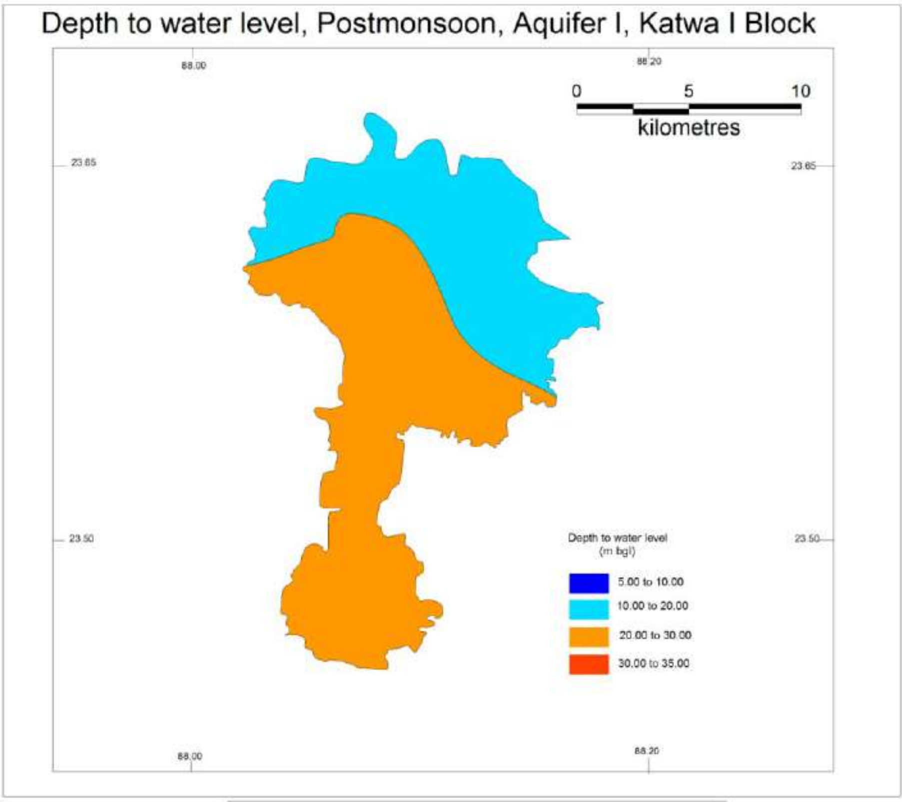


Fig. Depth to water level, Aquifer I, Post monsoon

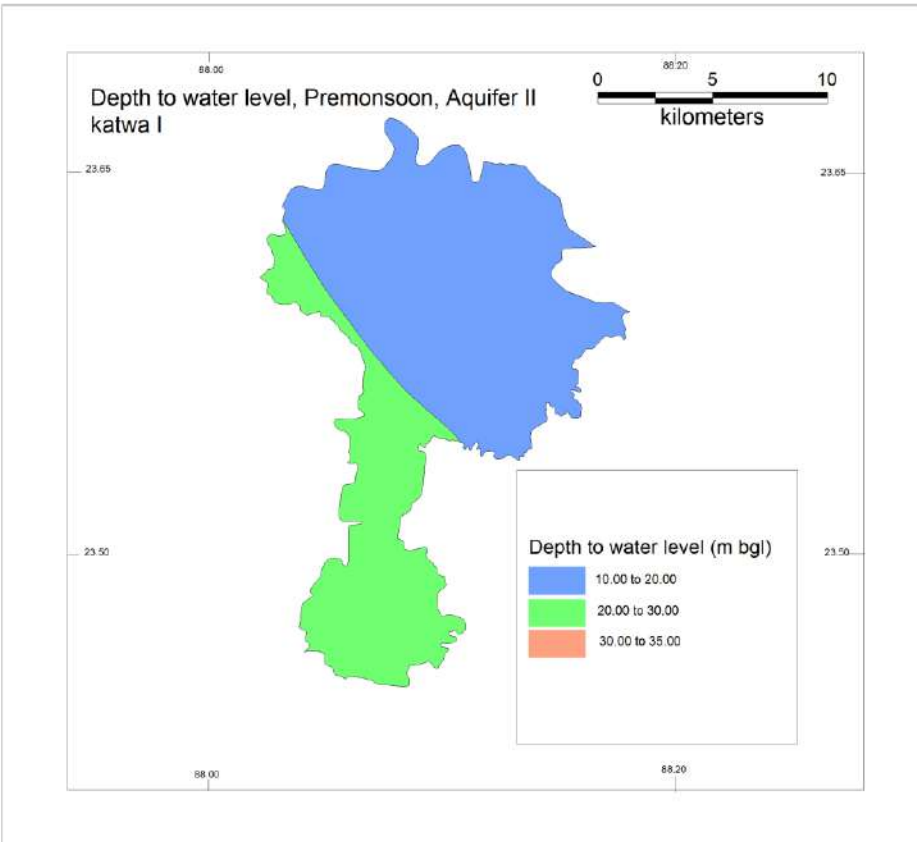


Fig. Depth to water level, Aquifer II, Pre monsoon

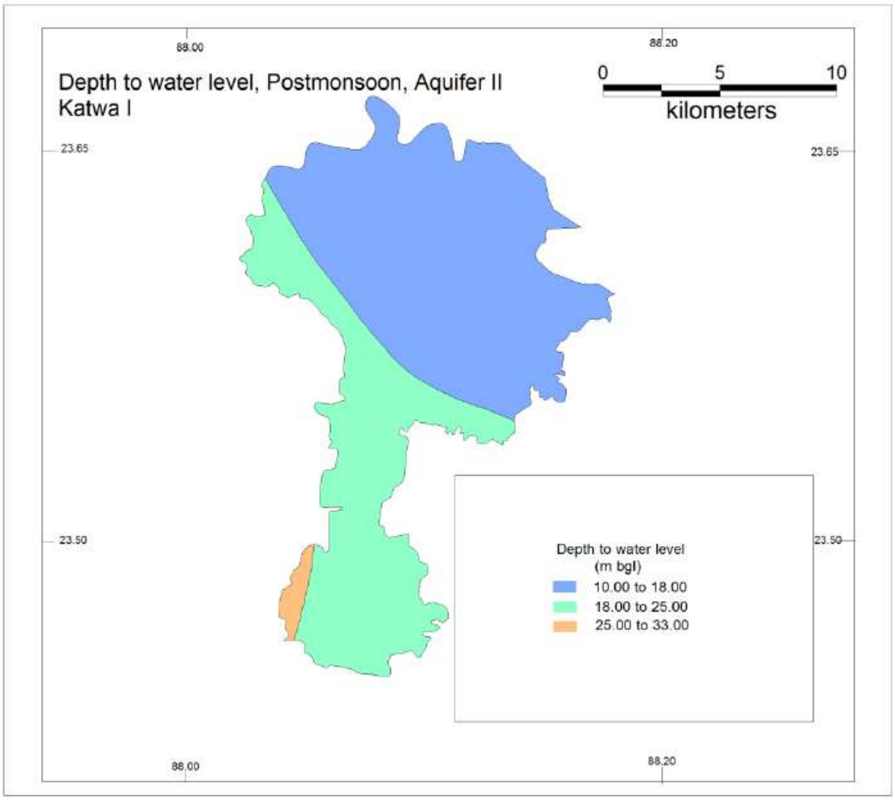


Fig. Depth to water level, Aquifer II, Post monsoon

Aquifer-wise Statement

Aquifer I			**Aquifer II**			**Aquifer '0'**		
Depth Range (mbgl)	**Discharge (m^3/hr)**	**T, m^2/day, (S)**	**Depth Range (mbgl)**	**Discharge (m^3/hr)**	**T, m^2/day, (S)**	**Depth Range (mbgl)**	**Discharge (m^3/hr)**	**T (m^2/day)**
21-121	14.4 – 122.40	11.4- 1254, ($7.09x10^{-4}$ - $3.1x10^{-5}$)	180-220	14.4 – 122.40	172-216; **($3.1x10^{-5}$ -** 7.09 $x10^{-4}$ **)**	6.5-12.5	50	-

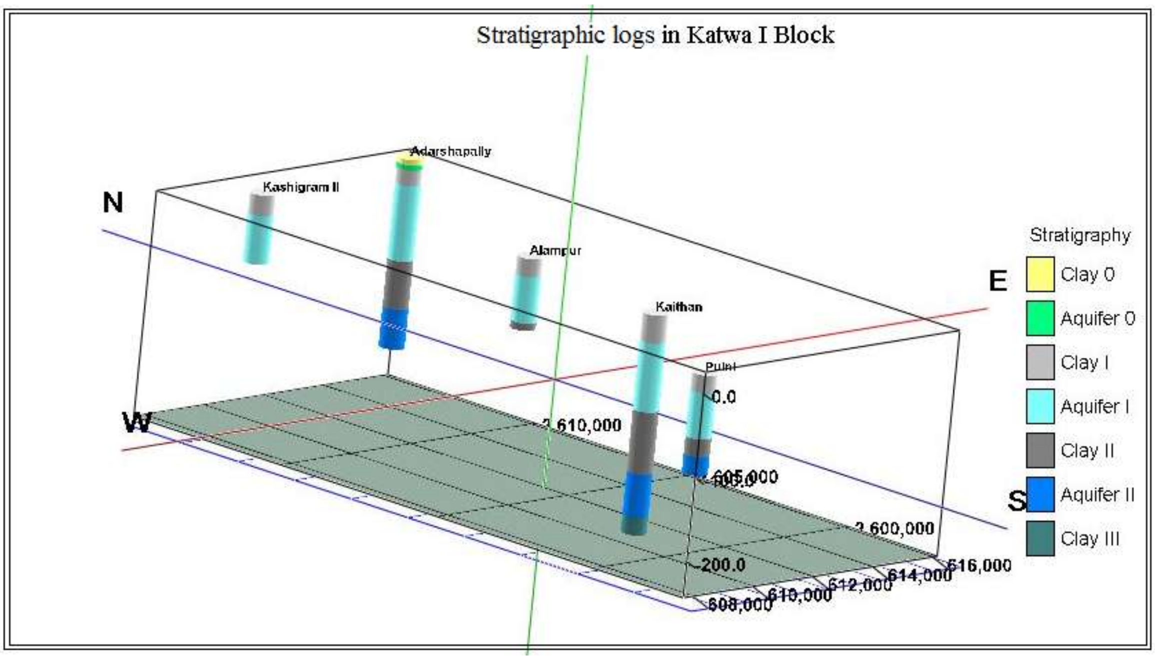


Plate 9.7.1: Stratigraphic logs in Katwa I, Bardhaman district

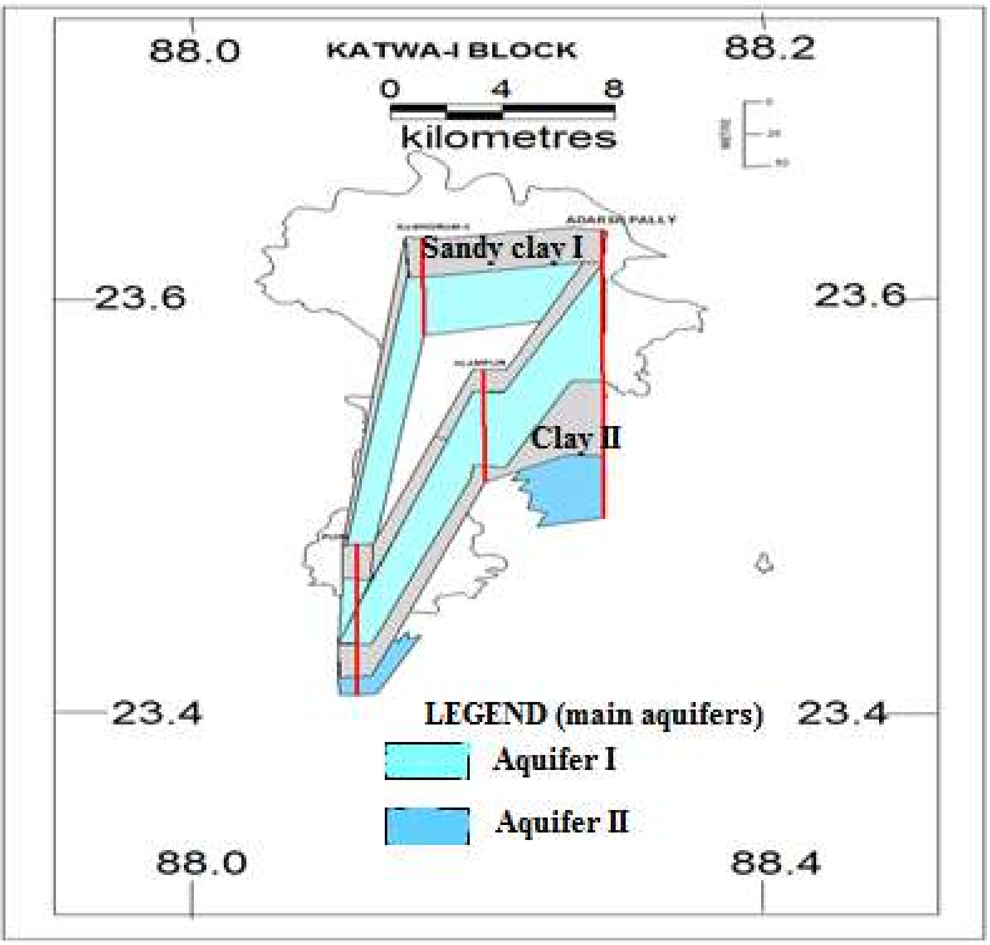


Plate 9.7.2: Aquifer disposition (3D) in Katwa I, Bardhaman district

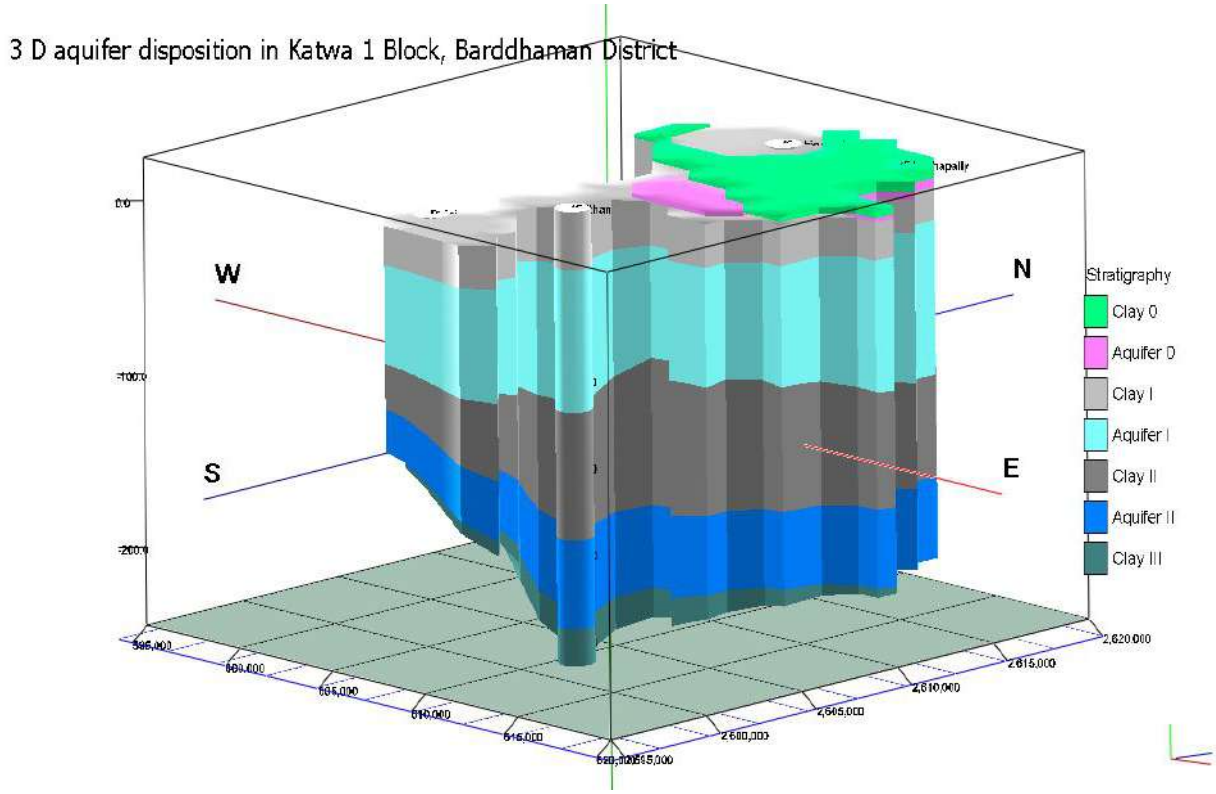


Plate 9.7.3: Aquifer disposition (3D) in Katwa I, Bardhaman district

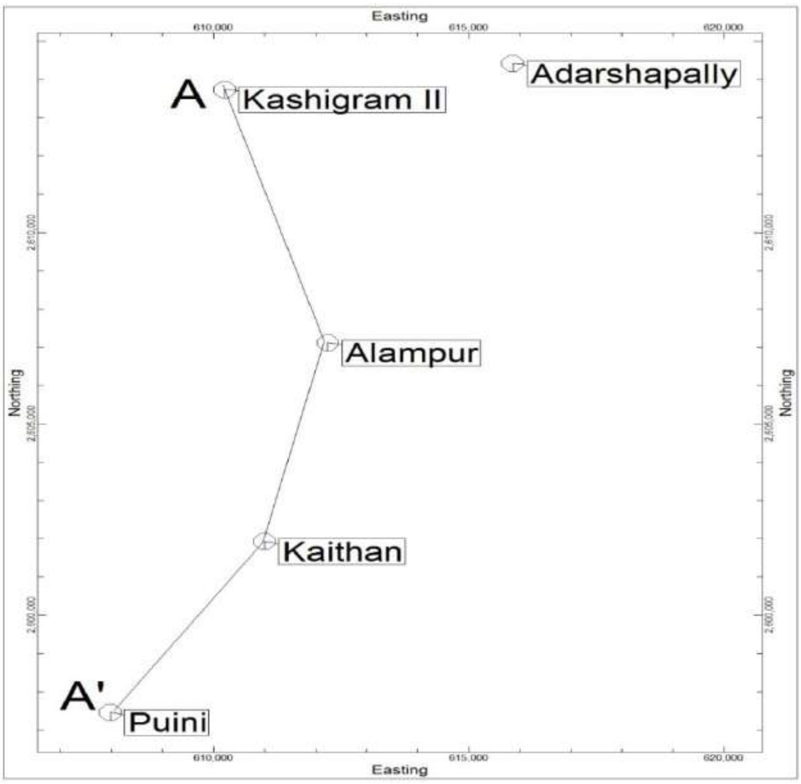


Plate 9.7.4: N-S Section Index Line in Katwa I, Bardhaman district

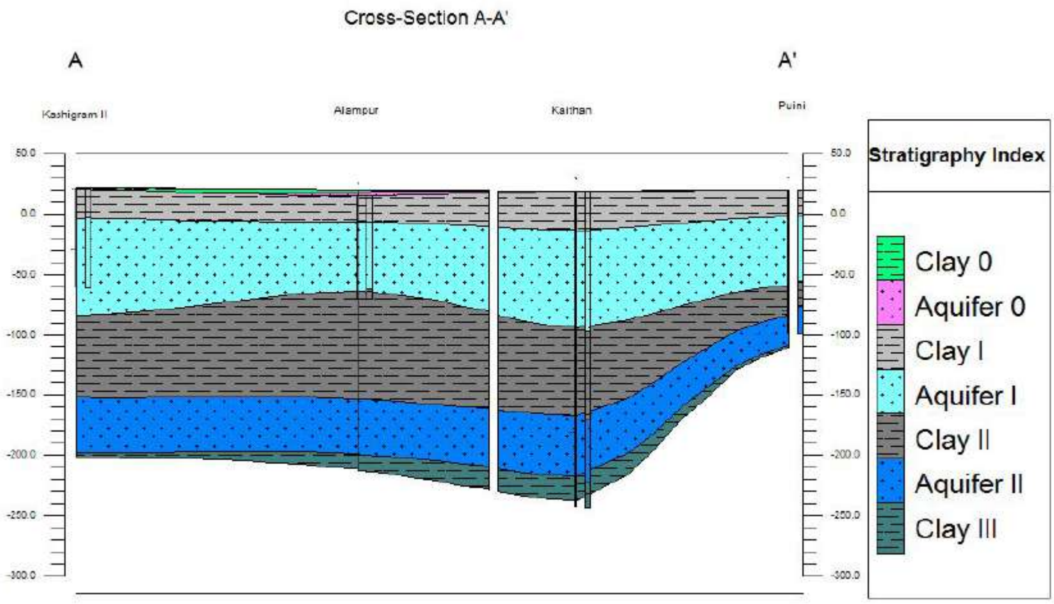


Plate 9.7.5: N-S Section in Katwa I, Bardhaman district

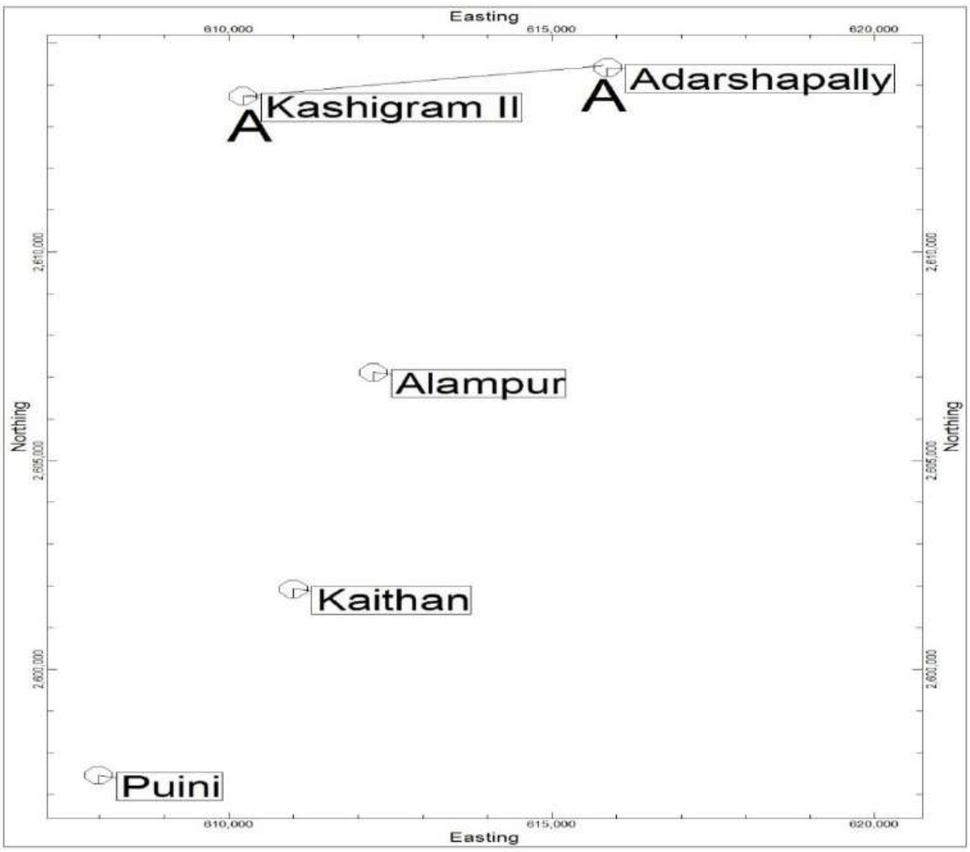


Plate 9.7.6: W-E Section Index Line in Katwa I, Bardhaman district

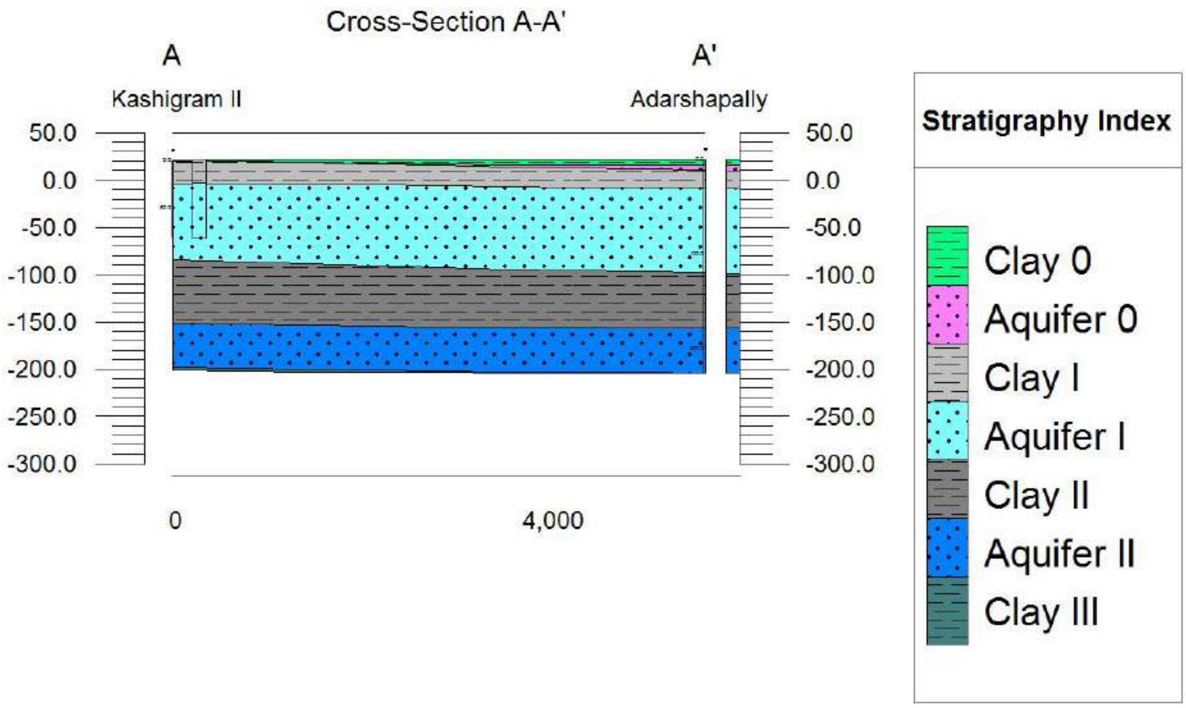


Plate 9.7.7: W-E Section in Katwa I, Bardhaman district

12.3.2 Ground Water Resource, Extraction, Contamination & other Issues:

Aquifer Wise Resource Availability & Extraction:

Dynamic ground water resources as on 31st March'11

Block	Net ground water availability (MCM)	Gross ground water draft (MCM)	Stage of development (%)	Category	Provision for domestic and industrial requirement supply up to next 25 years (MCM)
Katwa1	61.6064	30.2022	51.15	Semi-critical	3.2424

12.3.3 Chemical quality of Ground water & contamination:

Range of Chemical Pollutants:

Block	As (mg/l)	TH (mg/l)	EC (µS/cm)	F (mg/l)	NO_3 (mg/l)
Katwa1	0	95-120	388-523	1.13-1.44	bdl

Percent of tube wells based on data of SOES, Kolkata

SI. No.	Blocks	Arsenic (<0.01 ing/1)	Arsenic (>0.01-<0.05 mg/1)	Arsenic (> 0.05 mg/1)	Total Tube well (max. concentration based on samples with As> 1 mg/l)
1	Katwa I	NA	5.4	1.3	313 (2.230 (1))

Arsenic affected Risk Population:

(Source – PHED, Govt. of West Bengal)

12.3.4 Ground Water Resource Enhancement & Management:

Ground Water Management Plan for drinking purposes

District	**Block (As affected)**	**No. of habitations in the risk zone where As conc. >0.05 mg/l**	**No. of habitations in the risk zone where As conc. 0.01 to 0.05 mg/l**	**Risk Population (2011) where As conc. >0.05 mg/l**
Bardhaman	Katwa I	2	13	166614

Table 9.7.5.1: Status of existing water supply schemes

(Source – PHED, Govt. of West Bengal)

Proposed interventions:

Potential aquifers are encountered within 21-121m; It is generally potable, bur report of sporadic arsenic in ground water in hand pump tapping this aquifer has been authenticated by

	Ongoing scheme		New scheme		Augmented scheme	
Block	Nos. of ongoing PWSS scheme	Population covered	Nos. of new PWSS scheme	Population covered	Nos. of augmented PWSS	Population covered
Katwa I	4	41671	-	-	1	18394

Task for Arsenic, Govt. of West Bengal; it may be due to the fact that the ground water from upper Aquifer '0', which might be the source of arsenic, is leaching down below to impart arsenic contamination in these tube wells. Therefore, caution should be taken up for using ground water of this aquifer and cement sealing technique is to be implemented invariably to make ground water tapping these zone potable.

As mentioned above, there is another aquifer up to a depth of about 40 m bgl, in which sporadic arsenic contamination of ground water has been reported in adjoining blocks.

To provide drinking water, exploration based drilling down to about 600 m bgl will provide information about both potential zones and presence of arsenic, if any, in ground water in the area. In future, tube wells tapping the fresh deeper aquifer with proper cement sealing against clay bed (if arsenic is reported in future) has been proved to supply arsenic free fresh ground water to villages.

Table-9.7.5.2: Arsenic affected Risk Population to be covered

Sl. No.	Block	Number of Villages to be covered by water supply schemes	Population in risk zone (as per Census 2011) to be covered by water supply schemes.	Comments on providing water supply to the risk population
1	Katwa I	2	4420	Tube wells may be constructed tapping aquifer by using cement sealing

(Source – PHED, Govt. of West Bengal)

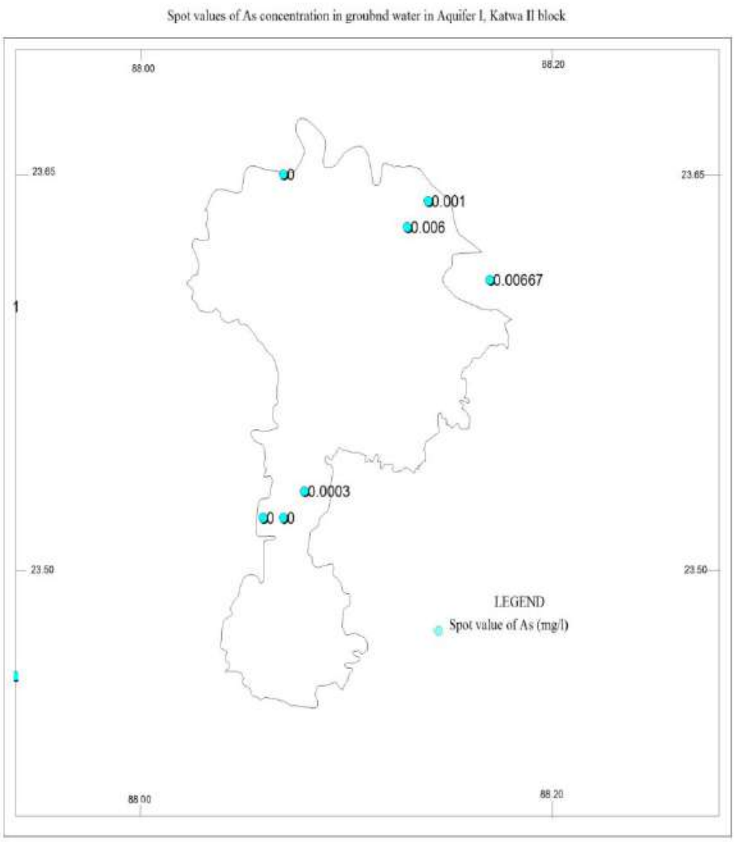


Fig. Arsenic concentration in ground water of Aquifer

Cost of construction of tube wells by using cement sealing technique

In arsenic infested Katwa I block, ground water exclusively tapped by using cement sealing technique. In Tables 9.4a & 9.4b, cost estimation has been done for covering pipe water supply in the risk population of Katwa I block.

Table-9.7.5.3a :Cost estimation for construction of tube wells in arsenic infested villages yet to be covered

Table-9.7.5.3b: Cost estimation for construction of tube wells in arsenic infested villages yet to be covered

Name of Block	Name of Villages	Population in risk zone (as per Census 2011)	Projected population upto 2021 (considering growth 11.92% per decade as per Census 2011	Water required for drinking & domestic purposes @ 70 lpcd (in lpd)	Cattle Population (Considering 0.2 per capita human population) as on 2011	Cattle Population (Considering 0.36 annual growth rate) as on 2021	Water required for drinking & domestic purposes @ 20 lpcd (in lpd)
Katwa I	Saragram	2,613	2924	204680	523	542	10834
Katwa I	Gopkhanj	1337	1496	104720	267	277	5544
		3,950	**4420**	**309400**	**790**	**819**	**16378**

Total Water Requirement in lpd	Average expected yield of Arsenic free water in lps	Supply of arsenic free water by running 8 hrs/day (lpd)	No of Tube Well required	Cost of the tube well of 300 m depth (approx) & 10"x6" dia @ Rs. 25 lakhs (In lakh) as per EFC
215514	12.5	360000	1	25
110264	12.5	360000	1	25
325778	-		**2**	**50**

Ground Water Management Plan for Irrigation

9.7.5.2: Irrigation Scenario in Katwa I block

Total CCA (Ha)	Dug well		Shallow Tube well		Deep Tube well		Surface Flow		Surface Lift		CCA (Ha)	
	Nos.	CCA(Ha)	Nos.	CCA(Ha)	Nos.	CCA (Ha)	Nos.	CCA (Ha)	Nos.	CCA (Ha)	Ground water	Surface water
6068.4 8	0	0	872	4402.26	37	1440. 00	1	2.66	24	223.56	5842.26	226.22

The data of 4th MI census for Culturable Command Area in Katwa I block is given Table 9.7.5.3.

Table 9.7.5.3: CCA and sources of irrigation in Katwa I

(Source- Dept. of M.I., Govt. of West Bengal)

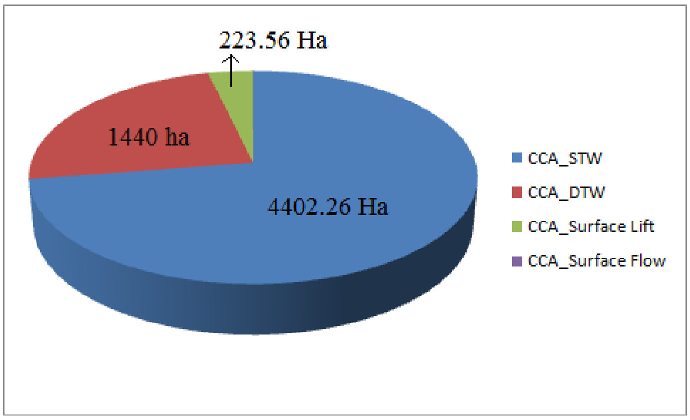


Fig. 9.7.6.1: Per Cent contribution of different sources in irrigation

Table 9.7.6.3 and Fig. 9.7.6.1 indicate that almost 72.54 % and 23.73 % of the cultivable area is irrigated by shallow tube wells and deep tube wells respectively. These sources are mostly

Name of Block	Cultivable area in ha	Net irrigated area in ha	Area to be irrigated in ha	SOD in %	Pre monsoon WL Trend 2016 in cm/yr	Post monsoon WL Trend 2016 in cm/yr	Average Pre monsoon WL in m bgl	Average Post monsoon WL in m bgl
Katwa1 (Aquifer I)	12400	6068.48	6331.52	51.1 5	Average Fall 103.7	Fall 57.9	21.91	22.90

used for rabi crops, boro paddy, etc. Surface Lift contributes 3.68 %. Surface flow is contributing a very meagre amount in irrigation.

Data indicate that in pre-monsoon and post –monsoon, water level long term trends of this block show falling at a rate of 103.7 cm/year and 57.9 cm/ year. Depth to water level is also deep in nature. To improve this ground water scenario, rain water harvesting and artificial recharge may be implemented which might restrict the declining trend.

Space Available For Recharge and Proposed Interventions:

Table 9.7.6.4: Area suitable for recharge in the study area:

District	Block Name	Area (in sq. km)	Total Area suitable for recharge (sq. km.)
Barddhaman	Katwa1	182.99	182.99

Proposed Interventions:

Ground Water Resource Estimation shows that 6331.52 Ha of cultivable area is still not being covered by any irrigation schemes; it also indicates that ground water resource available for future irrigation is 2891.22 Ham. Considering Unit Draft of STW 0.022 MCM & Command Area of STW 6 Ha (0.06 sq. km), additional 16800 Ha area can be made irrigable (vide Table 9.7.6.5).

Table – 9.7.6.5: Additional Irrigation Potential created by Available Ground Water Resource

Net Ground Water Resource (MCM)	SOD (%)	Ground Water Resource available (MCM)	Available area to be irrigated (Ha)	Additional Nos. of STWs feasible	Additional Irrigation Potential Created(ha)
61.6064	51.15	28.9122	6331.52	2800	16800

Therefore, the whole area can be covered by the additional ground water resource available for irrigation, which has been estimated by the competent authority. However, if required, in near future during exigency rain water can be harvested.

Water column recommended in consultation with expert of Bidhan Chandra Krishi Vidyalaya Kalyani, for crops

Scope for Rain Water Harvesting and Artificial Recharge in Study Area:

Using method of Dhruvanarayana, 1993, in Katwa I block, the number and types of artificial recharge and conservation structures proposed to be constructed for harvesting rain water and the estimated cost involved for doing this, have been shown in Table 9.6.6.6a & Table 9.6.6.6 b. 19.07 MCM of rain water has been estimated to be harvested. This harvested water can be utilized in 35:35:20:10 ratio for construction of Irrigation Cum Recharge Pond, Re-excavation of Existing Tank, Injection Well and Farm Pond. For this, an estimated Rupees 896 lakh is required. Also, by the harvested water the irrigation of cultivable land is possible, if needed. By this way, ground water scenario can be improved as well as the inclusive economic growth can be achieved.

District	Block	Major crops/vegetables/ fruits/flowers currently in practice	Water column depth(m)	Crops suggested for better management(considering ground water quality & quantity)	Water column depth(m) recommended	Remarks e.g. Irrigation techniques etc
Barddhaman	Katwa I	Rice, potato, mustard, gram	Rice (1.2-1.4), mustard (0.2-0.25), potato (0.2-0.25), gram (0.10-0.12)	Rice, mustard, potato, gram	Rice (0.75-0.85), mustard (0.2), potato (0.2), gram (0.08-0.12)	Conjunctive use of fresh and contaminated water: 1:1 ratio/drip for vegetable, flowers

Attempt has also been made to modify cropping pattern as per the management strategy mentioned under section **Management Strategy of irrigation water & modification in cropping pattern.** In Table 9.7.7, it has been shown that by using this strategy production of cereals, pulses, oil seeds, etc. would be manifold. At the same time, due to restriction of Boro cultivation by 10% less than the present area of cultivation, a huge amount of vital ground water resources could be saved.

Table 9.7.6.6.a: budgeting of harvested surface run off rain

Normal monsoon rainfall in m(50 yrs data from data.gov.in) 'Rn'	Area(Ha) 'A'	Annual total volume of rain fall in Ham=(Rn X A)	Run off co-efficient from Dhruvanarayana,1993 (Land slope, type of land and soil type) 'C' land slope 0-5%	Major type of soil available in that block	Total volume of surface runoff available Annually 'Vt' (RnXAXC) Ham	75% of 'Vt' = V Ham	50% of V (Non committed) = Vnc Ham	60% of Vnc considered for harvesting = Vf Ham
1.029	18299	18829.67	0.45	25 % clay, 75 % sandy/silty loam	8473.352	6355.014	3177.51	1906.504189

Table 9.7.6.6.b:Proposed Artificial Recharge & conservation structures in Katwa I Block (Details of structures given in Section II):

Block	Net runoff water availability for recharge in MCM (1)	Source Water Allocation (MCM)				Number of Structures				Structure-wise Cost Estimate (lakh Rs.)				Total Cost Estimate (lakh Rs.)
		Irrigation cum recharge Tank – 35 % 0f Col. 1	Re-excavation of existing tanks with RS - – 35 % 0f Col. 1	Injection Well for recharging deeper layer – 20 % 0f Col. 1	Farm Pond - – 10 % 0f Col. 1	Irrigation cum recharge Tank	Re-excavation of existing tanks with RS	Injection Well for recharging deeper layer	Farm Pond	Irrigation cum recharge Tank	Re-excavation of existing tanks with RS	Injection Well for recharging deeper layer	Farm Pond	
Katwa I	19.07	6.67	6.67	3.81	1.91	13	67	13	19	104	536	104	152	896

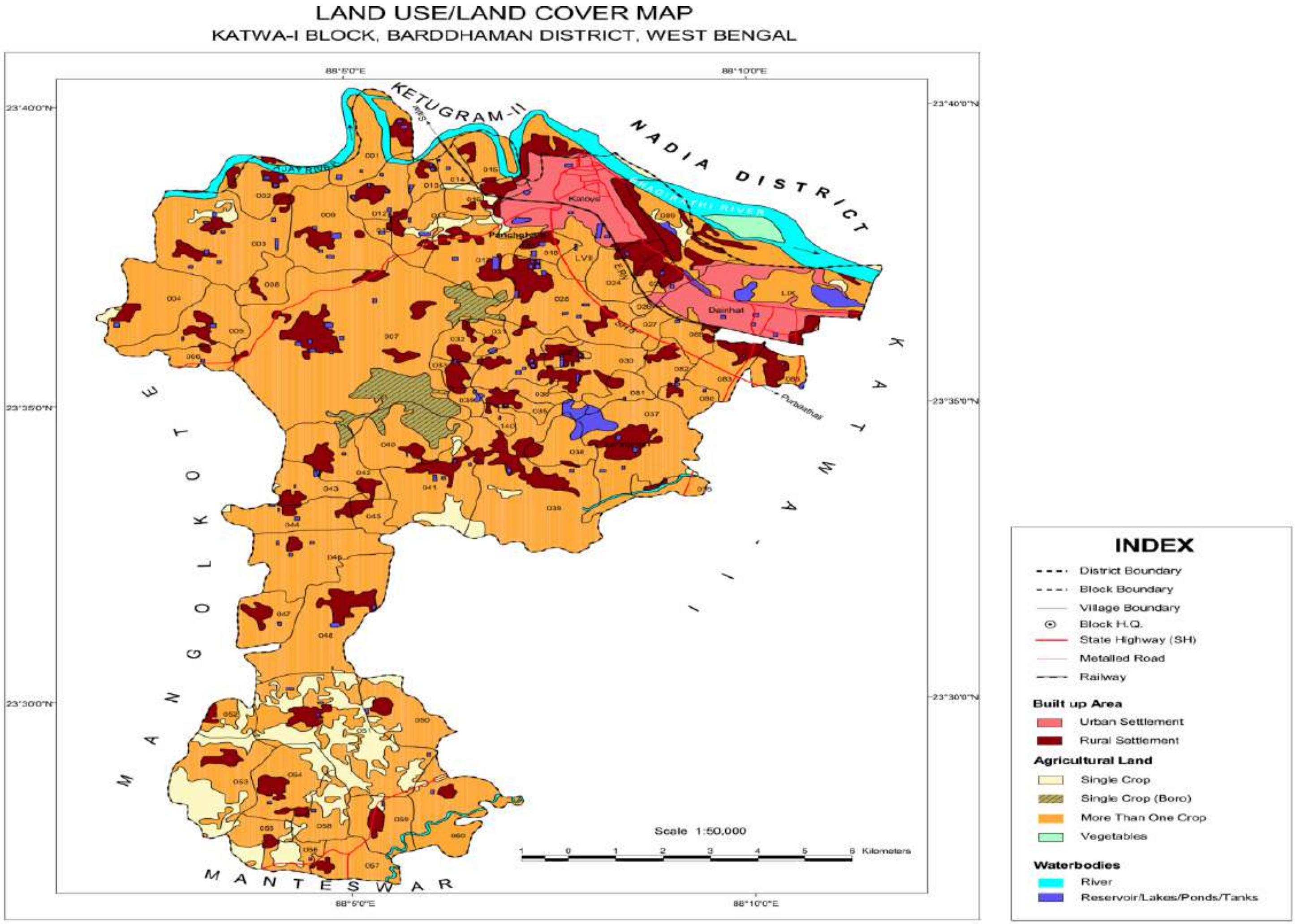


Plate 9.7.6: Land use/ land cover in Katwa I block

(Source: Land Use & Land Reforms Dept., Govt. W. B.)

Table 9.7.6.7 a: Cropping pattern of major crops (area in Ha, production in '000 M. Tons)

Aus (Area)	Aus (Production)	Aman (Area)	Aman (Production)	Boro (Area)	Boro (Production)	Jute (Area)	Jute (Production)	Wheat (Area)	Wheat (Production)
216	0.56	12392	35.109	10784	41.254	126	1.27	28	0.056

Table 9.7.6.7 b: Cropping pattern of major crops (area in Ha, production in '000 M. Tons)

Potato (Area)	Potato (Production)	Masur (Area)	Musur (Production)	Mustard (Area)	Mustard (Production)	Til (Area)	Til (Production)	Gram (Area)	Gram (Production)
279	8.449	-	-	-	-	181	0.097	-	-

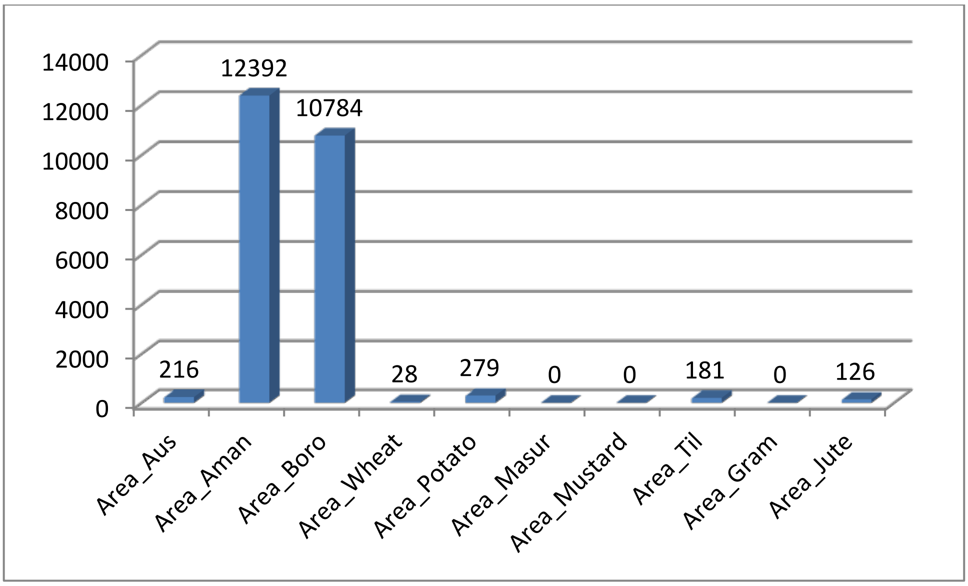


Fig. 9.7.6 C: Graphical representation of areas of major crops (area in Ha)

Table 9.7.7: Proposed modification of cropping pattern in Katwa I block, Barddhaman district

Area of Boro cultivation (Ha)	**Average Water column required (m) for Col. I**	**G W draft due to boro cultivation (MCM) for Col. I**	**Proposed 10 % reduction of area of boro cultivation (Ha)**	**Amount of ground water saved (MCM) as in Col. I**	**Loss (Kg of Boro paddy) due to reduction in area of Boro cultivation yield rate 3264.40 kg/ Ha (in M. Ton)**	**Proposed cropping in 1:1:1 ratio in lost area of Boro cultivation as proposed in Col IV**	**Gain (M. Ton each) due to alternate cropping @ existing yield rate Til @ 908.89 kg/hec, Ground nut @ 1770.45 kg/Ha & Mung @ 1182.23 kg/Ha**	**Ground water draft (MCM) for cultivation of Til, Ground nut & Mung**	**Gain due to increase in area of Aus cultivation in Kharif (at least 10 % of existing area of Boro cultivation, i.e. 1078.4 Ha.) at yield rate 3361.24 kg/ Ha (M. Ton)**	Ground water saved (MCM)
(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)	(IX)	(X)	(XI)
10784	1.3	140.19	1078.4	14.02	3520.33	Til, Ground nut & Mung 359.47Ha each.	Til-326.72, Ground nut-636.42 & Mung-424.98	1.62	3624.76	12.4

12.4 BHATAR

Salient Information

Block Name: Bhatar

Area (in Km^2): 393.00

District: Bardhaman

State: West Bengal

Population(as on 2011):

Rural	Urban	Total
263064	----	263064

Approximate Decadal Growth Rate from 2001-2011: 11.28%

Rainfall:

Average annual district rainfall for the period 2012 -16 (in mm):1380.28

Block	Normal	Actual (Annual)				
		2012	2013	2014	2015	2016
Bhatar	1315.2	1276.6	1535.5	1134.4	1546.5	1408.4

Agriculture & Irrigation (area in ha) :

SI. No	Name of the Block	Geographic Area	Cultivable Area	Area under pasture & orchard	Cultivable Waste Land	Forest Land
1.	Bhatar	39300	313.87	0.01	7.60	3.01

Aquifer Wise Ground Water Resource Availability & Extraction(in MCM):

Resource Availability	Aquifer I	Aquifer II*	Extraction (for Aquifer I)
Dynamic Resource	130.2567	0.25	57.2361
Static Resource	2762.1612	-	-

*Ground water flow through Aquifer II towards SSE – 3299.13 m^3/day

12.4.1 Disposition of Aquifer:

Block	Depth range of Aquifer in m bgl	
Bhatar	1st Aquifer	2nd aquifer
	10-88	82-122, 107-130

Aquifer I occur under unconfined condition, Aquifer II occurs under semi-confined to confined condition.

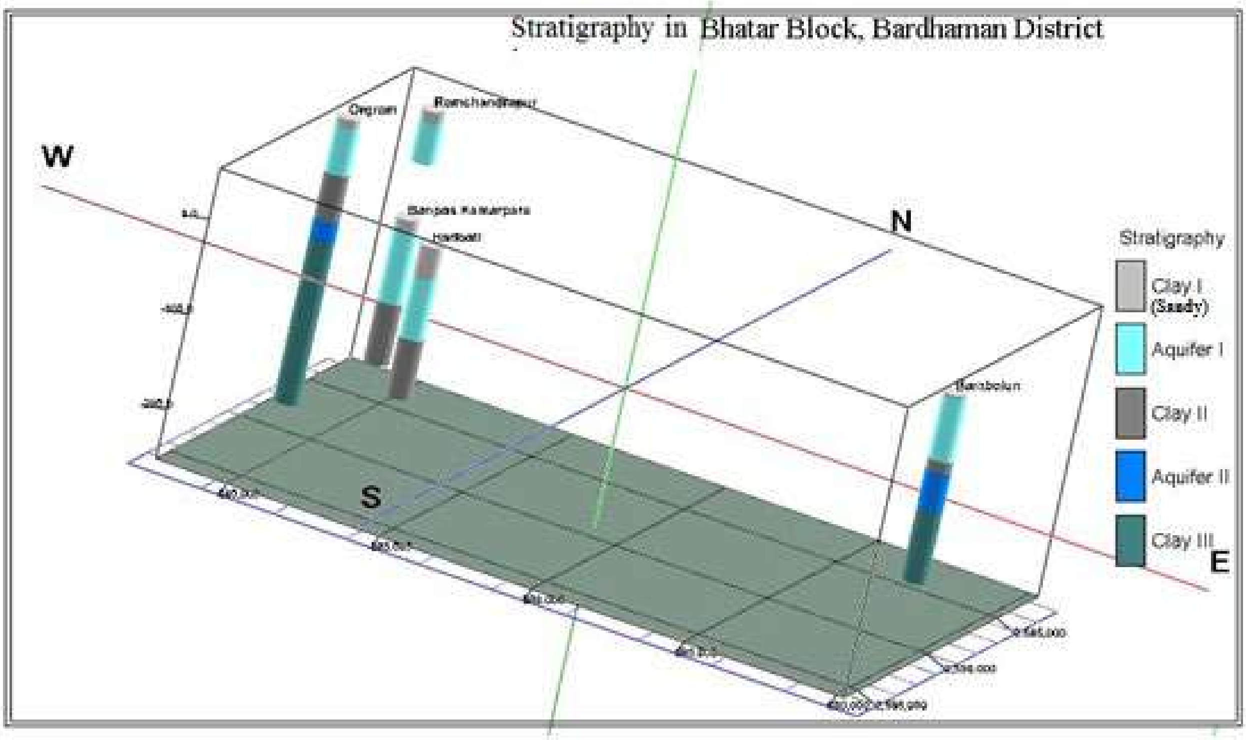


Plate 9.8.1: Stratigraphic Logs in Bhatarblock, Bardhaman district

Aquifer wise water level ranges and seasonal water level trends:

SI. No.	Block	Aquifer	Pre-monsoon Trend			Post-monsoon Trend		
			Water Level Range (m bgl)	Rise (cm/year)	Fall (cm/year)	Water Level Range (m bgl)	Rise (cm/year)	Fall (cm/year)
1.	Bhatar	I	9.53-30.87	-	Average Fall 88.4	6.91-29.13	-	Average Fall 182.28
2.	Bhatar	II	17.05-31.87	-	-	16.4-25.65	-	-

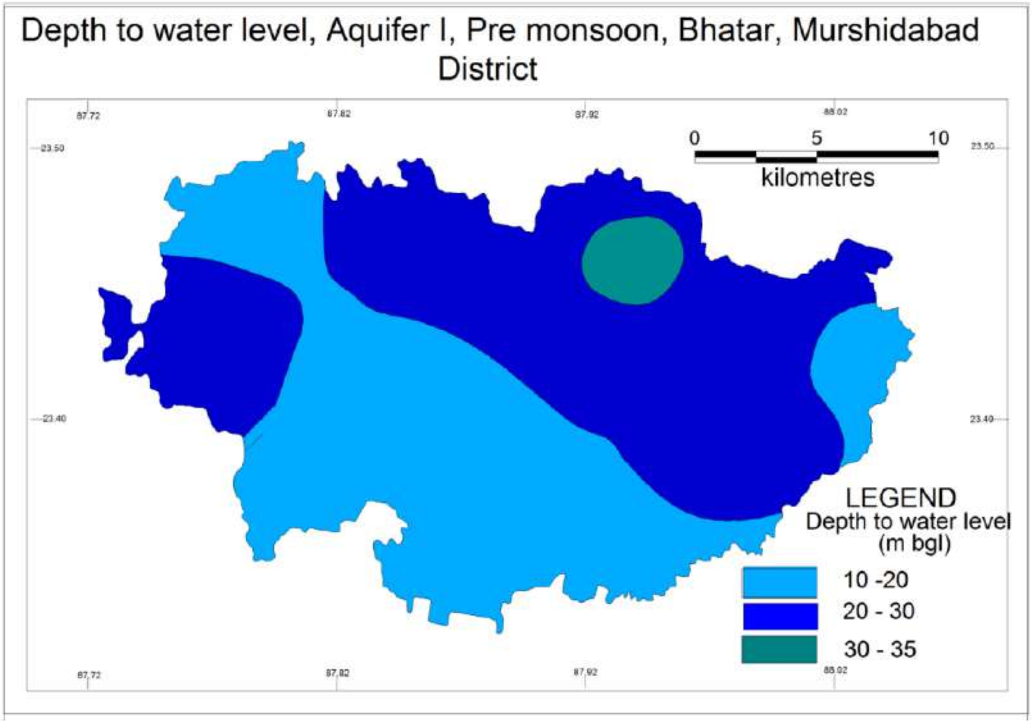


Fig. Depth to water level, Aquifer I, Pre monsoon

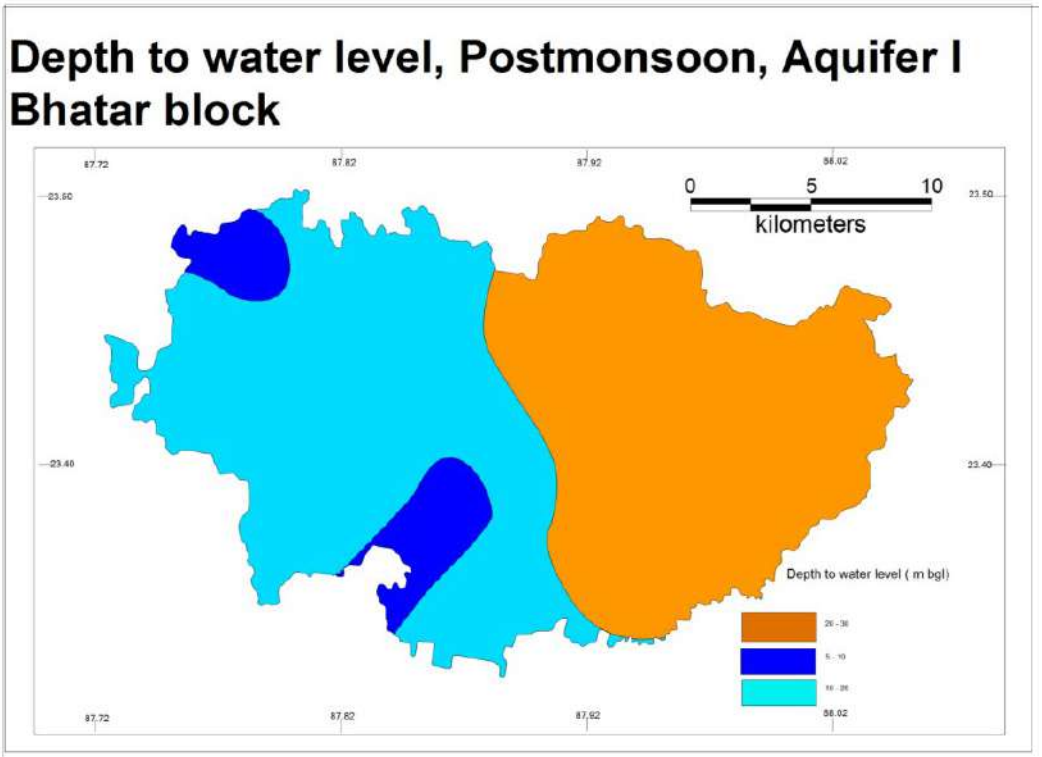


Fig. Depth to water level, Aquifer I, Post monsoon

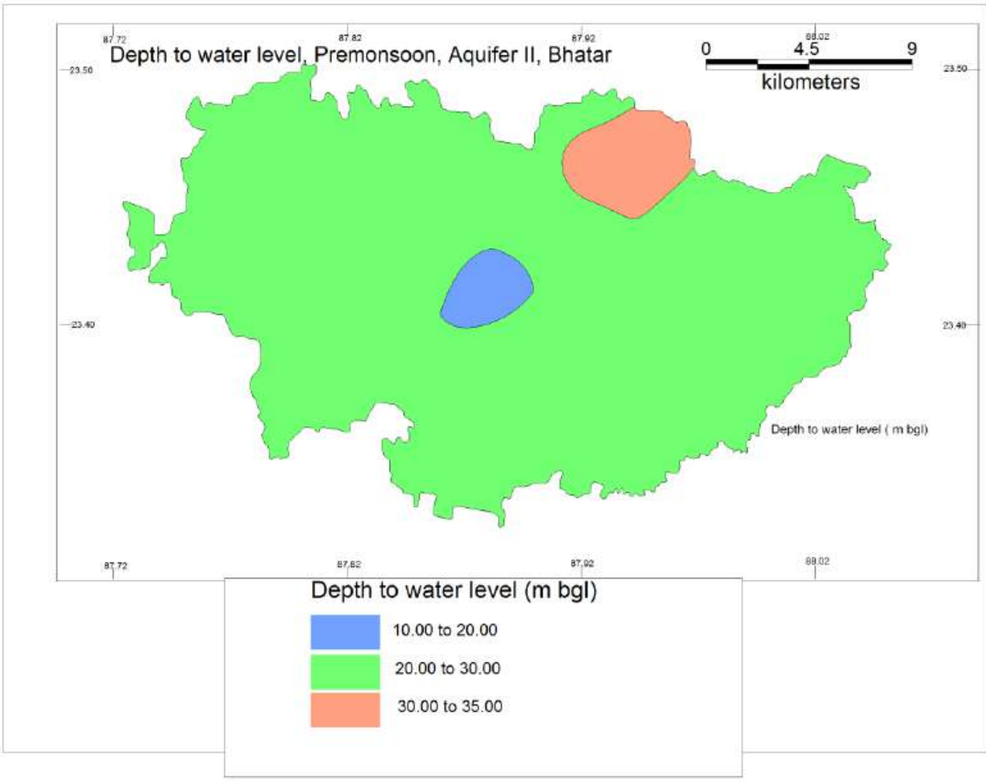


Fig. Depth to water level, Aquifer II, Pre monsoon

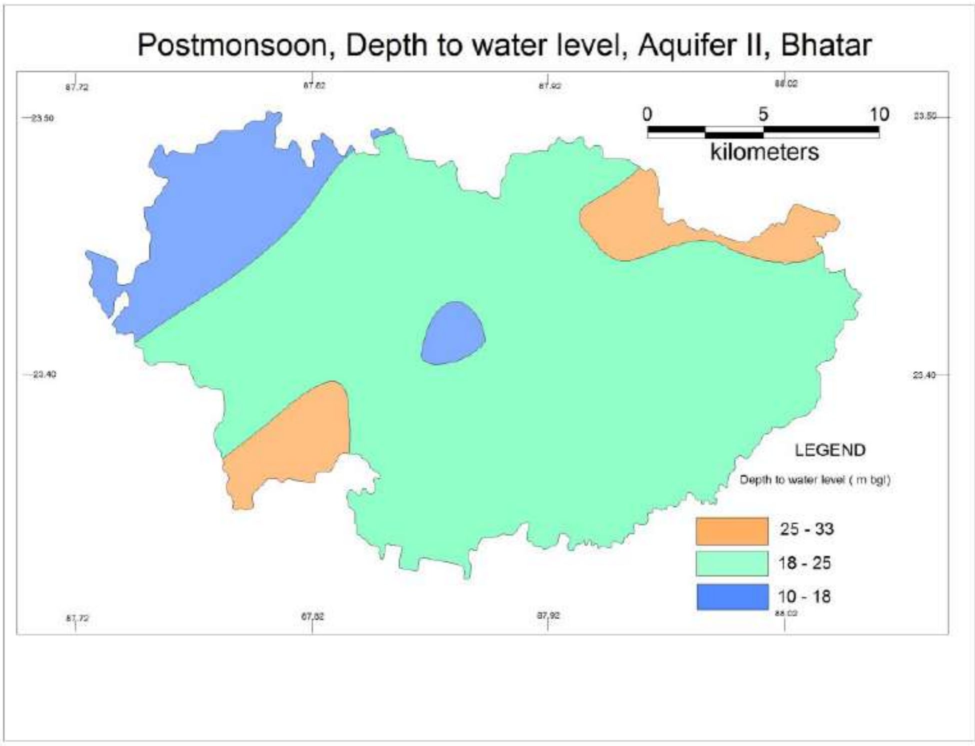


Fig. Depth to water level, Aquifer II, Post monsoon

Thickness of aquifer (average):

Block	Area (sq. km)	Thickness of the Granular Zone in Aquifer I (m)	Thickness of the Granular Zone in Aquifer II (m)
Bhatar	393	59.76	30.51

Aquifer-wise Statement

Name of Block	Aquifer I			Aquifer II		
	Depth Range (m bgl)	Discharge (m^3/hr)	T (m^2/day)	Depth Range (m bgl)	Discharge (m^3/hr)	T (m^2/day)
Bhatar	10-125	42-126 m^3/hr	619	165-240	7.92 -22 m^3/hr	91

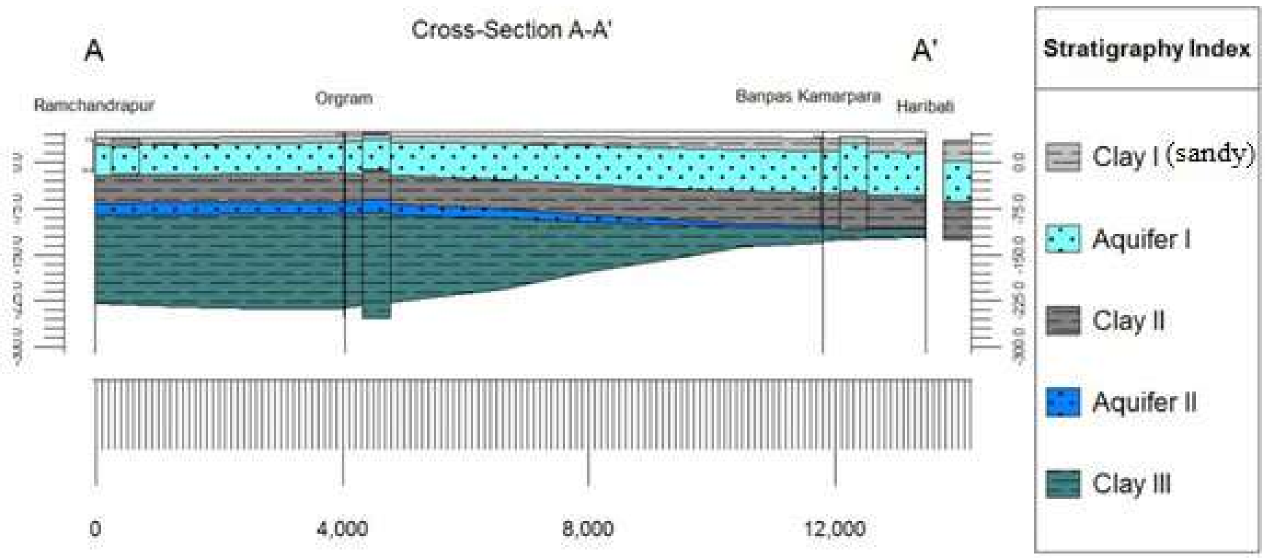


Plate 9.8.2: Aquifer disposition (3D) in Bhatar block, Barddhaman district

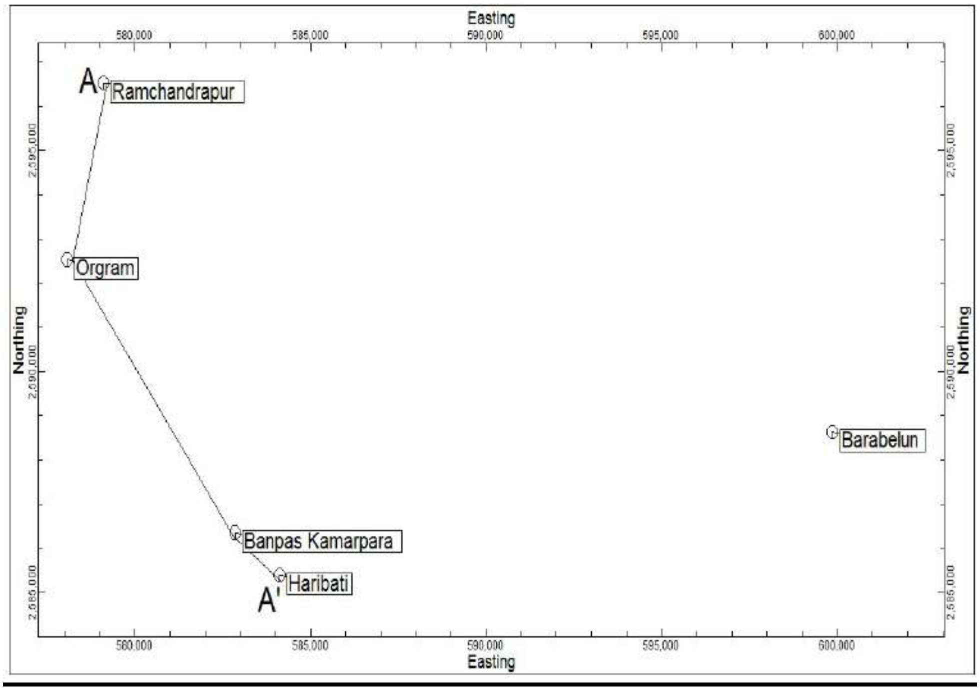


Plate 9.8.3: N-S Section Index line inBhatarblock, Bardhaman district

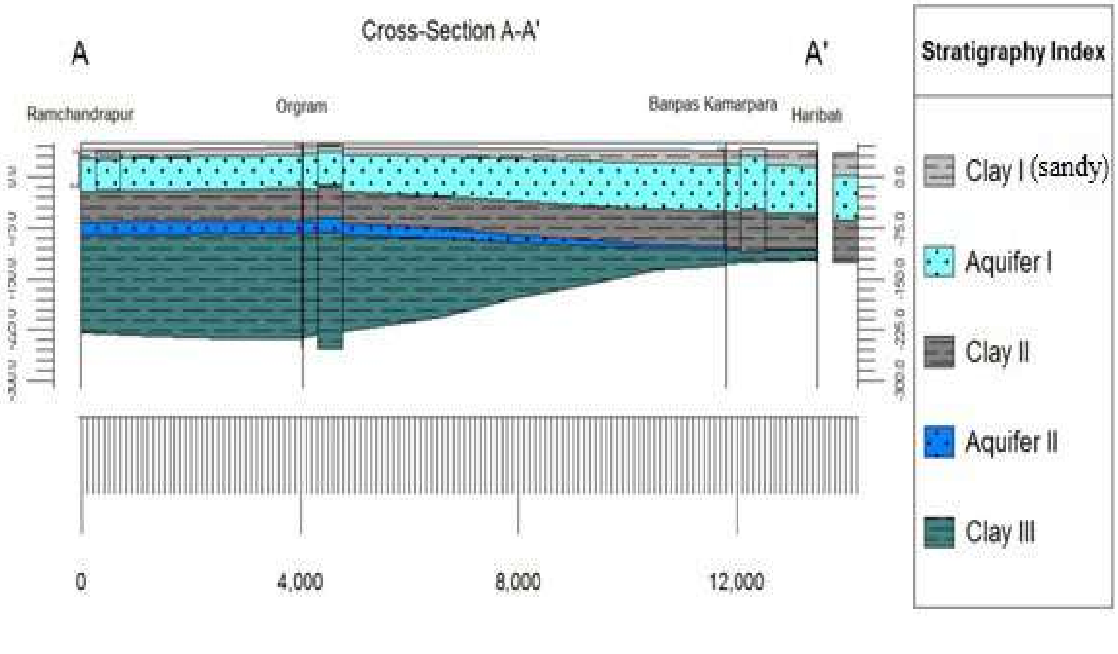


Plate 9.8.4: N-S section in Bhatar block, Barddhaman district

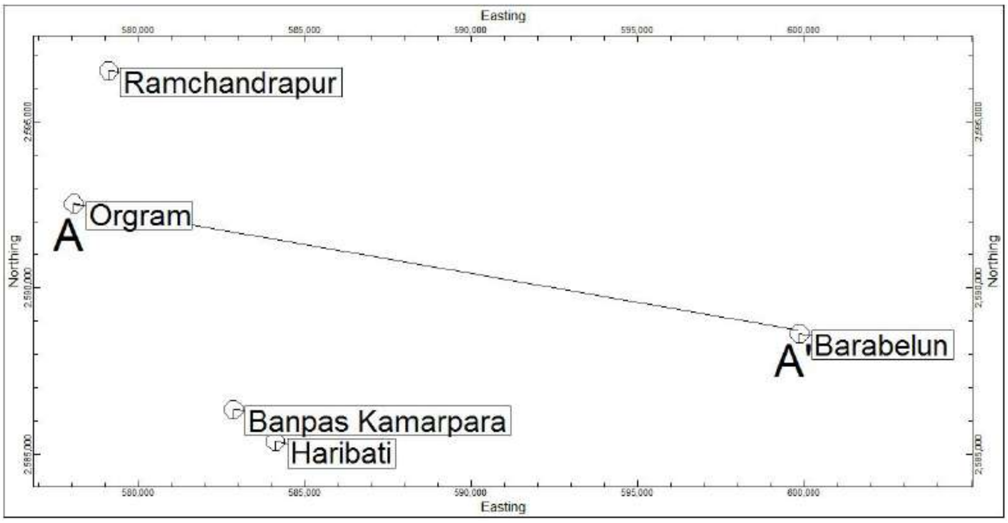


Plate 9.8.5:WNW-ESESection Index Line in Bhatar block, Bardhaman district

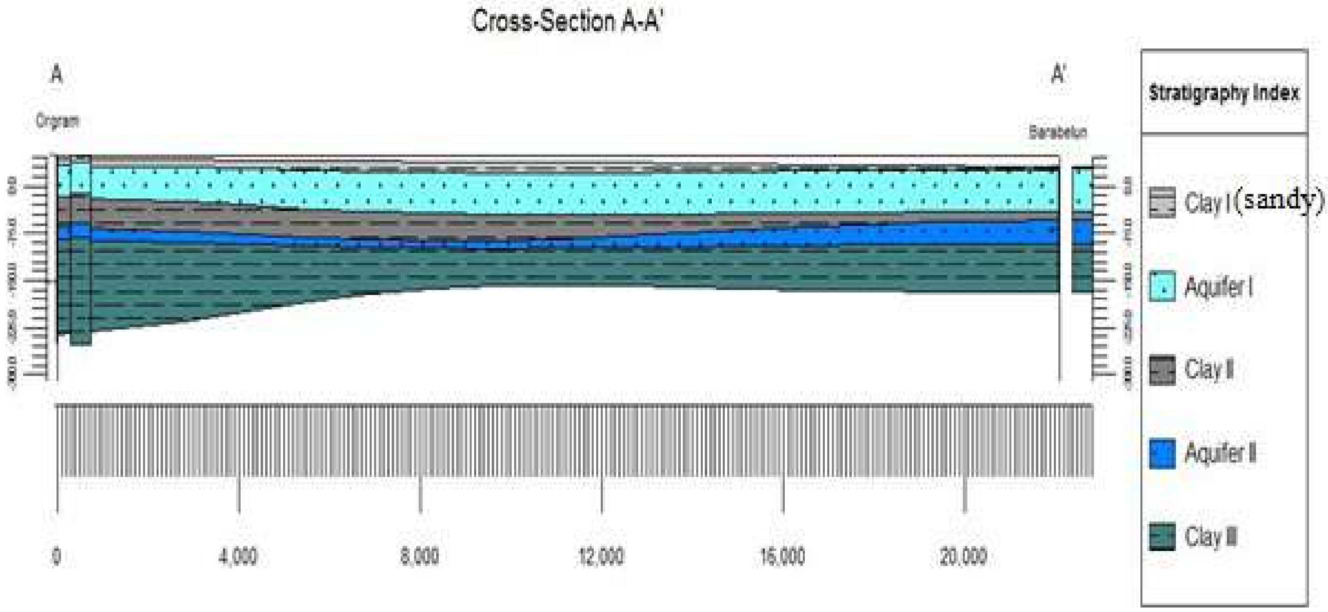


Plate 9.8.6: WNW-ESE section in Bhatar block, Bardhaman district

12.4.2 Ground Water Resource, Extraction, Contamination & other Issues:

Aquifer Wise Resource Availability & Extraction:

Dynamic ground water resources as on 31st March'13

Block	Net ground water availability (MCM)	Gross ground water draft (MCM)	Stage of development (%)	Category	Provision for domestic and industrial requirement supply up to next 25 years (MCM)
Bhatar	130.2567	57.2361	45.01	Semi-critical	5.4066

12.4.3 Chemical Quality of Ground Water & Contamination:

Range of Chemical Pollutants:

As -data based on 5 samples of spl. Drive in 15-16 & other parameters based on limited samples of 16-17. As = 0.001 mg/l has been reported in hand pumps at Amarun & Kubajpur.

Block	As (mg/l)	TH (mg/l)	EC (µS/cm)	F (mg/l)	NO_3 (mg/l)
Bhatar	**Nil-0.001**	**35-125**	**147-404**	**1.15-1.62**	**Bdl-2.3**

Percentage of tube wells having arsenic content in the block based on SOES data:

SI. No.	Blocks	Arsenic (<0.01 ing/1)	Arsenic (>0.01-<0.05 mg/1)	Arsenic (> 0.05 mg/1)	Max. conc. mg/l (samples with As >1000□g/L
1	Bhatar	NA	-	-	0.009

Arsenic affected Risk Population:

No record available.

12.4.4 Ground Water Resource Enhancement& Management Plan:

Ground Water Management Plan for drinking purposes

Table 9.8.5.1: Status of existing water supply schemes

	Ongoing scheme		New scheme		Augmented scheme	
Block	Nos. of ongoing PWSS scheme	Population covered	Nos. of new PWSS scheme	Population covered	Nos. of augmented PWSS	Population covered
Bhatar	8	133438	1	17131	-	-

(Source – PHED, Govt. of West Bengal)

Proposed interventions:

Potential aquifers are encountered within 10-125 m in Aquifer I; apart from this there is another aquifer up to a depth between 165 & 240 m bgl i.e. Aquifer II. Both are potable and recommended for drinking purpose. However, it is suggested always to tap deeper aquifer for PWSS putting cement seal to prevent leaching of ground water from upper aquifer, if any, into the tapped deeper aquifer in future.

Low to high discharge within 42-126 m3/hr has been encountered in 1st aquifer (105-125)and a low discharge of 7.92 - 22 m3/hr has been found in 2nd aquifer within depth of 165 and 240. Hence, to provide potable water, the following recommendations may be suggested:

Deep drilling down to about 350 m bgl may provide information about potentiality & quality of ground water in the block; presence of arsenic, if any, in ground water in the area may be negotiated by. In future, tube wells tapping the fresh deeper aquifer with proper cement sealing against clay bed (if arsenic is reported in future) has been proved to supply arsenic free fresh ground water to villages.

Ground Water Management Plan for Irrigation purposes

9.8.5.2: Irrigation Scenario in Bhatar block (Aquifer I)

Name of Block	Cultivable area in Ha	Net irrigated area in Ha	Area to be irrigated in Ha	SOD in %	Pre monsoon WL Trend 2016 in cm/yr	Post monsoon WL Trend 2016 in cm/yr	Average Pre monsoon WL in m bgl	Average Post monsoon WL in m bgl
Bhatar	31387	12433.87	18953.13	45.01	**Average Fall 88.4**	**Average Fall 182.28**	20.43	19.13

The data of 4th MI census for Culturable Command Area in Bhatar block is given Table 9.8.5.3.

Table 9.8.5.3: CCA and sources of irrigation in Bhatar

Total CCA (Ha)	Dug well		Shallow Tube well		Deep Tube well		Surface Flow		Surface Lift		CCA (Ha)	
	Nos.	CCA(Ha)	Nos.	CCA(Ha)	Nos.	CCA (Ha)	Nos.	CCA (Ha)	Nos.	CCA (Ha)	Ground water	Surface water
12433.87	1	13.49	2078	11748.95	3	120.00	1	14.00	72	537.43	11882.44	551.43

(Source – Dept. of M.I., Govt. of West Bengal)

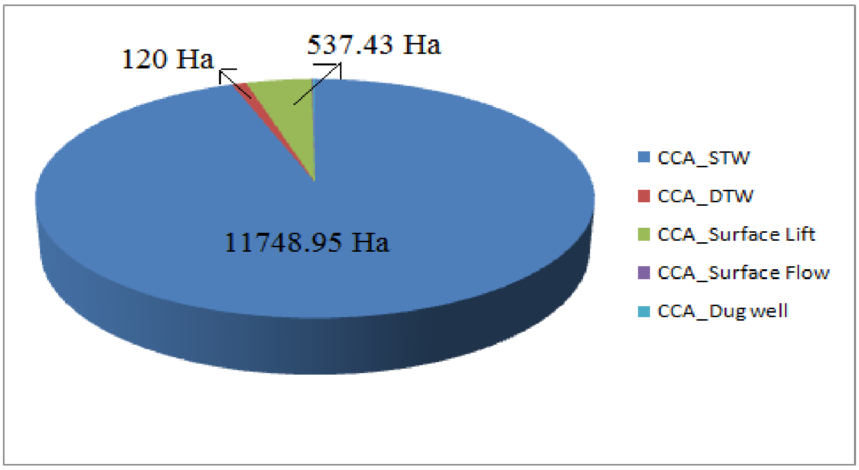


Fig. 9.8.6.1: Per Cent contribution of different sources in irrigation

Table 9.8.6.3 and Fig. 9.8.6.1 indicate that almost 94.49% and 0.11% of the culturable area is irrigated by shallow tube wells and deep tube wells respectively. These sources are mostly used for rabi crops, boro paddy, etc. Surface Lift contributes 4.32 %. Surface flow is contributing a very meagre amount in irrigation.

Data indicate that water level long term trends of this block show falling at an average rate of 88.4 cm/year and 182.28 cm/ year in Aquifer I during in pre-monsoon and post-monsoon respectively: in Aquifer II shows falling trend of 110.7 cm/year (1 datum) and 154.5 cm/year (1 datum) respectively. Depth to water level is also deep in nature. To improve this ground water scenario, rain water harvesting and artificial recharge may be implemented which might restrict the declining trend.

Space Available For Recharge and Proposed Interventions:

Table 9.8.6.4 Area suitable for recharge in the study area:

District	Block Name	Area (in sq. km)	Total Area suitable for recharge (sq. km.)
Bardhaman	Bhatar	393	393

Proposed Interventions:

Ground Water Resource Estimation shows that 18953.13 Ha of cultivable area is still not being covered by any irrigation schemes; it also indicates that ground water resource available for future irrigation is 7038.61 Ham. Considering Unit Draft of STW 0.022 MCM & Command Area of STW 6 Ha (0.06 sq. km), additional 19194 Ha area can be made irrigable (vide Table 9.8.6.5).

Table – 9.8.6.5: Additional Irrigation Potential created by Available Ground Water Resource

Net Ground Water Resource (MCM)	SOD (%)	Ground Water Resource available (MCM)	Available area to be irrigated (Ha)	Additional Nos. of STWs feasible	Additional Irrigation Potential Created (Ha)
130.2567	45.01	70.3861	18953.13	3199	19194

Therefore, the whole area can be covered by the additional ground water resource available for irrigation, which has been estimated by the competent authority. However, if required, in near future during exigency rain water can be harvested

Water column recommended in consultation with expert of Bidhan Chandra Krishi Vidyalaya Kalyani, for crops

District	Block	Major crops/vegetables/ fruits/flowers currently in practice	Water column depth (m)	Crops suggested for better management(considering ground water quality & quantity)	Water column depth (m) recommended	Remarks e.g. Irrigation techniques etc.
Barddhaman	Bhatar	Rice, potato, mustard, gram	Rice (1.2-1.4), mustard (0.2-0.25), potato (0.2-0.25), gram (0.10-0.12)	Rice, mustard, potato, gram	Rice (0.75-0.85), mustard (0.2), potato (0.2), gram (0.08-0.12)	Alternate dry and wet method for rice, for others based on crop physiology

Scope for Rain Water Harvesting and Artificial Recharge in Study Area:

Using method of Dhruvanarayana, 1993, in Bhatar block, the number and types of artificial recharge and conservation structures proposed to be constructed for harvesting rain water and the estimated cost involved for doing this, have been shown in Table 9.8.6.6a & Table 9.8.6.6 b. 27.30 MCM of rain water has been estimated to be harvested. This water can be utilized in 35:35:20:10 for construction of Irrigation Cum Recharge Pond, Re-excavation of Existing Tank, Injection Well and Farm Pond. For construction of these structures, an estimated Rupees 1280 lakh is required. By doing this, ground water scenario can be improved as well as the inclusive economic growth can be achieved. Also, by this harvested water cultivable land can be irrigated, if needed.

Table 9.8.6.7 a: Cropping pattern of major crops (area in Ha, production in '000 M. Tons)

Aus (Area)	Aus (Production)	Aman (Area)	Aman (Production)	Boro (Area)	Boro (Production)	Jute (Area)	Jute (Production)	Wheat (Area)	Wheat (Production)
211	0.62	32551	87.218	21755	81.81	-	-	24	0.058

Table 9.8.6.7 b: Cropping pattern of major crops (area in Ha, production in '000 M. Tons)

Potato (Area)	Potato (Production)	Masur (Area)	Musur (Production)	Mustard (Area)	Mustard (Production)	Til (Area)	Til (Production)	Gram (Area)	Gram (Production)
1160	25.667	7	0.004	1257	1.238	102	0.06	-	-

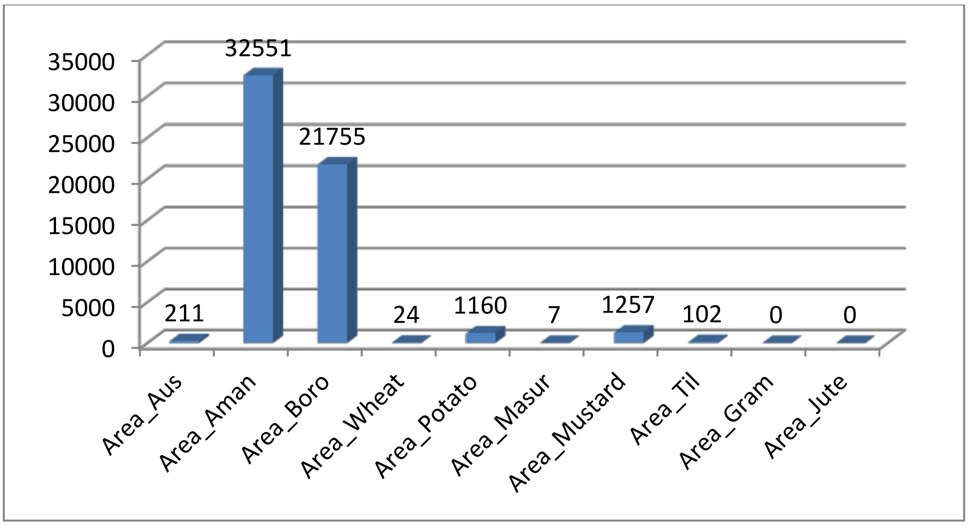


Fig. 9.8.6.7 C: Graphical representation of cropping pattern in Bhatar block

Attempt has also been made to modify cropping pattern as per the management strategy mentioned under section **Management Strategy of irrigation water & modification in cropping pattern.** In Table 9.8.7, it has been shown that by using this strategy production of cereals, pulses, oil seeds, etc. would be manifold. At the same time, due to restriction of Boro cultivation by 10% less than the present area of cultivation, a huge amount of vital ground water resources could be saved.

Table 9.8.6.6.a: Budgeting rain fall run off availability in Bhatar block

Normal monsoon rainfall in m(50 yrs data from data.gov.in) 'Rn'	Area(Ha) 'A'	Annual total volume of rain fall in Ham=(Rn X A)	Run off co-efficient from Dhruvanarayana,1993(Land slope, type of land and soil type) 'C' land slope 0-5%	Major type of soil available in that block	Total volume of surface runoff available Annually 'Vt' (RnXAXC) Ham	75% of 'Vt' = V Ham	50% of V (Non committed) = Vnc Ham	60% of Vnc considered for harvesting = Vf Ham
1.029	39300	40439.7	0.3	100 sandy/silty loam	12131.91	9098.933	4549.47	2729.67975

Table 9.8.6.6.b: Proposed Artificial Recharge Structures in the Study area (Details of structures given in Section - Part II)

Block	Net surface water availability for recharge in MCM (1)	Source Water Allocation (MCM)				Number of Structures				Structure-wise Cost Estimate (lakh Rs.)				Total Cost Estimate (lakh Rs.)
Bhatar	27.30	Irrigation cum recharge Tank – 35 % 0f Col. 1	Re-excavation of existing tanks with RS - – 35 % 0f Col. 1	Injection Well for recharging deeper layer – 20 % 0f Col. 1	Farm Pond- – 10 % 0f Col. 1	Irrigation cum recharge Tank	Re-excavation of existing tanks with RS	Injection Well for recharging deeper layer	Farm Pond-	Injection Well for recharging deeper layer	Irrigation cum recharge Tank	Re-excavation of existing tanks with RS	Farm Pond-	
		9.56	9.56	5.46	2.73	19	96	18	27	144	152	768	216	1280

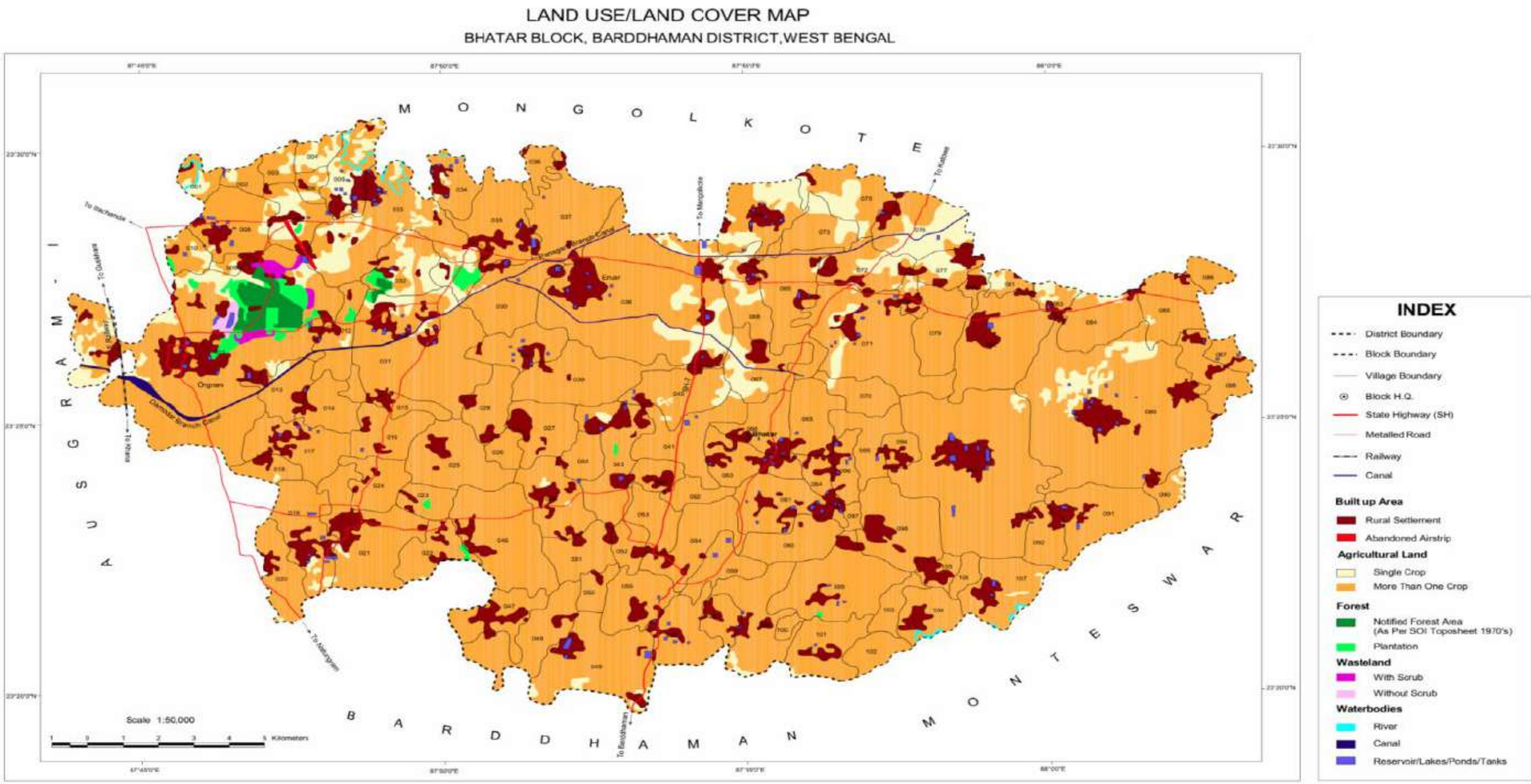


Plate 9.8.6: Land use/ land cover in Bhatar block *(Source: Land Use & Land Reforms Dept., Govt. W. B.)*

Table 9.8.7: Proposed modification of cropping pattern in Bhatar block, Barddhaman district

Area of Boro cultivation (Ha)	**Average Water column required (m) for Col. I**	**G W draft due to boro cultivation (MCM) for Col. I**	**Proposed 10 % reduction of area of boro cultivation (Ha)**	**Amount of ground water saved (MCM) as in Col. I**	**Loss (MCM) of Boro due to reduction in area of cultivation @yield rate of 3264.40 kg/ Ha (in M. Ton)**	**Proposed cropping in 1:1:1 ratio in lost area of Boro cultivation as proposed in Col IV**	**Gain (M. Ton each) due to alternate cropping @ existing yield rate Til @ 908.89 kg/hec, Ground nut @ 1770.45 kg/Ha & Mung @ 1182.23 kg/Ha**	**Ground water draft (MCM) for cultivation for Til, Mung & Ground nut**	**Gain due to increase in area of Aus cultivation in Kharif (at least 10 % of existing area of Boro cultivation, i.e. 2175.5 Ha.) at yield rate 3361.24 kg/ Ha (M. Ton)**	Ground water saved (MCM)
(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)	(IX)	(X)	(XI)
21755	1.3	282.82	2175.5	28.28	7101.70	Til, Ground nut & Mung 725.17Ha each.	Til-659.100, Ground nut-1283.88 & Mung-857.32	3.26	7312.38	25.02

12.5 MANTESWAR

Salient Information

Block Name: **Manteswar**

Area (in Km^2): 319.00

District: Bardhaman

State: West Bengal

Population(as on 2011):

Rural	Urban	Total
237398	----	237398

Approximate Decadal Growth Rate from 2001-2011: 11.31%

Rainfall:

Average annual rainfall (district) for the period 2012 -16 (in mm):1380.28

Block	Normal	Actual (Annual)				
		2012	2013	2014	2015	2016
Bardhaman	1315.2	1276.6	1535.5	1134.4	1546.5	1408.4

Agriculture & Irrigation (area in sq. Km):

SI. No	Name of the Block	Geographic Area	Cultivable Area	Area under pasture & orchard	Cultivable Waste Land	Forest Land
1.	**Manteswar**	319	246.06	-	228	-

Aquifer Wise Ground Water Resource Availability & Extraction (in MCM):

Resource Availability	Aquifer I	Aquifer II	Extraction (for Aquifer I)
Dynamic Resource	96.9411	-	64.0124
Static Resource	4743.6576	-	-

12.5.1 Disposition of Aquifer:

Block	Depth range of Aquifer in m bgl	
	1st Aquifer	2nd aquifer
Manteswar	3-142	-

Aquifer I occur under unconfined condition.

Aquifer Wise Water Level Ranges & Pre-monsoon and Post-monsoon water level trends (2006 to 2016) based on historical data of hydrograph stations

SI. No.	Block	Aquifer	Pre-monsoon Trend			Post-monsoon Trend		
			Water Level Range (m bgl)	Rise (cm/year)	Fall (cm/year)	Water Level Range (m bgl)	Rise (cm/year)	Fall (cm/year)
1.	Manteswar	I	16.57-26.75	-	Fall (118.7)	18.55-26.10	-	Fall 168.08

Thickness of Aquifer(average):94.31 (Aquifer I)

Aquifer-wise Statement

Name of Block	Depth range of 1st Aquifer (in m bgl)			Depth range of 2nd Aquifer (in m bgl)			Remarks
	Depth Range (m bgl)	Discharge (m^3/hr)	T (m^2/day)	Depth Range (mbgl)	Discharge (m^3/hr)	T (m^2/day)	
Manteswar	3-142	7.92 - 126	91- 619 $0.81X10^{-4}$ - $4.3X10^{-4}$)	-	-	-	There is only one single aquifer within 200 m

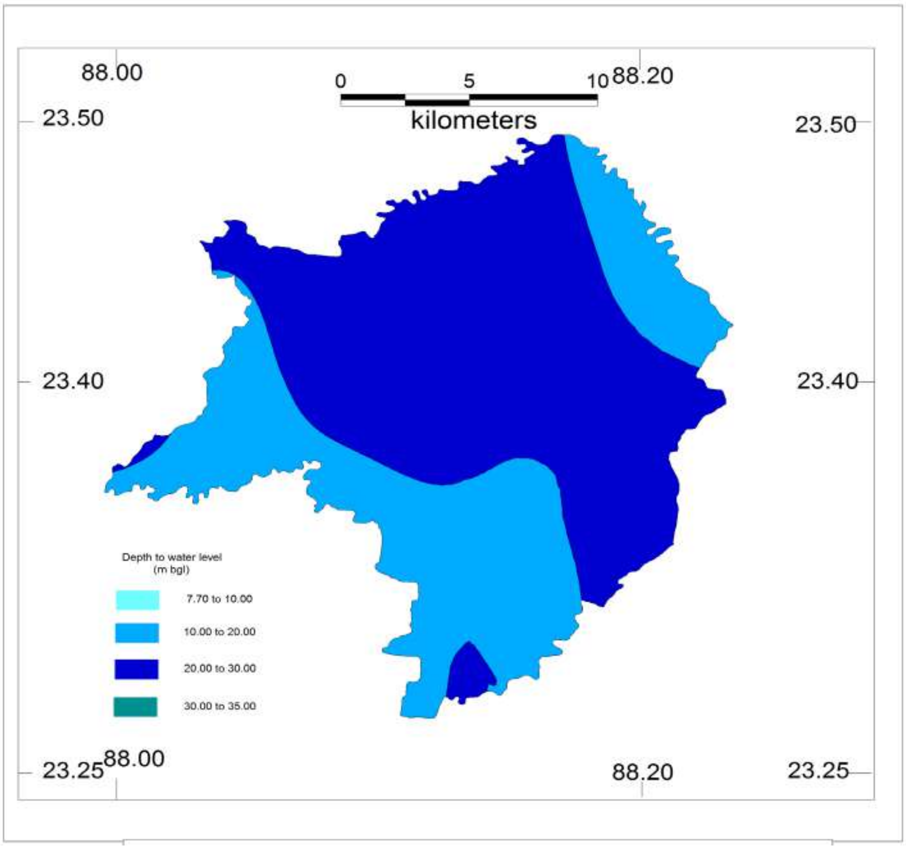


Fig. Depth to water level, Aquifer I, Premonsoon

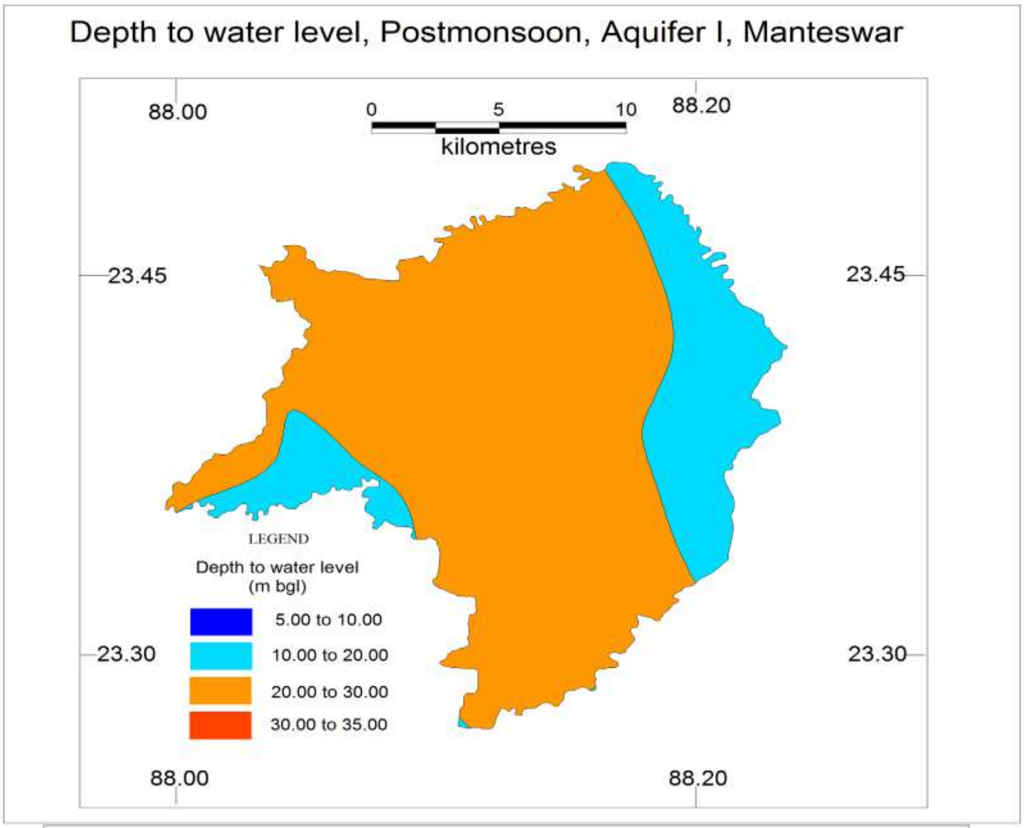


Fig. Depth to water level, Aquifer I, Post monsoon

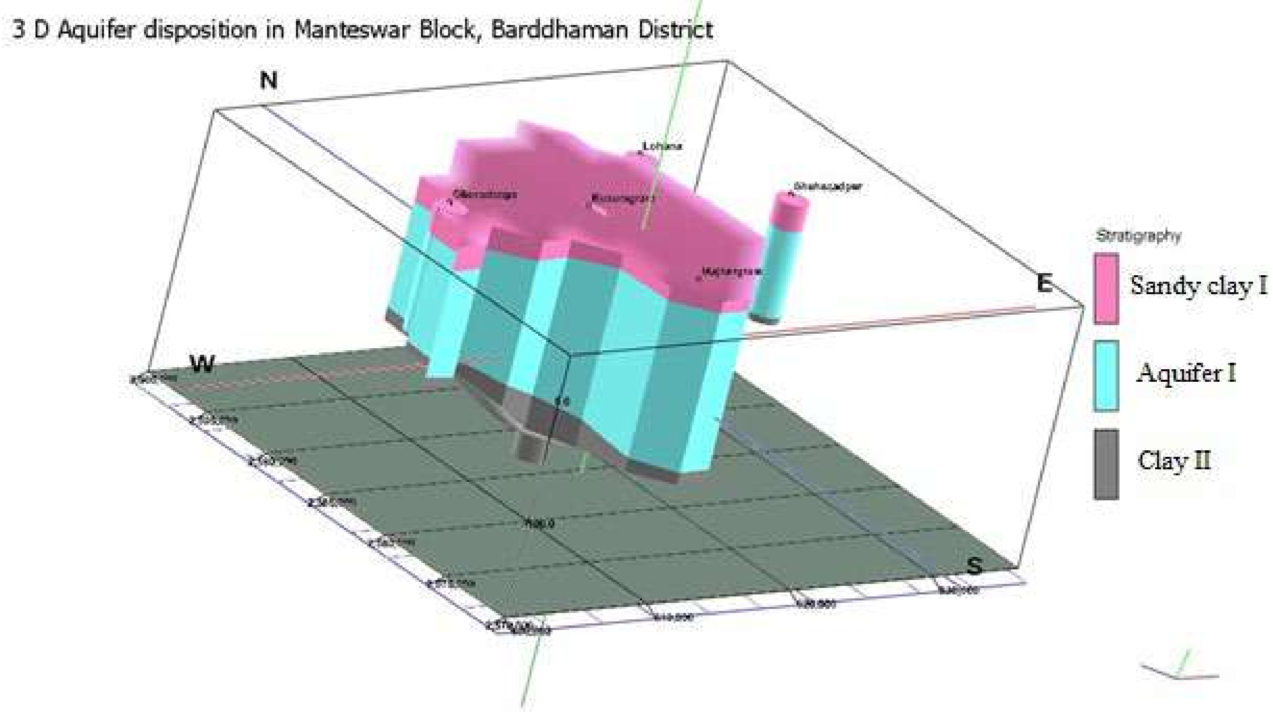


Plate 9.9.1: Aquifer disposition (3D) in Manteswarblock, Bardhaman district

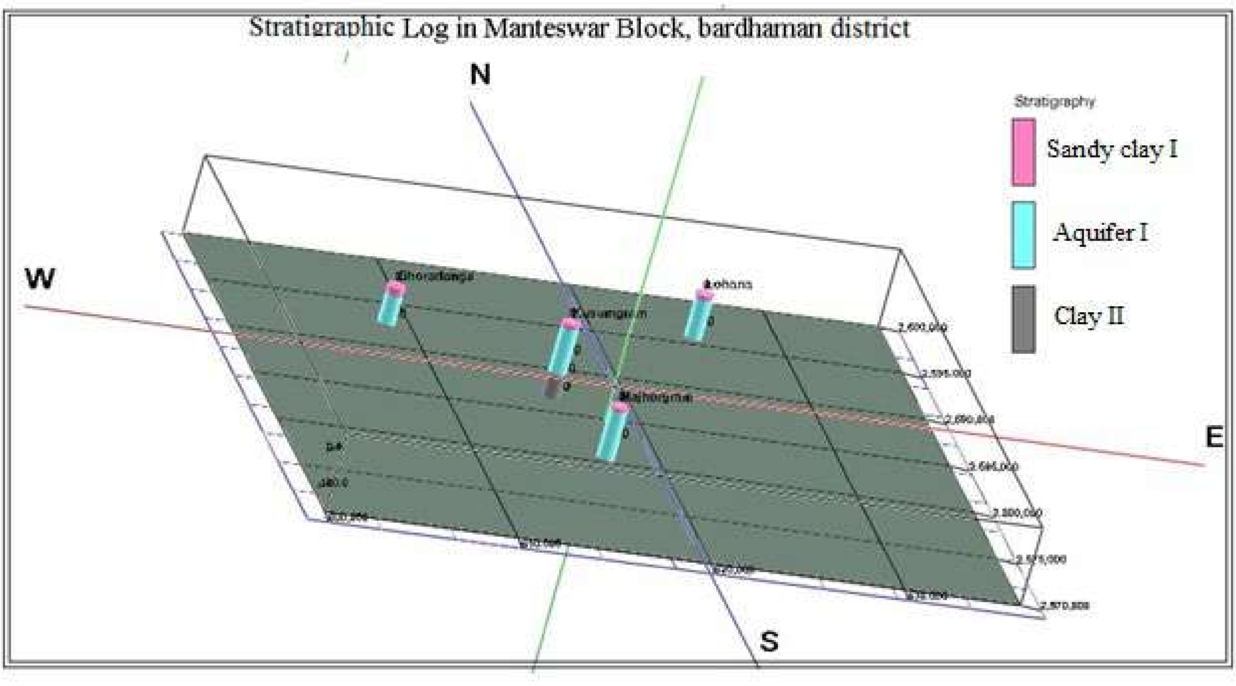


Plate 9.9.2: Stratigraphic logs in Manteswar block, Bardhaman district

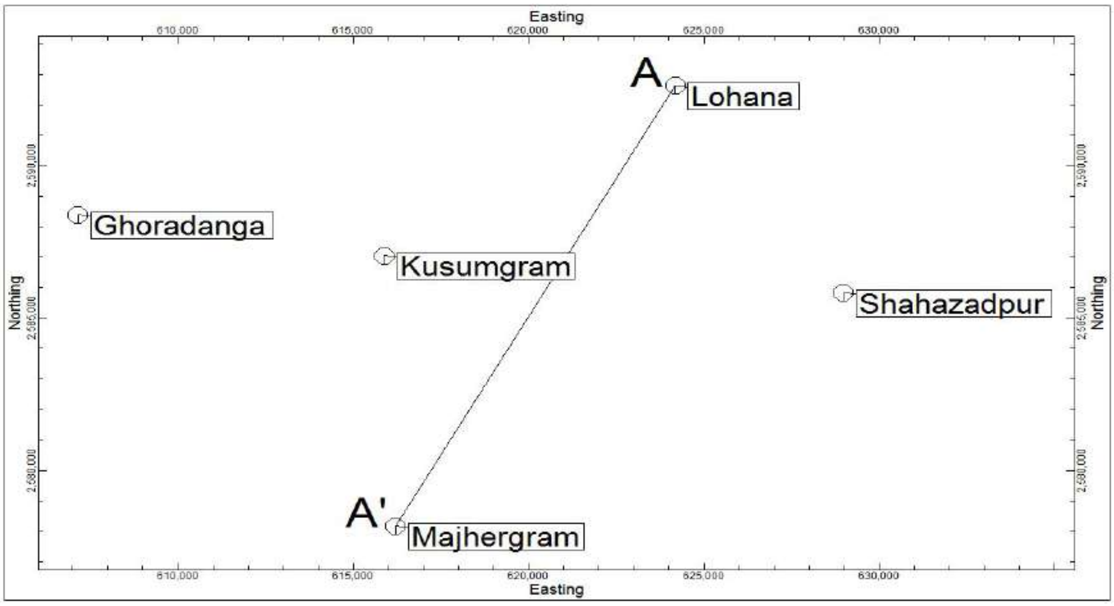


Plate 9.9.3: NE-SW Section Index Line in Manteswar block, Bardhaman district

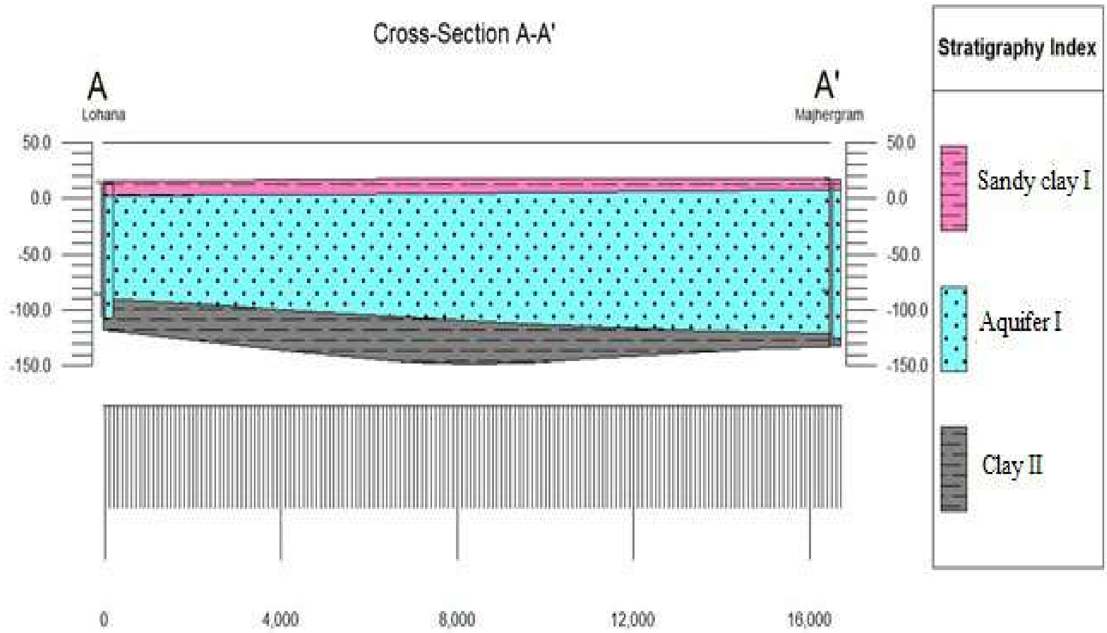


Plate: 9.9.4: NE-SW Section in Manteswar block, Bardhaman district

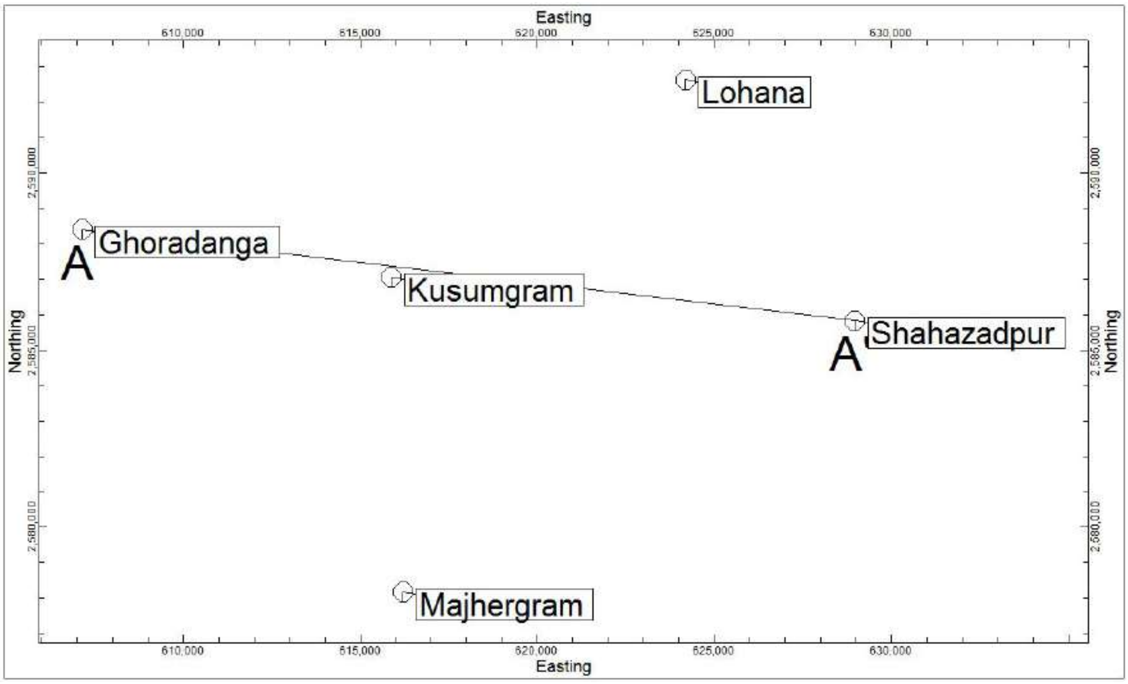


Plate 9.9.5: W-E Section Index Line in Manteswar block, Bardhaman district

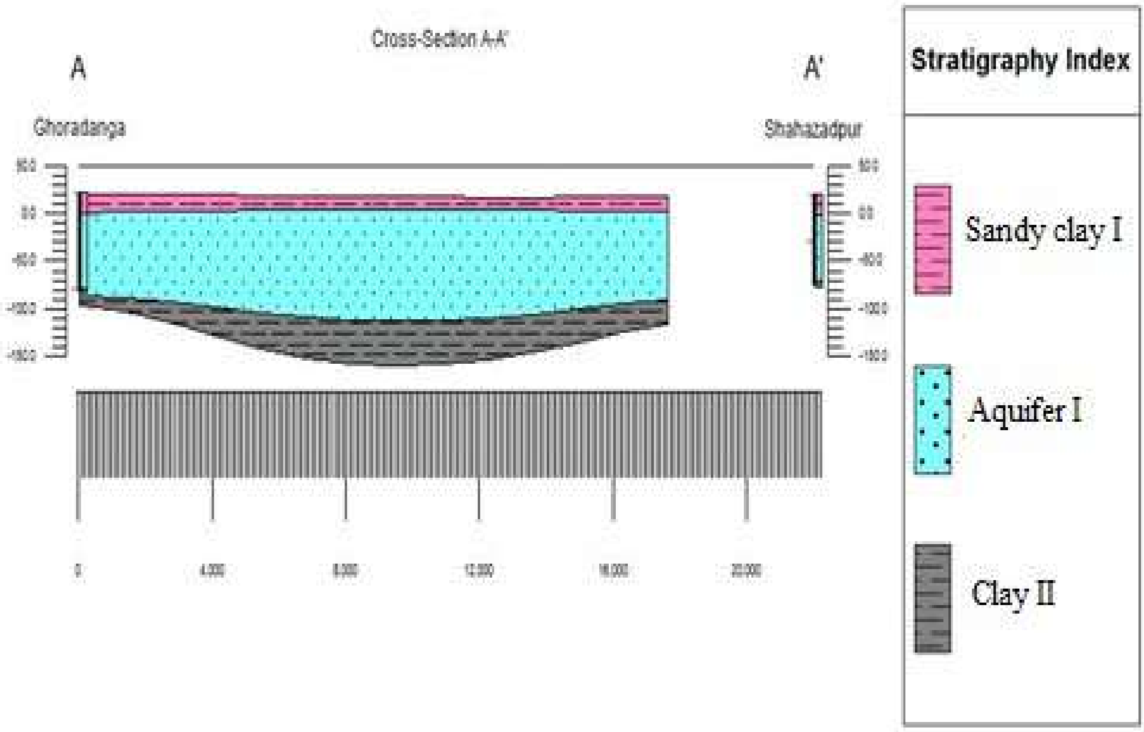


Plate 9.9.6: W-E Section in Manteswar block, Bardhaman district

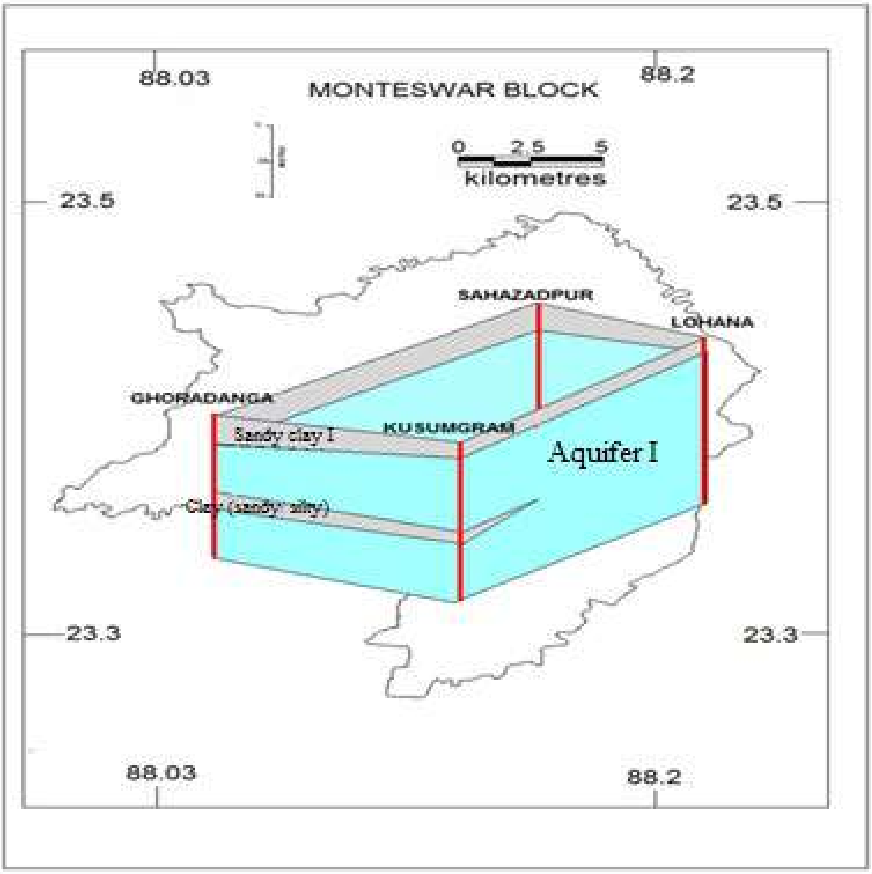


Plate 9.9.7: 3D view of Aquifer I in Manteswarblock, Bardhaman district

12.5.2 Ground Water Resource, Extraction, Contamination & other Issues:

Aquifer Wise Resource Availability & Extraction:

Dynamic ground water resources as on 31st March'13

Block	Net ground water availability (MCM)	Gross ground water draft (MCM)	Stage of development (%)	Category	Provision for domestic and industrial requirement supply upto next 25 years(MCM)
Manteswar	96.9411	64.0124	66.85	Semi-critical	3.1018

12.5.3 Chemical Quality of Ground Water & Contamination:

As -data based on 5 samples of spl. Drive' 15-16 & other parameters based on limited samples of 16-17.

Range of Chemical Pollutants:

Block	As (mg/l)	TH (mg/l)	EC (µS/cm)	F (mg/l)	NO_3(mg/l)
Manteswar	**Nil - 0.0001**	**95-115**	**442-508**	**1.06-1.75**	**bdl**

Percentage of tube wells having arsenic content in the block based on SOES data:

SI. No.	Blocks	Arsenic (<0.01 ing/1)	Arsenic (>0.01- <0.05 mg/1)	Arsenic (> 0.05 mg/1)	**Max. conc. mg/l (samples with As >1000□g/L (total samples)**
1	Manteswar	NA	-	-	.003 (47)

Arsenic affected Risk Population:

District	**Block (As affected)**	**No. of habitations in the risk zone where As conc. >0.05 mg/l**	**No. of habitations in the risk zone where As conc. 0.01 to 0.05 mg/l**	**Risk Population (2011) where As conc. >0.05 mg/l**
Barddhaman	Manteswar	Nil	Nil	Nil

12.5.4 Ground Water Resource Enhancement& Management Plan:

Ground Water Management Plan for drinking purposes

Table 9.9.5.1: Status of existing water supply schemes

(Source – PHED, Govt of West Bengal)

Proposed interventions:

There is only one single potential aquifer which has been encountered within 3-142m. Moderate to high discharge within 8-126 m^3/hr has been encountered in this aquifer. Hence,

Sr No.	Name of Block	Cultivable area in ha	Net irrigated area in ha	Area to be irrigated in ha	SOD in %	Pre monsoon WL Trend 2016 in cm/yr	Post monsoon WL Trend 2016 in cm/yr	Average Pre monsoon WL in mbgl	Average Post monsoon WL in mbgl	Remarks for GW Management Plan
1	Manteswar	24606	19241.96	5364.04	66.85	Fall 118.7	Fall 168.08	21.06	22.09	Can be developed for GW based Irrigation

to provide potable water, the following recommendations may be suggested:

Deep drilling down to about 350 m bgl may provide information about potentiality & quality of ground water in the block; presence of arsenic, if any, in ground water in the area may be negotiated. In future, tube wells tapping the fresh deeper aquifer with proper cement sealing against clay bed (if arsenic is reported in future) has been proved to be fruitful in supplying arsenic free fresh ground water to villages.

	Ongoing scheme		New scheme		Augmented scheme	
Block	Nos. of ongoing PWSS scheme	Population covered	Nos. of new PWSS scheme	Population covered	Nos. of augmented PWSS	Population covered
Manteswar	5	61814	2	11971		

Ground Water Management Plan for Irrigation purposes

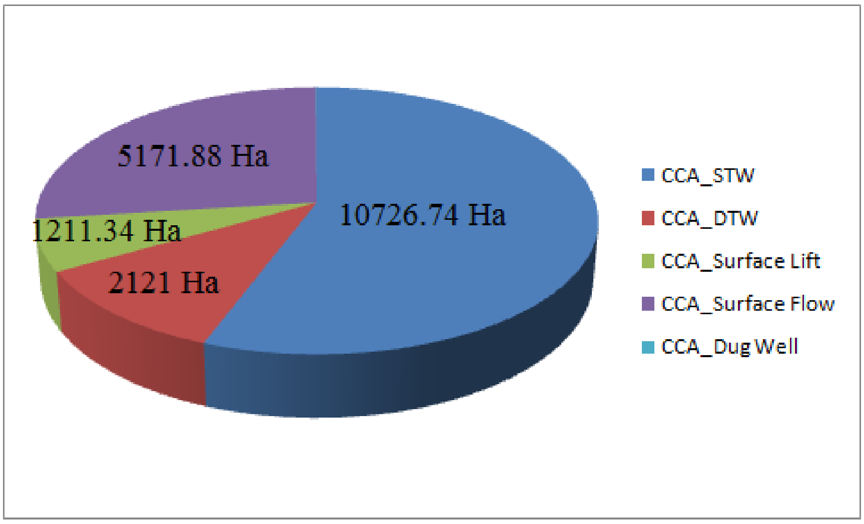
9.9.5.2: Irrigation Scenario in Bhatar block

The data of 4th MI census for Culturable Command Area in Bhatar block is given Table 9.9.5.3.

Table 9.9.5.3: CCA and sources of irrigation in Manteswar

(Source – Dept. of M.I., Govt. of West Bengal)

Table 9.9.6.3 and Fig. 9.9.6.1 indicate that almost 55.75 % and 11.02 % of the culturable area is irrigated by shallow tube wells and deep tube wells respectively. These sources are mostly used for rabi crops, boro paddy, etc. Surface Lift contributes 6.3 %, whereas Surface flow is contributing 26.88 % in irrigation.



Total CCA (Ha)	Dug well		Shallow Tube well		Deep Tube well		Surface Flow		Surface Lift		CCA (Ha)	
	Nos.	CCA (Ha)	Nos.	CCA(Ha)	Nos.	CCA (Ha)	Nos.	CCA (Ha)	Nos.	CCA (Ha)	Ground water	Surface water
19241.96	3	11.00	2061	10726.74	52	2121.00	43	5171.88	39	1211.34	12858.74	6383.22

Fig. 9.9.6.1: Per Cent contribution of different sources in irrigation

Data indicate that water level long term trends of this block show falling at a rate of 118.7 cm/year and 168.08 cm/ year in Aquifer I during in pre-monsoon and post-monsoon respectively. Depth to water level is also deep in nature. To improve this ground water scenario, rain water harvesting and artificial recharge may be implemented which might restrict the declining trend.

Space Available For Recharge and Proposed Interventions:

Table 9.9.6.4 Area suitable for recharge in the study area:

District	Block Name	Area (in sq. km)	Total Area suitable for recharge (sq. km.)
Bardhaman	Manteswar	319	319

Ground Water Management Plan for Irrigation purposes

Proposed Interventions:

Ground Water Resource Estimation shows that 5364.04 Ha of cultivable area is still not being covered by any irrigation schemes; it also indicates that ground water resource available for future irrigation is 3141.73 Ham. Considering Unit Draft of STW 0.022 MCM & Command Area of STW 6 Ha (0.06 sq. km), additional 8568 Ha area can be made irrigable (vide Table 9.9.6.5).

District	Block	Major crops/vegetable	Water column	Crops suggested for better	Water column depth(m)	Remarks e.g.

Net Ground Water Resource (MCM)	SOD (%)	Ground Water Resource available (MCM)	Available area to be irrigated (Ha)	Additional Nos. of STWs feasible	Additional Irrigation Potential Created(ha)
96.9411	66.85	31.4173	5364.04	1428	8568

Table – 9.9.6.5: Additional Irrigation Potential created by Available Ground Water Resource

Therefore, the whole area can be covered by the additional ground water resource available for irrigation, which has been estimated by the competent authority. However, if required, in near future during exigency rain water can be harvested.

Water column recommended in consultation with expert of Bidhan Chandra Krishi Vidyalaya Kalyani, for crops

		s/ fruits/flowers currently in practice	depth(m)	management(considering ground water quality & quantity)	recommended	Irrigation techniques etc
Barddhaman	Manteswar	Rice, potato, mustard, gram	Rice (1.2-1.4), mustard (0.2-0.25), potato (0.2-0.25), gram (0.10-0.12)	Rice, mustard, potato, Aram	Rice (0.75-0.85), mustard (0.2), potato (0.2), gram (0.08-0.12)	Alternate dry and wet method for rice, for others based on crop physiology

Scope for Rain Water Harvesting and Artificial Recharge in Study Area:

Using method of Dhruvanarayana, 1993, in Manteswar block, the number and types of artificial recharge and conservation structures proposed to be constructed for harvesting rain water and the estimated cost involved for doing this, have been shown in Table 9.9.6.6a & Table 9.9.6.6 b. 33.24 MCM of rain water has been estimated to be harvested. This Run off component of rainfall can be utilized in 45:45:10 ratio for construction of Irrigation Cum Recharge Tank, Re-excavation of Existing Tank and Farm Pond. By doing this, ground water scenario can be improved as well as the inclusive economic growth can be achieved. The harvested water can also be used for irrigation of cultivable land, if needed.

Table 9.9.6.6.a: Budgeting rain fall run off availability in Manteswar block

Normal monsoon rainfall in m(50 yrs data from data.gov.in) 'Rn'	Area(Ha) 'A'	Annual total volume of rain fall in Ham=(Rn X A)	Run off co-efficient from Dhruvanarayana,1993 (Land slope, type of land and soil type) 'C' land slope 0-5%	Major type of soil available in that block	Total volume of surface runoff available Annually 'Vt' (RnXAXC) Ham	75% of 'Vt' = V Ham	50% of V (Non committed) = Vnc Ham	60% of Vnc considered for harvesting = Vf Ham
1.029	31900	32825.1	0.45	50 % loam & 50 % silty clay	14771.3	11078.47	5539.24	3323.541375

Table 9.9.6.6.b: Proposed Artificial Recharge & conservation Structures (Details of structures given in Section II)

Block	Net run off water availability for recharge in MCM (1)	Source Water Allocation (MCM)				Number of Structures				Structure-wise Cost Estimate (lakh Rs.)				Total Cost Estimate (lakh Rs.)
		Irrigation cum recharge Tank – 45 % 0f Col. 1	Re-excavation of existing tanks with RS - – 45 % 0f Col. 1	Injection Well for recharging deeper layer – 0 % 0f Col. 1	Farm Pond- – 10 % 0f Col. 1	Irrigation cum recharge Tank	Re-excavation of existing tanks with RS	Injection Well for recharging deeper layer	Farm Pond-	Irrigation cum recharge Tank	Re-excavation of existing tanks with RS	Injection Well for recharging deeper layer	Farm Pond-	
Manteswar	33.24	14.96	14.96	0	3.32	30	150	0	33	240	1200	0	264	1704

Table 9.9.6.7 a: Cropping pattern of major crops (area in ha, production in '000 M. Tons)

Aus (Area)	Aus (Production)	Aman (Area)	Aman (Production)	Boro (Area)	Boro (Production)	Jute (Area)	Jute (Production)	Wheat (Area)	Wheat (Production)
1094	2.713	24160	48.314	23074	66.567	94	1.449	26	0.045

Table 9.9.6.7 b: Cropping pattern of major crops (area in ha, production in '000 M. Tons)

Potato (Area)	Potato (Production)	Masur (Area)	Musur (Production)	Mustard (Area)	Mustard (Production)	Til (Area)	Til (Production)	Gram (Area)	Gram (Production)
672	16.585	-	-	-	-	588	0.343	-	-

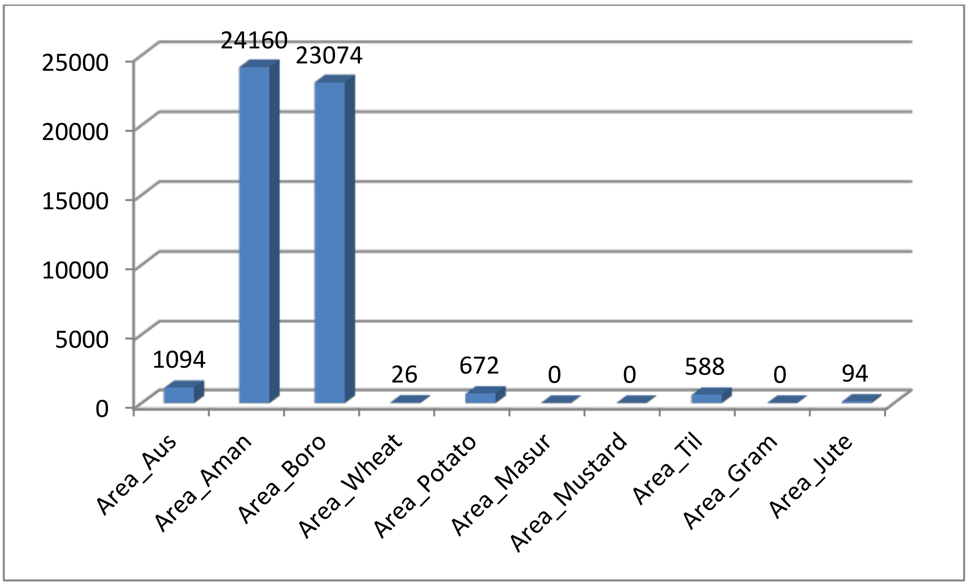


Fig. 9.9.7C: Graphical representation of cropping area in Manteswar block

For construction of the above said artificial recharge and conservation structures, an estimated Rupees 1704 lakh is required.

An attempt has also been made to modify cropping pattern as per the management strategy mentioned under section **Management Strategy of irrigation water & modification in cropping pattern.** In Table 9.9.7, it has been shown that by using this strategy production of cereals, pulses, oil seeds, etc. would be manifold. At the same time, due to restriction of Boro cultivation by 10% less than the present area of cultivation, a huge amount of vital ground water resources could be saved.

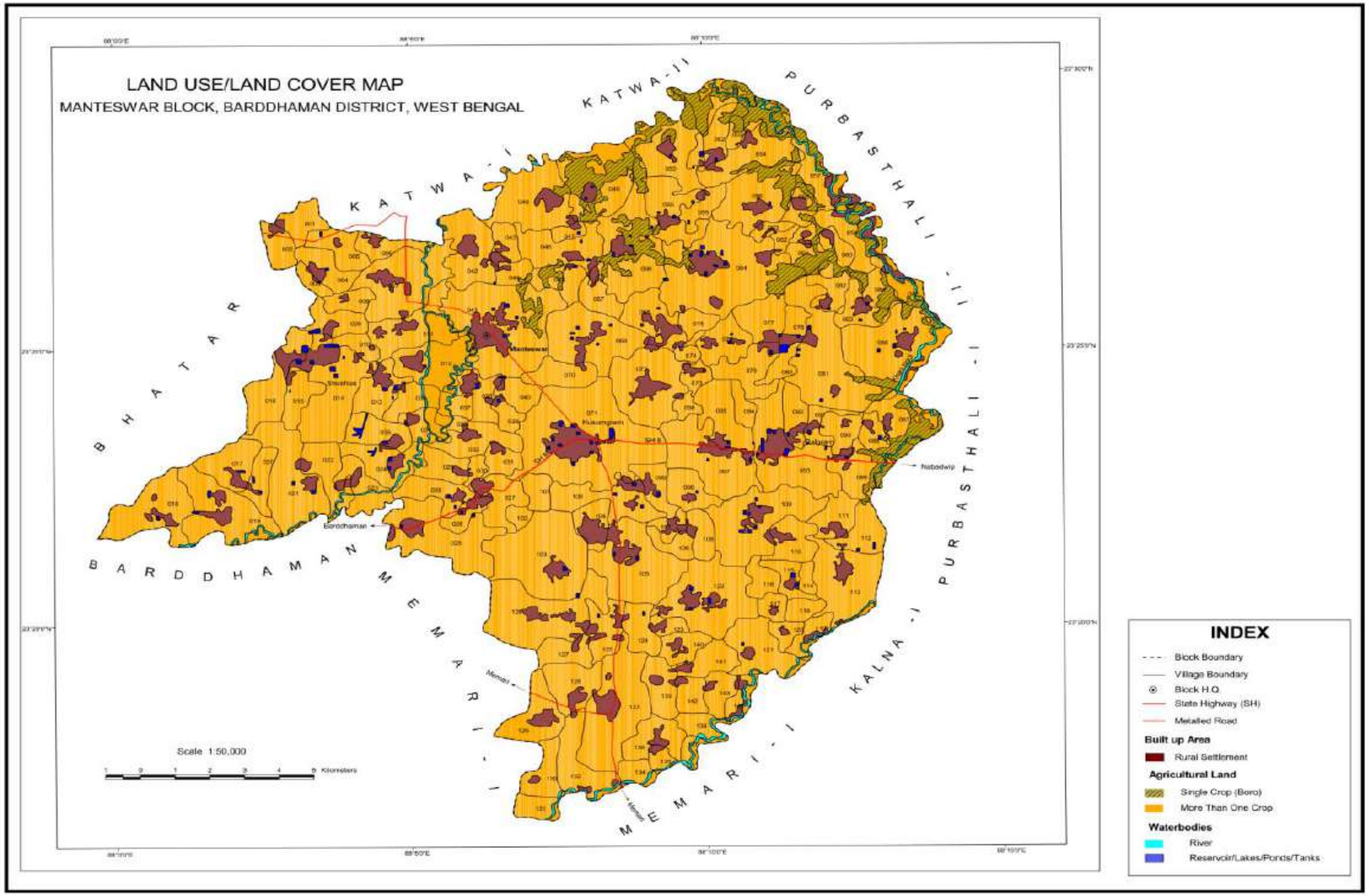


Plate 9.9.6: Land use/ land cover in Manteswar block

(Source: Land Use & Land Reforms Dept., Govt. W. B.)

Table 9.9.7: Proposed modification of cropping pattern in Manteswar block, Barddhaman district

Area of Boro cultivation (Ha)	**Average Water column required (m) for Col. I**	**G W draft due to boro cultivation (MCM) for Col. I**	**Proposed 10 % reduction of area of boro cultivation (Ha)**	**Amount of ground water saved (MCM) as in Col. I**	**Loss (MCM) of Boro due to reduction in area of cultivation @ yield rate of 3264.40 kg/ Ha**	**Proposed cropping in 1:1:1 ratio in lost area of Boro cultivation as proposed in Col IV**	**Gain (M. Ton each) due to alternate cropping @ existing yield rate Til @ 908.89 kg/hec, Ground nut @ 1770.45 kg/Ha & Mung @ 1182.23 kg/Ha**	**Ground water draft (MCM) for cultivation of TIl, Mung & Ground nut @ 0.15 m per Ha**	**Gain due to increase in area of Aus cultivation in Kharif (at least 10 % of existing area of Boro cultivation, i.e., 2307.4 Ha.) at yield rate 3361.24 kg/ Ha (M. Ton)**	Ground water saved (MCM)
(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)	(IX)	(X)	(XI)
23074	1.3	299.96	2307.4	30.00	7532.28	Til, Ground nut & Mung 769.13 Ha each.	Til-699.05, Ground nut-1361.71& Mung-909.29	3.46	7755.73	26.54

12.6 MANGALKOTE

Salient Information

Block Name: **Mangalkote**

Area (in km^2): 360.00

District: Bardhaman

State: West Bengal

Population (as on 2011):

Rural	Urban	Total
263240	----	263240

Approximate Decadal Growth Rate from 2001-2011: 12.52%

Rainfall:

Average annual district rainfallfor the period 2012 -16 (in mm):1380.28

Block	Normal	Actual (Annual)				
		2012	2013	2014	2015	2016
Mangalkote	1315.2	1276.6	1535.5	1134.4	1546.5	1408.4

Agriculture & Irrigation (area in sq. Km) :

SI. No	Name of the Block	Geographic Area	Cultivable Area	Area under pasture & orchard	Cultivable Waste Land	Forest Land
1.	Mangalkote	360	286	.02	16.09	-

Aquifer Wise Ground Water Resource Availability & Extraction(in MCM):

Resource Availability	Aquifer I	Aquifer II*	Extraction (for Aquifer I)
Dynamic Resource	123.94	0.95	47.6767
Static Resource	1927.872	-	-

*Ground water flow through in Aquifer II towards SE – 1889.76 m^3/day

12.6.1 Disposition of Aquifer:

Block	Depth range of Aquifer in m bgl	
Mangalkote	1st Aquifer	2nd aquifer
	5-72	80.5-112

Aquifer occurs under unconfined to semi-confined condition.

Both the potential aquifers join to form a single aquifer in the east.

Thickness of Aquifer(Average):

Block	Area (sq km)	Thickness of the Granular Zone in 1st aquifer (m)	Thickness of the Granular Zone in 2nd aquifer (m)	Remarks
Mangalkote	360.00	36.36	19.04	The two aquifers tend to meet together in the east.

Aquifer wise Statement

Name of Block	Aquifer I (in m bgl)			Aquifer II			Remarks
	Depth Range (m bgl)	Discharge (m^3/hr)	T (m^2/day)	Depth Range (m bgl)	Discharge (m^3/hr)	T (m^2/day)	
Mangalkote	5-72	42.98 – 117.28	425 – 1128, (4.56×10^{-1})	80.5-112	31.32	80 (**2.8×10^{-4} - 1.03×10^{-3}**)	-

Aquifer Wise Water Level Ranges & Pre-monsoon and Post-monsoon water level trends (2007- 2016)

SI. No.	Block	Aquifer	Pre-monsoon Trend			Post-monsoon Trend		
			Water Level Range (m bgl)	Rise (cm/year)	Fall (cm/year)	Water Level Range (m bgl)	Rise (cm/year)	Fall (cm/year)
1.	Mangalkote	I& II	12.8-25.49	-	Fall 84.77	6.49-26.93	-	Fall 101.5
2.	Mangalkote	II	18.19-28.82	-	-	11.05-29.2	-	-

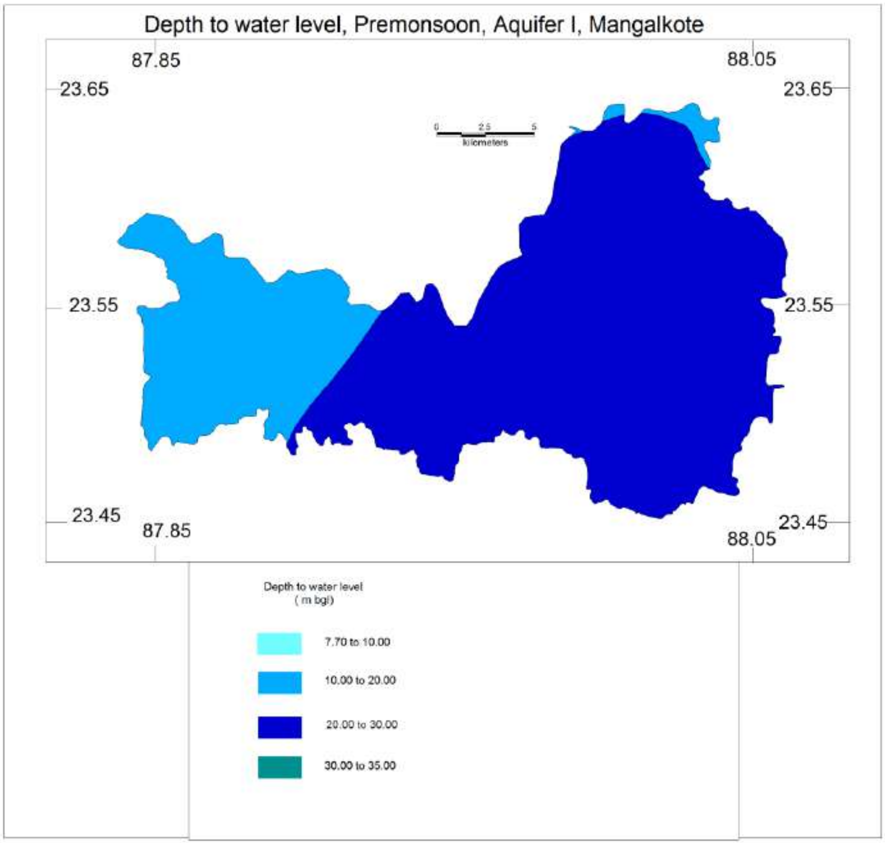


Fig. Depth to water level, Aquifer I, Pre monsoon

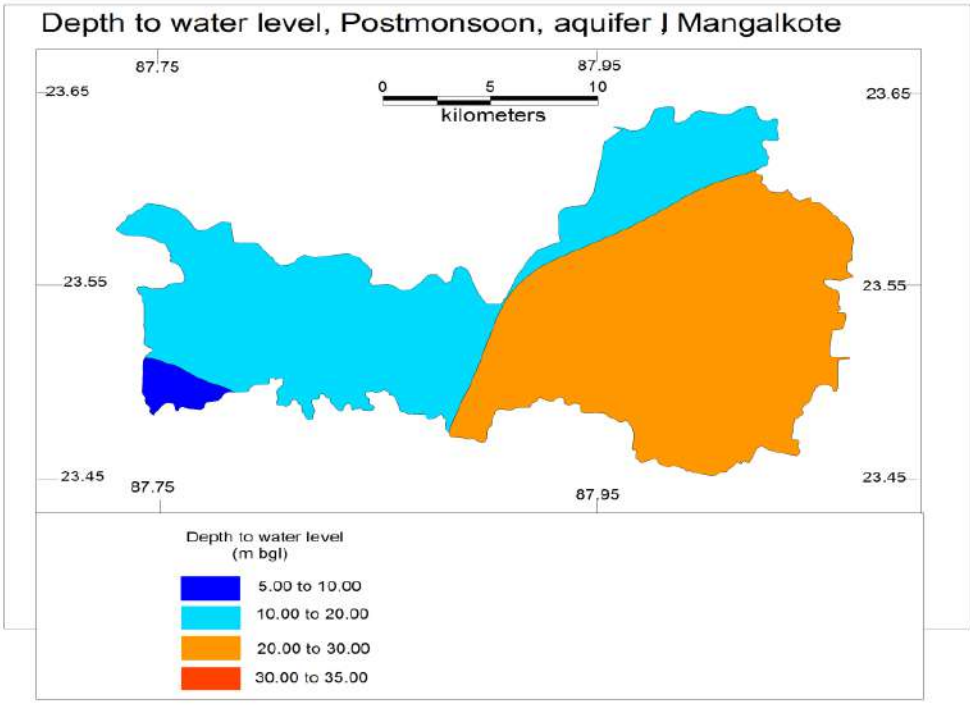


Fig. Depth to water level, Aquifer I, Post monsoon

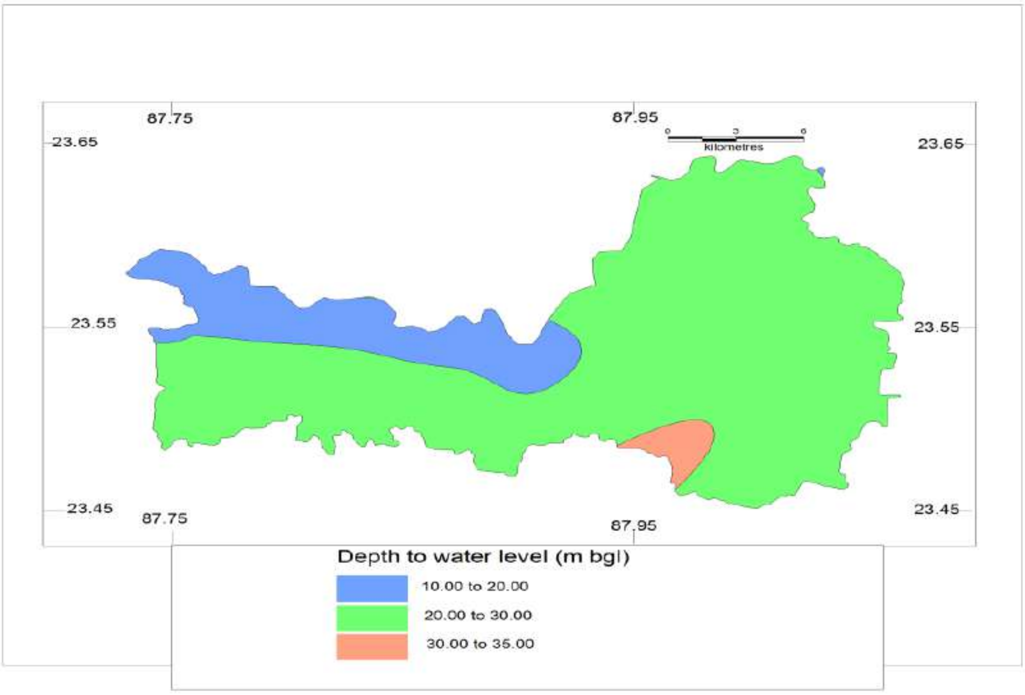


Fig. Depth to water level, Aquifer II, Pre monsoon

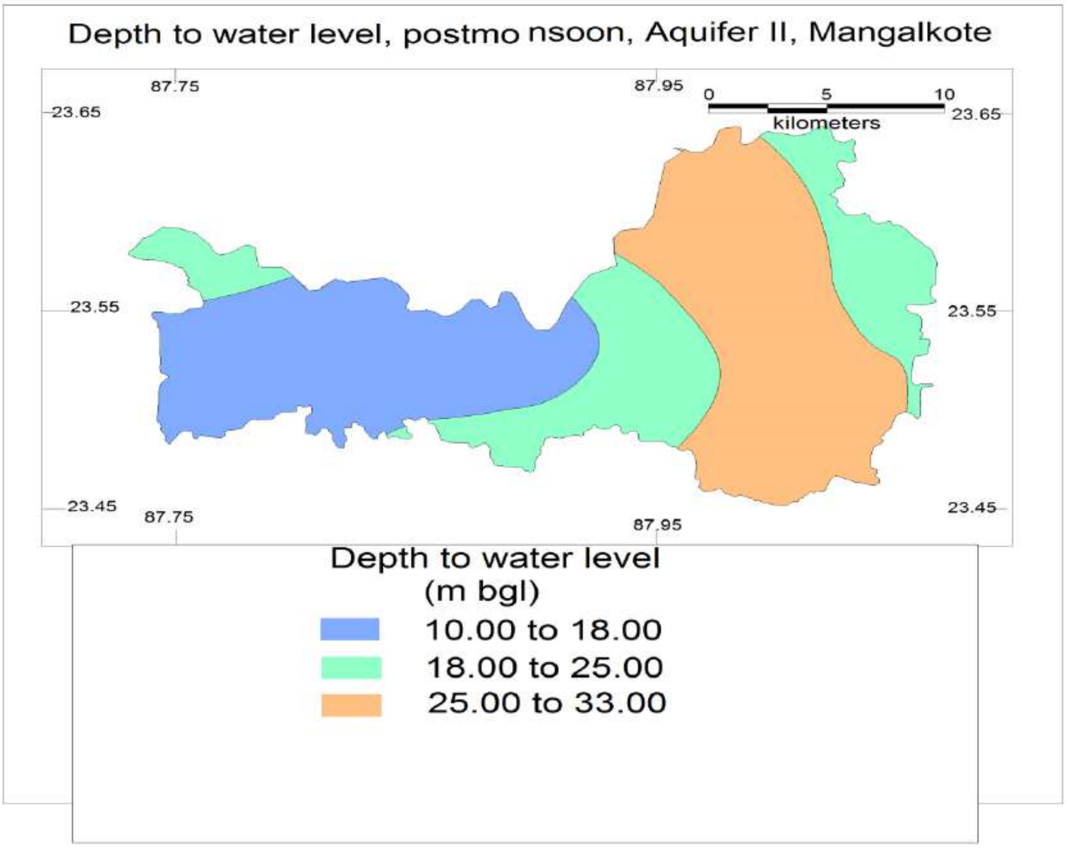


Fig. Depth to water level, Aquifer II, Post monsoon

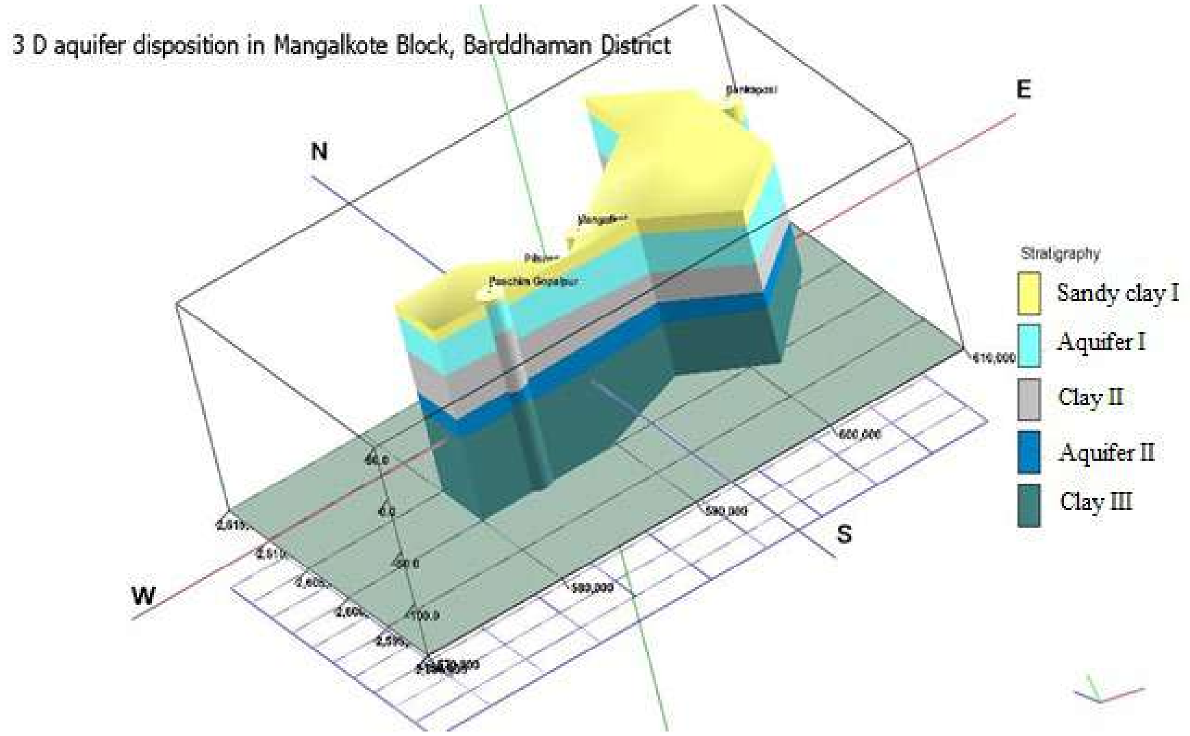


Plate 9.10.1: Aquifer disposition (3D) in Mangalkote block, Barddhaman district

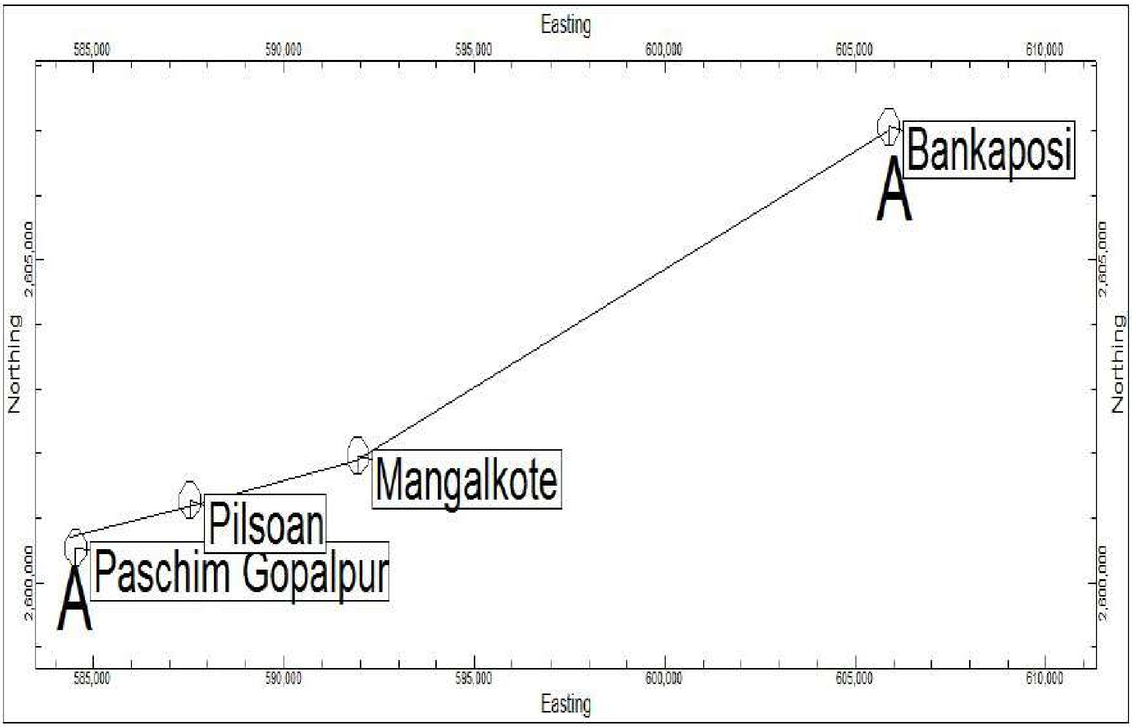


Plate 9.10.2: WNW-ESE Section Index Line in Mangalkote block, Barddhaman district

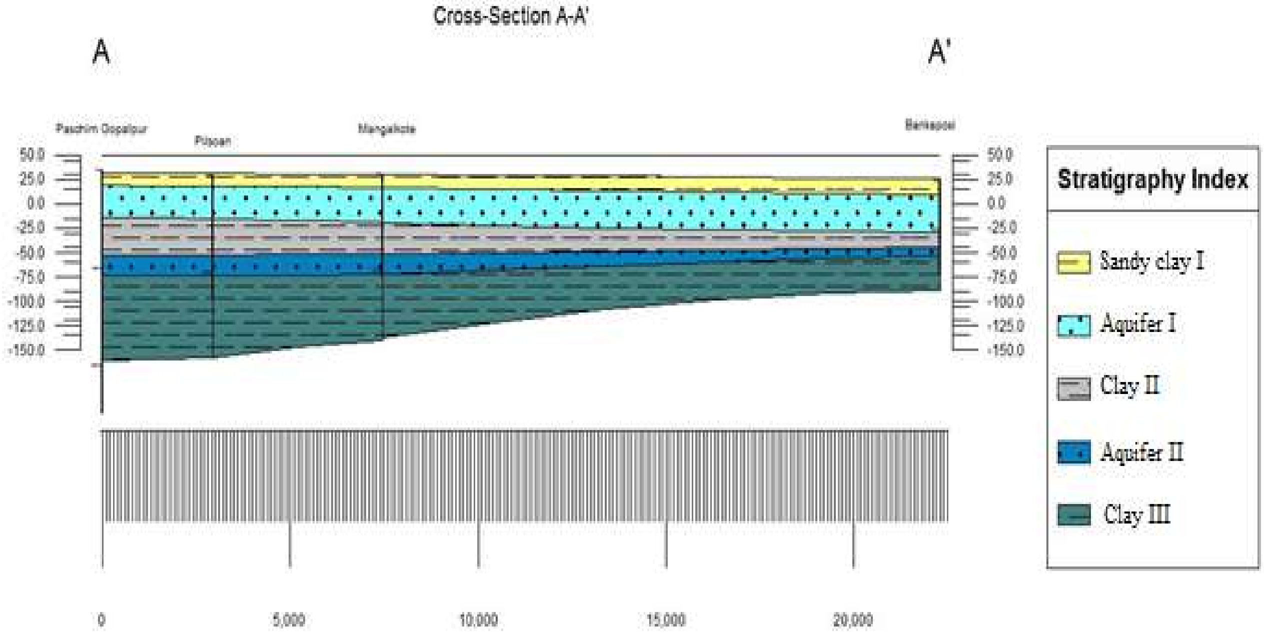


__Plate 9.10.3: WNW-ESE Section in Mangalkote block, Barddhaman district__

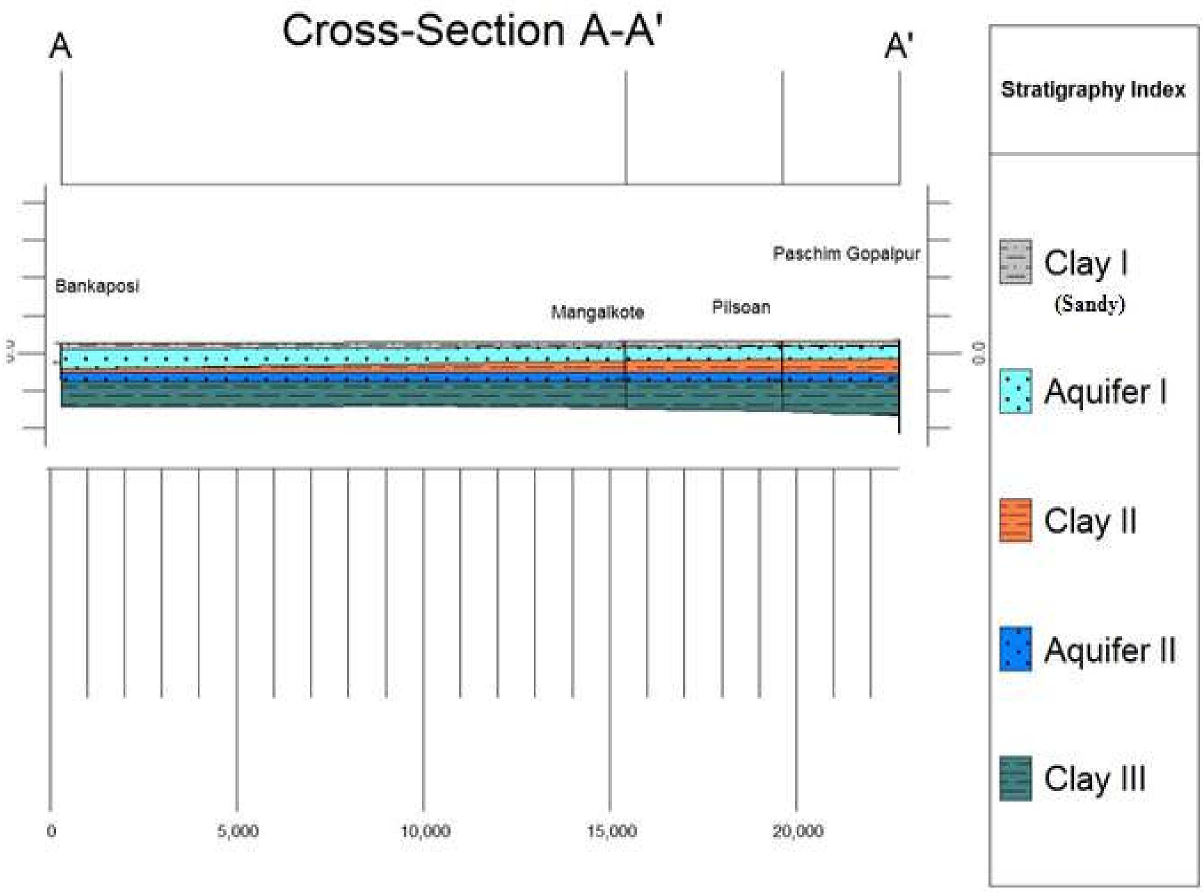


__Plate 9.10.4: NNE-SSW Section in Mangalkote block, Barddhaman district__

12.6.2 Ground Water Resource, Extraction, Contamination & other Issues:

Aquifer Wise Resource Availability & Extraction:

Dynamic ground water resources as on 31st March'11

Block	Net ground water availability (MCM)	Gross ground water draft (MCM)	Stage of development (%)	Category	Provision for domestic and industrial requirement supply up to next 25 years (MCM)
Mangalkote	123.94	47.6767	39.48	Semi-critical	13.7711

12.6.3 Chemical Quality of Ground Water & Contamination:

As -data based on3 samples of spl. Drive' 15-16 & other parameters based on limited samples of 16-17.

Range of Chemical Pollutants:

Block	As (mg/l)	TH (mg/l)	EC (µS/cm)	F (mg/l)	NO_3(mg/l)
Mangalkote	**Nil-0.001**	**85-100**	**271-383**	**0.98-1.81**	**Bdl-9.4**

Percentage of tube wells having arsenic content in the block based on SOES data:

SI. No.	Blocks	Arsenic (<0.01 ing/1)	Arsenic (>0.01- <0.05 mg/1)	Arsenic (> 0.05 mg/1)	Max. conc. mg/l (samples with As >1000□g/L (total samples)
1	Mangalkote	NA	-	-	0.004(73)

Arsenic affected Risk Population:

No record available

12.6.4 Ground Water Resource Enhancement& Management Plan:

Ground Water Management Plan for drinking purposes.

Table 9.10.5.1: Status of existing water supply schemes

(Source- PHED, Govt. of West Bengal)

Proposed interventions:

There are two aquifers which have been encountered within depth of 5-72 m and 80.5-112 m respectively. Discharge is very high up to about 117.30 m^3/hr in Aquifer I and low to moderate to an extent of 31.32 m^3/hr. Both these aquifers tend to coalesce together nearby.

Block	Ongoing scheme		New scheme		Augmented scheme	
	Nos. of ongoing PWSS scheme	Population covered	Nos. of new PWSS scheme	Population covered	Nos. of augmented PWSS	Population covered
Mangalkote	4	50774	1	7574	3	50193

Ground water in both of these aquifers are potable. However, for drinking purpose deeper aquifer is always better.

Deep drilling down to about 350 m bgl may provide information about potentiality & quality of ground water in the block; presence of arsenic, if any, in ground water in the area may be negotiated. In future, tube wells tapping the fresh deeper aquifer with proper cement sealing against clay bed (if arsenic is reported in future) has been proved to be fruitful in supplying arsenic free fresh ground water to villages.

Ground Water Management Plan for Irrigation purposes

9.10.5.2: Irrigation Scenario in Mangalkote block (Aquifer I)

The data of 4th MI census for Culturable Command Area in Mangalkote block is given Table 9.10.5.3.

Table 9.10.5.3: CCA and sources of irrigation in Mangalkote

Name of Block	**Cultivable area in ha**	**Net irrigated area in Ha**	**Area to be irrigated in Ha**	**SOD in %**	**Pre monsoon WL Trend 2016 in cm/yr**	**Post monsoon WL Trend 2016 in cm/yr**	**Average Pre monsoon WL in m bgl**	**Average Post monsoon WL in m bgl**
Mangalkote	28600	9697.7	18902.3	39.48	Fall 84.77	Fall 101.5	19.54	19.43

(Source – Dept. of M.I., Govt. of West Bengal)

Block		Dug well		Shallow Tube well		Deep Tube well		Surface Flow		Surface Lift		CCA (Ha)	
	Total CCA (Ha)	Nos.	CCA(Ha)	Nos.	CCA(Ha)	Nos.	CCA (Ha)	Nos.	CCA (Ha)	Nos.	CCA (Ha)	Ground water	Surface water
Mangalkote	9697.70	1	6.07	1715	8677.51	13	521.00	7	11.31	142	481.81	9204.58	493.12

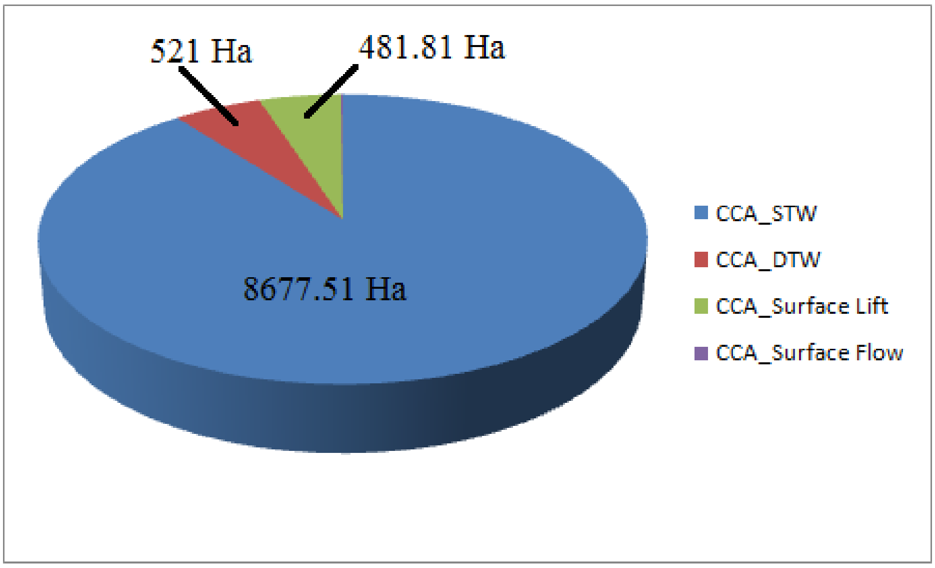


Fig. 9.10.6.1: Per Cent contribution of different sources in irrigation

Table 9.10.6.3 and Fig. 9.10.6.1 indicate that almost 89.88 % and 5.37 % of the cultivable area is irrigated by shallow tube wells and deep tube wells respectively. These sources are mostly used for rabi crops, boro paddy, etc. Surface Lift contributes 4.97 %, whereas Surface flow is contributing only 0.12 % in irrigation.

Data indicate that water level long term trends of this block show falling at a rate of cm/year and cm/ year in Aquifer I during in pre-monsoon and post-monsoon respectively. Aquifer II tends to coalesce withn Aquifer I nearby. Depth to water level is also deep in nature. To improve this ground water scenario, rain water harvesting and artificial recharge may be implemented which might restrict the declining trend.

Space Available for Recharge and Proposed Interventions:

Table 9.10.6.4 **Area suitable for recharge in the study area:**

District	Block Name	Area (in sq. km)	Total Area suitable for recharge (sq. km.)
Barddhaman	Mangalkote	360	360

Ground Water Management Plan for Irrigation purposes

Proposed Interventions:

Ground Water Resource Estimation shows that 18902.3 Ha of cultivable area is still not being covered by any irrigation schemes; it also indicates that ground water resource available for future irrigation is 7388.48 Ham. Considering Unit Draft of STW 0.022 MCM & Command Area of STW 6 Ha (0.06 sq. km), additional 20148 Ha area can be made irrigable (vide Table 9.10.6.5).

Table – 9.10.6.5: Additional Irrigation Potential created by Available Ground Water Resource

Net Ground Water Resource (MCM)	SOD (%)	Ground Water Resource available (MCM)	Available area to be irrigated (Ha)	Additional Nos. of STWs feasible	Additional Irrigation Potential Created(ha)
123.94	39.48	73.8848	18902.3	3358	20148

Therefore, the whole area can be covered by the additional ground water resource available for irrigation, which has been estimated by the competent authority. However, if required, in near future during exigency rain water can be harvested.

Water column recommended in consultation with expert of Bidhan Chandra Krishi Vidyalaya Kalyani, for crops

Scope for Rain Water Harvesting and Artificial Recharge in Study Area:

Using method of Dhruvanarayana, 1993, in Mangalkote block, the number and types of artificial recharge and conservation structures proposed to be constructed for harvesting rain water and the estimated cost involved for doing this, have been shown in Table 9.10.6a & Table 9.10.6 b. 42.51 MCM of rain water has been estimated to be harvested. This

Run off component of rain fall can be utilized in 45:45:10 ratio for construction of suitable Irrigation Cum Recharge Tank, Re-excavation of Existing Tank with Recharge Shaft andfarm Pond. For construction of the above said structures, an estimated Rupees 2176 lakh is required. The harvested water can also be utilized for irrigation of cultivable land, if needed. By doing this, ground water scenario can be improved as well as the inclusive economic growth can also be achieved.

District	Block	Major crops/vegetables/ fruits/flowers currently in practice	Water column depth (m)	Crops suggested for better management (considering ground water quality & quantity)	Water column depth (m) recommended	Remarks e.g. Irrigation techniques etc
Barddhaman	Mangalkote	Rice, potato, mustard, gram	Rice (1.2-1.4), mustard (0.2-0.25), potato (0.2-0.25), gram (0.10-0.12)	Rice, mustard, potato, gram	Rice (0.75-0.85), mustard (0.2), potato (0.2), gram (0.08-0.12)	Alternate dry and wet method for rice, for others based on crop physiology

Table 9.10.6.6.a: Budgeting rain fall run off availability in Mangalkote block

Normal monsoon rainfall in m (50 yrs data from data.gov.in) 'Rn'	Area (Ha) 'A'	Annual total volume of rain fall in Ham = (Rn X A)	Run off co-efficient from Dhruvanarayana, 1993 (Land slope, type of land and soil type) 'C' land slope 0-5%	Major type of soil available in that block	Total volume of surface runoff available Annually 'Vt' (RnXAXC) Ham	75% of 'Vt' = V Ham	50% of V (Non committed) = Vnc Ham	60% of Vnc considered for harvesting = Vf Ham
1.029	36000	37044	0.51	30 % loam & 70 % silty clay	18892.44	14169.33	7084.67	4250.799

Table 9.10.6.6.b: Proposed Artificial Recharge & Conservation Structures in Mangalkote Block (Details of structures given in Section II)

Block	Net surface water availability for recharge in MCM (1)	Source Water Allocation (MCM)				Number of Structures				Structure-wise Cost Estimate (lakh Rs.)				Total Cost Estimate (lakh Rs.)
		Irrigation cum recharge Tank- 45 % of Col. 1	Re-excavation of existing tanks with RS -- 45 % of Col. 1	Injection Well for recharging deeper layer-- 0% of Col. 1	Farm Pond- - 10 % of Col. 1	Irrigation cum recharge Tank	Re-excavation of existing tanks with RS	Injection Well for recharging deeper layer	Farm Pond-	Irrigation cum recharge Tank	Re-excavation of existing tanks with RS	Injection Well for recharging deeper layer	Farm Pond-	
Mangalkote	42.51	19.13	19.13	0	4.25	38	191	0	43	304	1528	0	344	2176

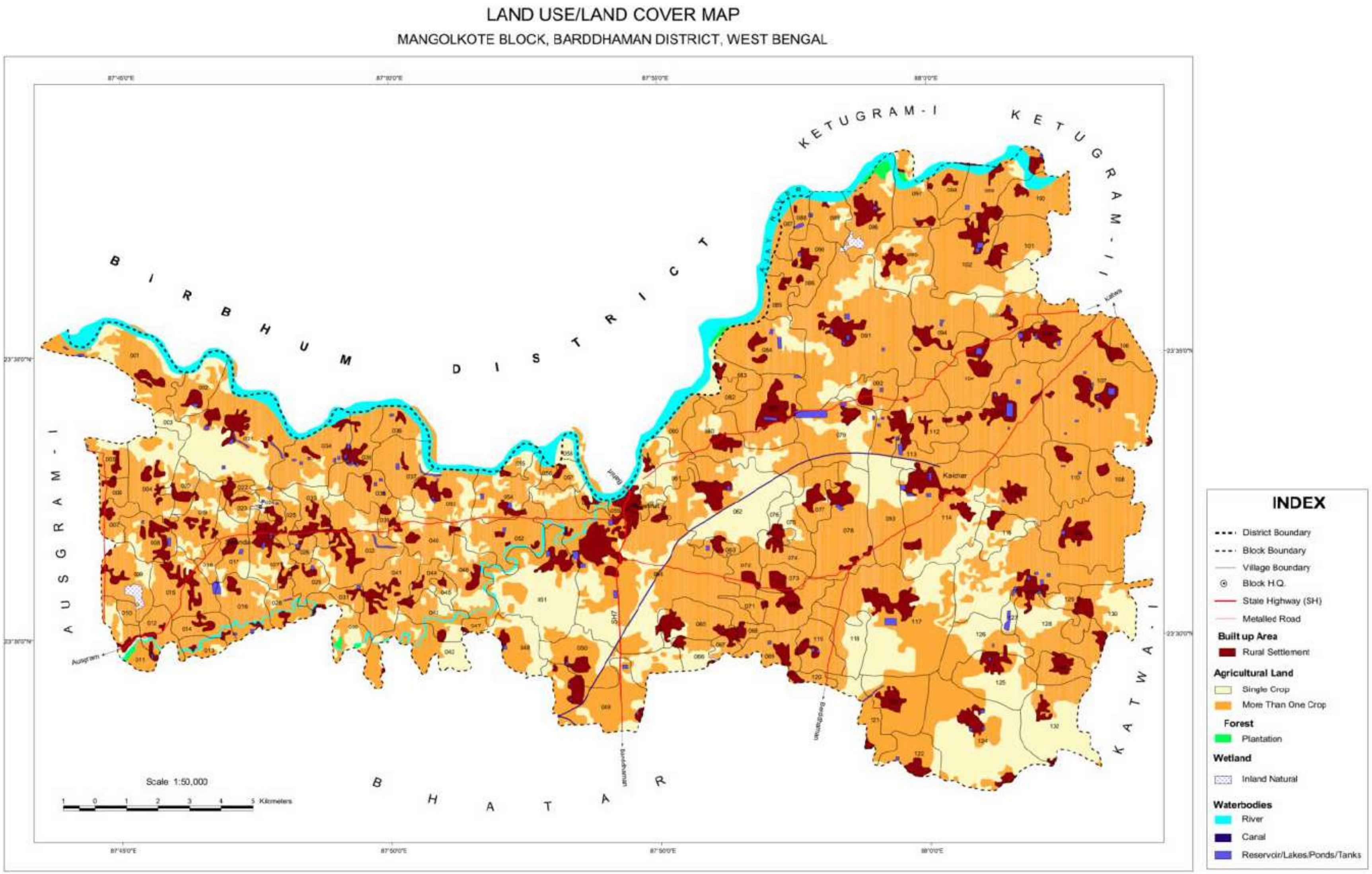


Plate 9.10.6: Land use/ land cover in Mangalkote blocK ***(Source: Land Use & Land Reforms Dept., Govt. W. B.)***

Table 9.10.6.7 a: Cropping pattern of major crops (area in ha, production in '000 m tons)

Aus (Area)	Aus (Production)	Aman (Area)	Aman (Production)	Boro (Area)	Boro (Production)	Jute (Area)	Jute (Production)	Wheat (Area)	Wheat (Production)
1763	4.363	25944	67.551	15492	57.708	2	0.024	82	0.2

Table 9.10.6.7 b: Cropping pattern of major crops (area in ha, production in '000 m tons)

Potato (Area)	Potato (Production)	Masur (Area)	Musur (Production)	Mustard (Area)	Mustard (Production)	Til (Area)	Til (Production)	Gram (Area)	Gram (Production)
4046	90.75	9	0.004	-	-	1566	1.337	-	-

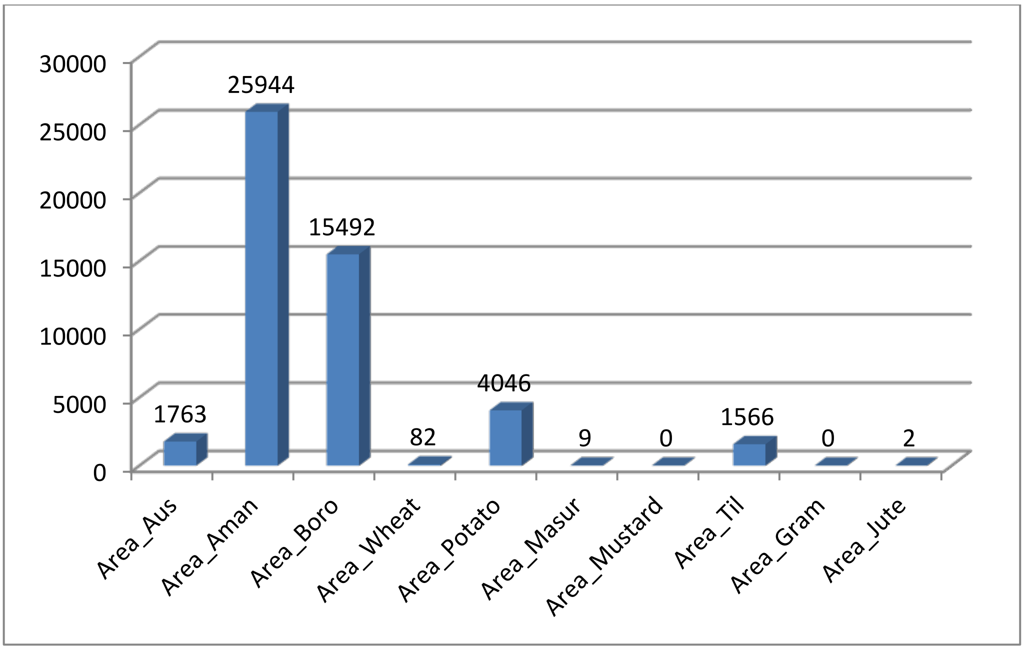


Fig. 9.10.6.7 b: Graphical presentation of cropping pattern of major crops (area in ha)

An attempt has also been made to modify cropping pattern as per the management strategy mentioned under section **Management Strategy of irrigation water & modification in cropping pattern.** In Table 9.10.7, it has been shown that by using this strategy production of cereals, pulses, oil seeds, etc. would be manifold. At the same time, due to restriction of Boro cultivation by 10% less than the present area of cultivation, a huge amount of vital ground water resources could be saved.

Table 9.10.7: Proposed modification of cropping pattern in Mangalkote block, Barddhaman district

Area of Boro cultivation (Ha)	**Average Water column required (m) for Col. I**	**G W draft due to boro cultivation (MCM) for Col. I**	**Proposed 10 % reduction of area of boro cultivation (Ha)**	**Amount of ground water saved (MCM) as in Col. I**	**Loss (Kg of Boro paddy) due to reduction in area of Boro cultivation yield rate 3264.40 kg/ Ha (in M. Ton)**	**Proposed cropping in 1:1:1 ratio in lost area of Boro cultivation as proposed in Col IV**	**Gain (M. Ton each) due to alternate cropping @ existing yield rate Til @ 908.89 kg/hec, Ground nut @ 1770.45 kg/Ha & Mung @ 1182.23 kg/Ha**	**Ground water draft (MCM) for cultivation of Til, Mung & Ground nut @ 0.15 m per Ha**	**Gain due to increase in area of Aus cultivation in Kharif (at least 10 % of existing area of Boro cultivation, i.e. 1549.2 Ha.) at yield rate 3361.24 kg/ Ha (M. Ton)**	Ground water saved (MCM)
(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)	(IX)	(X)	(XI)
15492	1.3	20.13	1549.2	20.14	5057.21	Til, Ground nut & Mung 516.4 Ha each.	Til- 469.35, Ground nut-914.26& Mung-610.50	2.32	5207.23	17.81

12.7 MEMARI II

Salient Information

Block Name: **Memari II**

Area reported (in km^2): 186.64

District: Bardhaman

State: West Bengal

Population(as on 2011):

Rural	Urban	Total
150252	----	150252

Approximate Decadal Growth Rate from 2001-2011: 10.78%

Rainfall:

Average district annual rainfall for the period 2012 -16 (in mm): 1380.28

Block	Normal	Actual (Annual)				
		2012	2013	2014	2015	2016
Memari II	1315.2	1276.6	1535.5	1134.4	1546.5	1408.4

Agriculture & Irrigation (area in sq. Km) :

Sl. No	Name of the Block	Area reported	Cultivable Area	Area under pasture & orchard	Cultivable Waste Land	Forest Land
1.	Memari II	186.64	145.08	0.11	-	0

.Aquifer Wise Ground Water Resource Availability & Extraction (in MCM):

Resource Availability	Aquifer I	Aquifer II*	Extraction (for Aquifer I)
Dynamic Resource	55.6745	0.096	35.0025
Static Resource	150223.2	-	-

*Ground water flow through Aquifer II towards E – 3432.97 m^3/day

12.7.1 Disposition of Aquifer:

Block	Depth range of Aquifer in mbgl	
	1st Aquifer	2nd aquifer
MemariII	7.5-80	105-118, 165-178

Aquifer I occur under unconfined condition, Aquifer II occurs under semi-confined to confined condition.

Aquifer Wise Water Level Ranges & Pre-monsoon and Post-monsoon water level trends (2006 to 2016):

SI. No.	Block	Aquifer	Pre-monsoon Trend			Post-monsoon Trend		
			Water Level Range (m bgl)	Rise (cm/year)	Fall (cm/year)	Water Level Range (m bgl)	Rise (cm/year)	Fall (cm/year)
1.	MemariII	I	14.96-21.87		Fall 100.4	12.1-23.15		Fall 94.6
2.	MemariII	II	24.36-33.13		-	24.7-26.54		-

Thickness of Aquifer(average):

Block	Area (sq km)	Thickness of the Granular Zone in Aquifer I (m)	Thickness of the Granular Zone in Aquifer II (m)
Memari II	106	49.96	61.98

Aquifer-wise Statement

Name of Block	Aquifer I			Aquifer II			Remarks
	Depth Range (m bgl)	Discharge (m^3/hr)	T (m^2/day)	Depth Range (m bgl)	Discharge (m^3/hr)	T (m^2/day)	
Memari II	7.5-115	36	40.44 - 41.40	105-118, 165-178	14.40	-	-

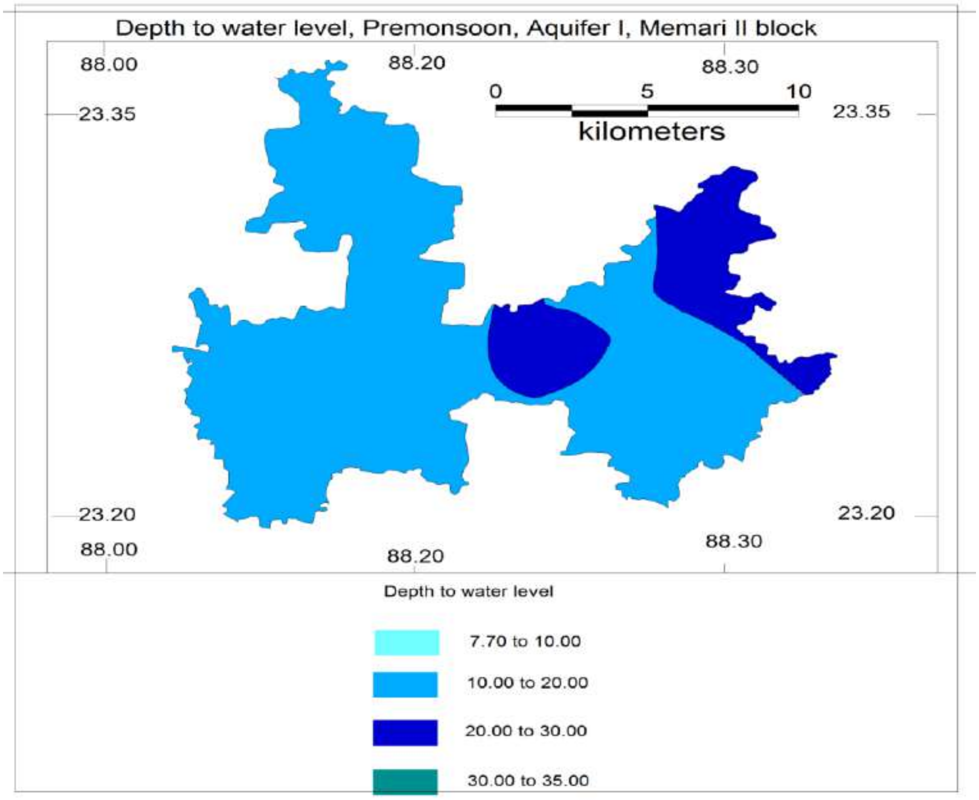


Fig. Depth to water level, Aquifer I, Pre monsoon

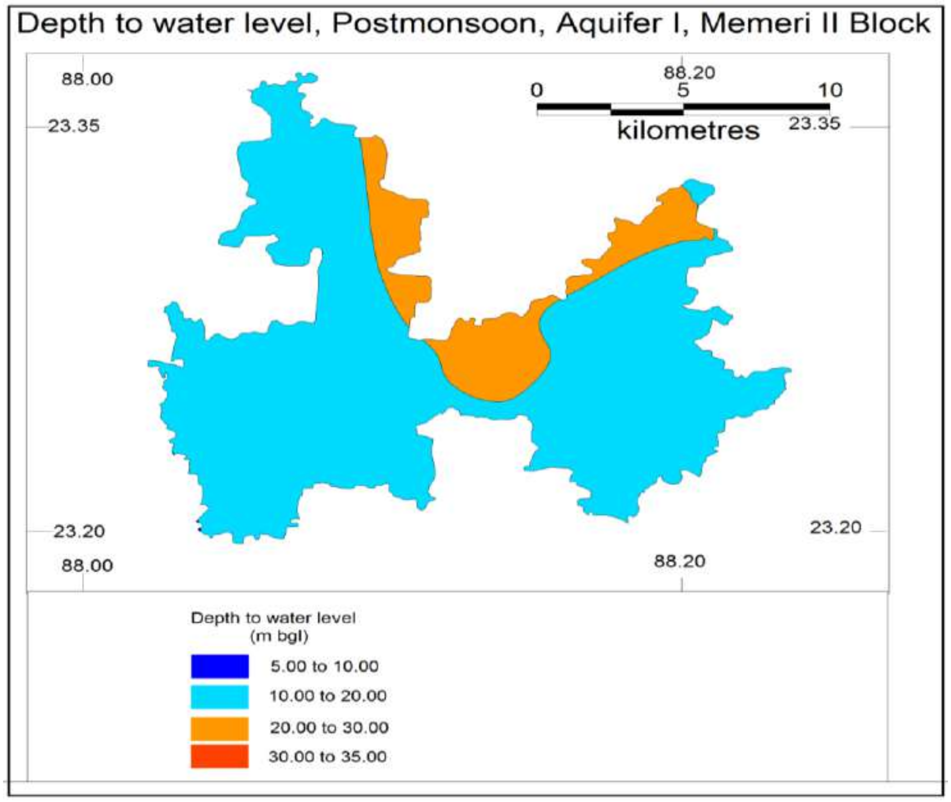


Fig. Depth to water level, Aquifer I, Post monsoon

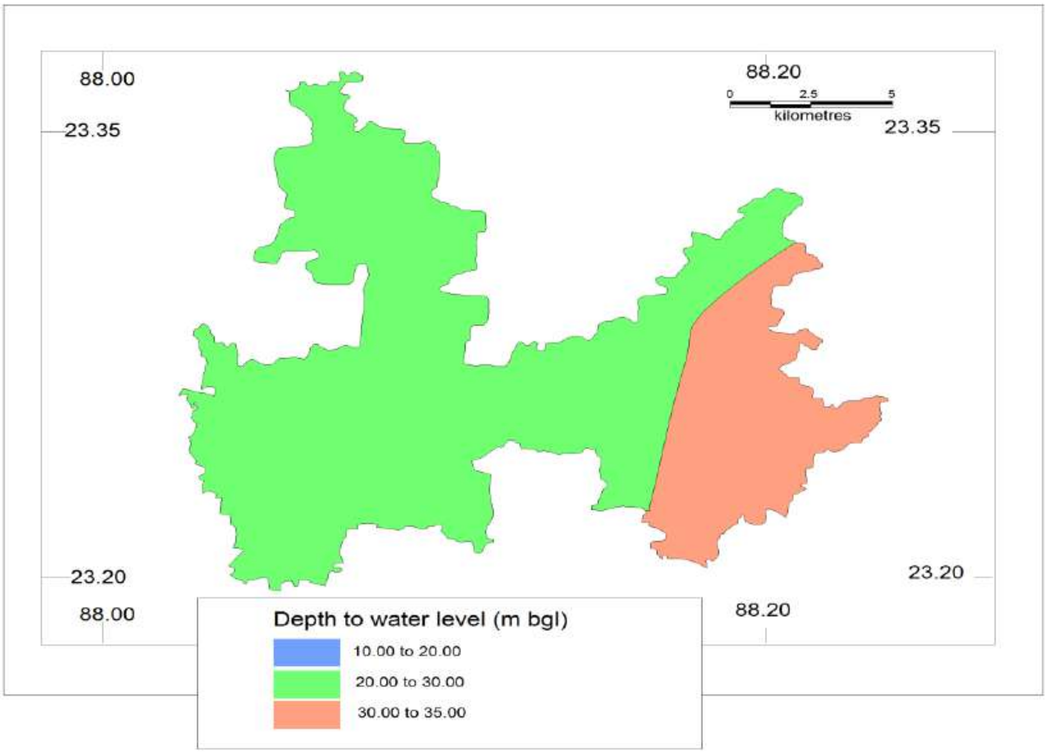


Fig. Depth to water level, Aquifer II, Pre monsoon

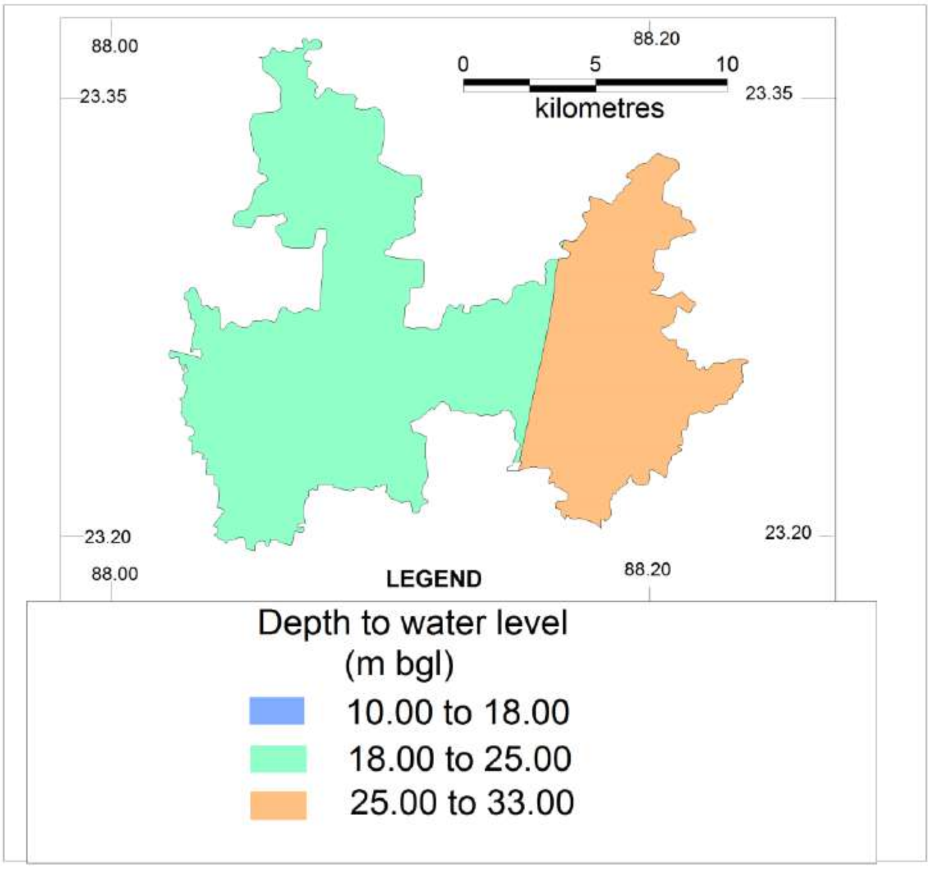


Fig. Depth to water level, Aquifer II, Post monsoon

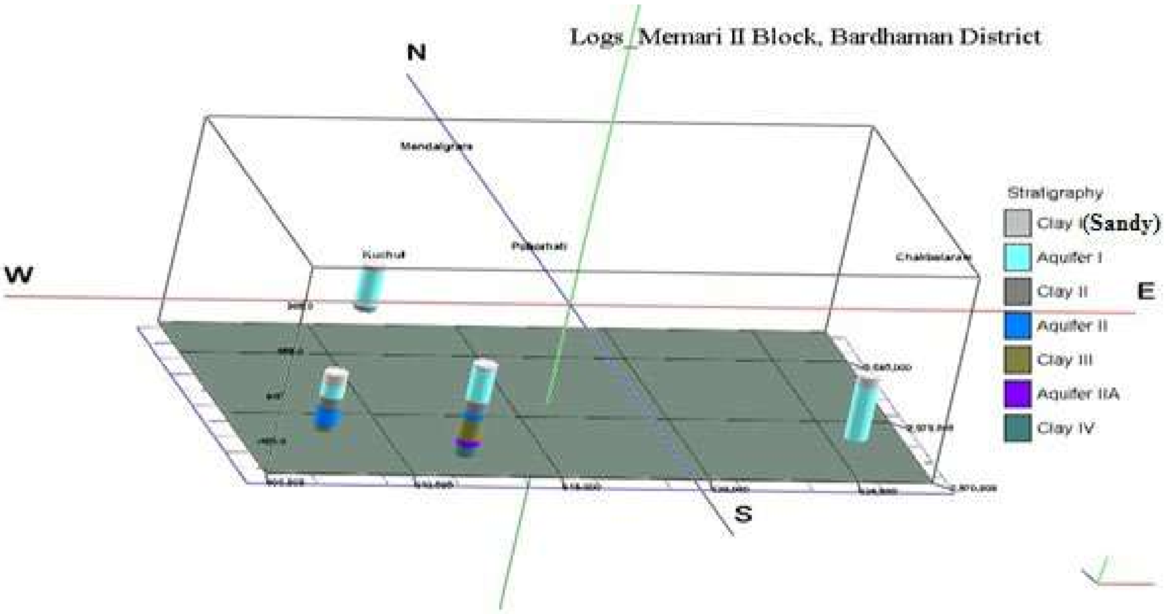


Plate 9.11.1: Stratigraphic Logs at four locations in Memari II block, Bardhaman district

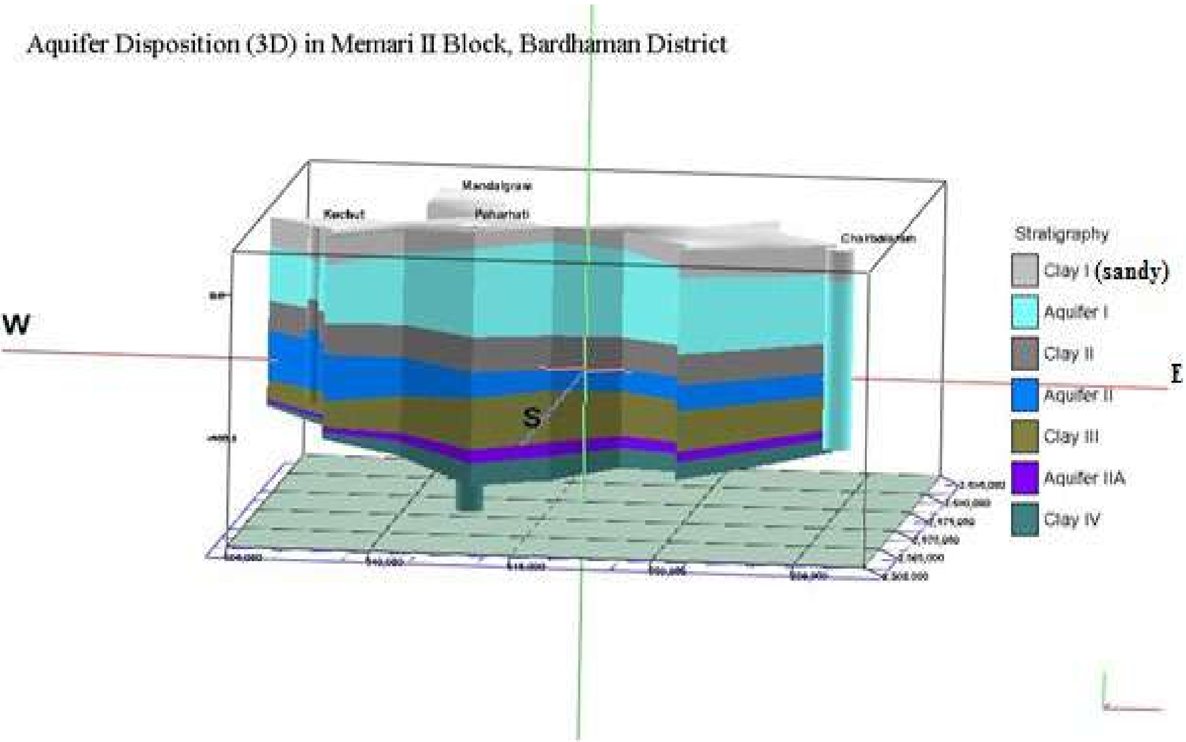


Plate 9.11.2: 3D disposition of aquifers in Memari II block, Bardhaman district

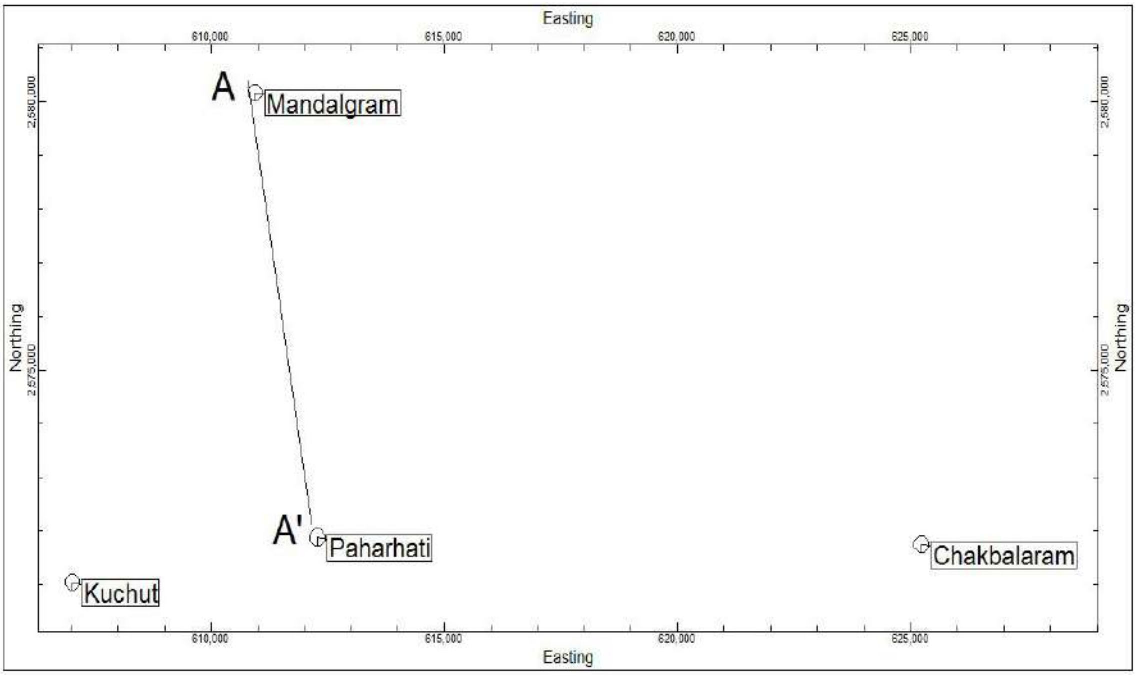


Plate 9.11.3: North-South Profile Index of Memari II block

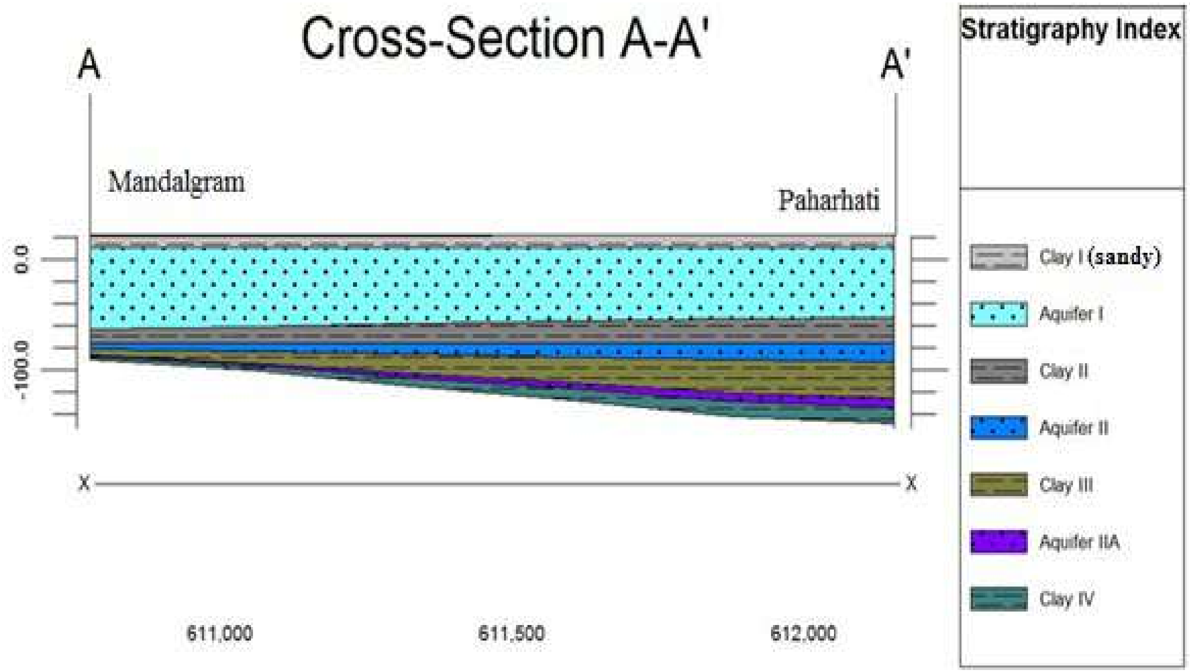


Plate 9.11.4: North-South profile section in Memari II block, Barddhaman district

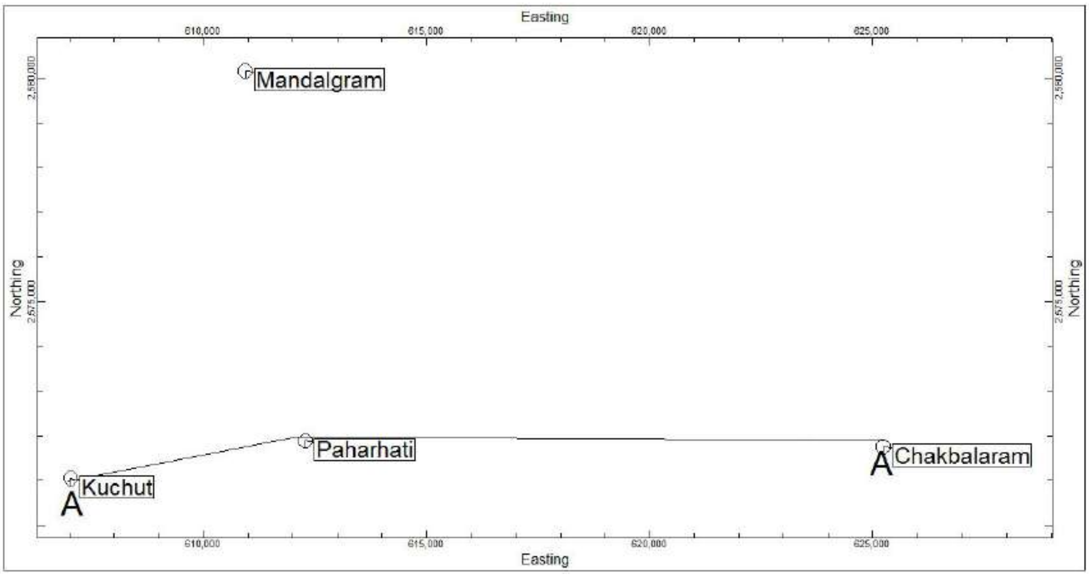


Plate 9.11.5: West – East Section Index Line in Memari II block

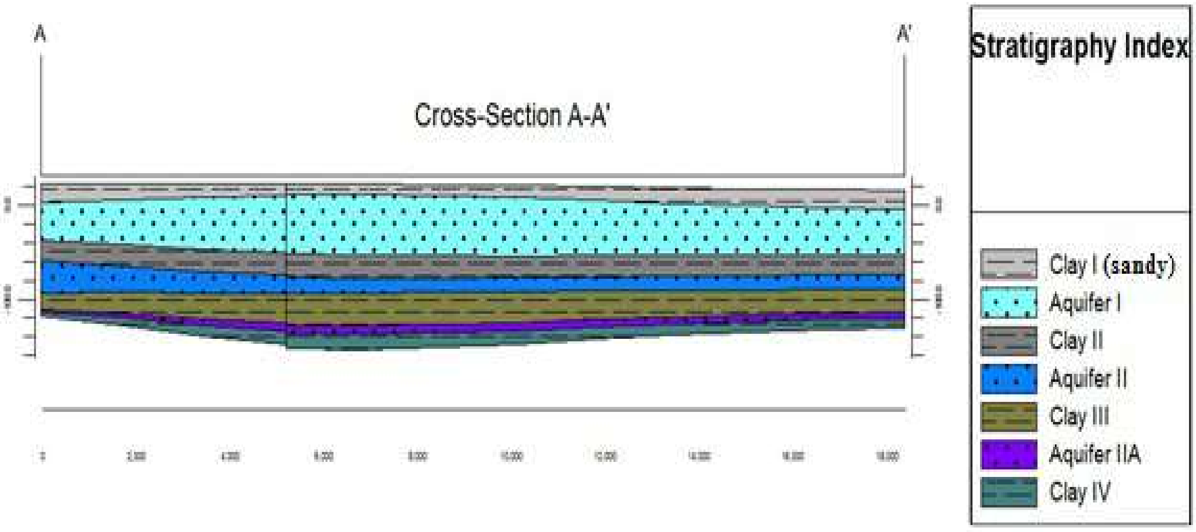


Plate 9.11.6: West – East Section in Memari II block

12.7.2 Ground Water Resource, Extraction, Contamination & other Issues:

Aquifer Wise Resource Availability & Extraction:

Dynamic ground water resources as on 31st March'13

Block	Net ground water availability (MCM)	Gross ground water draft (MCM)	Stage of development (%)	Category	Provision for domestic and industrial requirement supply up to next 25 years (MCM)

Memari II	55.6745	35.0025	65.33	Semi-critical	5.3490

12.7.3 Chemical Quality of Ground Water & Contamination:

As data based on2 samples of spl. Drive' 15-16 & other parameters based on limited samples of 16-17.

Range of Chemical Pollutants:

Block	As (mg/l)	TH (mg/l)	EC (µS/cm)	F (mg/l)	NO_3 (mg/l)
Memari II	**nil**	**80-165**	**413-475**	**1.21-1.44**	**nil**

Percentage of tube wells having arsenic content in the block based on SOES data:

SI. No.	Blocks	Arsenic (<0.01 ing/1)	Arsenic (>0.01-<0.05 mg/1)	Arsenic (> 0.05 mg/1)	**Max. conc. mg/l (samples with As >1000□g/L (total samples)**
1	Memari II	NA	5.6	1.1	0.170 (90)

Arsenic affected Risk Population:

District	**Block (As affected)**	**No. of habitations in the risk zone where As conc. >0.05 mg/l**	**No. of habitations in the risk zone where As conc. 0.01 to 0.05 mg/l**	**Risk Population (2011) where As conc. >0.05 mg/l**
Barddhaman	Memari II	0	0	0

12.7.4 Ground Water Resource Enhancement& Management Plan:

Ground Water Management Plan for drinking purposes

Table 9.11.5.1: Status of existing water supply schemes

(Source- PHED, Govt. of West Bengal)

Proposed interventions:

	Ongoing scheme		New scheme		Augmented scheme	
Block	Nos. of ongoing PWSS scheme	Population covered	Nos. of new PWSS scheme	Population covered	Nos. of augmented PWSS	Population covered
Memari II	4 (1 along with Memari I)	51380	-	-	1	8733

There are two aquifers which have been encountered within depth of 7.5-115 m and 105-118, 165-178 m respectively. Discharge is very high up to about 36 m^3/hr in Aquifer I and low to moderate to an extent of 14.4 m^3/hr. Both these aquifers tend to coalesce together nearby. Ground water in both of these aquifers is potable. But it is better to use deeper aquifer for drinking.

Deep drilling down to about 350 m bgl may provide information about potentiality & quality of ground water in the block; presence of arsenic, if any, in ground water in the area may be negotiated. In future, tube wells tapping the fresh deeper aquifer with proper cement sealing against clay bed (if arsenic is reported in future) has been proved to be fruitful in supplying arsenic free fresh ground water to villages.

Name of Block	Cultivable area in ha	Net irrigated area in Ha	Area to be irrigated in Ha	SOD in %	Pre monsoon WL Trend 2016 in cm/yr	Post monsoon WL Trend 2016 in cm/yr	Average Pre monsoon WL in m bgl	Average Post monsoon WL in m bgl
Memari II	14508	7789.33	6718.67	65.33	**Fall 100.4**	**Fall 94.6**	19.14	18.33

Ground Water Management Plan for Irrigation purposes

9.11.5.2: Irrigation Scenario in Memari II block (Aquifer I)

The data of 4th MI census for Culturable Command Area in Memari II block is given Table 9.11.5.3.

Table 9.11.5.3: Nos. and CCAs of different sources of water

Block	Total CCA (Ha)	Nos.	CCA(Ha)	Nos.	CCA(Ha)	Nos.	CCA (Ha)	Nos.	CCA (Ha)	Nos.	CCA (Ha)	Ground water	Surface water
Memari II	7789.33	0	0	1199	6370.60	29	1160.26	0	0	6	258.47	7530.86	258.47

(Source – Dept. of M.I., Govt. of West Bengal)

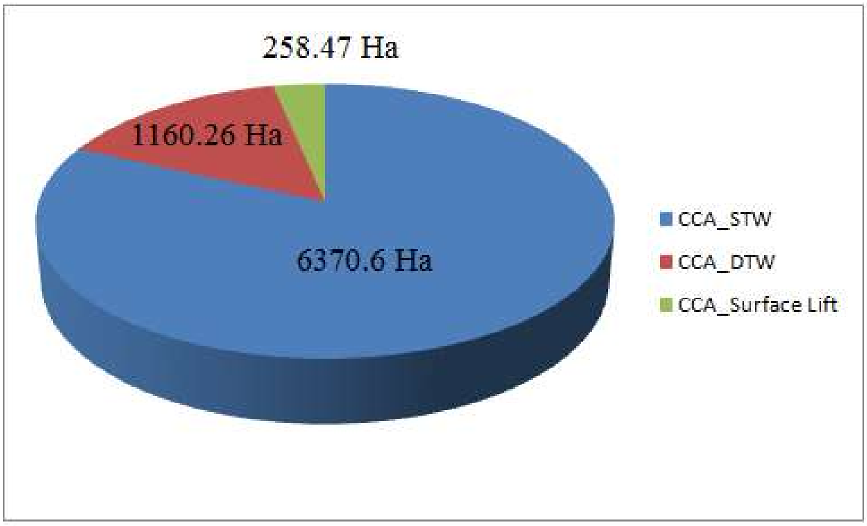


Fig. 9.11.6.1: Per Cent contribution of different sources in irrigation

Table 9.11.6.3 and Fig. 9.11.6.1 indicate that almost 81.79% and 14.9% of the cultivable area is irrigated by shallow tube wells and deep tube wells respectively. These sources are mostly used for rabi crops, boro paddy, etc. Surface Lift contributes 3.32 %, whereas Surface flows do not contribute in irrigation.

Data indicate that water level long term trends of this block show falling at a rate of 65.2 cm/year and 101 cm/ year in Aquifer I during in pre-monsoon and post-monsoon respectively. Aquifer II tends to coalesce within Aquifer I nearby Depth to water level is also deep in nature. To improve this ground water scenario, rain water harvesting and artificial recharge may be implemented which might restrict the declining trend.

Space Available for Recharge and Proposed Interventions:

Table 9.11.6.4 Area suitable for recharge in the study area:

District	Block Name	Area (in sq. km)	Total Area suitable for recharge (sq. km.)
Bardhaman	Memari II	106	106

Proposed Interventions:

Ground Water Resource Estimation shows that 6718.67 Ha of cultivable area is still not being covered by any irrigation schemes; it also indicates that ground water resource available for future irrigation is

1806.55 Ham. Considering Unit Draft of STW 0.022 MCM & Command Area of STW 6 Ha (0.06 sq. km), additional 4926 Ha area can be made irrigable (vide Table 9.11.6.5).

Table – 9.11.6.5: Additional Irrigation Potential created by Available Ground Water Resource

Net Ground Water Resource (MCM)	SOD (%)	Ground Water Resource available (MCM)	Available area to be irrigated (Ha)	Additional Nos. of STWs feasible	Additional Irrigation Potential Created(ha)
55.6745	65.33	18.0655	6718.67	821	4926

Still 1792.67 Ha i.e. 6718.67- 4926 Ha is left to be covered by irrigation facilities. To cover the left out portion, budgeting of surface run off component of rain water has been estimated and the same can be harvested for construction of artificial recharge and conservation structures.

Water column recommended in consultation with expert of Bidhan Chandra Krishi Vidyalaya Kalyani, for crops

Scope for Rain Water Harvesting and Artificial Recharge in Study Area:

Using method of Dhruvanarayana, 1993, in Memari II block, the number and types of artificial recharge and conservation structures proposed to be constructed for harvesting rain

District	Block	Major crops/vegetables/ fruits/flowers currently in practice	Water column depth(m)	Crops suggested for better management(considering ground water quality & quantity)	Water column depth(m) recommended	Remarks e.g. Irrigation techniques etc
Barddhaman	Memari II	Rice, potato, mustard, gram	Rice (1.2-1.4), mustard (0.2-0.25), potato (0.2-0.25), gram (0.10-0.12)	Rice, mustard, potato, gram	Rice (0.75-0.85), mustard (0.2), potato (0.2), gram (0.08-0.12)	Alternate dry and wet method for rice, for others based on crop physiology

water and the estimated cost involved for doing this, have been shown in Table 9.11.6a & Table 9.11.6 b. 9.57 MCM of rain water has been estimated to be harvested. The runoff component of rain fall can be utilized in 35:35:20:10 ratio for construction of Irrigation Cum Recharge Tank, Re-excavation of Existing Tank, Injection Well and Farm Pond. For construction of these structures, an estimated amount of Rupees 456 lakh is required. The harvested water can also be utilized for irrigation of parts of still uncovered cultivable land of 1792.67 Ha. By doing this, ground water scenario can be improved as well as the inclusive economic growth can be achieved.

Table 9.11.6.6.a: Budgeting rain fall run off availability in Memari II block

Normal monsoon rainfall in m (50 yrs data from data.gov.in) 'Rn'	Area(Ha) 'A'	Annual total volume of rain fall in Ham = (Rn X A)	Run off co-efficient from Dhruvanarayana, 1993 (Land slope, type of land and soil type) 'C' land slope 0-5%	Major type of soil available in that block	Total volume of surface runoff available Annually 'Vt' (RnXAXC) Ham	75% of 'Vt' = V Ham	50% of V (Non committed) = Vnc Ham	60% of Vnc considered for harvesting = Vf Ham
1.029	10600	10907.4	0.39	70 % loam &30 % silty clay	4253.886	3190.415	1595.21	957.12435

Table 9.11.6.6.b: Proposed Artificial Recharge & Conservation Structures in Memari II Block (Details of structures given in Section II):

Block	Net run off water availability for recharge in MCM (1)	Source Water Allocation (MCM)				Number of Structures				Structure-wise Cost Estimate (lakh Rs.)				Total Cost Estimate (lakh Rs.)
		Irrigation cum recharge Tank – 35 % 0f Col. 1	Re-excavation of existing tanks with RS - 35 % 0f Col. 1	Injection Well for recharging deeper layer -20 % 0f Col. 1	Farm Pond- – 10 % 0f Col. 1	Irrigation cum recharge Tank – 35 % 0f Col. 1	Re-excavation of existing tanks with RS - 35 % 0f Col. 1	Injection Well for recharging deeper layer -20 % 0f Col. 1	Farm Pond- – 10 % 0f Col. 1	Irrigation cum recharge Tank	Re-excavation of existing tanks with RS	Injection Well for recharging deeper layer	Farm Pond	
Memari II	9.57	3.35	3.35	1.91	0.96	7	34	6	10	56	272	48	80	456

Table 9.11.6.7 a: Cropping pattern of major crops (area in Ha, production in '000 M. Tons)

Aus (Area)	Aus (Production)	Aman (Area)	Aman (Production)	Boro (Area)	Boro (Production)	Jute (Area)	Jute (Production)	Wheat (Area)	Wheat (Production)
3254	10.226	11392	33.519	9424	30.52	-	-	4	0.012

Table 9.11.6.7 b: Cropping pattern of major crops (area in Ha, production in '000 M. Tons)

Potato (Area)	Potato (Production)	Masur (Area)	Musur (Production)	Mustard (Area)	Mustard (Production)	Til (Area)	Til (Production)	Gram (Area)	Gram (Production)
4266	153.889	-	-	-	-	1385	0.833	224	0.242

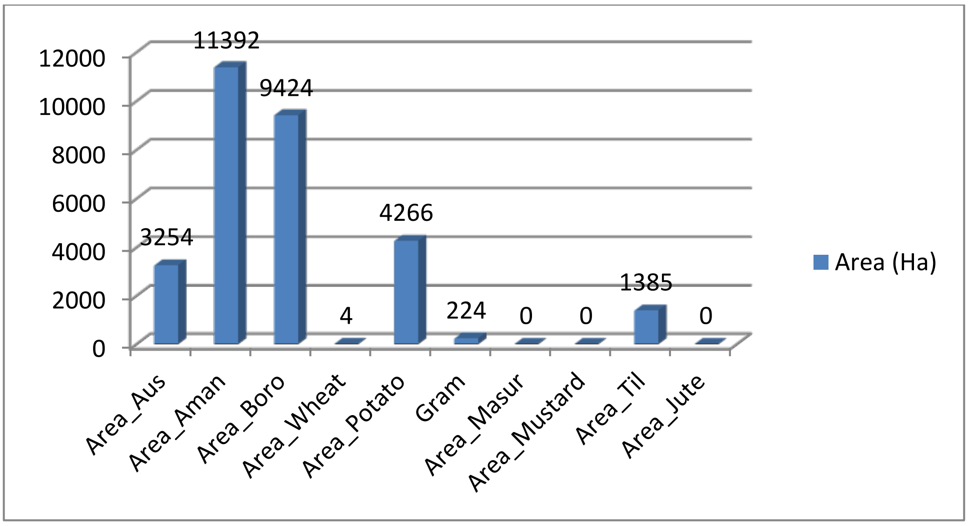


Fig.9.11.7: Graphical representation of Cropping pattern of major crops (area in Ha)

Attempt has also been made to modify cropping pattern as per the management strategy mentioned under section **Management Strategy of irrigation water & modification in cropping pattern.** In Table 9.11.7, it has been shown that by using this strategy production of cereals, pulses, oil seeds, etc. would be manifold. At the same time, due to restriction of Boro cultivation by 10% less than the present area of cultivation, a huge amount of vital ground water resources could be saved.

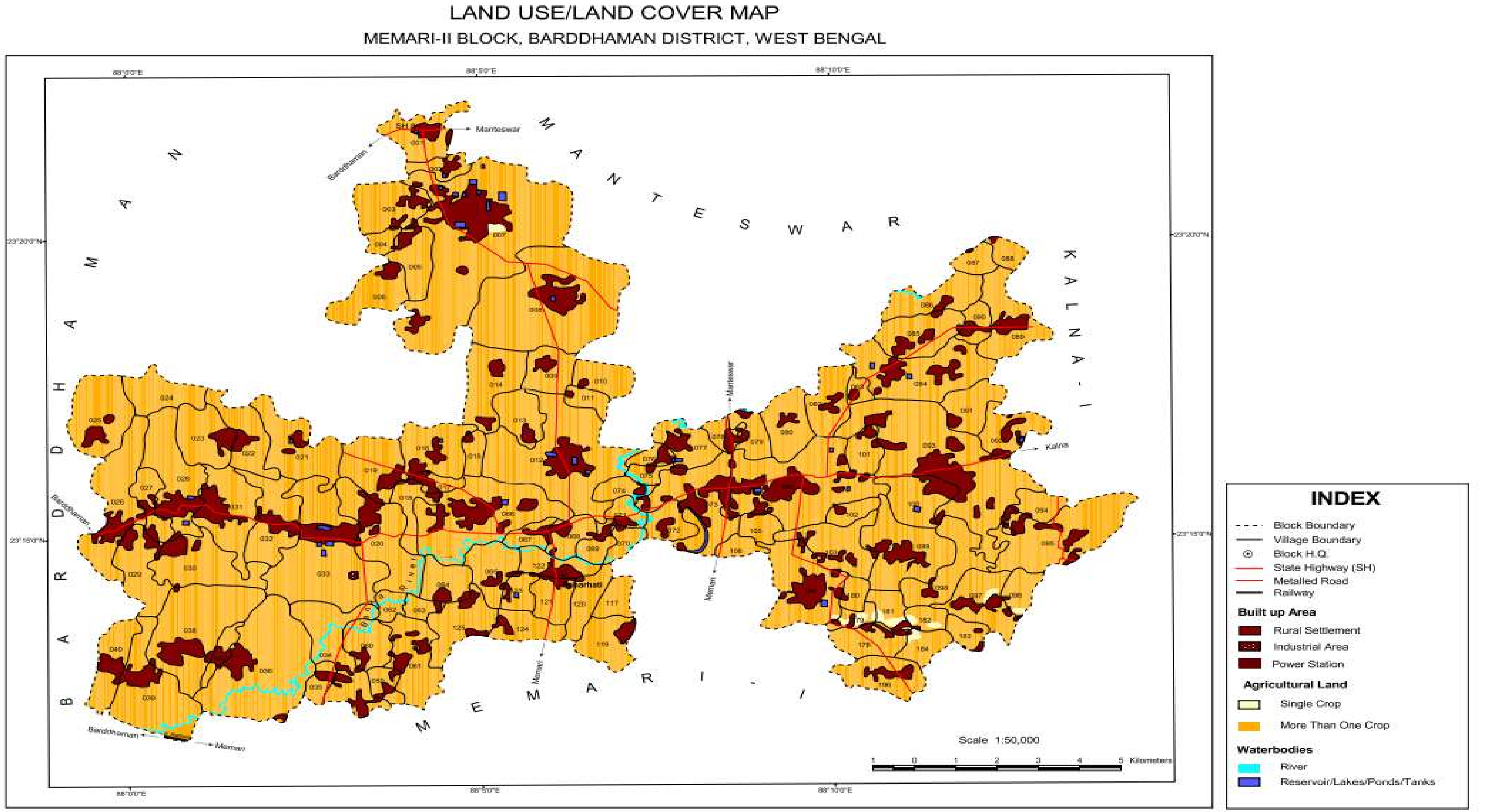


Plate 9.11.6: Land use/ land cover in Memari II block

(Source: Land Use & Land Reforms Dept., Govt. W. B.)

Table 9.11.7: Proposed modification of cropping pattern in Memari II block, Barddhaman district

Area of Boro cultivation (Ha)	**Average Water column required (m) for Col. I**	**G W draft due to boro cultivation (MCM) for Col. I**	**Proposed 10 % reduction of area of boro cultivation (Ha)**	**Amount of ground water saved (MCM) as in Col. I**	**Loss (MCM) of Boro due to reduction in area of cultivation @ yield rate of 3264.40 kg/ Ha (in M. Ton)**	**Proposed cropping in 1:1:1 ratio in lost area of Boro cultivation as proposed in Col IV**	**Gain (M. Ton each) due to alternate cropping @ existing yield rate Til @ 908.89 kg/hec, Ground nut @ 1770.45 kg/Ha & Mung @ 1182.23 kg/Ha**	**Ground water draft (MCM) for cultivation of Til, Ground nut & Mung @ 0.15 m per Ha**	**Gain due to increase in area of Aus cultivation in Kharif (at least 10 % of existing area of Boro cultivation, i.e. 942.4 Ha.) at yield rate 3361.24 kg/ Ha (M. Ton)**	Ground water saved (MCM)
(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)	(IX)	(X)	(XI)
9424	1.3	122.51	942.4	12.25	3076.37	Til, Ground nut & Mung 314.13 Ha each.	Til-285.51, Ground nut-556.15 & Mung-371.37	1.41	3167.63	10.84

12.8 KATWA II

Salient Information

Block Name: Katwa II

Area (in Km²): 168.71

District: Bardhaman

State: West Bengal

Population(as on 2011):

Rural	Urban	Total
136708	----	136708

Approximate Decadal Growth Rate from 2001-2011: 13.63%

Rainfall:

Average district annual rainfall for the period 2012 -16 (in mm): 1380.28

Block	Normal	Actual (Annual)				
		2012	2013	2014	2015	2016
Katwa II	1315.2	1276.6	1535.5	1134.4	1546.5	1408.4

Agriculture & Irrigation (area in sq. Km):

SI. No	Name of the Block	Geographic Area	Cultivable Area	Area under pasture & orchard	Cultivable Waste Land	Forest Land
1.	Katwa II	168.71	117	0.21	0.64	0

Aquifer Wise Ground Water Resource Availability & Extraction(in MCM):

Resource Availability	Aquifer I	Aquifer II	Extraction (for Aquifer I)
Dynamic Resource	69.3776	-	30.0733
Static Resource	2541.4474	-	-

12.8.1 Disposition of Aquifer

Block	Depth range of Aquifer in m bgl		
	'0' Aquifer	1st Aquifer	2nd aquifer
Katwa II	11.75-24.4	12-98	-

Aquifer '0' occurs under unconfined condition; Aquifer I occur under semi-confined to confined condition.

Aquifer Wise Water Level &Pre-monsoon and Post-monsoon water level trends (2006 to 2016):

SI. No.	Block	Aquifer	Pre-monsoon Trend			Post-monsoon Trend		
			Water Level Range (m bgl)	Rise (cm/year)	Fall (cm/year)	Water Level Range (m bgl)	Rise (cm/year)	Fall (cm/year)
1	Katwa II	‘0’	1.87 (1 datum)	-	-	5.71(1 datum)	-	-
2.	Katwa II	I	9.29-21.45	-	Fall 97.2	7.07-23.27	-	Fall 108.05

Thickness of Aquifer (Maximum): 85 m (Aquifer I) Aquifer-wise Statement

Name of Block	Aquifer ‘0’			Aquifer I		
	Depth Range (m bgl)	Maximum Discharge (m^3/hr)	T (m^2/day), S	Depth Range (m bgl)	Discharge (m^3/hr)	T (m^2/day), S
Katwa II	11.75-24.4	50	-	12-98	14.4 - 47.7	11.4- 1254, $3.1x10^{-5}$- $7.09x10^{-4}$

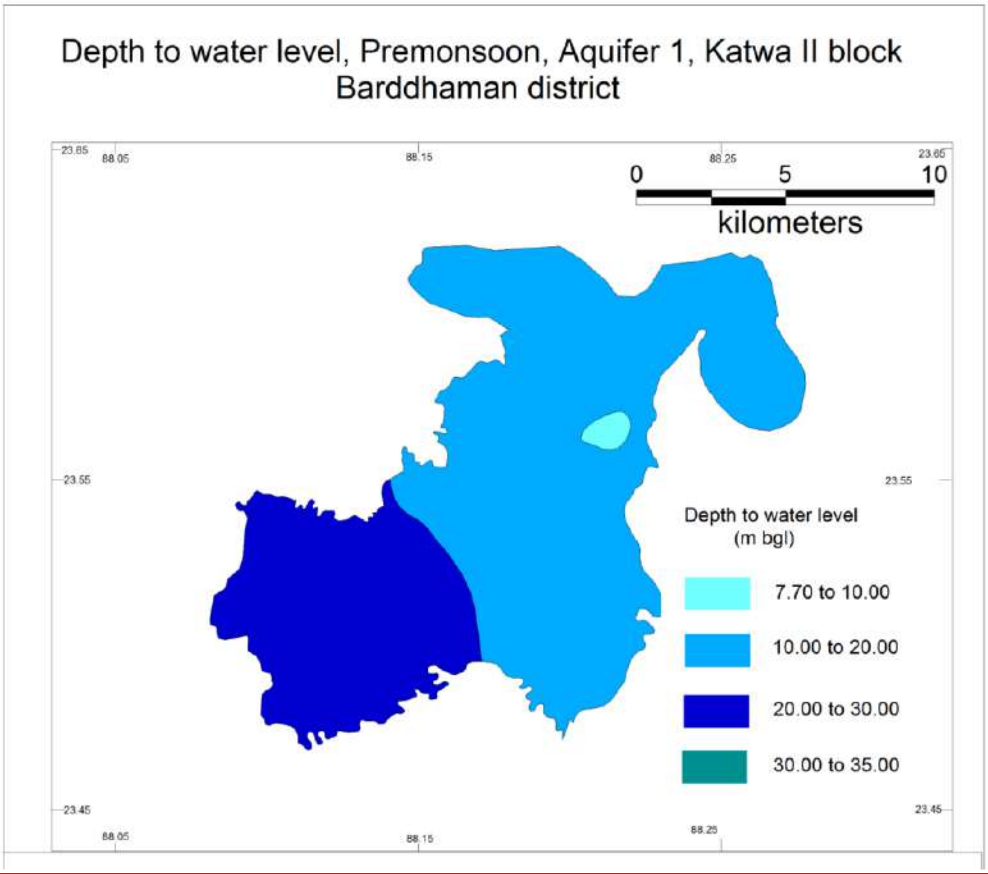


Fig. Depth to water level, Aquifer I, Premonsoon

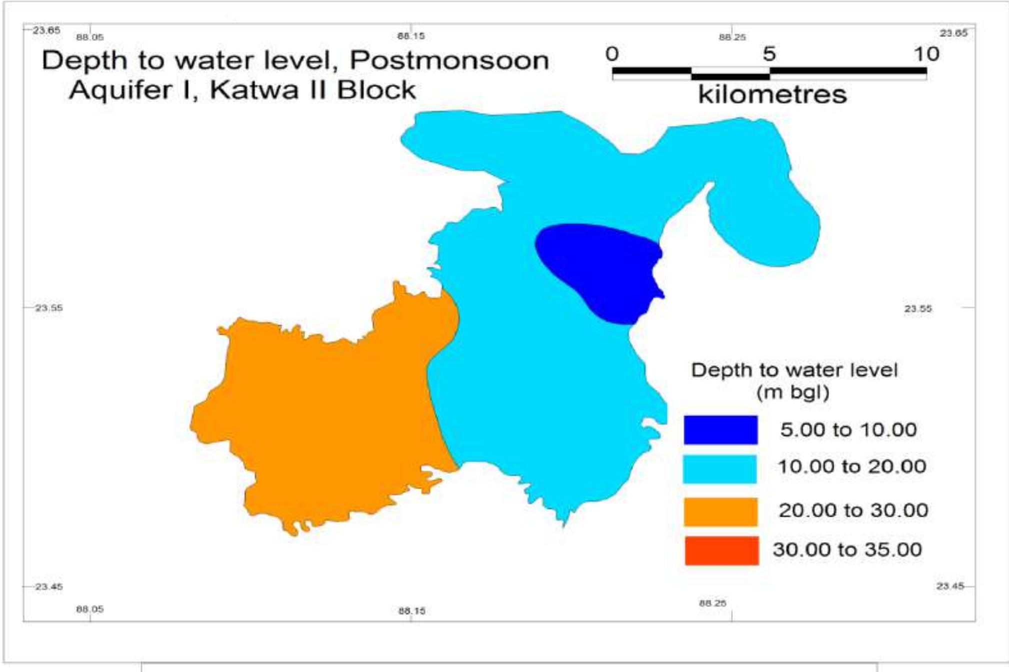


Fig. Depth to water level, Aquifer I, Post monsoon

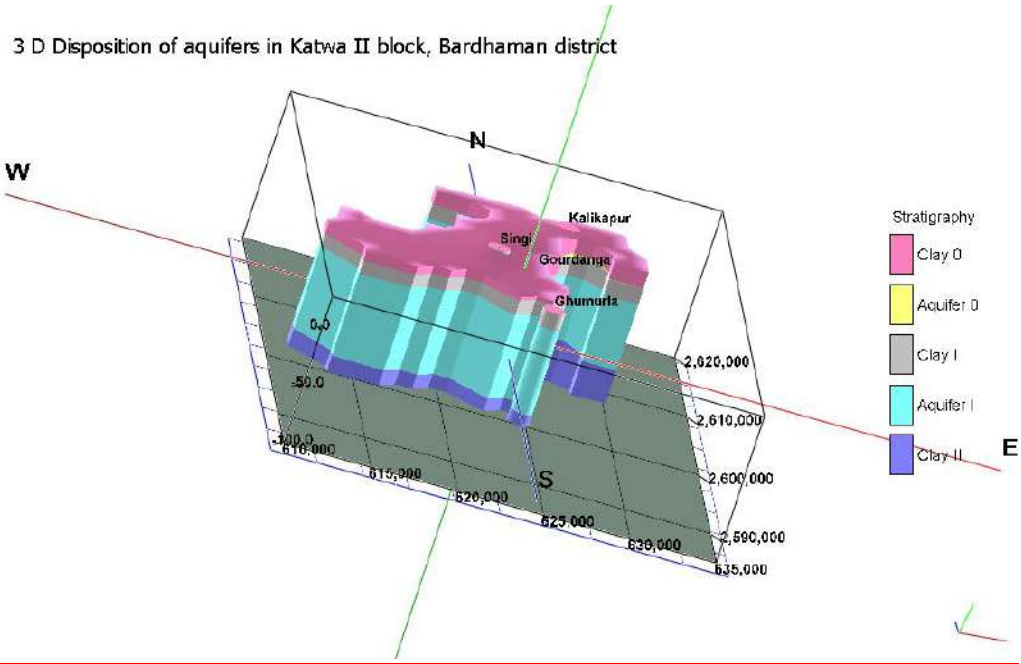


Plate 9.12.1: Aquifer disposition (3D) in Katwa II block, Barddhaman district

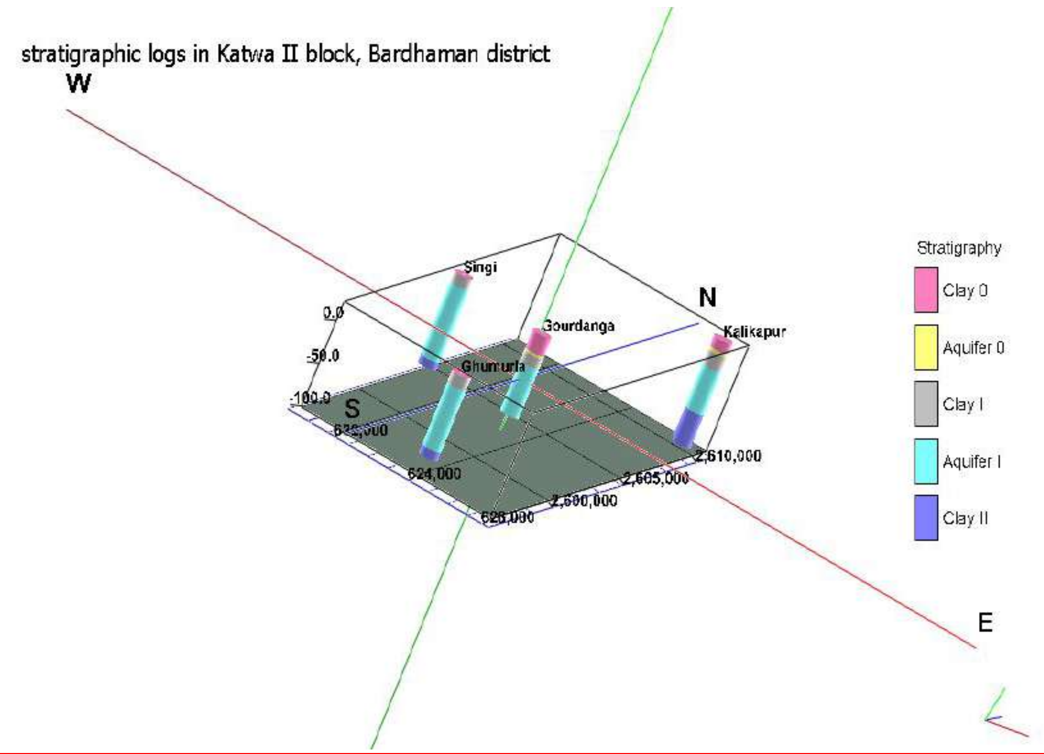


Plate 9.12.2: Stratigraphic Logs in Katwa II block, Barddhaman district

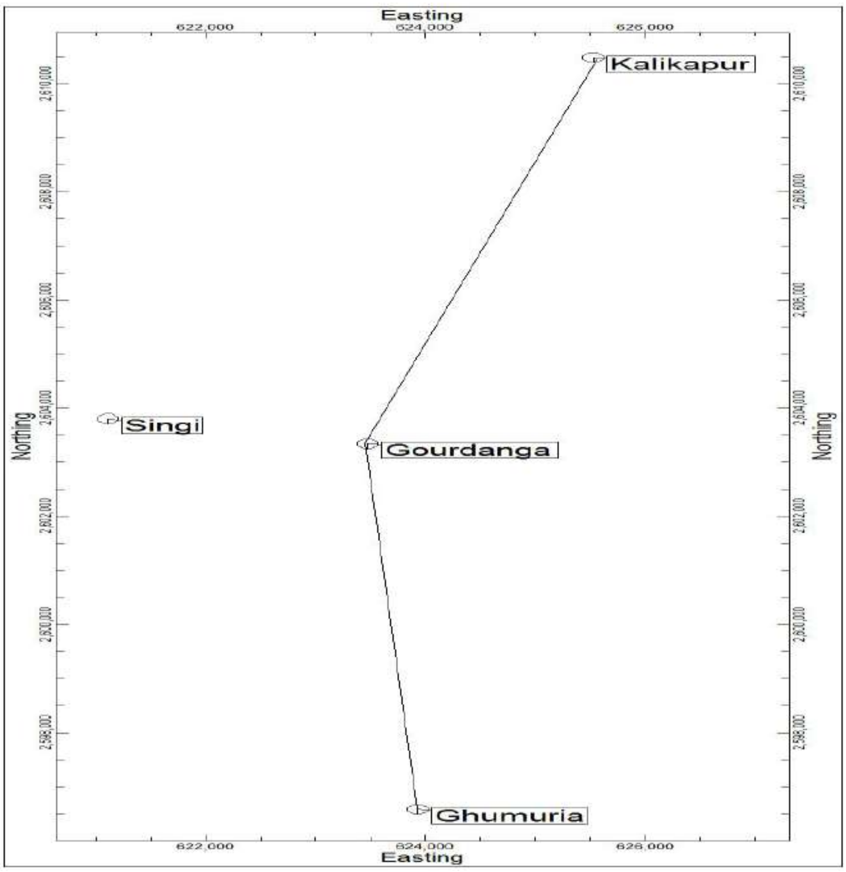


Plate 9.12.3: NNE-SSW Section Index Line in Katwa II block, Barddhaman district

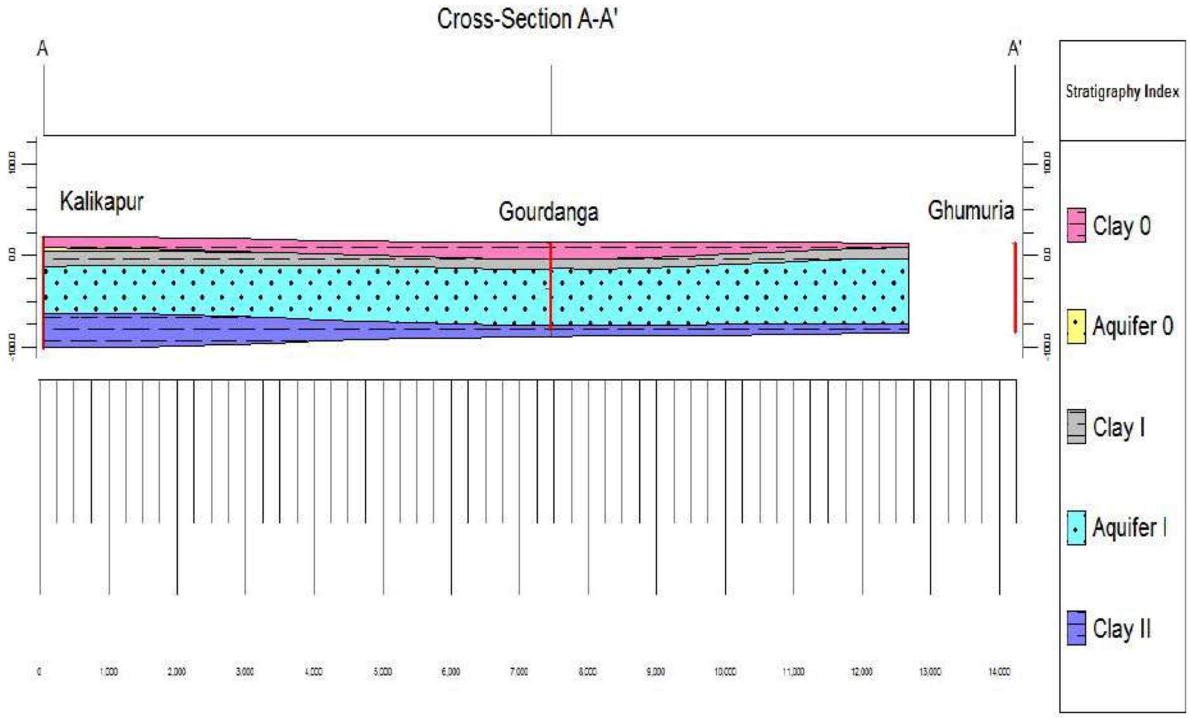


Plate 9.12.4: NNE-SSW Section in Katwa II block, Barddhaman district

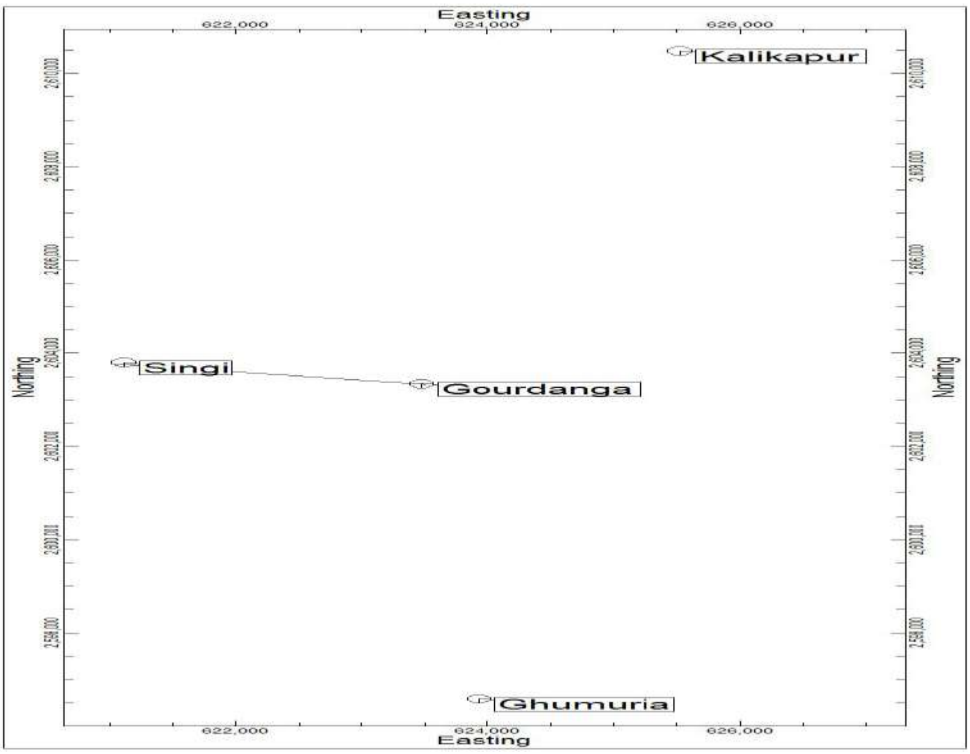


Plate 9.12.5: W-E Section Index Line in Katwa II block, Barddhaman district

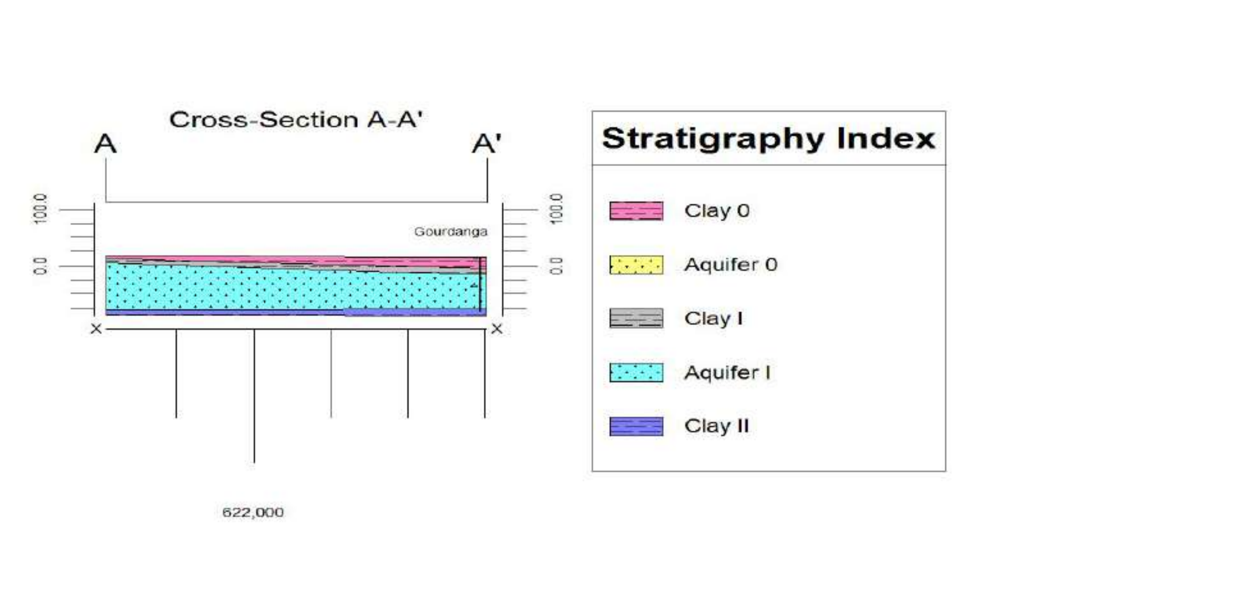


Plate 9.12.6: W-E Section in Katwa II block, Barddhaman district

12.8.2 Ground Water Resource, Extraction, Contamination & other Issues:

Aquifer wise Resource Availability & Extraction:

Dynamic ground water resources as on 31st March'13

Block	Net ground water availability (MCM)	Gross ground water draft (MCM)	Stage of development (%)	Category	Provision for domestic and industrial requirement supply up to next 25 years (MCM)
Katwa II	69.3776	30.0733	44.55	Semi-critical	7.7086

Sl. No.	Name of arsenic affected block	No. of Tube well analysed	Arsenic Concentration (in mg/l)

12.8.3 Chemical Quality of Ground water & Contamination:

As -data based on6 samples of spl. Drive' 15-16 in Katwa II block and around, & other parameters

Block	As(mg/l)	TH (mg/l)	EC(µS/cm)	F(mg/l)	NO_3(mg/l)
Katwa II	**0.00127 – 0.00667**	**100-195**	**429-686**	**1.19-1.53**	**bdl**

based on limited samples of16-17.

Range of Chemical Pollutants:

			<& =0.01		>0.01 &<=0.05		>0.05		Max. Concentration (mg/l)
			%	**No.**	**%**	**No.**	**%**	**No.**	
1	Katwa II	1079	90.08	972	7.78	84	2.13	23	0.84

Percentage of tube wells having arsenic content in the block (based on PHED tube wells):

Percentage of tube wells having arsenic content in the block based on SOES data:

SI. No.	Blocks	Arsenic (<0.01 ing/1)	Arsenic (>0.01-<0.05 mg/1)	Arsenic (> 0.05 mg/1)	**Max. conc. mg/l (samples with As >1000□g/L (total samples)**
1	KatwaII	NA	-	-	0.005 (143)

Arsenic affected Risk Population:

District	**Block (As affected)**	**No. of habitations in the risk zone where As conc. >0.05 mg/l**	**No. of habitations in the risk zone where As conc. 0.01 to 0.05 mg/l**	**Risk Population (2011) where As conc. >0.05 mg/l**
Barddhaman	Katwa II	9	14	136708

(Source – PHED, Govt. of West Bengal)

12.8.4 Ground Water Resource Enhancement& Management Plan:

	Ongoing scheme		New scheme		Augmented scheme	
Block	Nos. of ongoing PWSS scheme	Population covered	Nos. of new PWSS scheme	Population covered	Nos. of augmented PWSS	Population covered
Katwa II	4	30676	-	-	-	-

Ground Water Management Plan for drinking purposes

Table 9.12.5.1: Status of existing water supply schemes

(Source – PHED, Govt. of West Bengal)

Proposed interventions:

As per CGWB exploration data, potential aquifers are encountered up to a depth of 30 m in Aquifer ‘0’and within 12-98 m bgl. Beyond this depth thick clay layer exist down to the drilled depth of 250 m bgl. Aquifer ‘0’ is likely contaminated by arsenic and it lies as outlier in the eastern periphery of the block underlying Aquifer I, which may be used for drinking purpose.

Deep drilling down to about 600 m bgl will provide information about arsenic free aquifers in the area.

9.12.5.2: Irrigation Scenario in Katwa II block

Name of Block	Cultivable area in ha	Net irrigated area in Ha	Area to be irrigated in Ha	SOD in %	Pre monsoon WL Trend 2016 in cm/yr	Post monsoon WL Trend 2016 in cm/yr	Average Pre monsoon WL in m bgl	Average Post monsoon WL in m bgl
Katwa II	6242.27	5457.73	44.55		Fall 97.2	Fall 108.05	18.32	Can be developed for GW based Irrigation; irrigation can be taken up

The data of 4th MI census for Culturable Command Area in Katwa II block has been graphically presented in **Fig. 9.12.6.1.**

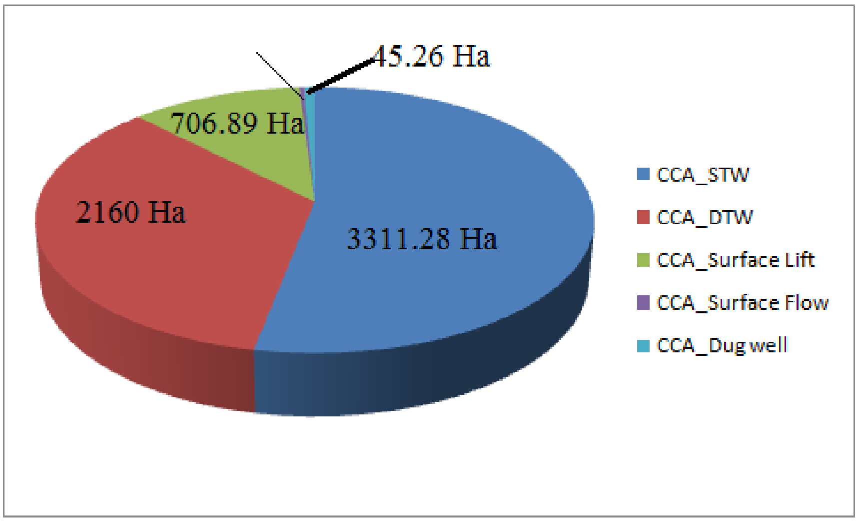


Fig. 9.12.6.1: Per Cent contribution of different sources in irrigation

Table 9.12.6.3 and Fig. 9.12.6.1 indicate that almost 53.05 % and 34.6 % of the cultivable area is irrigated by shallow tube wells and deep tube wells respectively. These sources are mostly used for rabi crops, boro paddy, etc. Surface Lift contributes 11.32 %, whereas Surface flows and dug wells contribute meagre amount in irrigation.

Data indicate that water level long term trends of this block show falling at a rate of 63.53 cm/year and97.83cm/ year in Aquifer I during in pre-monsoon and post-monsoon respectively. Depth to water level is also deep in nature. To improve this ground water scenario, rain water harvesting and artificial recharge may be implemented which might restrict the declining trend.

Space Available for Recharge and Proposed Interventions:

Table 9.12.5.4: Area suitable for recharge in the study area:

District	Block Name	Area (in sq. km)	Total Area suitable for recharge (sq. km.)
Bardhaman	Katwa II	277.56	277.56

Proposed Interventions:

Ground Water Resource Estimation shows that 5457.73 Ha of cultivable area is still not being covered by any irrigation schemes; it also indicates that ground water resource available for future irrigation is 3771.21 Ham. Considering Unit Draft of STW 0.022 MCM & Command Area of STW 6 Ha (0.06 sq. km), additional 10284 Ha area can be made irrigable (vide Table 9.12.6.5).

Table – 9.12.6.5: Additional Irrigation Potential created by Available Ground Water Resource

Net Ground Water Resource (MCM)	**SOD (%)**	**Ground Water Resource available (MCM)**	**Available area to be irrigated (Ha)**	**Additional Nos. of STWs feasible**	**Additional Irrigation Potential Created (Ha)**
69.377669.3776	44.55	37.7121	5457.73	1714	10284

Therefore, the whole area can be covered by the additional ground water resource available for irrigation, which has been estimated by the competent authority. However, if required, in near future during exigency rain water can be harvested.

District	Block	Major crops/vegetables/ fruits/flowers currently in practice	Water column depth(m)	Crops suggested for better management(considering ground water quality & quantity)	Water column depth(m) recommended	Remarks e.g., Irrigation techniques etc
Barddhaman	Katwa II	Rice, potato, mustard, gram	Rice (1.2-1.4), mustard (0.2-0.25), potato (0.2-0.25), gram (0.10-0.12)	Rice, mustard, potato, gram	Mustard (0.2), potato (0.2), gram (0.08-0.12)	Conjunctive use of fresh and contaminated water: 1:1 ratio/drip for vegetable, flowers

Water column recommended in consultation with expert of Bidhan Chandra Krishi Vidyalaya Kalyani, for crops

Scope for Rain Water Harvesting and Artificial Recharge in Study Area:

Using method of Dhruvanarayana,1993, in Katwa II block, the number and types of artificial recharge and conservation structures proposed to be constructed for harvesting rain water and the estimated cost involved for doing this, have been shown in Table 9.11.6a & Table 9.11.6 b.

25.39 MCM of rainwater has been estimated to be harvested. The runoff component of rainfall can be utilized in 45:45:10 ratio for construction of Irrigation Cum Recharge Tank, Re-excavation of Existing Tank with Recharge Shaft and Farm Pond. For construction of these structures, an estimated cost of Rupees 1296 lakh will be incurred. The harvested water can also be utilised for irrigation of cultivable land, if needed. By doing so, ground water scenario can be improved as well as the inclusive economic growth can be achieved.

Table 9.12.6.6.a: Budgeting rain fall run off availability in Katwa II block

Normal monsoon rainfall in m(50 yrs data from data.gov.in) 'Rn'	Area(Ha) 'A'	Annual total volume of rain fall in Ham = (Rn X A)	Run off co-efficient from Dhruvanarayana, 1993(Land slope, type of land and soil type) 'C' land slope 0-5%	Major type of soil available in that block	Total volume of surface runoff available Annually 'Vt' (RnXAXC) Ham	75% of 'Vt' = V Ham	50% of V (Non committed) = Vnc Ham	60% of Vnc considered for harvesting = Vf Ham
1.029	16871	17360.26	0.65	90 % clay, 10 % loam	11284.17	8463.126	4231.56	2538.937879

Table 9.12.6.6.b: Proposed artificial recharge and conservation structures in Katwa II block (Details of structures given in Section II):

Block	Net run off water availability for recharge in MCM	Source Water Allocation (MCM)				Number of Structures				Structure-wise Cost Estimate (lakh Rs.)				Total Cost Estimate (lakh Rs.)
		Irrigation cum recharge Tank – 45 % 0f Col. 1	Re-excavation of existing tanks - 45 % 0f Col. 1	Injection Well for recharging deeper layer -0 % 0f Col. 1	Farm Pond- – 10 % 0f Col. 1	Irrigation cum recharge Tank	Re-excavation of existing tanks	Injection Well for recharging deeper layer	Farm Pond-	Irrigation cum recharge Tank	Re-excavation of existing tanks with RS	Injection Well for recharging deeper layer	Farm Pond	
Katwa II	25.39	11.43	11.43	0	2.54	23	114	0	25	184	912	0	200	1296

Table 9.12.6.7 a: Cropping pattern of major crops (area in Ha, production in '000 M. Tons)

Aus (Area)	Aus (Production)	Aman (Area)	Aman (Production)	Boro (Area)	Boro (Production)	Jute (Area)	Jute (Production)	Wheat (Area)	Wheat (Production)
-	-	11478	23.957	4241	12.142	2539	28.64	39	0.092

Table 9.12.6.7 b:Cropping pattern of major crops (area in Ha, production in '000 M. Tons)

Potato (Area)	Potato (Production)	Masur (Area)	Musur (Production)	Mustard (Area)	Mustard (Production)	Til (Area)	Til (Production)	Gram (Area)	Gram (Production)
267	3.02	32	0.019	-	-	778	0.568	-	-

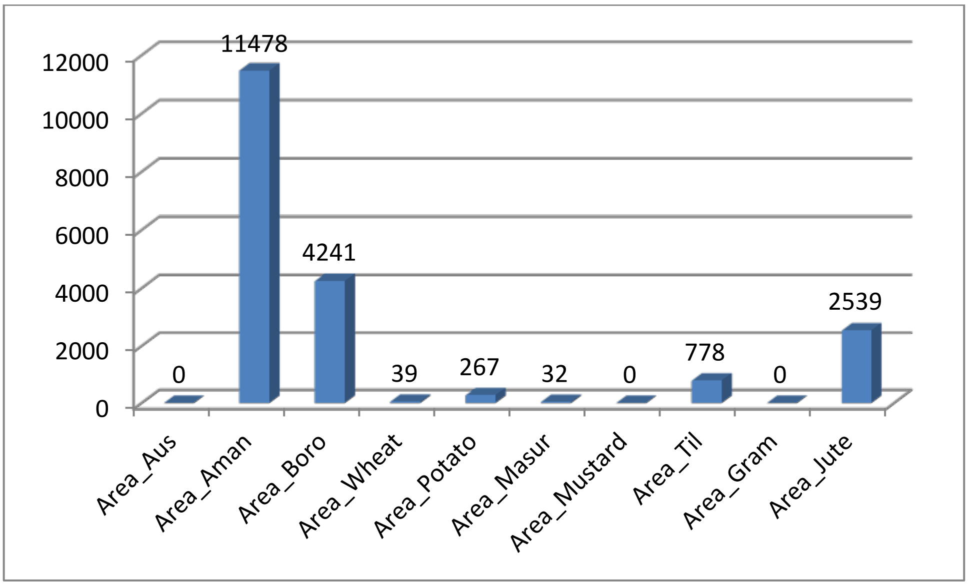


Fig. 9.12.7: Graphical representation of cropping area of major crops in Katwa II block

Attempt has also been made to modify cropping pattern as per the management strategy mentioned under section **Management Strategy of irrigation water & modification in cropping pattern.** In Table 9.12.7, it has been shown that by using this strategy production of cereals, pulses, oil seeds, etc. would be manifold. At the same time, due to restriction of Boro cultivation by 10% less than the present area of cultivation, a huge amount of vital ground water resources could be saved.

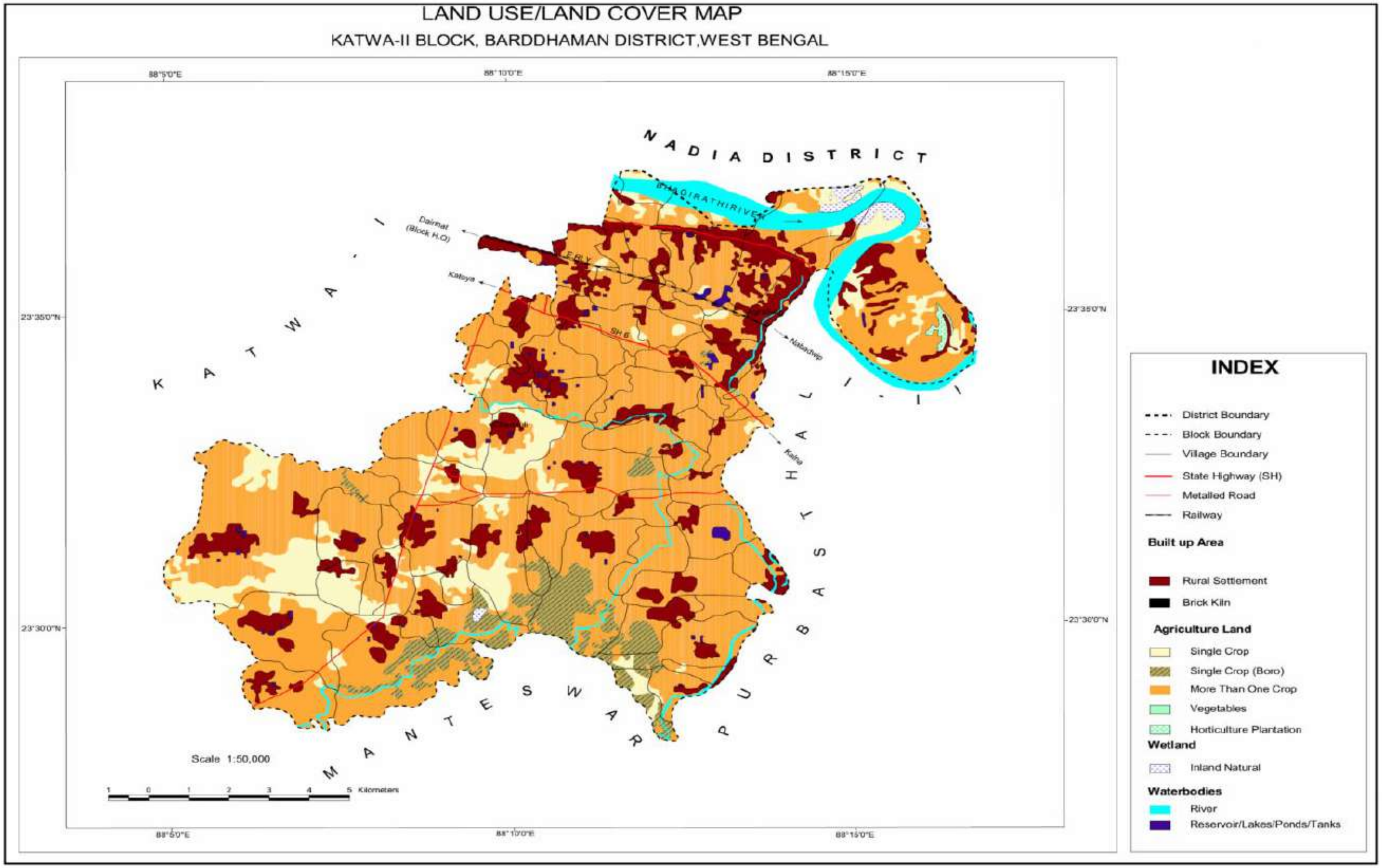


Plate 9.12.6: Land use/ land cover in Katwa II block(Source: Land Use & Land Reforms Dept., Govt. W. B.)

Table 9.12.7: Proposed modification of cropping pattern in Katwa II block, Barddhaman district

Area of Boro cultivation (Ha)	**Average Water column required (m) for Col. I**	**G W draft due to boro cultivation (MCM) for Col. I**	**Proposed 10 % reduction of area of boro cultivation (Ha)**	**Amount of ground water saved (MCM) as in Col. I**	**Loss (MCM) of Boro due to reduction in area of cultivation @ yield rate of 3264.40 kg/ Ha (in M. Ton)**	**Proposed cropping in 1:1:1 ratio in lost area of Boro cultivation as proposed in Col IV**	**Gain (M. Ton each) due to alternate cropping @ existing yield rate Til @ 908.89 kg/hec, Ground nut @ 1770.45 kg/Ha & Mung @ 1182.23 kg/Ha**	**Ground water draft (MCM) for cultivation of Til, Mung & Ground nut @ 0.15 m par Ha**	**Gain due to increase in area of Aus cultivation in Kharif (at least 10 % of existing area of Boro cultivation, i.e. 424.1 Ha.) at yield rate 3361.24 kg/ Ha (M. Ton)**	Ground water saved (MCM)
(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)	(IX)	(X)	(XI)
4241	1.3	55.13	424.1	5.51	1384.43	Til, Ground nut & Mung 141.37 Ha each.	Til -128.49, Ground nut-250.29 & Mung-167.13	0.64	1425.50	4.87

DATA GAP ANALYSIS IN PARTS OF DISTRICTS OF MURSHIDABAD, BIRBHUM & BARDDHAMAN, WEST BENGAL

13.0 Data Gap Analysis in Parts of Barddhaman, Murshidabad & Birbhum districts, West Bengal

AAP 2016- 2017

National Aquifer Mapping studies have been carried out in blocks of Barddhaman, Murshidabad and Birbhum districts during AAP 2016-17. As a pre-requisite of this study, first data gap analysis analysis has been performed in the entire area in CGWB, ER. Then, the aquifer mapping has been carried out by generation of data on different themes and collection of data on different aspects from various agencies, both govt. as well as private. Then, compilation of various data has been made followed by preparation of aquifer maps and block wise management plan to achieve the primary objective of this study.

The study area comprises of 12 blocks in 3 districts namely Murshidabad, Birbhum and Bardhaman districts in West Bengal. The present area covers a total area of 2807.7 sq km. The area extends between North latitudes 23° 11' 34.8" and 24° 3' 57.6" and East longitudes 87° 43' 26.4" and 88° 16' 48". The study area partly falls in the Survey of India Degree Sheet no. 72P, 73 M, 78 D and 79A. A major part of study area falls in parts of 6 toposheets, viz. 73 M/13, 73 M/14, 73 M/15, 79 A/1, 79 A/2 and 79 A/3; negligible parts of the present area fall in other 5 toposheets, viz. 79 A/4, 79 A/67, 72 P/16, 73 M/10 and 73 M/11.

Location of existing exploratory wells and existing Network Hydrograph Stations including piezometers and other structures have been shown in Fig. 1 and Fig. 2 respectively. Details of Exploratory tube wells have been tabulated in Table 7. Data gap in terms of requirement of exploratory tube well (EW), water level monitoring station (key wells), geophysical studies, viz. Vertical Electrical Sounding (VES), Transient Electromagnetic Method (TEM), additional water quality monitoring stations, etc. to study different aquifers (Aq) in the area and the same have been tabulated quadrant wise in different Toposheets in Table 1, Table 2, Table 3, Table 4, Table 5 and Table 6. Adequacy of geophysical data have been shown in different quadrants of toposheets have been represented from Table 8 to Table 14; and Data Gap of geophysical data have been studied from Table 15 to Table 20. Tentative locations and details of tube wells proposed for construction for aquifer mapping has been shown in Table 21. Summary of nos. of tube wells including EWs & OWs, additional monitoring wells, water quality wells, etc. have been shown in Table 1, Table 2, Table 3, Table 4, Table 5 and Table 6.

From data gap analysis, it has been found that for aquifer mapping study, additional 39 tube wells are required: 3 EW and 3 OW for Aquifer I - Aq I (Depth 100 m) and 5 EW and 5 OW for Aquifer II- Aq II (Depth 200 m) and, 5 EW and 5 OW for Aquifer III - Aq III (Depth 300 m). Besides, 13 SPEW (Special Purpose Exploratory Tube wells) have also been proposed for Aquifer III. These SPEW could be converted to piezometers afterwards.

DATA GAP ANALYSIS FOR AQUIFER MAPPING PROGRAMME IN PARTS OF MURSHIDABAD, BARDDHAMAN & BIRBHUM DISTRICTS, WEST BENGAL STATE

(AAP 2016 – 2017)

Table 1: Summary of Requirement of Exploratory Wells & VES/TEM, water level monitoring stations and water quality stations in Toposheet No. 73 M/13

Quadrant No.	No. of additional EW required			No. of additional VES/TEM required			No. of additional water level monitoring stations required			No. of additional water quality stations required			Remarks
	Aq-I	Aq-II	Aq-III	Aq-I	Aq-II	Aq-III	Aq-I	Aq-II	Aq-III	Aq-I	Aq-II	Aq-III	
1B	0	0	0	1	2	1	0	1	1	0	1	1	
1C	0	0	1	3	3	1	0	1	1	0	1	1	
2B	1	1	1	3	3	1	0	1	1	0	1	1	
2C	0	0	0	3	3	1	0	1	1	0	1	1	
3B	0	0	0	3	3	1	0	0	0	0	0	0	
3C	0	0	1	3	3	1	0	1	1	0	1	1	
Total	**1**	**1**	**3**	**16**	**17**	**6**	**0**	**5**	**5**	**0**	**5**	**5**	

Note:

No. of additional EW required- 5 (Aq-I:1, Aq-II:1, Aq-III: 3); 3 OW in 2B

No. of additional VES/TEM required- 39 (Aq-I:16, Aq-II: 17, Aq-III:6)

No. of additional water level monitoring stations required -10 (Aq-I: 0, Aq-II: 5, Aq-III: 5)

No. of additional water quality stations required-10 (Aq-I: 0, Aq-II: 5, Aq-III: 5)

Table 2: Summary of Requirement of Exploratory Wells & VES/TEM, water level monitoring stations and water quality stations in Toposheet No. 73 M/14

Quadrant No.	No. of additional EW required			No. of additional VES/TEM required			No. of additional water level monitoring stations required			No. of additional water quality stations required			Remarks
	Aq-I	Aq-II	Aq-III	Aq-I	Aq-II	Aq-III	Aq-I	Aq-II	Aq-III	Aq-I	Aq-II	Aq-III	
1A	0	0	1	1	3	1	0	1	1	0	1	1	
1B	0	0	0	3	3	1	0	1	1	0	1	1	
1C	0	0	0	3	3	1	0	1	1	0	1	1	
2A	0	0	0	1	2	1							
2B	1	1	1	3	3	1	0	1	1	0	1	1	
2C	0	0	0	3	3	1	0	1	1	0	1	1	
3A	0	0	1	3	3	1	0	1	1	0	1	1	
3B	0	0	0	3	3	0	0	1	1	0	1	1	
3C	0	0	1	3	3	0	0	1	1	0	1	1	
Total	1	1	**3**	**23**	**26**	**7**	**0**	**8**	**8**	**0**	**8**	**8**	

Note:

No. of additional EW required- 5 (Aq-I:1, Aq-II:1, Aq-III: 3); 3 OW in 2B

No. of additional VES/TEM required- 56 (Aq-I:23, Aq-II: 26, Aq-III:7)

No. of additional water level monitoring stations required -8 (Aq-I: 0, Aq-II: 8, Aq-III: 8)

No. of additional water quality stations required-8 (Aq-I: 0, Aq-II: 8, Aq-III: 8)

Table 3: Summary of Requirement of Exploratory Wells & VES/TEM, water level monitoring stations and water quality stations in Toposheet No. 73 M/15

Quadrant No.	No. of additional EW required			No. of additional VES/TEM required			No. of additional water level monitoring stations required			No. of additional water quality stations required			Remarks
	Aq-I	**Aq-II**	**Aq-III**	**Aq-I**	**Aq-II**	**Aq-III**	**Aq-I**	**Aq-II**	**Aq-III**	**Aq-I**	**Aq-II**	**Aq-III**	
1A	0	0	0	3	3	1	0	1	0	0	1	0	
1B	0	0	0	2	3	1	1	1	1	1	1	1	
1C	0	0	1	1	3	1	0	1	1	0	1	1	
2A	0	0	0	1	2	1	0	0	0	0	0	0	
2B	0	1	0	3	3	1	1	1	1	1	1	1	
2C	0	0	0	3	3	1	0	1	1	0	1	1	
Total	**0**	**1**	**1**	**13**	**17**	**6**	**2**	**5**	**4**	**2**	**5**	**4**	

Note:

No. of additional EW required- 2 (Aq-I:0, Aq-II:1, Aq-III: 1); 1 OW in 2B

No. of additional VES/TEM required-36 (Aq-I:1, Aq-II: 13, Aq-III:17)

No. of additional water level monitoring stations required -11 (Aq-I:2, Aq-II: 5, Aq-III: 4)

No. of additional water quality stations required-11 (Aq-I:2, Aq-II: 5, Aq-III: 4)

Table 4: Summary of Requirement of Exploratory Wells & VES/TEM, water level monitoring stations and water quality stations in

Toposheet No.: 79 A/1

Quadrant No.	**No. of additional EW required**			**No. of additional VES/TEM required**			**No. of additional water level monitoring stations required**			**No. of additional water quality stations required**			**Remarks**
	Aq-I	**Aq-II**	**Aq-III**	**Aq-I**	**Aq-II**	**Aq-III**	**Aq-I**	**Aq-II**	**Aq-III**	**Aq-I**	**Aq-II**	**Aq-III**	
2A	0	0	0	0	0	0	0	1	1	0	1	1	
2B	1	0	1	0	0	0	1	1	1	1	1	1	
2C	0	0	0	0	0	0	0	0	0	0	0	0	
3A	0	0	0	0	0	0	0	1	1	0	1	1	
3B	0	0	1	0	0	0	0	0	0	0	0	0	
3C	0	0	0	0	0	0	0	1	0	0	1	0	
Total	**1**	**0**	**2**	**0**	**0**	**0**	**2**	**6**	**5**	**2**	**6**	**5**	

Note:

No. of additional EW required- 3 (Aq-I:1, Aq-II:0, Aq-III: 2); 2 OW in 2B

No. of additional VES/TEM required- 0

No. of additional water level monitoring stations required -13 (Aq-I:2, Aq-II: 6, Aq-III: 5)

No. of additional water quality stations required-13 (Aq-I:2, Aq-II: 6, Aq-III: 5)

Table 5: Summary of Requirement of Exploratory Wells & VES/TEM, water level monitoring stations and water quality stations in

Toposheet No.: 79 A/2

Quadrant No.	No. of additional EW required			No. of additional VES/TEM required			No. of additional water level monitoring stations required			No. of additional water quality stations required			Remarks
	Aq-I	**Aq-II**	**Aq-III**	**Aq-I**	**Aq-II**	**Aq-III**	**Aq-I**	**Aq-II**	**Aq-III**	**Aq-I**	**Aq-II**	**Aq-III**	
1A	0	0	0	3	3	1	0	1	1	0	1	1	
1B	0	0	0	2	3	1							
2A	0	0	0	3	3	1	1	1	1	1	1	1	
2B	0	0	1	3	3	1	0	1	1	0	1	1	
2C	0	0	0	3	3	1	0	1	1	0	1	1	
3A	0	0	1	3	3	1	0	1	1	0	1	1	
3B	0	0	0	3	3	1	0	1	1	0	1	1	
3C	0	0	1	3	3	1	0	1	1	0	1	1	
Total	**0**	**0**	**3**	**23**	**24**	**8**	**0**	**7**	**7**	**0**	**7**	**7**	

Note:

No. of additional EW required- 3 (Aq-III: 3); 1 OW in 2B

No. of additional VES/TEM required- 55 (Aq-I:23, Aq-II: 24, Aq-III:8)

No. of additional water level monitoring stations required -14 (Aq-I:0, Aq-II: 7, Aq-III: 7)

No. of additional water quality stations required-14 (Aq-I:0, Aq-II: 7, Aq-III: 7)

Table 6: Summary of Requirement of Exploratory Wells & VES/TEM, water level monitoring stations and water quality stations in

Toposheet No.: 79 A/3

Quadrant No.	No. Of additional EW required			No. Of additional VES/TEM required			No. Of additional water level monitoring stations required			No. Of additional water quality stations required			Remarks
	Aq-I	Aq-II	Aq-III	Aq-I	Aq-II	Aq-III	Aq-I	Aq-II	Aq-III	Aq-I	Aq-II	Aq-III	
1A	0	0	1	3	3	1	0	1	1	0	1	1	
1B	0	0	0	3	3	1	0	1	1	0	1	1	
1C	0	0	1	3	3	1	0	1	1	0	1	1	
2A	0	0	0	2	2	1	0	1	1	0	1	1	
2B	1	1	1	3	3	1	0	1	1	0	1	1	
2C	0	0	0	3	3	1	1	1	1	1	1	1	
3A	0	0	1	3	3	1	1	1	1	1	1	1	
3B	0	0	0	2	3	1	0	1	1	0	1	1	
3C	0	0	0	1	1	1	0	0	0	0	0	0	
Total	1	1	**4**	**23**	**24**	**9**	**1**	**8**	**8**	**1**	**8**	**8**	

Note:

No. of additional EW required- 6 (Aq-I:1, Aq-II:1, Aq-III:4); 3 OW in 2B

No. of additional VES/TEM required- 56 (Aq-I:23, Aq-II: 24, Aq-III:9)

No. of additional water level monitoring stations required -17 (Aq-I:1, Aq-II: 8, Aq-III:8)

No. of additional water quality stations required-17 (Aq-I:1, Aq-II: 8, Aq-III:8)

Table 7: Existing Exploration data

District	Block	Location	Well Type	AAP	Lat	Long	Drill Depth (mbgl)	Well Depth (mbgl)	Zone tapped/ Fractures encountered (mbgl)	Geology	SWL (mbgl)	Discharge (lps)	Drawdown (m)	T (m2 /day)	S	EC	Cl (mg/l)	Fe (mg/l)	As (mg/l)	F (mg/ l)
BARDDHAMAN	Bhatar	Bhatar (DEW)	DEW	1989-90	23.4083	87.9208	300.3	126.5	105.50-123.50	Alluvium / Tertiary	10.82	6.32 (1000 minutes of pumping)	11.22	91	$4.3X10^{-4}$	520	11	0.72		
BARDDHAMAN	Bhatar	Bhatar (DEW)	DOW	1989-90	23.4083	87.9208	141.2	126	105.0-123.0	Alluvium / Tertiary	10.83		3.56							
BARDDHAMAN	Bhatar	Bhatar (SEW)	SEW	1989-90	23.3988	87.9099	80.2	61	28.00-34.00,40.00-58.00	Alluvium	10.63	11.79 (3000 minutes of pumping)	3.62	619	$0.81X10^{-4}$	351	14			
BARDDHAMAN	Bhatar	Bhatar (DEW)	SOW	1989-90	23.4083	87.9208	68	57	42-54	Alluvium	10.65		1.267							
BARDDHAMAN	Bhatar	Orgram(DEW-I)	DEW-I	1988-89	23.4585	87.7890	300	297	181.00-184.00,200.00-206.00,200.00-206.00,249.00-252.00,282.00-288.00,292.00-295.00	Alluvium / Tertiary		2.2								

BARDDHAMAN	Bhatar	Orgram(SEW-I)	SEW-I	1988-89	23.4585	87.7890	61.9	55	30.00-42.00,46.00-52.00	Alluvium	18.25	35	2.94							
BARDDHAMAN	Bhatar	Orgram (SEW-II)	SEW-II	1988-89	23.4585	87.7890	61.9		30.00-42.00,46.00-52.00	Alluvium		34.99	2.94							
BARDDHAMAN	Katwa-I	Adarsha Pally High School	DEW-II	2006-07	23.6295	87.1261	221.5	220	206-213	Alluvium	7.14	4	10.84	172	3.1x10-5	777	39	0.09	0.006	0.38
BARDDHAMAN	Katwa-I	Adarsha Pally High School	SEW	2005-06	23.6295	87.1261	102	74	58.00-70.00	Alluvium	5.1	13.25, (300 minutes of pumping)	2.8	892	7.09x10-4	495	14	0.03	BDL	0.31
BARDDHAMAN	Katwa-I	Adarsha Pally High School	SOW	2005-06	23.6295	87.1261		74	58-70	Alluvium	4.85		0.66	11.4		506	21	0.14		0.22
BARDDHAMAN	Katwa-I	Adarsha Pally High School	DEW-I	2005-06	23.6294	87.1261	226.3	223.5	185.50-209.50, 212.50-221.50	Alluvium	7.3	13,(400 minutes of pumping)	10.12	216	4.10x10-5	794	39	0.23	BDL	0.45
BARDDHAMAN	Ketugram –I	Rajoor (DEW)	DEW	1989-90	23.7025	87.9285	300.3	158	122.00-134.00,150.00-156.00	Tertiary		9.50(C)								
BARDDHAMAN	Ketugram –I	Rajoor (SEW)	SEW	1989-90	23.7025	87.9285	80.7		35.00-47.00,50.00-68.00	Alluvium	8.62	35.64	6.18	1700	2.5X10-4					
BARDDHAMAN	Mangolkot	Mangolkot (SEW)	SEW	1990-91	23.5253	87.9006	60	52	29.00-50.00	Alluvium	6.66	32.58	2.73	1128	2.8X10-4					

BARDDHAMAN	Purbasthali-I	Chandpur	EW	2012-13	23.4127	88.3377	225.00	147	114-123, 141-144	Alluvium	9.00	6.00								
BIRBHUM	Nanoor	Kirnahar (EW-I)	EW-I	1996-97	23.7422	87.8815	350	264	247 – 250,252 – 255,258 - 261	Older Alluvium & Tertiary Formation	4.07	1.66 (500 minutes of pumping)	17.91							
BIRBHUM	Nanoor	Kirnahar (SEW-II)	SEW-II	1996-97	23.7422	87.8815	113.3	91	42-48, 56-66,76-88	Older Alluvium & Tertiary Formation	4.87	1.66 (600 minutes of pumping)	14.56							
MURSHIDABAD	Bharatpur-I	Dengapara (DEW)	DEW	1991-92	23.9051	88.0921	294.2	276	184.0-190.0,199.0-205.0,209.0-221.0,246.0-249.0,252.0-258.0,267.0-273.0	Tertiary / Older Alluvium		1.66	6	97.58						
MURSHIDABAD	Bharatpur-I	Dengapara (SEW)	SEW	1991-92	23.9051	88.0921	129.5	127	25.0-28.0,34.0-37.0,46.0-52.0,90.0-96.0,107.0-110.0,121.0-124.0	Older Alluvium		16.6	6	601						

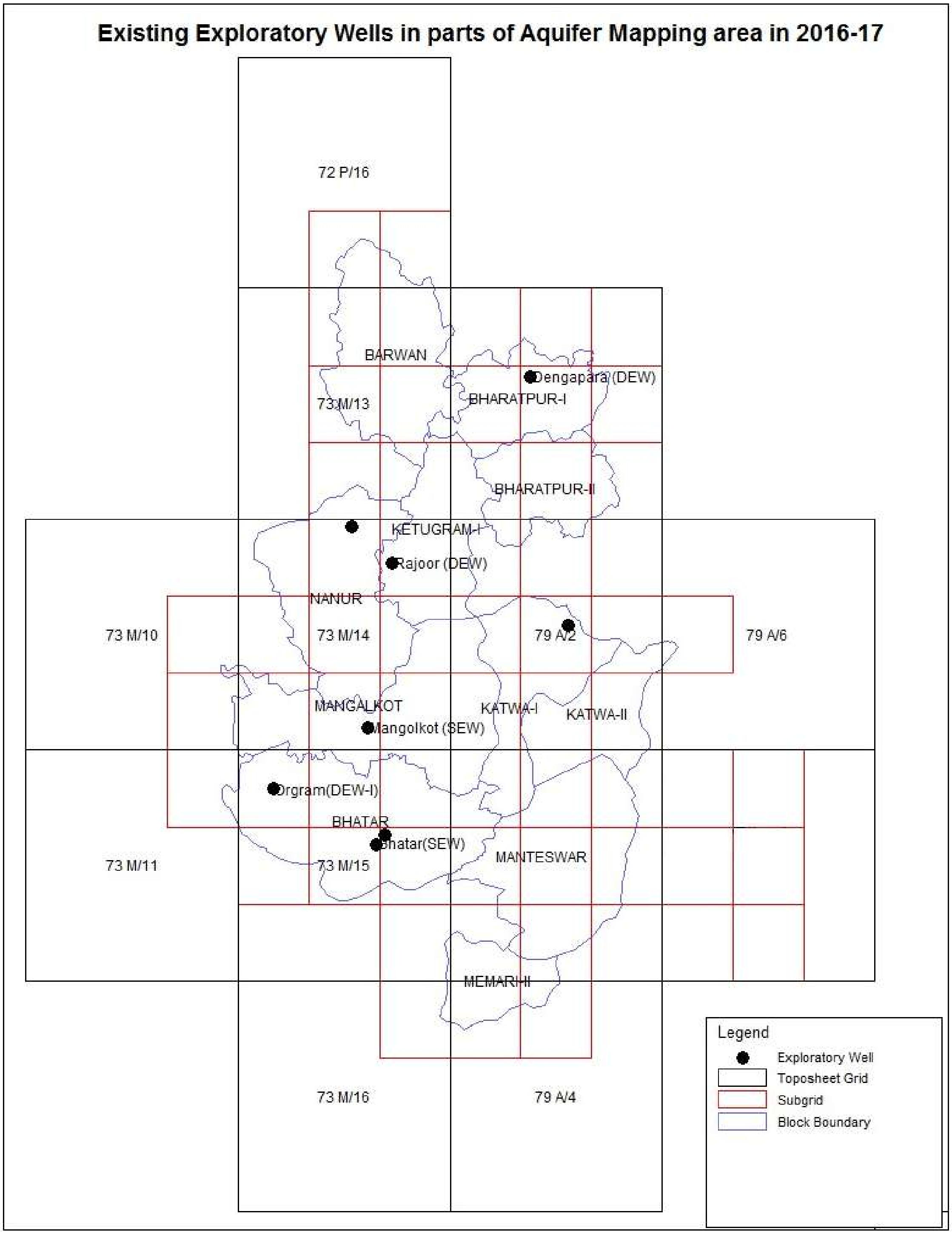


Fig. 1: Location of existing exploratory tube wells in study area

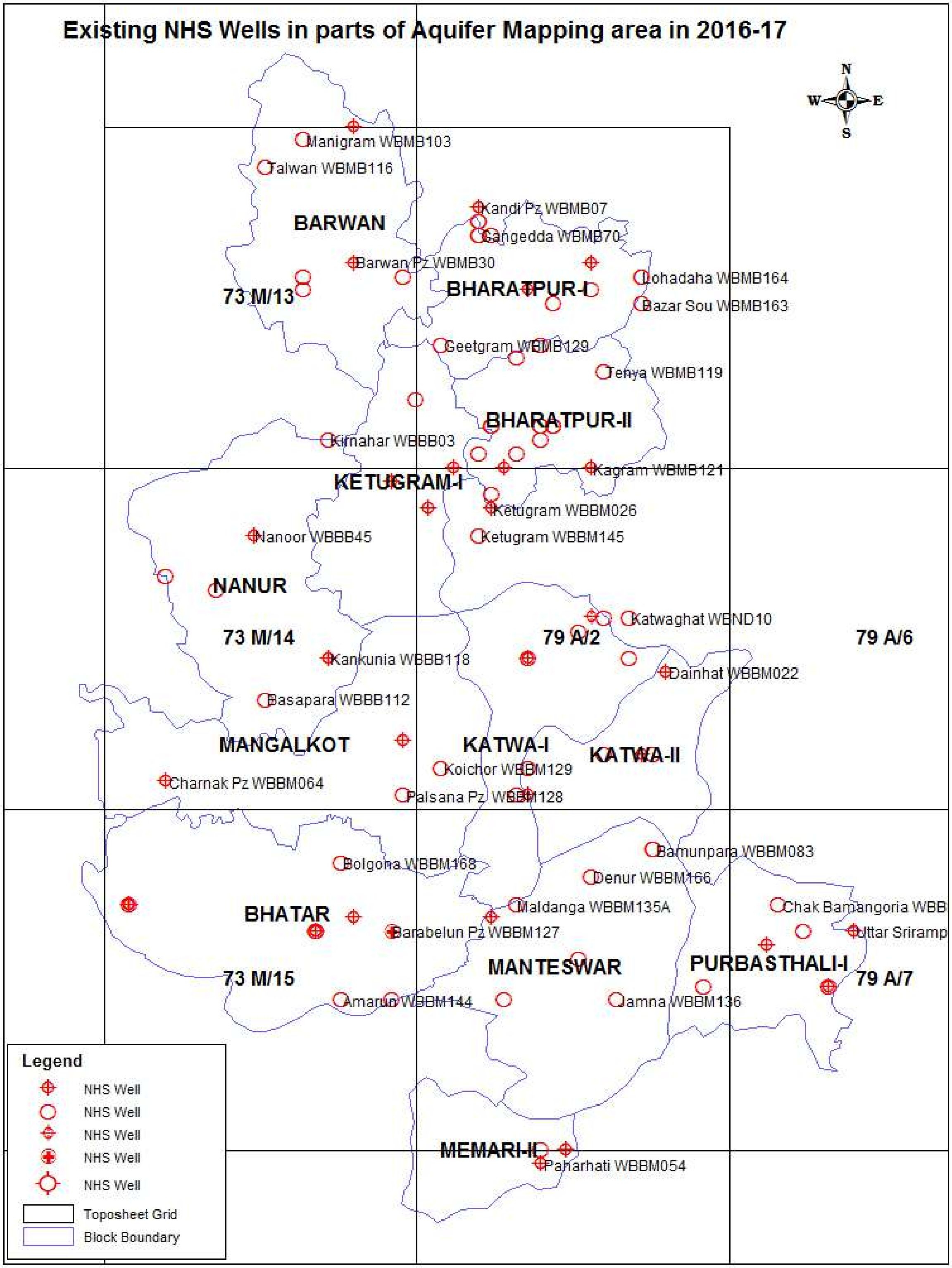


Fig. 2: Location of existing Hydrograph stations in study area

Table 8

Data adequacy of Geophysical data for Two Aquifer group system in Alluvial areas (quadrant wise)

Toposheet No. 73 M/13

Not included in the AAP 2016-17

No. of Elec. Logging: Nil

Aq. Gp.	VES/ TEM
Ist	Nil
IInd	Nil

No. of Elec. Logging: Nil

Aq. Gp.	VES/ TEM
Ist	Nil
IInd	Nil

No. of Elec. Logging: Nil

Not included in the AAP 2016-17

No. of Elec. Logging: Nil

Aq. Gp.	VES/ TEM
Ist	Nil
IInd	Nil

No. of Elec. Logging: Nil

Aq. Gp.	VES/ TEM
Ist	Nil
IInd	Nil

No. of Elec. Logging: Nil

Not included in the AAP 2016-17

No. of Elec. Logging: Nil

Aq. Gp.	VES/ TEM
Ist	Nil
IInd	Nil

No. of Elec. Logging: Nil

Aq. Gp.	VES/ TEM
Ist	Nil
IInd	Nil

No. of Elec. Logging: Nil

Table 9

Data adequacy of Geophysical data for Two Aquifer group system in Alluvial areas (quadrant wise)

Toposheet No. 73 M/14

Aq. Gp.	VES/ TEM
Ist	Nil
IInd	Nil

No. of Elec. Logging: Nil

Aq. Gp.	VES/ TEM
Ist	Nil
IInd	Nil

No. of Elec. Logging: Nil

Aq. Gp.	VES/ TEM
Ist	Nil
IInd	Nil

No. of Elec. Logging: Nil

Aq. Gp.	VES/ TEM
Ist	Nil
IInd	Nil

No. of Elec. Logging: Nil

Aq. Gp.	VES/ TEM
Ist	Nil
IInd	Nil

No. of Elec. Logging: 01

Aq. Gp.	VES/ TEM
Ist	Nil
IInd	Nil

No. of Elec. Logging: Nil

Aq. Gp.	VES/ TEM
Ist	Nil
IInd	Nil

No. of Elec. Logging: Nil

Aq. Gp.	VES/ TEM
Ist	Nil
IInd	Nil

No. of Elec. Logging: Nil

Aq. Gp.	VES/ TEM
Ist	Nil
IInd	Nil

No. of Elec. Logging: 01

Table 10

Data adequacy of Geophysical data for Two Aquifer group system in Alluvial areas (quadrant wise)

Toposheet No. 73 M/15

Aq. Gp.	VES/ TEM
Ist	Nil
IInd	Nil

No. of Elec. Logging: Nil

Aq. Gp.	VES/ TEM
Ist	Nil
IInd	Nil

No. of Elec. Logging: Nil

Aq. Gp.	VES/ TEM
Ist	Nil
IInd	Nil

No. of Elec. Logging: Nil

Aq. Gp.	VES/ TEM
Ist	Nil
IInd	Nil

No. of Elec. Logging: Nil

Aq. Gp.	VES/ TEM
Ist	Nil
IInd	Nil

No. of Elec. Logging: Nil

Aq. Gp.	VES/ TEM
Ist	Nil
IInd	Nil

No. of Elec. Logging: Nil

Not included in the AAP 2016-17

No. of Elec. Logging: Nil

Not included in the AAP 2016-17

No. of Elec. Logging: Nil

Not included in the AAP 2016-17

No. of Elec. Logging: Nil

Table 11

Data adequacy of Geophysical data for Two Aquifer group system in Alluvial areas (quadrant wise)

Toposheet No. 79 A/1

Aq. Gp.	VES/ TEM
Ist	Nil
IInd	Nil

No. of Elec. Logging: Nil

Aq. Gp.	VES/ TEM
Ist	Nil
IInd	Nil

No. of Elec. Logging: Nil

Not included in the AAP 2016-17

No. of Elec. Logging: Nil

Aq. Gp.	VES/ TEM
Ist	Nil
IInd	Nil

No. of Elec. Logging: Nil

Aq. Gp.	VES/ TEM
Ist	Nil
IInd	Nil

No. of Elec. Logging: Nil

Aq. Gp.	VES/ TEM
Ist	Nil
IInd	Nil

No. of Elec. Logging: Nil

Aq. Gp.	VES/ TEM
Ist	Nil
IInd	Nil

No. of Elec. Logging: Nil

Aq. Gp.	VES/ TEM
Ist	Nil
IInd	Nil

No. of Elec. Logging: 01

Aq. Gp.	VES/ TEM
Ist	Nil
IInd	Nil

No. of Elec. Logging: Nil

Table 12

Data adequacy of Geophysical data for Two Aquifer group system in Alluvial areas (quadrant wise)

Toposheet No. 79 A/2

Aq. Gp.	VES/ TEM
Ist	Nil
IInd	Nil

No. of Elec. Logging: Nil

Aq. Gp.	VES/ TEM
Ist	Nil
IInd	Nil

No. of Elec. Logging: Nil

Not included in the AAP 2016-17

No. of Elec. Logging: Nil

Aq. Gp.	VES/ TEM
Ist	Nil
IInd	Nil

No. of Elec. Logging: Nil

Aq. Gp.	VES/ TEM
Ist	Nil
IInd	Nil

No. of Elec. Logging: Nil

Aq. Gp.	VES/ TEM
Ist	Nil
IInd	Nil

No. of Elec. Logging: Nil

Aq. Gp.	VES/ TEM
Ist	Nil
IInd	Nil

No. of Elec. Logging: Nil

Aq. Gp.	VES/ TEM
Ist	Nil
IInd	Nil

No. of Elec. Logging: Nil

Aq. Gp.	VES/ TEM
Ist	Nil
IInd	Nil

No. of Elec. Logging: Nil

Table 13

Data adequacy of Geophysical data for Two Aquifer group system in Alluvial areas (quadrant wise)

Toposheet No. 79 A/3

Aq. Gp.	VES/ TEM
Ist	Nil
IInd	Nil

No. of Elec. Logging: Nil

Aq. Gp.	VES/ TEM
Ist	Nil
IInd	Nil

No. of Elec. Logging: Nil

Aq. Gp.	VES/ TEM
Ist	Nil
IInd	Nil

No. of Elec. Logging: Nil

Aq. Gp.	VES/ TEM
Ist	Nil
IInd	Nil

No. of Elec. Logging: Nil

Aq. Gp.	VES/ TEM
Ist	Nil
IInd	Nil

No. of Elec. Logging: Nil

Aq. Gp.	VES/ TEM
Ist	Nil
IInd	Nil

No. of Elec. Logging: Nil

Aq. Gp.	VES/ TEM
Ist	Nil
IInd	Nil

No. of Elec. Logging: Nil

Aq. Gp.	VES/ TEM
Ist	Nil
IInd	Nil

No. of Elec. Logging: Nil

Aq. Gp.	VES/ TEM
Ist	Nil
IInd	Nil

No. of Elec. Logging: Nil

Table 14

<table>
<tr><td colspan="3">Data adequacy of Geophysical data for Two Aquifer group system in Alluvial areas (quadrant wise)

Toposheet No. 79 A/4</td></tr>
<tr>
<td><table><tr><td>Aq. Gp.</td><td>VES/ TEM</td></tr><tr><td>Ist</td><td>Nil</td></tr><tr><td>IInd</td><td>Nil</td></tr></table>No. of Elec. Logging: Nil</td>
<td><table><tr><td>Aq. Gp.</td><td>VES/ TEM</td></tr><tr><td>Ist</td><td>Nil</td></tr><tr><td>IInd</td><td>Nil</td></tr></table>No. of Elec. Logging: Nil</td>
<td>Not included in the AAP 2016-17
No. of Elec. Logging: Nil</td>
</tr>
<tr>
<td>Not included in the AAP 2016-17
No. of Elec. Logging: Nil</td>
<td>Not included in the AAP 2016-17
No. of Elec. Logging: Nil</td>
<td>Not included in the AAP 2016-17
No. of Elec. Logging: Nil</td>
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No. of Elec. Logging: Nil</td>
<td>Not included in the AAP 2016-17
No. of Elec. Logging: Nil</td>
</tr>
</table>

Table 15

Data gap analysis for geophysical data of Two Aquifer group system in Alluvial areas (quadrant wise)

TOPOSHEET No. 73 M/13

Not included in the AAP 2016-17

Aq. Gp.	VES/TEM		
	Req	Exist	Gap
I^{st}	1	0	1
II^{nd}	2	0	2

Aq. Gp.	VES/TEM		
	Req	Exist	Gap
I^{st}	3	0	3
II^{nd}	3	0	3

Not included in the AAP 2016-17

Aq. Gp.	VES/TEM		
	Req	Exist	Gap
I^{st}	3	0	3
II^{nd}	3	0	3

Aq. Gp.	VES/TEM		
	Req	Exist	Gap
I^{st}	3	0	3
II^{nd}	3	0	3

Not included in the AAP 2016-17

Aq. Gp.	VES/TEM		
	Req	Exist	Gap
I^{st}	3	0	3
II^{nd}	3	0	3

Aq. Gp.	VES/TEM		
	Req	Exist	Gap
I^{st}	3	0	3
II^{nd}	3	0	3

Table 16

Data gap analysis for geophysical data of Two Aquifer group system in Alluvial areas (quadrant wise)

TOPOSHEET No. 73 M/14

Aq. Gp.	VES/TEM		
	Req	Exist	Gap
Ist	1	0	1
IInd	3	0	3

Aq. Gp.	VES/TEM		
	Req	Exist	Gap
Ist	3	0	3
IInd	3	0	3

Aq. Gp.	VES/TEM		
	Req	Exist	Gap
Ist	3	0	3
IInd	3	0	3

Aq. Gp.	VES/TEM		
	Req	Exist	Gap
Ist	1	0	1
IInd	2	0	2

Aq. Gp.	VES/TEM		
	Req	Exist	Gap
Ist	3	0	3
IInd	3	0	3

Aq. Gp.	VES/TEM		
	Req	Exist	Gap
Ist	3	0	3
IInd	3	0	3

Aq. Gp.	VES/TEM		
	Req	Exist	Gap
Ist	3	0	3
IInd	3	0	3

Aq. Gp.	VES/TEM		
	Req	Exist	Gap
Ist	3	0	3
IInd	3	0	3

Aq. Gp.	VES/TEM		
	Req	Exist	Gap
Ist	3	0	3
IInd	3	0	3

Table 17

Data gap analysis for geophysical data of Two Aquifer group system in Alluvial areas (quadrant wise)

TOPOSHEET No. 73 M/15

Aq. Gp.	VES/TEM		
	Req	Exist	Gap
Ist	3	0	3
IInd	3	0	3

Aq. Gp.	VES/TEM		
	Req	Exist	Gap
Ist	2	0	2
IInd	3	0	3

Aq. Gp.	VES/TEM		
	Req	Exist	Gap
Ist	1	0	1
IInd	3	0	3

Aq. Gp.	VES/TEM		
	Req	Exist	Gap
Ist	1	0	1
IInd	2	0	2

Aq. Gp.	VES/TEM		
	Req	Exist	Gap
Ist	3	0	3
IInd	3	0	3

Aq. Gp.	VES/TEM		
	Req	Exist	Gap
Ist	3	0	3
IInd	3	0	3

Not included in the AAP 2016-17

Not included in the AAP 2016-17

Not included in the AAP 2016-17

Table 18

Data gap analysis for geophysical data of Two Aquifer group system in Alluvial areas (quadrant wise)

TOPOSHEET No. 79 A/2

Aq. Gp.	VES/TEM		
	Req	Exist	Gap
Ist	3	0	3
IInd	3	0	3

Aq. Gp.	VES/TEM		
	Req	Exist	Gap
Ist	2	0	2
IInd	3	0	3

Not included in the AAP 2016-17

Aq. Gp.	VES/TEM		
	Req	Exist	Gap
Ist	3	0	3
IInd	3	0	3

Aq. Gp.	VES/TEM		
	Req	Exist	Gap
Ist	3	0	3
IInd	3	0	3

Aq. Gp.	VES/TEM		
	Req	Exist	Gap
Ist	3	0	3
IInd	3	0	3

Aq. Gp.	VES/TEM		
	Req	Exist	Gap
Ist	3	0	3
IInd	3	0	3

Aq. Gp.	VES/TEM		
	Req	Exist	Gap
Ist	3	0	3
IInd	3	0	3

Aq. Gp.	VES/TEM		
	Req	Exist	Gap
Ist	3	0	3
IInd	3	0	3

Table 19

Data gap analysis for geophysical data of Two Aquifer group system in Alluvial areas (quadrant wise)

TOPOSHEET No. 79 A/3

Aq. Gp.	VES/TEM		
	Req	Exist	Gap
I^{st}	3	0	3
II^{nd}	3	0	3

Aq. Gp.	VES/TEM		
	Req	Exist	Gap
I^{st}	3	0	3
II^{nd}	3	0	3

Aq. Gp.	VES/TEM		
	Req	Exist	Gap
I^{st}	3	0	3
II^{nd}	3	0	3

Aq. Gp.	VES/TEM		
	Req	Exist	Gap
I^{st}	2	0	2
II^{nd}	2	0	2

Aq. Gp.	VES/TEM		
	Req	Exist	Gap
I^{st}	3	0	3
II^{nd}	3	0	3

Aq. Gp.	VES/TEM		
	Req	Exist	Gap
I^{st}	3	0	3
II^{nd}	3	0	3

Aq. Gp.	VES/TEM		
	Req	Exist	Gap
I^{st}	3	0	3
II^{nd}	3	0	3

Aq. Gp.	VES/TEM		
	Req	Exist	Gap
I^{st}	2	0	2
II^{nd}	3	0	3

Aq. Gp.	VES/TEM		
	Req	Exist	Gap
I^{st}	1	0	1
II^{nd}	1	0	1

Table 20

Data gap analysis for geophysical data of Two Aquifer group system in Alluvial areas (quadrant wise)

TOPOSHEET No. 79 A/4

Aq. Gp.	VES/TEM		
	Req	Exist	Gap
Ist	1	0	1
IInd	2	0	2

Aq. Gp.	VES/TEM		
	Req	Exist	Gap
Ist	1	0	1
IInd	1	0	1

Not included in the AAP 2016-17

Not included in the AAP 2016-17

Not included in the AAP 2016-17

Not included in the AAP 2016-17

Not included in the AAP 2016-17

Not included in the AAP 2016-17

Not included in the AAP 2016-17

Table 21: Tentative locations/ sites of Exploration in parts of Murshidabad, Bardhaman, Birbhum district in West Bengal to be outsourced during AAP 2016-17

Well No.	Toposheet No.	Quadrant No.	Block/District	Tentative Location	No. of exploratory wells			Design of wells		
					Aquifer I (up to 100 m)	Aquifer II (up to 200 m)	Aquifer III (up to 300 m)	Aquifer I (up to 100 m/ as per actual depth of aquifer)	Aquifer II (up to 200 m/ as per actual depth of aquifer)	Aquifer III (up to 300 m/ as per actual depth of aquifer)
15	72 P/16	3B	Barwan (Murshidabad)	Kalyanpur			1 (SPEW)			152 mm dia with 24-30 m strainer as per availability of aquifer & with 0.5 to 1 mm slot.
16	73 M/13	1C	Barwan (Murshidabad)	Kulee			1 (SPEW)			152 mm dia with 24-30 m strainer as per availability of aquifer & with 0.5 to 1 mm slot.
17	73 M/13	2B	Barwan (Murshidabad)	Bhagulla	1EW+1OW	1EW+1OW	1EW+1OW	**EW**: 254x152 mm with 40 m Housing & 24-30 m strainer as per availability of aquifer & with 0.5 to 1 mm slot. . **OW**: 152 mm dia	**EW**: 254x152 mm with 40 m Housing & 24-30 m strainer as per availability of aquifer & with 0.5 to 1 mm slot. . **OW**: 152 mm dia	**EW**: 254x152 mm with 40 m Housing & 24-30 m strainer as per availability of aquifer & with 0.5 to 1 mm slot. . **OW**: 152 mm dia
18	73 M/13	3C	Ketugram I (Bardhaman)	Berugram			1 (SPEW)			152 mm dia with 24-30 m strainer as per availability of aquifer & with 0.5 to 1 mm slot.

19	79 A/1	2B	Bharatpur I (Murshidabad)	Bharatpur		1EW+1OW	1EW+1OW		**EW**: 254x152 mm with 40 m Housing & 24-30 m strainer as per availability of aquifer & with 0.5 to 1 mm slot. . **OW**: 152 mm dia	**EW**: 254x152 mm with 40 m Housing & 24-30 m strainer as per availability of aquifer & with 0.5 to 1 mm slot. . **OW**: 152 mm dia
20	79 A/1	3B	Bharatpur II (Murshidabad)	Baidyapur			1 (SPEW)			152 mm dia with 24-30 m strainer as per availability of aquifer & with 0.5 to 1 mm slot.
21	73 M/14	1A	Nanoor (Birbhum)	Bilauti			1 (SPEW)			152 mm dia with 24-30 m strainer as per availability of aquifer & with 0.5 to 1 mm slot.
22	73 M/14	2B	Nanoor (Birbhum)	Purandarpur	1EW+1OW	1EW+1OW	1EW+1OW	**EW**: 254x152 mm with 40 m Housing & 24-30 m strainer as per availability of aquifer & with 0.5 to 1 mm slot. . **OW**: 152 mm dia	**EW**: 254x152 mm with 40 m Housing & 24-30 m strainer as per availability of aquifer & with 0.5 to 1 mm slot. . **OW**: 152 mm dia	**EW**: 254x152 mm with 40 m Housing & 24-30 m strainer as per availability of aquifer & with 0.5 to 1 mm slot. . **OW**: 152 mm dia
23	73 M/14	3A	Mangalkote (Bardhaman)	Krishnapur			1 (SPEW)			152 mm dia with 24-30 m strainer as per availability of aquifer & with 0.5 to 1 mm slot.

24	73 M/14	3C	Mangalkote (Bardhaman)	Majhigram			1 (SPEW)			152 mm dia with 24-30 m strainer as per availability of aquifer & with 0.5 to 1 mm slot.
25	79 A/2	3A	Katwa I (Bardhaman)	Goshumba			1 (SPEW)			152 mm dia with 24-30 m strainer as per availability of aquifer & with 0.5 to 1 mm slot.
26	79 A/2	2B	Katwa I (Bardhaman)	Mondalhat			1EW+ 1OW			**EW**: 254x152 mm with 40 m Housing & 24-30 m strainer as per availability of aquifer & with 0.5 to 1 mm slot. . **OW**: 152 mm dia
27	79 A/2	3C	Katwa II (Bardhaman)	Dangapara			1 (SPEW)			152 mm dia with 24-30 m strainer as per availability of aquifer & with 0.5 to 1 mm slot.
28	73 M/15	2B	Bhatar (Bardhaman)	Karjona		1EW+ 1OW			**EW**: 254x152 mm with 40 m Housing & 24-30 m strainer as per availability of aquifer & with 0.5 to 1 mm slot. . **OW**: 152 mm dia	
29	73 M/15	1C	Bhatar (Bardhaman)	Bhatakul			1 (SPEW)			152 mm dia with 24-30 m strainer as per availability of aquifer & with 0.5 to 1 mm slot.

30	79 A/3	1A	Bhatar/ Katwa I/ Mangalkote (Bardhaman)	Chowdrapu r			1 (SPEW)			152 mm dia with 24-30 m strainer as per availability of aquifer & with 0.5 to 1 mm slot.
	79 A/3	1C	Manteswar (Bardhaman)	Chowdrapu r			1 (SPEW)			152 mm dia with 24-30 m strainer as per availability of aquifer & with 0.5 to 1 mm slot.
31	79 A/3	2B	Manteswar (Bardhaman)	Kusumgra m	1EW+1O W	1EW+1O W	1EW+1O W	**EW**: 254x152 mm with 40 m Housing & 24-30 m strainer as per availability of aquifer & with 0.5 to 1 mm slot. . **OW**: 152 mm dia	**EW**: 254x152 mm with 40 m Housing & 24-30 m strainer as per availability of aquifer & with 0.5 to 1 mm slot. . **OW**: 152 mm dia	**EW**: 254x152 mm with 40 m Housing & 24-30 m strainer as per availability of aquifer & with 0.5 to 1 mm slot. . **OW**: 152 mm dia
32	79 A/3	3A	Memari II (Bardhaman)	Bodhpur			1 (SPEW)			152 mm dia with 24-30 m strainer as per availability of aquifer & with 0.5 to 1 mm slot.
TOTAL (13 EW+ 13 OW+ 13 SPEW)					**3 EW+ 3 OW**	**5 EW+ 5 OW**	**5 EW + 5 OW+13 SPEW**			
All the wells of 100 m depth (3 EW 3 OW), 200 m depth (5 EW+ 5 OW) , 300 m (5 EW, 5 OW) & 13 SPEW of 300 m depth will be constructed **SPEW: Special purpose Exploratory wells to be converted to Piezometer**										