केंद्रीय भूमि जल बोर्ड

जल संसाधन, नदी विकास और गंगा संरक्षण

विभाग, जल शक्ति मंत्रालय

भारत सरकार

Central Ground Water Board

Department of Water Resources, River Development and Ganga Rejuvenation,

Ministry of Jal Shakti

Government of India

AQUIFER MAPPING AND MANAGEMENT OF GROUND WATER RESOURCES

Parts of Murshidabad District (9 Blocks), Farakka, Samserganj, Suti II, Suti I, Raghunathganj I, Sagardighi, Nabagram, Khargram and Kandi

पूर्वी क्षेत्र, कोलकाता

Eastern Region, Kolkata

GOVERNMENT OF INDIA

MINISTRY OF JAL SHAKTI
Dept. of Water Resources, River Development &Ganga Rejuvenation

Report on Aquifer Mapping Studies in districts (pts.) of Murshidabad
West Bengal
(AAP 2017-2018)

By:

S. Brahma, Scientist 'D'

Central Ground Water Board
Eastern Region, Kolkata
November 2020

CONTENTS

PART-II:

Chapter 10: BLOCK WISE AQUIFER MAPS AND MANAGEMENT PLAN

PART-III:

Report on Aquifer Mapping Studies in districts (pts.) of Murshidabad West Bengal (AAP 2017-2018)

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. As per the Annual Action Plan under NAQUIM, ground water management studies in 9 blocks of Murshidabad district covering an area of approximately 1834 sq. km. was taken up. In this report, aquifer mapping studies in the above mentioned blocks of Murshidabad district have been dealt in detail. 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 GovernmentDeptts. Viz. Public Health engineering Deptt.,Agri – Irrigation Deptt., 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 step-wise.

i) Compilation of existing data
ii) Identification of data gaps
iii) Data generation based on data gaps
iv) Preparation of thematic maps on GIS platform
v) Preparation of 2D/3D aquifer disposition maps
vi) Compilation of 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 9 blocks, Farakka, Samserganj, Suti II, Suti I, Raghunathganj I, Sagardighi, Nabagram, Khargram and Kandi, in Murshidabad district of West Bengal have been covered. The study area covers an area of about 1833.9sq km. The study area is located just in the West of Bhagirathi River. The area extends between North latitudes 23° 54' and 24° 51' 18" and East longitudes 87° 49' 1.2" and $88^0$14'31.2".The study area partly falls in the Survey of India Degree Sheet no. 72P, 78 D and 79A. The study area is well connected by road and rail.

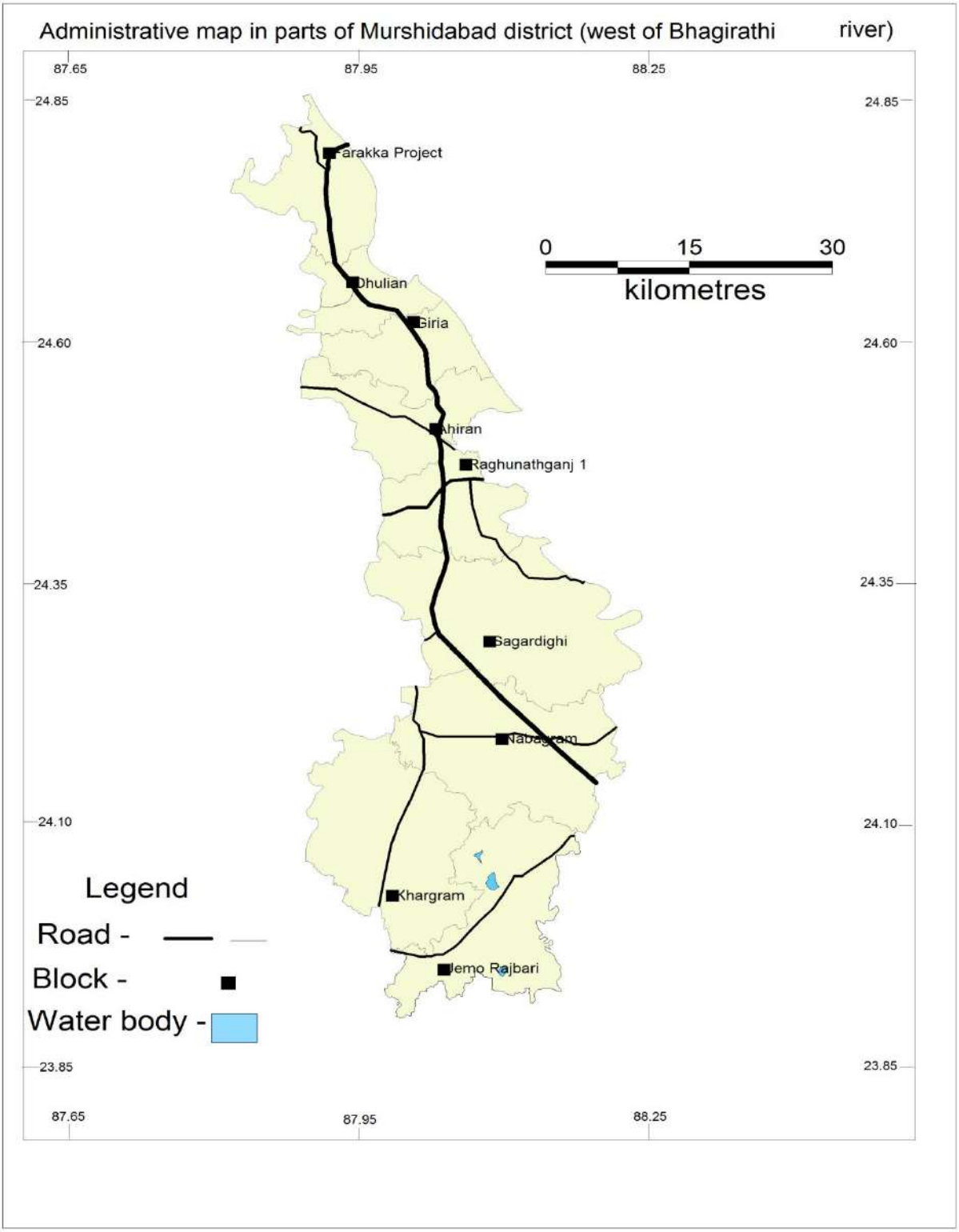


Plate 1: Administrative map of study area

1. 5:Administrative Divisions:

This area covers 9 blocks in Murshidabad district, eg. Farakka, Samserganj, Suti II, Suti I, Raghunathganj I, Sagardighi, Nabagram, Khargram and Kandi, covering an area of 1833.9sq km. Details of administrative divisions are summarized in Table1.5.1.

Table 1.5.1: Details of administrative divisions

Sr. No.	District	Block	Area* (sqkm)	Name of Sub-division	Number of Panchayat samity	Number of Gram Panchayat	Gram Samsad
1	Murshidabad	Farakka	132.74	Jangipur	1	9	147
2	Murshidabad	Samserganj	94.48	Jangipur	1	9	154
3	Murshidabad	Suti I	143.68	Jangipur	1	6	106
4	Murshidabad	Suti II	111.13	Jangipur	1	10	157
5	Murshidabad	Raghunathganj I	140.91	Jangipur	1	6	117
6	Murshidabad	Sagardighi	345.42	Jangipur	1	11	199
7	Murshidabad	Nabagram	306.63	Lalbagh	1	10	155
8	Murshidabad	Khargram	318.45	Kandi	1	12	186
9	Murshidabad	Kandi	240.43	Kandi	1	10	151
Total area			1833.87	-	9	83	1372

In the present area, there are 9Panchyat Samity, 83 Gram Panchyat and 1372 Gram Samsads. The distribution of population of the area is presented in Table 1.5.2 a.

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

Distribution of Rural and Urban Population by sex in thestudy 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
Kandi Sub-Division	252322	241155	493477	28442	27190	55632	280764	268345	549109
Kandi	112789	107356	220145	-	-	-	112789	107356	220145
Khargram	139533	133799	273332	-	-	-	139533	133799	273332
Kandi (M)	-	-	-	28442	27190	55632	28442	27190	55632
Lalbagh Sub-Division	116134	111452	227586	-	-	-	116134	111452	227586
Nabagram	116134	111452	227586	-	-	-	116134	111452	227586
Jangipur Sub-Division	499448	482241	981689	320283	316835	637118	819731	799076	1618807
Farakka	85302	82524	167826	53924	52361	106285	139226	134885	274111
Samserganj	54532	54186	108718	87502	87852	175354	142034	142038	284072
Suti I	77047	73756	150803	14858	14247	29105	91905	88003	179908
Suti II	55790	54977	110767	84205	83950	168155	139995	138927	278922
Raghunathganj I	68136	64978	133114	32159	30354	62513	100295	95332	195627
Sagardighi	158641	151820	310461	-	-	-	158641	151820	310461
Dhuliyan (M)	-	-	-	47635	48071	95706	47635	48071	95706
Part of district Total	867904	834848	1702752	348725	344025	692750	1216629	1178873	2395502

1.6 Landuse and irrigation

Out of the total area concerned,about 59.06 % areais occupied by cultivable land, about0.30 % area is occupied by 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 blocks is shown in Table-1.6.1.

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)
1	Farakka	13274	4460	-	-	257
2	Samserganj	9448	3061	-	5	-
3	Suti I	14368	7923	-	-	-
4	Suti II	11113	7352	-	-	-
5	Raghunathganj I	14091	11264	-	14	-
6	Sagardighi	34542	29297	11	3	118
7	Nabagram	30663	25645	-	6	184
8	Khargram	31845	26189	-	2	-
9	Kandi	24043	18425	-	-	-
Total		183387				

Irrigation plays an important role for crop production and intensity of crops. Apart from rainfall, irrigation is done in 89.22 % of cultivable area, whereas surface water contributes about remaining 10.88 %. Ground water irrigation is done mainly by shallow &deep 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 study area have been tabulated in Table-1.6.2a.

The majority of the study area is covered under “Rarh” area. Rice including ‘Boro’ forms the principal crop of the study area. Other crops with a substantial production include Aman, wheat,jute, pulses, oil seeds, vegetables, etc.

Table-1.6.2a: Block wise details of Irrigation in Murshidabad district (based on 4th M. I. Census) in Ha

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	Farakka	0	0.00	115	479.70	0	0.00	1	6.00	102	579.90	585.90	479.70	1065.6
2	Samserganj	0	0.00	401	1179.45	7	274.00	6	42.00	46	144.05	186.05	1453.45	1639.5
3	Suti I	0	0.00	950	2467.70	4	160.00	0	0.00	17	430.00	430.00	2627.70	3057.7
4	Suti II	0	0.00	1253	3010.68	15	584.00	0	0.00	1	53.00	53.00	3594.68	3647.68
5	Raghunathganj I	0	0.00	776	2399	5	200.00	1	2.00	30	267.00	269.00	2599.79	2868.79
6	Sagardighi	0	0.00	2103	11284.55	22	870.00	31	148.00	590	2369.42	2517.42	12154.55	14671.97
7	Nabagram	0	0.00	1606	5522.50	47	1860.00	30	89.00	7	109.00	198.00	7382.50	7580.5
8	Khargram	0	0.00	1425	9389.37	25	990.00	3	64.00	45	570.05	634.05	10379.37	11013.42
9	Kandi	1	2.00	1246	6474.71	20	784.00	15	36.27	49	911.84	948.11	7511.65	8459.76
Total		1	2	9875	42207.66	145	5722	87	387.27	887	5434.26	5821.53	48183.39	54004.92

1.7 Urban areas, Industries and Mining activities

Urban areas in the study area include one municipality in the study area i.e. Dhuliyanin the study area of Murshidabad 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, However, in the adjoining Pakur district in Jharkhand State, there is enough mining activity for road metal. National Thermal Power Corporation has one important set up at Farakka, which is located at the border of neighbouring Malda district.

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 have been tabulated and presented in Table-2.1.1 below. Normal Annual Rainfall is 1391.1 mm, Normal Monsoon Rainfall is 1039 mm

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**

(Source: IMD)

3. PHYSIOGRAPHY

3.1 Geomorphology

Overall the study area appears to be flat, but actually it is somewhat warping in nature mainly having alluvial plain topography engulfed by flood plain; in the northwestern extremity, there is a remnant of denudational hill of Rajmahal Trap basaltic lava flows. The area shows maximum surface elevation of about 40 m above mean sea level (MSL) in the central part in Sagardighi block, whereas minimum elevation of about 20 m above MSLhas been encountered in central part of Samserganj block in the northern part of present area,southeastern parts of blocks of Nabagram and Kandi and in east of Khargramblock in southern part of study area.

In south of Sagardighi, the average slope is about 0.61 m/kmtowards SE of Kandi, about 1.3 m/km towards SE of Nabagram and about 1.0 m/km towards E of Khargram; whereas in north of Sagardighi, the average slope is about 0.43 m/km towards centre of Samserganj.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.

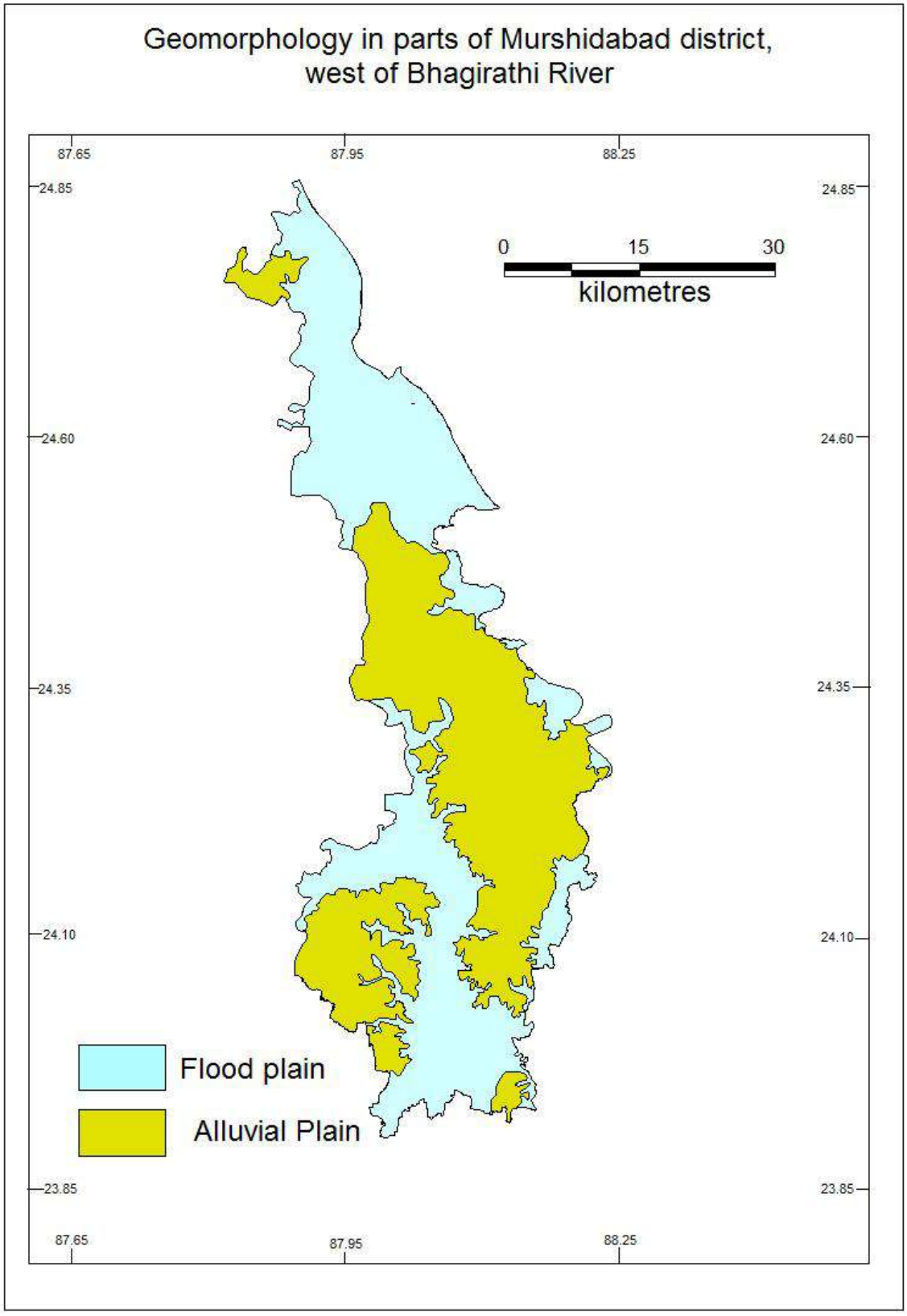


Plate-3.1.1: Geo-morphology in study area

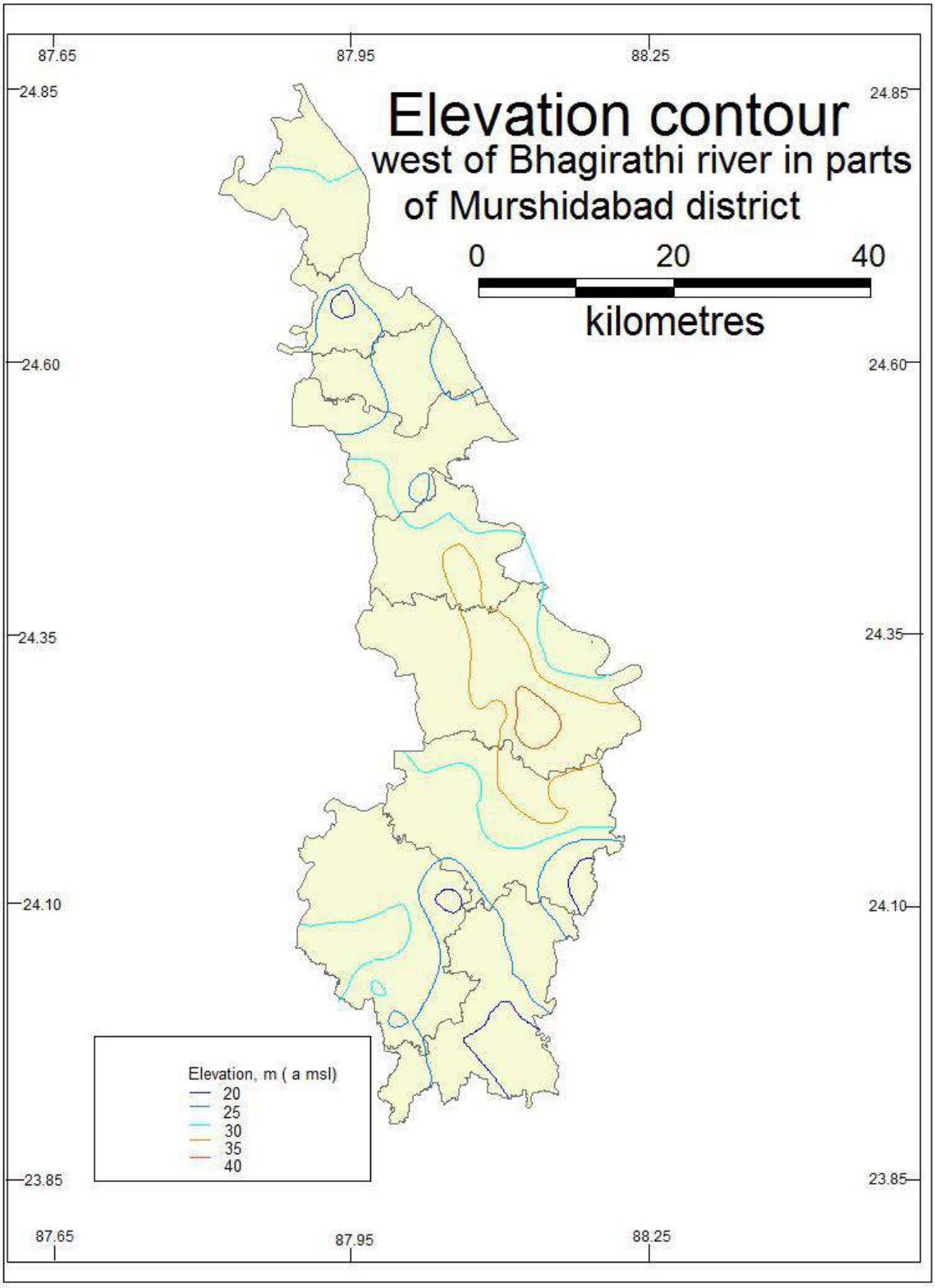


Plate 3.1.2: Elevation in study area

Geo-morphologically, GSI has divided the study area into two geomorphic units, viz. 1. Flood plain, and 2. Para Deltaic Fan Surface. The Flood Plain refers to the part of meander belt and adjoining area of present day channels of Bhagirathi River and its tributaries, viz. Dwarka/ Brahmani N., GambhiraN.and Bans N.; this unit constitutes the lowest topograthic bench and still under the process of formation and prone to flood and water logging etc. The Para Deltaic Fan Surface covers the higher ground above the occasional and usual flood level.

3.2 Drainage

The whole area is drained by the rivers and tributaries of Bhagirathi/Hugly/Ganga/Padma drainage system. Bhagirathi River is perennial in nature; it borders the eastern side of present area and flows almost in N-S direction. Dwarka/ Brahmani N., Gambhira N. and Bans N. are important tributaries of the area and they flow mostly in N-S direction. Besides, there are many major water bodies covering huge area mostly in northern part in blocks of Samserganj, Suti II, Suti I and Raghunathganj I, and in Kandi block (BelunBil, PatanBil, SankuraBil, Narialbil, etc.) in the south of study area. The Drainage in the study area is shown in Plate-3.2.1.

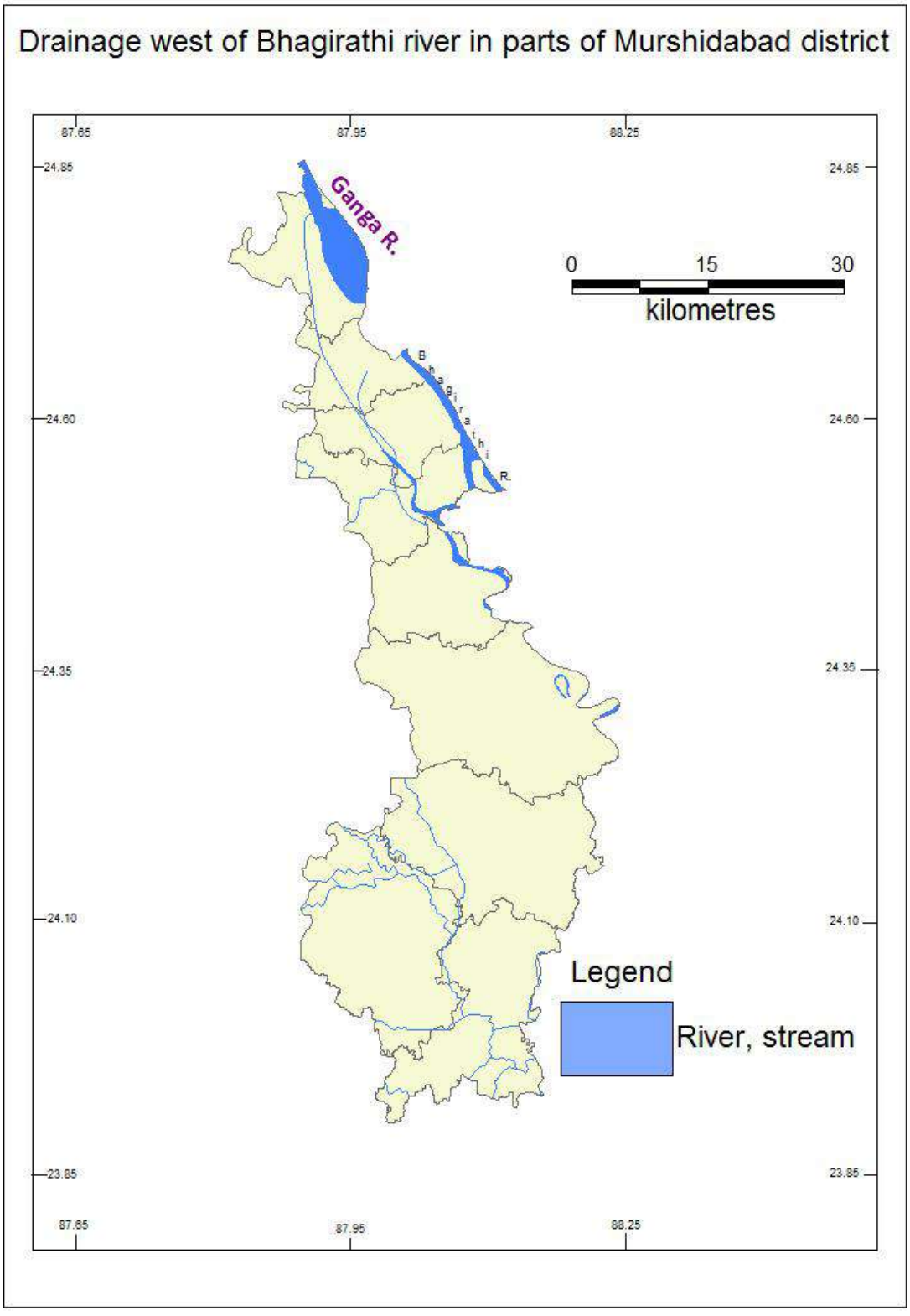


Plate-3.2.1: Drainage Map of the study area

3.3 Soil characteristics

Main types of soil in the study area are imperfectly 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).

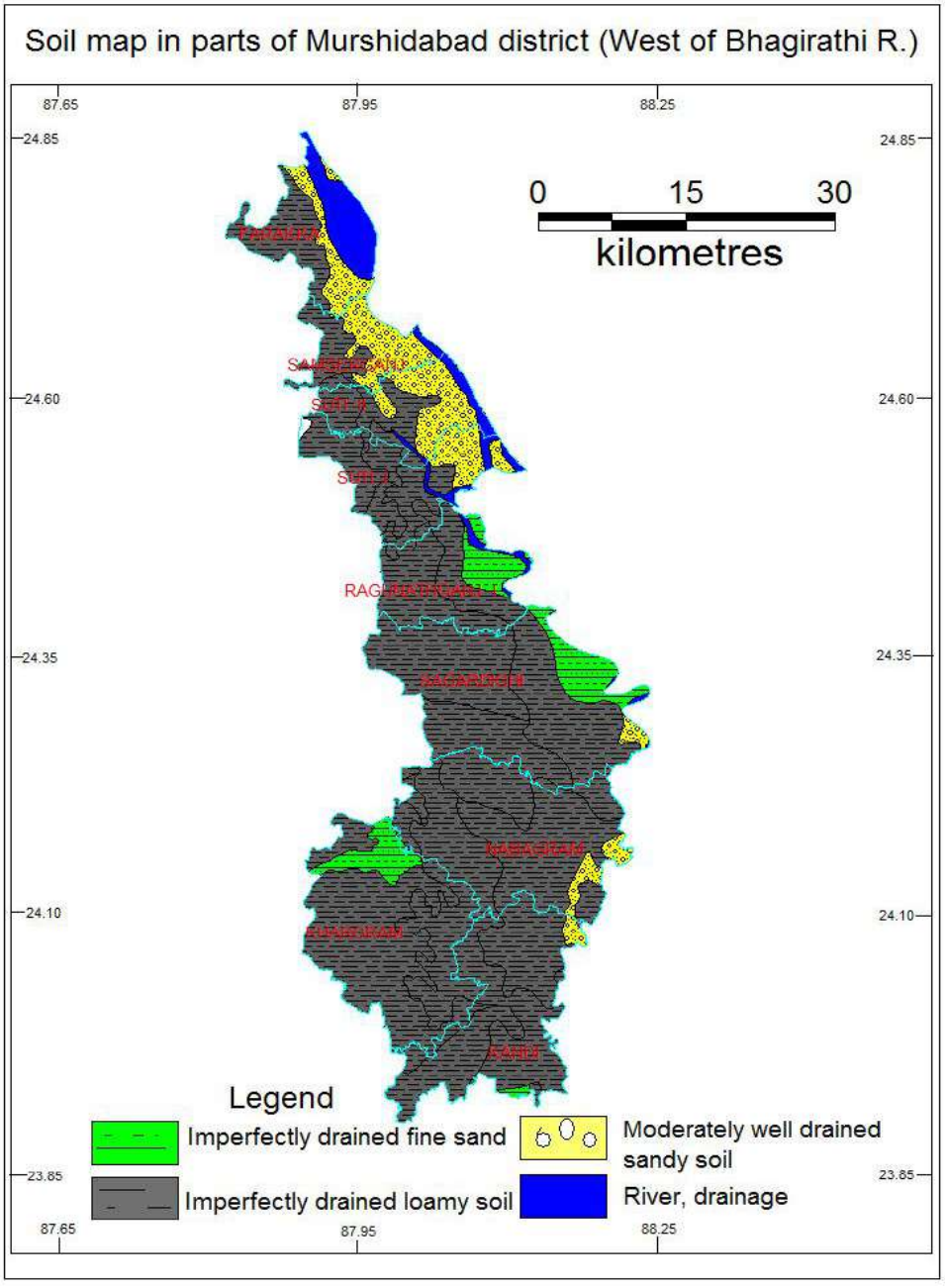


Plate-3.3.1: Soil map in study area

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

SI. No.	Block	Area (Ha)	Imperfectly drained, fine sand		Imperfectly drained, loamy soil		Moderately well drained, sandy soils (coarse loam)	
			Area (Ha)	%	Area (Ha)	%	Area (Ha)	%
1	Farakka	13274	-	-	5556	41.86	3115	23.47
2	Samserganj (with M.)	9448	-	-	3950	41.81	4471	47.32
3	Suti I	14368	-	-	10594	73.73	3774	28.71
4	Suti II	11113	-	-	5723	51.50	4823	43.40
5	Raghunathganj I	14091	2783	19.75	10654	75.61	10	0.073
6	Sagardighi	34542	4003	11.59	29893	86.11	622	1.80
7	Nabagram	30663	104	0.34	28918	94.31	1640	5.35
8	Khargram	31845	28718	90.18	-	-	3127	9.82
9	Kandi (with M.)	24043	264	1.10	23230	96.62	548	2.28

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 greyish black and or dark finer fractions of sediments are generally encountered during exploration up to deeper depth. Quaternaries of Hugli-Bhagirathi river system are represented by Older Alluvium of Late Pleistocene to Late Holocene age and Younger Alluvium of Late Holocene to Recentage. Older Alluvium, representedgenerally by fine to medium sands, are mainly pale yellow to brownish in colour, oxidised, and mostly developed in upland areas of parts of study

areareprесenting relatively higher elevation covering Alluvial Plain. Recent to Sub-Recent Younger Alluvium of the Ganga river system consists of clay, silt, sand and gravel and it occupies the Flood Plain of study area in geomorphic lows; these deposits are characteristically light coloured / greyish, fine to medium, and very often micaceous and their composition is mainly quartzo-feldspathic.

In the northwestern extremity, there lies a remnant of denudational hill of Rajmahal Trap basalts of Jurassic to Creataceous age. It has been reported to be represented by lava flows with intercalated carbonaceous shales and clays. It is dark, fine grained amygdaloidal rock.

5.0 SUBSURFACE AQUIFER DISPOSITION

In present study, data gathered through exploratory drilling& construction of tube wells by out sourcing (Table) in CGWB and other sub surface data collected from State Govt. Depts., viz. PHED, Agri Irrigation, etc. reveal the presence of about 300 m thick sediments.Generally, Top soil, mixed with kankars, concretions and clayoccur at or near the surface up to a maximum depth generally ranging up to about 10 mbelow ground level (bgl). In this area, there are two main groups of aquifers: Aquifer I Group and Aquifer II Group, besides, there is another localised aquifer group, viz. Aquifer III Group, which is encountered in Kandi.

Table 5.1 : Tube wells constructed by outsourcing in CGWB

ID No.	Location	Block	Type of Well	Depth	OW	Lat	Long
1	Panchgram	Nabagram	EW	200	No	24.19884	88.0102
2	Amarkundu	Nabagram	EW	300	Yes	88.14765	88.14765
3	Nagar	Khargram	EW	300	Yes	24.08321	87.98348
4	Kandi	Kandi	EW	300	Yes	23.92634	88.06214
5	Arjunpur	Farakka	EW	200	No	24.713	87.92826
6	Hafania	Suti II	EW	300	Yes	24.62172	88.01619
7	Raghunathganj	Raghunathganj I	EW	300	No	24.45965	88.0616
8	Kankuria-Jafrabad	Samserganj	EW	200	No	24.65464	87.96564
9	Manigram_Balarambati	Sagardighi	EW	300	No	24.35115	88.11664
10	Popara	Sagardighi	EW	200	No	24.29843	88.0973
11	Jagdal	Sagardighi	EW	300	Yes	24.28468	88.08471
12	Ramakantapur	Suti I	EW	200	No	24.54048	88.07064
13	Gatla	Kandi	EW	300	No	24.08177	88.08446

Aquifer I Group: this aquifer is mainly restricted in flood plains within Younger Alluvium deposits. These are encountered in northern part in blocks of Farakka, Samserganj, Suti II and Suti I block,and eastern periphery beside Bhagirathi River covering parts of blocks of Raghunathganj I andSagardighi; this aquifer has also been encountered in very small areas of blocks of Kandi and Khargram. Aquifer Group I is generally restricted within a very shallow depth.It occurs under unconfined or phreatic condition, but in northern blocks including blocks of Farakka, Samserganj and Suti II, where top clay layer is sufficiently thick,this aquifer is under semi-confined to confined condition. This aquifer mainly consists

of light coloured, fine to medium grained deposits. Aquifer I, where exists, occurs as outliers over Aquifer II.

Aquifer II group: this aquifer is the most prolific, occurs within Older Alluvium and omnipresent in all the nine blocks under study. This aquifer includes one or more layers. It is encountered within depth ranges between 3 and 112.63 m bgl;The average thickness of this group ranges generally between 24 m and 71 m,maximum and minimum thicknesses have been encountered in blocks of Kandi and Farakka respectively. This aquifer consists of reddish / brownish granular zone, generally comprising of fine tocoarse sand, sometimes mixed with gravel with or without intervening clay lenses/ beds. The aquifer mainly occurs under semi-confined to confined condition in major part of study area. This group occurs throughout the study area; average thickness of clay layer separating Aquifer II and Aquifer IIIranges between 19.97 m and 49.6 m; thickness increases towards south.

Aquifer III Group: the signs of deeper aquifer has been encountered mainly in blocks of Kandi, and Khargram, and obscure section has also been encountered in Sagardighi, RaghunathganjI and Nabagram (silty clay aquifer). This aquifer is generally very thin, very fine grained and occurs within the Tertiaries. Its potentiality is very limited and tapping this aquifer is very much difficult and costly. Therefore, nos. of tube wells in this aquifer is very limited or their lithological data are only available.The aquifer occurs under confined condition.

It has been tried to visualise the aquifers of the study area in 3 D and 2 D aquifer dispositions. The Aquifer I is generally thin and, wherever exists, has been encounteredwithin about 40 m depth. Aquifer II is generally limited to 100 m and; below this depth Aquifer III has been encountered in a few blocks.

In Fig. 5.0.1 and Fig. 5.02, respectively the Stratigraphic Logs of Tube wells studied & 3D aquifer disposition in the area have been shown. In Figs. 5.03 &5.04, N-S Section Index line from Farakka to Kandi and corresponding stratigraphic section has been shown. In Fig. 5.05, another N-S Section index Line along Ahiran– Kandiand in Fig. 5.06, corresponding Section has been shown. In Fig. 5.07 and Fig. 5.08, W-E Section Index Line (Kusumgachhi-Fatellapur) and corresponding Stratigraphic Section have been shown respectively. Similarly, in Fig. 5.09 and Fig. 5.10, another set of W-E Section Index Line (Kanduri – Udaychandpur) and corresponding Stratigraphic Section have been shown respectively. From the said figs. it is evident that in the study area, **Aquifer II** is the most prolific, persistent and potential

aquiferin ‘Older Alluvium’ and this group is more or less flat having a very gentle slope towards south. **Aquifer I** is encountered only in ‘Younger Alluvium’, and it is thin and as per present study it covers fully of the northern blocksof Farakka, Samserganj, Suti II &Suti I but partially southern block areas of Raghunathganj I &Sagardighi and a few patches in blocks of Kandi&Khargram.

Apart from the aforesaid aquifers, there is another local aquifer group, **Aquifer III Group**, consists mainly of thin layers and are housed in theTertiaries. They have been encounteredmainly in blocks ofKandi and Khargram.

Stratigraphic Logs_Study area

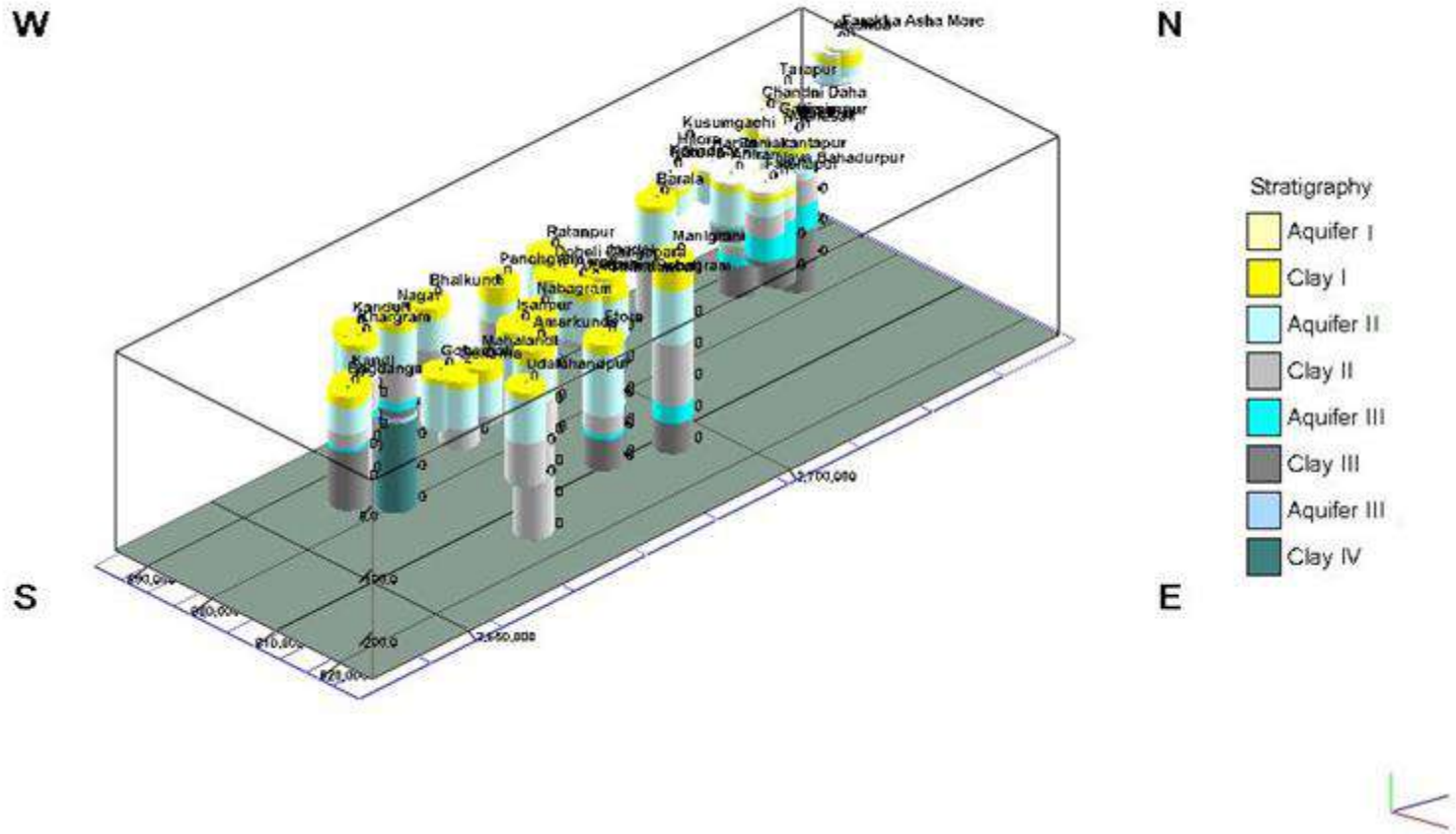


Fig. 5.01: Stratigraphic logs in study area

3D Aquifer Disposition in study area

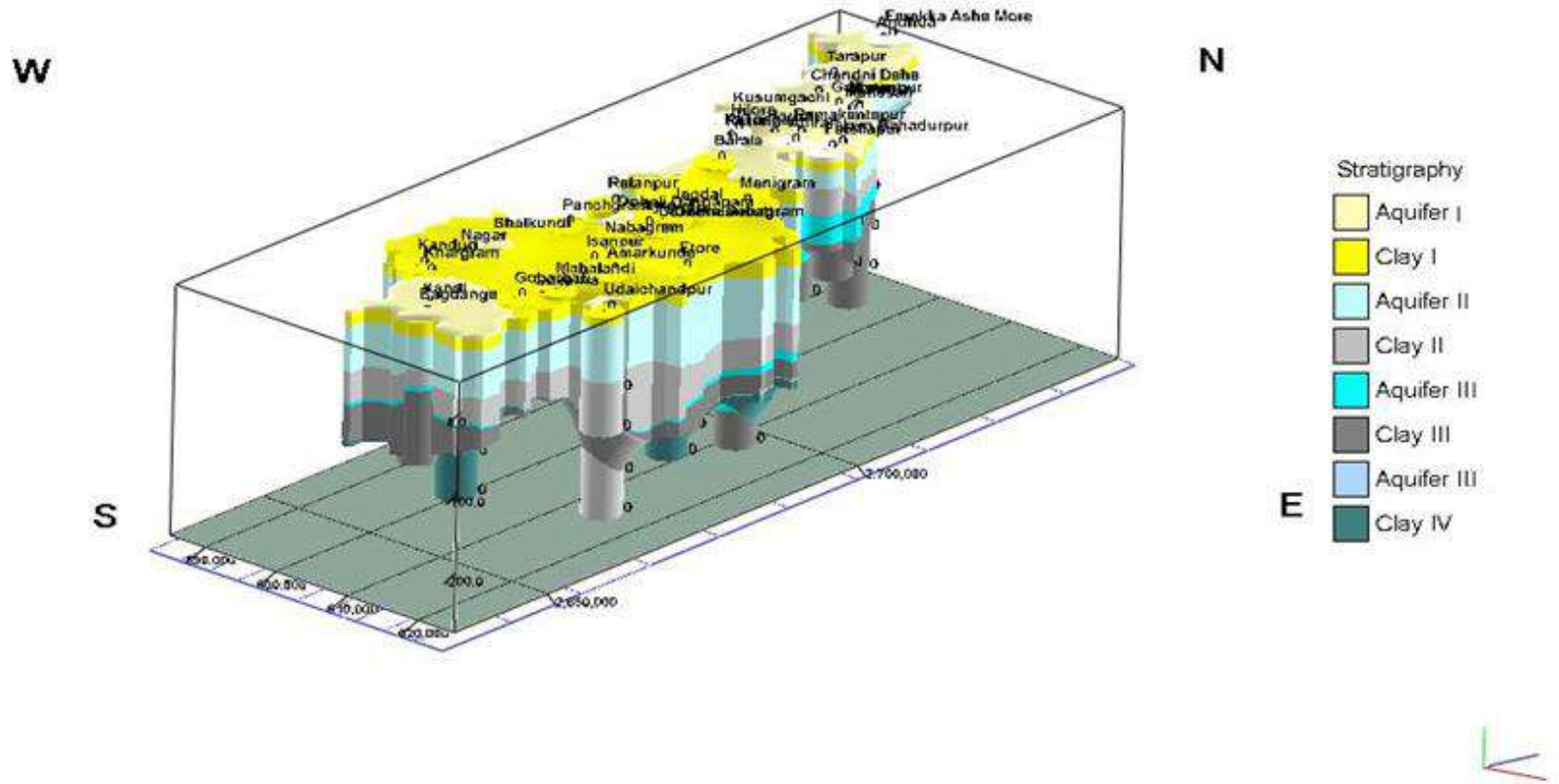


Fig. 5.02: 3D Aquifer disposition in parts of study area

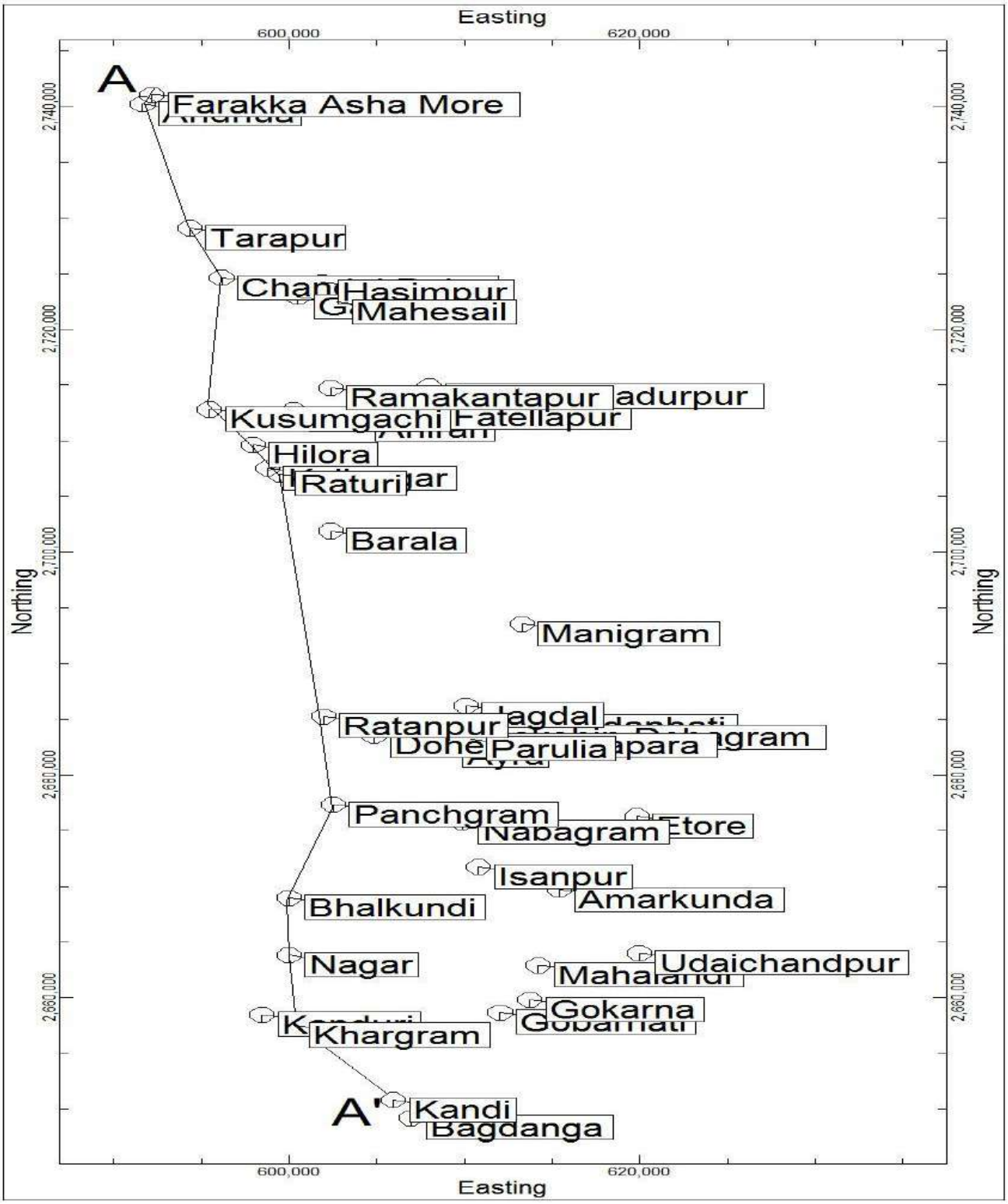


Fig. 5.03: Tube wells studied in the area with N-S Farakka – Kandi Section Index Line

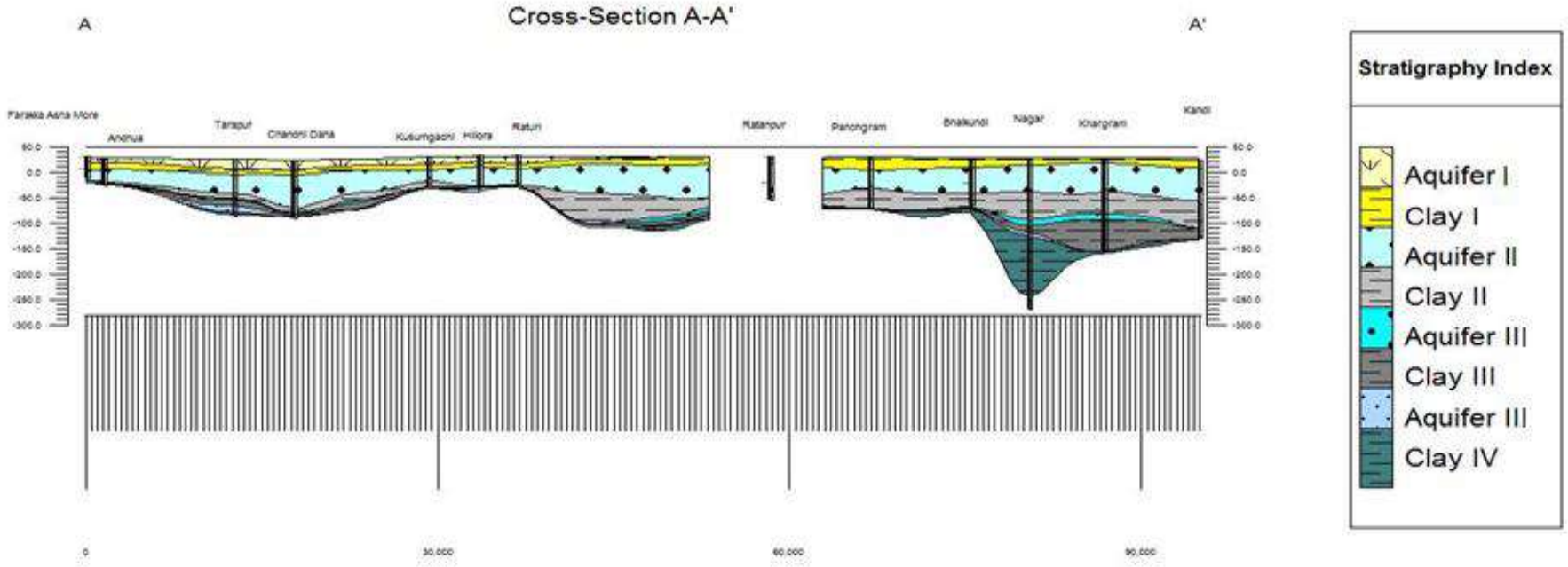


Fig. 5.04: 2D aquifer disposition along N-S Index Line (as shown in Fig 5.03) in Farakka – Kandi sector

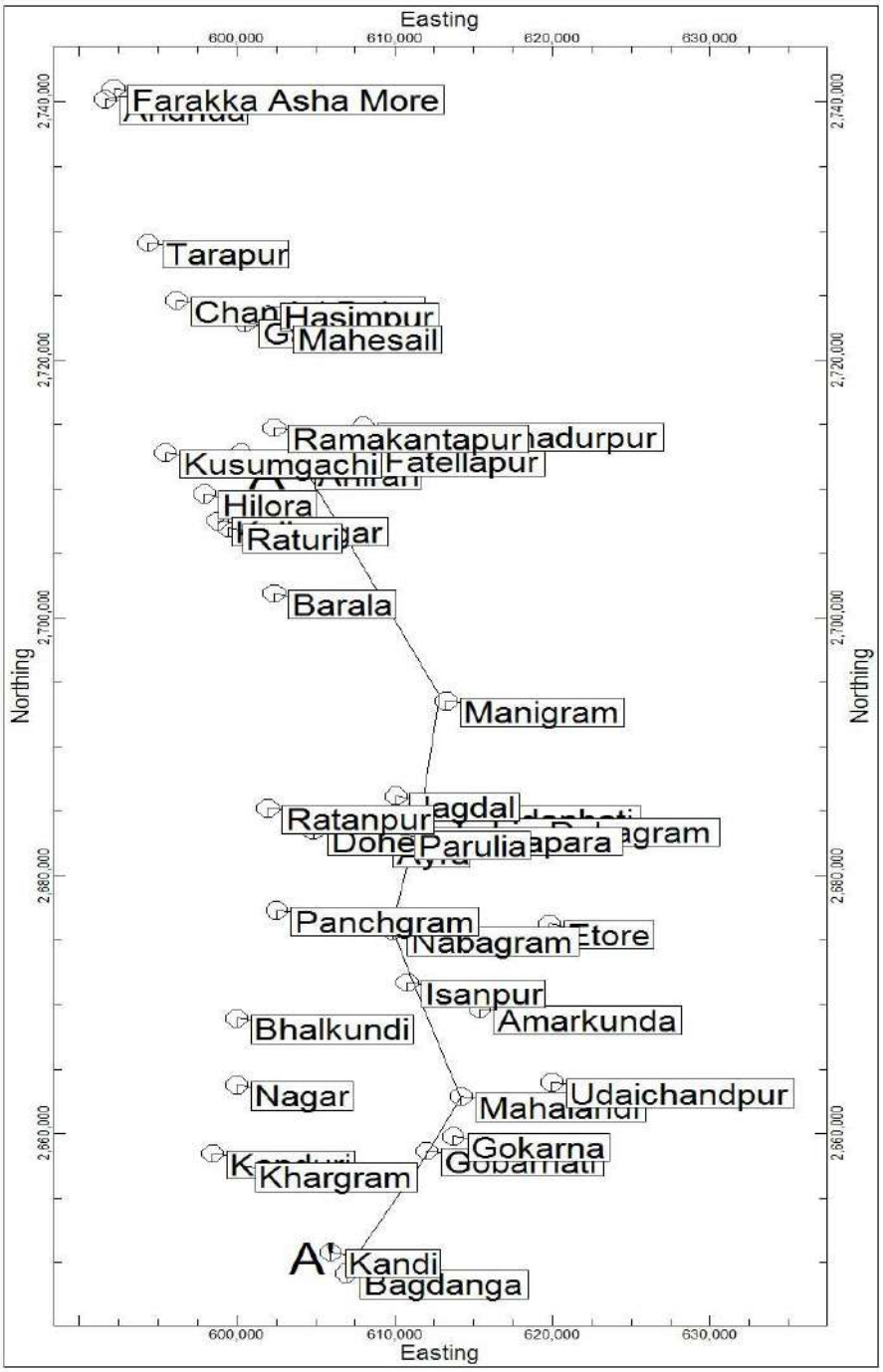


Fig. 5.05: N-S Section - 2D aquifer disposition Section Index Line (Ahiran – Kandi)

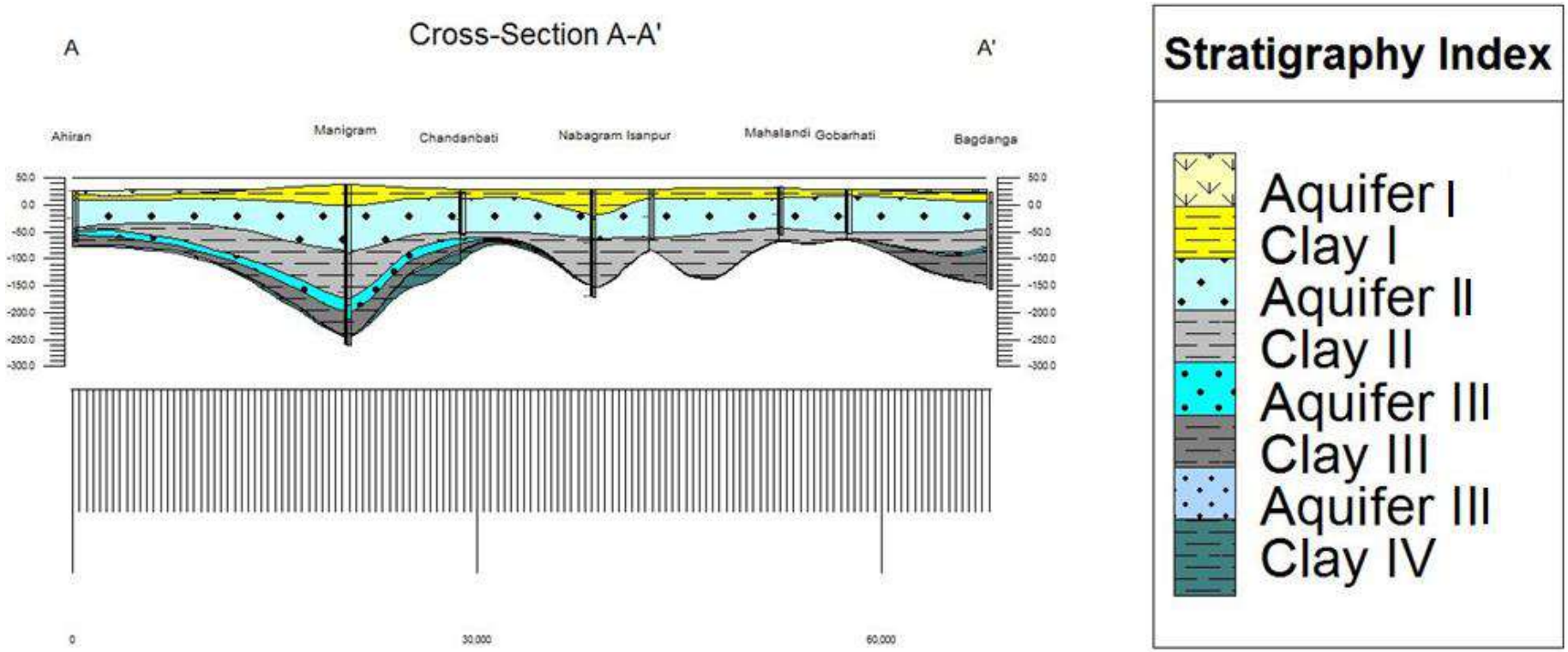


Fig. 5.06: 2D aquifer disposition along N-S, Ahiran – Kandi Index Line

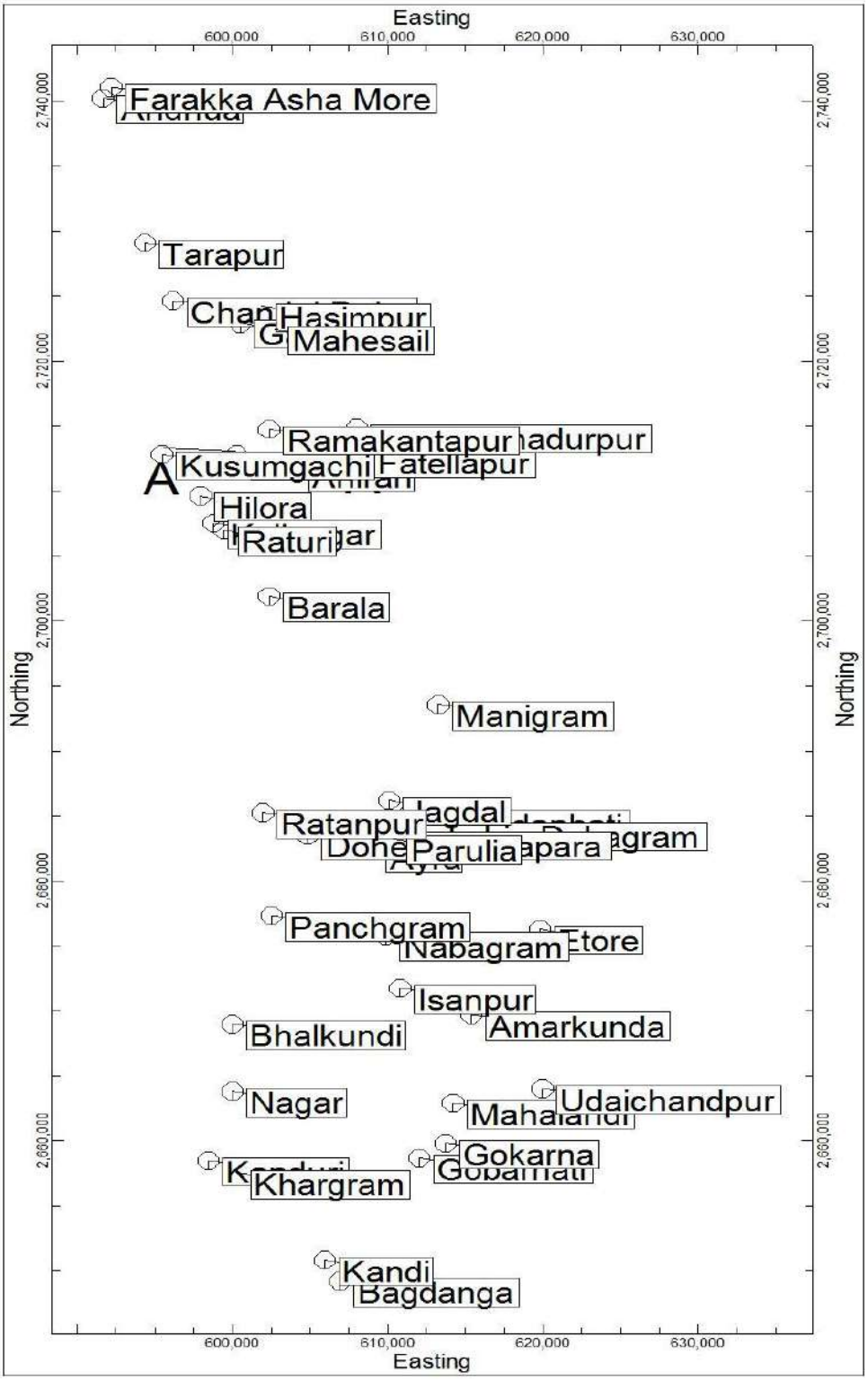


Fig. 5.07: W-E Stratigraphic Section Index Line (Kusumgachhi – Fatellapur)

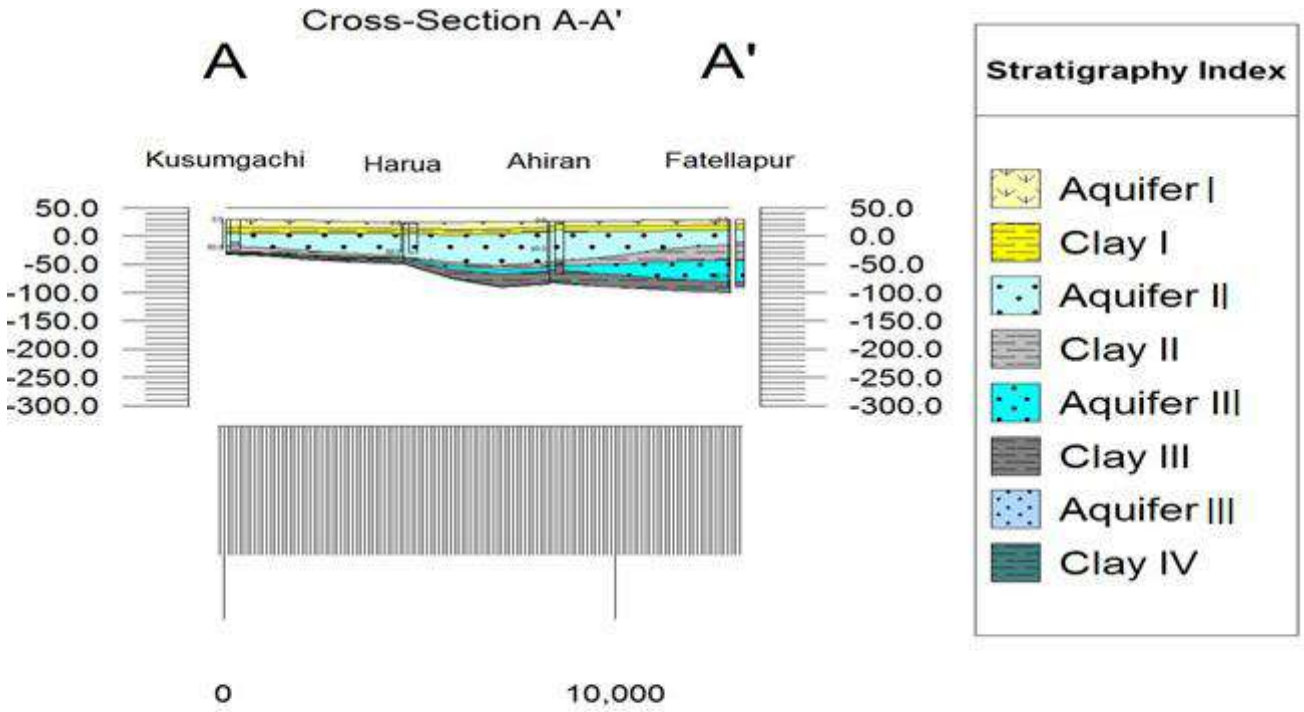


Fig. 5.08: W-E Stratigraphic Section along Index Line as shown in Fig 5.07 (Kusumgachhi – Fatellapur)

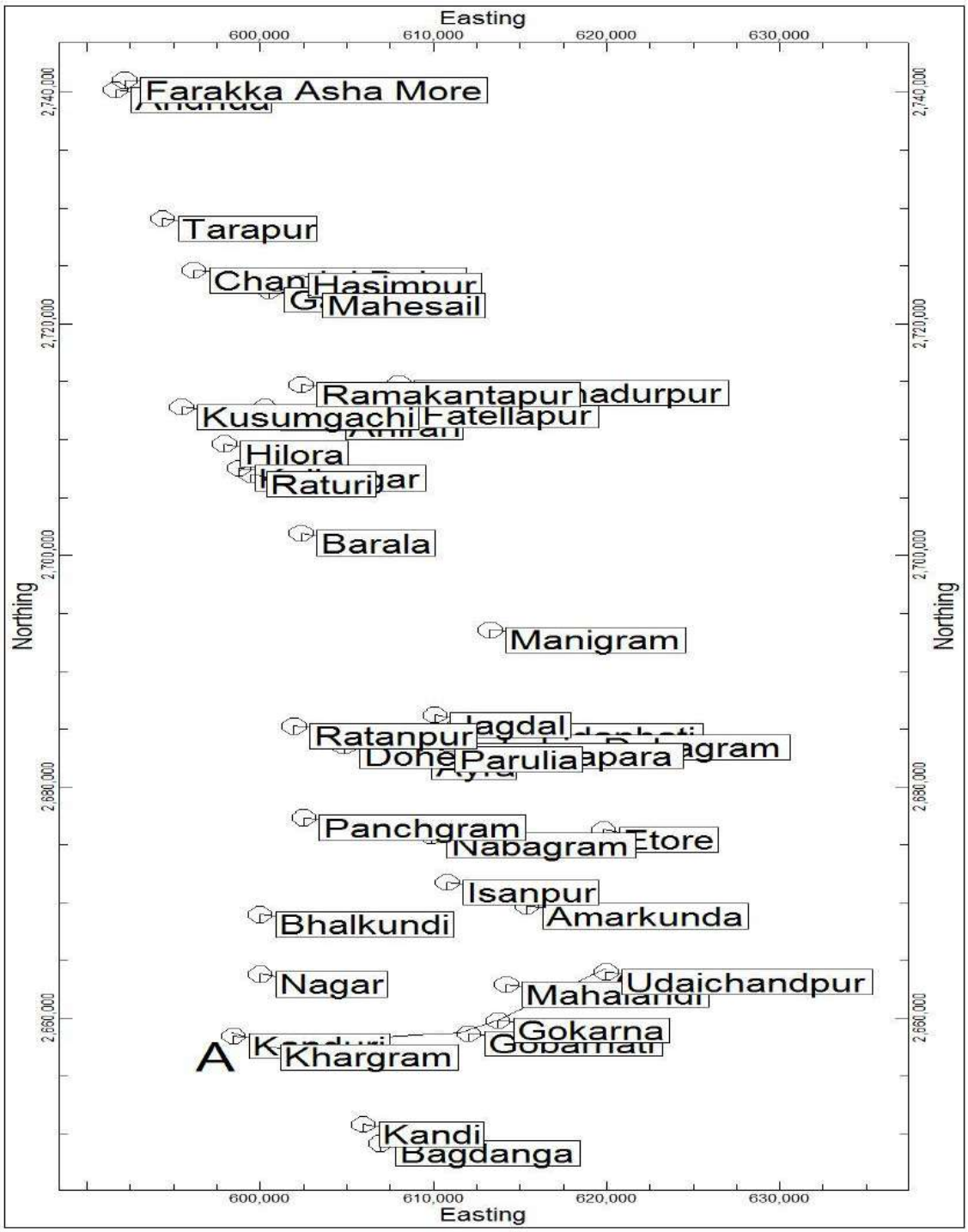


Fig. 5.09: W-E Stratigraphic Section Index Line (Kanduri –Udaichandpur)

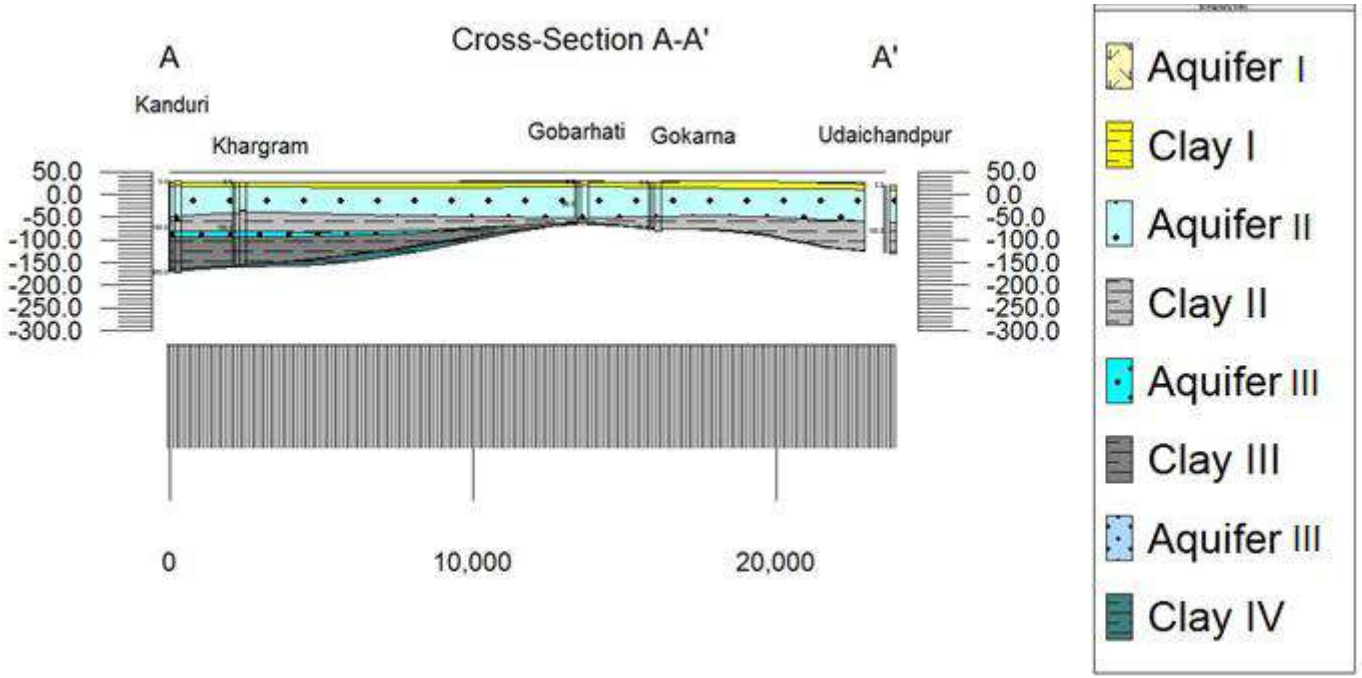


Fig. 5.10: W-E Stratigraphic Section along Index Line shown in Fig. 5.09 (Kanduri – Udaichandpur)

6. HYDROGEOLOGY

6.1 Water bearing Formation and Aquifer groups:

The area under study isoccupied mainly by Older Alluvium overlying the Tertiaries throughout the whole area and the same is underlain by a thin veneer of Younger Alluvium covering almost totally 4 blocks in the north, viz. Farakka, Samserganj, Suti II and Suti I, and partially covering fringe eastern parts of southern blocks of Raghunathganj I and Sagardighi; a very small parts of Kandi and Khargram blocks are also covered by Younger Alluvium.After analysing exploratory data of CGWB up to a maximum depth of about 300 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 is one localised Group, i.e. Aquifer III. In this report, Aquifer I has been studied in parts of 6 blocks, eg. Farakka, Samserganj, Suti II, Suti I, Raghunathganj I and Sagardighi, in Younger Alluvium up to a depth of about 40 m. The most prolific or Aquifer II has been encountered in all the 9 blocks including Kandi,Khargram and Nabagram in Older Alluvium up to a depth of 100 m.The Tertiaries are encountered below 100 m in southern part of present area, whereas in north it is encountered even at shallow depth of 50 m; within Tertiaries at places insignificant Aquifer III is encountered.

The aquifer groups comprises a single or more aquifers with intervening thin clay lenses/ beds. Parting and coalescence of aquifers are also encountered at places.

Out of these aquifer groups, i.e. Aquifer I, Aquifer II and Aquifer III, Aquifer II is prolific one and regionally extensive; this aquifer is encountered generally within Older Alluvium, but found to be extended up to about 100 m; sometimes there is continuity of Aquifer II even in Tertiaries without any clay layer in between. Thick Aquifer II has been encountered in Kandi, Nabagram, Khargram, sagardighi and Raghunathganj I blocks. Maximum thickness of 79 m of Aquifer II has been encountered at Bagdanga in Kandiblock. In Older Alluvium, it is mainly greyish brown to yellowish brown to even golden brown in colour, fine to very coarse sand and even sometimes with gravel sized in nature; but, when it extends in the Tertiaries, it is grey/blackish grey and generally finer in nature.

Layers of third aquifer, i.e. Aquifer III, is thin in nature and is encountered below Aquifer II up to a depth of 164 m in the Tertiaries within about 200 m of available exploration record.Maximum thickness of Aquifer III is about20 to 30 m at Khargram. Sediments inAquifer III is mainly greyish or dark grey in colour, very often becomes totally dark in nature and generally finer grained.

Between Aquifer II and Aquifer III, there is a thick clay layer, the thickness of which varies from block to block; maximum average thickness of this clay has been encountered up to 50 m in Kandi block. Parting and coalescence of aquifers and presence of sticky clay layers is very common in Aquifer III.

Top most Aquifer Iof average thickness of 20 m, comprising mixture of sand silt and clay two layers has been encountered in Younger Alluvium in geomorphological lows of blocks of Farakka, Samserganj, Suti II, Suti I and in parts of Raghunathganj I and Sagardighi.

The 2D/3D views of the aquifer system in the subsurface of study area have been shown inFig. 5.01 to Fig. 5.10.

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. Mainly two aquifer groups have been deciphered: Aquifer I encountered in 4 blocks and in smaller portions in four otherblocks, Aquifer II encountered in all the 9 blocks under study, and, Aquifer IIImainly in2blocks. Aquifer wise depth characteristics of different aquifers in study area have been enumerated in Table 6.1.1.

Table 6.1.1: Block wise depth range of aquifers studied

Blocks	Area (ha)	Aquifer I	Average Thickness (m)	Aquifer II	Average Thickness (m)	Aquifer III	Average Thickness (m)
Farakka	13274	9.98 – 11.39 (maximum up to 15 m)	10.69	24.38 - 50	30	-	-
Samserganj	9448	7.10 - 25	20.61	43.69 – 112.63	65.5	-	-
Suti I	14368	Up to 15 to 20 m	18	25 – 76.2	56.8	109-118	Very Thin
Suti II	11113	5.50 - 20	15	25 – 76.2	38.90	109-118	-
Raghunathganj I	14091	16.38 – 30.68 (localised)	20 (localised)	38 – 82.31,	68.8	93- 113	Very low potentiality
Sagardighi	34542	24.38– 25.00 (localised)	24 (localised)	40 – 81.99	65.2	146-152, 170-182, 202-205	12
Nabagram	30663	-	-	12 – 80	70	105 - 155	Clayey silt
Khargram	31845	20 – 30 (Localised)	22 (Localised)	9.70 – 67.07	58.3	108.9 – 163.89	24.2
Kandi	24043	8. 75- 20.00 (localised	14.38 (localised)	30 – 86.8	71.18	131.1 – 149.7	18.6

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

During detailed survey 91 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, 23 nos. of stations within 50 m bgl represent AquiferI, 67 nos. of key wells represent Aquifer IIwith depth range between 9 and 114.6 mbgl, and 1 station of 156 m depth representing Aquifer III. In the present area, Aquifer II is most prolific and in this formation cost of construction of tube well is cheap. Therefore, tube wells are constructed tapping mainly in Aquifer II. Aquifer III is represented by finer fractions of sediments and potentiality is mostly insignificant; so tapping these aquifers is very difficult. Also, costof construction of tube wells tapping Aquifer III is very high. Pre-monsoon and post-monsoon depth to water levels of 23 wells representing Aquifer I and the same represented by 67 wells tapping Aquifer II have been tabulated and given in Annexure Ia& Annexure Ib respectively.Graphical representation of location of key wells representing Aquifer I and Aquifer II have been shown in Plate 6.2.1 and Plate 6.2.2.

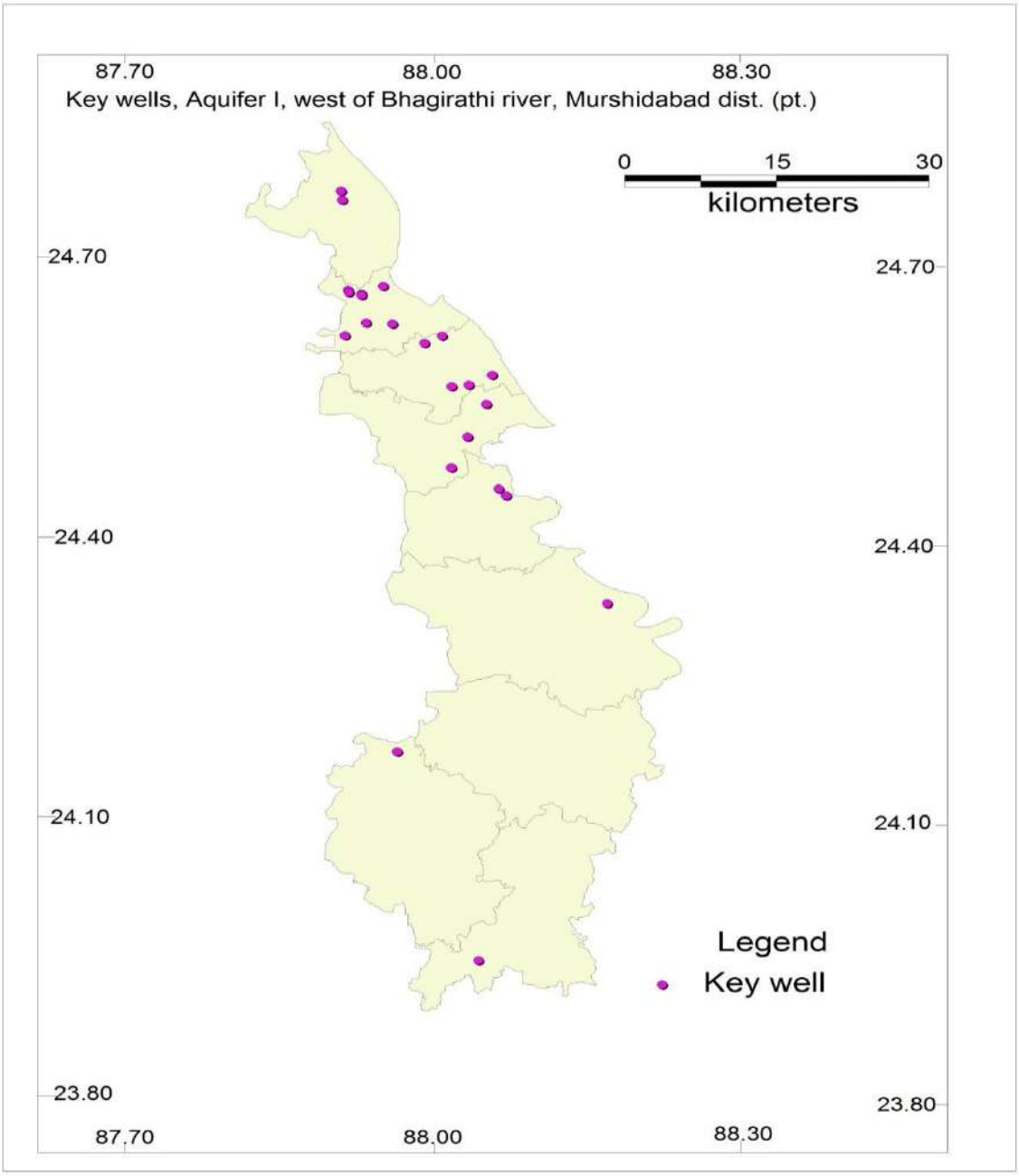


Plate 6.2.1:Key wells representing Aquifer Iin study area

6.2.1 Aquifer I

Aquifer I occurs generally within a depth of 40 m in northern blocks, eg. Farakka, Samserganj, Suti II, Suti I and in small eastern parts of blocks of Raghunathganj I and Sagardighi; A very smaller outliers of Aquifer I has also been encountered in blocks of Kandi and Khargram. Pre-monsoon depth to water level in AquiferI' in present area has

been graphically presented in Plate 6.2.1a, what reveals that the water level is generally moderate, ranging within 5-10.60 m bgl; but, zones of very shallow water level within 2 – 5 m bgl are mainly encountered in small parts of blocks of Suti I and Kandi.

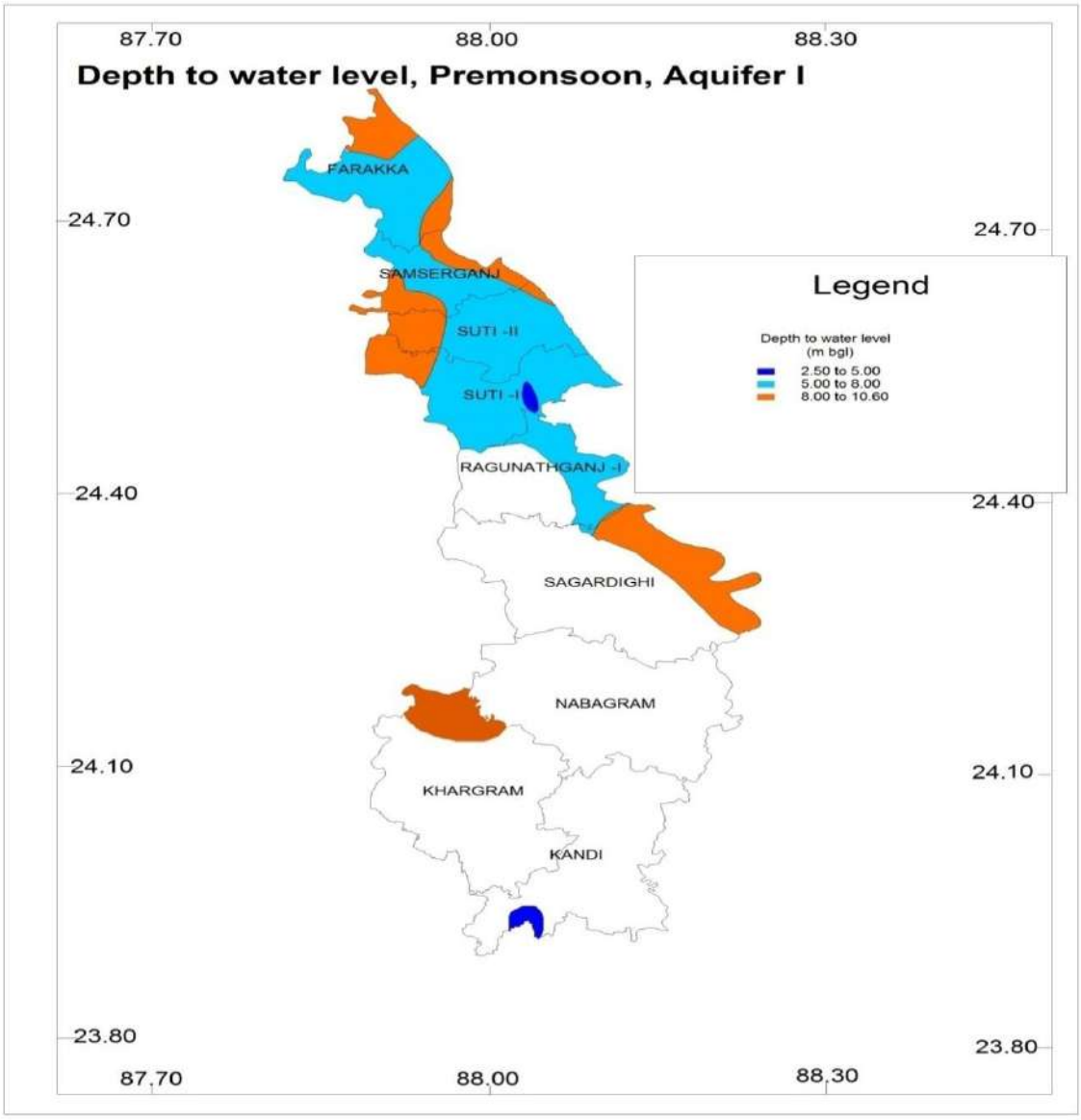


Plate 6.2.1a: pre-monsoon depth to water level in Aquifer I

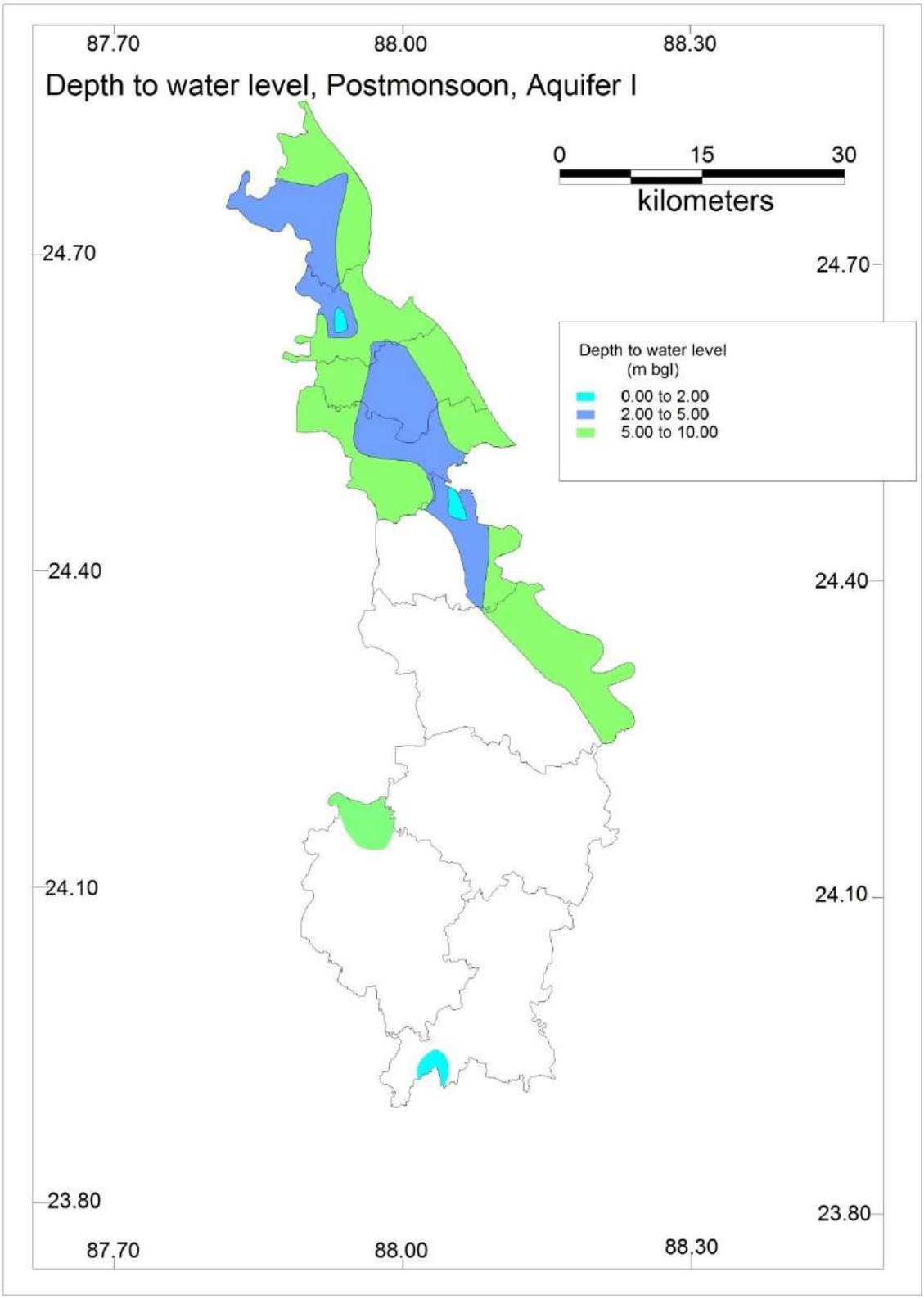


Plate 6.2.1b: post-monsoon depth to water level in Aquifer I

The post-monsoon depth to water level mapof Aquifer I, shown in Plate 6.2.1b,revealsthat in major part of the area, water level within 5 – 10m has been observed; besides, zones within 2- 5 m bgl are mainly encountered in patches in central parts of Farakka, Samserganj, Suti II and Suti I, being the geo-morphological low land in study area. A very shallow depth to water level of 0-2 m has been encountered in smaller patches in Kandi, Samserganj and Raghunathganj I.

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.

6.2.2 Aquifer II

AquiferII has been encountered almost throughout the area. Key wells representing Aquifer II has been shown in Plate – 6.2.2. Pre-monsoon depth to water level, drawn on the basis of available data, has been shown in Plate-6.2.2a,whichrevealsthat thedepth to water level is mostly deep ranging between 20-35 m in the southern blocks in the south of Sagardighi (though moderate water level within 15-20 m has been encountered in small patches within this zone) covering blocks of Sagardighi, Nabagram, Kandi, and Khargram, and within 10-20 mbgl in northern blocks, north of Sagardighi.

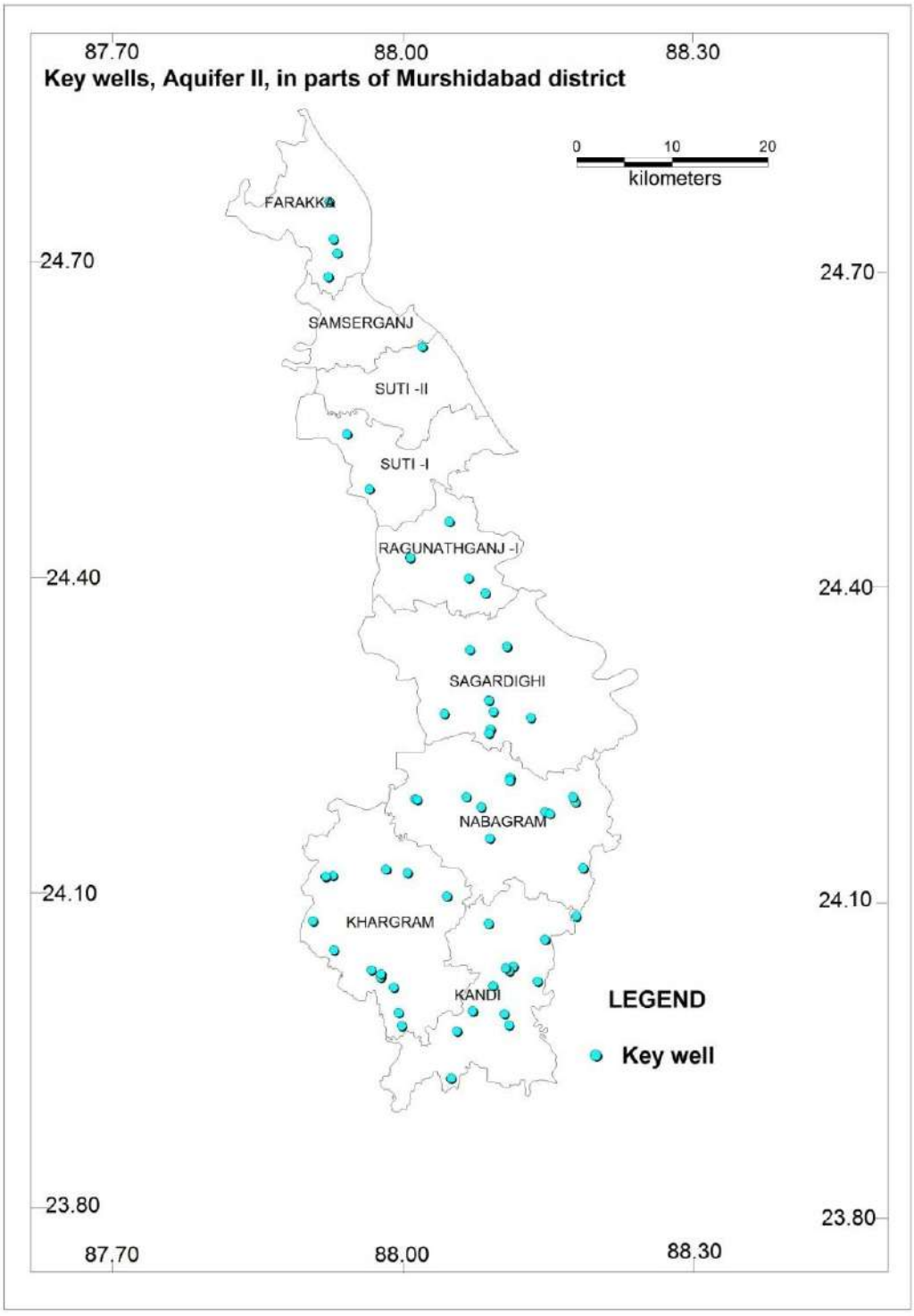


Plate 6.2.2: key wells representing Aquifer II

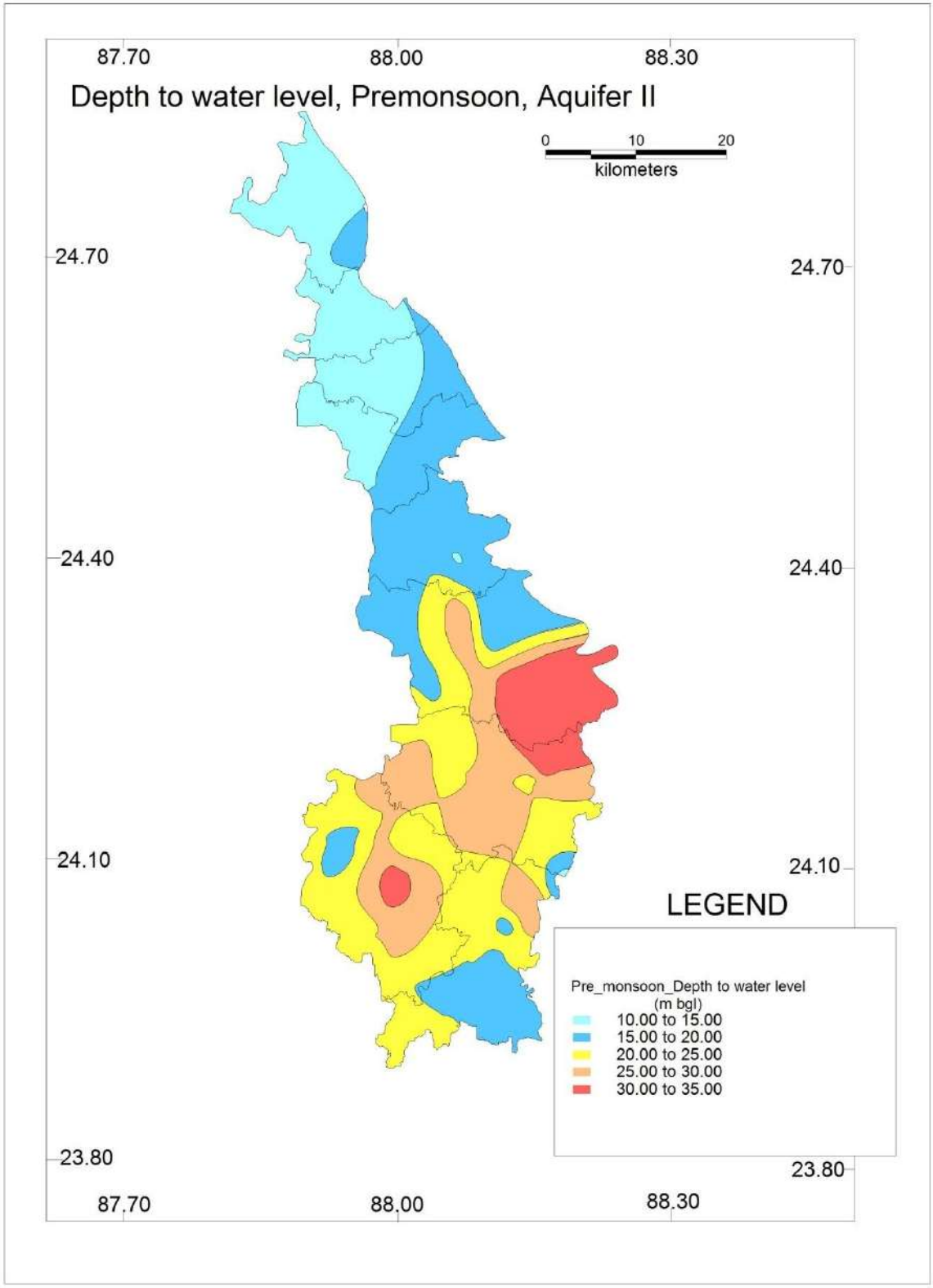


Plate 6.2.2 a: pre-monsoon depth to water level representing Aquifer II

Likewise, post-monsoon depth to water level map (vide Plate-6.2.2 b) for Aquifer IIin study area has also been drawn and the same reveals that shallow to moderate water level within 10-15m bglmainly in the 5 northern blocks of Farakka, Samserganj, Suti II, Suti I and Raghunathganj I (pt.), and water level between 15 -30 m has been encountered mainly in southern parts of Sagardighi, Nabagram, Khargram and Kandi blocks.

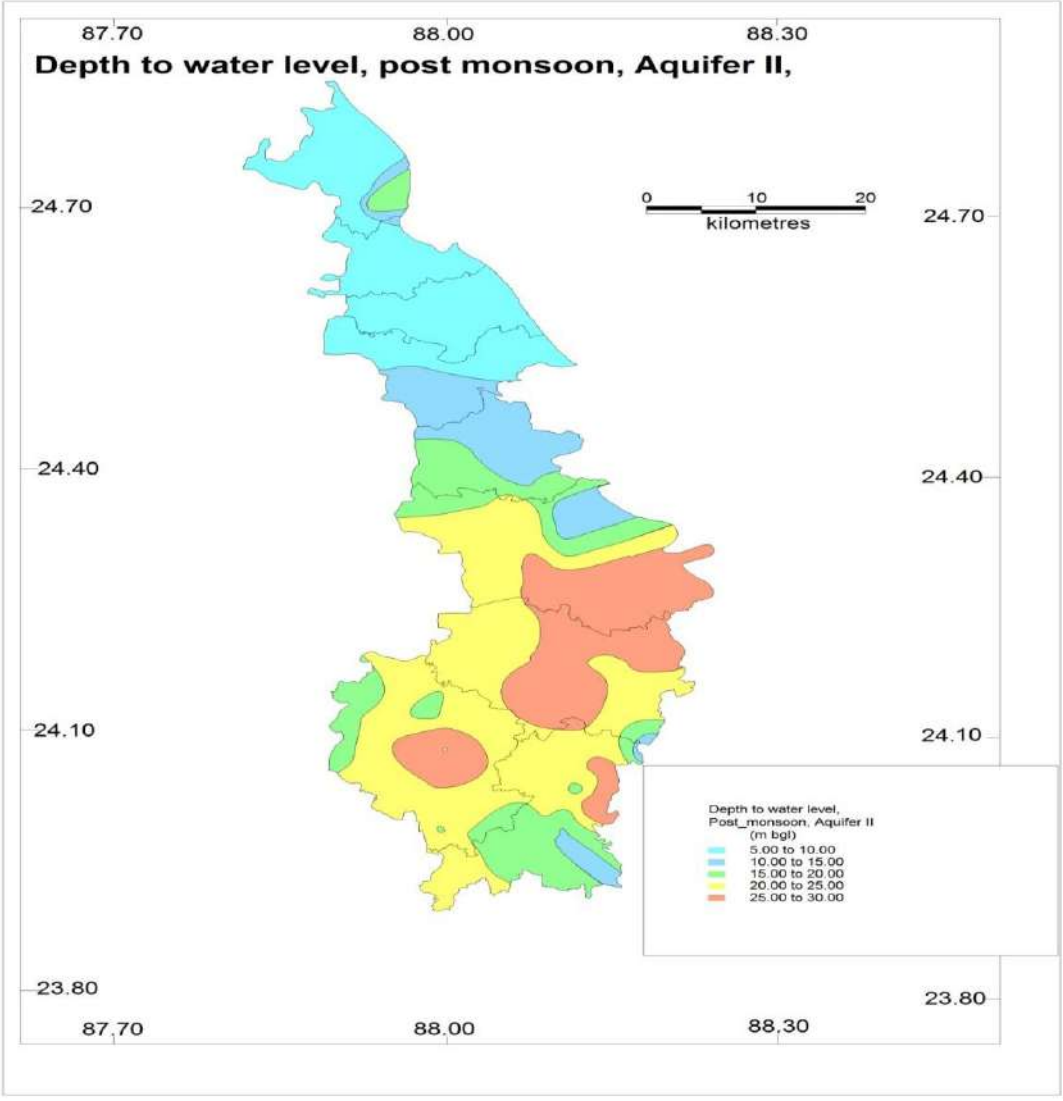


Plate 6.2.2 a: post-monsoon depth to water level representing Aquifer II

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

6.3 Occurrence and movement of ground water:

In study area, ground water occurs under water table conditions in Aquifer I. Aquifer II,when underlain by sufficiently thick clay layer, it behaves as semi-confined to confined aquifer as encountered in most parts of all blocks; Aquifer III has been encountered in blocks of Samserganj, Suti I,Raghunathganj I, Sagardighi, Kandi&Khargram; very less data are available about it.

Aquifer I and AquiferII are two main aquifers and these aquifers have been studied in detail. Therefore, discussion has been made regarding these two aquifers only.

6.3.1 Aquifer I

From the Water Table Map, Plate 6.3.1a, representing Aquifer Ishowswater table contours (May-2017). It is observed that,maximum elevation of 23 m ofwater table has been encountered in Farakka and in north of Raghunathganj I and lowest elevation of 0 m has been encountered towards west of Suti I and Suti II blocks, which is located in geo-morhological low land. Ground water flow is towards lower elevation.

From the post-monsoon water table contour map (Plate 6.3.1 b: November - December, 2017), i.e., during post-monsoon period, Ground water table ranges from 2 m a mslin Raghunathganj I to 28 m a msl(meter below mean sea level) in Farakka and around. In the northern part of study area, ground water flow is generally towards southern low ground.

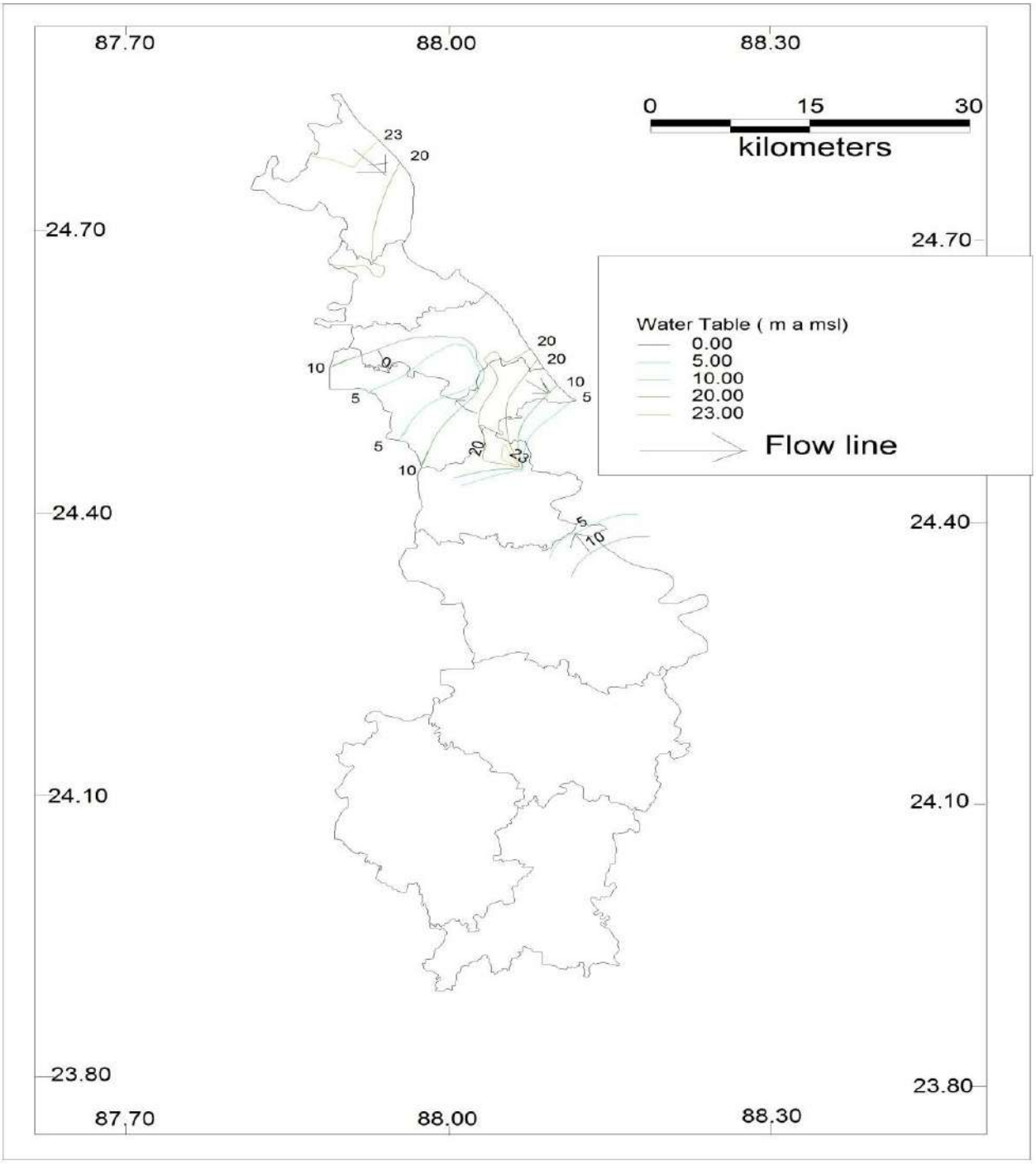


Plate 6.3.1 a: Pre monsoon Water table: Aquifer I

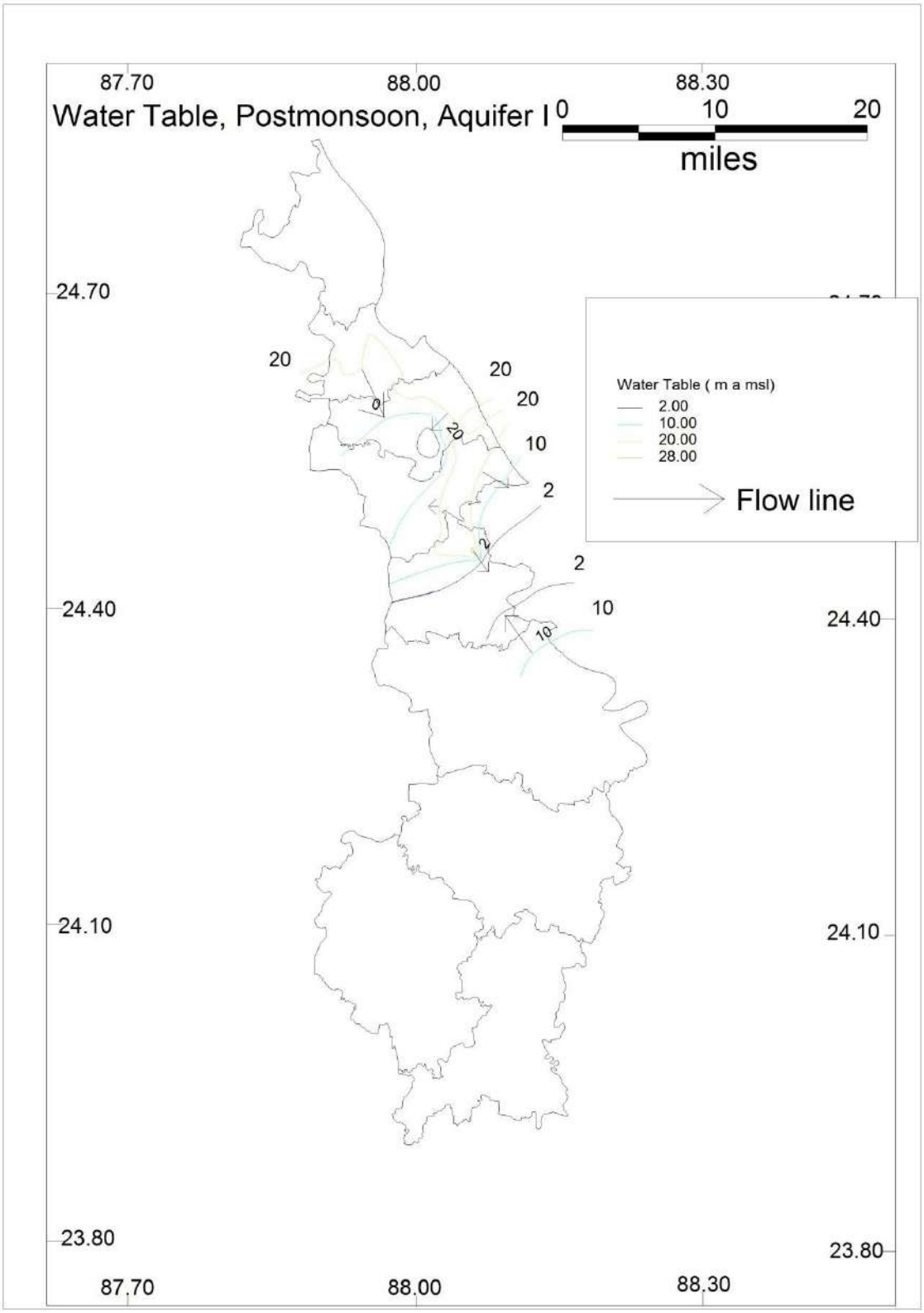


Plate 6.3.1 b: Post-monsoon water table: Aquifer I

6.3.2 Aquifer II

Water Table/ piezometric surface has been drawn for premonsoon and postmonsoon and shown in maps Plate-6.3.2a and Plate-6.3.2b. FromPlate-6.3.2adrawn based on data of premonsoon (May, 2017),the following has been observed:

In the southern part of study area, maximum elevation of Water Table of 23.25 m a mslis restricted in Sagardighi block and less than (–)5 m below mslhas been found in Khargram block. It appears that ground water generally flows from Sagardighi area towards south/ southeast; also, recharge mound has been created in Sagardighi and trough s have been formed in adjoining Khargram - Nabagram area.

Inthe northern part, maximum and minimum elevationof Piezometric surfaces are 15 m and 10 m a msl. In this part, ground water also flows towards south.

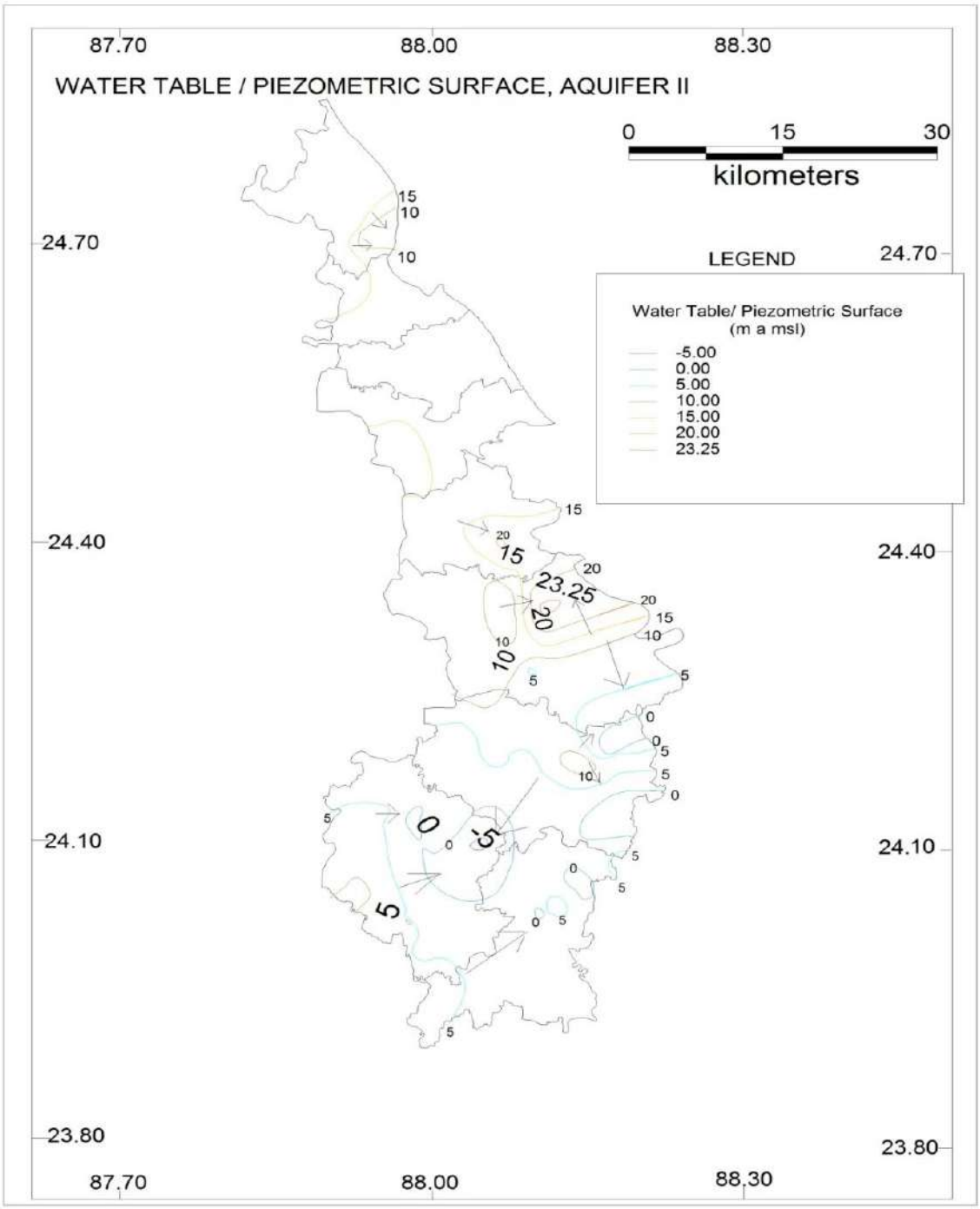


Plate 6.3.2 a: Water Table/ piezometric surface, pre-monsoon: Aquifer II

From the piezometricsurface map (**Plate-6.4.2b)**for post-monsoon period (November-December, 2017), it is observed that:

In southern part, maximum elevation range of water table within 15-20 m a msl is restricted in Sagardighi and around and elevation of 0 m a mslin and around Kandi, the former being the recharge mound and the later being the trough area; ground water flow direction is towards south.

Likewise, in northern part, maximum elevation is about 20 m and general direction of flow is also towards south.

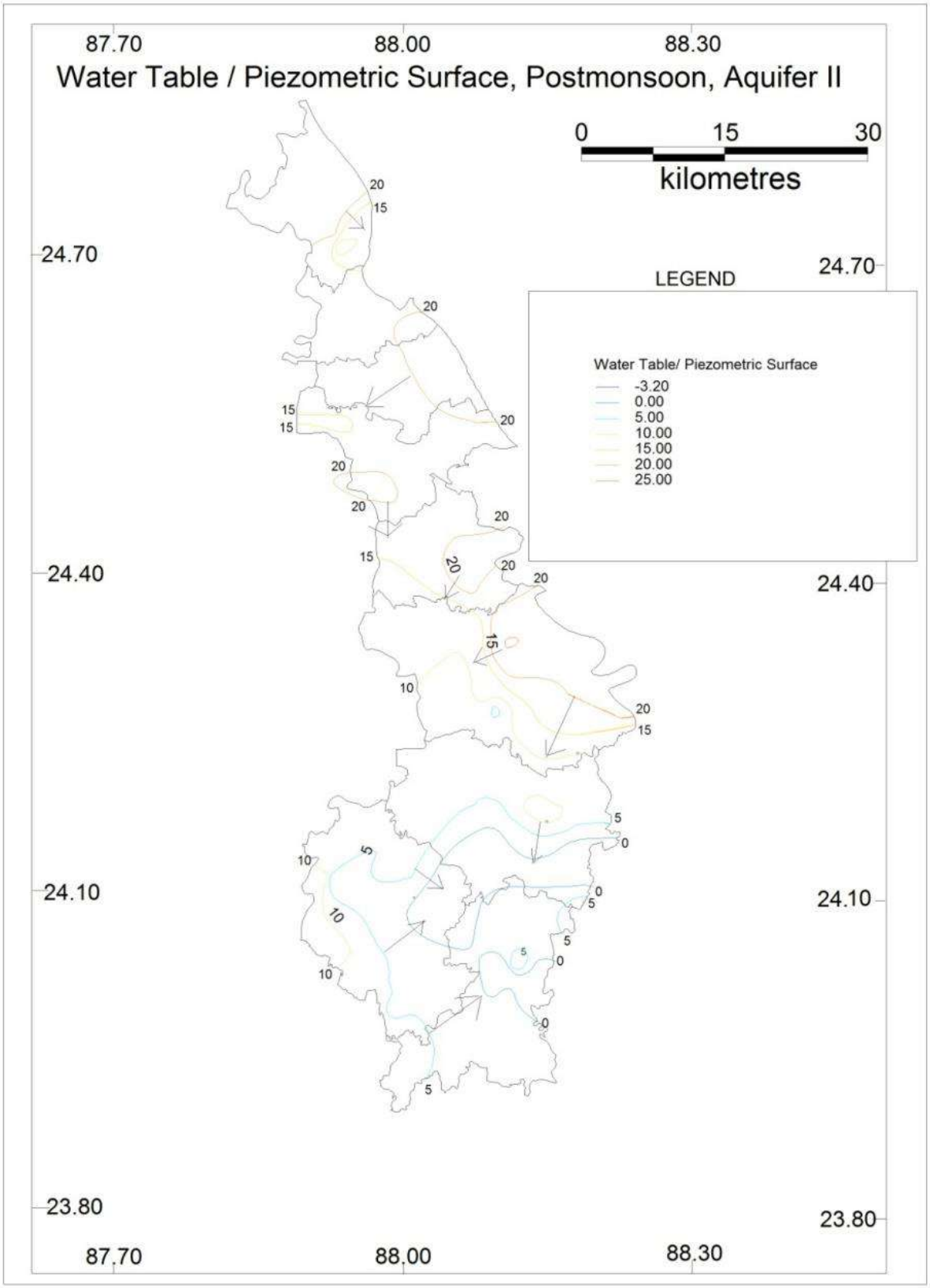


Plate 6.3.2 b: Water Table/ piezometric surface, post monsoon: Aquifer II

6.4 Ground Water Flow through the Aquifers:

6.4.1: AquiferI

From the Water Table map (**Plate-6.3.1 a),** for Aquifer Ishowing water table contours (May 2017), it is observed that, a mild depression has developed in the sub-surface mainly in the northern part, in a small part of Suti II&Suti I block. Another mild depression has also developed in parts of Raghunathganj I block.

In pre-monsoon around Suti II, gradient of ground water flow is 1.14 m/km towards SE in the northern part & on the other side of Suti II, gradient of ground water flow is 3.75 m/km towards NW; around Raghunathganj I, gradient of ground water flow is 2.7 m/km towards SE in the northern part & 2.7 m/km towards NW on the southern part.

In post-monsoon around Suti II, gradient of ground water flow is 1.19 m/km towards SE in the northern part & on the other side of Suti II, gradient of ground water flow is 0.75 m/km towards NW; around Raghunathganj I, gradient of ground water flow is 1.99 m/km towards SE in the northern part & 1.74 m/km towards NW on the southern part.

The development of Aquifer Iis not pronounced in other parts of study area.

6.4.2: Aquifer II

Water Table/ piezometric surface has been drawn for pre monsoon and post monsoon and shown in maps Plate-6.3.2a and Plate-6.3.2b.

From Plate - 6.3.2adrawn based on data of pre monsoon (May, 2017),in the southern part of study area, maximum elevation of Water Table of 23.25 m a mslis restricted in Sagardighi block and less than (–) 5 m below msl has been found in Khargram block. It appears that ground water generally flows from Sagardighi area towards south/ southeast; also, recharge mound has been created in Sagardighi and trough s have been formed in adjoining Khargram - Nabagram area.

In the northern part, maximum and minimum elevation of Piezometric surfaces are 15 m and 10 m a msl. In this part, ground water also flows towards south.

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 post monsoon period, ground water flow has been estimated and given in Table below.

Table 6.4.2.1- Annual Flow of ground water through the blocks

Sr. No.	Block	Length of Flow path - L (m) / Flow Direction	*Transmissivity -T (m^2/day)	Gradient of ground water Flow - I	Ground water Flow (m^3/day)
1	Farakka	7500 / S	1500	0.00036	4050
2	Samserganj	6000 / SW	2000	0.0007	8400
3	Suti I	14000 / WSW	2000	0.0004	11200
4	Suti II	9000 / SW	2000	0.0003	5400
5	Raghunathganj I	11500 / SW	1000	0.0006	6900
6	Sagardighi	7550 / SW	2500	0.0011	20762.5
7	Nabagram	6500 / S	2500	0.0009	14625
8	Khargram	5000 / ESE	2000	0.0018	18000
9	Kandi	5050 / SE	1000	0.0014	7070

*- considering lower value of available data

6.5 **Premonsoon &Postmonsoon long term trend analysis** :

The long term trend analysis during 2006-2016 reveals that in Aquifer II, there is a generalfalling trend in all the Blocks both during Pre-monsoon and Post-monsoon periods. But, in Aquifer I, during post-monsoon there is a falling trend in most Blocks and in pre-monsoon a few blocks show falling trend and some blocks show rising trend too.

In Aquifer I', the Pre-monsoon trend varies from 0.221 m/year inSuti I &Suti II Blocks to 0.01 m/year in SamserganjBlock; Rising trend has been encountered in 3 / 4 blocks and it ranges from 0.015 m/yr in Raghunathganj I / Sagardighi Blocks to 0.108 m/yr in Farakka. In Post-monsoon, available data show falling trend ranging between 0.032 m/yr in Samserganj Block to 0.299 m/yr in Raghunathganj I / Sagardighi Blocks. Pre-monsoon and post-monsoon water level trend (from 2006 to 2016) in cm/year for individual Block is given in Table-6.5 a.

In Aquifer II, the Pre-monsoon falling trend varies from 0.15 m/year in RaghunathganjI / Sagardighi Blocks to 2.75 m/yr in Khargram. The Post-monsoon falling trend varies from 0.21 m/year (in Suti I &Suti II Blocks) to 3.285 m/year (in

KhargramBlock).However,severe falling trend has been encountered in southern blocks, viz. Sagardighi, Nabagram and Khargram both in premonsoon&postmonsoon seasons.

Table 6.5 a: Block-wise Pre- and Post-monsoon long term water level trend in AquiferI& Aquifer II (2006- 2016)

SI. No.	Block	Premonsoon AqI		Postmonsoon Aq I		PremonsoonAq II		Postmonsoon_Aq II	
		Rise (m/year)	Fall (m/year)	Rise (m/year)	Fall (m/year)	Rise (m/year)	Fall (m/year)	Rise (m/year)	Fall (m/year)
1	2	3	4	5	6	7	8	9	10
1.	Farakka	0.108		-	0.083 - 0.222	0.10	-	-	0.188
2.	Samserganj	-	0.01		0.032-0.274				
3.	Suti I &Suti II	-	0.221		0.129	-	0.049		0.21
4.	Raghunathganj I &Sagardighi	0.015	-		0.299		0.15 – 1.39		0.575 – 0.711
5.	Nabagram	-	-	-	-	-	0.437 – 0.735		0.521 – 0.85
6.	Khargram					-	0.516 –0.90		0.283 – 1.10
7.	Kandi	0.049	-		0	-	0.144 - 1.096		0.361-1.086

It is observed that in 6 blocks, the stage of development is between 70 % and 100 %; however, in 2 blocks, eg. Farakka and Samserganj, the stage of development is between 29 and 39 %. In latter group of 2 blocks, long term water level does not show falling trend, whereas in the former group of 6 blocks, it in 2(Suti I and Suti II) does not show significant falling trend but in 4 other blocks (Raghunathganj I (pt.), Sagardighi, Khargram and Kandi), it show significant falling trend.

6.6 Aquifers with yield prospects :

The northern part is the possible recharge area of the distant southern parts. Ground water potentiality in Aquifer II is the most prolific one. Aquifer III is mostly in Tertiaries and not so much potential. However, Aquifer Iis in Quaternaries, though potential, but limited I its areal extent in some blocks. The wells in Aquifer I are mainly shallow, mostly private shallow tube wells within 30 m depth. Maximum discharge of the shallow tube wells in

Quaternary aquifer is about 50 m^3/hr.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 300 mbgl in the area under study. Aquifer IIexists within a depth span of 3-140 mbgl with yieldpotential to the tune of 18 -217 m^3/hr. The Transmissivity of this 2ndaquifer system varies from 59.30 - 8633. The third aquifer groups in the depth span of 109-256mbgl, are found to occur only in the blocks of Kandi and Khargram. The yield of the tube wells, constructed by tapping the granular zones in the above depth span, ranges from 12.46 – 58.38 m^3/hr. Aquifer wise parameters in the study area is given in the followingTable-6.6.

Aquifer Ihas been found in blocks, viz. Farakka, Samserganj, Suti II, Suti I, and partly in blocks of Raghunathganj I, Sagardighi, Kandi and Khargram. Mostly, this aquifer is mostly tapped by dug wells, hand pumps (Mark I) and shallow wells.

Aquifer properties i.e. Transmissivity, Storativity of Aquifer I, Aquifer II& Aquifer IIIbased on earlier CGWB data,data generated through outsourcing and data available from State Govtdeptts. have been tabulated and given in Table 6.6.

7. 0 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 31.03.2017.The block wise computed data of dynamic ground water resources of Aquifer I, as on 31st March 2017 is given in Table 7.0.1. 2 blocks, eg. Farakka and Samserganjhave been categorized as Safe Blocks, 4 blocks, viz. Suti I, Suti II, Sagardighi and Kandi have been categorized as Semi Critical and Raghunathganj I and Khargram are Critical Blocks. In Nabagram Block, no significant phreatic zone has been encountered; hence, no resource has been given.

The Static Ground Water Resources (block-wise) of Aquifer I, has been presented in Table 7.0.2.

In Table 7.03 & Table 7.04 respectively, estimation of static & dynamic ground water resources in Aquifer II have been presented. In Table 7.05, possibility of construction of tube wells tapping Aquifer II by allowing 2 m fall in piezometric head has been presented.

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

Block	Aquifer I				Aquifer II				Aquifer III			
	Depth range (m bgl)	*SWL (m bgl)	Discharge (m^3/hr)	T (m^2/day)	Depth range (m bgl)	*SWL (m bgl)	Discharge (m^3/hr)	T, S (m^2/day)	Depth range / Zone tapped (m bgl)	*SWL (m bgl)	Discharge (m^3/hr)	T (m^2/day)
Farakka	Up to 15 m	7.6	1.8 – 3.6		24.38 - 50	8.96 - 10.91	73.15 – 177.36	2000 – 4225.5, $1.28*10^{-3}$				
Samserganj	Up to 25 m	6.86	28.67		43.69 – 112.63	19.34	100 - 193.56	1486.73 - 2500 , $9.9*10^{-4}$				
Suti I – Suti II	Up to 15 to 20 m	6.9	26.02 -49.32		25 - 76.2	5.85 - 13.67	20.16 – 177	80.57 - 4877 , $9.9*10^{-4}$	109-118	It's own potentiality is very meagre Total potentiality along with Aquifer II is 41.48 m^3/day		
Raghunathganj I	Up to 30.50 m (occurs in eastern part)	6.49 – 7.55	7.2 -40 – 21.35		38 – 82.31	17.59	86.58	360 , $1.8*10^{-4}$	93 -113	Very low potentiality & clayey silt aquifer		
Sagardighi	Up to 25 m (occurs in eastern part)	9.2	30-40		40 – 81.99	19.75 – 34.65	95.5 – 212.8	2500, $2.2*10^{-3}$	146-152, 170-182, 202-205	26.52	41.58	220
Nabagram	-	-	-	-	12 – 114.6	26.97 – 30.09	184.1 – 583.64	2248 - 3000, $8.99*10^{-3}$	112.4 - 150	Clayey silt; difficult to tap		
Khargram	Up to 30 m	9.1	30-40		10-70	22.16	222- 615	2248, $8.99*10^{-3}$	126 – 153, 165 – 171, 281 - 287	19.28 – 21.70	12.38 - 58.38	17.90 - 286
Kandi	Up to 20.00	1.95 - 2.58	14.4	210.8; $3.01*10^{-2}$	30 – 90	10.87 – 31.23	17.57 – 200	59.30 – 1268; $4.98*10^{-4}$	131.1 – 149.7	10.74 – 11.93	12.46 - 17.56	92.29 – 105.77

Table-7.0.1:Block wise dynamic ground water resources (Aquifer I)as on 31st March'17 – asestimated jointly by SWID & CGWB, ER

SI. No.	Blocks	Annual Extractable Ground Water Recharge (MCM)	Current Annual Ground Water Extraction (MCM)	Stage of development (%)	Category	Annual GW Allocation for for Domestic Use as on 2042
1.	Farakka	38.7052	11.4074	29.47	Safe	3.8177
2.	Samserganj	65.6402	25.318	38.57	Safe	5.6357
3.	Suti I	53.9762	45.7607	84.78	Semi-critical	2.4321
4.	Suti II	54.9485	48.0065	87.37	Semi-critical	3.6464
5.	*Raghunathganj I	63.444	58.7203	92.54	Critical	4.1229
6.	*Sagardighi	98.3945	75.471	76.7	Semi-critical	5.6074
7.	*Khargram	61.4062	61.3639	99.94	Critical	4.6874
8.	*Kandi	88.8164	64.9562	73.14	Semi-critical	4.6156

- Present study shows that phreatic Aquifer I partly occupy the C. D. Blocks of Raghunathganj I,Sagardighi, Khargram and Kandi; but, in Nabagram block nowhere Aquifer I has been encountered.

Table-7.0.2: Block wise Static Ground Water Resources (Aquifer I) based on data of 2017-18

Sr. No.	Block	**Area in Ha (**with Aquifer I**)**	**Average depth of bottomunconfined aquifer (m bgl)**	**Average Pre-monsoon Water Level (m bgl) in Aquifer I**	**Average Specific Yield**	**Thickness of the Saturated Zone in unconfined aquifer below WLF zone (m)**	**In-storage Ground water resources in Aquifer I (MCM)**
1	Farakka	13274	10.69	7.60	0.12	3.09	49.22
2	Samserganj	9448	16.88	6.85	0.12	10.03	113.72
3	Suti I	14368	27	7.66	0.12	19.34	333.45
4	Suti II	11113	20.29	6.15	0.20	14.14	314.28
5	Raghunathganj I	6341 (* 45 % of block area)	23.43	6.49	0.20	16.94	214.83
6	Sagardighi	8636 (*25% of block area)	24.38	9.2	0.12	15.18	157.31
7	Nabagram	-	-	-	0.12	-	-
8	Khargram	4777 (* 15 % of block area)	15	9.1	0.12	5.9	33.82
9	Kandi	2404 (* 10 % of block area)	10	2.58	0.12	7.42	21.41

Only part of C. D. Block area is occupied by phreatic aquifer

Table 7.0.3: Block wise In-Storage Ground Water Resources (ham) in Aquifer II

Sr. No.	Area (including that of municipality)	Area in ha	Average depth of bottom_confined aquifer (m bgl)	Average Pre-monsoon Water Level (m bgl)	Average Storage coefficient	Thickness of the Saturated Zone of the Confined aquifer below WLF zone (m)	Volume of Saturated Zone of the confined aquifer below WLF zone (ham)	Static / In-Storage Ground Water Resources (Ham)
1	Farakka	13274	46.3	10.91	0.00128	35.39	469766.86	601.3015808
2	Samserganj	9448	74.19	19.34	0.00099	54.85	518222.8	513.040572
3	Suti I	14368	50.75	12.37	0.00099	38.38	551443.84	545.9294016
4	Suti II	11113	51.66	14.97	0.00099	36.69	407735.97	403.6586103
5	Raghunathganj I	14091	81.33	17.59	0.00018	63.74	898160.34	161.6688612
6	Sagardighi	34542	86.59	25.17	0.0022	61.42	2121569.64	4667.453208
7	Nabagram	30663	87.72	26.97	0.00899	60.75	1862777.25	16746.36748
8	Khargram	31845	69.86	22.16	0.00899	47.7	1519006.5	13655.86844
9	Kandi	24043	76.46	21.05	0.000498	55.41	1332222.63	663.4468697

Incidentally, out of 9 blocks excepting Nabagram all other blocks have been declared as arsenic infested.

Table 7.0.4: Block wise dynamic ground water resources (ham) in Aquifer II

Sr. No.	Block /Municipality	Area in sq km	Seasonal fluctuation (m)	Storage co-efficient	Ground water resource (Ham)	Ground water resource (MCM)
1	Farakka	13274	7.67	0.00128	130.318822	1.303188
2	Samserganj	8421	0.67	0.00099	5.5856493	0.055856
3	Dhuliyan (M)	1027	0.67	0.00099	0.6812091	0.006812
4	Suti I	14368	2.16	0.00099	30.7245312	0.307245
5	Suti II	11113	3.63	0.00099	39.9367881	0.399368
6	Raghunathganj I	14091	3.52	0.00018	8.9280576	0.089281
7	Sagardighi	34542	0.51	0.0022	38.756124	0.387561
8	Nabagram	30663	1.69	0.00899	465.866025	4.65866
9	Khargram	31845	1.44	0.00899	412.252632	4.122526
10	Kandi	22748	0.33	0.000498	3.73840632	0.037384
11	Kandi (M)	1295.00	0.33	0.000498	0.2128203	0.002128

8.0 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. Also, ground water sampling has been done specially for NAQUIM study in the above mentioned period of AAP 2017-18. Besides, some samples have also been collected afterwards for analysis of arsenic content in ground water in shallow aquifer. Due to constrain in departmental Chemical Laboratory, only some selected samples were analysed for basic parameters from this laboratory. Departmental AAS was not operational since a long period and found there was no hope for analysis of As in this lab., special sampling was made as it has been mentioned earlier and these samples got analysed on request from GSI, Central Lab., Kolkata. Based on analytical data of limited samples and data of basic parameters, it is inferred that quality of ground water occurring in phreatic and deeper aquifers generally do not differ. The water, in general, is mildly alkaline. Ground water of

Aquifer I and Aquifer II is mainly HCO_3type in study area.However, in one or two places, Cl content in ground water has also been found higher (vide Fig. 8.1.1).

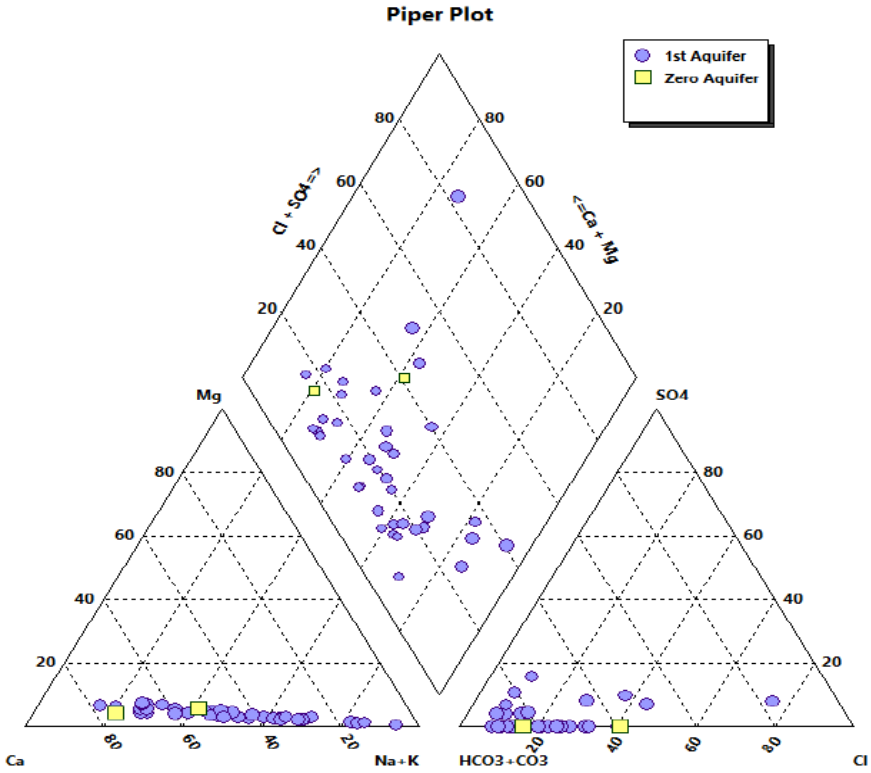


Fig. 8.1.1: Ground water type (Piper plot) of Aquifer I & Aquifer II in study area

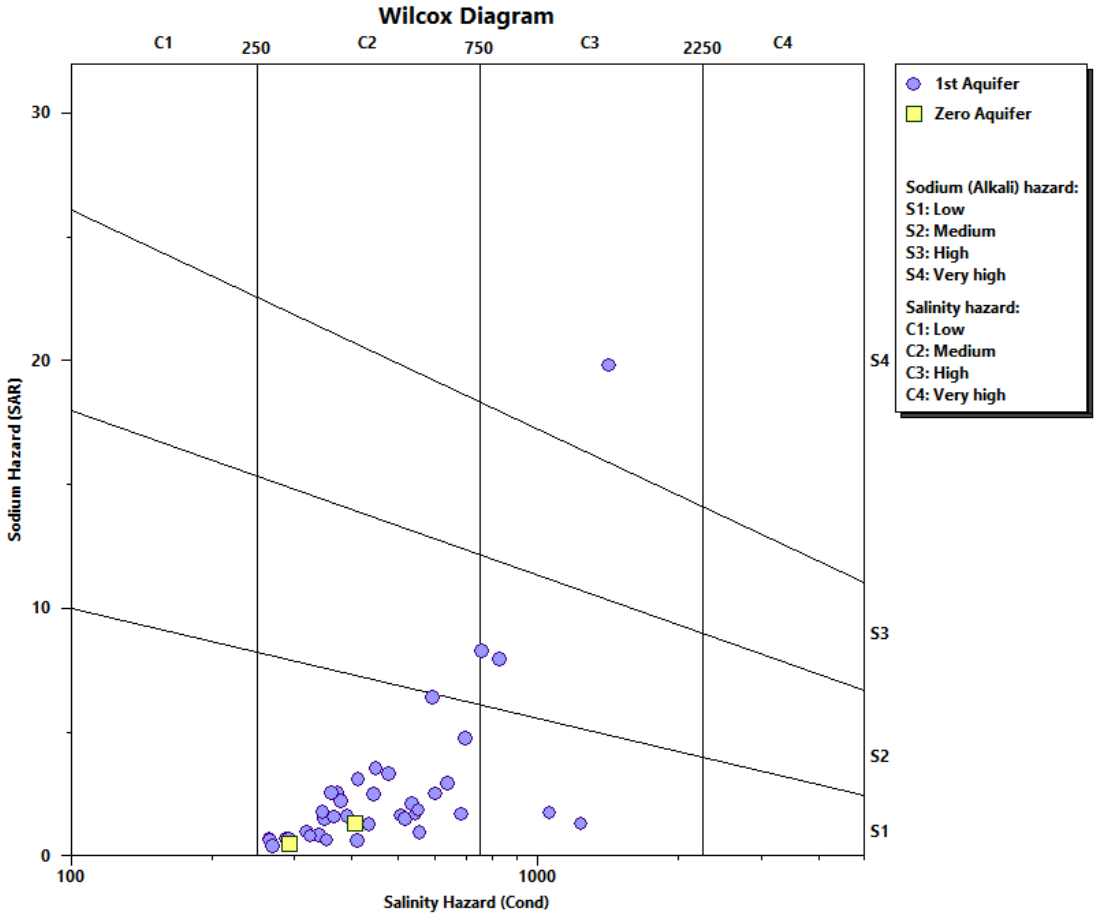


Fig. 8.1.2: Wilcox Diagram showing salinity & alkali hazards in ground water

Graphical representation of analytical data of ground water has been presented in Wilcox Diagram (vide Fig. 8.1.2) to show salinity & alkali hazards, if any. The diagram depicts that ground water is in general free from such type of hazards.

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 between 7.13 and 7.82 and, EC between 266 and 1217 µS/cm (vide Table 8.2.1). Concentrations of Na and K ranges from 9 to 302 mg/1 and from 0.17 to 20.12 mg/1, respectively. TDS varies between 174& 916 mg/l. (vide Table 8.2.1). Mg is available sporadically from 5 to 49 mg/1. HCO**3** present in the range of 116 - 561 mg/1and Cl is mostly in the range of 11 - 305 mg/1. F ranges from 0.18 - 1.89 mg/1. **SO_4**concentrations are varying from bdl to 16. Total Hardness as CaCO**3** ranges from 80 - 500 mg/1, whereas Ca varies from14 to 120 mg/1. Nitrate concentration is

generally low ranging between 0 to 12 mg/1; higher concentration of NO_3 has been observed at Nazirpur (Suti I). As a whole, it can be said that the water of the area is generally potable.

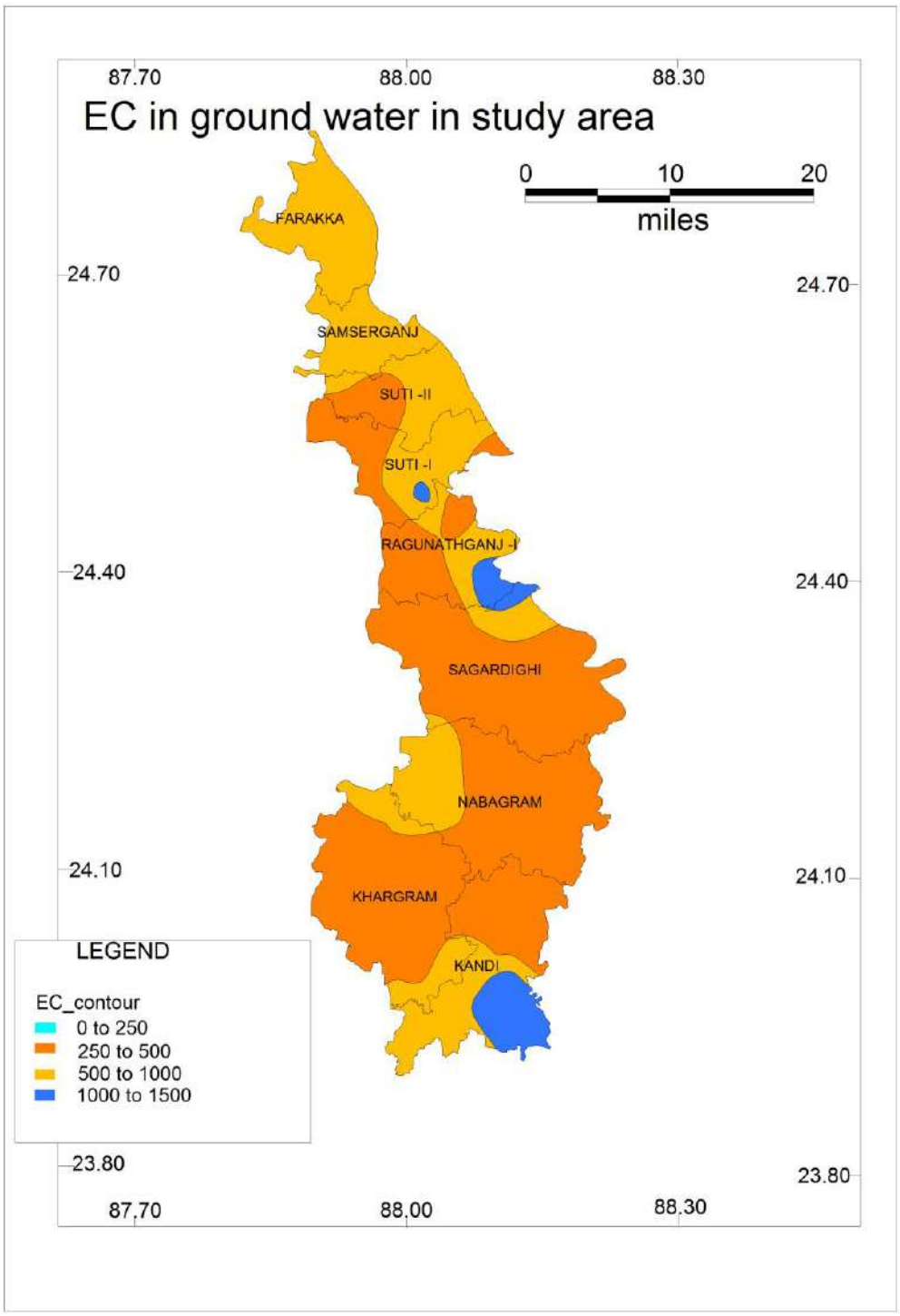


Fig. 8.2.1: EC in ground water of study area

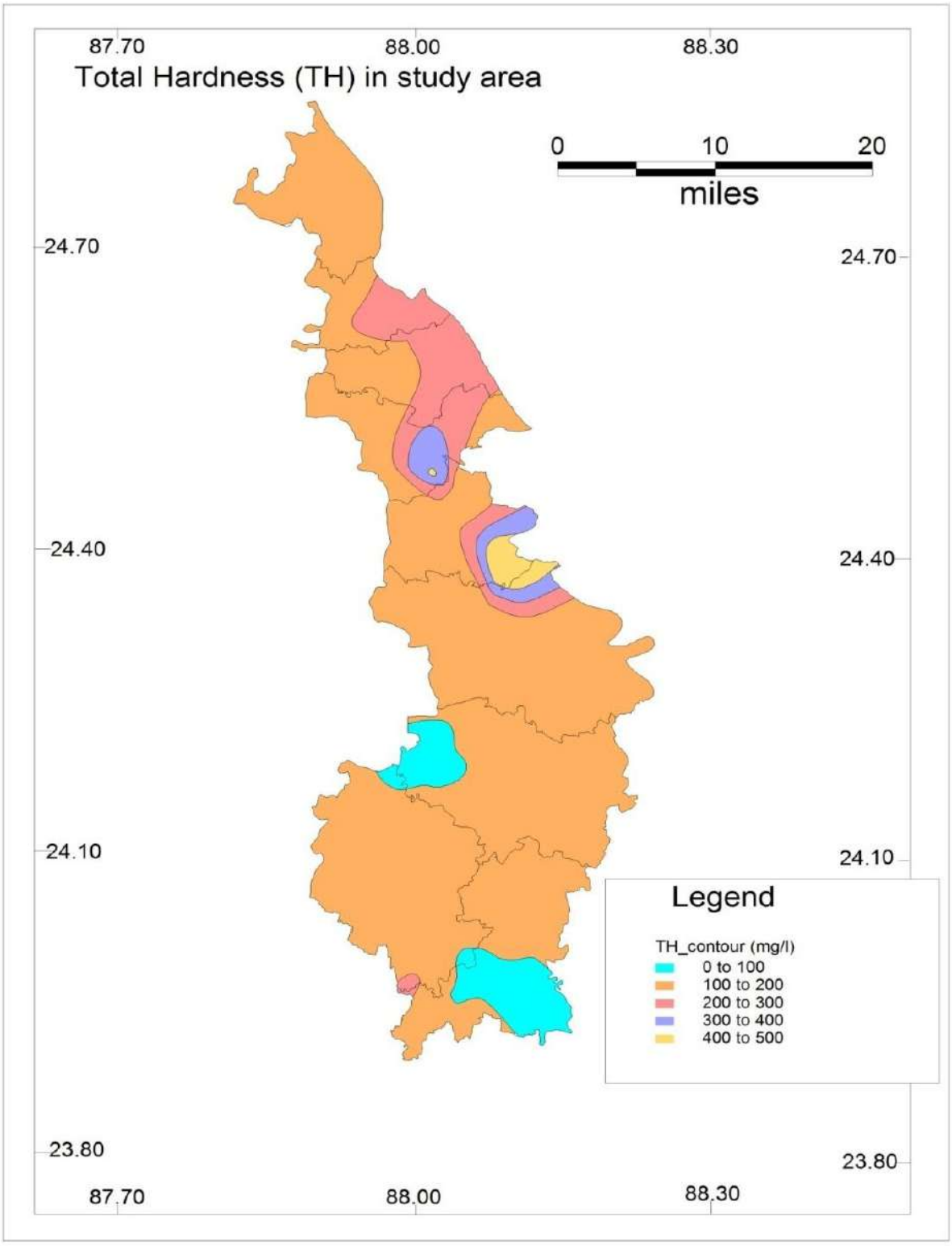


Fig. 8.2.2: Total Hardness (TH) in ground water of study area

Table 8.2.1: Analytical data of ground water

Sl. no.	Village	Block	Lat	Long	Location	Structure	pH	EC	TH	Ca	Mg	Na	K	HCO_3	Total Alk as $CaCO_3$	Cl	NO_3	SO_4	F	SiO_2	TDS	Aquifer	SAR
1	New Momrijpur (near Arjunpur)	Farakka	24.69499	87.92369	Pump House	Tube well	7.19	539	165	28	23	41	2.57	275	225	25	0	14	0.58	21	322	II	8.1559825
2	Ramrampur (Baniagram)	Farakka	24.731078	87.9295	Opposite to PHE overhead Tank	Tube well	7.37	548	185	26	29	32	6.29	256	210	39	0	14	0.23	23	326	II	6.1561412
3	BaniagramAchuamore	Farakka	24.76667	87.92464	Near House of Sh. Nurul Sk.	Tube well	7.84	559	200	48	19	24	20.12	281	230	18	1	13	0.67	19	334	II	4.1898486
4	Udychandpur	Kandi	24.08686	88.180281	School field (CGWB)	Tube well	7.81	391	130	30	13	33	2.31	220	180	18	0	0	0.86	11	242	II	7.1771458
5	Gokarna	Kandi	24.03728	88.10718	Beside main road	Tube well	7.74	411	175	56	9	17	1.25	207	170	35	0	2	0.56	21	269	II	3.0075037
6	Gobarhati	Kandi	24.0247	88.1403	Beside main road	Tube well	7.68	326	135	40	9	19	0.71	159	130	25	0	9	0.54	20	219	II	3.8154742
7	Gobarhati	Kandi	24.0247	88.1404	From Gokarna 4 Kms on metalled road	Tube well	7.46	271	125	38	7	9	0.17	146	120	18	0	0	0.63	14	177	II	1.9438179
8	Purandarpur	Kandi	23.9967	88.0733	In the premises of High School	Tube well	7.58	829	90	22	9	140	1.02	311	255	89	1	25	1.15	15	492	II	35.924204
9	HizalNatungram	Kandi	23.98319	88.11075	Behind village	Tube well	7.93	1420	80	16	10	302	9.50	561	460	213	2	0	1.89	20	916	II	84.242305
10	Kandi	Kandi	23.96583	88.04102	In the nearby field of Kandi Athletic Club	Tube well	7.87	789	95	18	12	133	0.81	384	315	78	0	0	1.30	19	497	II	34.360552
11	Rasorah	Kandi	23.9325	88.0508	Within AmbikaHSchool	PZ	7.45	699	125	42	5	116	2.09	348	285	67	1	0	1.10	18	465	II	23.987417
12	Mahalandi	Kandi	24.08688	88. 18042	Near PHE Pump House & opposite to idgah	Tube well	7.72	295	125	28	13	10	0.22	159	130	18	2	0	0.80	16	185	II	2.2560351
13	Mahisar	Khargram	23.9822	88	Within MM HS School	PZ	7.82	604	205	36	28	57	1.01	214	175	85	0	34	0.81	12	384	II	10.103595
14	Khargram	Khargram	24.01914	87.99144	Within Hospital	Tube well	7.91	294	120	32	10	14	0.72	140	115	25	0	5	0.80	15	188	II	3.0652852
15	Khargram	Khargram	24.03183	87.97848	Within PHE Overhead Tank compound	Tube well	7.74	367	130	26	16	30	0.89	183	150	21	12	5	1.24	17	242	II	6.6041351

16	Purapara	Khargram	24.12428	87.92111	Within H S School	Tube well	8.02	346	120	18	18	29	1.10	183	150	25	0	1	1.25	7	212	II	6.8916445
17	Parulia	Khargram	24.08234	87.90786	Within Haricharan H S School	Tube well	7.37	353	155	30	19	13	1.27	207	170	14	0	0	0.44	13	219	II	2.6991578
18	Bhalkundi	Khargram	24.13161	87.98358	PHE, Zone II, Pump 1	Tube well	7.65	480	125	22	17	58	1.01	238	195	35	0	0	1.49	10	290	II	13.146316
19	Shankarpur	Khargram	24.10594	88.04633	On the way to Sherpur on Jibanti-Sherpur Road	Tube well	7.59	408	155	30	19	27	0.40	153	125	64	0	7	0.48	16	256	II	5.3399881
20	Palsonda	Nabagram	24.18434	88.15281	Near piezometer of CGWB	Tube well	7.66	373	110	20	15	43	0.42	214	175	14	1	1	0.88	9	234	II	10.302722
21	Etore	Nabagram	24.20019	88.17689	Near agricultural land of Shri Rashid	Tube well	7.85	380	120	22	16	39	1.17	220	180	11	0	0	0.49	18	241	II	9.072662
22	Etore	Nabagram	24.19545	88.17948	Near kitchen of Lr. Primary school	Mark II HP	7.64	445	140	22	21	44	0.48	238	195	14	1	0	0.50	17	265	II	9.622858
23	Ishanpur	Nabagram	24.16111	88.09097	In agricultural land of Shri Sital Ghosh	Tube well	7.70	450	110	22	13	62	0.84	232	190	39	0	0	0.71	18	297	II	14.746532
24	Panchgram	Nabagram	24.19755	88.01589	Near agricultural land of shriBrindaban Saha	Tube well	7.23	596	95	18	12	103	0.97	232	190	60	0	16	0.52	14	366	II	26.453557
25	Karjora	Nabagram	24.21606	88.11125	Near agricultural land of Sh. Biswanathmandal	Tube well	7.97	266	115	30	10	14	0.81	153	125	11	0	0	0.68	15	174	II	3.1280461
26	Deoli (Raghunathganj)	Raghunathganj I	24.46242	88.04886	Near Primary School & opposite to house of sh. NetaiMajhi	Tube well	7.82	392	120	18	18	41	0.83	214	175	21	0	5	0.59	7	243	II	9.6219857
27	Dhalgram	Raghunathganj I	24.39438	88.086333	In premises of primary school on Raghunathganj-Mirzapur Road	Tube well	7.84	1217	500	120	49	53	1.60	116	95	305	8	84	0.58	24	716	II	5.7964365

28	PaschimMatiapara	Sagardighi	24.27566	88.13313	At the entrance of village from Suki's More side	Tube well	7.78	290	125	26	15	13	0.21	159	130	11	2	0	0.53	12	175	II	2.8882599
29	Parulia	Sagardighi	24.26069	88.09008	In agricultural land of Shri Shyamaprasad Paul	Tube well	7.58	341	140	30	16	17	0.80	177	145	21	0	6	0.54	14	213	II	3.5317721
30	Ekrokhi	Sagardighi	24.34019	88.07033	In agricultural land of Shri Bikash Kr. Mandal	Tube well	7.60	350	140	22	21	17	1.01	201	165	18	0	0	0.55	15	217	II	3.6681191
31	Sagardighi	Sagardighi	24.29235	88.08991	Block Seed Farm	Tube well	7.92	271	110	26	11	12	0.18	146	120	14	6	0	0.45	17	176	II	2.8505721
32	Ramnagar	Sagardighi	24.33752	88.17106	In agricultural land of Shri Prasanta Das beside damosh river	Tube well	7.96	413	130	14	23	44	0.91	250	205	14	0	0	0.38	14	263	I	10.241285
33	BhasaiPaikar (Dogachhi)	Samserganj	24.62535	87.91511	In the main market	Tube well	7.60	622	190	26	30	54	1.34	287	235	28	0	53	0.45	20	388	I	10.186111
34	Jaykrishnapur	Samserganj	24.63786	87.96156	Within pump house	Tube well	7.57	555	210	34	30	41	5.18	238	195	21	3	72	0.30	6	358	I	7.1738251
35	Nazirpur	Suti I	24.48361	88.01869	Inside village	Tube well	7.39	1060	405	90	44	62	0.97	177	145	156	209	44	0.74	19	734	I	7.5696358
36	Hillora/Bansabati	Suti I	24.49311	87.96606	Inside village	Tube well	7.49	435	150	48	7	33	0.67	183	150	50	0	16	0.43	10	277	II	6.2934454
37	Kadoa	Suti I	24.54583	87.94311	Inside village	Tube well	7.35	349	125	26	15	28	0.54	195	160	18	0	0	0.54	18	224	II	6.1139645
38	Gazipur	Suti II	24.61708	87.9928	Inside village	Tube well	7.36	509	200	32	29	35	2.87	238	195	50	0	11	0.18	12	317	I	6.3418655
39	IslampurKankramari	Suti II	24.58309	88.05853	Pump House	Tube well	7.90	571	215	34	32	33	4.34	250	205	57	2	26	0.20	24	364	I	5.7729664
40	Jagtai	Suti II	24.62869	88.02129	Pump House	Tube well	7.81	687	255	50	32	43	4.16	207	170	85	0	37	0.23	9	386	II	6.6665661

Table 8.2.2: As concentration in ground water in study area

Sample No.	Location	Block	Abstraction Structure	Depth of Structure (m)	As (mg/l)
1	Sujapur	Raghunathganj I	Tube well (Mark I)	33.53	0.128
2	Srikantabati	Raghunathganj I	Tube well (Mark II)	45.72?	<0.001
3	Panchabati, near Ajagarpara	Suti I	Tube well (Mark II)	36.58	<0.001
4	Chander More	Suti I	Tube well (Mark I)	25.91	0.013
5	Ramakantapur	Suti I	Tube well (Mark I)	13.72	0.052
6	Bara Kankramari	Suti II	Tube well (Mark I)	18.29	0.024
7	Aurangabad	Suti II	Tube well (Mark II)	30.48	<0.001
8	Dhulian	Samserganj	Submersible pump fitted Tube well	24	<0.001
9	Udaichandpur	Kandi	Tube well (Mark II)	50?	<0.001
10	Rameswarpur	Kandi	Tube well (Mark I)	27.43	0.012
11	Jehangirpur	Khargram	Tube well (Mark II)	**45.72**	<0.001
12	Goai	Khargram	Tube well (Mark I)	36.58	0.003
13	Khesar	Khargram	Cylinder Tube well	27.43	<0.001
14	Khargram	Khargram	Submersible pump fitted Tube well	30	0.002
15	Khargram More	Khargram	Tube well (Mark II)	45.72	<0.001
16	Sherpur	Khargram	Tube well (Mark I)	39.62	<0.001
17	Kabilpur	Sagardighi	Tube well (Mark I)	33.53	0.004
18	Harua	Suti I	Submersible pump fitted Tube well	33.53	<0.001
19	Barala	Raghunathganj I	CGWB Tube well	52	0.002
20	Balanagar	Sagardighi	Tube well (Mark I)	33.53	0.002
21	Mangaljan	RaghunathganjI	Tube well	24.38	<0.001

			(Mark I)		
22	Ranagram	Kandi	Tube well (Mark II)	45.72	0.003
23	Chandpara More, Manigram	Sagardighi	Tube well (Mark II)	24.38	<0.001
24	Hijal	Kandi	Tube well (Mark I)	27.43	0.003
25	BaliaRamnagar	Sagardighi	Tube well (Mark I)	24.38	0.004
26	Ajagarpara	Suti I	Tube well (Mark I)	39.62	<0.001
27	Mirzapur	Sagardighi		30.48	<0.001
28	Jarur	Raghunathganj I	Tube well (Mark II)	24.38	<0.001
29	Khargram Outskirt	Khargram	Tube well (Mark II)	54.86	<0.001

Table 8.2.3: As concentration in ground water of NHS in study area

I D No.	Block	Location	Well No.	Lat	Long	type of well	As (ppm)
1	Farakka	Arjunpur	WBMB50	24.7178	87.9331	Tube Well	0.064
2	Farakka	Chaukigram	WBMB58	24.7700	87.9200	Dug Well	0.038
3	Farakka	Farakka	WBMB01	24.7447	87.9125	Dug Well	0.007
4	Farakka	Jorpukuria	WBMB61A	24.7522	87.9014	Tube Well	0.186
5	Kandi	Basabari	WBMB162	23.9492	88.0447	Tube Well	0.001
6	Kandi	Gantla	WBMB110	24.0800	88.0897	Tube Well	0.002
7	Kandi	Gokarna	WBMB157	24.0347	88.1111	Tube Well	0.013
8	Kandi	Gokarna	WBMB32	24.0392	88.1153	Tube Well	0.04
9	Kandi	Jibanti	WBMB96	24.0864	88.1703	Tube Well	0.0002
10	Kandi	Kandi	WBMB06A	23.9544	88.0458	Dug Well	0.001
11	Kandi	Manoharpur	WBMB158	23.9775	88.0569	Tube Well	0.002
12	Kandi	Nabagram	WBMB161	24.0647	88.1481	Tube Well	0.013
13	Kandi	Purandarpur	WBMB97A	23.9967	88.0733	Tube Well	0.024
14	Kandi	Rasorah	WBMB133	23.9325	88.0508	Tube Well	0
15	Khargram	Khargram	WBMB72	24.0286	87.9811	Tube Well	0.065

			A				
16	Khargram	Mahisar	WBMB108	23.9822	88.0000	Tube Well	0.001
17	Khargram	Purapara	WBMB105	24.1244	87.9214	Tube Well	0.0003
18	Nabagram	Amatpur	WBMB142	24.1375	88.3375	Tube Well	0.0003
19	Nabagram	Daffarpur	WBMB146	24.132506	88.187306	Tube Well	0.0002
20	Nabagram	Gurah - Pashla	WBMB111	24.2003	88.0667	Tube Well	0.026
21	Nabagram	Mahadipur	WBMB100	24.1367	88.2025	Tube Well	0.001
22	Nabagram	Polsanda	WBMB37	24.18434	88.15281	Tube Well	0.006
23	Nabagram	Polsonda	WBMB143	24.1917	88.1542	Tube Well	0
24	Raghunathganj I	Barala	WBMB101	24.4278	88.0086	Tube Well	0.0002
25	Raghunathganj I	Mirzapur Jain Colony	WBMB88A	23.9081	88.2364	Dug Well	0.024
26	Raghunathganj I	Raghunathganj	WBMB40	24.4608	88.0650	Dug Well	0.042
27	Sagardighi	Megha - Sihara	WBMB113	24.2794	88.0438	Tube Well	0.003
28	Sagardighi	Sagardighi	WBMB27	24.29235	88.08991	Tube Well	0.0003
29	Samserganj	Churapukur	WBMB67	24.7300	87.9300	Dug Well	0.043
30	Samserganj	Dhulian	WBMB49A	24.678393	87.95264	Tube Well	0.017
31	Samserganj	Jayrampur	WBMB68A	23.2786	87.8231	Dug Well	0.051
32	Samserganj	Krishnanagar	WBMB66	24.6500	87.9400	Dug Well	0.001
33	Samserganj	NatunMalancha	WBMB55	24.6733	87.9303	Dug Well	0.05
34	Samserganj	Puratanmalancha	WBMB65A	24.6714	87.9283	Dug Well	0.002
35	Samserganj	Putimari	WBMB59	24.6403	87.9350	Dug Well	0.001

(Based on special study during 2015-16)

In Table 8.2.2, point concentration of arsenic in ground water of the study area have been shown for samples collected from the area during surveys and were analysed in GSI, Kolkata. In Table 8.2.3, data of As in ground water for samples analysed during special drive while monitoring hydrograph stations in the area and surrounding wells in concerned blocks in year 2015-16, have been tabulated.

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 7.19 and 8.2.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 PHED, Govt. of West Bengal, sporadic occurrence of arsenic in ground water of parts of 8 blocks of the study area, eg. Farakka, Samserganj, Suti II, Suti I, Raghunathganj I, Sagardighi, Kandi and Khargram have been reported, excepting the block of Nabagram, where no report of arsenic contamination in ground water has so far been reported. As per the report of the PHED, Govt. of West Bengal, data of arsenic contamination in tube wells of 5 blocks of Farakka, Samserganj, Suti I, Suti II and Raghunathganj I as available are given in Table 8.3.1:

Table 8.3.1: Block wise nos. of Tube wells showing arsenic in ground water

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	Farakka	1067	26.15	279	59.04	630	14.71	157	0.51
2	Samserganj	1788	16.78	300	63.53	1136	19.69	352	0.30
3	Suti II	2307	19.68	454	50.50	1165	29.78	687	0.66
4	Suti I	929	60.28	560	24.97	232	14.75	137	0.70
5	Raghunathganj I	1075	67.35	724	27.07	291	5.58	60	0.25

(Source –PHED, Govt. of West Bengal)

Table 8.3.2: Risk population in affected blocks (based on PHED data) & requirement of T.Ws

Block	Nos. of habitations in risk zone	Whereas As infested	As infested population in 2011	Projected As infested population in 2021	Population already covered	Water (lit.) required for uncovered population @ 70 lpcd	Nos. of TWs required considering each TW's discharge of 12.5 lps& 8 hrs. run per day	Cost of construction of required TWs @ 18 lakh per TW as per approved rate	Remarks
Farakka	**45**	**Infested**	**238576 (excepting NTPC Barrage Project)**	**288843**	**472671**	**Already covered**	**-**	**-**	**For drinking water construction (10" X 6") of tube wells are to be made in Aquifer II, which is arsenic free, wherever present. Besides, surface water is another option in Murshidabad district.**
Samserganj	**31**	**Infested**	**274392**	**332206**	**218394**	**70 X 113812 = 7966840**	**22****	**396**	
Suti II	**37**	Infested	**127513**	**337690**	**215755**	**70 X 121935 = 8535450**	**24****	**432**	
Suti I	**30**	Infested	**278922**	**217814**	**248452**	**Already covered**	**-**	**-**	
Raghunathganj I	**41**	**Infested**	**151338**	**183224**	**299200**	**Already covered**	**-**	**-**	
Sagardighi	**-**	**Infested (Reported lately)**	**-**	**-**	**1081823**	**-***	**-**	**-**	
Nabagram	**-**	**Not infested**	**-**	**-**	**80647**	**-***	**-**	**-**	

Khargram	**-**	**Infested (Reported lately)**	**-**	**-**	**73163**	**-***	**-**	**-**	
Kandi	**-**	**Infested (Reported lately)**	**-**	**-**	**129885**	**- ***	**-**	**-**	

*** there is enough scope of construction of tube well, if needed. Always, deeper aquifer has to be tapped**

8.4 Ground Water Suitability for irrigation:

The Sodium Adsorption Ratio (SAR) of water in the study area ranges from1.94 to84.24 .However, 5 nos or 12.5 % of total samples (vide Table 8.2.1) having SAR value is more than 18, which are normally not suitable for irrigational use. Piper-Trilinear Diagram and Salinity Hazardbased on samples of study area have been presented in Fig. 8.1.1 and Fig. 8.1.2 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 all purposes, i.e. domestic, agriculture and industrial uses. Ground water in some pockets have been reportedly show higher concentration of Fe, 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 (2015) 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 ground water Resources, Draft, SOD and Category

Sr. No.	Name of Block	Net Annual Extractable GW Recharge(MCM)	Net GW Availability for future use (MCM)	SOD (%)
1	**Farakka**	38.7052	25.5663	29.47
2	**Samserganj**	65.6402	39.0587	38.57
3	**Suti II**	53.9762	6.5066	84.78
4	**Suti I**	54.9485	7.8541	87.37
5	**Raghunathganj I**	63.444	3.8606	92.54
6	**Sagardighi**	98.3945	20.8901	76.7
7	**Nabagram**	-	-	-
8	**Khargram**	61.4062	-1.5021	99.94
9	**Kandi**	88.8164	22.4194	73.14

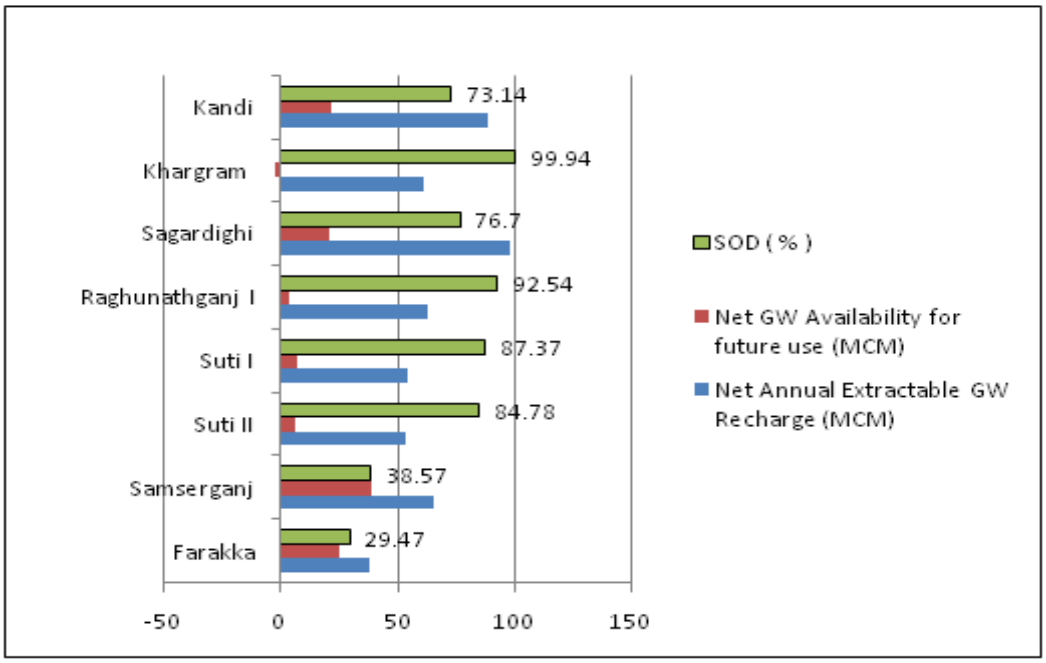


Fig. 8.4.1: Available ground water resources in different blocks of study area in aquifer I

It is observed that in 6 blocks, the stage of development is between 70 % and 100 %; however, in 2 blocks, eg. Farakka and Samserganj, the stage of development is between 29 and 39 %. In latter group of 2 blocks, long term water level does not show falling trend, whereas in the former group of 6 blocks, it in 3 (Raghunathganj I, Suti I and Suti II) does not show significant falling trend but in 3 other blocks (Sagardighi, Khargram and Kandi), it show significant falling trend ranging within 27.78 – 42.28 cm/yr in pre monsoon and within 43.56 – 75.63 in post monsoon. .

9.0 AQUIFER MANAGEMENT PLAN

9.1.1: For drinking purpose

A few years back arsenic contamination in ground water of sporadic nature has been reported in 5 blocks, viz. Farakka, Samserganj, Suti II, Suti I and Raghunathganj I, of study area of a total of 9 blocks in Murshidabad district.But, of late, arsenic contamination in ground water has also been reported in limited parts of 3 other blocks, eg.Sagardighi, Khargram and Kandi, but this contamination has not yet been reported in remaining 1 block i.e. Nabagram. An estimate (vide Table 8.3.2) shows that a total of 1070741 (as per 2011 Census) of people, excepting NTPC Barrage Project, in early - reported 5 As infested blocks, viz. Farakka, Samserganj, Suti II, Suti I and Raghunathganj I, are at risk zone.

Scope for construction of tube wells tapping arsenic free aquifers for catering potable water to the population of risk zone may be covered by water supply scheme; block wise suggestion for water supply is presented in Table 9.1.1. However, tube wells should be constructed by tapping the deeper aquifers which is separated from top arseniferous aquifers by a persistent clay blanket. Provision for sealing the top arseniferous aquifers with proper cement sealing against clay layer should be kept in order to prevent the vertical percolation of arseniferous water from the top contaminated aquifer.

Table 9.1.1: Block wise suggestion on supply of ground water especially to the risk population

Sl. No.	Block	Population in risk zone (as per Census 2011) to be covered by water supply schemes.	Projected population in 2021	Tentative Population already covered	Suggestions on providing water supply to the risk population
1	Farakka	**238576**	**288843**	**472671**	Already covered. CGWB exploration data show that bed rock is encountered at the depth of 50 to 55 mbgl. Deeper Aquifer within **24.50 – 50** m is potential one; besides, surface water sources or river water is proposed in the block.
2	Samserganj	**274392**	**332206**	**218394**	22 TWs have been suggested (vide Table 8.3.2) tapping deeper Aquifer within 43.69 – 112.63 m under semi-confined to confined condition, which might be arsenic free and potential one; besides, use of existing surface water sources, rain water harvesting &construction of conservation structures are also proposed.
3	Suti II	**127513**	**337690**	**215755**	24 TWs have been suggested (vide Table 8.3.2) tapping deeper Aquifer at about within 60-76 m under confined condition, besides, use of existing surface water sources, rain water harvesting & construction of conservation structures are also proposed.
4	Suti I	**278922**	**217814**	**248452**	If needed, TW can be tapping deeper aquifer within 55 - 110 m: besides, use of existing surface water sources, rain water harvesting & construction of conservation structures are proposed.
5	Raghunathganj	**151338**	**183224**	**299200**	If needed, TW can be tapping

	I				deeper aquifer within 38 –82.31,93 -113m in Older Alluvium; besides, use of existing surface water sources, rain water harvesting & construction of conservation structures are proposed, especially in eastern part of block.
6	Sagardighi	-	-	**1081823**	If needed, TW can be tapping deeper aquifer within 40 – 82 m in Older Alluvium; besides, use of existing surface water sources, rain water harvesting & construction of conservation structures are proposed, especially in eastern part of block.
7	Kandi	-	-	**129885**	If needed, TW can be tapping deeper aquifer within 30 – 90 m in Older Alluvium; besides, use of existing surface water sources, rain water harvesting & construction of conservation structures are proposed, especially in eastern part of block. Very low potential aquifers has been encountered in the depth span of 131.1 – 149.7 206 -256 mbgl.
8	Khargram	-	-	73163	TW can be tapping deeper aquifer within 10 - 70 m in Older Alluvium; besides, use of existing surface water sources, rain water harvesting & construction of conservation structures are also proposed.

9.1.2: Management Strategy for irrigation

- 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 area of cultivation of Til and ground nut (in upland areas). 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 spring, 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.

9.1.3 Scope for Rain Water Harvesting and Artificial Recharge:

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 most part of 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-offcomponent for recharge and conservation has been determined, followed by proposal of different types of artificial recharge and conservation structures in different blocks, and totalcost estimate for different blocks has been assessed for implementationof development 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 rain water 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.	Normal monsoon rainfall in m '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(considering e-flow)= Vf Ham
1	1.04	Farakka	13274	13804.96	0.32	23.47 % moderately well drained sandy soil & 41.86 % imperfectly drained loamy soil, rest is covered by drainage	4417.5872	3313.1904	1656.5952	993.95712
2	1.04	Samserganj	9448	9825.92	0.39	47.32 % moderately well drained sandy soil & 41.81 % imperfectly drained loamy soil, rest is covered by drainage	3832.1088	2874.0816	1437.0408	862.22448
3	1.04	Suti I	14368	14942.72	0.53	28.71 % moderately well drained sandy soil & 73.73 % imperfectly drained loamy soil	7919.6416	5939.7312	2969.8656	1781.91936
4	1.04	Suti II	11113	11557.52	0.44	43.40 % moderately well drained sandy soil & 51.50 % imperfectly drained loamy soil	5085.3088	3813.9816	1906.9908	1144.19448
5	1.04	Raghunathganj I	14091	14654.64	0.55	0.073 % moderately well drained sandy soil, 75.61 % imperfectly drained loamy soil & 19.75 % imperfectly drained fine sand	8060.052	6045.039	3022.5195	1813.5117
6	1.04	Sagardighi	34542	35923.68	0.58	1.80 % moderately well drained sandy soil, 86.11% imperfectly drained loamy soil & 11.59 % imperfectly drained fine sand	20835.7344	15626.8008	7813.4004	4688.04024
7	1.04	Nabagram	30663	31889.52	0.58	5.35 % moderately well drained sandy soil, 94.31 % imperfectly drained loamy soil & 0.34 % imperfectly drained fine sand	18495.9216	13871.9412	6935.9706	4161.58236
8	1.04	Khargram	31845	33118.8	0.51	9.82 % imperfectly drained loamy soil & 90.18 % imperfectly drained fine sand, rest is covered by drainage	16890.588	12667.941	6333.9705	3800.3823
9	1.04	Kandi	24043	25004.72	0.59	2.28 % moderately well drained sandy soil, 96.62 % imperfectly drained loamy soil & 1.10 % imperfectly drained fine sand	14752.7848	11064.5886	5532.2943	3319.37658

Table 9.2: Nos. of Conservation & recharge structures and cost estimate

Block (3)	Amount of water for artificial recharge and / or conservation (Ham) (4)	Source water allocation for Percolation Tank and REET with Recharge Shaft in Ham (5)	Source water allocation for REET with Recharge Shaft (Ham): 50 % of Col. 5 (6)	Source water allocation for Irrigation Cum Recharge Tank (Ham): 50 % of Col. 5 (7)	Source water allocation for Injection Well (8)	Source water allocation for Farm/Conservation Pond in Ham (9)	Nos. of REET with Recharge Shaft suggested @ 10 Ham per unit (10)	Nos. of Irrigation Cum Recharge Tank suggested @ 50 Ham per unit (11)	Nos. of injection wells @ 30 Ham per unit (12)	Nos. of Farm/conservation ponds @ 10 Ham per unit (13)	Cost of REET with Recharge Shaft @ Rs 8 lakh per unit (14)	Cost of Irrigation cum Recharge tank @ Rs 8 lakh per unit (15)	Cost of Injection wells @ Rs 8 lakh per unit (16)	Cost of Farm pond @ Rs 8 lakh per unit (17)	Total Cost
Farakka	993.95712	90 % of Col. 4 i.e. 894.56 Ham	447.28	447.28	Nil	10 % of Col. 4 i.e. 99.40 Ham	45	9	-	10	360	72	-	80	512
Samsergan j	862.22448	70 % of Col. 4 i.e. 603.56 Ham	301.78	301.78	20 % of Col. 4 i.e. 172.44 Ham	10 % of Col. 4 i.e. 86.22 Ham	30	6	6	9	240	48	48	72	408
Suti I	1781.91936	70 % of Col. 4 i.e. 1247.34 Ham	623.67	623.67	20 % of Col. 4 i.e. 356.38 Ham	10 % of Col. 4 i.e. 178.19 Ham	62	12	12	18	496	96	96	144	832
Suti II	1144.19448	90 % of Col. 4 i.e. 1029.78 Ham	514.89	514.89	Nil	10 % of Col. 4 i.e. 114.42 Ham	51	10	-	11	408	80	-	88	576
Raghunath ganj I	1813.5117	90 % of Col. 4 i.e. 1632.16 Ham	816.08	816.08	Nil	10 % of Col. 4 i.e. 181.35 Ham	82	16	-	18	656	128	-	144	928
Sagardighi	4688.04024	70 % of Col. 4 i.e. 3281.63 Ham	1640.82	1640.82	20 % of Col. 4 i.e. 656.33 Ham	10 % of Col. 4 i.e. 468.80 Ham	164	33	22	47	1312	264	176	376	2128
Nabagram	4161.58236	70 % of Col. 4 i.e. 2913.11 Ham	1456.56	1456.56	20 % of Col. 4 i.e. 832.32 Ham	10 % of Col. 4 i.e. 416.16 Ham	146	29	28	42	1168	232	224	336	1960
Khargram	3800.3833	70 % of Col. 4 i.e. 2600.27 Ham	1300.14	1300.14	20 % of Col. 4 i.e. 760.08 Ham	10 % of Col. 4 i.e. 380.04 Ham	130	26	25	38	1040	208	200	304	1752
Kandi	3319.37658	70 % of Col. 4 i.e. 2323.56 Ham	1161.78	1161.78	20 % of Col. 4 i.e. 663.88 Ham	10 % of Col. 4 i.e. 331.94 Ham	116	23	22	33	928	184	176	264	1552

- ****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 in to deeper zones as well as for pumping**

10. Block wise Management Plan

10.1 Block Name: FARAKKA

10.1.1 Salient Information

Area (in Km^2): 132.74

District: Murshidabad

State: West Bengal

Population (as on 2011):

Rural	Urban	Total
167826	106285	274111

Approximate Decadal Growth Rate: Farakka block registered a population growth of 24.13 per cent during the 1991-2001 decade, and in 2001-2011 it was 24.57%.

Rainfall:

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

District	Normal - 2014 (in mm)	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):

Sl. No	Name of the Block	Geographic Area	Cultivable Area	Area under pasture & orchard	Cultivable Waste Land	Forest Land
1.	Farakka	132.74	44.60	-	-	2.57

(Source: Dept. of Agriculture, Govt. of West Bengal)

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

Resource Availability	Aquifer I	Aquifer II	Current Annual G W Extraction (MCM) (Aquifer I)
Dynamic Resource (in MCM)	38.7052	1.303188	11.4074
Static Resource (in MCM)	49.22	6.01302	

10.1.2: Disposition of Aquifer:

Depth range of aquifers:

Block	**Depth range of Aquifer in m bgl**	
Farakka	**Aquifer I**	**Aquifer II**
	9.98 – 11.39 (maximum up to 25 m)	24.38 - 50

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

Sl. No.	**Block**	Aquifer	**Pre-monsoon Trend**			**Post-monsoon Trend**		
			Water Level Range (m bgl)	**Rise (m/yr)**	**Fall (m/yr)**	Water Level Range (m bgl)	**Rise (m/yr)**	**Fall (m/yr)**
1.	Farakka	I	6.53 – 8.66	0.108	-	4.09 – 6.79	-	0.083 - 0.22
2.	Farakka	II	10.05 – 11.89	0.10	-	6.65 – 8.45	-	0.188

Average Thickness of Aquifer:

Block	Area (sq km)	Thickness of the Granular Zone in Aquifer I (m)	Thickness of the Granular Zone in Aquifer II (m)
Farakka	132.74	10.69	24.15

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)
Farakka	10.00 – 15.00	1.8 - 3.6	-	24.38 - 50	73.15 – 177.36	2000 – 4225.5

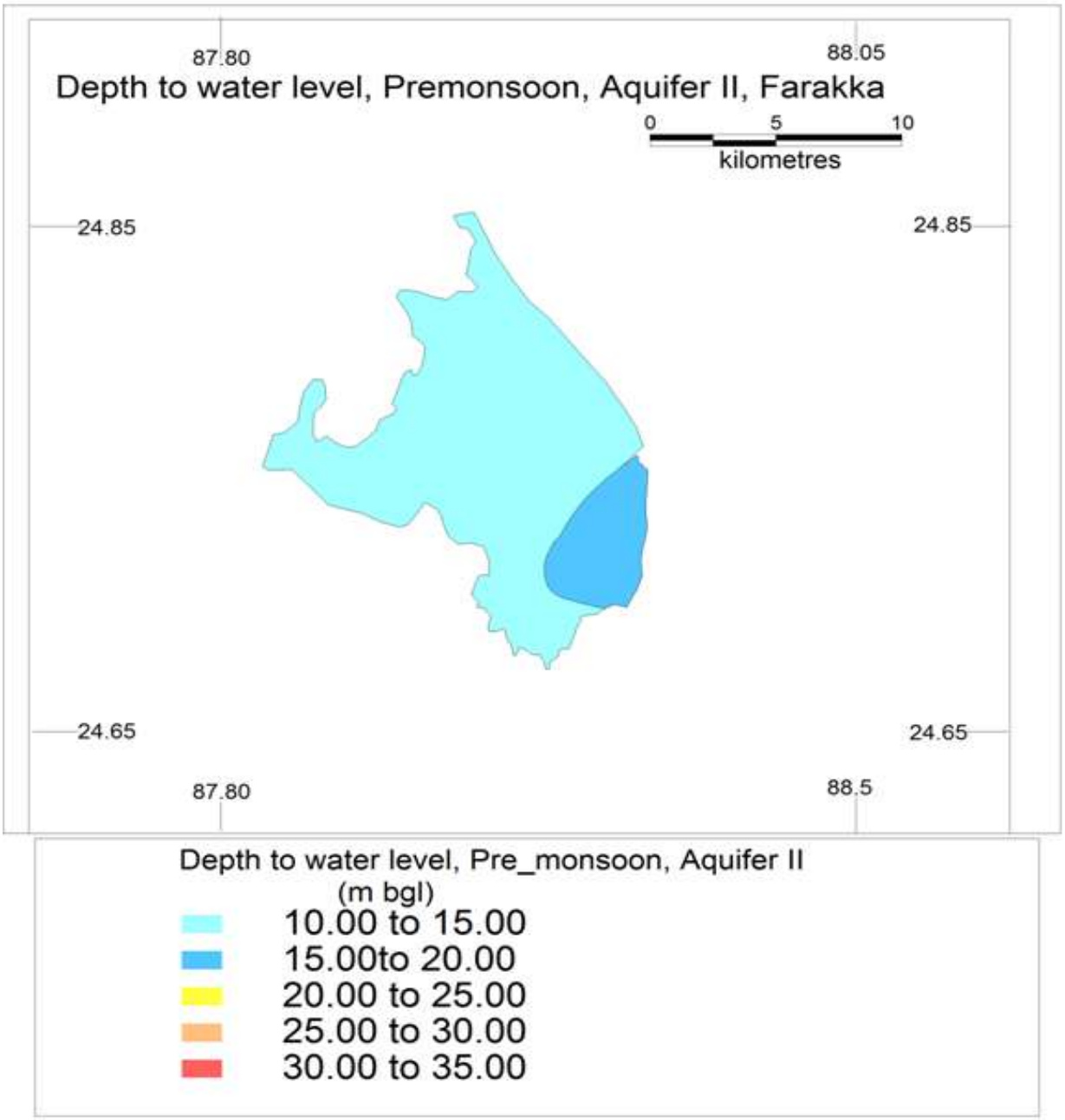


Fig. 10.1.2.1: Depth to water level, Aquifer II, Pre monsoon

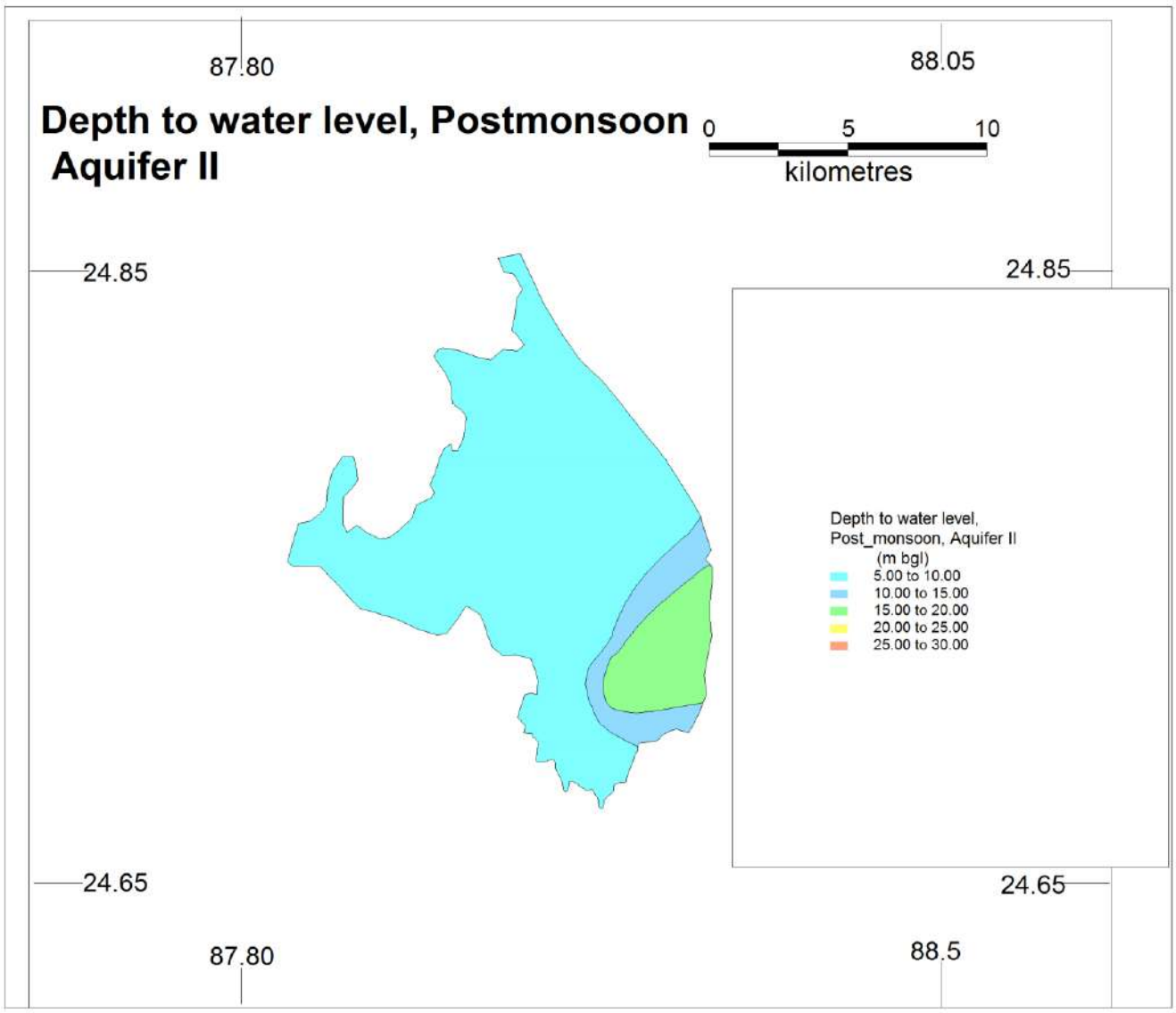


Fig. 10.1.2.2: Depth to water level, Aquifer II, Post monsoon

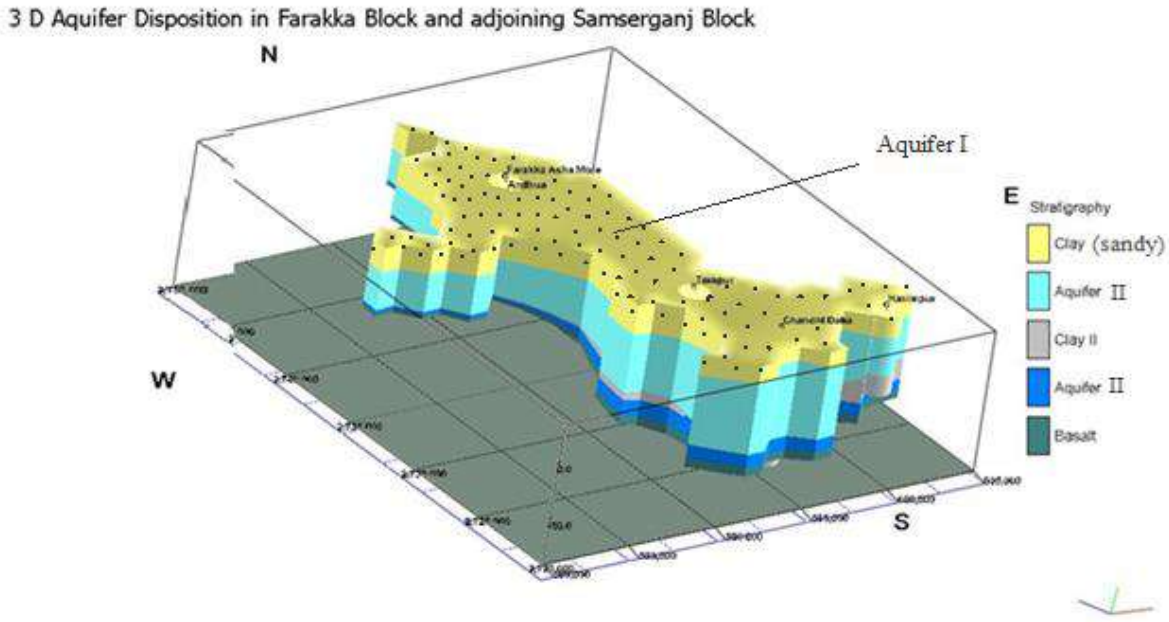


Fig. 10.1.2.3: - 3 D Aquifer disposition in Farakka block and adjoining area.

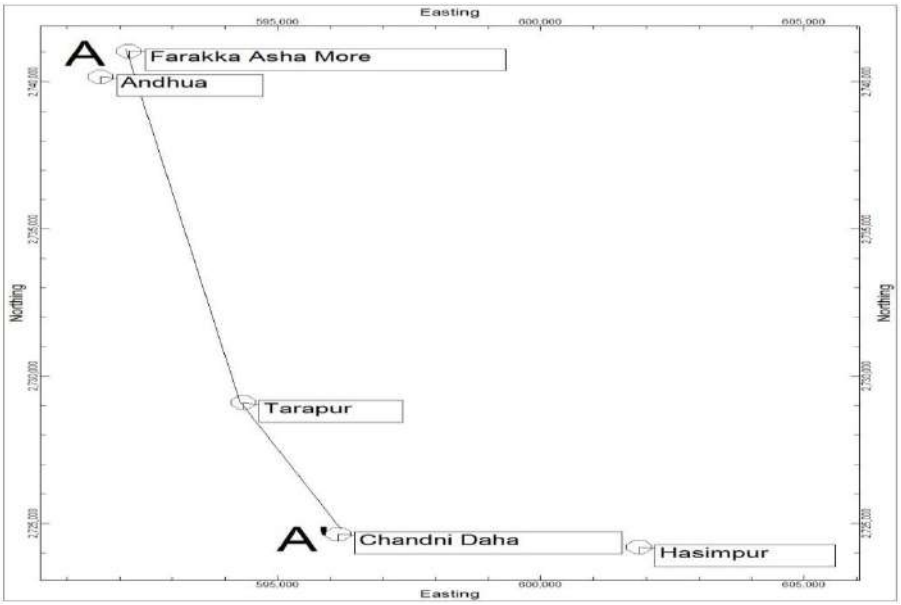


Fig. 10.1.2.4: - N-S section index line in and around Farakka block

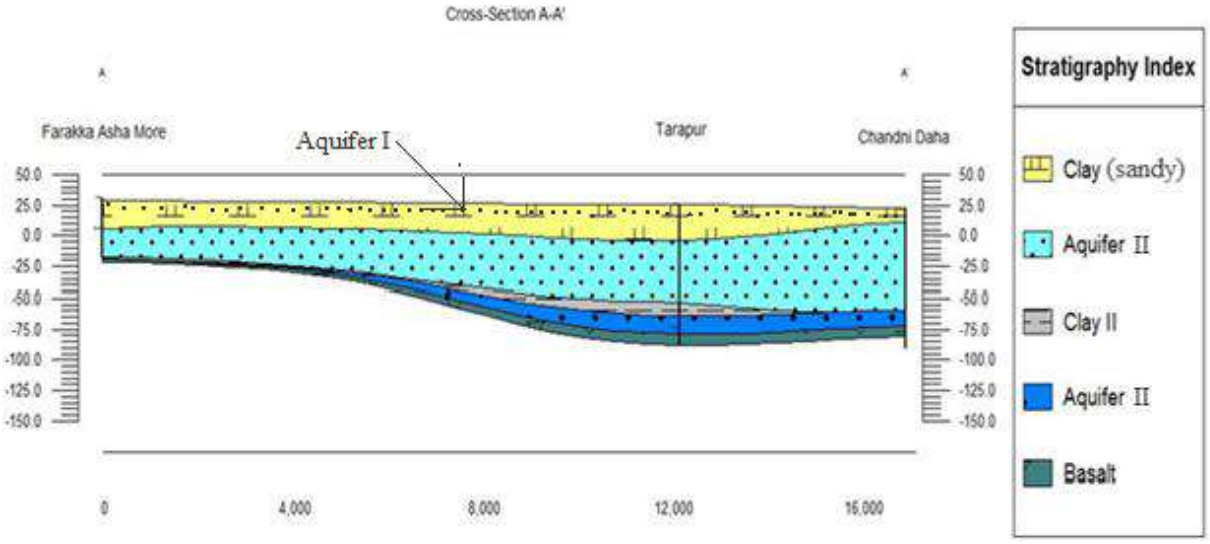


Fig. 10.1.2.4 - N-S section in and around Farakka block

10.1.3: Ground Water Resource & status of Extraction:

Dynamic ground water resources (Aquifer I) as on 31st March'17

Block	Net Annual Extractable Ground Water Recharge (MCM)	Current Annual GW Extraction (MCM)	Stage of development (%)	Category	Annual GW allocation for domestic use as on 2042(MCM)	Ground water availability for future use (MCM)
Farakka	38.7052	11.4074	29.47	Safe	3.8177	26.5633

Static (in-storage) Resources (Aquifer I): 49.22 MCM

Dynamic ground water resources (Aquifer II): 1.303188 MCM

Static (in-storage) Resources (Aquifer II): 601.30 MCM

10.1.4: Chemical quality of Ground Water & other issues:

Range of important Chemical Parameters:

Arsenic (As) data are based on 4 random samples of Special Drive' 15-16 & other routine parameters are based on limited samples of 17-18. As more than 0.01 mg/l, WHO limit of potable water, has been reported in 4 out of 4 wells (2 dug wells & 2 tube wells). Maximum has been encountered at Jorpukuria.

Block	As (mg/l)	TH (mg/l)	EC (µS/cm)	F (mg/l)	NO_3 (mg/l)
Farakka	**0.007 – 0.186**	**165-200**	**539 -559**	**0.23-0.67**	**0-1.0**

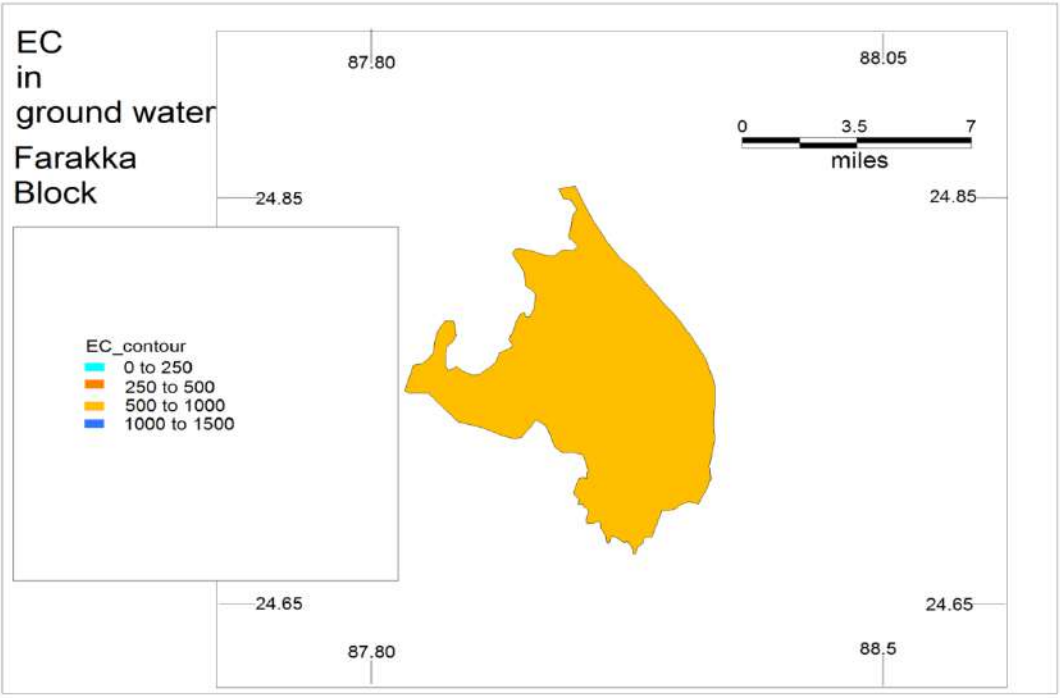


Fig. 10.1.4.1: Electrical Conductivity (EC) in ground water

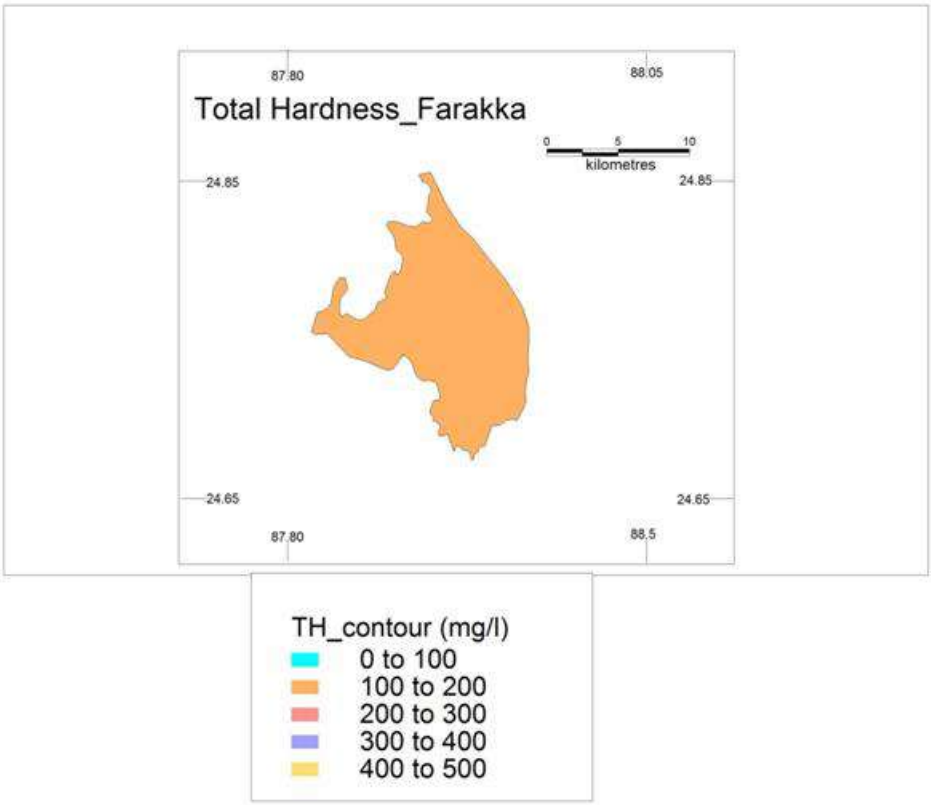


Fig. 10.1.4.2: Total Hardness (TH) in ground water

Percentage of tube wells having arsenic content:

Block	Arsenic (<0.01 mg/1)		Arsenic (>0.01-<0.05 mg/1) %		Arsenic (> 0.05 mg/1) %		Total Tube well (max. concentration of As(mg/l)
	%	Count	%	Count	%	Count	
Farakka	26.15	279	59.04	630	14.71	157	1067 (0.51)

(Source: PHED, Govt. of West Bengal)

Population in arsenic infested area (based on PHED hand pump data):

Block	Nos. of habitations in risk zone	Whereas As infested	As infested population in 2011	Projected As infested population in 2021
Farakka	45	Infested	238576 (excepting NTPC Barrage Project)	288843

10.1.5: Major Issues:

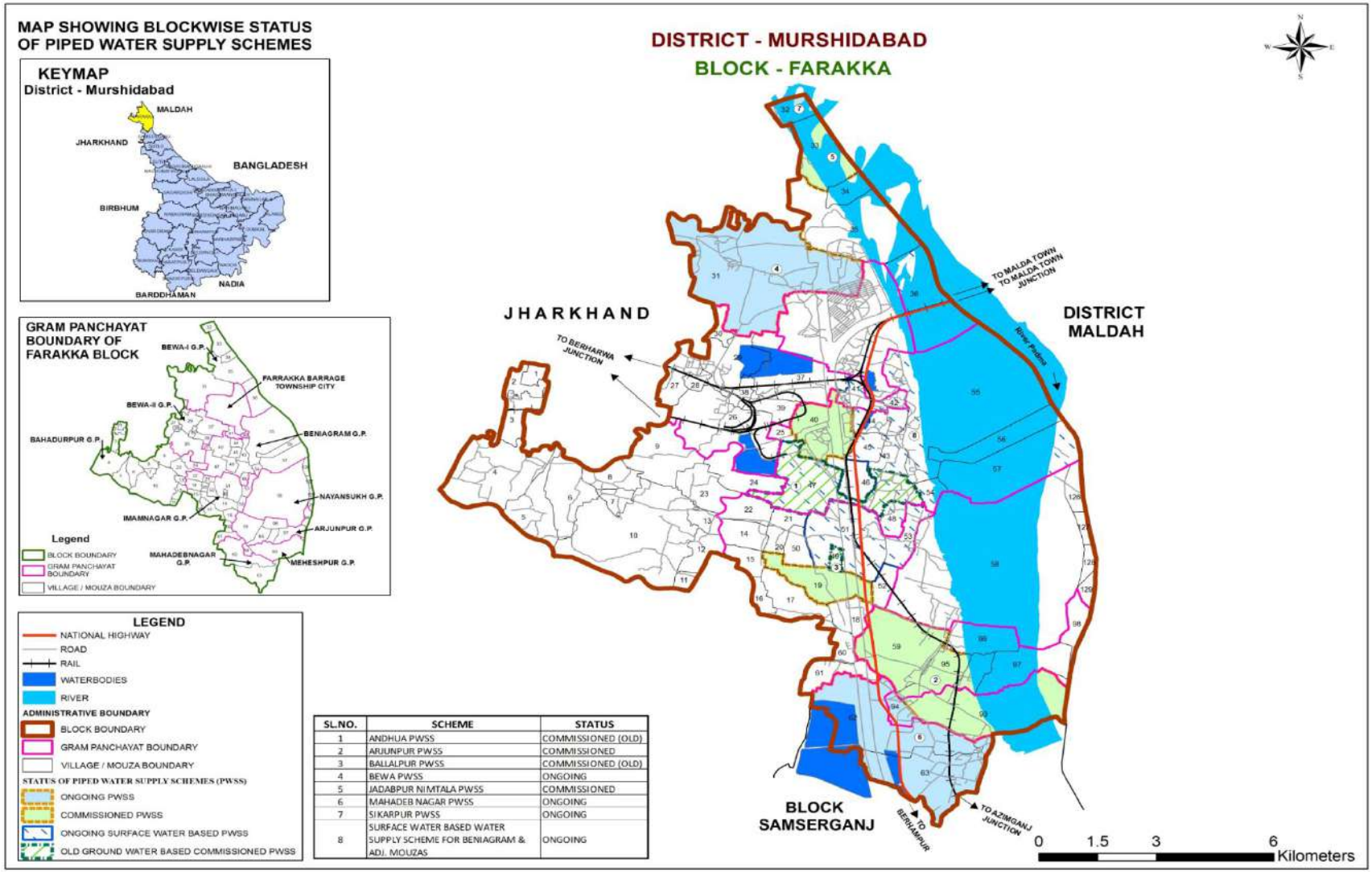
1. Sporadic ground water contamination by arsenic
2. Water logging in low land parts of block
3. Aquifers are restricted in occurrence, because basement is encountered at shallow depth of about 75m depth.

10.1.6: Ground Water Resource Enhancement & Management Plan:

Ground Water Management Plan for drinking purposes.

Table 10.1.6.1: As infested population & Status of water supply in Farakka Block:

Block	Nos. of habitations in risk zone	Whereas As infested	As infested population in 2011	Projected As infested population in 2021	Population already covered	Water (lit.) required for uncovered population @ 70 lpcd
Farakka	45	Infested	238576 (excepting NTPC Barrage Project)	288843	472671	Already covered



SL.NO.	SCHEME	STATUS
1	ANDHUA PWSS	COMMISSIONED (OLD)
2	ARJUNPUR PWSS	COMMISSIONED
3	BALLALPUR PWSS	COMMISSIONED (OLD)
4	BEWA PWSS	ONGOING
5	JADABPUR NIMTALA PWSS	COMMISSIONED
6	MAHADEB NAGAR PWSS	ONGOING
7	SIKARPUR PWSS	ONGOING
8	SURFACE WATER BASED WATER SUPPLY SCHEME FOR BENIAGRAM & ADJ. MOUZAS	ONGOING

Fig. 10.1.6.1: Status of present water supply schemes in Farakka Block

Proposed interventions for drinking water:

Sl. No.	Block	Suggestions for providing potable water supply to the risk population
1	Farakka	➢ For drinking purpose deeper aquifer is earmarked. ➢ Potable water aquifers are encountered within depth range of 25 – 60 m. Beneath this basement of basaltic rocks are encountered. ➢ Deeper aquifers are to be earmarked for PWSS & Tube wells should be constructed by proper cement sealing in the upper clay bed above the aquifer containing potable ground water. ➢ Surface water source is alternative source. ➢ However, deep drilling by combination rig may be tried in the basement rocks to explore the possibility of potential potable aquifer zone.

Other options for potable water:

1. Rain water harvesting

2. Installation of arsenic removal plants to make potable water from contaminated first Aquifer.

As infested Risk Polpulation:

Block	**Nos. of habitations in risk zone**	**Whereas As infested**	**As infested population in 2011**
Farakka	**45**	**Infested**	**238576 (excepting NTPC Barrage Project)**

Table 10.1.6.2: Irrigation scenario (Aquifer I) in Farakka 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	Remarks for GW Management Plan
Farakka	4460	1330	3120	29.47	**R 10.8**	F 8.3	7.60	5.44	Can be developed for GW based Irrigation

***Source - Statistical Hand Book 2013-14, **Source – Agriculture Dept., Govt. of West Bengal**

Data of 5th M. I. Census shows:

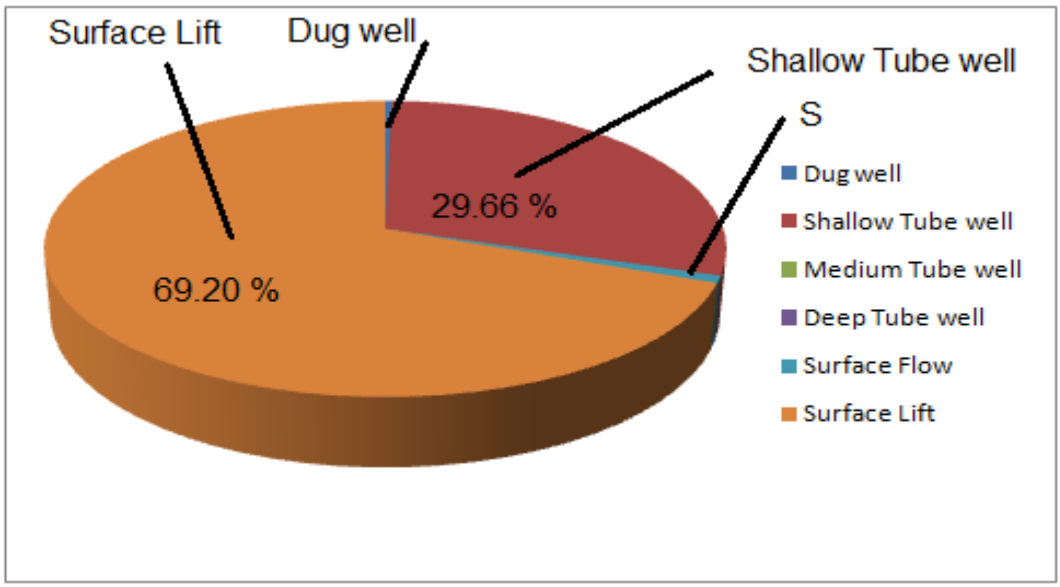


Fig. 10.1.6.2: Percent contribution of different sources of irrigation

Table 10.1.6.3: Percent contribution of different sources of irrigation

Type of abstraction structures	CCA (ha)	% of irrigation
Dug well	5	0.36%
Shallow Tube well	416.67	29.66%
Medium Tube well	0	-
Deep Tube well	0	-
Surface Flow	11	0.78%
Surface Lift	972.04	69.20%

Table 10.1.6.4: CCA & sources of irrigation

Block / District	Dug well		Shallow Tube well		Medium Tube well		Deep Tube well		Surface Flow		Sarface Lift		CCA (ha.)		Total CCA (ha.)
	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	Ground Water	Surface Water	
Block	2	5	156	416.67	0	0	0	0	5	11	135	972.04	421.67	983.04	1404.71
District	**178**	**728.67**	**54842**	**127809.5**	**2148**	**11550.14**	**1719**	**33386.23**	**292**	**1592.29**	**1499**	**13037.13**	**173474.5**	**14629.42**	**188103.9**

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

Table 10.1.6.5: Cropping Pattern in Farakka block during 2016-17

Name of Block	Aus	Aman	Boro	Wheat	Potato	Masur	Maskalai	Jute	Khesari	Til	Mustard	Linseed	Gram
Farakka	25	2264	95	945	113	11	166	823	1385	-	753	107	-

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

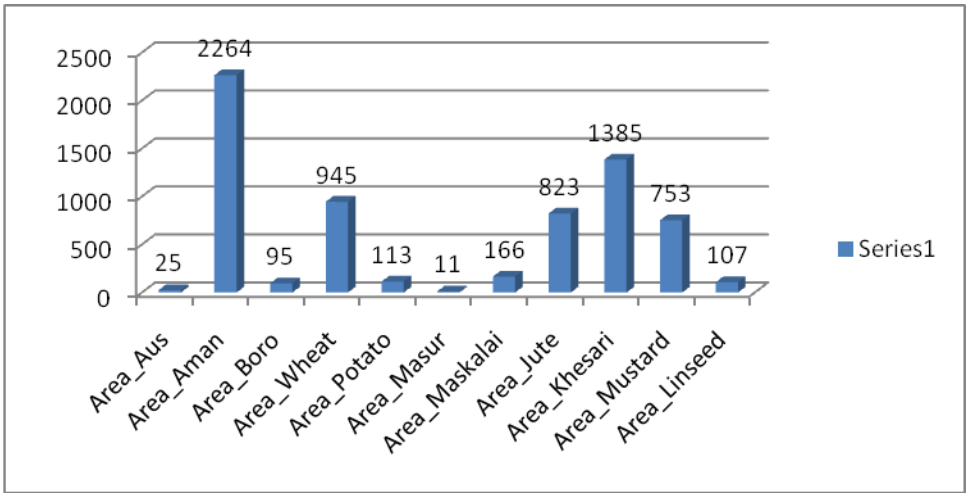


Fig. 10.1.6.3: Graphical representation of cropping pattern in Farakka block

Management Strategy/ Proposed interventions for irrigation:

- On principle, Boro cultivation is not encouraged. Boro needs 1.2 to 1.4 m.
- Wheat, Pulses & Oil seeds including Til, Ground nut cultivation in upland area could be encouraged; wheat needs about 0.35 m & Pulses & Oil seeds about 0.15 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.
- To improve the ground water scenario, implementation of modern irrigation practices like drip water irrigation system, sprinklers can be made.
- Cultivation of low water requiring crops and change in cropping pattern may be done for better and efficient water management.
- Some parts of this block is prone to water logging; therefore it is advisable for conjunctive use of both surface and ground water.

  Also, in area of shallow water level, cultivation of cash crops, eg. sugar cane is highly suggested.

- In this block, during Rabi & spring/ summer months, the existing area wise cropping pattern vide **Table 10.1.6.5 & Fig. 10.1.6.3)** is as follows:

  Wheat – 27.16 %, vegetables – 0.032 % (neglisible), Pulses & Oil seeds – 69.60%.
- As per the aforesaid cropping pattern, from the remaining area to be irrigated of 3120 Ha, cultivation proposed: wheat – 847.39 Ha; Pulses & Oil seeds -2171.52 Ha.
- For wheat (@ 0.35 m/ha) & Pulses & Oil seeds (@0.15 m/Ha) estimation shows an amount of 622.32 Ham of water is needed.
- Ground Water Estimation 2017 shows that an amount of 26.5633 MCM of ground water from the top aquifer has been earmarked for future use.

  Therefore, the remaining cultivable area can be easily covered by the available ground water resource.

Table 10.1.6.6: Water column recommended 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
Murshidabad	Farakka	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

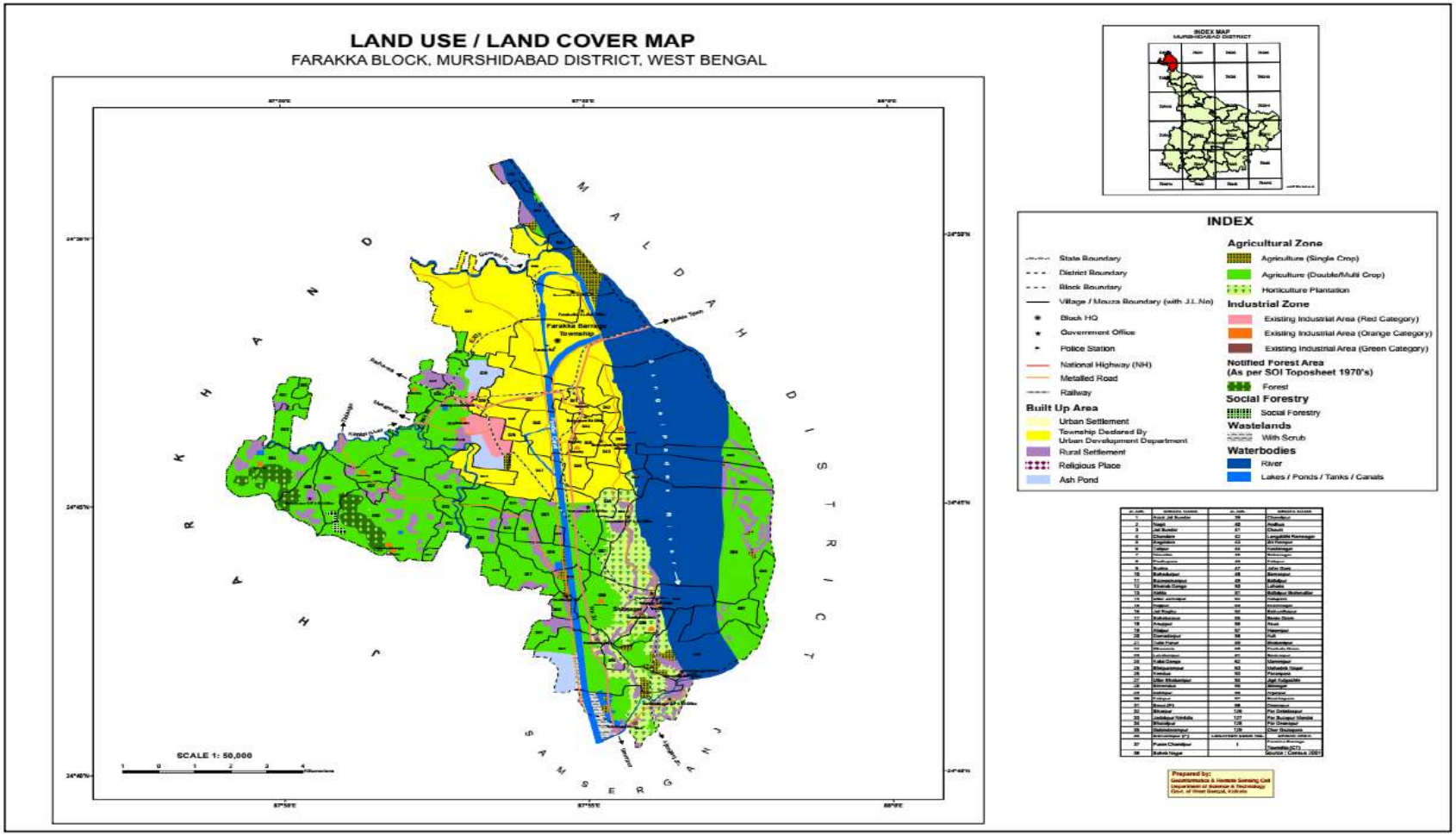


Fig. 10.1.7.1: Land use/ land cover in Farakka block

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

10.1.7.: Scope for Rain Water Harvesting and Artificial Recharge:

Using Dhruvanarayana,1993 method in Farakka 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 10.1.7.1a & Table 10.1.7.1b. 9.9396 MCM of rain water has been estimated to be harvested. This harvested water can be utilized for construction of suitable structures for artificial recharge and conservation of water; by doing this ground water scenario can be improved as well as the inclusive economic growth can be achieved.

Area suitable for recharge in the study area (vide Part I : Plate 6.2.1b):

District	Block Name	Area (in sq. km)	Total Area suitable for recharge (sq km.)
MURSHIDABAD	Farakka	132.74	53.10

Utilization of Harvested Rain Water: Table 10.1.7.1a shows that 9.9396 MCM of rain water could be harvested in Farakka block. In Fig. 10.1.7.1, land use & land cover in this block has been shown; from it it is visualized that the land is suitable for even for double / multi-crop cultivation. The amount of 9.9396 MCM of rain water can be utilized in following ways:

For storing of rain water in constructed tanks, a total land of 298.32 ha with 3 m depth is required (by keeping aside 10 % of 9.9396 MCM water as wastage by spillage, etc.). The remaining amount of harvested water i.e. 894.96 Ham can be utilized for irrigation, if needed, in future.

It is proposed to modify cropping pattern, if needed in future, for efficient irrigation practices. Less water requiring crops, eg. pulses, oil seeds, are always preferable. By this, a huge amount of vital ground water resources could be saved.

Table 10.1.7.1a: Estimation of harvested rain water in Farakka 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 (considering e-flow) = Vf Ham
1.04	13274	13804.96	0.32	23.47 % moderately well drained sandy soil & 41.86 % imperfectly drained loamy soil, rest is covered by drainage	4417.59	3313.19	1656.60	993.96

Table 10.1.7.1b: Proposed Artificial Recharge & conservation Structures in Farakka block:

Amount of water for artificial recharge and / or conservation (Ham) (4)	Source water allocation for Percolation Tank and REET with Recharge Shaft in Ham (5)	Source water allocation for REET with Recharge Shaft (Ham): 50 % of Col. 5 (6)	Source water allocation for Irrigation Cum Recharge Tank (Ham): 50 % of Col. 5 (7)	Source water allocation for Injection Well (8)	Source water allocation for Farm/Conservation Pond in Ham (9)	Nos. of REET with Recharge Shaft suggested @ 10 Ham per unit (10)	Nos. of Irrigation Cum Recharge Tank suggested @ 50 Ham per unit (11)	Nos. of injection wells @ 30 Ham per unit (12)	Nos. of Farm/conservation ponds @ 10 Ham per unit (13)	Cost of REET with Recharge Shaft @ Rs 8 lakh per unit (14)	Cost of Irrigation cum Recharge tank @ Rs 8 lakh per unit (15)	Cost of Injection wells @ Rs 8 lakh per unit (16)	Cost of Farm pondnjection wells @ Rs 8 lakh per unit (17)	Total Cost
993.95712	90 % of Col. 4 i.e. 894.56 Ham	447.28	447.28	Nil	10 % of Col. 4 i.e. 99.40 Ham	45	9	-	10	360	72	-	80	512

10.2: Samserganj

10.2.1: Salient information

Block Name: Samserganj

Area (in Km^2): C. D. Block - 84.21; Dhuliyan (M) – 10.27; Total Area – 94.48

District: Murshidabad

State: West Bengal

Population (as on 2011):

Area	Rural	Urban	Total
Samserganj C. D. Block	108718	175354	271060
Dhuliyan (M)	-	95706	

Approximate Decadal Growth Rate: 17.33 per cent during the 1991-2001 & 34.09% in 2001-2011.

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.	Samserganj Total	94.48	30.61	-	0.05	-

(Source: Dept. of Agriculture, Govt. of West Bengal)

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

Resource Availability	Aquifer I	Aquifer II	Current Annual G W Extraction (MCM) (Aquifer I)
Dynamic Resource (in MCM)	65.6402	0.055856	25.318
Static Resource (in MCM)	113.72	5.13041	

10.2.2: Disposition of Aquifers

Depth range of aquifers

Block	**Depth range of Aquifer in m bgl**	
Samserganj	**Aquifer I**	**Aquifer II**
	7.10 - 25	43.69 – 112.63

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

Sl. No.	**Block**	Aquifer	**Pre-monsoon Trend**			**Post-monsoon Trend**		
			Water Level Range (m bgl)	**Rise (m/year)**	**Fall (m/year)**	Water Level Range (m bgl)	**Rise (m/year)**	**Fall (m/year)**
1.	Samserganj	I	3.57- 10.6	-	0.01	1.07 – 6.78	-	0.032-0.274
2.	Samserganj	II	19.34			18.67		

Average Thickness of Aquifer :

	Area (sq km)	Thickness of the Granular Zone in 1st aquifer (m)	Thickness of the Granular Zone in 2nd aquifer (m)
Samserganj	94.48	15	65.5

Aquifer-wise Statement

Name of Block	1st Aquifer			2nd Aquifer		
	Depth Range (m bgl)	Discharge (m^3/hr)	T (m^2/day)	Depth Range (m bgl)	Discharge (m^3/hr)	T (m^2/day)
Samserganj	7.10 - 25	6.86	28.67	43.69 – 112.63	100 -193.56	1486.73 - 2500

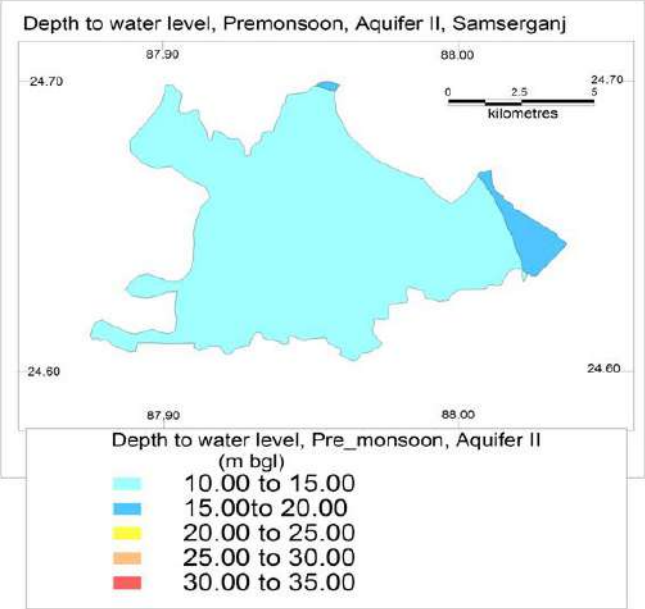


Fig. 10.2.2.1: Depth to water level, pre monsoon, Aquifer II

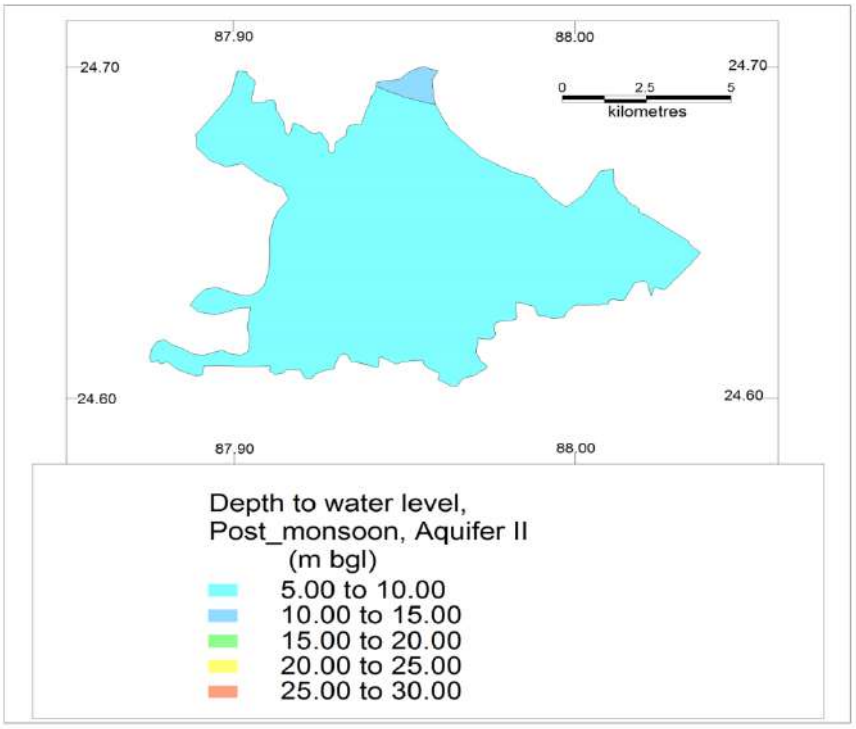


Fig. 10.2.2.2: Depth to water level, post monsoon, Aquifer II

Fig. 10.2.2.3: Lithological disposition in aquifers

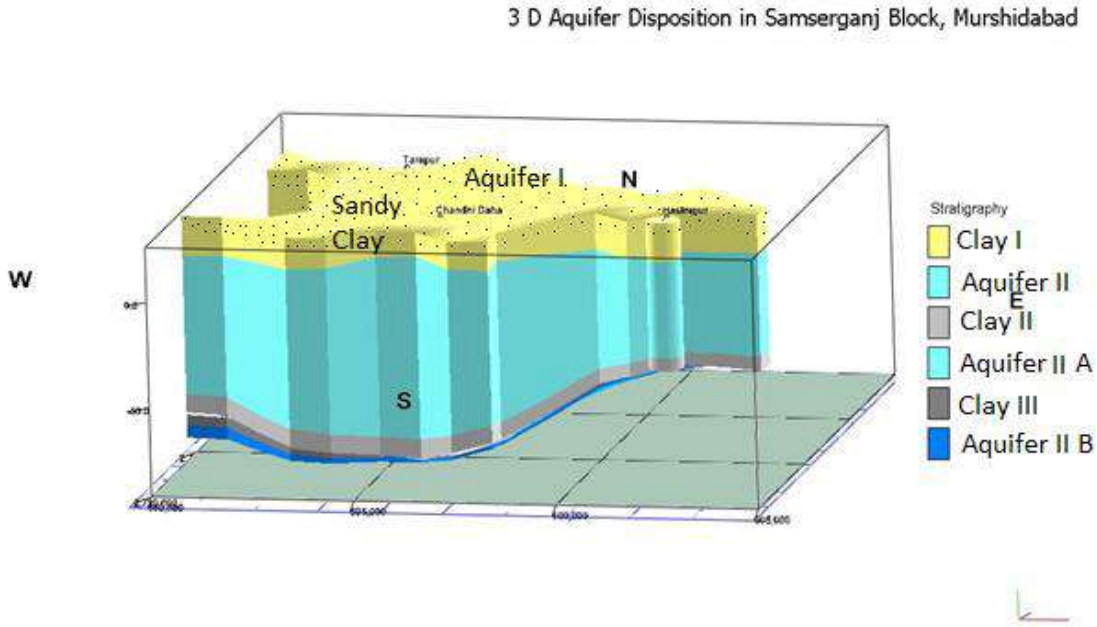


Fig. 10.2.2.4: 3D aquifer disposition in Samserganj bock

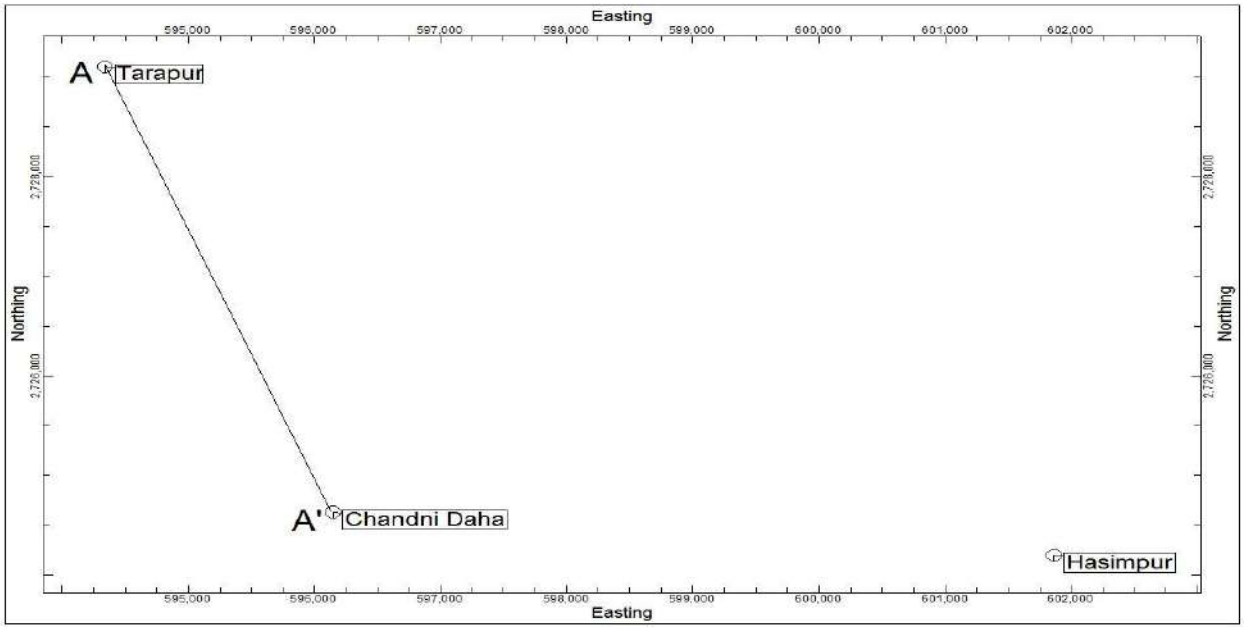


Fig. 10.2.2.5: NNW – SSE Section index line in Samserganj block

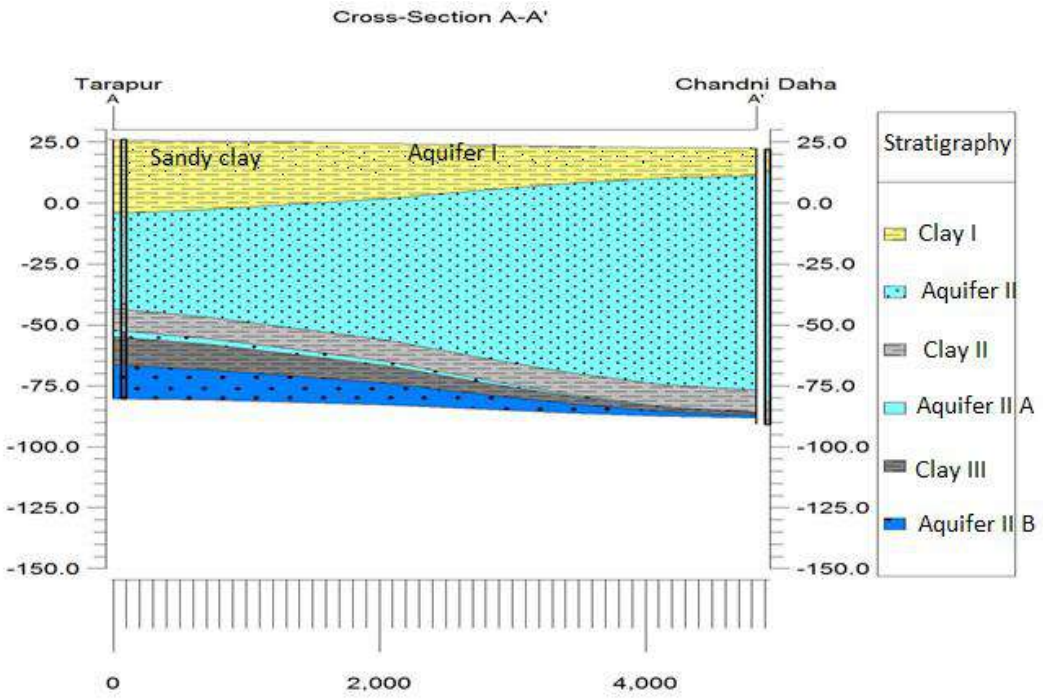


Fig. 10.2.2.6: NNW – SSE Section in Samserganj block

10.2.3: Ground Water Resource & status of Extraction:

Aquifer Wise Resource Availability & Extraction:

Dynamic ground water resources as on 31st March'17

Block	Annual Extractable Ground Water Recharge (MCM)	Current Annual Ground Water Extraction (MCM)	Stage of development (%)	Category	Annual GW Allocation for for Domestic Use as on 2042	Ground water availability for future use (MCM)
Samserganj	65.6402	25.318	38.57	Safe	5.6357	39.0587

Static (in-storage) Resources (Aquifer I): 113.72 **MCM**

Dynamic Ground Water Resources (Aquifer II): 0.055856 **MCM**

Static (in-storage) Resources (Aquifer II): 5.13041 **MCM**

10.2.4 Chemical Quality of Ground Water & Contamination:

Range of important Chemical Parameters:

Arsenic (As) data are based on 7 random samples of spl. Drive' 15-16 & other routine parameters are based on limited samples of 17-18. As more than 0.01 mg/l, WHO limit of potable water, has been reported in 4 out of 7 wells (6 dug wells & 1 tube well). Maximum has been encountered at Jayrampur.

Block	As (mg/l)	TH (mg/l)	EC (µS/cm)	F (mg/l)	NO_3 (mg/l)
Samserganj	0.001 – 0.051	190-210	555-622	0.30-0.45	0-3

Percentage of tube wells having arsenic content (based on data of PHED, Govt. of West Bengal):

Block	Arsenic (<0.01 ing/1)		Arsenic (>0.01-<0.05 mg/1) %		Arsenic (> 0.05 mg/1) %		Total Tube well (max. concentration of As(mg/l)
	%	Count	%	Count	%	Count	
Samserganj	16.78	300	63.53	1136	19.69	352	1788 (0.30)

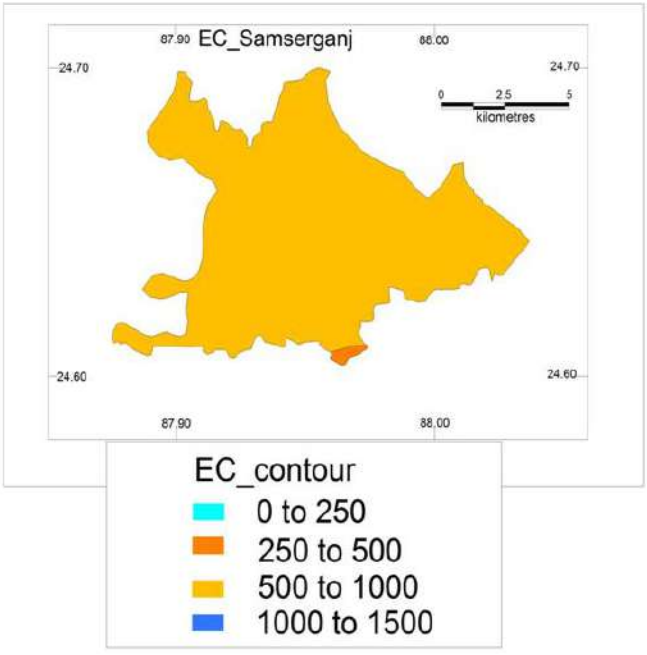


Fig. 10.2.4.1: Electrical Conductivity (EC) in ground water

10.2.5 Main issues:

1. Very deep water level in deeper aquifer and its long term trend shows alarming fall.
2. Sporadic ground water contamination by arsenic has been reported in Younger Alluvium of Aquifer I.
3. Irrigation in large area is done by ground water
4. Low lying areas are prone to water logging

10.2.6 Ground Water Resource Enhancement& Management Plan:

Ground Water Management Plan for drinking purposes

Table 10.2.6.1: As invested habitations & Status of present water supply

Nos. of habitations in risk zone	Whereas As infested	As infested population in 2011	Projected As infested population in 2021	Population already covered	Water (lit.) required for uncovered population @ 70 lpcd	Nos. of TWs required considering each TW's discharge of 12.5 lps& 8 hrs. run per day	Cost of construction of required TWs @ 18 lakh per TW as per approved rate	**Remarks**
31	Infested	274392	332206	218394	70 X 113812 = 7966840	22	396	For drinking water construction (10" X 6") of tube wells are to be made in Aquifer II, which is arsenic free, wherever present. Besides, surface water is another option in Murshidabad district.

Proposed Interventions for drinking:

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.	Suggestions for providing water supply to the risk population
Samsernaj	NA	Not estimated/declared by the authority	• Deeper aquifers encountered within 44- 113 m bgl has been found potential and generally potable. Tube wells may be constructed by using cement sealing technique tapping these aquifers. • Surface water is an alternative source.

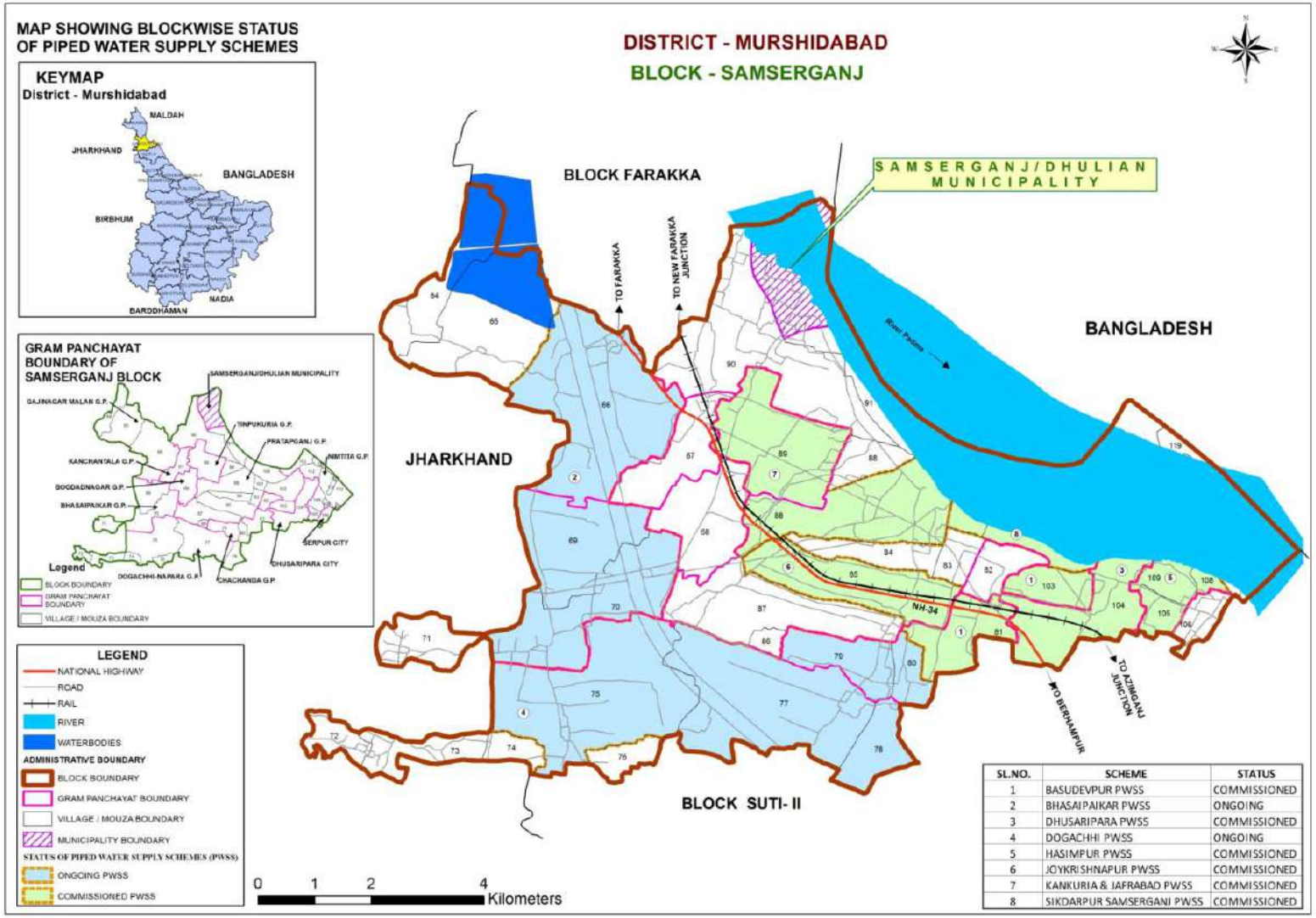


Fig. 10.2.6.1: Pipe Water Supply schemes in Samserganj block

Other options for potable water:

1. Rain water harvesting

2. Installation of arsenic removal plants to make potable water from contaminated first Aquifer.

Ground Water Management Plan for Irrigation purpose

Table 10.2.6.2: Irrigation scenario (Aquifer I) in Samserganj block

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 m bgl	Average Post monsoon WL in m bgl	Remarks for GW Management Plan
1	Samserganj	3061	1121	1940	38.57	F 1	F 3.2	6.85	3.98	Can be developed for ground water based irrigation

Data of 5th M. I. Census shows:

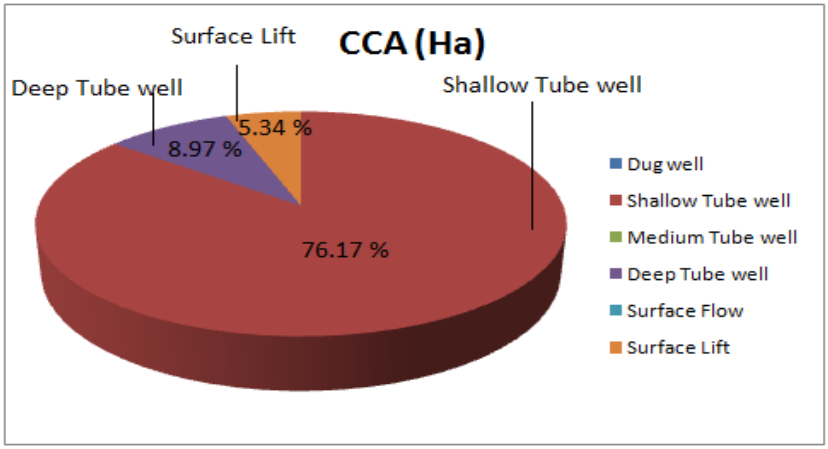


Fig. 10.2.6.2: Percent contribution of CCA by different sources of irrigation

Table 10.2.6.3: CCA & sources of irrigation

Block Total / District Total	Dug well		Shallow Tube well		Medium Tube well		Deep Tube well		Surface Flow		Surface Lift		CCA (ha.)		Total CCA (ha.)
	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	Ground Water	Surface Water	
Block Total	0	0	512	1556.38	0	0	6	163	0	0	31	97	1719.38	97	1816.38
District Total	**178**	**728.67**	**54842**	**127809.47**	**2148**	**11550.1**	**1719**	**33386.23**	**292**	**1592.29**	**1499**	**13037.13**	**173474.51**	**14629.42**	**188103.9**

Table 10.2.6.4: CCA, % of CCA & sources of irrigation

Type of abstraction structures	CCA (Ha)	% of irrigation
Dug well	**0**	0
Shallow Tube well	1556.38	76.17
Medium Tube well	0	0
Deep Tube well	163	8.97
Surface Flow	0	0
Surface Lift	97	5.34

Table 10.2.6.5: Cropping Pattern in Samserganj block during 2016-17

Name of Block	Aus	Aman	Boro	Wheat	Potato	Masur	Maskalai	Jute	Khesari	Til	Mustard	Linseed	Gram
Samserganj	54	3	3	694	9	88	-	2910	979	-	555	-	1

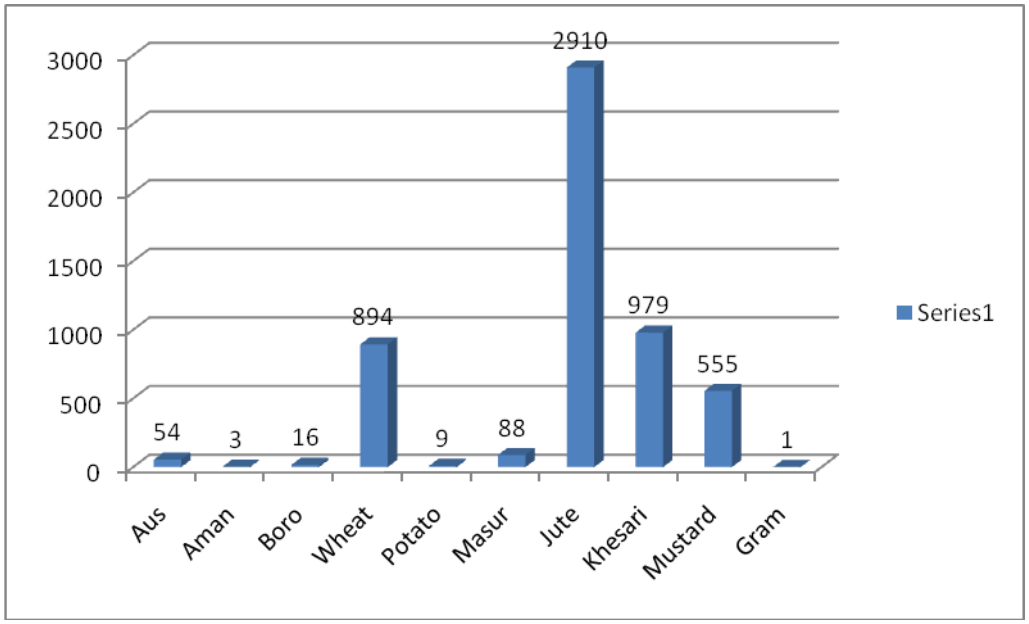


Fig. 10.2.6.3: Graphic presentation of cropping pattern

Proposed interventions for irrigation:

- On principle, Boro cultivation is not encouraged. Boro needs 1.2 to 1.4 m.
- Wheat, Pulses & Oil seeds including Til, Ground nut cultivation in upland area could be encouraged; wheat needs about 0.35 m & Pulses & Oil seeds about 0.15 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.
- To improve the ground water scenario, implementation of modern irrigation practices like drip water irrigation system, sprinklers can be made.
- Cultivation of low water requiring crops and change in cropping pattern may be done for better and efficient water management.
- Some parts of this block is prone to water logging; therefore it is advisable for conjunctive use of both surface and ground water.

  Also, in area of shallow water level, cultivation of cash crops, eg. sugar cane is highly suggested.
- In this block, during Rabi & spring/ summer months, the existing area wise cropping pattern vide **Table 10.2.6.5 & Fig. 10.2.6.3)** is as follows:

  Wheat – 35.39 %, vegetables – 0.36 % (neglisible), Pulses & Oil seeds – 64 %.
- As per the aforesaid cropping pattern, from the remaining area to be irrigated of 1940 Ha, cultivation proposed: wheat – 686.57 Ha; Pulses & Oil seeds – 1241.6 Ha.
- For wheat (@ 0.35 m/ha) & Pulses & Oil seeds (@0.15 m/Ha) estimation shows an amount of 426.54 Ham of water is needed.
- Ground Water Estimation 2017 shows that there is already a deficit of 39.0787 MCM of ground water from the top aquifer.

  So, there is sufficient available ground water resource for irrigation of remaining cultivable area.

Table 10.2.6.6: Water column recommended 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
Murshidabad	Samserganj	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

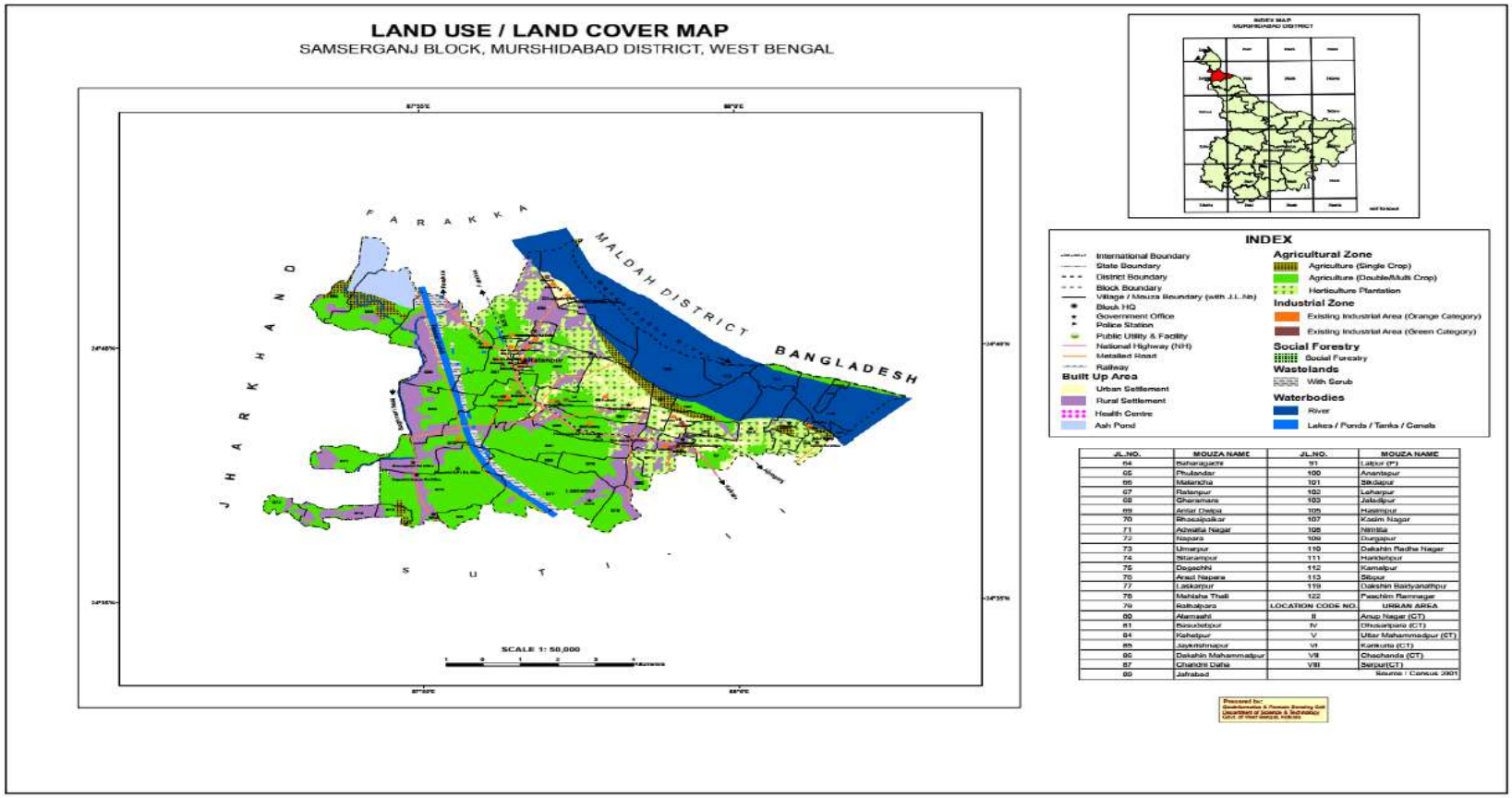


Fig. 10.2.7.1: Land use/ land cover in Samserganj block

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

10.2.7 Scope for rain water harvesting & Artificial recharge:

Using Dhruvanarayana, 1993 method in Samserganj 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 10.2.7.1a & Table 10.2.7.1b. 862.22448 Ham of rain water has been estimated to be harvested. This harvested water can be utilized for construction of suitable structures for artificial recharge and conservation of water; by doing this ground water scenario can be improved as well as the inclusive economic growth can be achieved.

Area suitable for recharge in the study area (vide Plate 6.2.1b) :

District	Block Name	Area (in sq. km)	Approx. total Area suitable for recharge (sq km.)
MURSHIDABAD	Samserganj	94.48	Approx. 66.00

Utilization of Harvested Rain Water: Table 10.2.7.1a shows that 862.22448 Ham of rain water could be harvested in Samserganj block. In Fig. 10.2.7.1 land use & land cover in this block has been shown; from it it is visualized that the land is suitable for even for double / multi-crop cultivation. The amount of 8.62224 MCM of rain water can be utilized in following ways:
For storing of rain water in constructed tanks, a total land of 259 ha with 3 m depth is required (by keeping aside 10 % of 862.224 Ham water as wastage by spillage, etc.). The remaining amount of harvested water i.e. 776.224 Ham can be utilized for irrigation in future, if needed.

Proposed Artificial Recharge Structures in the Study area:

Table 10.2.7.1a: Calculation of harvested rain water in Samserganj 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 (considering e-flow) = Vf Ham
1.04	9448	9825.92	0.39	47.32 % moderately well drained sandy soil & 41.81 % imperfectly drained loamy soil, rest is covered by drainage	3832.1088	2874.0816	1437.0408	862.22448

Table 10.2.7.1b: Proposed Artificial Recharge & conservation Structures in Samserganj block:

Amount of water for artificial recharge and / or conservation (Ham) (4)	Source water allocation for Percolation Tank and REET with Recharge Shaft in Ham (5)	Source water allocation for REET with Recharge Shaft (Ham): 50 % of Col. 5 (6)	Source water allocation for Irrigation Cum Recharge Tank (Ham): 50 % of Col. 5 (7)	Source water allocation for Injection Well (8)	Source water allocation for Farm/Conservation Pond in Ham (9)	Nos. of REET with Recharge Shaft suggested @ 10 Ham per unit (10)	Nos. of Irrigation Cum Recharge Tank suggested @ 50 Ham per unit (11)	Nos. of injection wells @ 30 Ham per unit (12)	Nos. of Farm/conservation ponds @ 10 Ham per unit (13)	Cost of REET with Recharge Shaft @ Rs 8 lakh per unit (14)	Cost of Irrigation cum Recharge tank @ Rs 8 lakh per unit (15)	Cost of Injection wells @ Rs 8 lakh per unit (16)	Cost of Farm pondnjection wells @ Rs 8 lakh per unit (17)	Total Cost
862.22448	70 % of Col. 4 i.e. 603.56 Ham	301.78	301.78	20 % of Col. 4 i.e. 172.44 Ham	10 % of Col. 4 i.e. 86.22 Ham	30	6	6	9	240	48	48	72	408

10.3 Suti I

10.3.1 Salient Information:

Area (in Km^2): 143.68

District: Murshidabad

State: West Bengal

Population (as on 2011):

Rural	Urban	Total
150803	29105	179908

Approximate Decadal Growth Rate: 25.03 per cent during the 1991-2001 & 29.02% in 2001-2011.

Rainfall:

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

District	Normal – 2014 (in mm)	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):

Sl. No	Name of the Block	Geographic Area	Cultivable Area	Area under pasture & orchard	Cultivable Waste Land	Forest Land
1.	Suti I	143.68	79.23	-	-	-

(Source: Dept. of Agriculture, Govt. of West Bengal)

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

Resource Availability	Aquifer I	Aquifer II	Current Annual G W Extraction (MCM) (Aquifer I)
Dynamic Resource (in MCM)	53.9762	0.307245	45.7607
Static Resource (in MCM)	333.45	5.45929	

10.3.2 Disposition of Aquifer:

Depth range of aquifers:

Block	**Depth range of Aquifer in m bgl**		
Suti I	**Aquifer I**	**Aquifer II**	**Aquifer III**
	Up to 15 to 20 m	25 – 76.2	109 - 118

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

Sl. No.	**Block**	Aquifer	**Pre-monsoon Trend**			**Post-monsoon Trend**		
			Water Level Range (m bgl)	**Rise (m/yr)**	**Fall (m/yr)**	Water Level Range (m bgl)	**Rise (m/yr)**	**Fall (m/yr)**
1.	Suti I	I	7.34 – 7.98	-	0.221	5.84 – 6.18	-	0.129
2.	Suti I	II	10.18 –19..34	-	0.049	9.07 – 18.67	-	0.21

Average Thickness of Aquifer:

	Area (sq km)	**Thickness of the Granular Zone in 1st aquifer (m)**	**Thickness of the Granular Zone in 2nd aquifer (m)**	**Thickness of the Granular Zone in 3rd aquifer (m)**
Suti I	143.68	15	37.26	4

Aquifer-wise Statement

Name of Block	1st Aquifer			2nd Aquifer		
	Depth Range (m bgl)	Discharge (m^3/hr)	T (m^2/day)	Depth Range (m bgl)	Discharge (m^3/hr)	T (m^2/day)
Suti I	Up to 15 to 20	26.02 - 49.32	-	25 – 76.02	20.16 – 177	80.57 - 4877

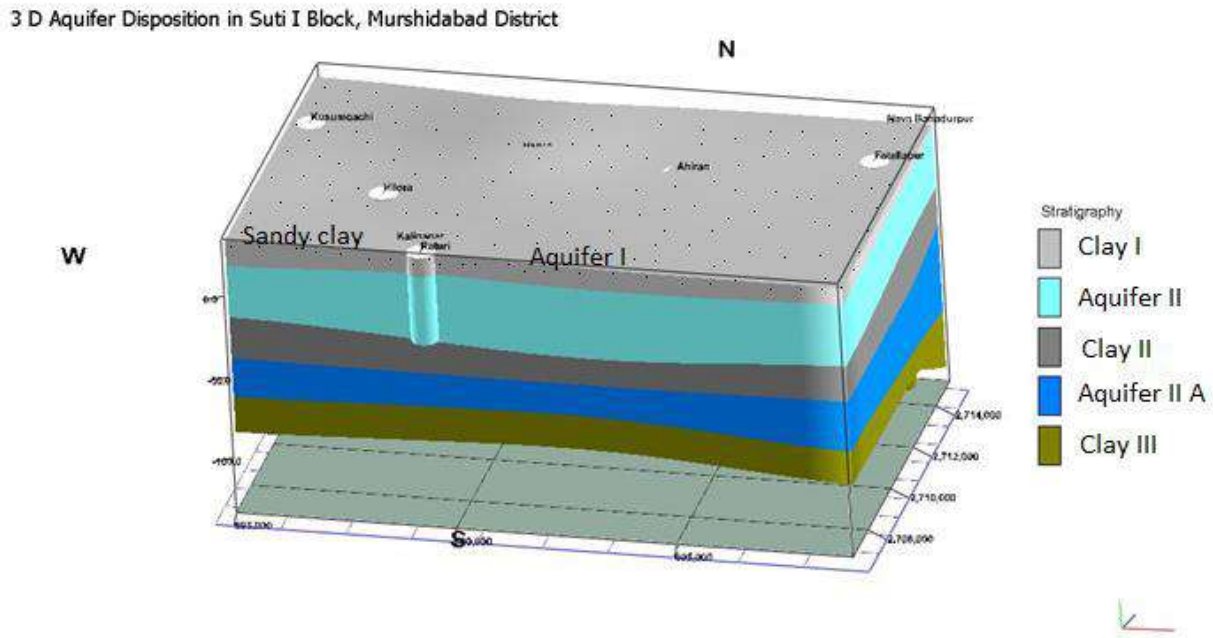


Fig. 10.3.2.1: 3 D Aquifer disposition in Suti I block

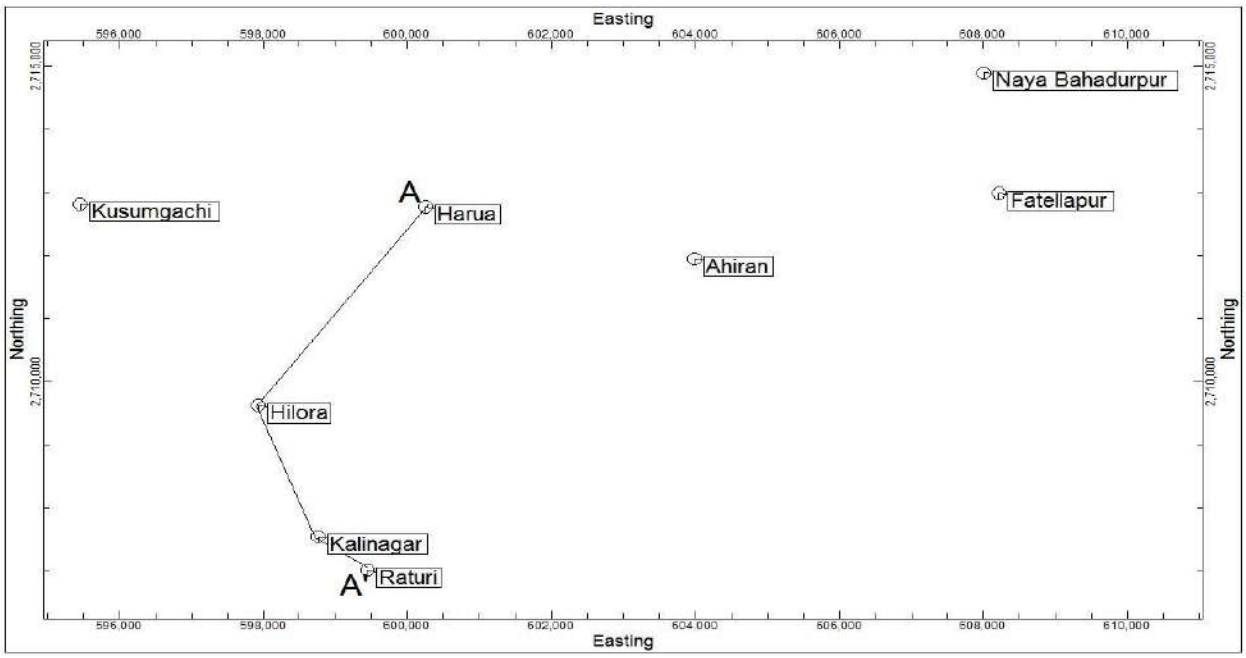


Fig. 10.3.2.2: N – S Section Index line in Suti I block

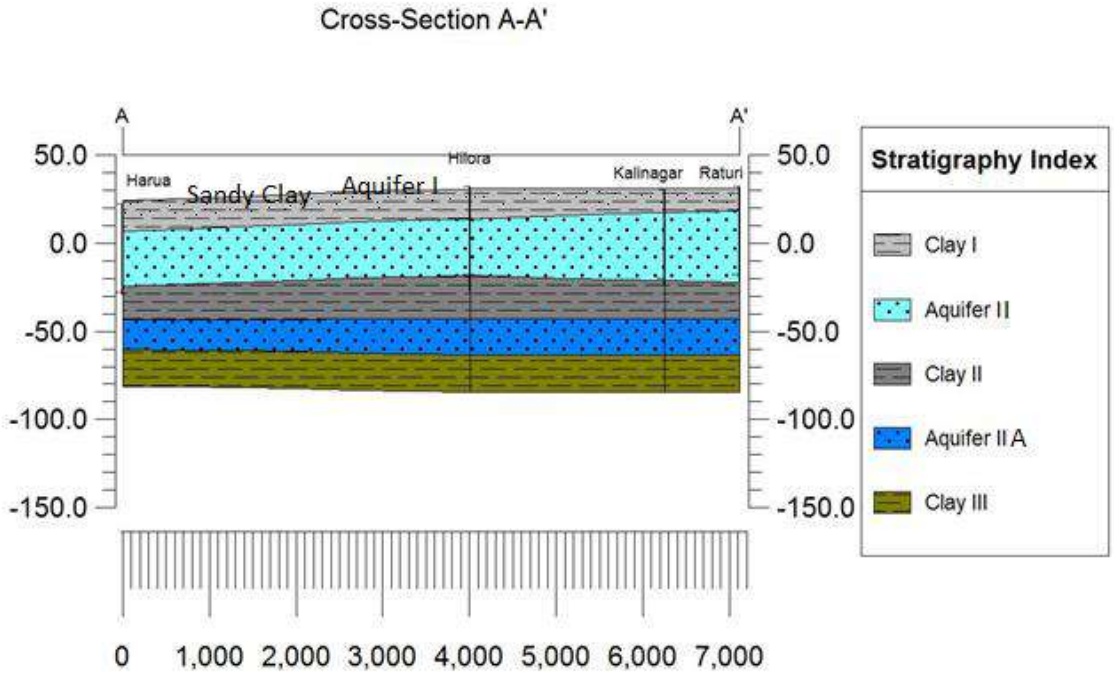


Fig. 10.3.2.2A: N – S Section in Suti I block

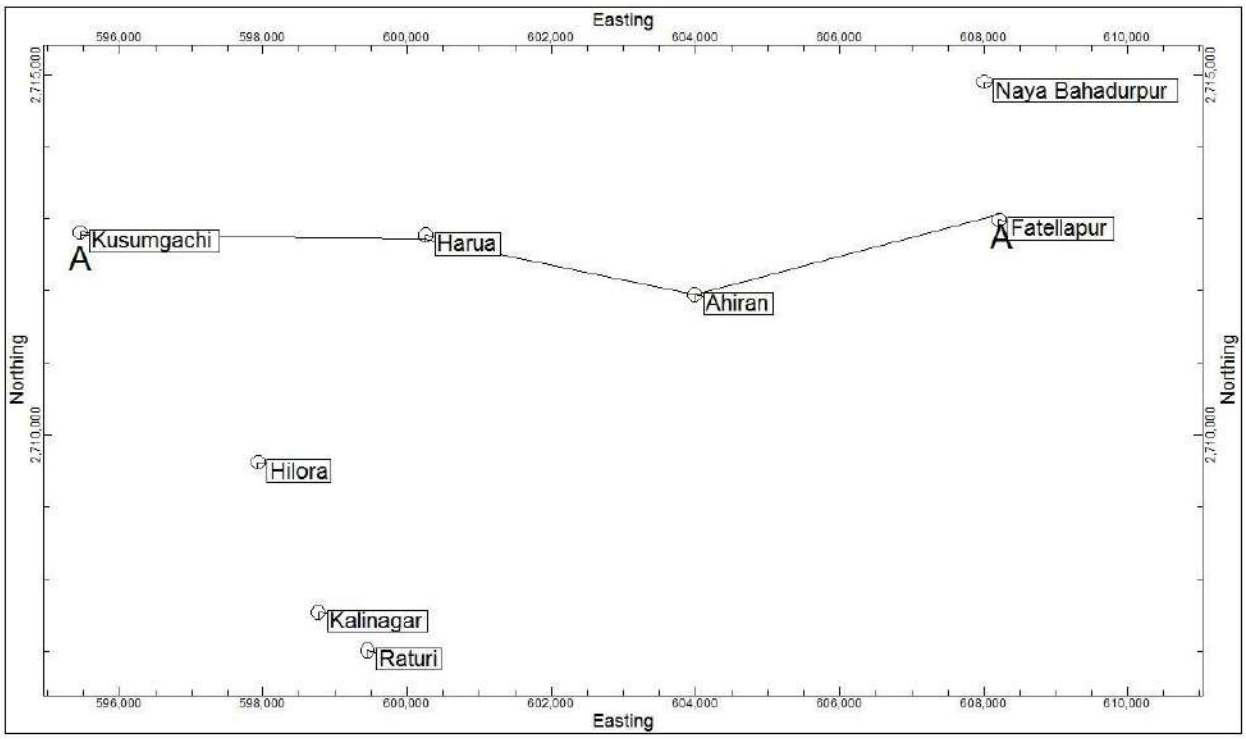


Fig. 10.3.2.3: W – E Section Index line in Suti I block

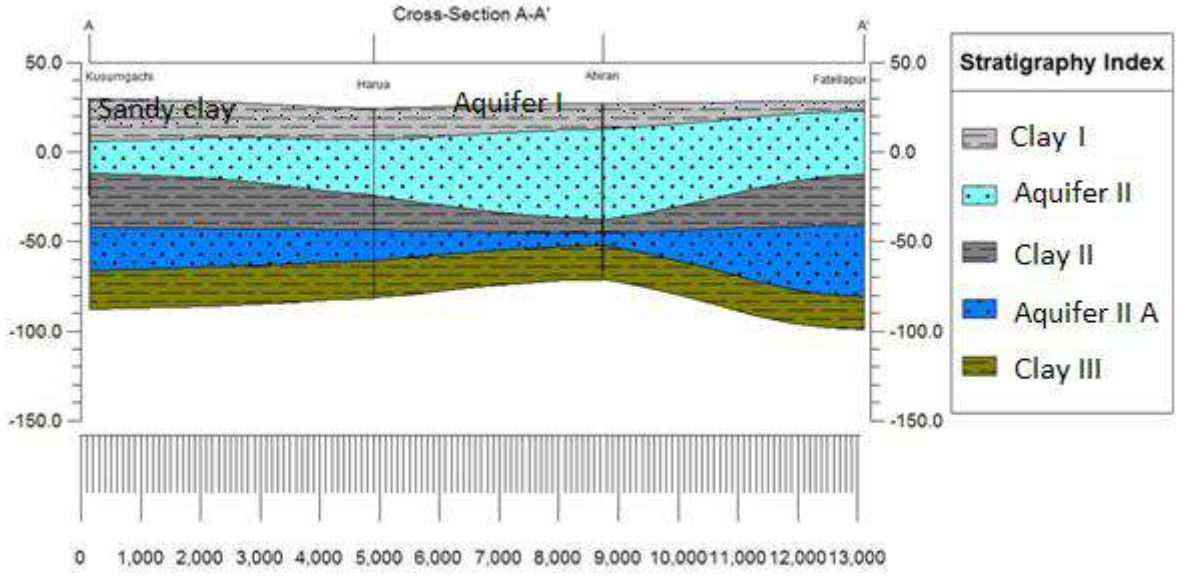


Fig. 10.3.2.3A: W – E Section in Suti I block

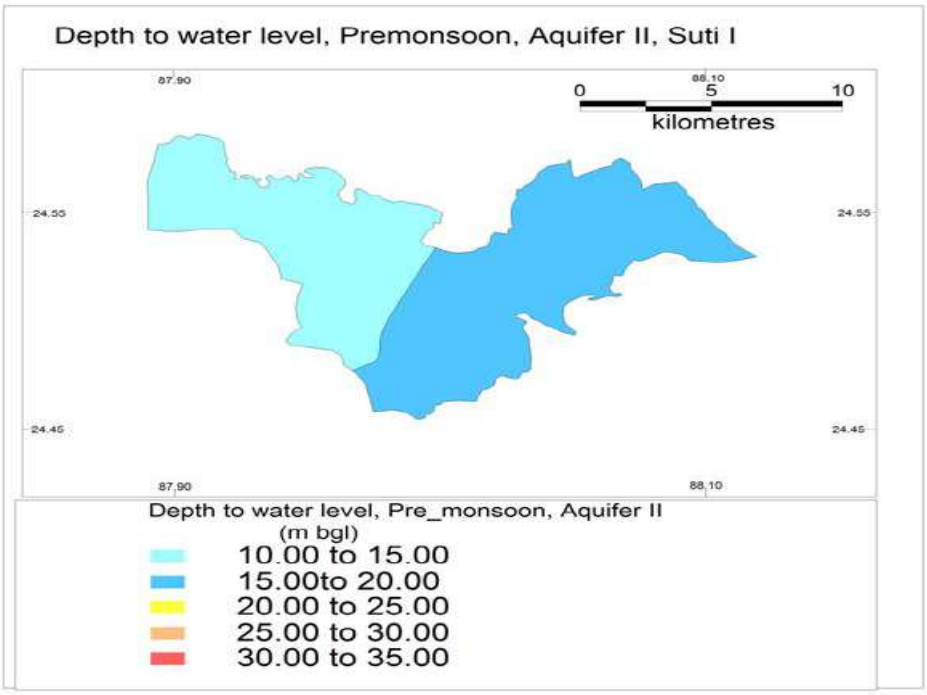


Fig. 10.3.2.4: Depth to water level, pre monsoon, Aquifer II

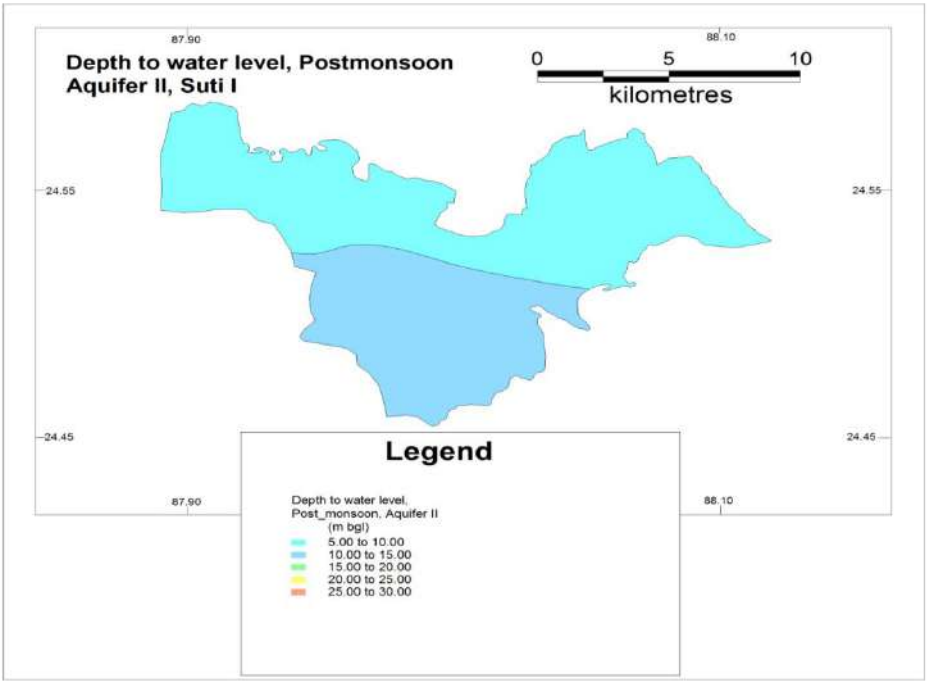


Fig. 10.3.2.5: Depth to water level, post monsoon, Aquifer II

10.1.3: Ground Water Resource & status of Extraction:

Aquifer Wise Resource Availability & Extraction:

Dynamic ground water resources as on 31st March'17

Block	Annual extractable Ground Water	Current Annual Ground Water	Stage of development (%)	Category	Annual GW Allocation for Domestic Use as on 2042	**Ground water availability for future use (MCM)**
Suti I	53.9762	45.7607	84.78	Semi-critical	2.4321	7.8545

Static (in-storage) Resources (Aquifer I): 333.45 **MCM.**

Dynamic Ground Water Resources (Aquifer II): 0.307245 **MCM**

Static (in-storage) Resources (Aquifer II): 5.45929 **MCM.**

10.3.4: Chemical Quality of Ground Water & Contamination:

Range of important Chemical Parameters:

As data based on 3 samples of spl. Drive' 15-16 & other parameters based on limited samples of 16-17.

As of 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)**
Suti I	**<0.001 – 0.052**	**125-405**	**349-1060**	**0.43-0.74**	**0-209**

Percentage of tube wells having arsenic content (based on data of PHED, Govt. of West Bengal):

Block	Arsenic (<0.01 ing/1)		Arsenic (>0.01-<0.05 mg/1) %		Arsenic (> 0.05 mg/1) %		Total Tube well (max. concentration of As(mg/l)
	%	Count	%	Count	%	Count	
Suti I	60.28	560	24.97	232	14.75	137	929 (0.70)

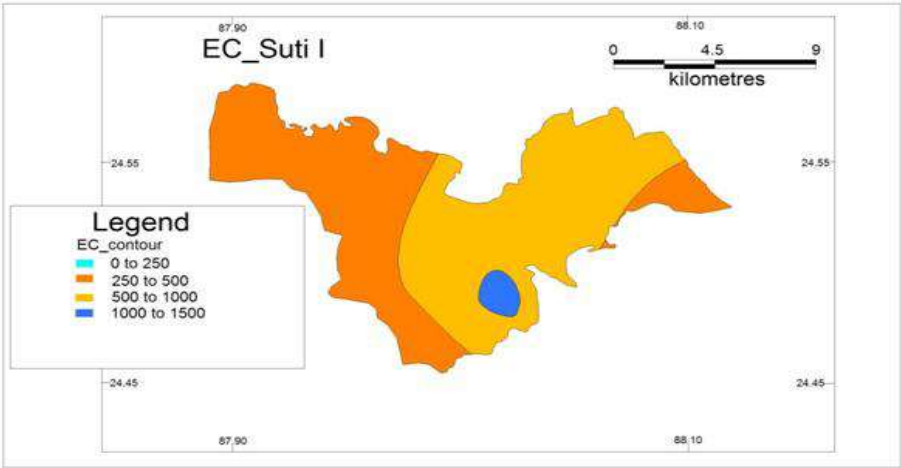


Fig. 10.3.4.1: Electrical conductivity (EC) in ground water

10.3.5: Major Issues:

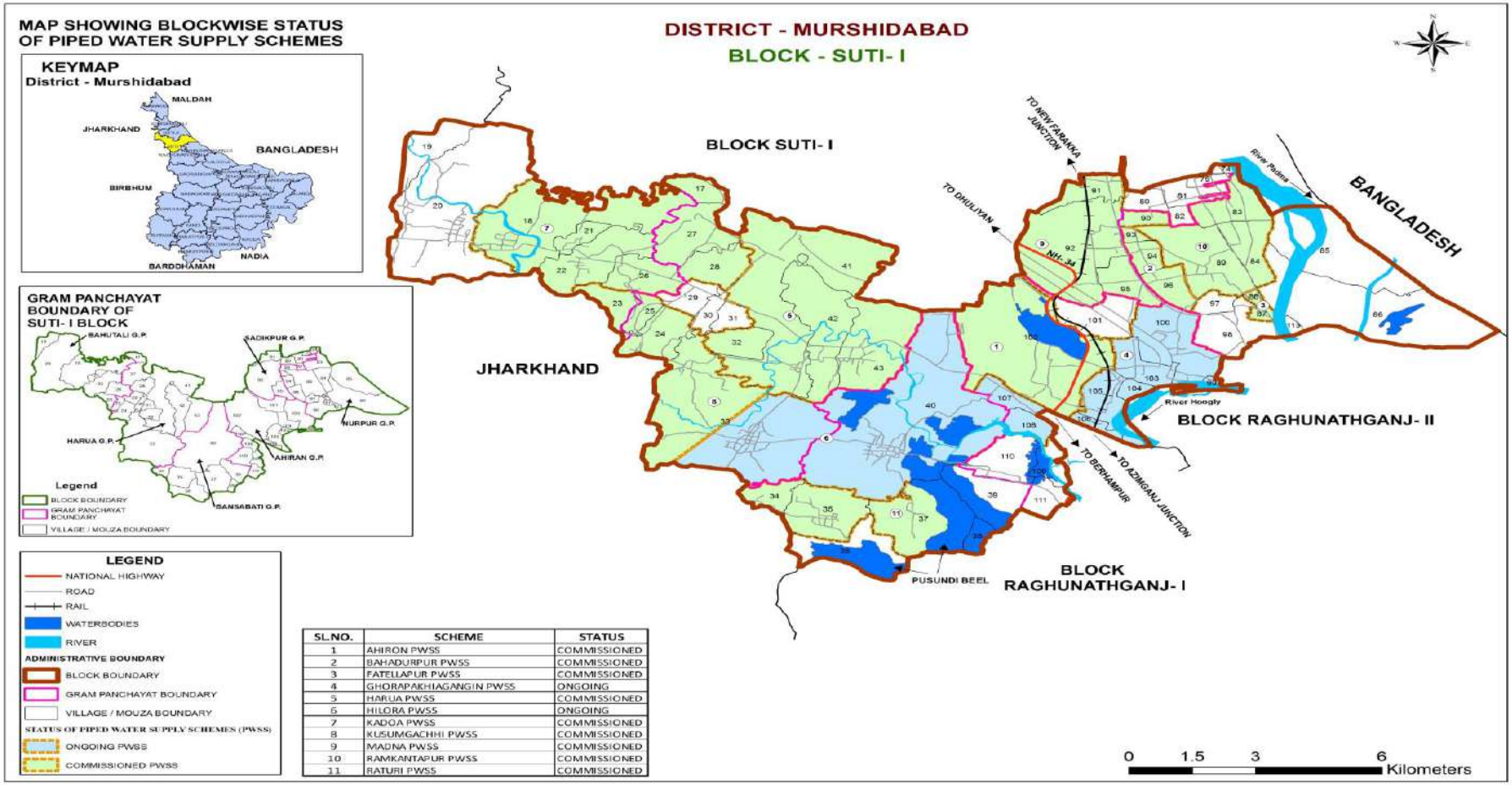
1. Very deep water level in deeper aquifer and its long term trend shows alarming fall.
2. Sporadic ground water contamination by arsenic has been reported in Younger Alluvium of Aquifer I
3. High SOD & Semi Critical category of block
4. Irrigation in large area is done by ground water
5. Low lying parts are prone to Water logging.

10.3.6: Ground Water Resource Enhancement& Management Plan:

Ground Water Management Plan for drinking purposes.

Table 10.3.6.1: As infested habitations & Status of present water supply:

Nos. of habitations in risk zone	Whereas As infested	As infested population in 2011	Projected As infested population in 2021	Population already covered	Water (lit.) required for uncovered population @ 70 lpcd
30	Infested	**278922**	**217814**	**248452**	**Already covered**



SL.NO.	SCHEME	STATUS
1	AHIRON PWSS	COMMISSIONED
2	BAHADURPUR PWSS	COMMISSIONED
3	FATELLAPUR PWSS	COMMISSIONED
4	GHORAPAKHIAGANGIN PWSS	ONGOING
5	HARUA PWSS	COMMISSIONED
6	HILORA PWSS	ONGOING
7	KADOA PWSS	COMMISSIONED
8	KUSUMGACHHI PWSS	COMMISSIONED
9	MADNA PWSS	COMMISSIONED
10	RAMKANTAPUR PWSS	COMMISSIONED
11	RATURI PWSS	COMMISSIONED

Fig. 10.3.6.1: Pipe water supply schemes

(Source: PHED, Govt. of West Bengal)

Proposed interventions for supply of potable water:

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.	Suggestions for providing water supply to the risk population
1	Suti I	NA	Not estimated/declared by the authority	Deeper aquifers within 54.86 – 76.2 m bgl are found to be potential and generally free from arsenic and potable. Hence, these aquifers could be tapped by cement sealing techniques for providing pipe water supply of potable water. • Surface water is an alternative source.

Other options for potable water:

1. Rain water harvesting

2. Installation of arsenic removal plants to make potable water from contaminated first Aquifer.

Ground Water Management Plan for Irrigation purpose

Table 10.3.6.2: Irrigation scenario in Suti I (Aquifer I) block

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	Suti I	7923	4521	3402	84.78	**F 22.1**	F 12.9	7.66	6.01	Can be developed for GW based Irrigation

Data of 5th M. I. Census shows:

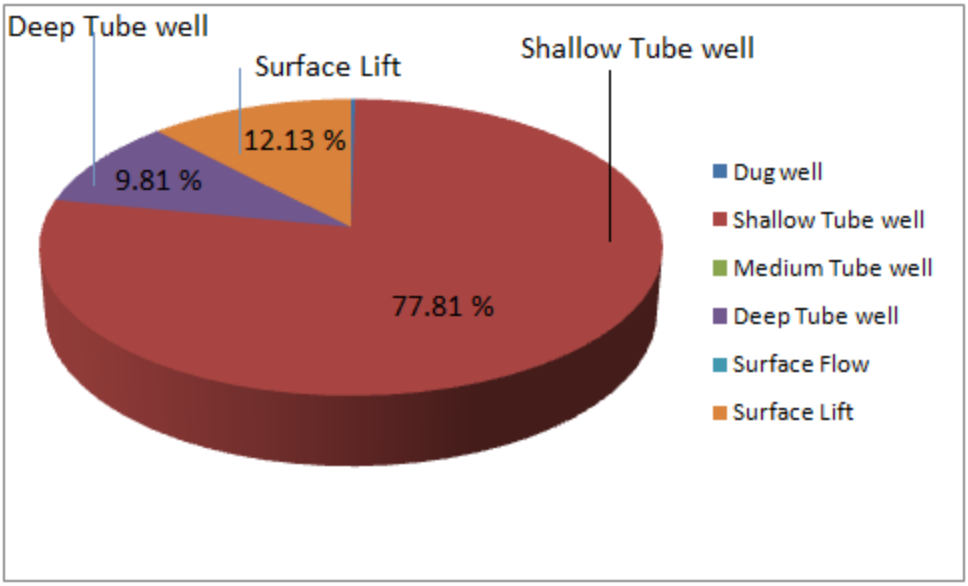


Fig. 10.3.6.2: Percent of CCA by different sources of irrigation

Table 10.3.6.3: CCA, % of CCA & different sources of irrigation

Type of abstraction structures	CCA (Ha)	% of CCA
Dug well	**4.5**	0.25
Shallow Tube well	1411.43	77.81
Medium Tube well	0	0
Deep Tube well	178	9.81
Surface Flow	0	0
Surface Lift	220.1	12.13

Table 10.3.6.4: CCA & sources of irrigation

Block Total / District Total	Dug well		Shallow Tube well		Medium Tube well		Deep Tube well		Surface Flow		Surface Lift		CCA (ha.)		Tota
	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	Ground Water	Surface Water	CCA (h
Block Total	2	4.5	624	1411.43	0	0	55	178	0	0	19	220.1	1593.93	220.1	1814
District Total	**178**	**728.67**	**54842**	**127809.47**	**2148**	**11550.1**	**1719**	**33386.23**	**292**	**1592.29**	**1499**	**13037.13**	**173474.51**	**14629.42**	**18810**

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

Table 10.3.6.5: Cropping Pattern in Suti I block during 2016-17

Name of Block	Aus	Aman	Boro	Wheat	Potato	Masur	Maskalai	Jute	Khesari	Til	Mustard	Linseed	Gram
Suti I	1262	5985	1305	1182	68	1439	-	2649	1238	-	1935	-	245

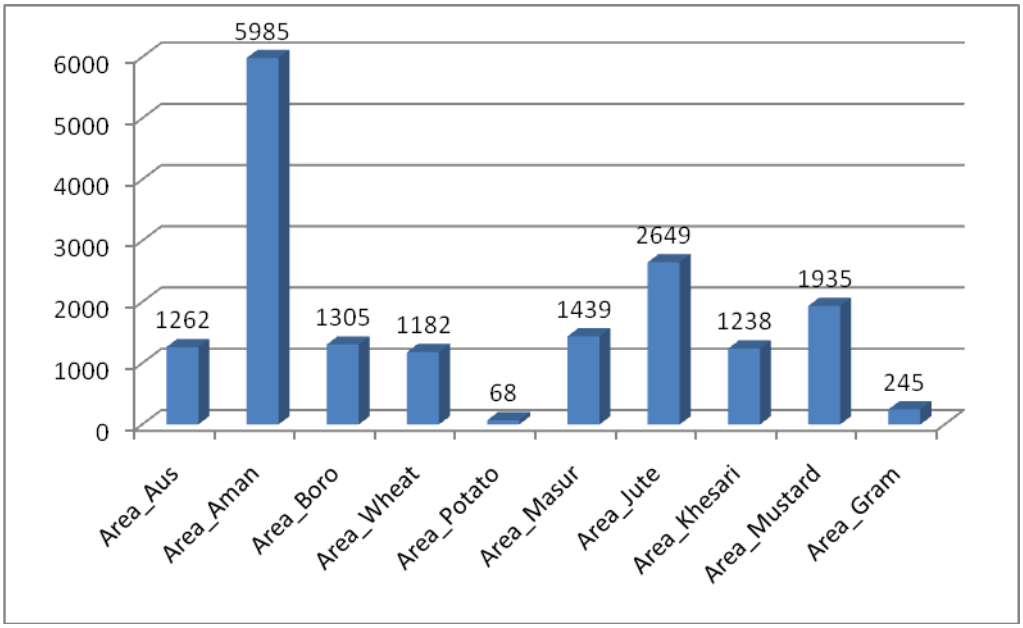


Fig. 10.3.6.3: Graphical presentation of cropping pattern in Suti I block

Proposed interventions for irrigation:

- On principle, Boro cultivation is not encouraged. Boro needs 1.2 to 1.4 m.
- Wheat, Pulses & Oil seeds including Til, Ground nut cultivation in upland area could be encouraged; wheat needs about 0.35 m & Pulses & Oil seeds about 0.15 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.
- To improve the ground water scenario, implementation of modern irrigation practices like drip water irrigation system, sprinklers can be made.
- Cultivation of low water requiring crops and change in cropping pattern may be done for better and efficient management practices.
- Some parts of this block might be prone to water logging; therefore it is advisable for conjunctive use of both surface and ground water.

Also, in area of shallow water level, cultivation of cash crops, eg. sugar cane is highly suggested.

- In this block, during Rabi & spring/ summer months, the existing area wise cropping pattern vide **Table 10.3.6.5 & Fig. 10.3.6.3)** is as follows (out of wheat, vegetables, Pulses & Oil seeds):

  Wheat – 25.60 %, vegetables – 0.014 % (neglisible), Pulses & Oil seeds – 73.22 %.
- As per the aforesaid cropping pattern, from the remaining area to be irrigated of 3402 Ha, cultivation proposed: wheat – 870.912 Ha; Pulses & Oil seeds - 2491 Ha.
- For wheat (@ 0.35 m/ha) & Pulses & Oil seeds (@0.15 m/Ha) estimation shows an amount of 678.47 Ham of water is needed.
- Ground Water Estimation 2017 shows that an amount of 785.45 Ham of ground water from the top aquifer has been earmarked for future use. Therefore, the whole area can be irrigated by the available resource.

Table 10.3.6.6: Water column recommended 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
Murshidabad	Suti 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

10.3.7 Scope for rain water harvesting & Artificial recharge:

Using Dhruvanarayana, 1993 method in Suti 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 10.3.7.1a & Table 10.3.7.1b. 1781.91376 Ham 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; by doing this ground water scenario can be improved as well as the inclusive economic growth can be achieved.

Area suitable for recharge in the study area (vide Part I: Plate 6.2.1b):

District	Block Name	Area (in sq. km)	Total Area suitable for recharge (sq km.)
MURSHIDABAD	Suti I	143.68	86.00

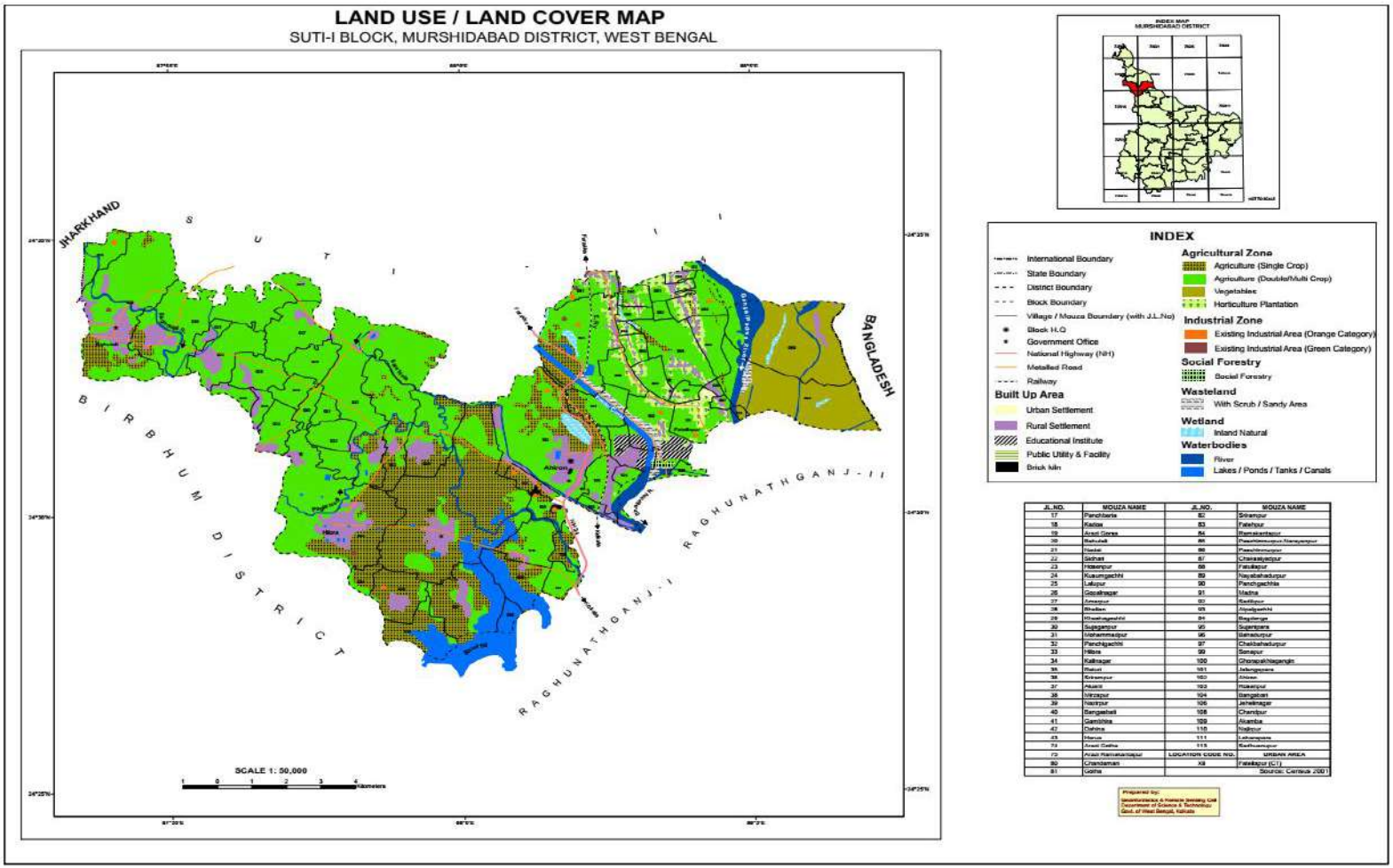


Fig. 10.3.7.1: Land use/ land cover in Suti I block

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

Utilization of Harvested Rain Water: Table 10.3.7.1a shows that 1781.91376 Ham of rain water could be harvested in Suti I block. In Fig. 10.3.7.1, land use & land cover in this block has been shown; from it it is visualized that the land is suitable for even for double / multi-crop cultivation. The amount of 17.81914 MCM of rain water can be utilized in following ways:

For storing of rain water in constructed tanks, a total land of 534 ha with 3 m depth is required (by keeping aside 10 % of 17.81914 MCM water as wastage by spillage, etc.). The remaining amount of harvested water i.e. 1603.91376 Ham can be utilized to irrigate cultivable land if needed.

Efforts 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 10.3.7.2, 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.

Proposed Artificial Recharge Structures in the Study area:

Table 10.3.7.1a: Estimation of harvested rain water in Suti 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 (considering e-flow) = Vf Ham
1.04	14368	14942.72	0.53	28.71 % moderately well drained sandy soil & 73.73 % imperfectly drained loamy soil	7919.6416	5939.7312	2969.8656	1781.91936

Table 10.3.7.1b: Proposed Artificial Recharge & conservation Structures in Suti I block:

Amount of water for artificial recharge and / or conservation (Ham) (4)	Source water allocation for Percolation Tank and REET with Recharge Shaft in Ham (5)	Source water allocation for REET with Recharge Shaft (Ham): 50 % of Col. 5 (6)	Source water allocation for Irrigation Cum Recharge Tank (Ham): 50 % of Col. 5 (7)	Source water allocation for Injection Well (8)	Source water allocation for Farm/Conservation Pond in Ham (9)	Nos. of REET with Recharge Shaft suggested @ 10 Ham per unit (10)	Nos. of Irrigation Cum Recharge Tank suggested @ 50 Ham per unit (11)	Nos. of injection wells @ 30 Ham per unit (12)	Nos. of Farm/conservation ponds @ 10 Ham per unit (13)	Cost of REET with Recharge Shaft @ Rs 8 lakh per unit (14)	Cost of Irrigation cum Recharge tank @ Rs 8 lakh per unit (15)	Cost of Injection wells @ Rs 8 lakh per unit (16)	Cost of Farm pondnjection wells @ Rs 8 lakh per unit (17)	Total Cost
1781.91936	70 % of Col. 4 i.e. 1247.34 Ham	623.67	623.67	20 % of Col. 4 i.e. 356.38 Ham	10 % of Col. 4 i.e. 178.19 Ham	62	12	12	18	496	96	96	144	832

Table **10.3.7.2: Proposed change in cropping pattern in Suti I 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 (Kg of Boro paddy) due to reduction in area of Boro cultivation yield rate 3613.69 kg/ Ha (in M. Ton)**	**Proposed cropping in 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 & Ground nut @ 2309.39 kg/Ha**	**Increase in area of wheat cultivation in winter (at least 10% more of existing area of 1182 Ha for wheat, i.e. 118.2 Ha) yield rate 2864.41 kg/ Ha (M. Ton)**
(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)	(IX)
1305	1.3 m	16.965	130.5	1.697	471.587	Til & Ground nut in 65.25 Ha each	Til- 59.460, Ground nut- 150.688	338.573

Ground water draft for til & ground nut, = 130.5*0.15 = 0.19575 MCM; Ground water draft for wheat = 118.2*0.35 =0.4137 MCM; **ground water saved = 1.08755 MCM; Boro paddy loss = 471.587 M. Ton; Gain of Til, Ground nut & wheat = 548.721**

Finally, Water saved: 1.08755 MCM

10.4 Suti II

10.4.1 Salient Information:

Area (in Km^2): 111.13

District: Murshidabad

State: West Bengal

Population (as on 2011):

Rural	Urban	Total
110767	168155	278922

Approximate Decadal Growth: 35.05 per cent during the 1991-2001 & 23.70 % in 2001-2011.

Rainfall:

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

District	Normal – 2014 (in mm)	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.	Suti II	111.13	73.52	-	-	-

(Source: Dept. of Agriculture, Govt. of West Bengal)

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

Resource Availability	Aquifer I	Aquifer II	Current Annual G W Extraction (MCM) in (Aquifer I)
Dynamic Resource (in MCM)	54.9485	0.399368	48.0065
Static Resource (in MCM)	314.28	4.03659	

10.4.2 Disposition of Aquifer:

Depth range of aquifers

Block	Depth range of Aquifer in m bgl	
	Aquifer I	**Aquifer II**
Suti II	5.50 - 20	25 - 76.2

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

Sl. No.	**Block**	Aquifer	**Pre-monsoon Trend**			**Post-monsoon Trend**		
			Water Level Range (m bgl)	**Rise (cm/yr)**	**Fall (cm/yr)**	Water Level Range (m bgl)	**Rise (cm/yr)**	**Fall (cm/yr)**
1.	Suti II	I	4.59 – 7.65	-	0.221	3.29 – 7.3	-	0.129
2.	Suti II	II	14.97	-	0.049	5.53	-	0.21

Average thickness of aquifer

Block	Area (sq km)	Thickness of the Granular Zone in Aquifer I (m)	Thickness of the Granular Zone in Aquifer II (m)
Suti II	111.13	15	38.90

Aquifer-wise Statement

Name of Block	1st Aquifer			2nd Aquifer		
	Depth Range (m bgl)	Discharge (m^3/hr)	T (m^2/day)	Depth Range (m bgl)	Discharge (m^3/hr)	T (m^2/day)
Suti II	5.50 - 20	26.02 -49.32	-	25 - 76.2	20.16 – 177	80.57 - 4877

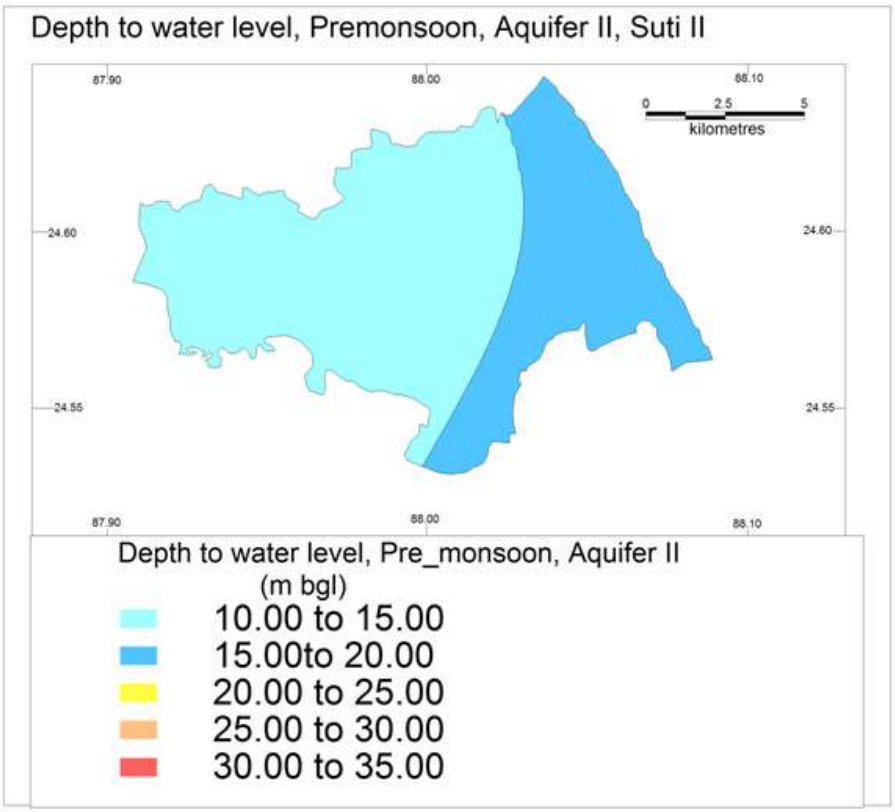


Fig. 10.4.2.1: Depth to water level, re monsoon, Aquifer II

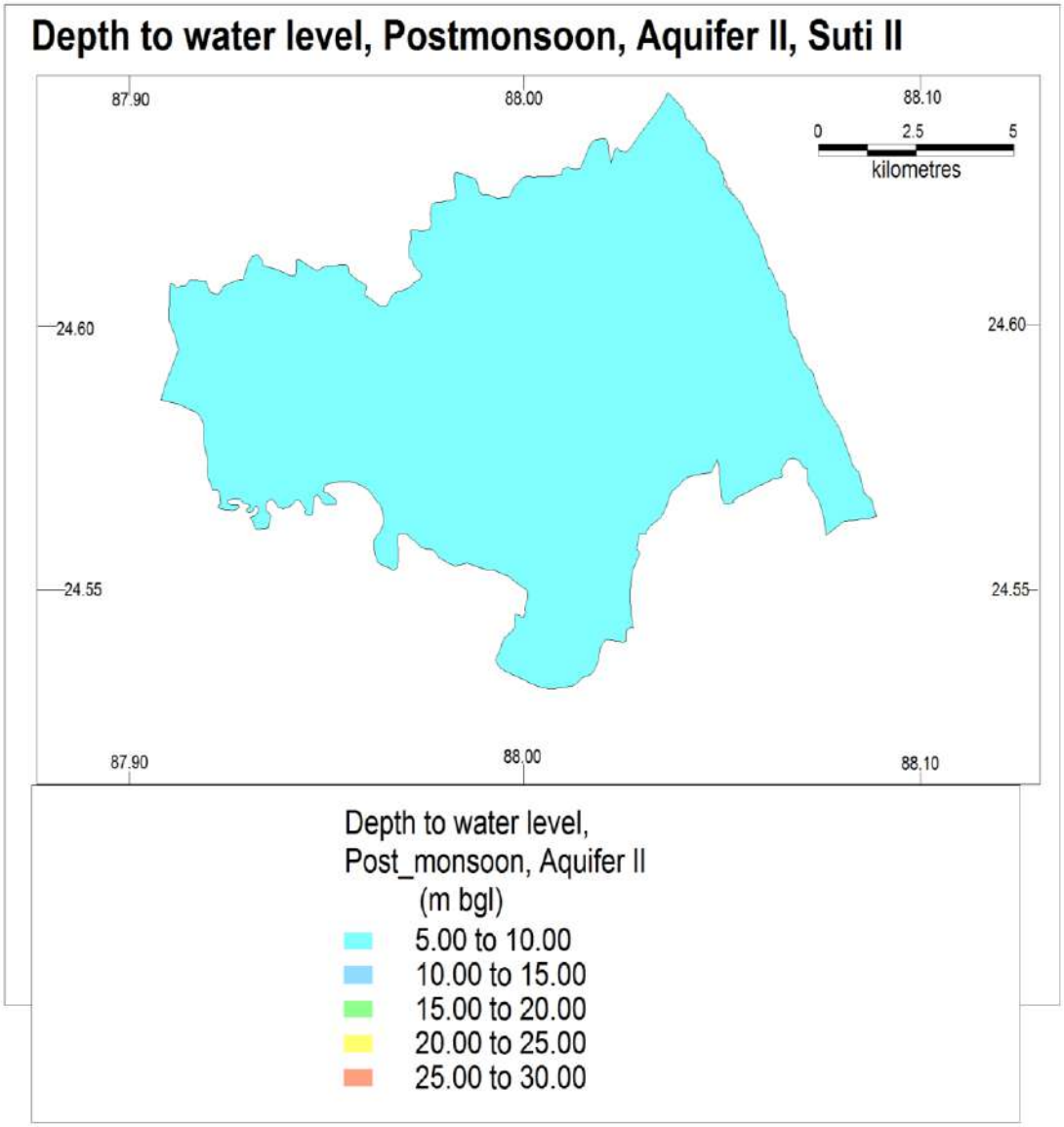


Fig. 10.4.2.2: Depth to water level, post monsoon, Aquifer II

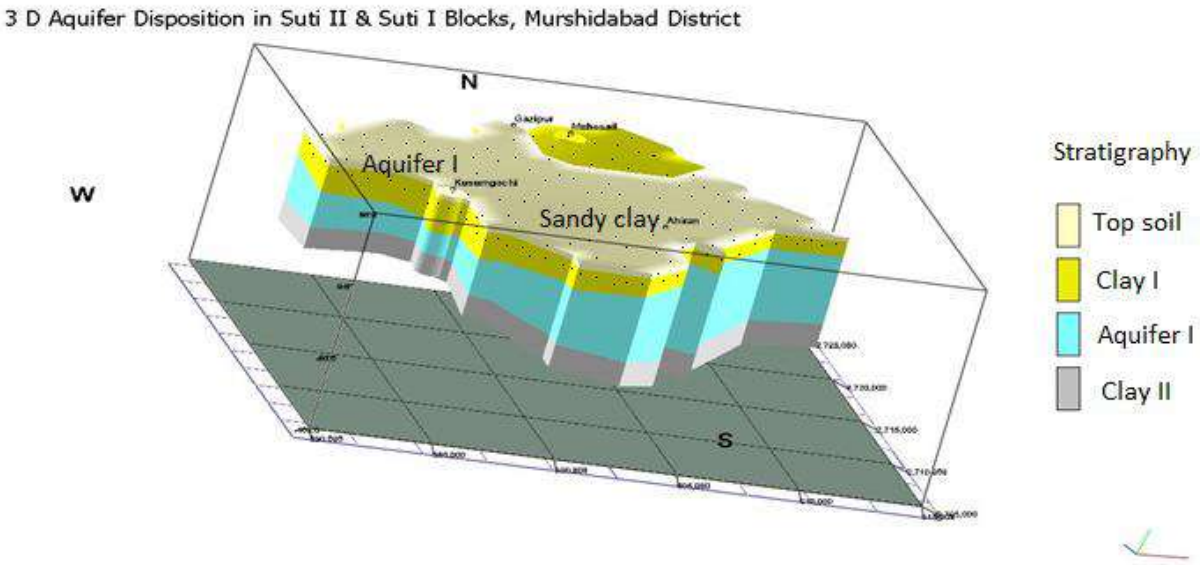


Fig. 10.4.2.4: 3D aquifer disposition in Suti II

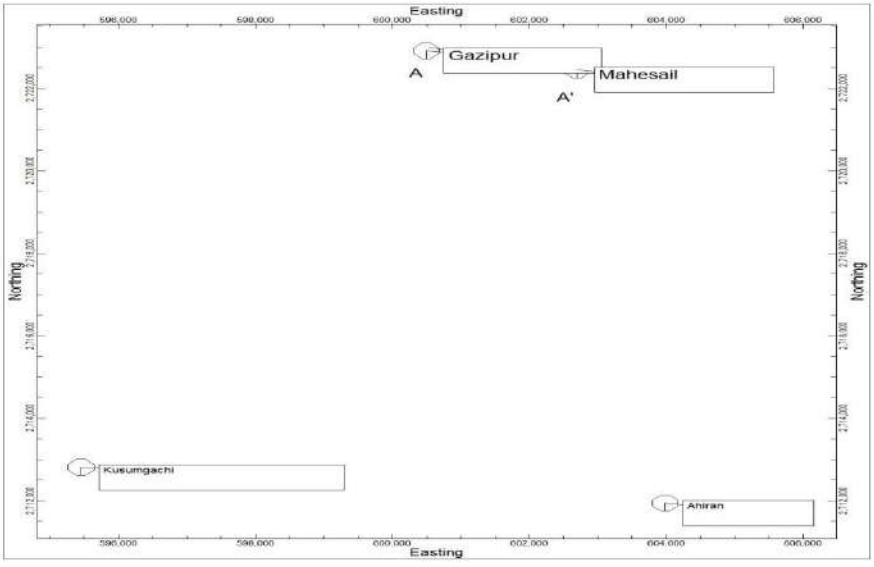


Fig. 10.4.2.5: W – E Section Index line in Suti II

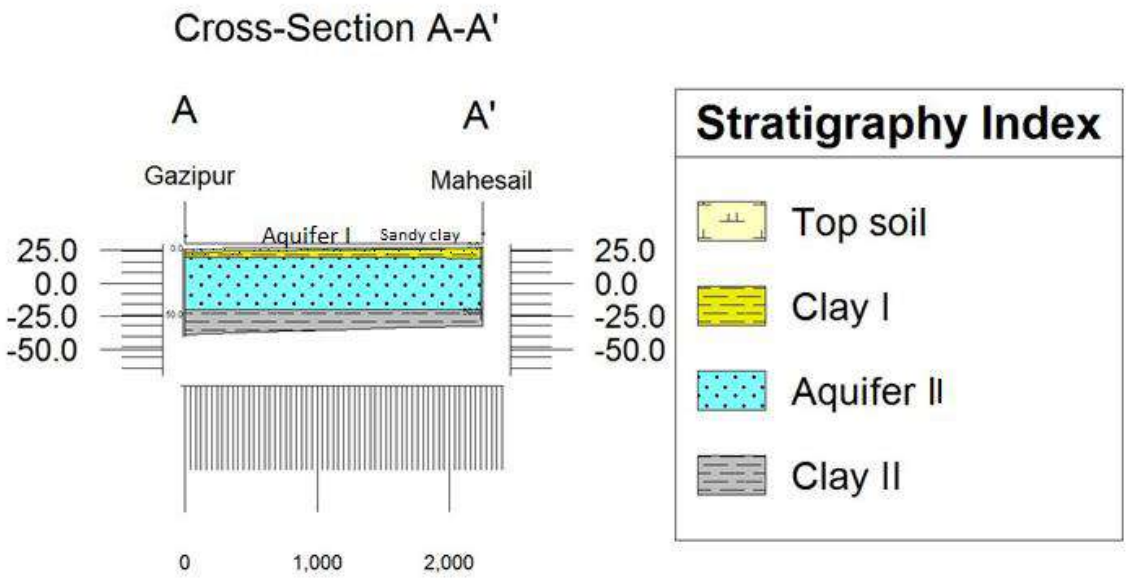


Fig. 10.4.2.5A: W – E Section in Suti II

10.4.3: Ground Water Resource & status of Extraction:

Aquifer Wise Resource Availability & Extraction:

Dynamic ground water resources as on 31st March'17

Block	Annual extractable Ground Water Recharge (MCM)	Current Annual Ground Water Extraction (MCM)	Stage of development (%)	Category	Annual GW Allocation for for Domestic Use as on 2042	**Ground water availability for future use (MCM)**
Suti II	54.9485	48.0065	87.37	Semi Critical	3.6464	6.5066

Static (in-storage) Resources (Aquifer I): 314.28 **MCM.**

Dynamic Ground Water Resources (Aquifer II): 0.399368 **MCM**

Static (in-storage) Resources (Aquifer II): 4.03659 **MCM.**

10.4.4 Chemical Quality of Ground Water & Contamination:

Range of important Chemical Parameters:

As -data based on 3 samples of spl. Drive' 15-16 & other parameters based on limited samples of 16-17. As of 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)**
Suti II	**<0.001 -**	**200-255**	**509-687**	**0.18-0.23**	**0-2**

Percentage of tube wells having arsenic content (based on data of PHED, Govt. of W. Bengal):

Block	Arsenic (<0.01 ing/1)		Arsenic (>0.01-<0.05 mg/1) %		Arsenic (> 0.05 mg/1) %		Total Tube well (max. concentration of As(mg/l)
	%	Count	%	Count	%	Count	
Suti II	19.68	454	50.50	1165	29.78	687	2307 (0.66)

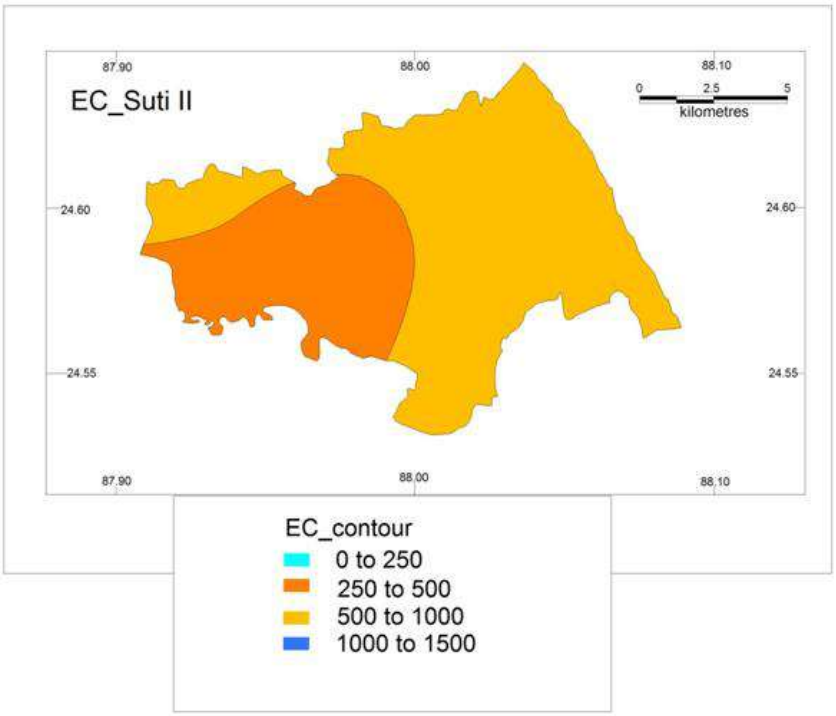


Fig. 10.4.4.1: Electrical Conductivity (EC) in ground water

10.4.5: Major Issues:

1. Very deep water level in deeper aquifer and its long term trend shows alarming fall.
2. Sporadic ground water contamination by arsenic has been reported in Younger Alluvium of Aquifer I.
3. High SOD & Semi Critical category of block
4. Irrigation in large area is done by ground water.
5. Low lying areas are prone to water logging

10.4.6: Ground Water Resource Enhancement& Management Plan:

Ground Water Management Plan for drinking purposes.

Table 10.4.6.1: As infested habitation & Status of present water supply:

Nos. of habitations in risk zone	Wherea as As infested	As infested population in 2011	Projected As infested population in 2021	Population already covered	Water (lit.) required for uncovered population @ 70 lpcd	Nos. of TWs required considering each TW's discharge of 12.5 lps& 8 hrs. run per day	Cost of construction of required TWs @ 18 lakh per TW as per approved rate
37	Infested	**127513**	**337690**	**215755**	**70 X 121935 = 8535450**	**24****	**432**

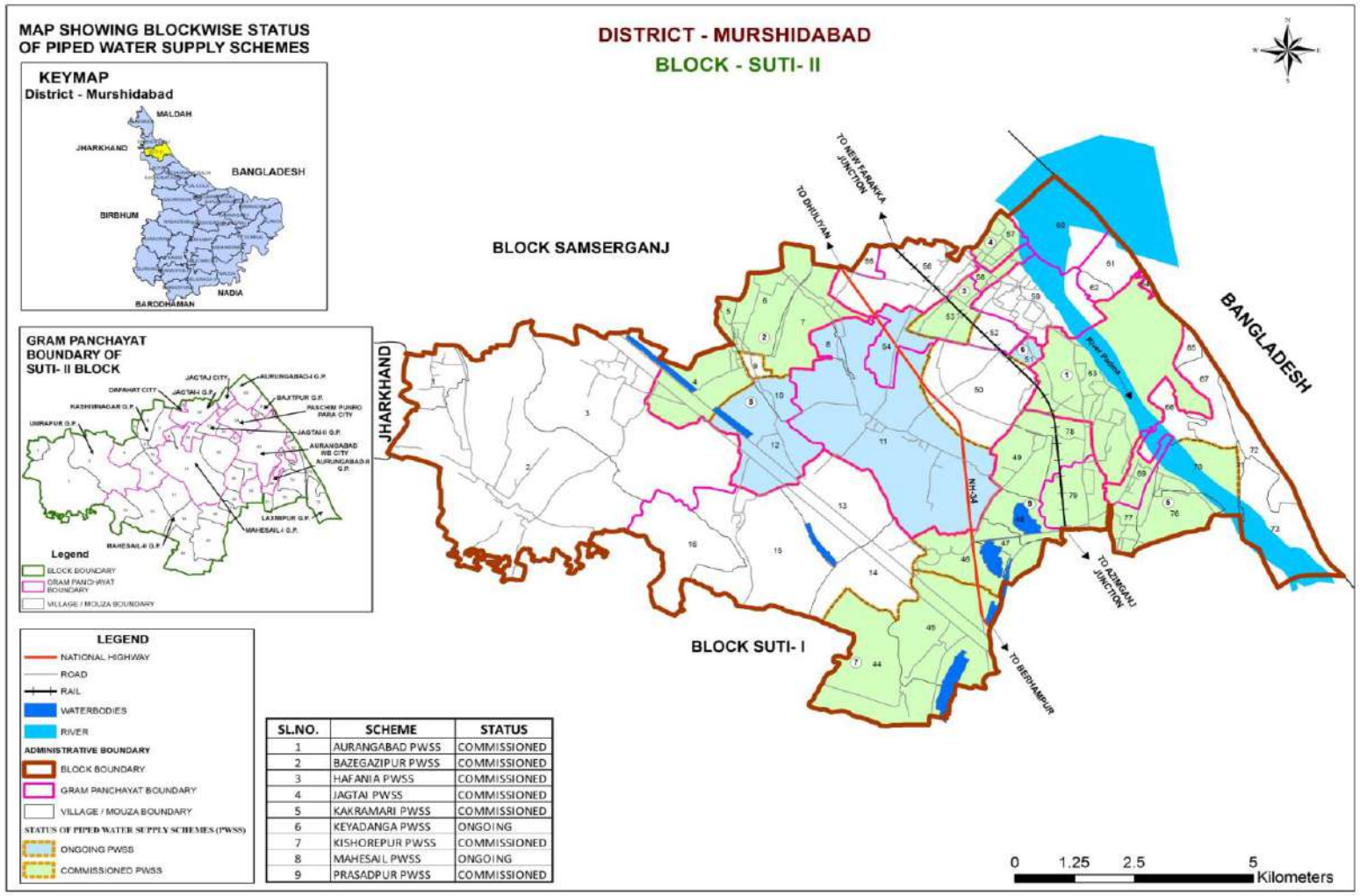
Proposed Interventions for potable water supply:

Sl. No.	Block	Suggestions for providing water supply to the risk population
1	Suti II	Deeper aquifers within 25.00 – 76.2 m bgl are found to be potential and generally free from arsenic and potable. Hence, these aquifers could be tapped by cement sealing techniques for providing pipe water supply of potable water. • Surface water is an alternative source.

Other options for potable water:

1. Rain water harvesting

2. Installation of arsenic removal plants to make potable water from contaminated first Aquifer.



SL.NO.	SCHEME	STATUS
1	AURANGABAD PWSS	COMMISSIONED
2	BAZEGAZIPUR PWSS	COMMISSIONED
3	HAFANIA PWSS	COMMISSIONED
4	JAGTAI PWSS	COMMISSIONED
5	KAKRAMARI PWSS	COMMISSIONED
6	KEYADANGA PWSS	ONGOING
7	KISHOREPUR PWSS	COMMISSIONED
8	MAHESAIL PWSS	ONGOING
9	PRASADPUR PWSS	COMMISSIONED

Fig. 10.4.6.1: Pipe Water Supply schemes in Suti II block

(Source: PHED, Govt. of West Bengal)

Table 10.4.6.2: Irrigation scenario (Aquifer I) in Suti II block

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 m bgl	Average Post monsoon WL in m bgl	Remarks for GW Management Plan
1	Suti II	7352	3349	4003	87.37	**F 22.1**	F 12.9	6.15	4.83	Can be developed for GW based Irrigation

Data of 5th M. I. Census shows:

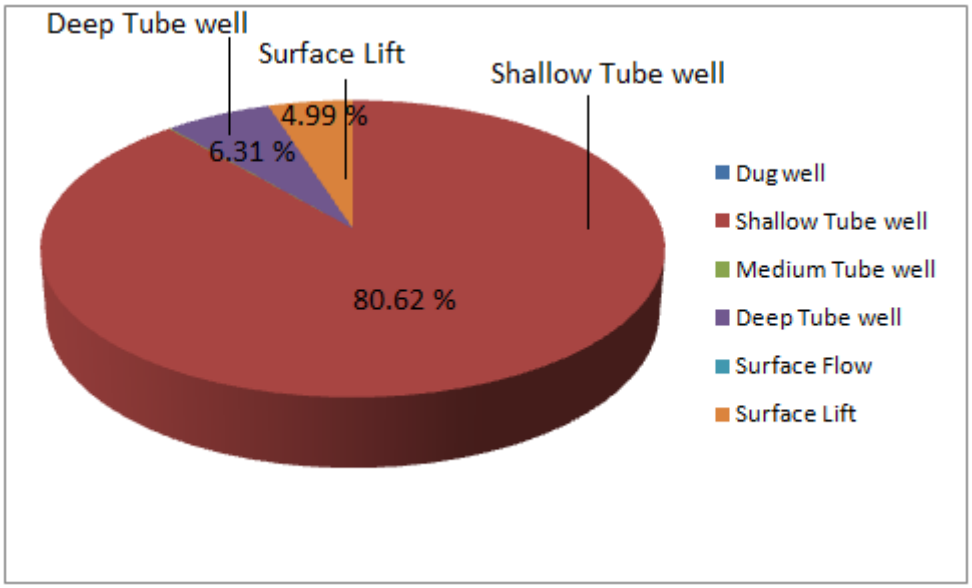


Fig. 10.4.6.2: Graphical presentation of Percentage of CCA & different sources of irrigation

Table 10.4.6.3: CCA, % of CCA & different sources of irrigation

Type of abstraction structures	CCA (Ha)	% of CCA
Dug well	**0**	0
Shallow Tube well	2529.79	80.62
Medium Tube well	2.5	0.09
Deep Tube well	180	6.31
Surface Flow	0	0
Surface Lift	142.5	4.99

Table 10.4.6.4: Cropping Pattern in Suti II block during 2016-17

Name of Block	Aus	Aman	Boro	Wheat	Potato	Masur	Maskalai	Jute	Khesari	Til	Mustard	Linseed	Gram
Suti II	1609	1322	224	1196	62	1013	-	3931	1523	-	1430	-	179

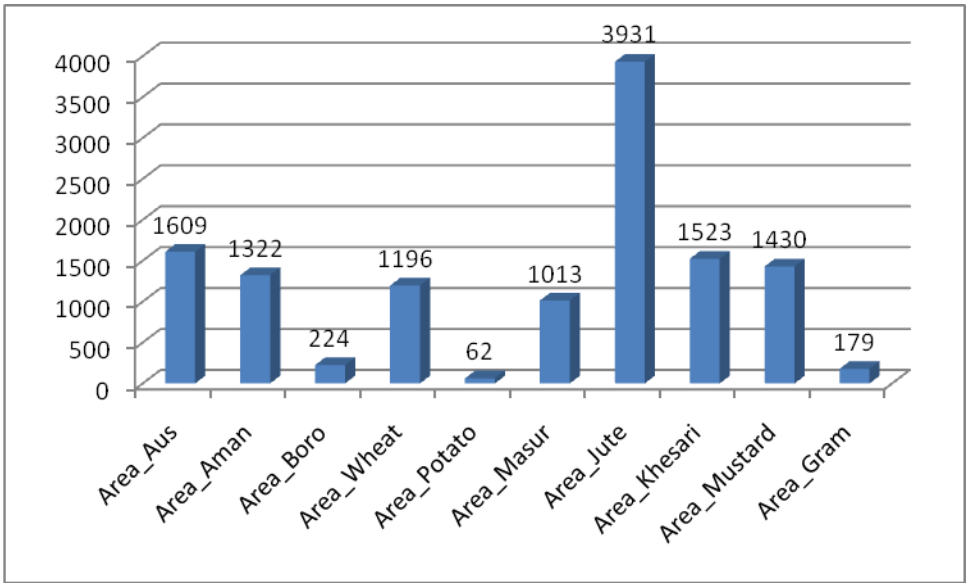


Fig. 10.4.6.3: Graphical presentation of Cropping Pattern in Suti II block during 2016-17

Management Strategy / Proposed interventions for irrigation:

- On principle, Boro cultivation is not encouraged. Boro needs 1.2 to 1.4 m.
- Wheat, Pulses & Oil seeds including Til, Ground nut cultivation in upland area could be encouraged; wheat needs about 0.35 m & Pulses & Oil seeds about 0.15 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.
- To improve the ground water scenario, implementation of modern irrigation practices like drip water irrigation system, sprinklers can be made.
- Cultivation of low water requiring crops and change in cropping pattern may be done for better and efficient water management.
- Some parts of this block is prone to water logging; therefore it is advisable for conjunctive use of both surface and ground water.

  Also, in area of shallow water level, cultivation of cash crops, eg. sugar cane is highly suggested.

- In this block, during Rabi & spring/ summer months, the existing area wise cropping pattern vide **Table 10.4.6.4 & Fig. 10.4.6.3)** is as follows:

  Wheat – 21%, Boro – 0.039 %, vegetables - 0.01% (neglisible), Pulses & Oil seeds – 73.66%.
- As per the aforesaid cropping pattern, from the remaining area to be irrigated of 4003 Ha, cultivation proposed: wheat – 840.63 Ha; Pulses & Oil seeds (including Boro area) - 2950.21 Ha.
- For wheat (@ 0.35 m/ha) & Pulses & Oil seeds (@0.15 m/Ha) estimation shows an amount of 736.75 Ham of water is needed.
- Ground Water Estimation 2017 shows that an amount of 650.66 Ham of ground water from the top aquifer has been earmarked for future use
- The remaining 736.75 – 650.66 Ham or 86.09 Ham can be available from Rain Water Harvesting as discussed in **Chapter 10.4.7**.

Table 10.4.6.5: Water column recommended 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
Murshidabad	Suti 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

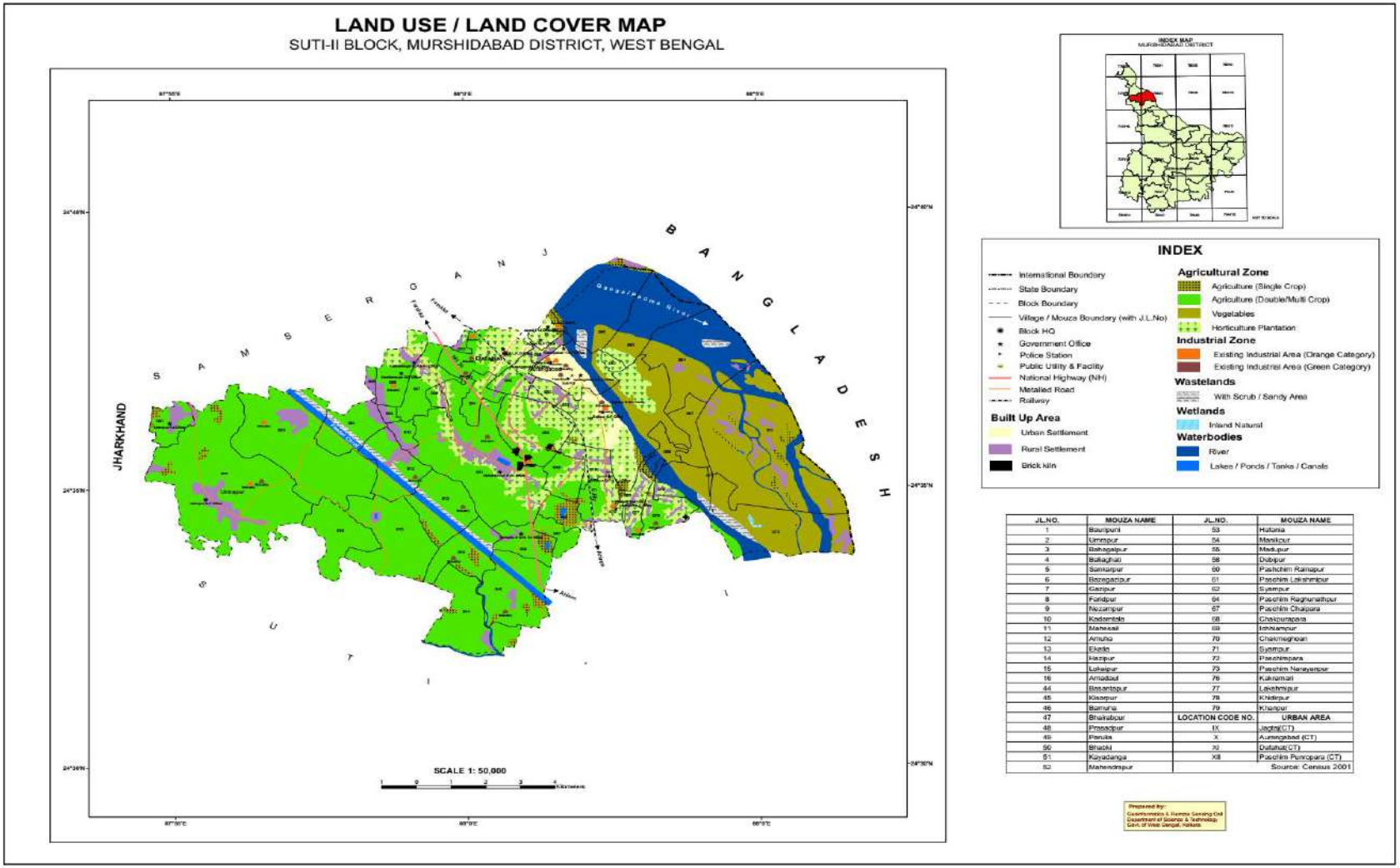


Fig. 10.4.7.1: Land use/ land cover in Suti II block

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

10.4.7: Scope for rain water harvesting & artificial recharge

Using Dhruvanarayana,1993 method in Suti 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 10.4.7.1a & Table 10.4.7.1b. 1144.19448 Ham 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; by doing this ground water scenario can be improved as well as the inclusive economic growth can be achieved.

Area suitable for recharge in the study area (vide Part I – Plate 6.2.1b):

District	Block Name	Area (in sq. km)	Total Area suitable for recharge (sq km.)
MURSHIDABAD	Suti II	111.13	55

Utilization of Harvested Rain Water: Table 10.4.7.1a shows that 1144.19448 Ham of rain water could be harvested in Suti II block. In Fig. 10.4.7.1 land use & land cover in this block has been shown; from it it is visualized that the land is suitable for even for double / multi-crop cultivation. The amount of 11.44194 MCM of rain water can be utilized in following ways:

For storing of rain water in constructed tanks, a total land of 343.40 ha is required (by keeping aside 10 % of 11.44194 MCM water as wastage by spillage, etc.). The remaining amount of harvested water i.e. 1030.19448 Ham can be utilized for irrigation purpose.

It is proposed to modify cropping pattern, if needed in future, for efficient irrigation practices. Less water requiring crops, eg. pulses, oil seeds, are always preferable. By this, a huge amount of vital ground water resources could be saved.

Proposed Artificial Recharge Structures in the Study area:

Table 10.4.7.1a: Calculation of harvested rain water in Suti II 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 (considering e-flow) = Vf Ham
1.04	11113	11557.52	0.44	43.40 % moderately well drained sandy soil & 51.50 % imperfectly drained loamy soil	5085.3088	3813.9816	1906.9908	1144.19448

Table 10.4. 7.1b: Proposed Artificial Recharge & conservation Structures in Suti II block:

Amount of water for artificial recharge and / or conservation (Ham) (4)	Source water allocation for Percolation Tank and REET with Recharge Shaft in Ham (5)	Source water allocation for REET with Recharge Shaft (Ham): 50 % of Col. 5 (6)	Source water allocation for Irrigation Cum Recharge Tank (Ham): 50 % of Col. 5 (7)	Source water allocation for Injection Well (8)	Source water allocation for Farm/Conservation Pond in Ham (9)	Nos. of REET with Recharge Shaft suggested @ 10 Ham per unit (10)	Nos. of Irrigation Cum Recharge Tank suggested @ 50 Ham per unit (11)	Nos. of injection wells @ 30 Ham per unit (12)	Nos. of Farm/conservation ponds @ 10 Ham per unit (13)	Cost of REET with Recharge Shaft @ Rs 8 lakh per unit (14)	Cost of Irrigation cum Recharge tank @ Rs 8 lakh per unit (15)	Cost of Injection wells @ Rs 8 lakh per unit (16)	Cost of Farm pondnjection wells @ Rs 8 lakh per unit (17)	Total Cost
1144.19448	90 % of Col. 4 i.e. 1029.78 Ham	514.89	514.89	Nil	10 % of Col. 4 i.e. 114.42 Ham	51	10	-	11	408	80	-	88	576

10.5 Raghunathganj I

10.5.1 Salient Information:

Area (in Km^2): 140.91

District: Murshidabad

State: West Bengal

Population (as on 2011):

Rural	Urban	Total
133114	62513	195627

Approximate Decadal Growth Rate: 30.09 per cent during 1991-2001 & 26.73% in 2001-2011.

Rainfall:

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

District	Normal - 2014 (in mm)	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):

Sl. No	Name of the Block	Geographic Area	Cultivable Area	Area under pasture & orchard	Cultivable Waste Land	Forest Land
1.	Raghunathganj I	140.91	112.64	-	0.14	-

(Source: Dept. of Agriculture, Govt. of West Bengal)

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

Resource Availability	Aquifer I*	Aquifer II	Current Annual G W Extraction (MCM) (Aquifer I)
Dynamic Resource (MCM)	63.444	0.089281	58.7203
Static Resource	214.83**	1.61669	-

*** Phreatic aquifer has been found to occur as outlier in eastern extremity of Raghunathganj I block only; however the data estimated by SWID and CGWB are given above.**

**** Data estimated in 45% of total block area as it's occurrence**

10.5.2 Disposition of Aquifer:

Depth range of aquifers:

Block	**Depth range of Aquifer in m bgl**		
Raghunathganj I	**Aquifer I**	**Aquifer II**	**Aquifer III**
	16.38 – 30.68	93-108	100 – 112.6

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

Sl. No.	**Block**	Aquifer	**Pre-monsoon Trend**			**Post-monsoon Trend**		
			Water Level Range (m bgl)	**Rise (m/yr)**	**Fall (m/yr)**	Water Level Range (m bgl)	**Rise (m/yr)**	**Fall (m/yr)**
1.	Raghunathganj I	I	5.48 – 7.5	0.015	-	0.86 – 4.55	-	0.299
2.	Raghunathganj I	II	14.8 – 19.31	-	0.15 – 1.39	11.11 – 15.80	-	0.575 – 0.711
3.	Raghunathganj I	III						

Average Thickness of Aquifer (Maximum):

Block	Area (sq km)	Thickness of the Granular Zone in Aquifer I (m)	Thickness of the Granular Zone in Aquifer II (m)	Thickness of the Granular Zone in Aquifer III (m)
Raghunmathganj I	140.91	10.69	56.76	12.6

Aquifer-wise Statement

Name of Block	Aquifer I (occurs in eastern part of block)			Aquifer II			Aquifer III		
	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)
Raghunathganj I	16. 38 – 30.68	7.2 - 40	-	38 - 82.31	86.58	360	93 - 113	-	-

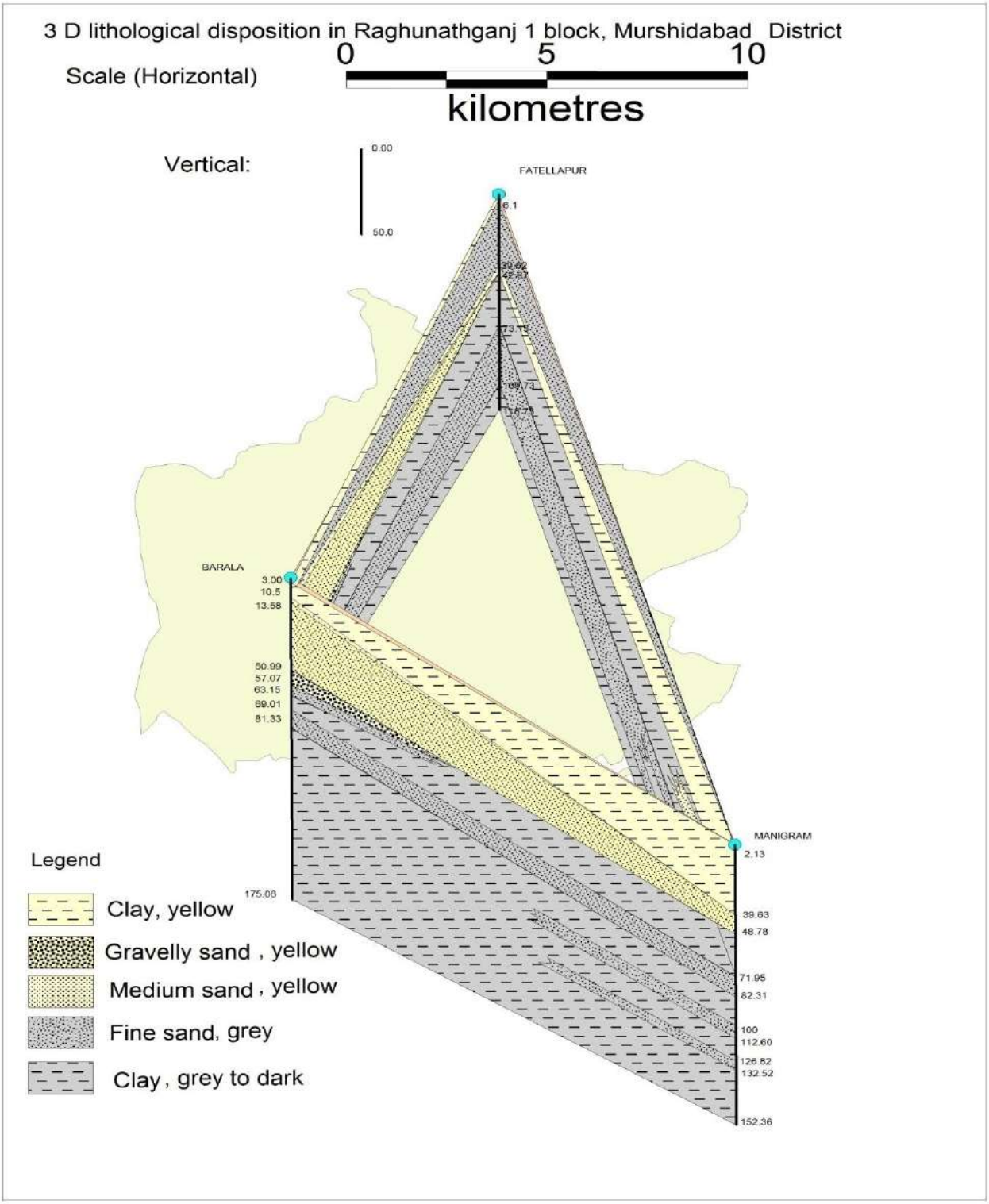


Fig. 10.5.2.1: Lithological disposition in aquifers in Raghunathganj I block

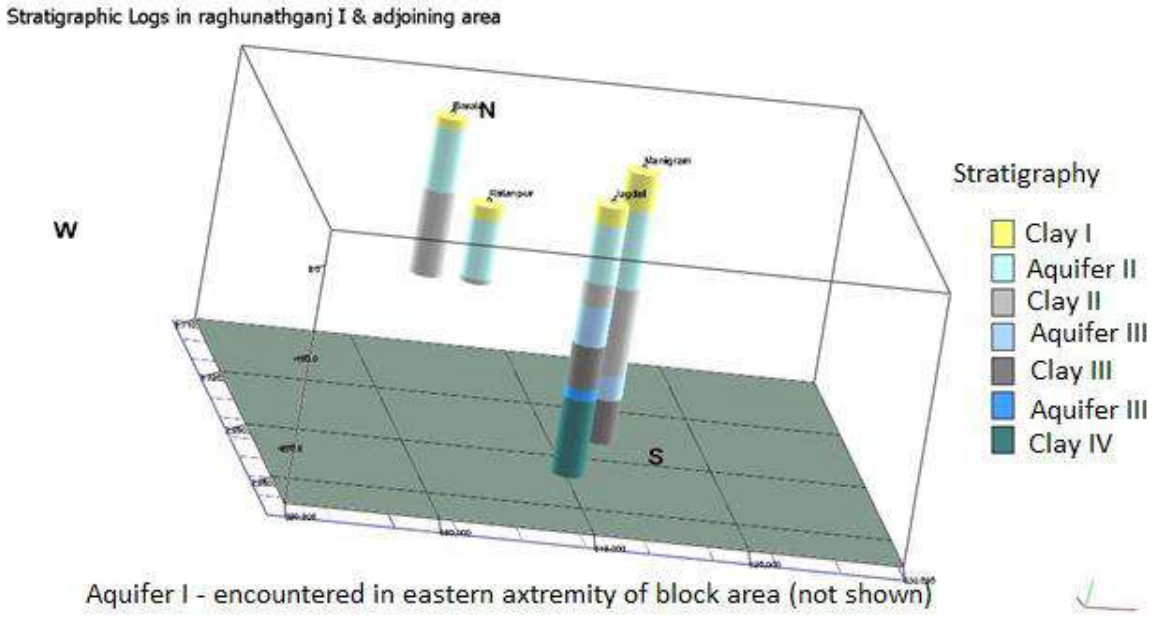


Fig. 10.5.2.2: Stratigraphic Logs in and around Raghunathganj I block

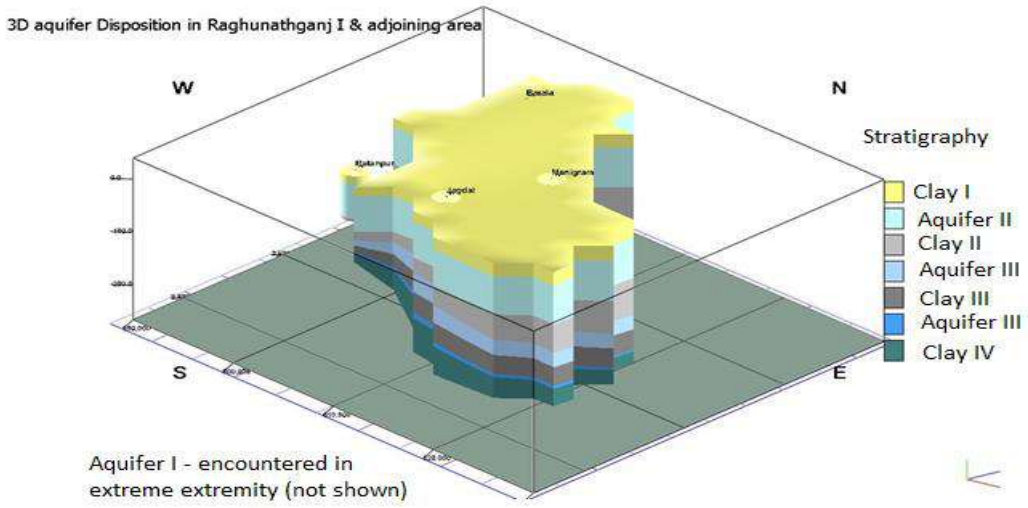


Fig. 10.5.2.3: 3D aquifer disposition in and around Raghunathganj I block

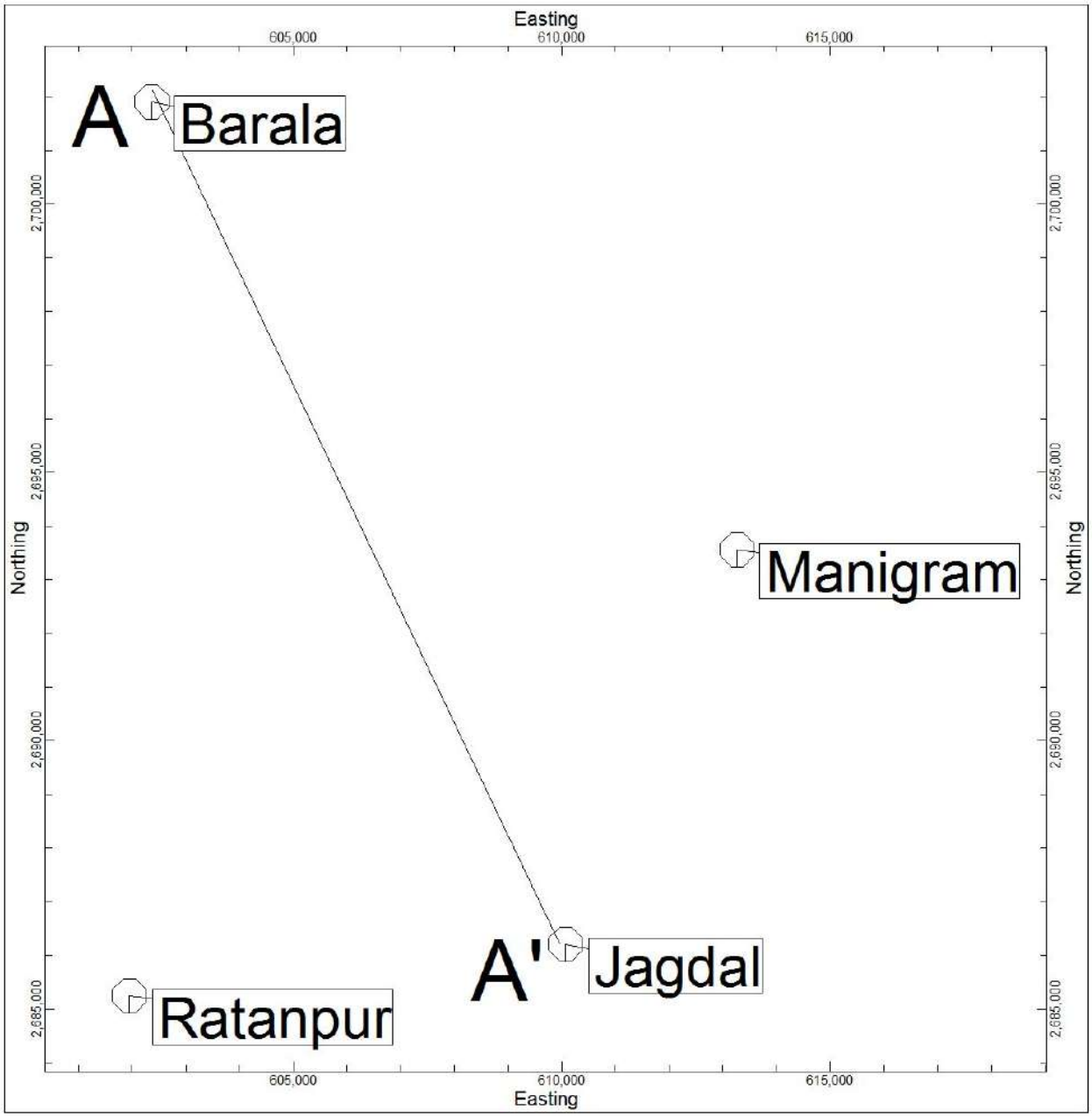


Fig. 10.5.2.4: NW – SE Stratigraphic Section Index Line in and around Raghunathganj I block

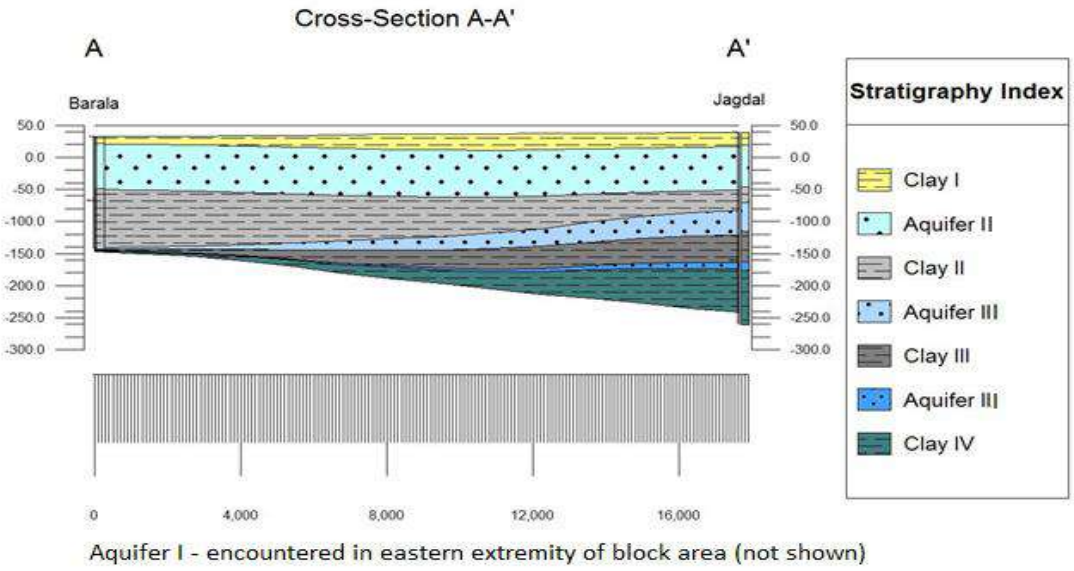


Fig. 10.5.2.5: NW – SE Stratigraphic Section in and around Raghunathganj I block

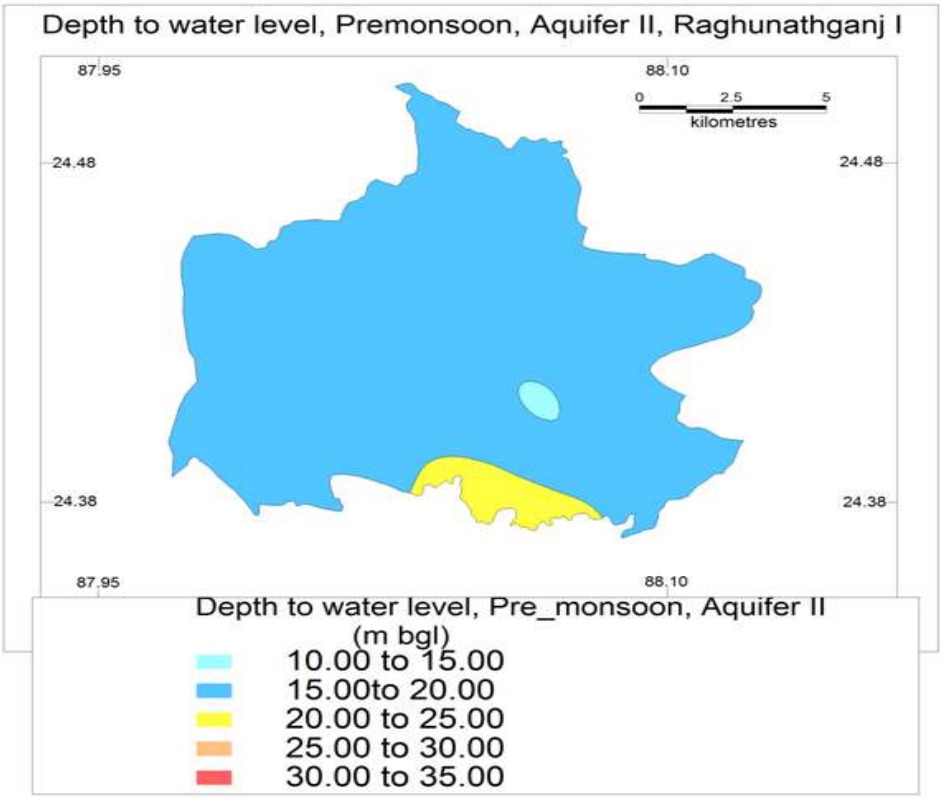


Fig. 10.5.2.6: Depth to water level, pre monsoon, Aquifer II

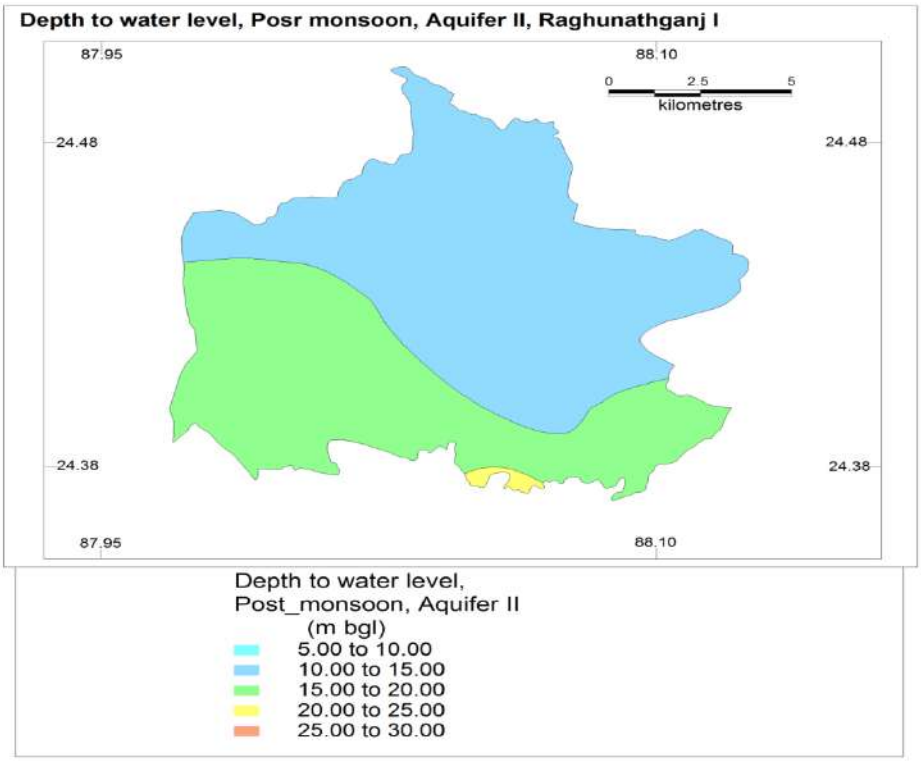


Fig. 10.5.2.7: Depth to water level, post monsoon, Aquifer II

10.5.3: Ground Water Resource & status of Extraction:

Aquifer Wise Resource Availability & Extraction:

Dynamic ground water resources as on 31st March'17

Block	Annual Extractable Ground Water Recharge (MCM)	Current Annual Ground Water Extraction (MCM)	**Stage of development (%)**	**Category**	Annual GW Allocation for for Domestic Use as on 2042	Ground water availability for future use (MCM)
Raghunathganj I	63.444	58.7203	92.54	Critical	4.1229	3.8606

Static (in-storage) Resources (Aquifer I): 214.83 **MCM.**

Dynamic Ground water resource (Aquifer II): 0.089281 **MCM**

Static (in-storage) Resources (Aquifer II): 1.61669 **MCM.**

10.5.4 Chemical Quality of Ground Water & Contamination:

Range of important Chemical Parameters:

Arsenic (As) data are based on 3 random samples of spl. Drive' 15-16 & other routine parameters are based on limited samples of 17-18. As more than 0.01 mg/l, WHO limit of potable water, has been reported in 2 out of 3 wells (2 dug wells & 1 tube well). Maximum has been encountered at Raghunathganj I.

Block	As (mg/l)	TH (mg/l)	EC (µS/cm)	F (mg/l)	NO_3 (mg/l)
Raghunathganj I	**0.0002 – 0.13**	**120 - 500**	**392 - 1217**	**0.58 - 0.59**	**0 - 8**

Percentage of tube wells having arsenic content (based on data of PHED, Govt. of West Bengal):

Block	Arsenic (<0.01 ing/1)		Arsenic (>0.01-<0.05 mg/1) %		Arsenic (> 0.05 mg/1) %		Total Tube well (max. concentration of As (mg/l)
	%	Count	%	Count	%	Count	
Raghunathganj I	67.35	724	27.07	291	5.58	60	1075 (0.25)

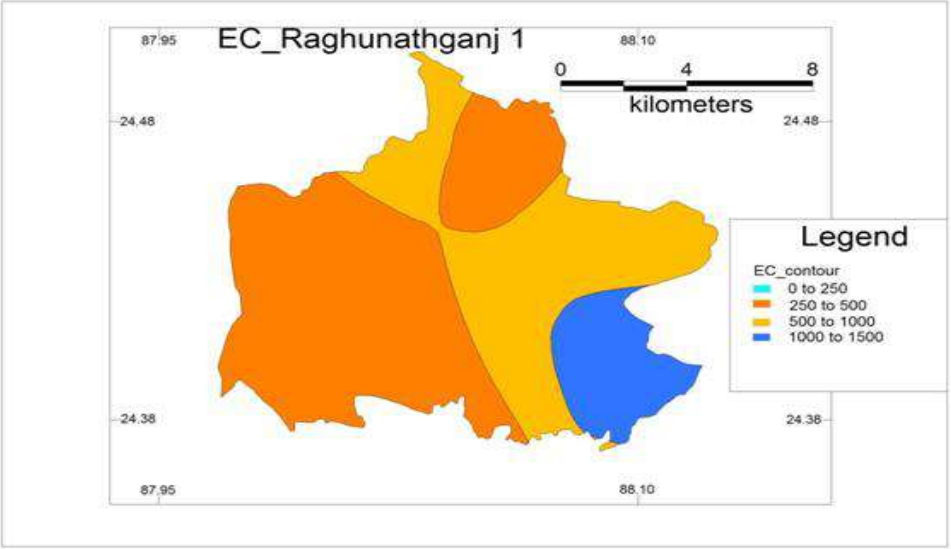


Fig. 10.5.4.1: Electrical Conductivity in ground water

10.5.5: Major Issues:

1. Very deep water level in deeper aquifer and its long term trend shows alarming fall.
2. Sporadic ground water contamination by arsenic has been reported in Younger Alluvium of Aquifer I (in eastern part of block area).
3. High SOD & Critical category of block
4. Irrigation in large area is done by ground water

10.5.6: Ground Water Resource Enhancement& Management Plan:

Ground Water Management Plan for drinking purposes.

Table 10.5.6.1: Status of present water supply schemes (Based on PHED data)

Nos. of habitations in risk zone	Whereas As infested	As infested population in 2011	Projected As infested population in 2021	Population already covered	Water (lit.) required for uncovered population @ 70 lpcd
41	**Infested**	**151338**	**183224**	**299200**	**Already covered**

Proposed Interventions:

Block	Suggestions for providing water supply to the risk population
Raghunathganj I	As per CGWB exploration data, potential and potable ground water bearing aquifers are encountered in deeper aquifers within 38 – 113 m bgl, excepting eastern parts occupied by Younger Alluvium. Beyond this depth, no potential aquifer has been encountered by exploration up to a depth of about 250 m bgl. Tube wells must be constructed by applying cement sealing technique. • Surface water is an alternative source.

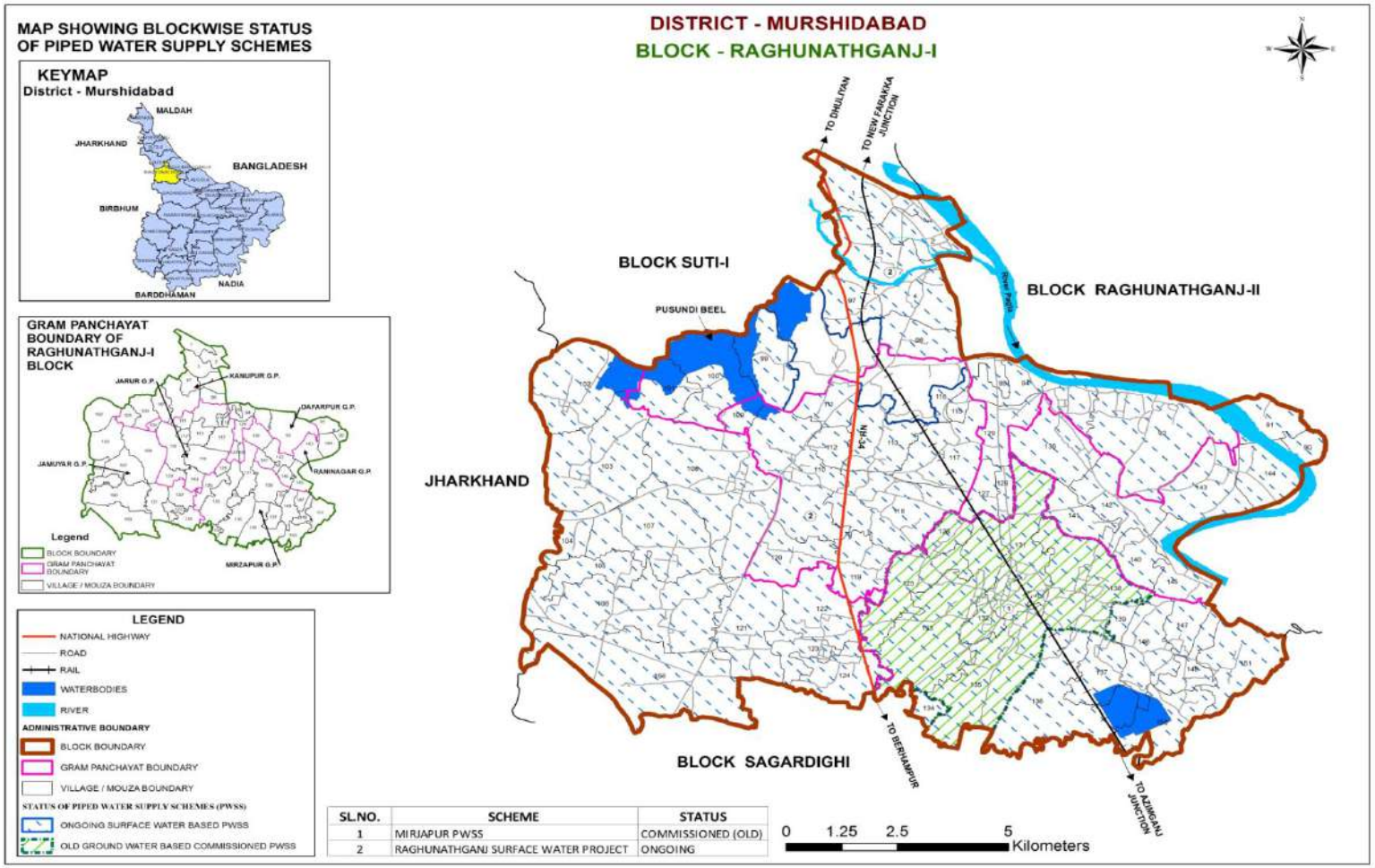


Fig. 10.5.6.1: Pipe Water Supply schemes in Raghunathganj I block

(Source: PHED, Govt. of West Bengal)

Other options for potable water:

1. Rain water harvesting

2. Installation of arsenic removal plants to make potable water from contaminated first Aquifer.

Ground Water Management Plan for Irrigation purpose

Table 10.5.6.2: Irrigation scenario (Aquifer II) in Raghunathganj I block

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 m bgl	Average Post monsoon WL in m bgl	Remarks for GW Management Plan
1	Raghunathganj I	11264	2204	9060	92.54	**R 1.5**	F 29.9	6.49	2.75	Can be developed for GW based Irrigation

Data of 5th M. I. Census shows:

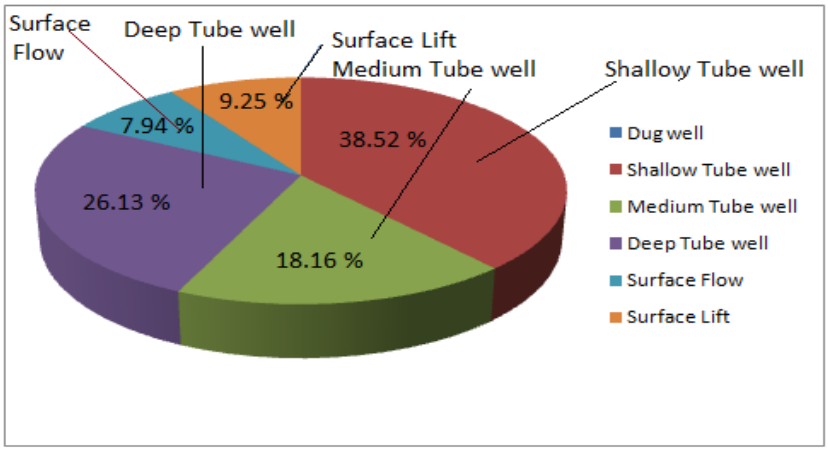


Fig. 10.5.6.2: Percent contribution of CCA by different sources of irrigation

Table 10.5.6.3: CCA & sources of irrigation

Block Total / District Total	Dug well		Shallow Tube well		Medium Tube well		Deep Tube well		Surface Flow		Surface Lift		CCA (ha.)		Total CCA (ha.)
	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	Ground Water	Surface Water	
Block Total	0	0	280	679.97	70	320.6	106	461.34	5	140.3	30	163.23	1461.91	303.53	1765.44
District Total	**178**	**728.67**	**54842**	**127809.47**	**2148**	**11550.1**	**1719**	**33386.23**	**292**	**1592.29**	**1499**	**13037.13**	**173474.51**	**14629.42**	**188103.9**

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

Table 10.5.6.4: CCA & Percent contribution of CCA by different sources of irrigation

Type of abstraction structures	CCA (Ha)	% of CCA
Dug well	**0**	0
Shallow Tube well	679.97	38.52
Medium Tube well	320.6	18.16
Deep Tube well	461.34	26.13
Surface Flow	140.3	7.94
Surface Lift	163.23	9.25

Table 10.5.6.5: Cropping pattern in Raghunathganj I block

Name of Block	Aus	Aman	Boro	Wheat	Potato	Masur	Maskalai	Jute	Khesari	Til	Mustard	Linseed	Gram
Raghunathganj-I	-	8704	2343	3665	313	585	8	2069	9	0.004	1715	-	704

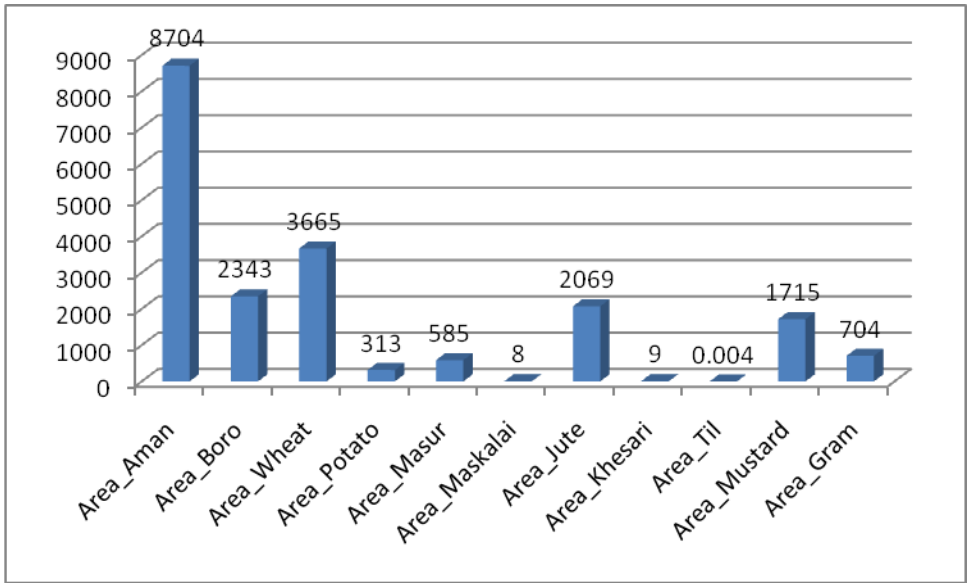


Fig. 10.5.6.3: Graphical presentation of Cropping pattern in Raghunathganj I block

Proposed interventions for irrigation:

- On principle, Boro cultivation is not encouraged. Boro needs 1.2 to 1.4 m.
- Wheat, Pulses & Oil seeds including Til, Ground nut cultivation in upland area could be encouraged; wheat needs about 0.35 m & Pulses & Oil seeds about 0.15 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.
- To improve the ground water scenario, implementation of modern irrigation practices like drip water irrigation system, sprinklers can be made.
- Cultivation of low water requiring crops and change in cropping pattern may be done for better and efficient water management.
- In this block, during Rabi & spring/ summer months, the existing area wise cropping pattern vide **Table 10.5.6.5 & Fig. 10.5.6.3** is as follows:

  Wheat – 52.36 %, vegetables – 0.004 % (neglisible), Pulses & Oil seeds –43.16 %.
- As per the aforesaid cropping pattern, from the remaining area to be irrigated of 9060 Ha, cultivation proposed: wheat – 4743.816 Ha; Pulses & Oil seeds -3910.296 Ha.
- For wheat (@ 0.35 m/ha) & Pulses & Oil seeds (@0.15 m/Ha) estimation shows an amount of 2246.88 Ham of water is needed.
- Ground Water Estimation 2017 shows that a resource of 386.06 Ham of ground water in top aquifer exists.

  So, by the available resource only part of remaining cultivable area could be covered and for 2246.88 – 386.06 Ham or 1860.82 Ham rain water harvesting is to be widely implemented and the same has been dealt in Chapter 10.5.7.

Table 10.5.6.6: Water column recommended 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
Murshidabad	Raghunathganj 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

10.5.7 Scope for rain water harvesting & Artificial recharge:

Using Dhruvanarayana, 1993 method in Raghunathganj 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 10.5.7.1a & Table 10.5.7.1b. 1813.5117 ham of rain water has been estimated to be harvested. This harvested water can be utilized for construction of suitable structures for artificial recharge and conservation of water; by doing this ground water scenario can be improved as well as the inclusive economic growth can be achieved.

Area suitable for recharge in the study area (vide Part I: Plate 6.2.1b):

District	Block Name	Area (in sq. km)	Total Area suitable for recharge (sq km.)
MURSHIDABAD	Raghunathganj I	140.91	77.50

Utilization of Harvested Rain Water: Table 10.5.7.1a shows that 1813.5117 Ham of rain water could be harvested in Raghunathganj I block. In Fig. 10.5.7.1, land use & land cover in this block has been shown; from it it is visualized that the land is suitable for even for double / multi-crop cultivation. The amount of 18.1351 MCM of rain water can be utilized in following ways:

For storing of rain water in constructed tanks, a total land of 544 ha is required with 3 m depth (by keeping aside 10 % of 18.1351 MCM water as wastage by spillage, etc.). The remaining amount of harvested water i.e. 1632.5117 Ha can met the shortage as estimated under section proposed interventions.

Furthermore, efforts have 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 10.5.7.2, 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.

Proposed Artificial Recharge Structures in the Study area:

Table 10.5.7.1a: Calculation of harvested rain water in Raghunathganj 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 (considering e-flow) = Vf Ham
1.04	14091	14654.64	0.55	0.073 % moderately well drained sandy soil, 75.61 % imperfectly drained loamy soil & 19.75 % imperfectly drained fine sand	8060.052	6045.039	3022.5195	1813.5117

Table 10.5.7.1b: Proposed Artificial Recharge & conservation Structures in Raghunathganj I block:

Amount of water for artificial recharge and / or conservation (Ham) (4)	Source water allocation for Percolation Tank and REET with Recharge Shaft in Ham (5)	Source water allocation for REET with Recharge Shaft (Ham): 50 % of Col. 5 (6)	Source water allocation for Irrigation Cum Recharge Tank (Ham): 50 % of Col. 5 (7)	Source water allocation for Injection Well (8)	Source water allocation for Farm/Conservation Pond in Ham (9)	Nos. of REET with Recharge Shaft suggested @ 10 Ham per unit (10)	Nos. of Irrigation Cum Recharge Tank suggested @ 50 Ham per unit (11)	Nos. of injection wells @ 30 Ham per unit (12)	Nos. of Farm/conservation ponds @ 10 Ham per unit (13)	Cost of REET with Recharge Shaft @ Rs 8 lakh per unit (14)	Cost of Irrigation cum Recharge tank @ Rs 8 lakh per unit (15)	Cost of Injection wells @ Rs 8 lakh per unit (16)	Cost of Farm pondnjection wells @ Rs 8 lakh per unit (17)	Total Cost
1813.5117	90 % of Col. 4 i.e. 1632.16 Ham	816.08	816.08	Nil	10 % of Col. 4 i.e. 181.35 Ham	82	16	-	18	656	128	-	144	928

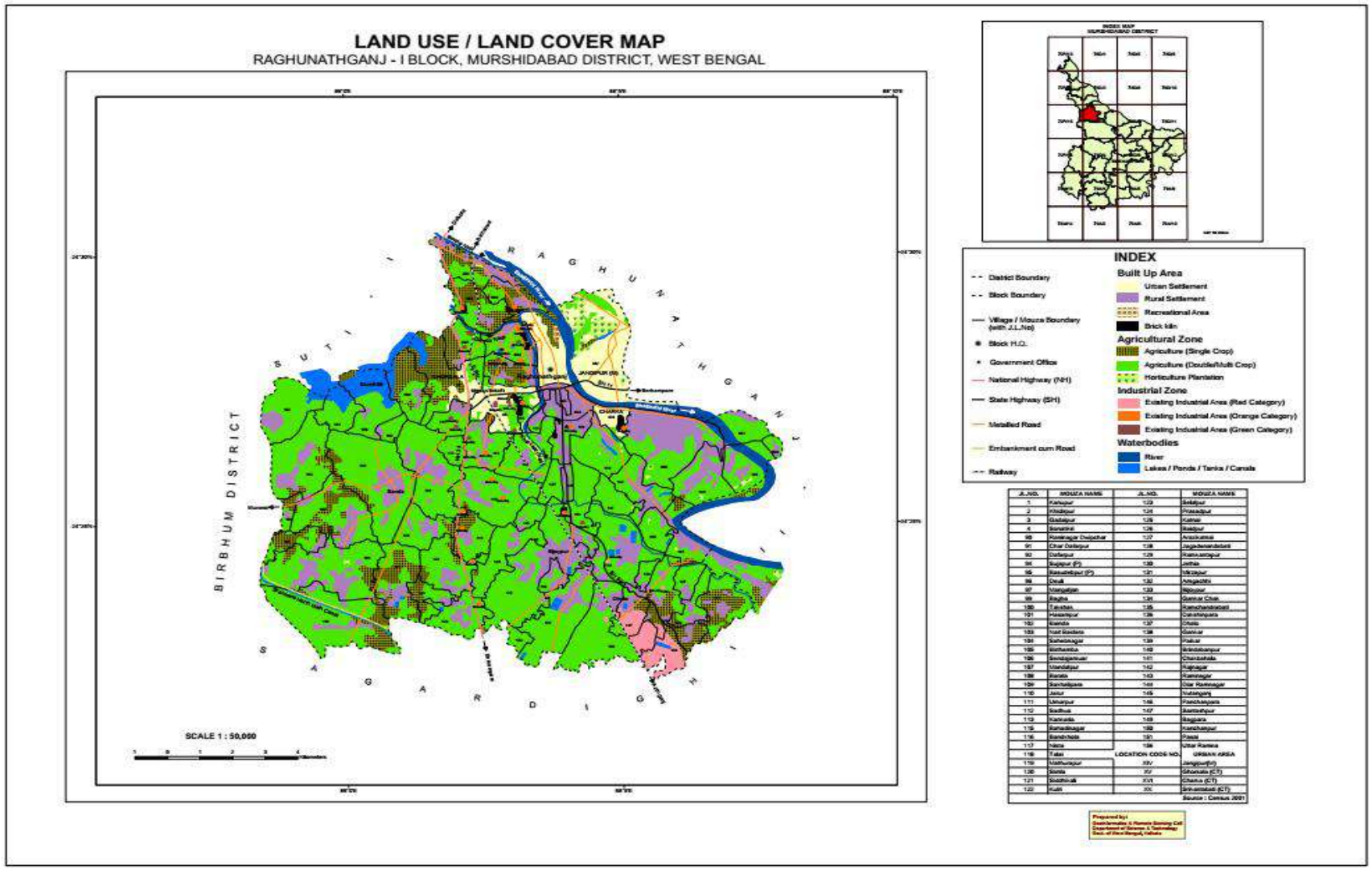


Fig. 10.5.7.1: Land use/ land cover in Raghunathganj I block

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

Table **10.5.7.2: Proposed change in cropping pattern in Raghunathganj I 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 (Kg of Boro paddy) due to reduction in area of Boro cultivation yield rate 3613.69 kg/ Ha (in M. Ton)**	**Proposed cropping in 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 & Ground nut @ 2309.39 kg/Ha**	**Increase in area of wheat cultivation in winter (at least 10% more of existing area of 3665 Ha for wheat, i.e. 366.5 Ha) yield rate 2864.41 kg/ Ha (M. Ton)**
(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)	(IX)
2343	1.3 m	30.459	234.3	3.0459	846.688	Til &Ground nut in 117.15 Ha each	Til – 106.754 Ground nut- 270.545	1049.806

Ground water draft for til & ground nut, =234.3*0.15 = 0.35 MCM; Ground water draft for wheat = 366.5*0.32 = 1.1728 MCM; **ground water saved = 1.5231 MCM; Boro paddy loss = 846.688 M. Ton; Gain of Til, Ground nut & wheat =14.27105 M. Ton**

Water saved: 1.5231 MCM

10.6: Sagardighi

10.6.1 Salient Information:

Area (in Km^2): 345.42

District: Murshidabad

State: West Bengal

Population (as on 2011):

Rural	Urban	Total
310461	-	310461

Approximate Decadal Growth Rate: in 1991-2001 it was 26.76 per cent & 23.06% in 2001 - 2011.

Rainfall:

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

District	Normal-2014 (in mm)	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):

Sl. No	Name of the Block	Geographic Area	Cultivable Area	Area under pasture & orchard	Cultivable Waste Land	Forest Land
1.	Sagardighi	345.42	292.97	0.11	0.03	1.18

(Source: Dept. of Agriculture, Govt. of West Bengal)

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

Resource Availability	Aquifer I*	Aquifer II	Current Annual G W Extraction (MCM) (Aquifer I)
Annual Extractable Ground Water Recharge (MCM)	98.3945	0.387561	75.471
Static Resource	157.31**	46.67453	

*** Phreatic aquifer has been to occur in eastern part of Sagardighi block only; however the data estimated by SWID and CGWB are given**

**** Data estimated in 25% of total block area as it's occurrence**

10.6.2 Disposition of Aquifer:

Block	Depth range of Aquifer in m bgl		
	Aquifer I	**Aquifer II**	**Aquifer III**
Sagardighi	Up to 24.38	9 – 81.99	146-152, 170-182, 202-205

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

Block	Aquifer	Pre-monsoon Trend			Post-monsoon Trend		
		Water Level Range (m bgl)	**Rise (m/year)**	**Fall (m/year)**	Water Level Range (m bgl)	**Rise (m/year)**	**Fall (m/year)**
Sagardighi	I	9.2	0.015	-	7.1	-	0.299
Sagardighi	II	15.52 – 34.65		0.15 – 1.39	13.89 – 27.60	-	0.575 – 0.711
Sagardighi	III	26.52					

Average Thickness of Aquifer :

Block	Area (sq km)	Thickness of the Granular Zone in 1st aquifer (m)	Thickness of the Granular Zone in 2nd aquifer (m)	Thickness of the Granular Zone in 2nd aquifer (m)
Sagardighi	345.42	24.38	65.22	12

Aquifer-wise Statement

Name of Block	1st Aquifer (occurs in eastern extremity of block)			2nd Aquifer			3rd Aquifer		
	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)
Sagardighi	0 - 24.38	30-40	-	9 - 81.99	95.5 – 212.8	2500	146-152, 170-182, 202-205	41.58	220

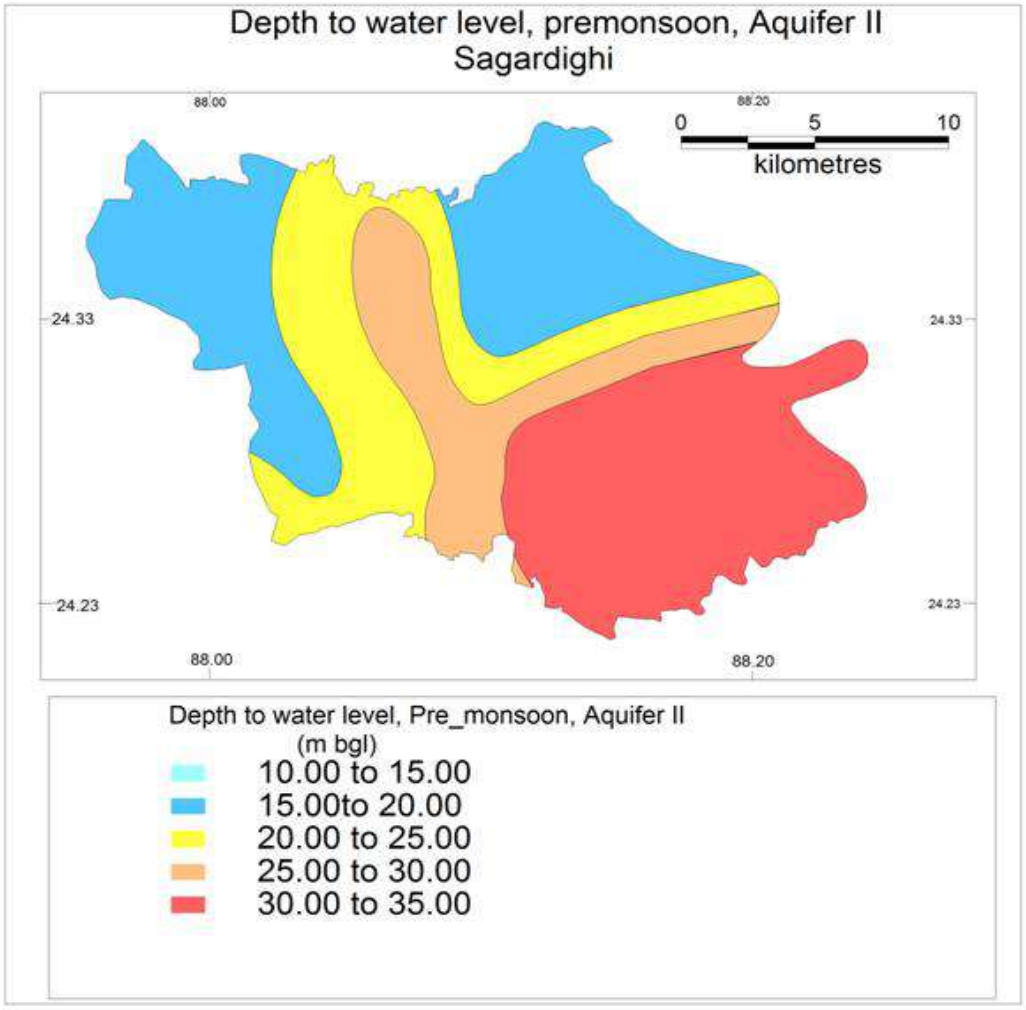


Fig. 10.6.2.1: Depth to water level, pre monsoon, Aquifer II

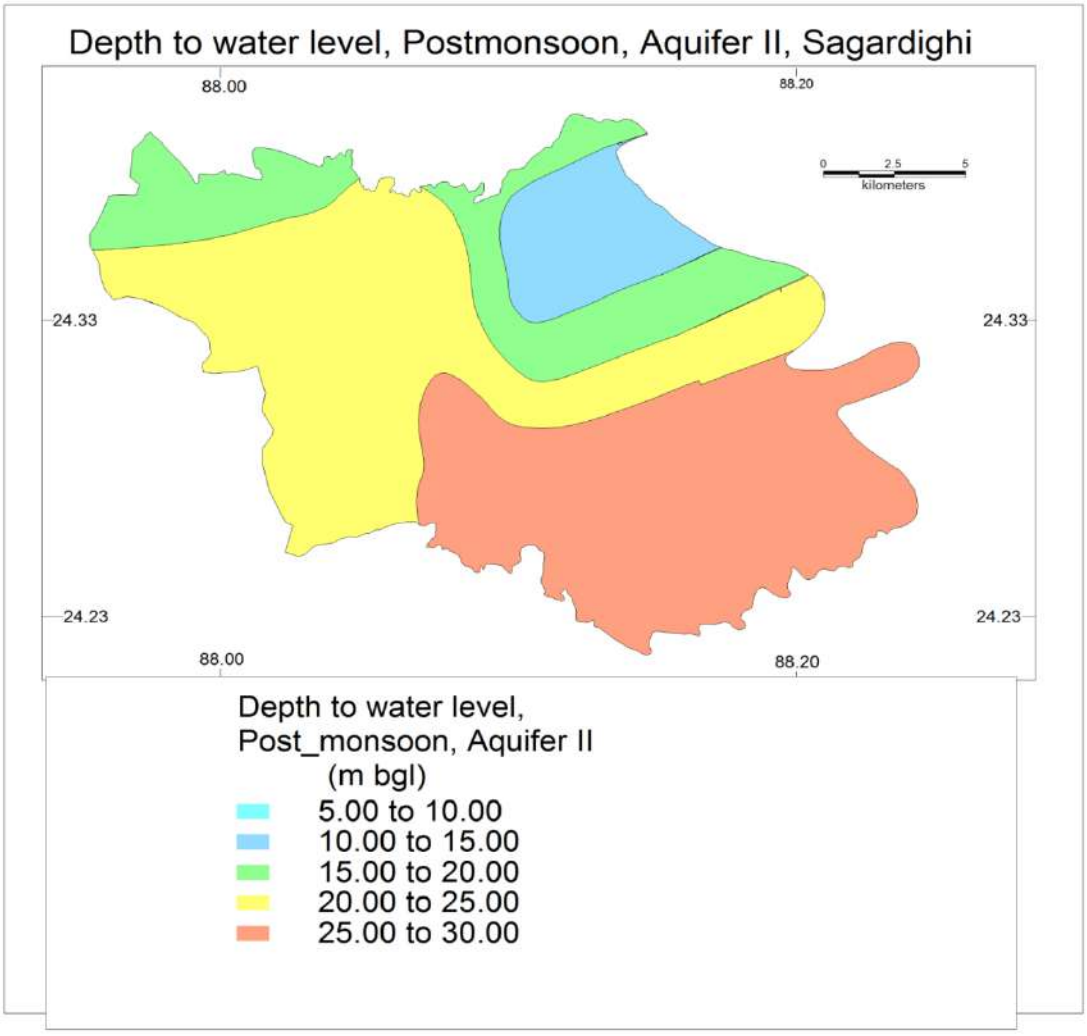


Fig. 10.6.2.2: Depth to water level, post monsoon, Aquifer II

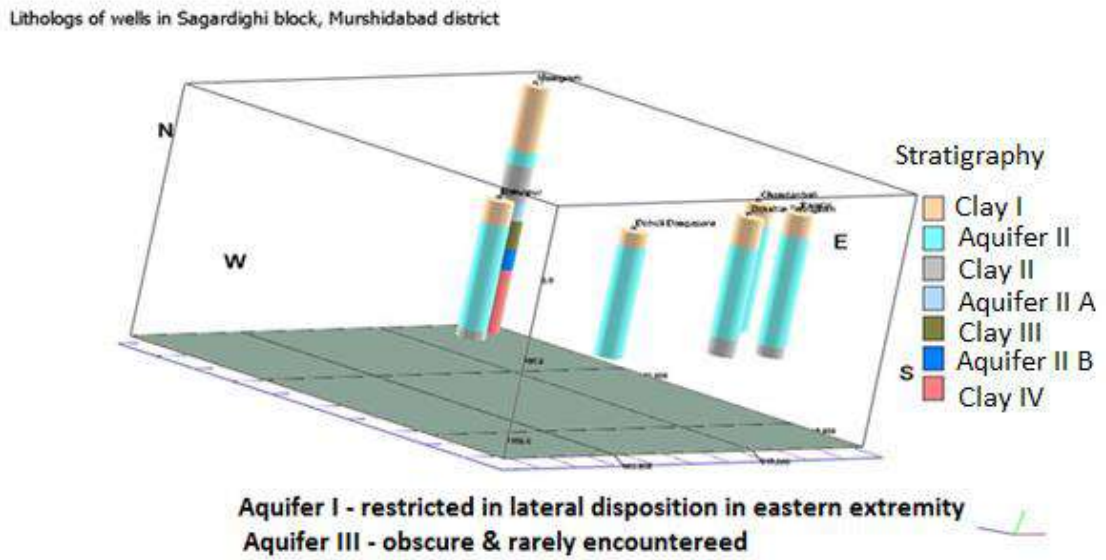


Fig. 10.6.2.3: Stratigraphic Logs in Sagardighi block

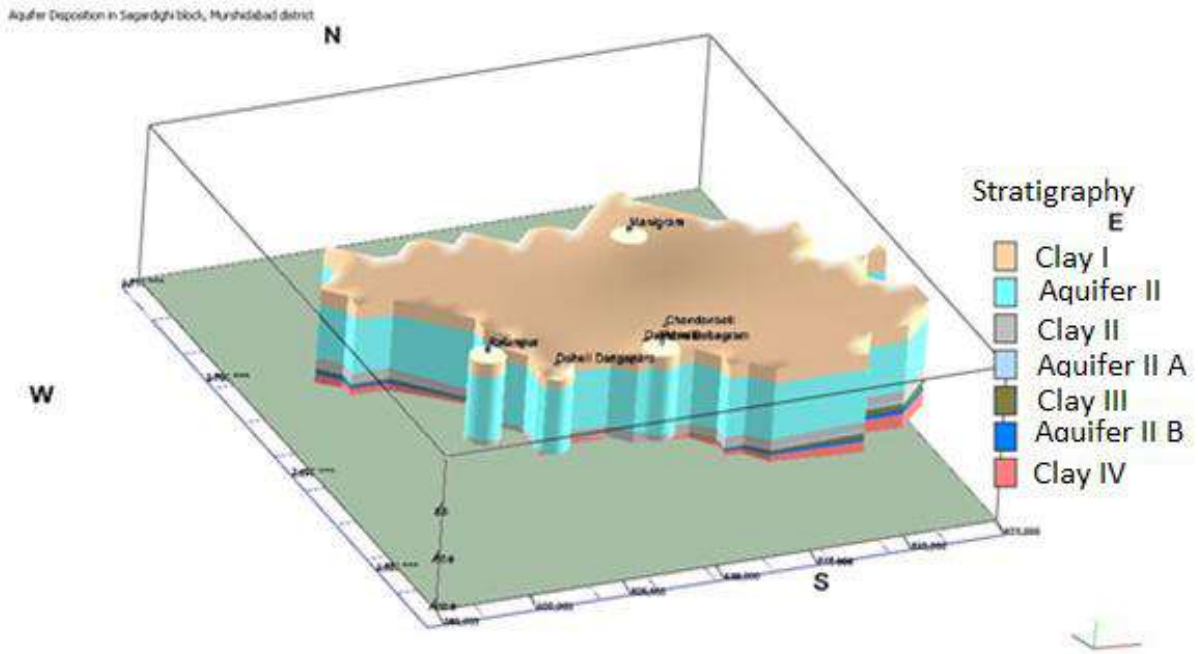


Fig. 10.6.2.4: 3 D Aquifer disposition in Sagardighi block

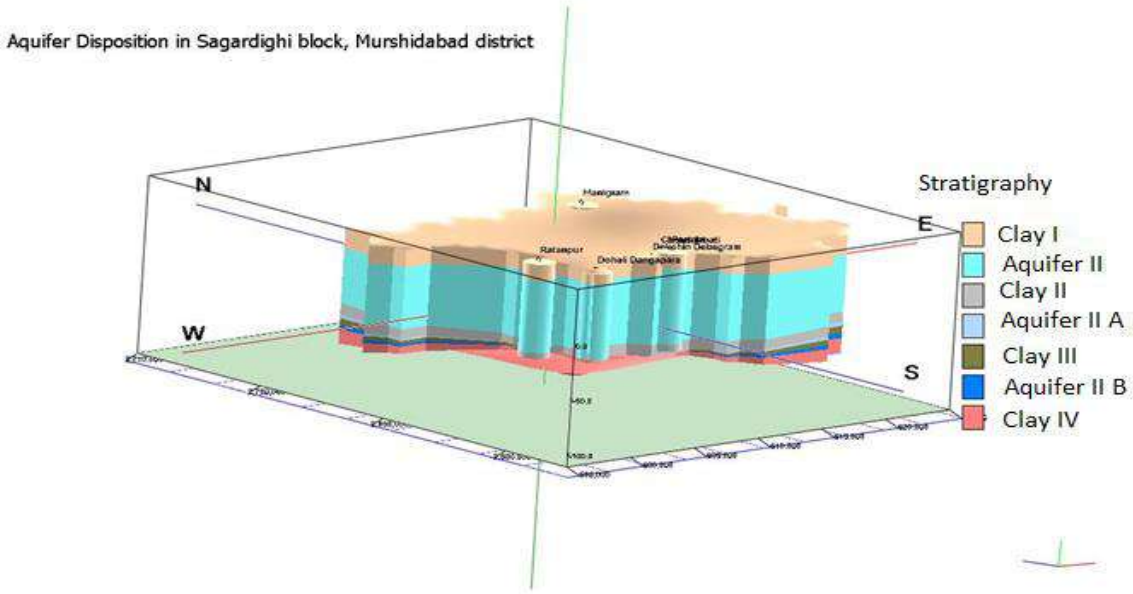


Fig. 10.6.2.4A: 3 D Aquifer disposition in Sagardighi block

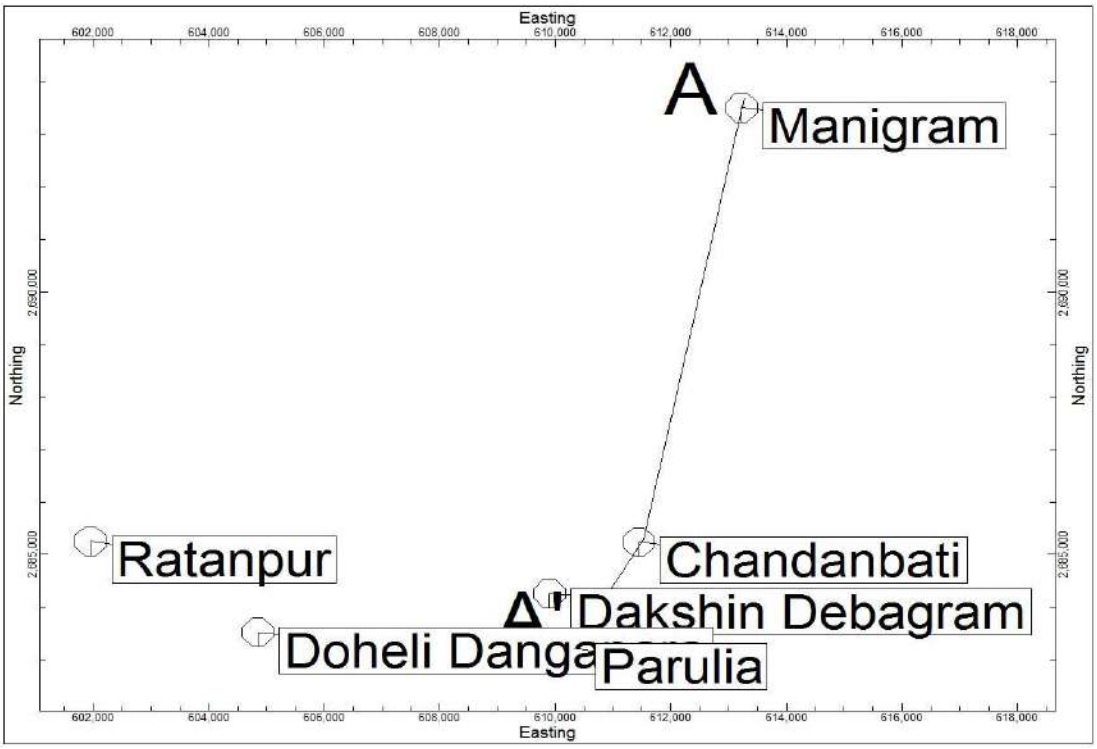


Fig. 10.6.2.5: NNE – SSW section index line in Sagardighi block

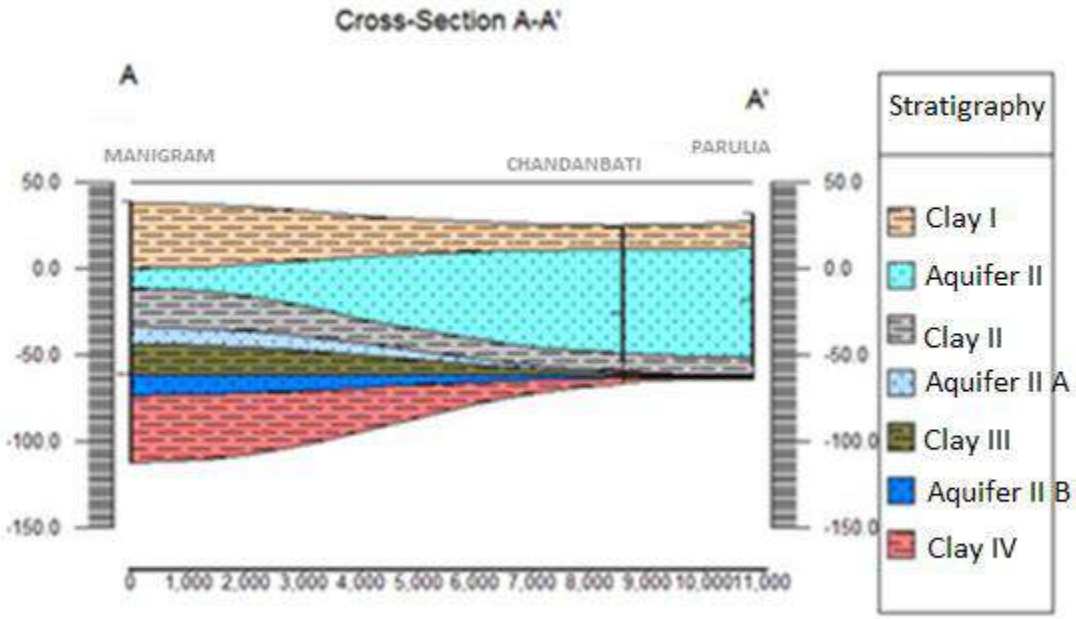


Fig. 10.6.2.5A: NNE – SSW Section in Sagardighi block

10.6.3: Ground Water Resource & status of Extraction:

Aquifer Wise Resource Availability & Extraction:

Dynamic ground water resources (Aquifer I) as on 31st March'17

Block	Annual Extractable Ground Water Recharge	Current Annual Ground Water Extraction	Stage of development (%)	**Category**	Annual GW Allocation for for Domestic Use as on 2042	Ground water availability for future use (MCM)
Sagardighi*	98.3945	75.471	76.7	Semi-	5.6074	20.8901

***Phreatic aquifer has been found to occur in eastern part of Sagardighi block only; however the data estimated by SWID and CGWB are given**

Static (in-storage) Resources (Aquifer I):** 157.31 **MCM.**

**** Data estimated in 25% of total block area as it's occurrence**

Dynamic Ground Water Resources (Aquifer II): 0.387561 **MCM**

Static (in-storage) Resources (Aquifer II): 46.67453 **MCM.**

10.6.4 Chemical Quality of Ground Water & Contamination:

Range of important Chemical Parameters:

Arsenic (As) data are based on 2 random samples of spl. Drive' 15-16 & other routine parameters are based on limited samples of 17-18. As more than 0.01 mg/l, WHO limit of potable water, has not been reported in any well out of 2 tube wells.

Block	As (mg/l)	TH (mg/l)	EC (µS/cm)	F (mg/l)	NO_3 (mg/l)
Sagardighi	**0.0004 – 0.01**	**110-140**	**271-413**	**0.38-0.55**	**0-6**

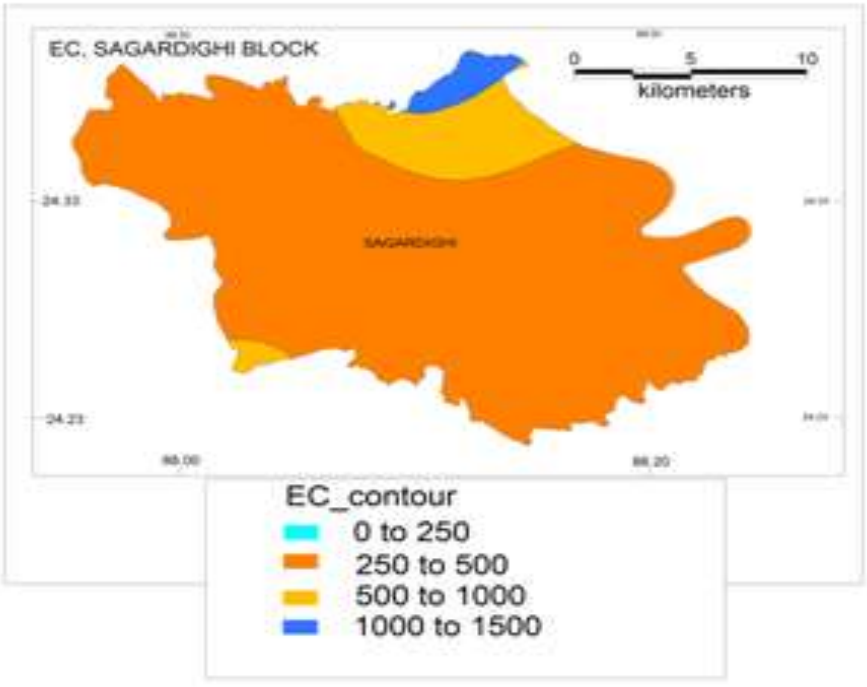


Fig. 10.6.4.1: Electrical Conductivity (EC) in ground water

Arsenic affected Risk Population: Of late arsenic infestation in sa few habitations have been reported.

10.6.5: Major Issues:

1. Very deep water level in deeper aquifer and its long term trend shows alarming fall.
2. Sporadic ground water contamination by arsenic has been reported in Younger Alluvium of Aquifer I (eastern part of block area).
3. High SOD & Semi Critical category of block
4. Irrigation in large area is done by ground water

10.6.6: Ground Water Resource Enhancement& Management Plan:

Ground Water Management Plan for drinking purposes.

Table 10.6.6.1: As infested population & Status of present water supply

Nos. of habitations in risk zone	Whereas As infested	As infested population in 2011	Projected As infested population in 2021	Population already covered	Water (lit.) required for uncovered population @ 70 lpcd
-	Infested (Reported lately)	-	-	1081823	-*

Proposed Interventions:

Sl. No.	Block	Suggestions for providing water supply to the risk population
1	Sagardighi	Deeper aquifers contain potable ground water and are encountered within 40 – 81.99 mbgl; by outsourcing other aquifer zones. eg. 146-152, 170-182,202-205 are also encountered but their potentiality is meagre. However, tube wells in deeper aquifers must be constructed by applying cement sealing technique to avoid leaching of water from Aquifer I at the top, if any. The Aquifer I in Younger Alluvium up to about 25 m depth in eastern part of block, reported to contain ground water contaminated by arsenic at places.

Other options for potable water:

1. Rain water harvesting

2. Installation of arsenic removal plants to make potable water from contaminated first Aquifer.

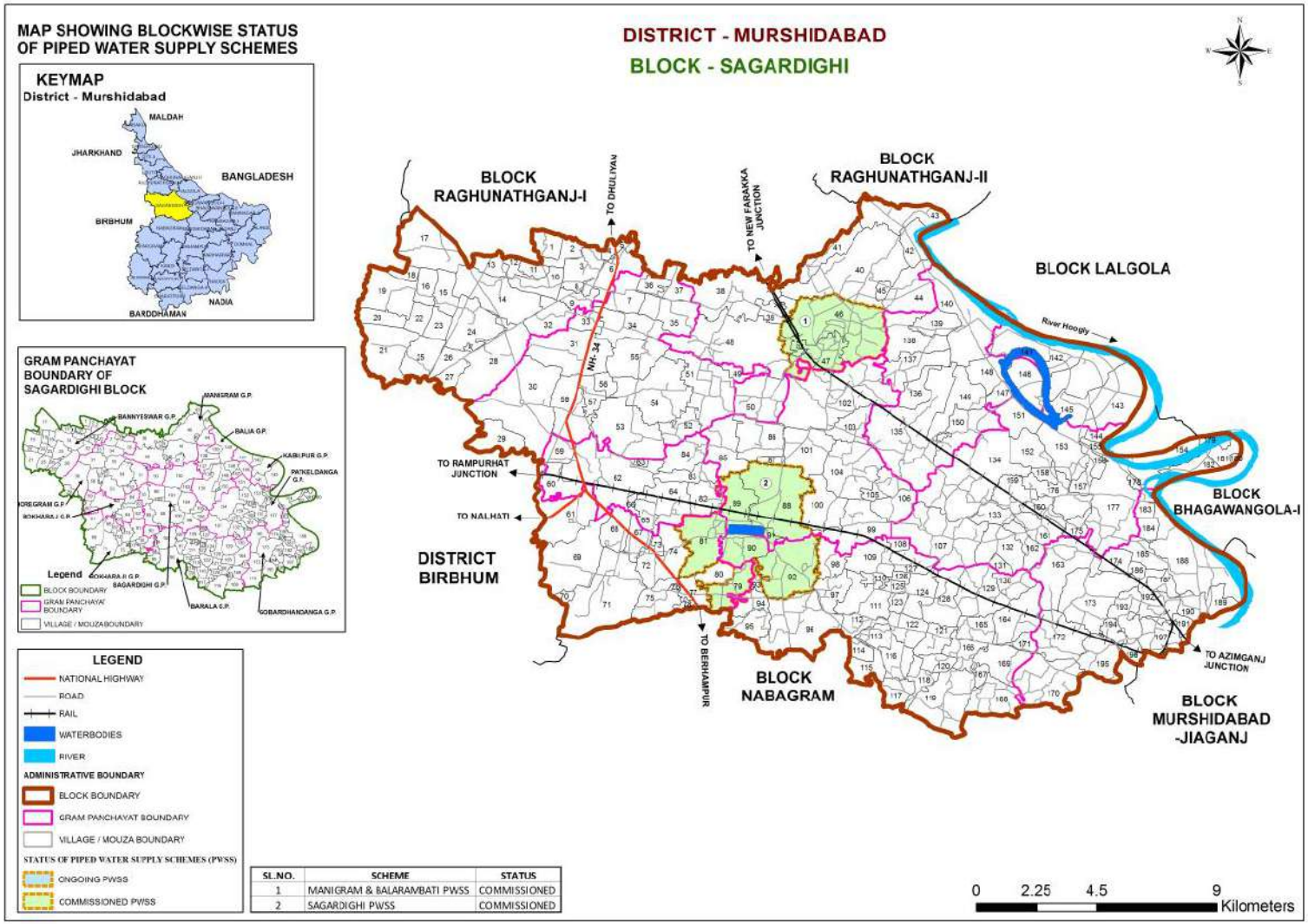


Fig. 10.6.6.1: Pipe water supply schemes

Table 10.6.6.2: Irrigation scenario (Aquifer I) in Sagardighi 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
29297	8686	20611	76.7	**R 1.5**	F 29.9	9.2	7.1	Can be developed for GW based Irrigation

Data of 5th M. I. Census shows:

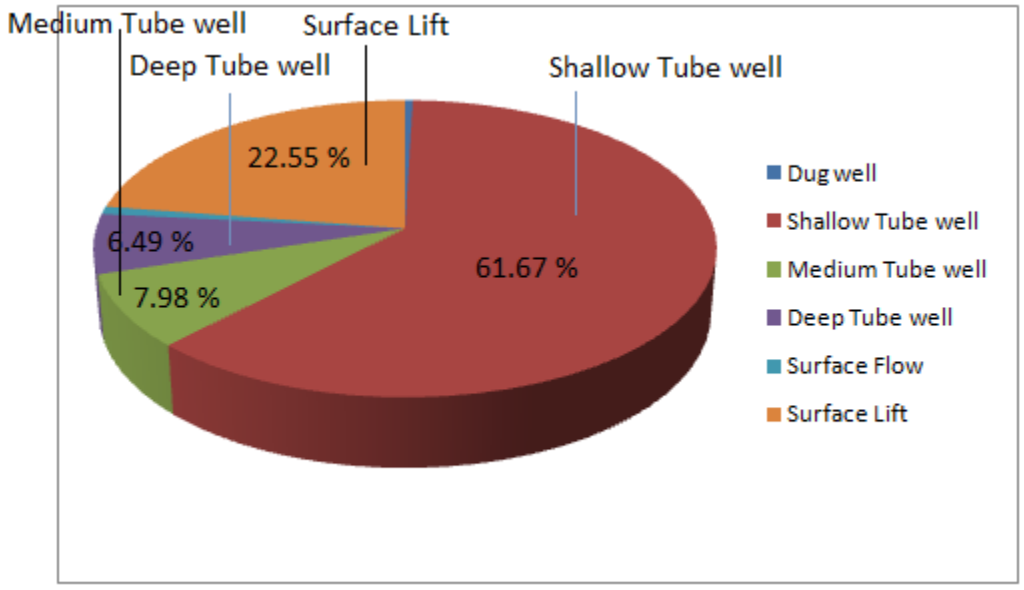


Fig. 10.6.6.2: Percent contribution of CCA by different sources of irrigation

Table. 10.6.6.3: CCA & Percent contribution of CCA by different sources of irrigation

Type of abstraction structures	CCA (Ha)	% of CCA
Dug well	**55**	0.46
Shallow Tube well	7405.66	61.67
Medium Tube well	958.52	7.98
Deep Tube well	779.28	6.49
Surface Flow	102.51	0.85
Surface Lift	2707.3	22.55

Table 10.6.6.4: CCA & sources of irrigation

Block Total / District Total	Dug well		Shallow Tube well		Medium Tube well		Deep Tube well		Surface Flow		Surface Lift		CCA (ha.)		Total CCA (ha.)
	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	Ground Water	Surface Water	
Block Total	5	55	1628	7405.66	179	958.52	74	779.28	18	102.51	498	2707.3	9198.46	2809.81	12008.27
District Total	**178**	**728.67**	**54842**	**127809.47**	**2148**	**11550.1**	**1719**	**33386.23**	**292**	**1592.29**	**1499**	**13037.13**	**173474.51**	**14629.42**	**188103.9**

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

Table 10.6.6.5: Cropping pattern in Sagardighi block

Name of Block	Aus	Aman	Boro	Wheat	Potato	Masur	Maskalai	Jute	Khesari	Til	Mustard	Linseed	Gram
Sagardighi	138	26612	10060	5176	327	618	-	1261	564	0.085	5269	2	640

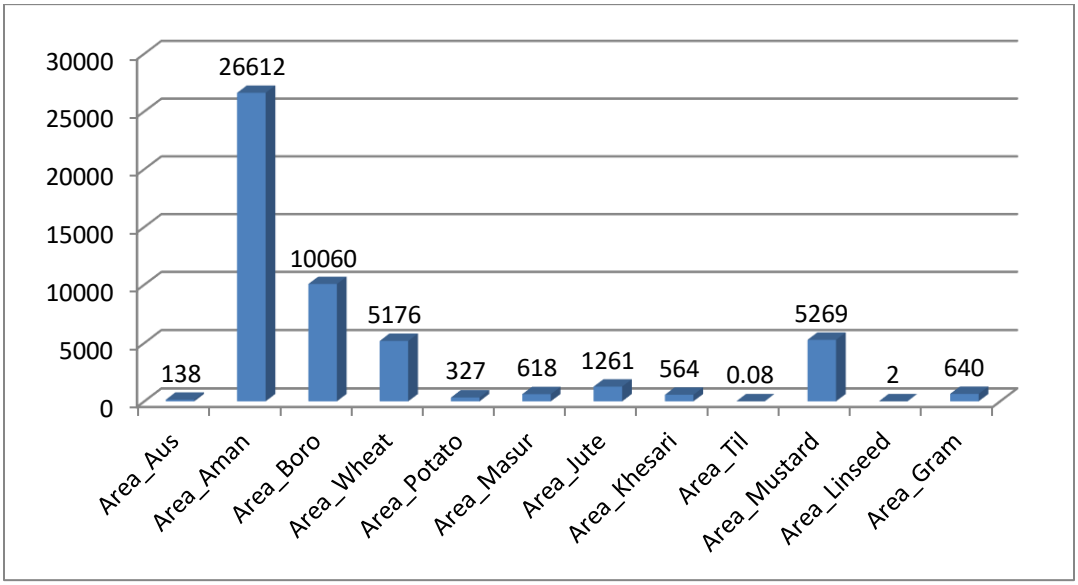


Fig. 10.6.6.3: Graphical representation of Cropping pattern in Sagardighi block

Proposed interventions for irrigation:

- On principle, Boro cultivation is not encouraged. Boro needs 1.2 to 1.4 m.
- Wheat, Pulses & Oil seeds including Til, Ground nut cultivation in upland area could be encouraged; wheat needs about 0.35 m & Pulses & Oil seeds about 0.15 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.
- To improve the ground water scenario, implementation of modern irrigation practices like drip water irrigation system, sprinklers can be made.
- Cultivation of low water requiring crops and change in cropping pattern may be done for better and efficient water management.

- In this block, during Rabi & spring/ summer months, the existing area wise cropping pattern vide **Table 10.6.6.5 & Fig. 10.6.6.3)** is as follows:

  Wheat – 41.09 %, vegetables – 0.026 % (neglisible), Pulses & Oil seeds –56.31 %.
- As per the aforesaid cropping pattern, from the remaining area to be irrigated in 20661 Ha, cultivation proposed: wheat –8489.60 Ha; Pulses & Oil seeds – 11634.21Ha.
- For wheat (@ 0.35 m/ha) & Pulses & Oil seeds (@0.15 m/Ha) estimation shows an amount of 4716.49 Ham of water is needed.
- Ground Water Estimation 2017 shows that there is already a deficit of 20.8901 MCM of ground water from the top aquifer.

  So, there is a deficit of 4716.49 – 2089.01 or 2627.48 Ham; For this rain water harvesting is to be widely implemented (vide Table 10.7.ng may be a solution and the same has been dealt in Chapter 10.6.7.2.

Table 10.6.6.6: Water column recommended 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
Murshidabad	Khargram	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

10.6.7 Scope for rain water harvesting & Artificial recharge:

Using Dhruvanarayana, 1993 method in Sagardighi 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 10.6.7.1a & Table 10.6.7.1b. 4688.04024 Ham 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; by doing this ground water scenario can be improved as well as the inclusive economic growth can be achieved.

Area suitable for recharge in the study area (vide Part I: Plate 6.2.1b):

District	Block Name	Area (in sq. km)	Approx. Area suitable for recharge (sq km.)
MURSHIDABAD	Sagardighi	345.42	259.00

Utilization of Harvested Rain Water: Table 10.6.7.1a shows that 4688.04024 Ham of rain water could be harvested in Sagardighi block. In Fig. 10.6.7.1 land use & land cover in this block has been shown; from it it is visualized that the land is suitable for even for double / multi-crop cultivation. The amount of 46.8804 MCM of rain water can be utilized in following ways:

For storing of rain water in constructed tanks, a total land of 1406 ha with 3 m depth is required (by keeping aside 10 % of 4688.04024 Ham water as wastage by spillage, etc.). The remaining amount of harvested water i.e. 4219.04024 Ham can be utilized to negotiate the deficit of water for irrigation as mentioned above under Proposed interventions for Irrigation.

Efforts 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 10.6.7.2, 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.

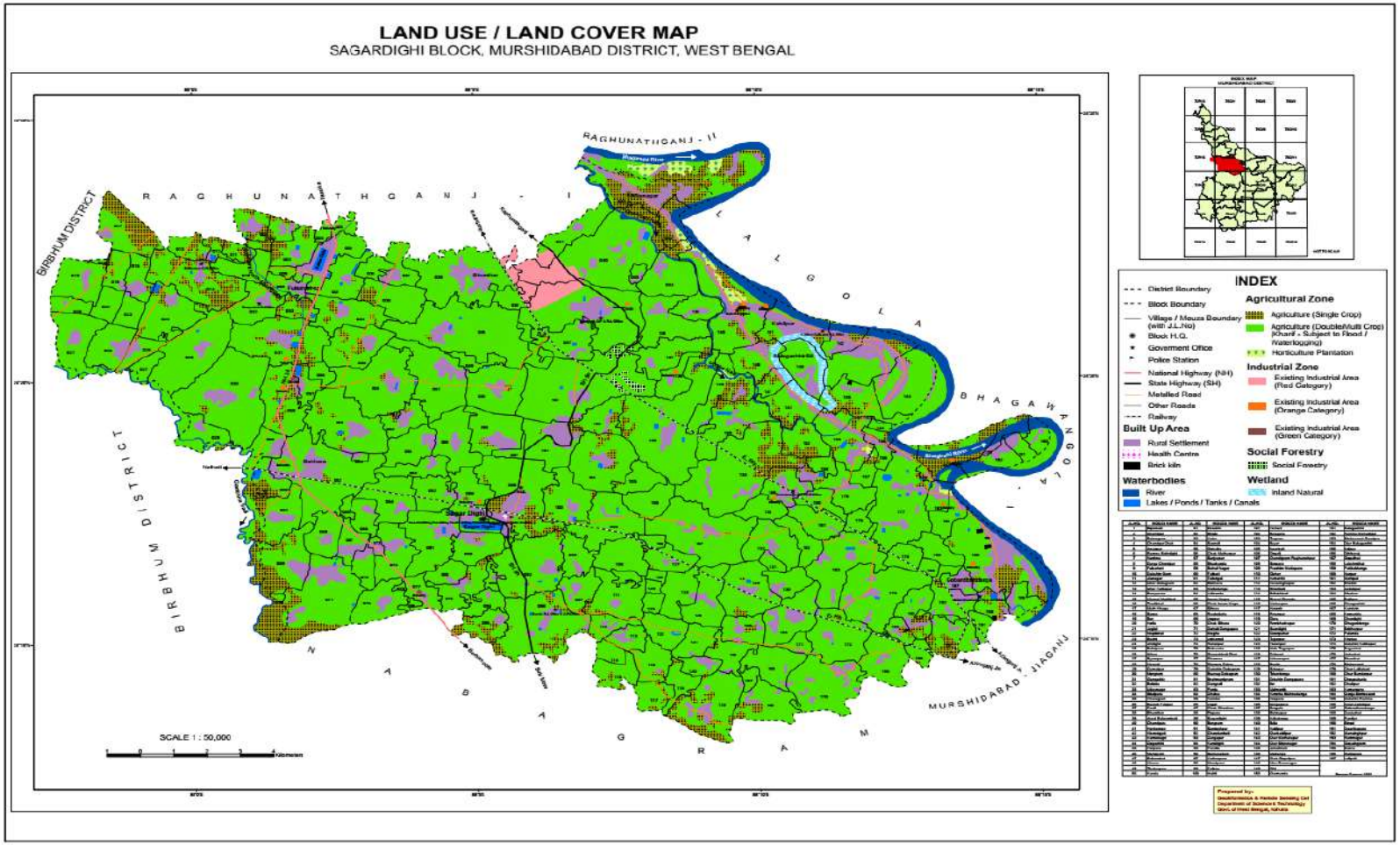


Fig. 10.6.7.1: Land use/ land cover in Sagardighi block

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

Proposed Rain Water Harvesting & Artificial Recharge in the Study area:

Table 10.6.7.1a: Estimation of harvested rain water in Sagardighi 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 (considering e-flow) = Vf Ham
1.04	34542	35923.68	0.58	1.80 % moderately well drained sandy soil, 86.11% imperfectly drained loamy soil & 11.59 % imperfectly drained fine sand	20835.7344	15626.8008	7813.4004	4688.04024

Table 10.6.7.1b: Proposed Artificial Recharge & conservation Structures in Sagardighi block:

Amount of water for artificial recharge and / or conservation (Ham) (4)	Source water allocation for Percolation Tank and REET with Recharge Shaft in Ham (5)	Source water allocation for REET with Recharge Shaft (Ham): 50 % of Col. 5 (6)	Source water allocation for Irrigation Cum Recharge Tank (Ham): 50 % of Col. 5 (7)	Source water allocation for Injection Well (8)	Source water allocation for Farm/Conservation Pond in Ham (9)	Nos. of REET with Recharge Shaft suggested @ 10 Ham per unit (10)	Nos. of Irrigation Cum Recharge Tank suggested @ 50 Ham per unit (11)	Nos. of injection wells @ 30 Ham per unit (12)	Nos. of Farm/conservation ponds @ 10 Ham per unit (13)	Cost of REET with Recharge Shaft @ Rs 8 lakh per unit (14)	Cost of Irrigation cum Recharge tank @ Rs 8 lakh per unit (15)	Cost of Injection wells @ Rs 8 lakh per unit (16)	Cost of Farm pondnjection wells @ Rs 8 lakh per unit (17)	Total Cost
4688.04024	70 % of Col. 4 i.e. 3281.63 Ham	1640.82	1640.82	20 % of Col. 4 i.e. 656.33 Ham	10 % of Col. 4 i.e. 468.80 Ham	164	33	22	47	1312	264	176	376	2128

Table **10.6.7.2: Proposed change in cropping pattern in Sagardighi 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 (Kg of Boro paddy) due to reduction in area of Boro cultivation yield rate 3613.69 kg/ Ha (in M. Ton)**	**Proposed cropping in 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 & Ground nut @ 2309.39 kg/Ha**	**Increase in area of wheat cultivation in winter (at least 10% more of existing area of 5176 Ha for wheat, i.e. 517.6 Ha) yield rate 2864.41 kg/ Ha (M. Ton)**
(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)	(IX)
10060	1.3 m	130.78	1006	13.08	3635.37	Til & Ground nut in 503 Ha each	Til- 458.36 & Ground nut- 1161.62	1482.62

Ground water draft for til & ground nut, =1006*0.15=1.51 MCM; Ground water draft for wheat = 517.6*0.22 = 1.14 MCM; **actual ground water saved = 10.43 MCM; Boro paddy loss = 3635.37 kg; Gain of Til, Ground nut & wheat = 3102.6**

Water saved: 13.08 MCM; Area yet to be covered by irrigation: 20611 Ha; To grow Vegetables in remaining area i.e. 20093.4 Ha = 20093.4* 0.11 or 22.1027 MCM. Remaining water needed for complete coverage under irrigation i.e. 9.0227 MCM could be met by the rain water harvested as mentioned in Section 10.6.7.

10.7: NABAGRAM BLOCK

10.7.1 Salient Information:

Block Name: NABAGRAM

Area (in Km^2): 306.63

District: Murshidabad

State: West Bengal

Population (as on 2011):

Rural	Urban	Total
227586	-	227586

Approximate Decadal Growth Rate: **22.75 per cent** during the 1991-2001 & 15.76% in 2001-2011.

Rainfall:

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

District	Normal – 2014 (in mm)	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):

Sl. No	Name of the Block	Geographic Area	Cultivable Area	Area under pasture & orchard	Cultivable Waste Land	Forest Land
1.	Nabagram	306.63	256.45	-	0.06	1.84

(Source: Dept. of Agriculture, Govt. of West Bengal)

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

Resource Availability	Aquifer I*	Aquifer II	Current Annual G W Extraction (MCM) (Aquifer I)
Dynamic Resource	-	4.65866	-
Static Resource	-	167.46367	-

***In Nabagram block, phreatic aquifer has not found to occur in significant part.**

10.7.2 Disposition of Aquifer:

Depth range of aquifers:

Block	Depth range of Aquifer in m bgl	
Nabagram	**Aquifer II**	**Aquifer III**
	12 – 80	105-155 (Fine silt)

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

Sl. No.	Block	Aquifer	Pre-monsoon Trend			Post-monsoon Trend		
			Water Level Range (m bgl)	**Rise (m/year)**	**Fall (m/year)**	Water Level Range (m bgl)	**Rise (m/year)**	**Fall (m/year)**
1.	Nabagram	II	21.3 – 34.4	-	0.437 – 0.735	17.85 - 31.5	-	0.521 – 0.85
2.	Nabagram	III	-	-	-	-	-	-

Average Thickness of Aquifer (Maximum):

Block	Area (sq km)	Thickness (m) of the Granular Zone in Aquifer II	Thickness (m) of the Granular Zone in Aquifer III
Nabagram	306.63	64.04	15 (Fine silt)

Aquifer-wise Statement

Name of Block	Aquifer II			Aquifer III		
	Depth Range (m bgl)	Discharge (m^3/hr)	T (m^2/day)	Depth Range (m bgl)	Discharge (m^3/hr)	T (m^2/day)
Nabagram	12 -80	184.1 – 216.8	2248 - 3368	105 - 155	-	-

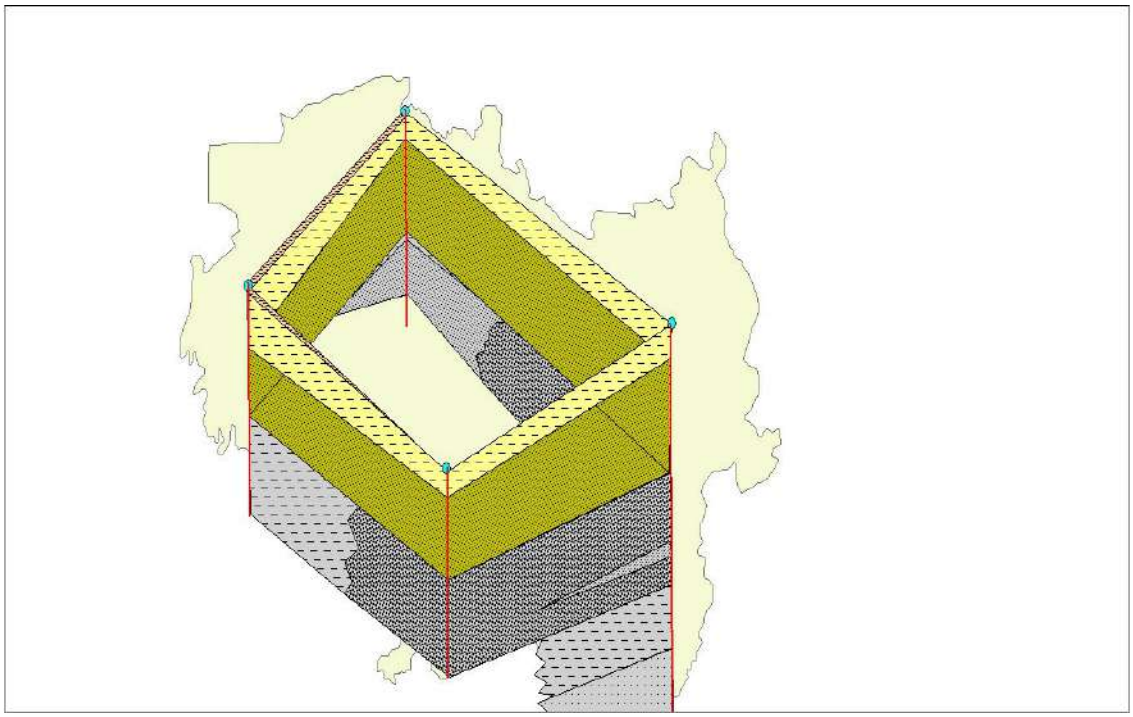


Fig. 10.7.2.1: Lithological characteristic in successive aquifers in Nabagram Block

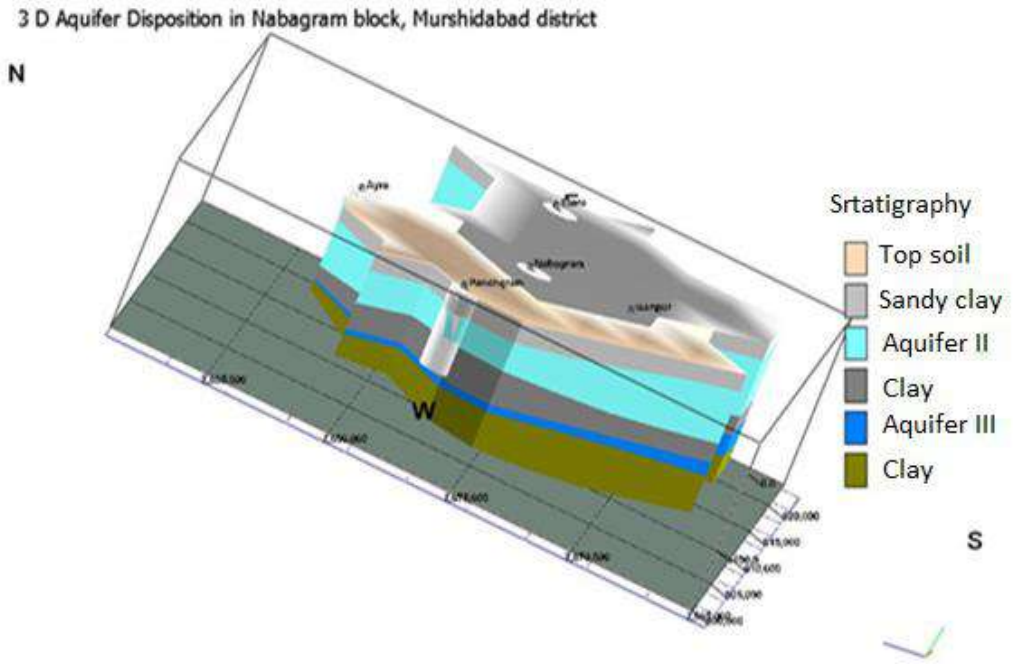


Fig. 10.7.2.2: 3 D Aquifer disposition in Nabagram block

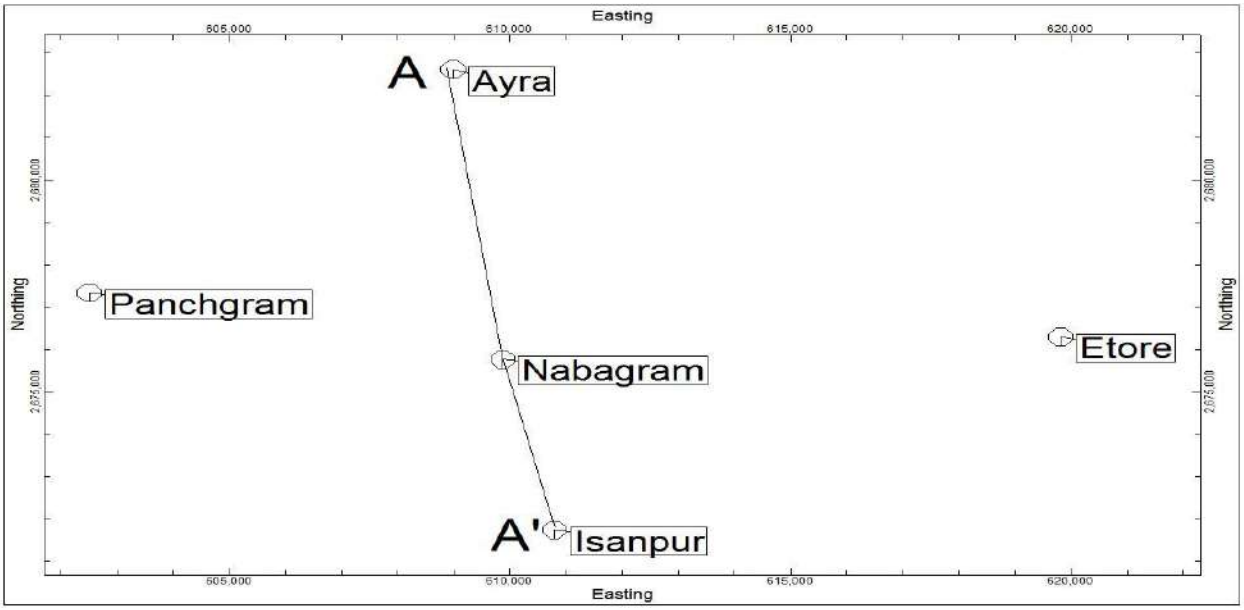


Fig. 10.7.2.3: N – S Section Index Line in Nabagram block

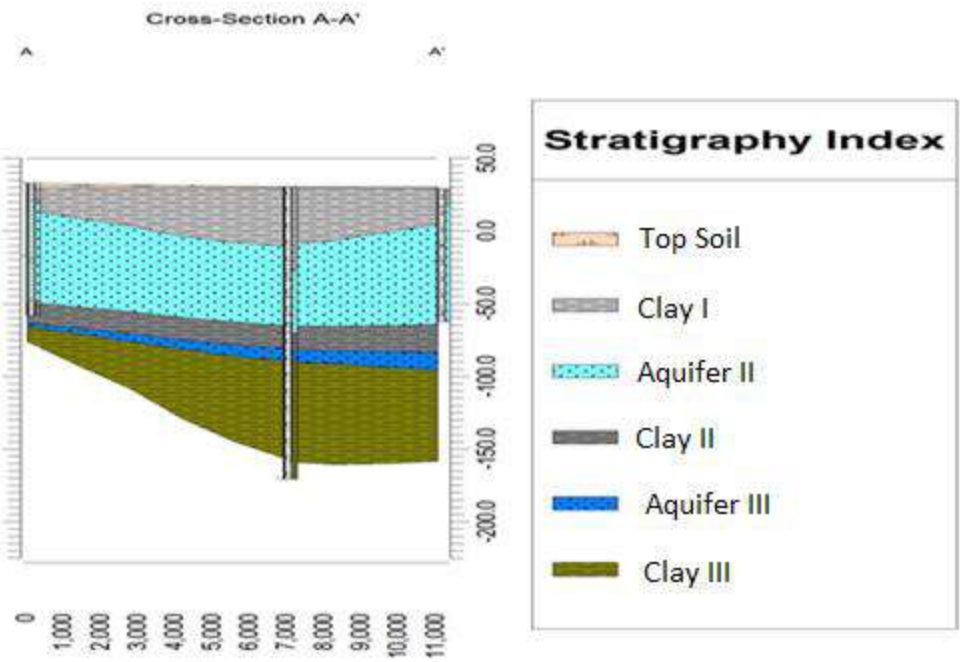


Fig. 10.7.2.3A: N – S Section in Nabagram block

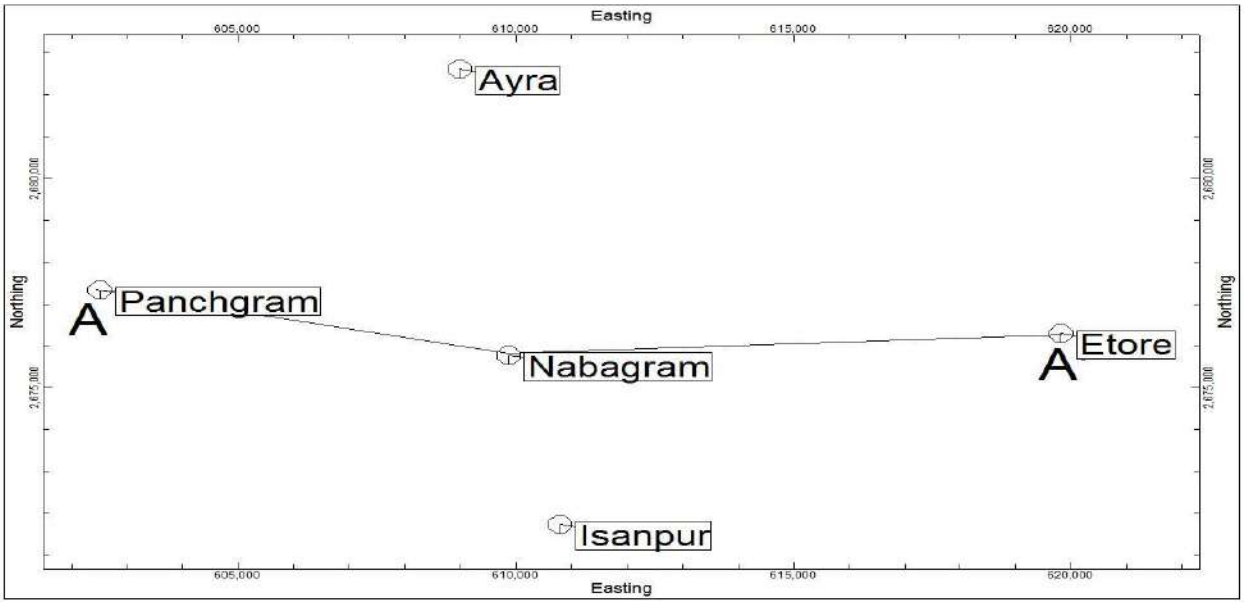


Fig. 10.7.2.4: W-E Section Index Line in Nabagram block

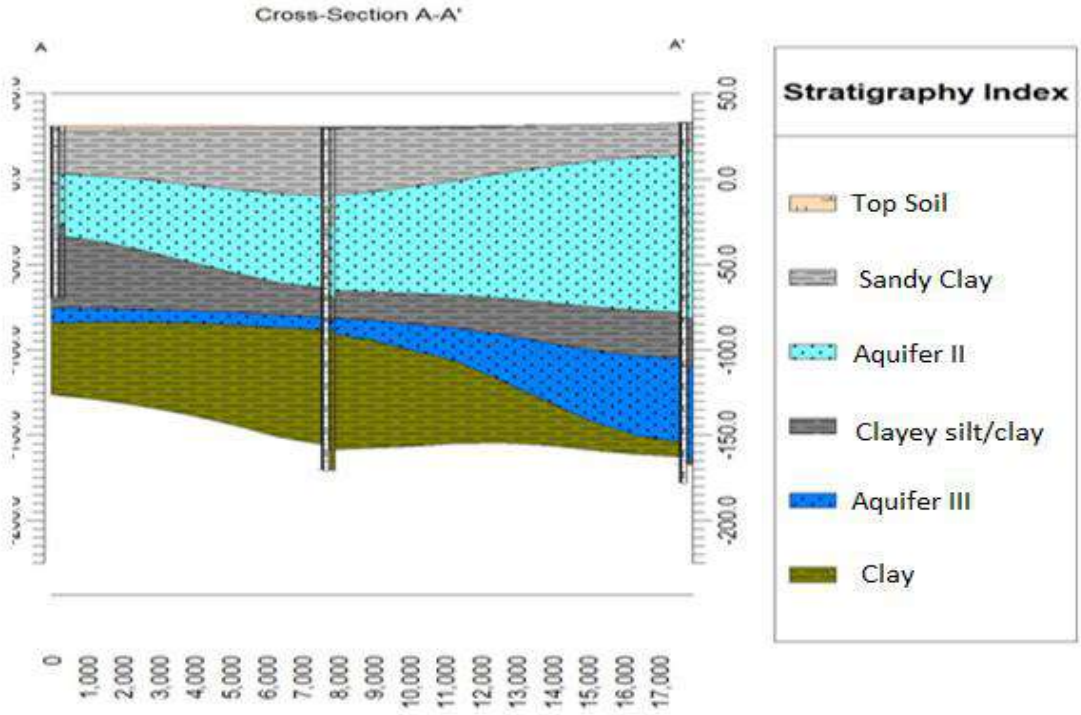


Fig. 10.7.2.4A: W – E Section in Nabagram block

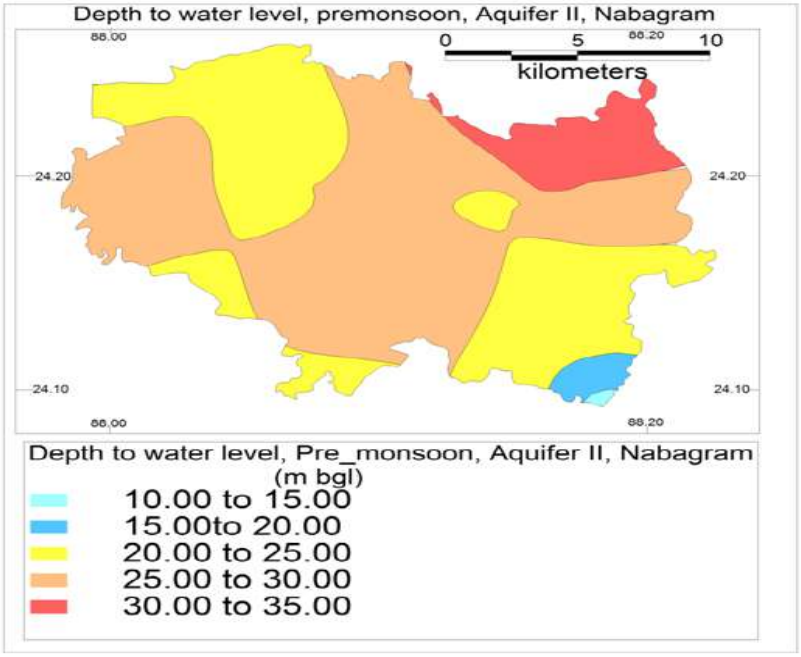


Fig. 10.7.2.5: Depth to water level, pre monsoon, Aquifer II

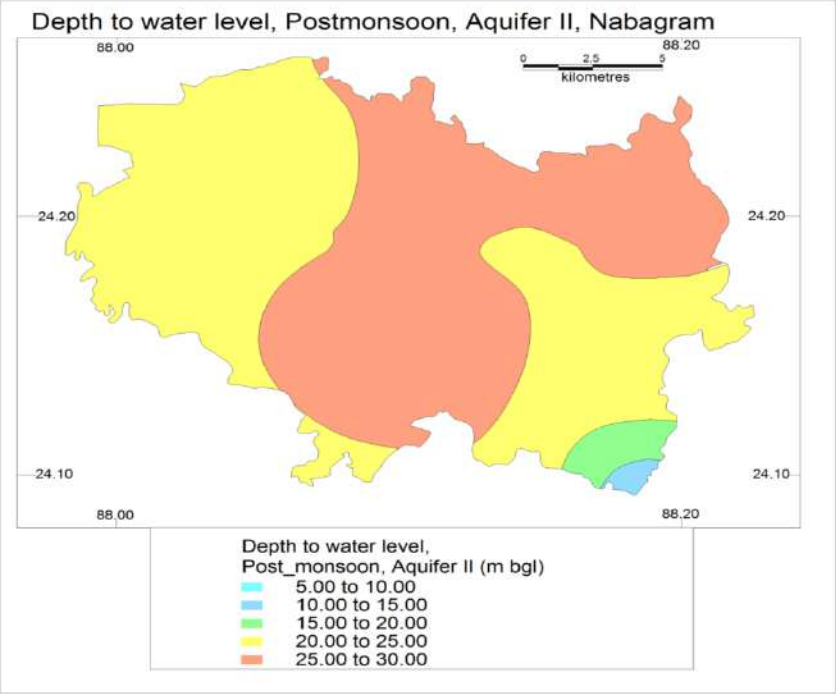


Fig. 10.7.2.6: Depth to water level, post monsoon, Aquifer II

10.7.3: Ground Water Resource & status of Extraction:

Aquifer Wise Resource Availability & Extraction:

Dynamic Phreatic aquifer (Aquifer I) has not been found to occur in significant part of Nabagram block. However, Ground Water Estimation Committee has estimated resources of top (Aquifer II ?) aquifer as follows:

Block	Annual Extractable Ground Water Recharge (MCM)	Current annual Ground Water Extraction (MCM)	Stage of development (%)	Category	Annual GW Allocation for Domestic Use as on 2042	Ground water availability for future use (MCM)
Nabagram	10091.73	7531.8	72.85	Semi - Critical	407.91	2594.02

Dynamic Ground Water Resources (Aquifer II): 4.65866 **MCM**

Static (in-storage) Resources (Aquifer II): 167.46367 **MCM.**

10.7.4: Chemical Quality of Ground Water & Contamination:

Range of important Chemical Parameters:

Arsenic (As) data are based on 6 random samples of spl. Drive' 15-16 & other routine parameters are based on limited samples of 17-18. As more than 0.01 mg/l, WHO limit of potable water, has been reported in 1 out of 6 wells (6 tube wells). Maximum has been encountered at Gurah Pashla.

Block	As (mg/l)	TH (mg/l)	EC (µS/cm)	F (mg/l)	NO_3 (mg/l)
Nabagram	**0.0 – 0.026**	**95-140**	**266-596**	**0.49-0.88**	**0-1**

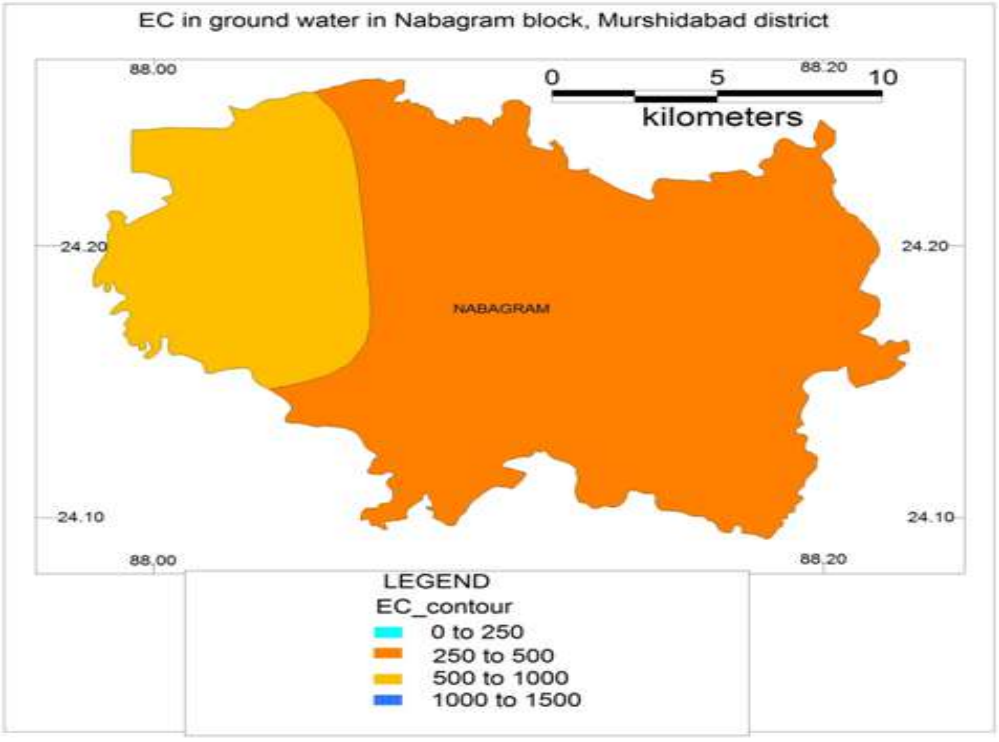


Fig. 10.7.4.1: Electrical Conductivity (EC) in ground water in Nabagram block

Arsenic affected Risk Population (based on PHED hand pump data):

Based on analytical data, Nabagram block is not considered to be infested by arsenic. Hence, Risk

population has not been estimated.

10.7.5: Major Issues:

1. Very deep water level and long term water level shows falling trend.

2. Irrigation is mainly done by ground water.

3. SWID & CGWB has estimated very high Stage of Development (72.85 %) based on estimation of top aquifer and this block has been categorised as Semi Critical.

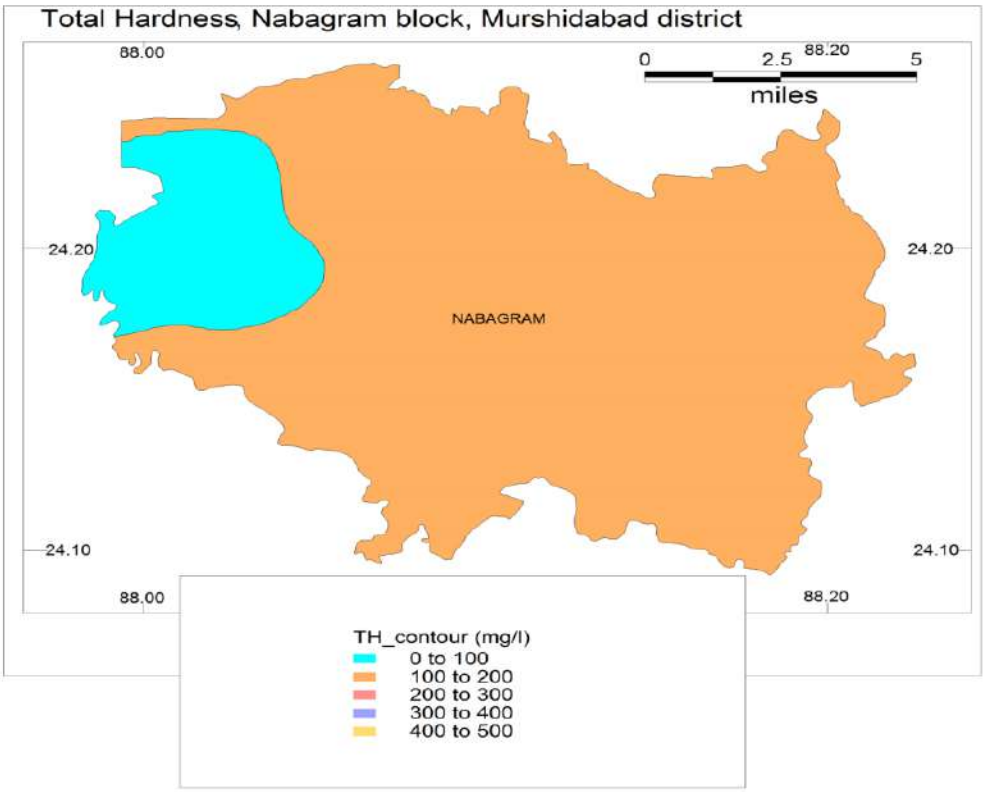


Fig. 10.7.4.2: Total Hardness (TH) in ground water in Nabagram block

10.7.6: Ground Water Resource Enhancement& Management Plan:

Ground Water Management Plan for drinking purposes

Table 10.7.6.1: As infested population & Status of present water supply

Nos. of habitations in risk zone	Whereas As infested	As infested population in 2011	Projected As infested population in 2021	Population already covered	Water (lit.) required for uncovered population @ 70 lpcd	Nos. of TWs required considering each TW's discharge of 12.5 lps& 8 hrs. run per day
-	**Not infested**	-	-	**80647**	-	-

Proposed Interventions for potable water:

Sl. No.	Block	Suggestions for providing water supply to the risk population
1	Nabagram	Potential aquifers are encountered within a depth of 12 – 80 m. Beneath this, another aquifer is also encountered within a depth of 148 m bgl, but, this one is silt type. • Surface water is an alternative source.

Other options for potable water:

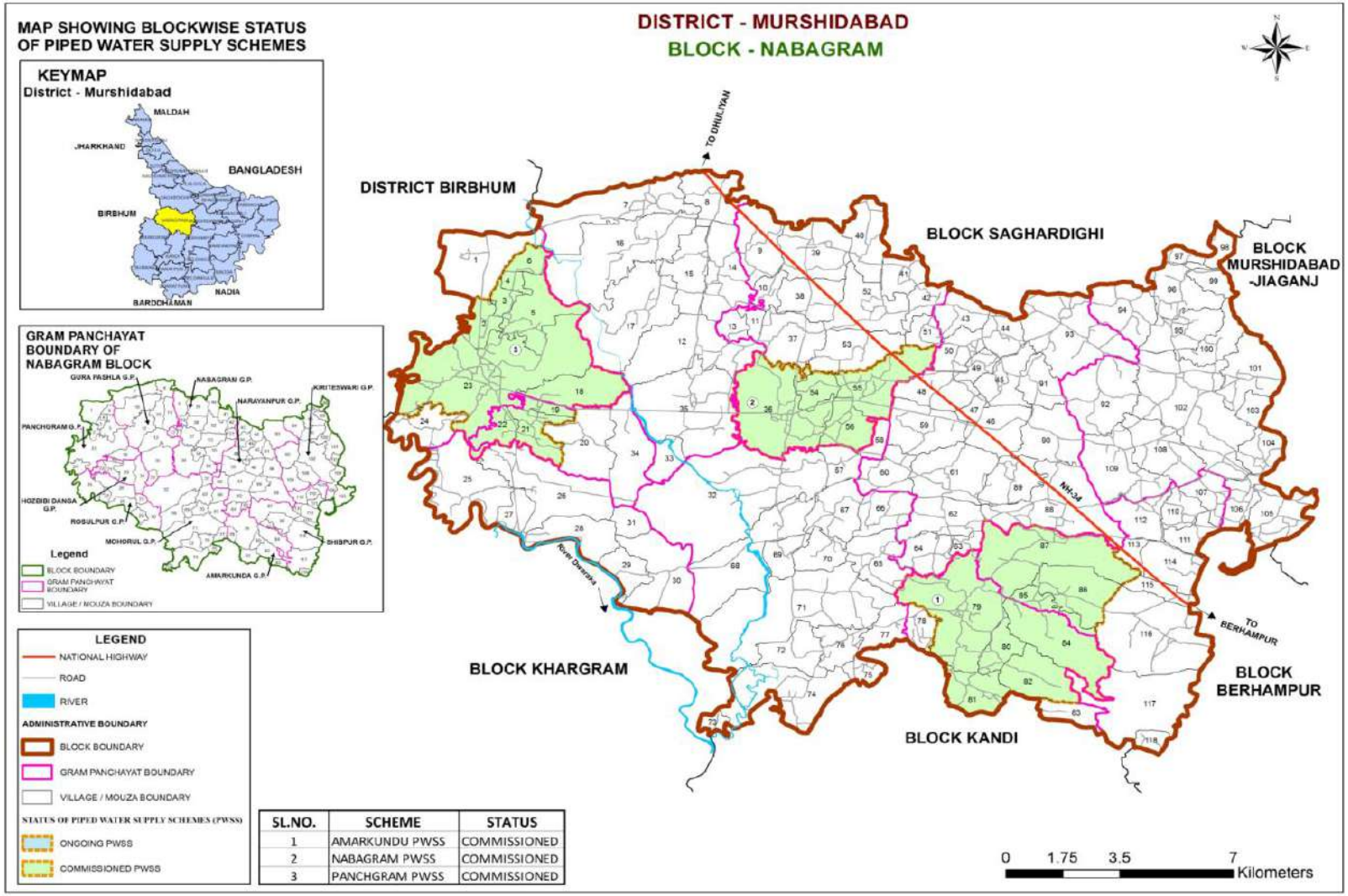
1. Rain water harvesting

2. Installation of arsenic removal plants to make potable water from contaminated first Aquifer.

Ground Water Management Plan for Irrigation purpose

Table 10.7.6.2: Irrigation scenario (Aquifer II) in Nabagram block

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 m bgl	Average Post monsoon WL in m bgl	Remarks for GW Management Plan
1	Nabagram	25645	17427	8218	72.85	**F 0.59**	F 0.69	26.97	25.28	Can be developed for GW based Irrigation



SL.NO.	SCHEME	STATUS
1	AMARKUNDU PWSS	COMMISSIONED
2	NABAGRAM PWSS	COMMISSIONED
3	PANCHGRAM PWSS	COMMISSIONED

(Source: PHED, Govt. of West Bengal)

Fig. 10.7.6.1: Pipe water supply schemes in Nabagram block

Data if 5th M. I. Census shows:

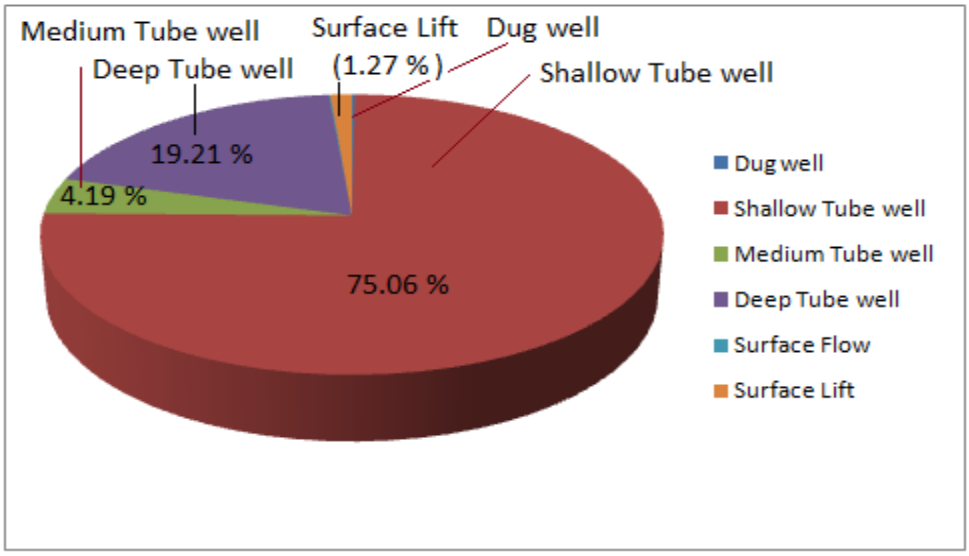


Fig. 10.7.6.2: Percent contribution of different sources of irrigation

Table 10.7.6.3: Percent contribution of different sources of irrigation

Type of abstraction structures	CCA (Ha)	% of CCA
Dug well	**20.69**	0.18
Shallow Tube well	8634.37	75.06
Medium Tube well	481.97	4.19
Deep Tube well	2209.46	19.21
Surface Flow	10	0.09
Surface Lift	146.16	1.27

Table 10.7.6.4: CCA & sources of irrigation

Block Total / District Total	Dug well		Shallow Tube well		Medium Tube well		Deep Tube well		Surface Flow		Sarface Lift		CCA (ha.)		Total CCA (ha.)
	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	Ground Water	Surface Water	
Block Total	6	20.69	1480	8634.37	57	481.97	159	2209.46	1	10	6	146.16	11346.49	156.16	11502.65
District Total	178	728.67	54842	127809.47	2148	11550.14	1719	33386.23	292	1592.29	1499	13037.13	173474.51	14629.42	188103.9

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

Table 10.7.6.4: Cropping pattern in Nabagram block

Name of Block	Aus	Aman	Boro	Wheat	Potato	Masur	Maskalai	Jute	Khesari	Til	Mustard	Linseed	Gram
Nabagram	2177	16878	13907	6013	476	739	22	532	602	0.292	6887	43	749

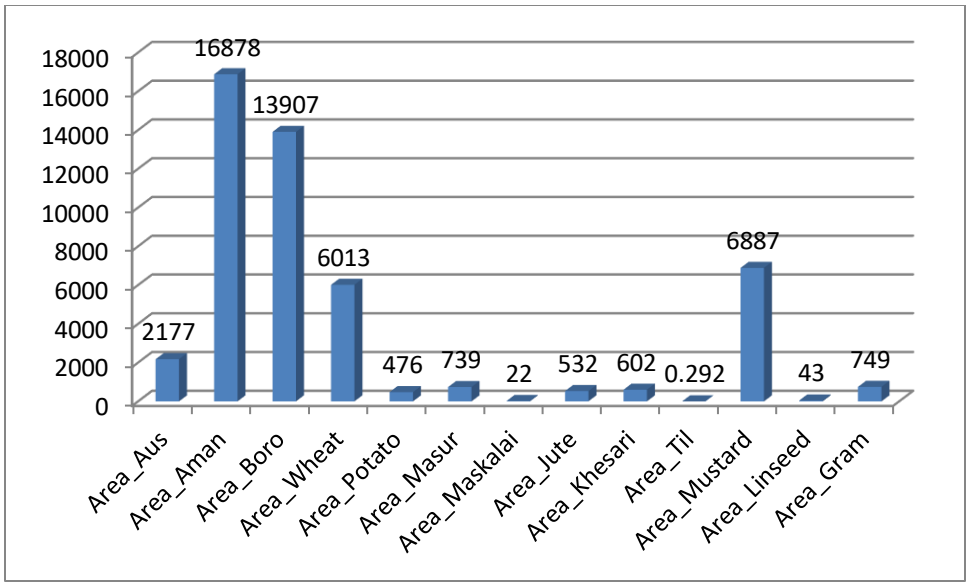


Fig. 10.7.6.3: Graphical representation of Cropping pattern in Nabagram Block

Area suitable for recharge in the study area:

District	Block Name	Area (in sq. km)	Total Area suitable for recharge (sq km.)
MURSHIDABAD	Nabagram	306.63	306.63

Proposed interventions for irrigation:

- On principle, Boro cultivation is not encouraged. Boro needs 1.2 to 1.4 m.
- Wheat, Pulses & Oil seeds including Til, Ground nut cultivation in upland area could be encouraged; wheat needs about 0.35 m & Pulses & Oil seeds about 0.15 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.
- To improve the ground water scenario, implementation of modern irrigation practices like drip water irrigation system, sprinklers can be made.

- Cultivation of low water requiring crops and change in cropping pattern may be done for better and efficient water management.
- In this block, during Rabi & spring/ summer months, the existing area wise cropping pattern (vide **Table 10.7.6.4 & Fig. 10.7.6.3)** is as follows:

  Wheat – 38.72 %, vegetables –.031 % (neglisible), Pulses & Oil seeds – 58.22 %.
- As per the aforesaid cropping pattern, from the remaining area to be irrigated of 8218 Ha, cultivation proposed: wheat – 3182.00 Ha; Pulses & Oil seeds – 4784.52 Ha.
- For wheat (@ 0.35 m/ha) & Pulses & Oil seeds (@0.15 m/Ha) estimation shows an amount of 1831.378 Ham of water is needed.
- Ground Water Estimation 2017 shows ground water resource of 2594.02 Ham available from the top aquifer.

  So, there is enough water for covering remaining are of cultivable area.

10.7.7 Scope for rain water harvesting & Artificial recharge:

Using Dhruvanarayana, 1993 method in Nabagram 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 10.7.7.1a & Table 10.7.7.1b. 4161.58236 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; by doing this ground water scenario can be improved as well as the inclusive economic growth can be achieved.

Area suitable for recharge in the study area (vide Part I: Plate 6.2.1b):

District	Block Name	Area (in sq. km)	Total Area suitable for recharge (sq km.)
MURSHIDABAD	Nabagram	318.45	318.45

Utilization of Harvested Rain Water: Table 10.7.7.1a shows that 4161.58236 Ham of rain water could be harvested in Nabagram block. In Fig. 10.7.7.1, land use & land cover in this block has

been shown; from it it is visualized that the land is suitable for even for double / multi-crop cultivation. The amount of 41.61582 MCM of rain water can be utilized in following ways:
For storing of rain water in constructed tanks, a total land of 1248 ha of 3 m depth is required (by keeping aside 10 % of 41.61582 MCM water as wastage by spillage, etc.). The remaining amount of harvested water i.e. 3745.42 Ha can be utilized to irrigate agricultural land in future.

Efforts 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 10.7.7.2, 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.

Proposed Artificial Recharge Structures in the Study area:

Table 10.4.a: Calculation of harvested rain water in Nabagram 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 (considering e-flow) = Vf Ham
1.04	30663	31889.52	0.58	5.35 % moderately well drained sandy soil, 94.31 % imperfectly drained loamy soil & 0.34 % imperfectly drained fine sand	18495.9216	13871.9412	6935.9706	4161.58236

Table 10.4. b: Proposed Artificial Recharge & conservation Structures in Nabagram block:

Amount of water for artificial recharge and / or conservation (Ham) (4)	Source water allocation for Percolation Tank and REET with Recharge Shaft in Ham (5)	Source water allocation for REET with Recharge Shaft (Ham): 50 % of Col. 5 (6)	Source water allocation for Irrigation Cum Recharge Tank (Ham): 50 % of Col. 5 (7)	Source water allocation for Injection Well (8)	Source water allocation for Farm/Conservation Pond in Ham (9)	Nos. of REET with Recharge Shaft suggested @ 10 Ham per unit (10)	Nos. of Irrigation Cum Recharge Tank suggested @ 50 Ham per unit (11)	Nos. of injection wells @ 30 Ham per unit (12)	Nos. of Farm/conservation ponds @ 10 Ham per unit (13)	Cost of REET with Recharge Shaft @ Rs 8 lakh per unit (14)	Cost of Irrigation cum Recharge tank @ Rs 8 lakh per unit (15)	Cost of Injection wells @ Rs 8 lakh per unit (16)	Cost of Farm pondnjection wells @ Rs 8 lakh per unit (17)	Total Cost
4161.58236	70 % of Col. 4 i.e. 2913.11 Ham	1456.56	1456.56	20 % of Col. 4 i.e. 832.32 Ham	10 % of Col. 4 i.e. 416.16 Ham	146	29	28	42	1168	232	224	336	1960

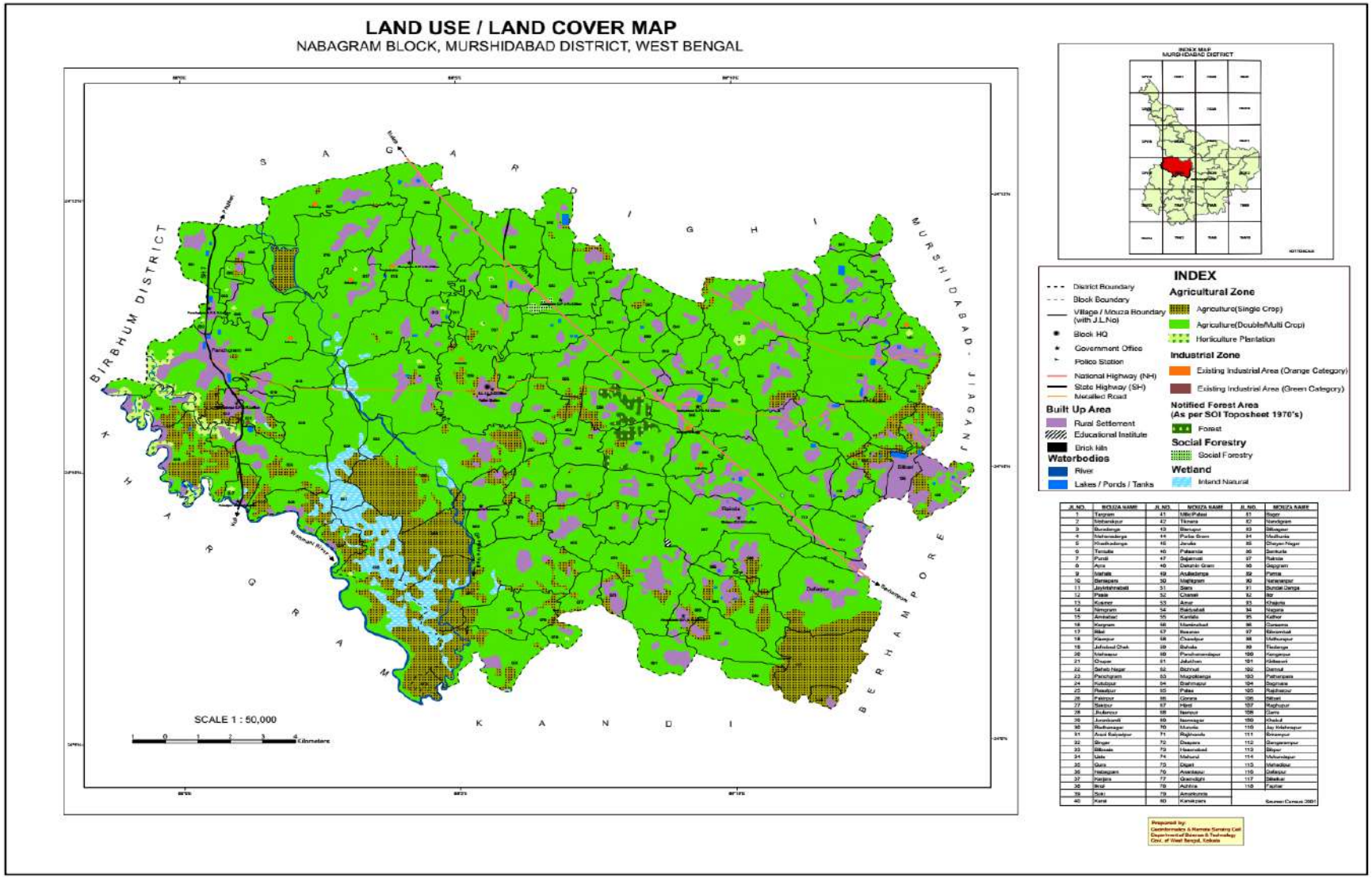


Fig. 10.7.7.1: Land use/ land cover in Nabagram block

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

Table **10.7.7.2: Proposed change in cropping pattern in Nabagram 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 (Kg of Boro paddy) due to reduction in area of Boro cultivation yield rate 3613.69 kg/ Ha (in M. Ton)**	**Proposed cropping in 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, & Ground nut @ 2309.39 kg/Ha**	**Increase in area of wheat cultivation in winter (at least 10% more of existing area of 6013 Ha for wheat, i.e. 601.3 Ha) yield rate 2864.41 kg/ Ha (M. Ton)**
(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)	(IX)
13907	1.3 m	180.79	1390.7	18.08	5025.559	Til & Ground nut in 695.35 Ha each	Til – 633.645 Ground nut- 1605.834	1722.370

Ground water draft for til & ground nut, = 1390.7*0.15 = 2.09 MCM; Ground water draft for wheat = 601.3*0.22 = 1.323 MCM; **actual ground water saved = 14.667 MCM; Boro paddy loss = 5025.559 M. Ton; Gain of Til, Ground nut & wheat = 3961.849 M. Ton**

Water saved: 14.667 MCM

10.8: Khargram

10.8.1 Salient Information

Area (in Km^2): 318.45

District: Murshidabad

State: West Bengal

Population (as on 2011):

Rural	Urban	Total
273332	-	273332

Approximate Decadal Growth Rate: **16.04 per cent** during the 1991-2001 &**16.42%** in 2001-2011.

Rainfall:

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

District	Normal – 2014 (in mm)	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):

Sl. No	Name of the Block	Geographic Area	Cultivable Area	Area under pasture & orchard	Cultivable Waste Land	Forest Land
1.	Khargram	318.45	261.89	-	0.02	-

(Source: Dept. of Agriculture, Govt. of West Bengal)

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

Resource Availability	Aquifer I	Aquifer II	Current Annual G W Extraction (MCM) (Aquifer I)
Dynamic Resource	61.4062*	4.122526	61.3639
Static Resource	33.82**	136.55868	-

*** Phreatic aquifer has been to occur in part of Khargram block only; however the data estimated by SWID and CGWB are given**

**** Data estimated based on 15 % block area of occurrence**

Disposition of Aquifer:

Depth range of aquifers:

Block	**Depth range of Aquifer in m bgl**		
Khargram	**Aquifer I (occurs in small part)**	**Aquifer II**	**Aquifer III**
	Up to 30 m	9.70 – 67.07	131-153, 165 – 171, 281 – 287

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

Sl. No.	**Block**	Aquifer	**Pre-monsoon Trend**			**Post-monsoon Trend**		
			Water Level Range (m bgl)	**Rise (m/year)**	**Fall (m/year)**	Water Level Range (m bgl)	**Rise (m/year)**	**Fall (m/year)**
1	Khargram	I	9.1 -11.03	-		6.5 – 7.50	-	
2.	Khargram	II	16.42 – 25.95	-	0.516 – 0.90	14.53 – 24.10	-	0.283 – 1.10
3.	Khargram	III	19.28 – 21.70	-				

Average Thickness of Aquifer:

Block	Area (sq km)	Thickness of the Granular Zone in Aquifer I (m)	Thickness of the Granular Zone in Aquifer II (m)	Thickness of the Granular Zone in Aquifer III (m)
Khargram	318.45	30	58.25	38

Aquifer-wise Statement

Name of Block	**Aquifer I**			**Aquifer II**			**Aquifer III**		
	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)**
Khargram	Up to 30 m	30-40	-	9.70 – 67.07	17.15 – 615	2248	126 – 153, 165 – 171, 281 - 287	17.15 – 58.38	17.90 - 286

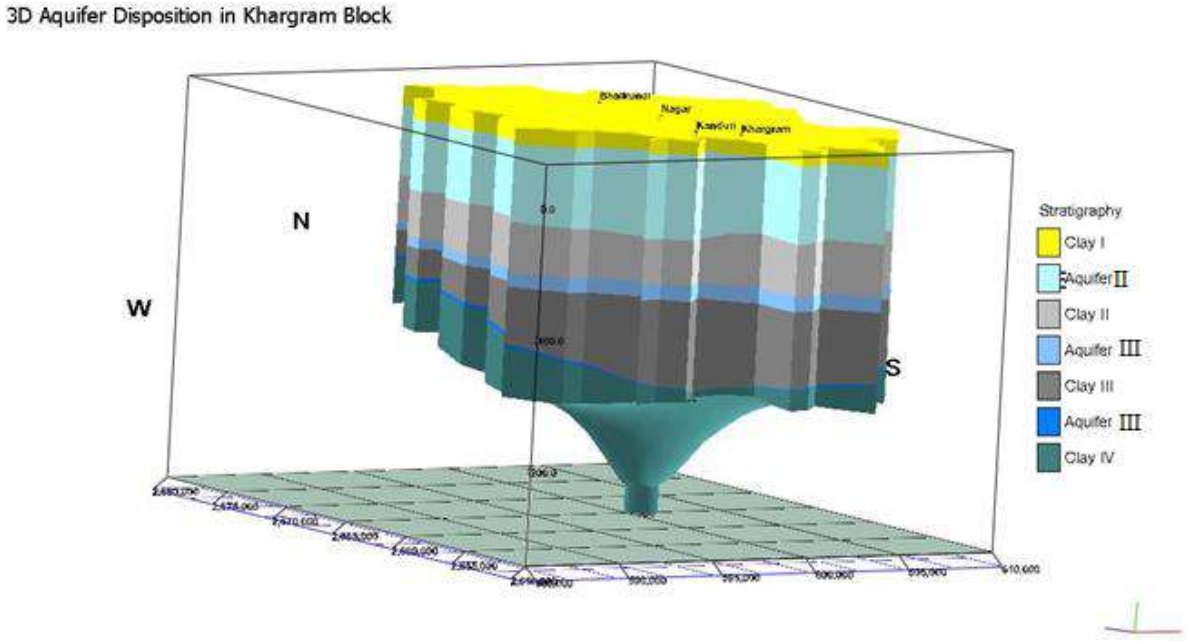


Fig. 10.8.2.1: 3D Aquifer disposition in Khargram block

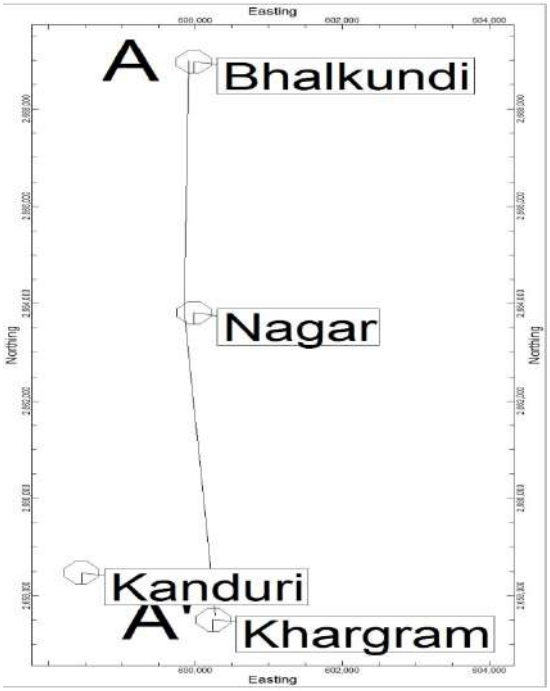


Fig. 10.8.2.2: N – S Section Index Line in Khargram block

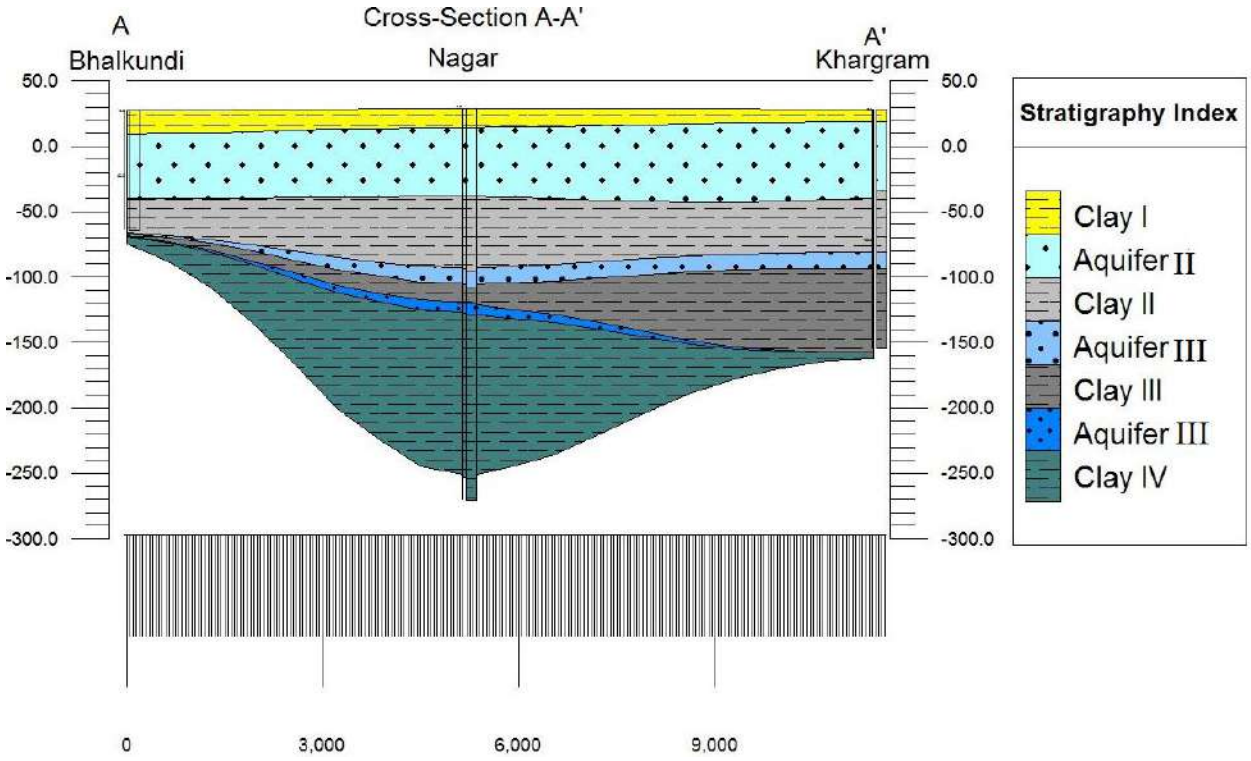


Fig. 10.8.2.3: N – S Section in Khargram block

Fig. 10.8.2.4: W – E Section Index Line in Khargram block

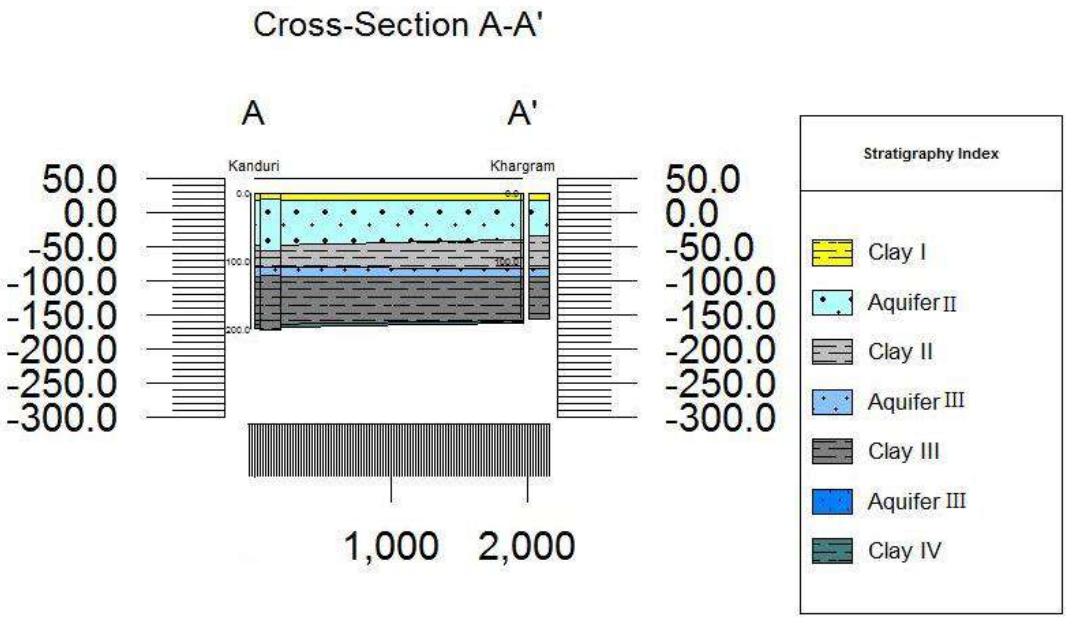


Fig. 10.8.2.5: W – E Section in Khargram block

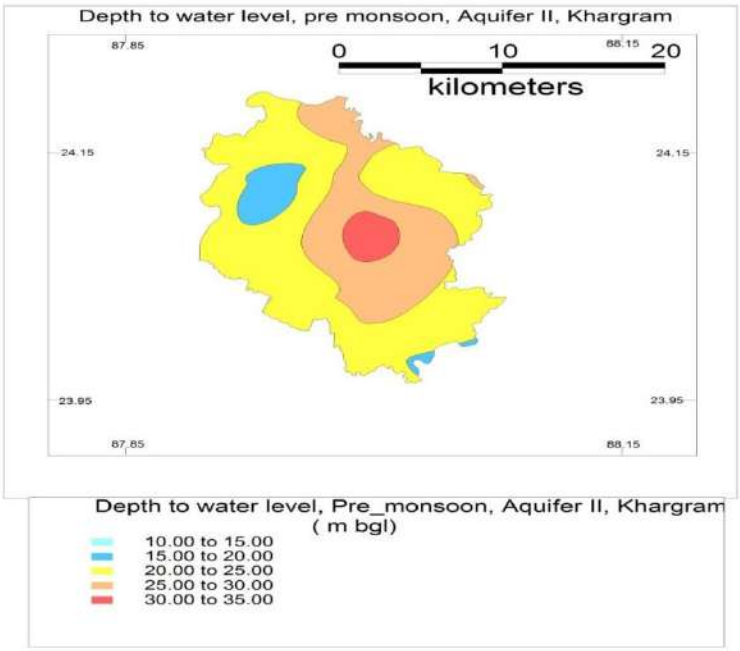


Fig. 10.8.2.6: Depth to water level, pre monsoon, Aquifer II

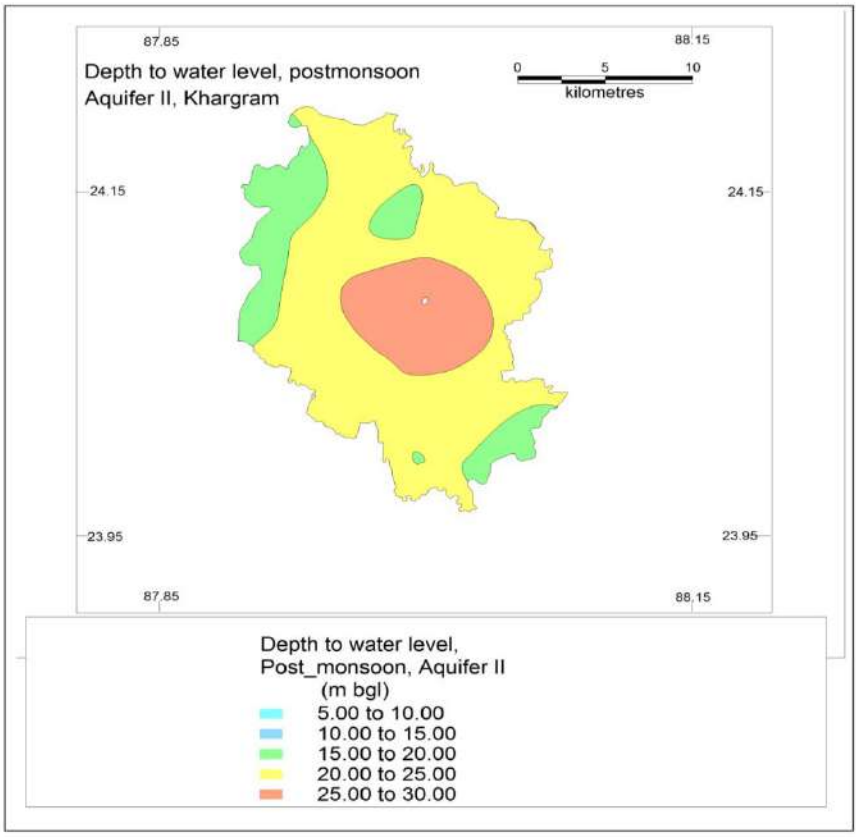


Fig. 10.8.2.7: Depth to water level, post monsoon, Aquifer II

10.8.3 Ground Water Resource &Status of Extraction:

Aquifer Wise Resource Availability & Extraction:

Dynamic ground water resources (Aquifer I) as on 31st March'17 in

Block	Annual Extractable Ground Water Recharge (MCM)	Current annual Ground Water Extraction (MCM)	Stage of development (%)	Category	Annual GW Allocation for Domestic Use as on 2042	Ground water availability for future use (MCM)
Khargram	61.4062	61.3639	99.94	Critical	4.6874	-1.5021

Static (in-storage) Resources (Aquifer I): 33.82 **MCM**

Dynamic ground water resources (Aquifer II): 4.122526 MCM

Static (in-storage) Resources (Aquifer II): 136.55868 **MCM**

10.8.4 Chemical Quality of Ground Water & Contamination:

Range of important Chemical Parameters:

Arsenic (As) data are based on 3 random samples of spl. Drive' 15-16 & other routine parameters are based on limited samples of 17-18. As more than 0.01 mg/l, WHO limit of potable water, has been reported in 2 out of 3 wells (3 tube wells). Maximum has been encountered at Khargram.

Block	As (mg/l)	TH (mg/l)	EC (µS/cm)	F (mg/l)	NO_3 (mg/l)
Khargram	**0.0003 – 0.065**	**120-205**	**294-604**	**0.44-1.49**	**0-12**

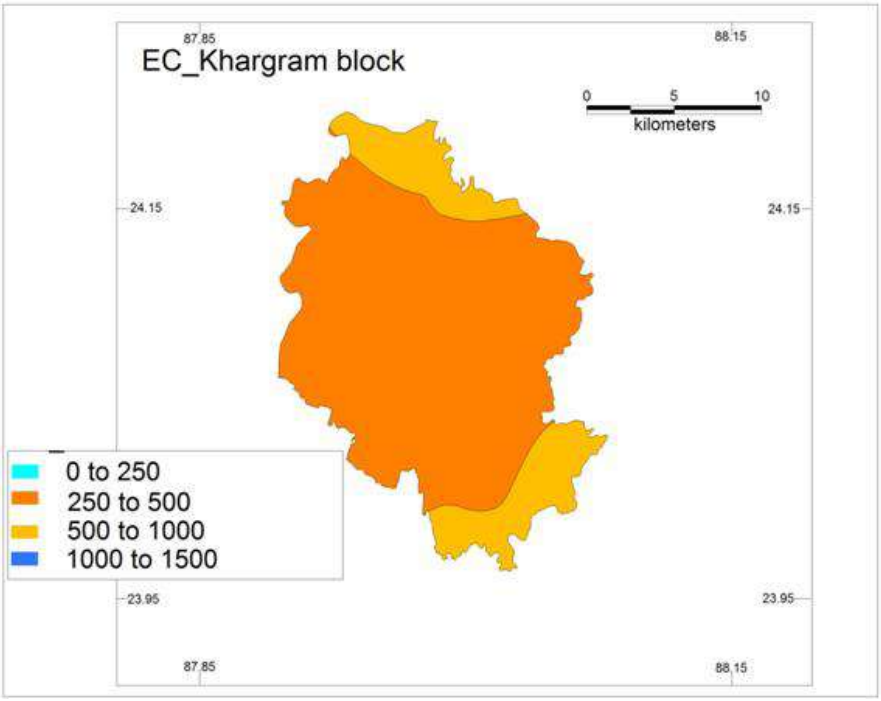


Fig. 10.8.4.1: Electrical Conductivity (EC) in ground water of Khargram

Arsenic Infestation: arsenic infestation has been reported in some habitations.

10.8.5: Major Issues:

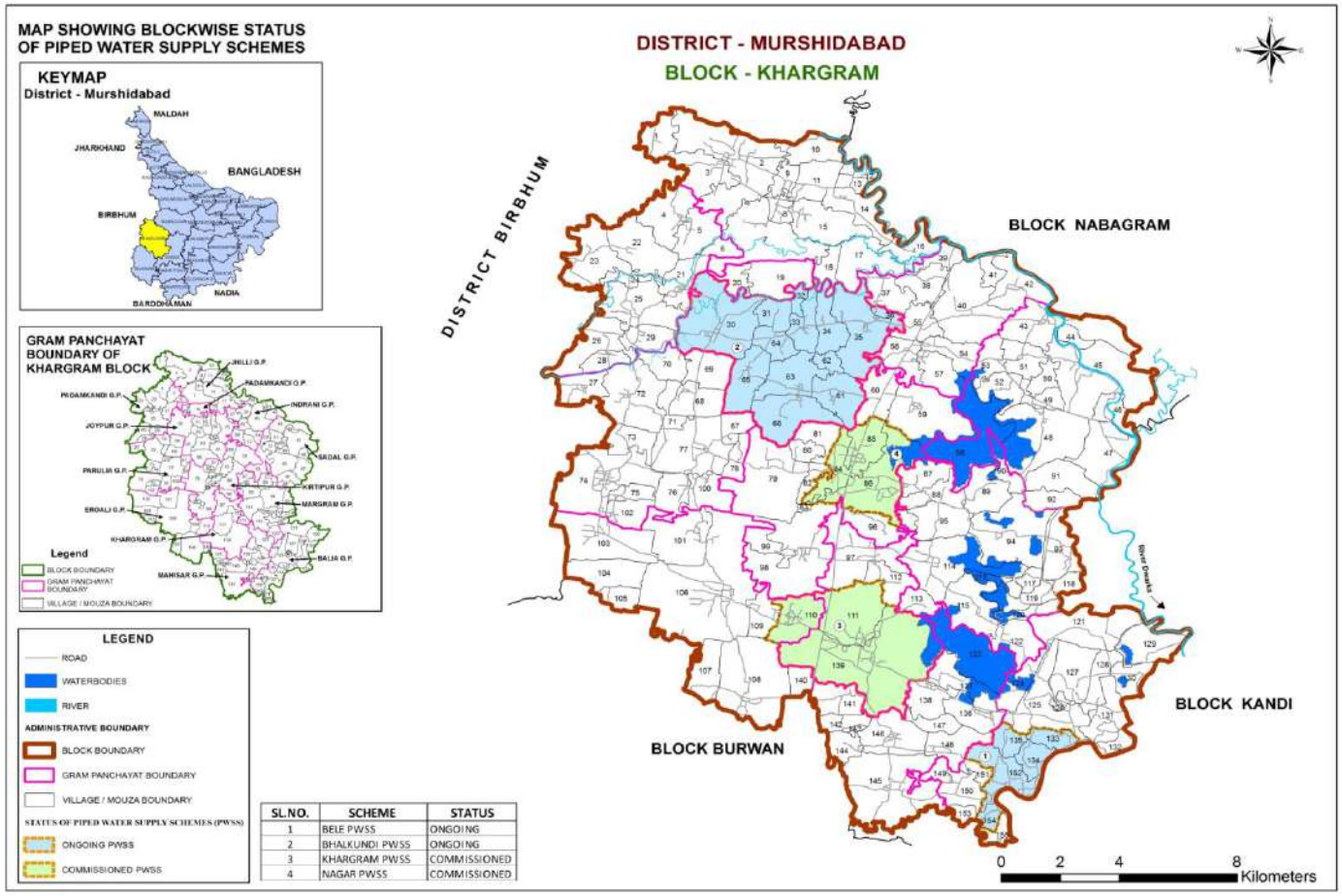
1. Sporadic occurrence of ground water contamination by arsenic in Younger Alluvium
2. Very deep water level and long term water level shows falling trend.
3. Very high Stage of Development (99.94%); this block has been categorised as Critical
4. Irrigation is mainly done by ground water

10.8.6: Ground Water Resource Enhancement& Management Plan:

Ground Water Management Plan for drinking purposes.

Table 10.8.6.1: As infested population & Status of present water supply

Nos. of habitations in risk zone	Whereas As infested	As infested population in 2011	Projected As infested population in 2021	Population already covered	Water (lit.) required for uncovered population @ 70 lpcd	Nos. of TWs required considering each TW's discharge of 12.5 lps& 8 hrs. run per day
-	Infested (Reported lately)	-	-	73163	-	-



SL.NO.	SCHEME	STATUS
1	BELE PWSS	ONGOING
2	BHALKUNDI PWSS	ONGOING
3	KHARGRAM PWSS	COMMISSIONED
4	NAGAR PWSS	COMMISSIONED

Fig. 10.8.6.1: Status of Pipe Water Supply Schemes in Khargram block

(Source: PHED, Govt. of West Bengal)

Proposed interventions for drinking water:

1	Khargram	➢ For drinking purpose deeper aquifer is earmarked. ➢ Potable water aquifers are encountered within depth range of 0 – 70 m excepting area underlain by Younger Alluvium, where up to about 30 m there may be probability of arsenic infestation . ➢ Deeper aquifers are to be earmarked for PWSS & Tube wells should be constructed by proper cement sealing in the upper clay bed above the aquifer containing potable ground water. ➢ Surface water source is alternative source.

Other options for potable water:

1. Rain water harvesting

2. Installation of arsenic removal plants to make potable water from contaminated first Aquifer.

Ground Water Management Plan for Irrigation purpose

Table 10.8.6.2: Irrigation scenarioin Aquifer II Khargram block

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 m bgl	Average Post monsoon WL in m bgl	Remarks for GW Management Plan
1	Khargram	26189	13447	12742	99.94	**F70**	F 69	22.16	20.72	Can be developed for GW based Irrigation

Data of 5th M. I. Census shows:

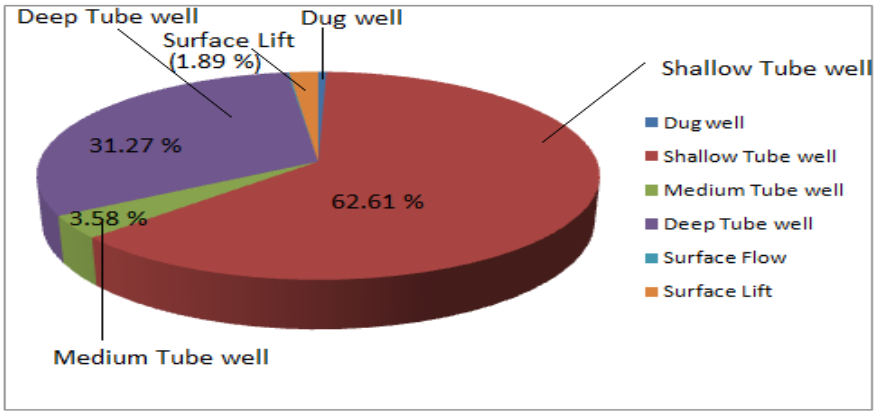


Fig. 10.8.6.2: Percent contribution of different sources of irrigation

Table 10.8.6.3: Percent contribution of different sources of irrigation

Type of abstraction structures	CCA (Ha)	%
Dug well	**38.5**	0.54
Shallow Tube well	4481.55	62.61
Medium Tube well	255.89	3.58
Deep Tube well	2237.8	31.27
Surface Flow	8.17	0.11
Surface Lift	135.55	1.89

Table 10.8.6.4: CCA & sources of irrigation

Block Total / District Total	Dugwell		Shallow Tubewell		Medium Tubewell		Deep Tubewell		Surface Flow		Surface Lift		CCA(ha.)		Total CCA(ha.)
	No.	CCA(ha.)	No.	CCA(ha.)	No.	CCA(ha.)	No.	CCA(ha.)	No.	CCA(ha.)	No.	CCA(ha.)	Ground Water	Surface Water	
Block Total	6	38.5	1171	4481.55	54	255.89	117	2237.8	4	8.17	17	135.55	7013.74	143.72	7157.46
District Total	**178**	**728.67**	**54842**	**127809.47**	**2148**	**11550.14**	**1719**	**33386.23**	**292**	**1592.29**	**1499**	**13037.13**	**173474.51**	**14629.42**	**188103.9**

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

Table 10.8.6.5: Cropping Pattern in Khargram block during 2016-17

Name of Block	Aus	Aman	Boro	Wheat	Potato	Masur	Maskalai	Jute	Khesari	Til	Mustard	Linseed
Khargram	16	19942	18148	4077	281	15	-	-	-	0.288	3178	-

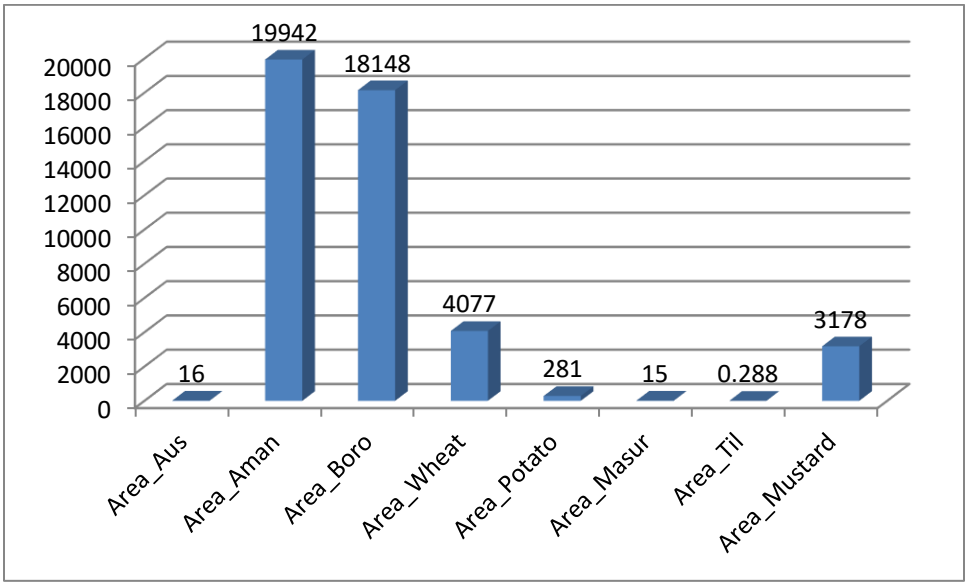


Fig. 10.8.6.3: Graphical representation of Cropping Pattern in Khargramblock during 2016-17

Proposed interventions for irrigation:

- On principle, Boro cultivation is not encouraged. Boroneeds 1.2 to 1.4 m.
- Wheat, Pulses & Oil seeds including Til, Ground nut cultivation in upland area could be encouraged; wheat needs about 0.35 m& Pulses & Oil seeds about 0.15 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.
- To improve the ground water scenario, implementation of modern irrigation practices like drip water irrigation system, sprinklers can be made.
- Cultivation of low water requiring crops and change in cropping pattern may be done for better and efficient water management.
- In this block, during Rabi & spring/ summer months, the existing area wise cropping pattern vide **Table 10.8.6.5 & Fig. 10.8.6.3)** is as follows:

  Wheat – 53.99 %, vegetables – 0.037 % (neglisible), Pulses & Oil seeds – 42.29 %.

- As per the aforesaid cropping pattern, from the remaining area to be irrigated of 12742 Ha, cultivation proposed: wheat – 6879.41 Ha; Pulses & Oil seeds -5388.59 Ha.
- For wheat (@ 0.35 m/ha) & Pulses & Oil seeds (@0.15 m/Ha) estimation shows an amount of 3216.08 Ham of water is needed.
- Ground Water Estimation 2017 shows that there is already a deficit of (–) 1.5029 MCM of ground water from the top aquifer.

  So, there is no available ground water resource. Hence, for irrigation of remaining cultivable area Rain Water Harvesting may be a solution and the same has been dealt in Chapter 10.8.7.

Table 10.8.6.6: Water column recommended 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
Murshidabad	Khargram	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

10.8.7 Scope for rain water harvesting & Artificial recharge:

Using Dhruvanarayana,1993 method in Khargram block, the number and types of artificial rechargeand conservation structures proposed to be constructed for harvesting rain water and the estimated cost involved for doing this, have been shown in Table 10.8.7.1a & Table 10.8.7.1b. 3800.3823 Ham 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; by doing this ground water scenario can be improved as well as the inclusive economic growth can be achieved.

Area suitable for recharge in the study area (vide Part I: Plate 6.2.1b):

District	Block Name	Area (in sq. km)	Total Area suitable for recharge (sq km.)
MURSHIDABAD	Khargram	318.45	270

Utilization of Harvested Rain Water: Table 10.8.7.1a shows that 3800.3823Ham of rain water could be harvested in Khargram block. In Fig. 10.8.7.1, land use & land cover in this block has been shown; from it it is visualized that the land is suitable for even for double / multi-crop cultivation. The amount of 38.0038 MCM of rain water can be utilized in following ways:

For storing of rain water in constructed tanks, a total land of 1140 ha with 3 m depth is required (by keeping aside 10 % of 38.0038 MCM water as wastage by spillage, etc.). The remaining amount of harvested water i.e. 3420.3823 Ha can be utilized to irrigate the left out 12742 – 1140 i.e. 11602 Ha of area for cultivation.

Efforts 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 10.8.7.2, 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.

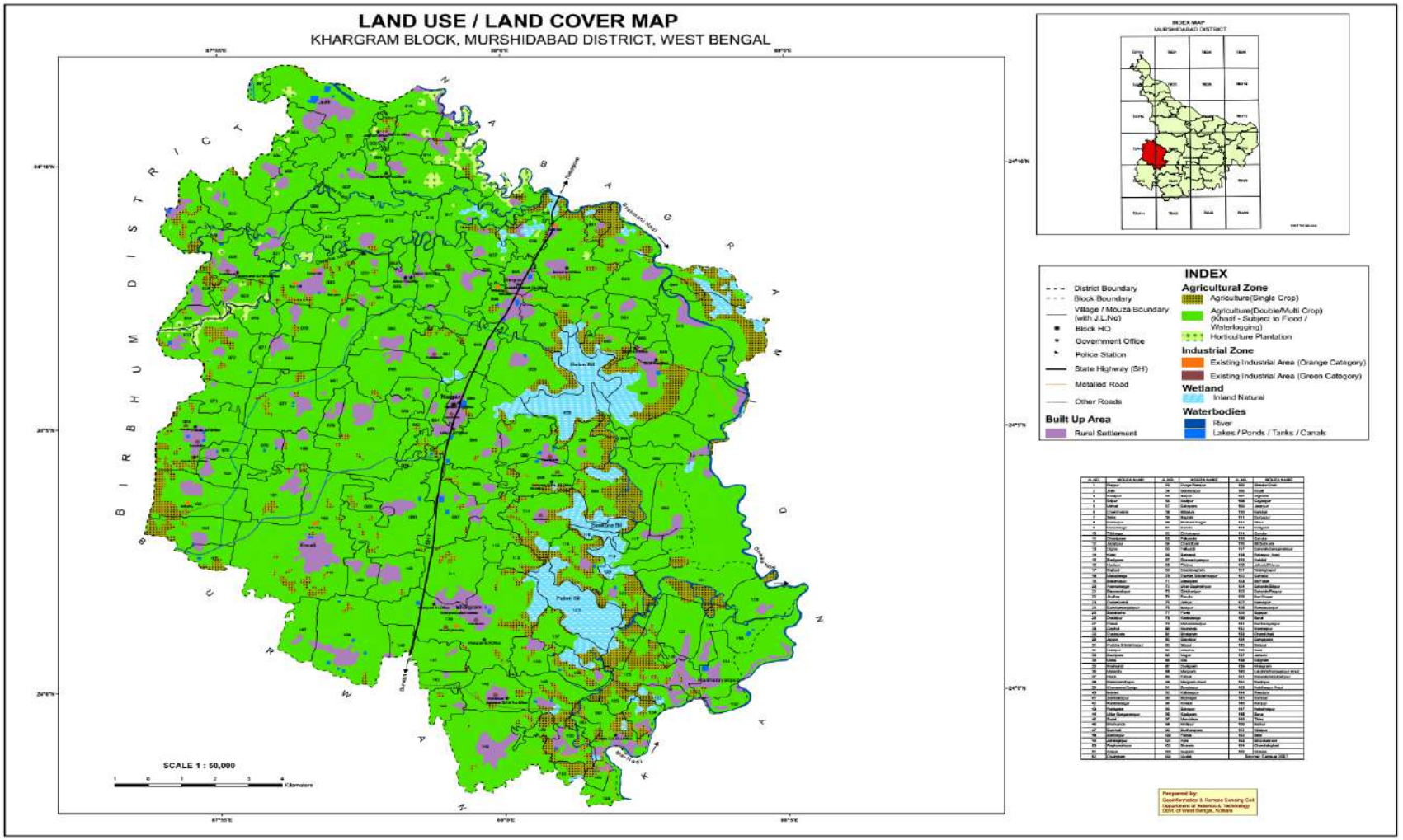


Fig. 10.8.7.1: Land use/ land cover in Khargram block

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

Proposed Artificial Recharge Structures in the Study area:

Table 10.8.7.1a: Estimation of harvested rain water in Khargramblock

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 (considering e-flow) = Vf Ham
1.04	31845	33118.8	0.51	9.82 % imperfectly drained loamy soil & 90.18 % imperfectly drained fine sand, rest is covered by drainage	16890.588	12667.941	6333.9705	3800.3823

Table 10.8.7.1b: Proposed Artificial Recharge & conservation Structures inKhargram block:

Amount of water for artificial recharge and / or conservation (Ham) (4)	Source water allocation for Percolation Tank and REET with Recharge Shaft in Ham (5)	Source water allocation for REET with Recharge Shaft (Ham): 50 % of Col. 5 (6)	Source water allocation for Irrigation Cum Recharge Tank (Ham): 50 % of Col. 5 (7)	Source water allocation for Injection Well (8)	Source water allocation for Farm/Conservation Pond in Ham (9)	Nos. of REET with Recharge Shaft suggested @ 10 Ham per unit (10)	Nos. of Irrigation Cum Recharge Tank suggested @ 50 Ham per unit (11)	Nos. of injection wells @ 30 Ham per unit (12)	Nos. of Farm/conservation ponds @ 10 Ham per unit (13)	Cost of REET with Recharge Shaft @ Rs 8 lakh per unit (14)	Cost of Irrigation cum Recharge tank @ Rs 8 lakh per unit (15)	Cost of Injection wells @ Rs 8 lakh per unit (16)	Cost of Farm pond @ Rs 8 lakh per unit (17)	Total Cost
3800.3833	70 % of Col. 4 i.e. 2600.27 Ham	1300.14	1300.14	20 % of Col. 4 i.e. 760.08 Ham	10 % of Col. 4 i.e. 380.04 Ham	130	26	25	38	1040	208	200	304	1752

Table 10.8.7.9: Proposed change in Cropping pattern in Khargram 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 (Kg of Boro paddy) due to reduction in area of Boro cultivation yield rate 3613.69 kg/ Ha (in M. Ton)	Proposed cropping in 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, & Ground nut @ 2309.39 kg/Ha	Increase in area of wheat cultivation in winter (at least 10% more of existing area of 4077 Ha for wheat, i.e. 407.7 Ha) yield rate 2864.41 kg/ Ha (M. Ton)
(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)	(IX)
18148	1.3 m	235.924	1814.8	23.5924	6558.125	Til &Ground nut in 907.4 Ha each	Til- 826.877, Ground nut- 2095.540	1167.820

Ground water draft for til& ground nut, =1814.8*0.15 = 2.7222 MCM; Ground water draft for wheat = 407.7*0.32 = 1.30464 MCM; ground water saved = 19.56556MCM; Boro paddy loss = 6558.125 kg; Gain of Til, Ground nut & wheat = 4090.237.

Water saved: 19.56556MCM; Area yet to be covered by irrigation: 11602 Ha; As dealt under proposed interventions for irrigation, that amount of water is also not fully covered.

Hence, for 11602 Ha too, change in cropping pattern is proposed for 3867.33 Ha each for wheat, Pulses & vegetables and vegetables.

Ground water draft for Vegetables & Pulses & Oilseeds, =7734.66*0.15 = 11.6020 MCM; Ground water draft for wheat = 3867.33*0.32 = 12.3755 MCM; a total of 23.9775 MCM water is required.

Therefore, with some more modifications in distribution system, implementation of micro irrigation techniques the deficit of 23.9775 – 19.56556 i.e. 4.41194 MCM could also be covered

10.9: Block Name: Kandi

10.9.1: Salient Information

Area (in Km^2): C. D. Block 227.48; Municipality – 12.95

District: Murshidabad

State: West Bengal

Population (as on 2011):

Rural	Urban	Total
220145	55632	275777

Approximate Decadal Growth Rate: 20.75 per cent during the 1991-2001 & in 2001-2011 it was 14.01%, the lowest amongst all CD Blocks in Murshidabad district.

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

District	Normal – 2014 (in mm)	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):

Sl. No	Name of the Block	Geographic Area	Cultivable Area	Area under pasture & orchard	Cultivable Waste Land	Forest Land
1.	Kandi	240.43	184.25	-	-	-

(Source: Dept. of Agriculture, Govt. of West Bengal)

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

Resource Availability	Aquifer I*	Aquifer II	Current Annual GW Extraction in MCM (for Aquifer 1)
Dynamic Resource	88.8164	0.03951 (including Municipality area)	64.9562
Static Resource	21.41**	6.63446	-

*** Phreatic aquifer has been to occur in part of Kandi block only; however the data estimated by SWID and CGWB are given**

**** Data estimated in 10% of total block area as it's occurrence**

10.9.2: Disposition of Aquifer:

Depth range of aquifers

Block	**Depth range of Aquifer in m bgl**		
	Aquifer I	**Aquifer II**	**Aquifer III**
Kandi	8.75 – 25.60 (restricted in small eastern Most part of block area)	30 – 86.8	131.1 – 149.7

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

Sl. No.	**Block**	Aquifer	**Pre-monsoon Trend**			**Post-monsoon Trend**		
			Water Level Range (m bgl)	**Rise (m/yr)**	**Fall (m/yr)**	Water Level Range (m bgl)	**Rise (m/yr)**	**Fall (m/yr)**
1	Kandi	I	2.58	-	-	1.95	-	-
2.	Kandi	II	13.05 – 31.23	0.049	0.144 – 1.096	10.87 – 30.02	-	0.361-1.086
3.	Kandi	III	10.74 – 11.93	-	-		-	-

Average Thickness of Aquifer:

Block	Area (sq km)	Thickness of the Granular Zone in Aquifer I (m)	Thickness of the Granular Zone in Aquifer II (m)	Thickness of the Granular Zone in Aquifer III (m)
Kandi	240.43	15 (approx.)	71.08	18.60

Aquifer-wise Statement:

Block	Aquifer I			Aquifer II			Aquifer III		
	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)
Kandi	8.75 – 25.60	14.4	210.8	30 – 86.8	17.57 – 200	59.30 – 1268	131.1 – 149.7	12.46 - 17.56	92.29 – 105.77

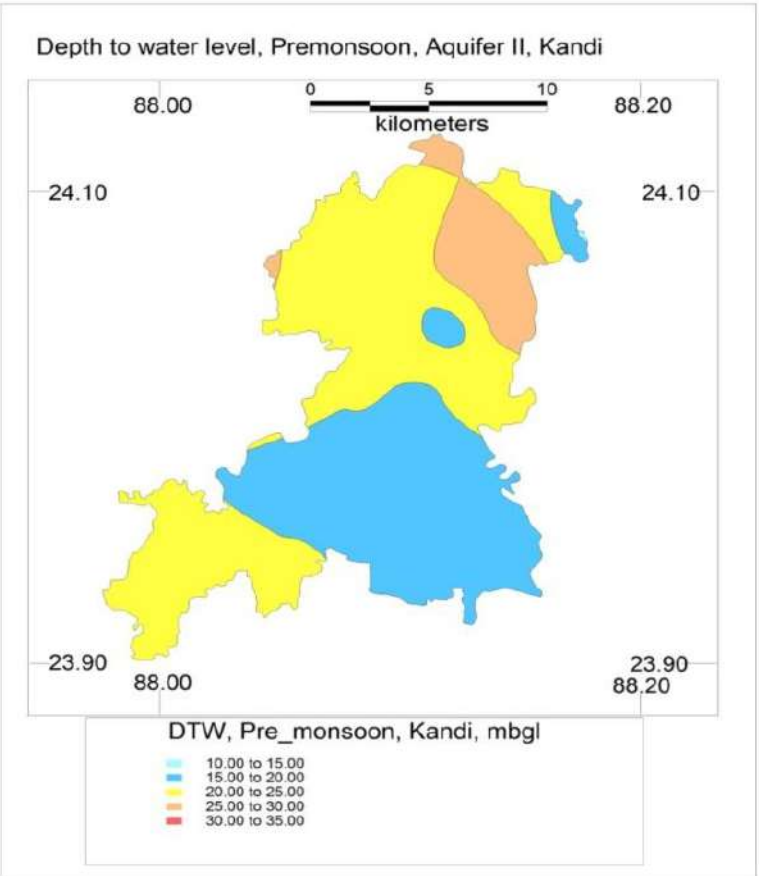


Fig. 10.9.2.1: Depth to water level, Aquifer II, Pre monsoon

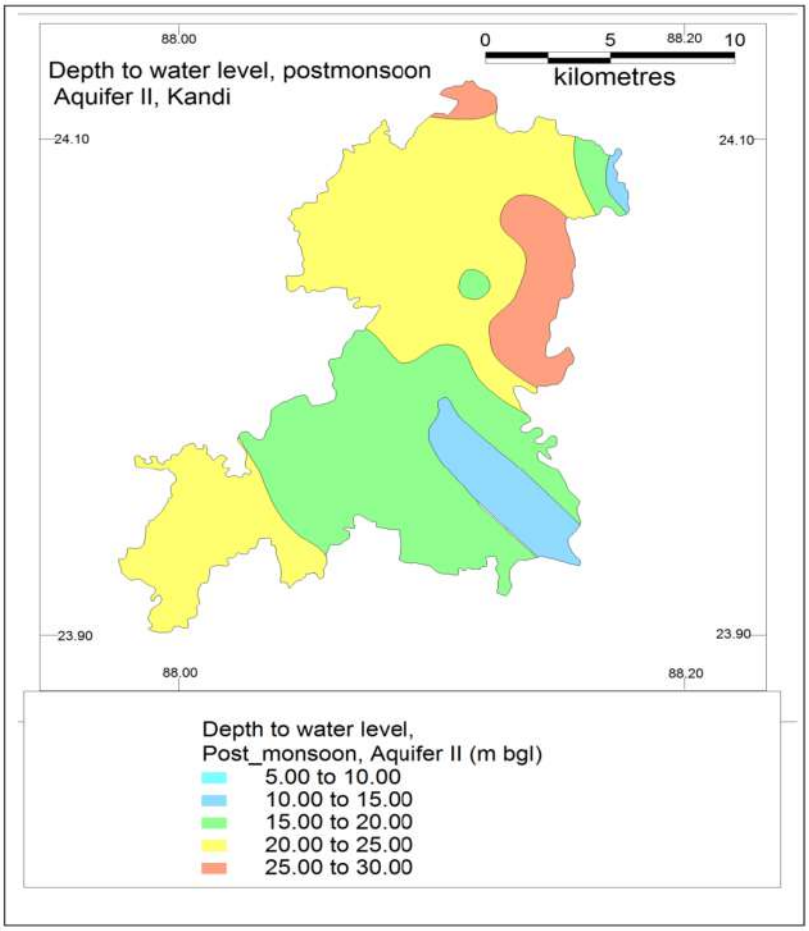


Fig. 10.9.2.2: Depth to water level, Aquifer II, Post monsoon

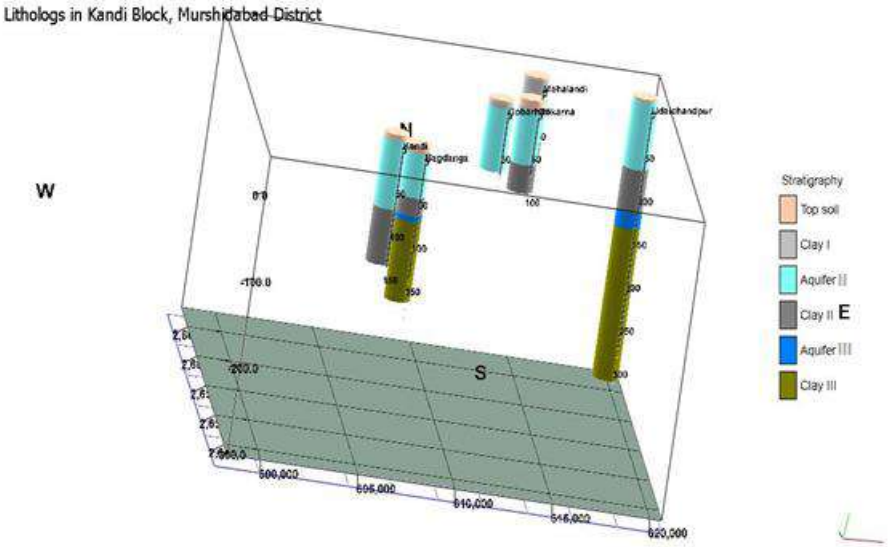


Fig. 10.9.2.3: Stratigraphic logs in Kandi block (Aquifer I – restricted in lateral disposition**)**

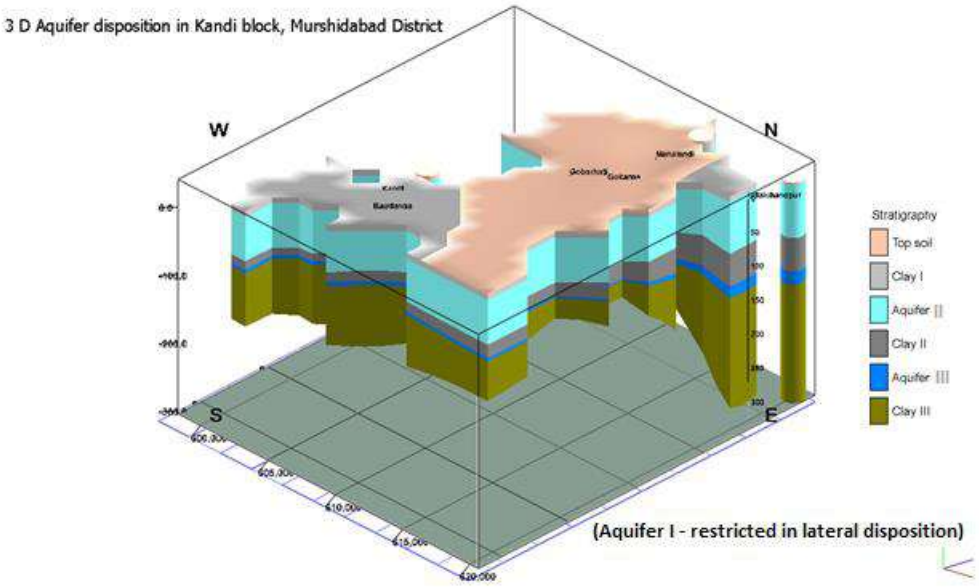


Fig. 10.9.2.4: 3 D Aquifer disposition in Kandi block

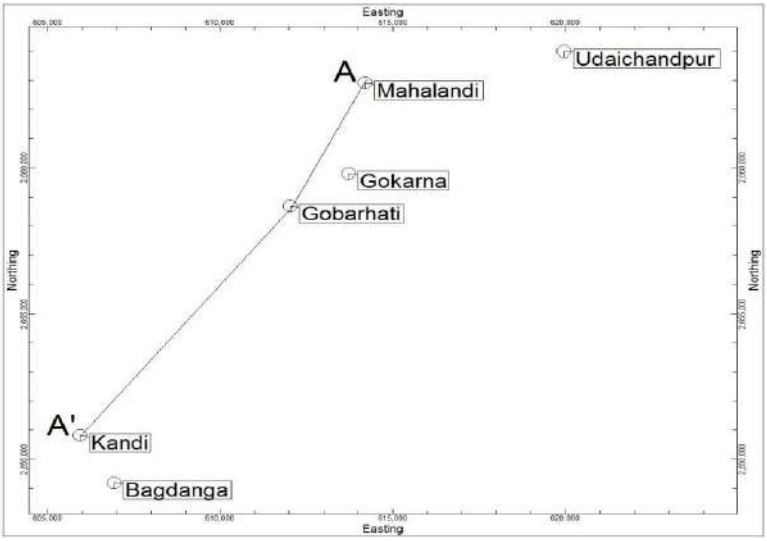


Fig. 10.9.2.5: NE-SW section index line in Kandi block

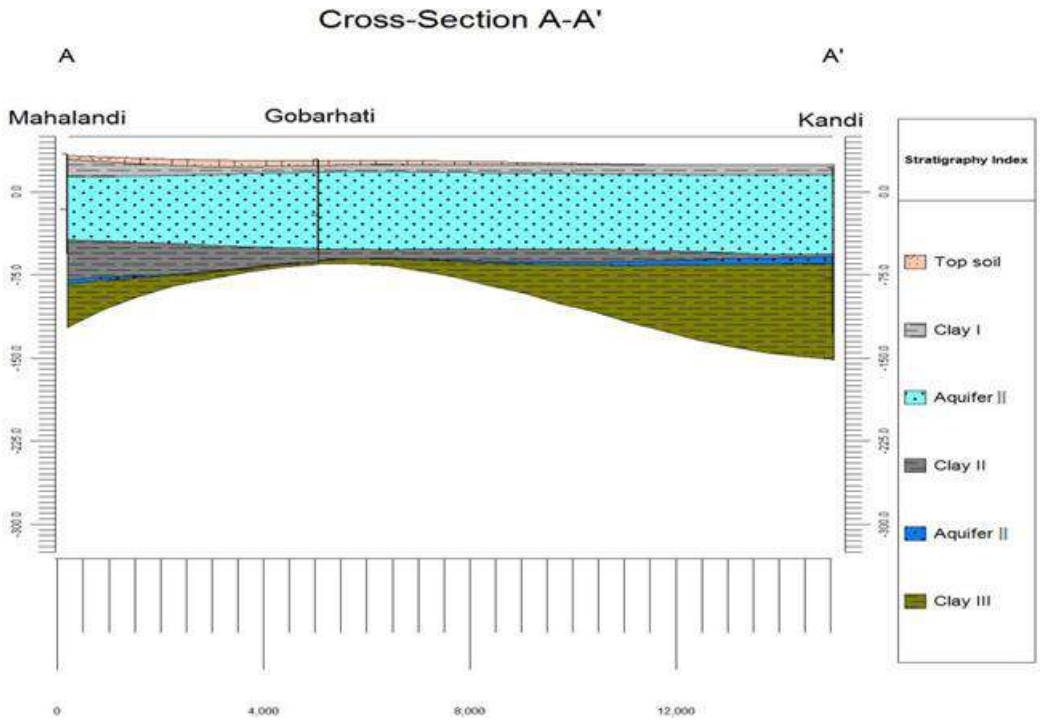


Fig. 10.9.2.6A: NE-SW section in Kandi block

10.9.3: Ground Water Resource & status of Extraction:

Aquifer Wise Resource Availability & Extraction:

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

Block	Net Annual Extractable Ground Water Recharge (MCM)	Current Annual GW Extraction (MCM)	Stage of development (%)	Category	Annual GW allocation for domestic use as on 2042(MCM)	Ground water availability for future use (MCM)
Kandi*	88.8164	64.9562	73.14	Semi-critical	4.6156	22.4194

- **As estimated by SWID & CGWB, ER; present study reveals that phreatic aquifer occupies part of C. D. Block area.**

Static (in-storage) Resources in Aquifer I: 21.41 MCM

Dynamic Ground Water Resources (Aquifer II) - 0.039512 MCM

Static (in-storage) Resources in Aquifer II: 6.63447 **MCM**

10.9.4: Chemical quality of Ground Water & Contamination:

Range of important Chemical Parameters:

Arsenic (As) data are based on 10 random samples of spl. Drive' 15-16 & other routine parameters are based on limited samples of 17-18. As more than 0.01 mg/l, WHO limit of potable water, has been reported in 4 out of 10 wells (1 dug wells & 9 tube wells). Maximum has been encountered near Gokarna.

Block	As (mg/l)	TH (mg/l)	EC (µS/cm)	F (mg/l)	NO_3 (mg/l)
Kandi	**0.0 – 0.04**	**80-175**	**271-1420**	**0.54-1.89**	**0-2**

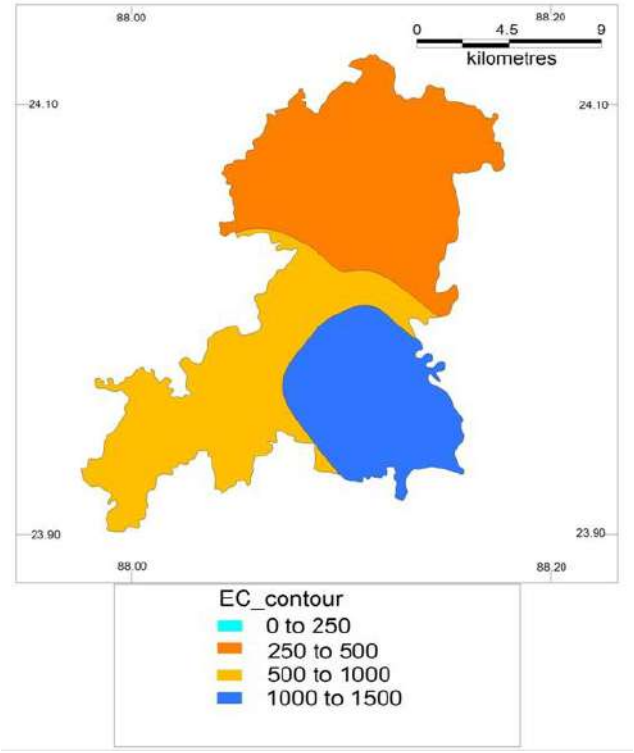


Fig. 10.9.4.1: Electrical Conductivity (EC) in ground water of Kandi Block

Arsenic affected Risk Population: Of late, arsenic infestation in some habitations reported.

10.9.5: Major Issues:

1. Very deep water level and its long term trend shows alarming fall.
2. Sporadic ground water contamination by arsenic has been reported.
3. High SOD & Semi Critical category of block
4. Irrigation in large area is done by ground water

10.9.6: Ground Water Resource Enhancement& Management Plan:

Ground Water Management Plan for drinking purposes.

Table 10.9.6.1: Status of Pipe Water Supply in Kandi block

Block	Nos. of habitations in risk zone	Whereas As infested	As infested population in 2011	Projected As infested population in 2021	Population already covered by PWSS	Water (lit.) required for uncovered population @ 70 lpcd	Nos. of TWs required considering each TW's discharge of 12.5 lps& 8 hrs. run per day
Kandi	-	Infested (Reported lately)	-	-	129885	- *	*

Proposed interventions for drinking water:

Block	Suggestions for providing potable water supply to the risk population
Kandi	➢ For drinking purpose deeper aquifer is earmarked. ➢ Potable water aquifers are encountered within depth range of 30 – 86 m; but Aquifer I, though restricted in lateral disposition & sporadic occurrence of As in ground water in it reported, generally gives As free ground water. ➢ Deeper aquifers are earmarked for PWSS & Tube wells should be constructed by proper cement sealing in the upper clay bed above the aquifer containing potable ground water. ➢ Surface water source is alternative source.

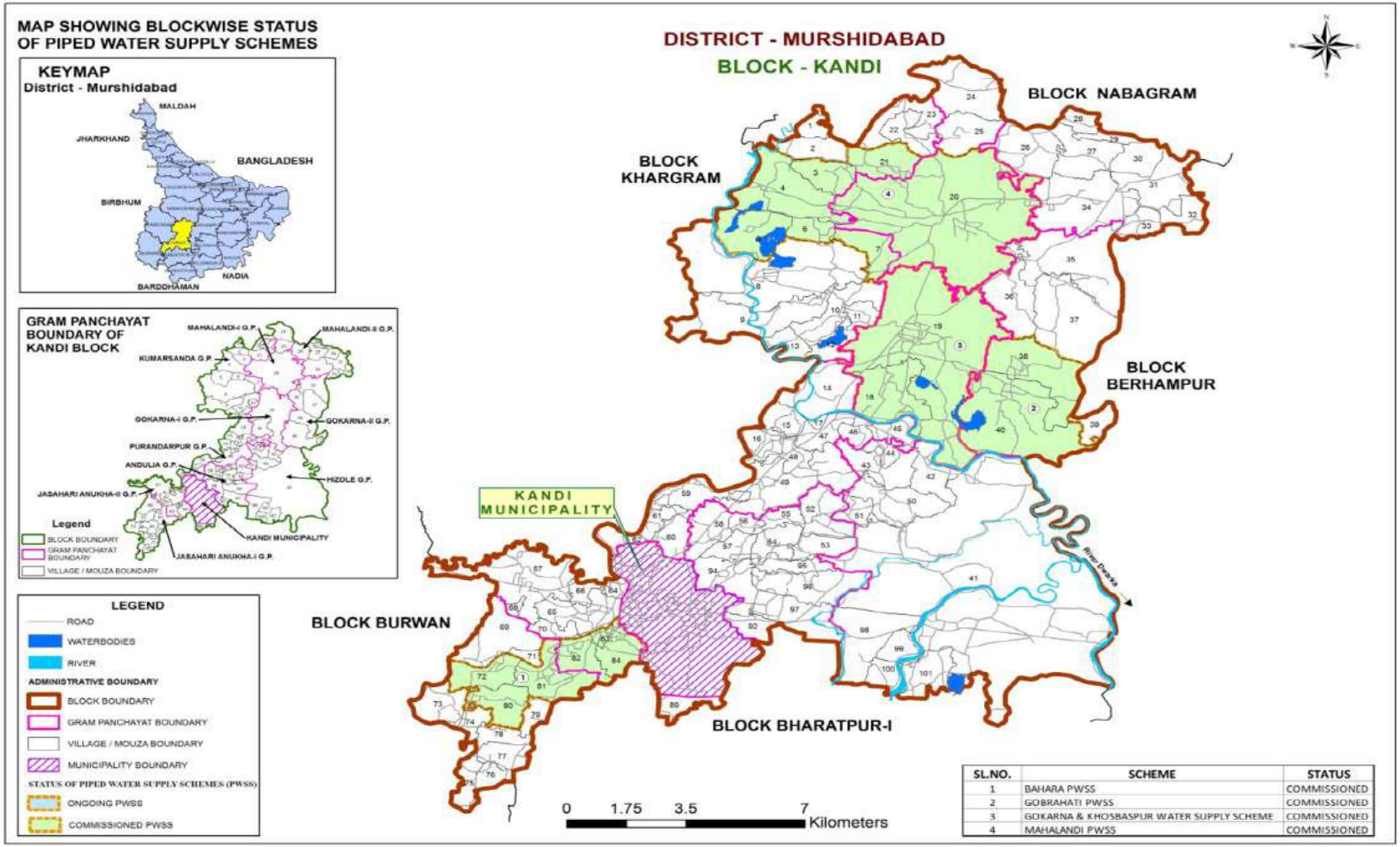


Fig. 10.9.6.1: Status of Pipe Water Supply schemes in Kandi block

(Source: PHED, Govt. of West Bengal)

Other options for potable water:

1. Rain water harvesting

2. Installation of arsenic removal plants to make potable water from contaminated first Aquifer.

Ground Water Management Plan for Irrigation purpose

Table 10.9.6.2: Irrigation scenario (Aquifers II) in Kandi 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	Remarks for GW Management Plan
Kandi	18425	3473	14952	73.14	**0.62**	0.72	21.04	20.72	Can be developed for GW based Irrigation

Data of 5th M. I. Census shows:

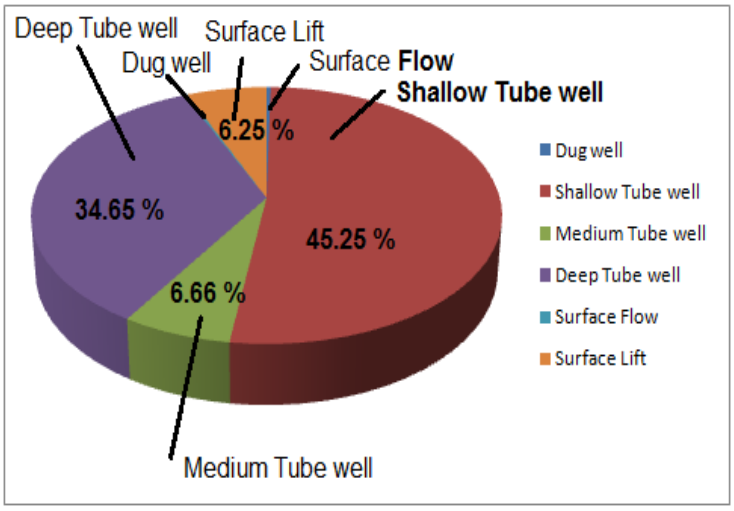


Fig. 10.9.6.4: Graphical presentation of contribution of different sources of irrigation

Table 10.9.6.3: Percent contribution of different sources of irrigation

Type of abstraction structures	CCA (ha)	
Dug well	29.06	0.32%
Shallow Tube well	4697.04	45.25%
Medium Tube well	602.9	6.66%
Deep Tube well	3136.85	34.65
Surface Flow	22.5	0.25%
Surface Lift	565.5	6.25%

Table 10.9.6.4: CCA & sources of irrigation

Block / District	Dug well		Sallow Tube well		Medium Tube well		Deep Tube well		Surface Flow		Surface Lift		CCA (ha.)		Total CCA (ha.)
	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	No.	CCA (ha.)	Ground Water	Surface Water	
Block	6	29.06	938	4697.04	96	602.9	197	3136.85	7	22.5	58	565.5	8465.85	588	9053.85
District	**178**	**728.67**	**54842**	**127809.5**	**2148**	**11550.14**	**1719**	**33386.23**	**292**	**1592.29**	**1499**	**13037.13**	**173474.5**	**14629.42**	**188103.9**

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

Table 10.9.6.5: Cropping Pattern in Kandi block during 2016-17

Name of Block	Aus	Aman	Boro	Wheat	Potato	Masur	Maskalai	Jute	Khesari	Til	Mustard	Linseed	Gram
Kandi	-	16305	14941	1250	744	11	7	177	-	0.209	1911	-	62

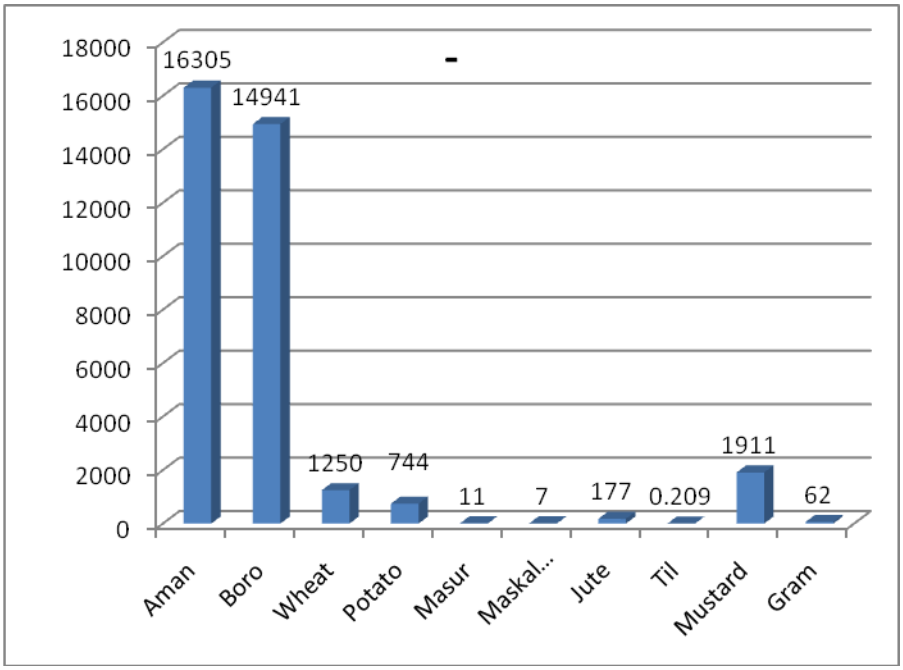


Fig. 10.9.6.5: Graphical representation of cropping pattern in Kandi Block

Proposed interventions for irrigation:

- On principle, Boro cultivation is not encouraged. Boro needs 1.2 to 1.4 m.
- Wheat, Pulses & Oil seeds including Til, Ground nut cultivation in upland area could be encouraged; wheat needs about 0.35 m & Pulses & Oil seeds about 0.15 m of water column.
- Rain water harvesting and artificial recharge may be implemented to eliminate the problem of both overall declining of water level and arsenic contamination, if any.
- To improve the ground water scenario, implementation of modern irrigation practices like drip water irrigation system, sprinklers can be made.
- Cultivation of low water requiring crops and change in cropping pattern may be done for better and efficient water management.
- In area of shallow water level, cultivation of cash crops, eg. sugar cane may be suggested.
- In this block, during Rabi & spring/ summer months, the existing area wise cropping pattern vide **Table 10.9.6.5 & Fig. 10.9.6.5)** is as follows:
  Wheat – 31.41%, vegetables – 18.72%, Pulses & Oil seeds – 49.83%.
- As per the aforesaid cropping pattern, from the remaining area to be irrigated of 14952 Ha, cultivation proposed: wheat – 4696.42 Ha; Vegetables – 743.97 Ha, Pulses & Oil seeds – 1980.35 Ha.
- For wheat (@ 0.35 m/ha), vegetables (@ 0.15 m/ha) & Pulses & Oil seeds (@0.15 m/Ha) estimation shows an amount of 2052.40 Ham of water is needed.
- Ground Water Estimation 2017 shows that an amount of 22.4194 MCM Ham of ground water from the top aquifer has been earmarked for future use

Therefore, from the available ground water resources as per Resource Estimation 2017, the remaining cultivable area could be irrigated.

Table 10.9.6.6: Water column recommended 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
Murshidabad	Farakka	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

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

Using Dhruvanarayana, 1993 method in Kandi 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 10.9.7.1a & Table 10.9.7.1b. 33.19377 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; by doing this ground water scenario can be improved as well as the inclusive economic growth can be achieved.

Table 10.9.7.1: Area suitable for recharge in the study area (vide Part I: Plate 6.2.1b):

District	Block Name	Area (in sq. km)	Total Area suitable for recharge (sq km.)
MURSHIDABAD	Kandi	240.43	216

Utilization of Harvested Rain Water: Table 10.9.7.1a shows that 33.19377 MCM of rain water could be harvested in Kandi block. In Fig. 10.9.7.1, land use & land cover in this block has been shown; from it it is visualized that the land is suitable for even for double / multi-crop cultivation. The amount of 33.1938 MCM of rain water can be utilized in following ways:
For storing of rain water in constructed tanks, a total land of 996 ha is required with 3 m depth (by keeping aside 10 % of 33.19377 MCM water as wastage by spillage, etc.). The remaining amount of harvested water i.e. 2987.377 Ham can be utilized for irrigation in future, if needed.

The cultivation of 'Boro' has been done in this block in a massive area of 14941 Ha (vide **Table 10.9.6.5 & Fig. 10.9.6.5). However, there is enough water in the top aquifer as mentioned in aforesaid chapters. But,** It is proposed to modify cropping pattern, if needed in future, for efficient irrigation practices. Less water requiring crops, eg. pulses, oil seeds, are always preferable. By this, a huge amount of vital ground water resources could be saved.

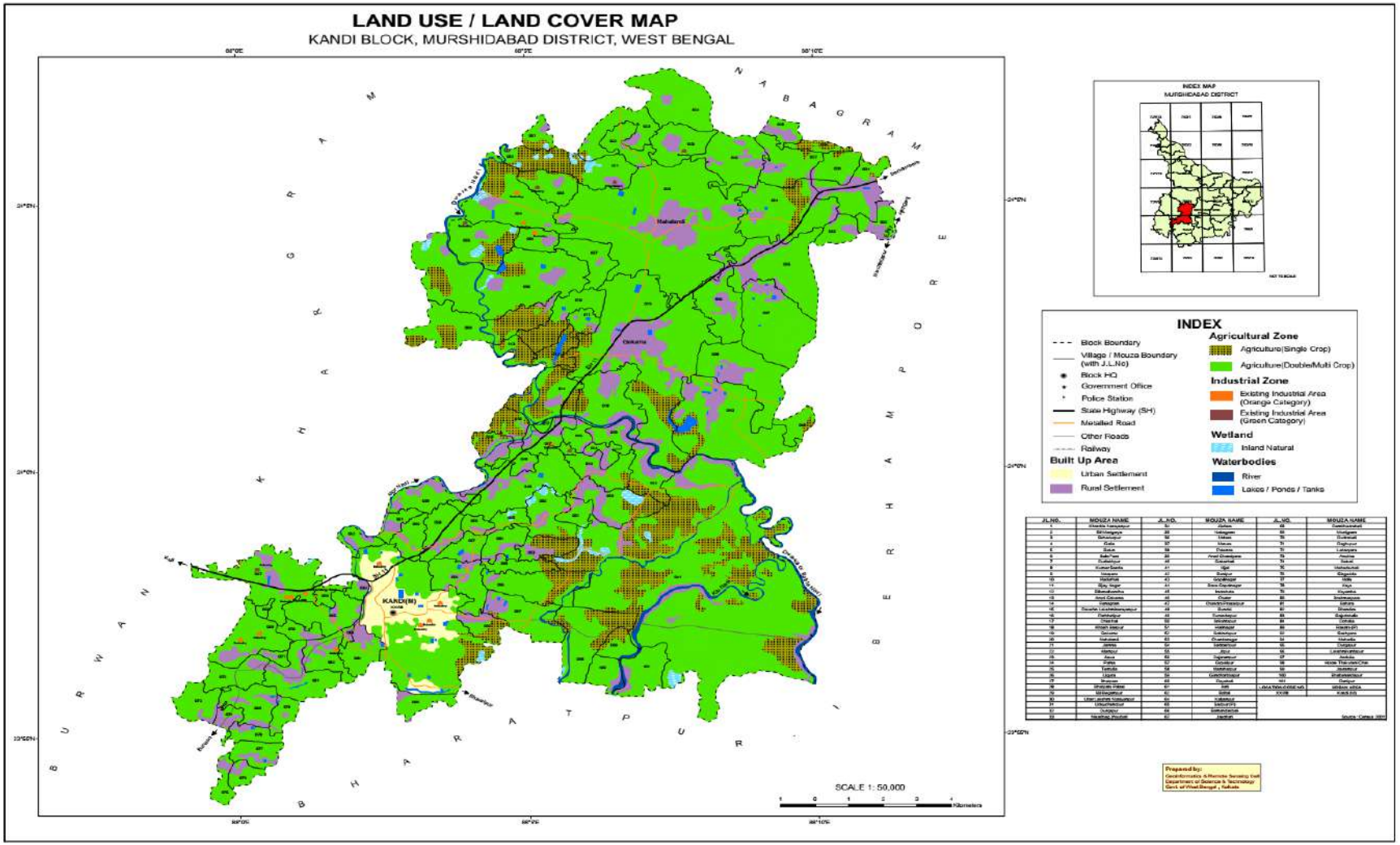


Fig. 10.9.7.1: Land use/ land cover in Kandi block

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

Proposed Artificial Recharge Structures in the Study area:

Table 10.9.7.1a: Calculation of harvested rain water in Kandi 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 (considering e-flow) = Vf Ham
1.04	24043	25004.72	0.59	2.28 % moderately well drained sandy soil, 96.62 % imperfectly drained loamy soil & 1.10 % imperfectly drained fine sand	14752.7848	11064.5886	5532.2943	3319.37658

Table 10.9.7.1b: Proposed Artificial Recharge & conservation Structures in Kandi block:

Amount of water for artificial recharge and / or conservation (Ham) (4)	Source water allocation for Percolation Tank and REET with Recharge Shaft in Ham (5)	Source water allocation for REET with Recharge Shaft (Ham): 50 % of Col. 5 (6)	Source water allocation for Irrigation Cum Recharge Tank (Ham): 50 % of Col. 5 (7)	Source water allocation for Injection Well (8)	Source water allocation for Farm/Conservation Pond in Ham (9)	Nos. of REET with Recharge Shaft suggested @ 10 Ham per unit (10)	Nos. of Irrigation Cum Recharge Tank suggested @ 50 Ham per unit (11)	Nos. of injection wells @ 30 Ham per unit (12)	Nos. of Farm/conservation ponds @ 10 Ham per unit (13)	Cost of REET with Recharge Shaft @ Rs 8 lakh per unit (14)	Cost of Irrigation cum Recharge tank @ Rs 8 lakh per unit (15)	Cost of Injection wells @ Rs 8 lakh per unit (16)	Cost of Farm pondnjection wells @ Rs 8 lakh per unit (17)	Total Cost
3319.37658	70 % of Col. 4 i.e. 2323.56 Ham	1161.78	1161.78	20 % of Col. 4 i.e. 663.88 Ham	10 % of Col. 4 i.e. 331.94 Ham	116	23	22	33	928	184	176	264	1552

Data Gap Analysis in Parts of Murshidabad district, West Bengal

AAP 2017- 2018

1. INTRODUCTION

National Aquifer Mapping studies have been carried out in 9 blocks of Murshidabad district during AAP 2017-18. 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 entire area covers about 1814 sq km. The area extends between North latitudes 23° 54' and 24° 51' 18" and East longitudes 87° 49' 1.2" and 88° 14' 31.2". The study area partly falls in the Survey of India Degree Sheet no. 72P, 78 D and 79A. The major part of study area falls in parts of 8 toposheets, viz. 72 P/13, 14, 15, 16, 78 D/2, 3, 4, and 7; neglisible parts of the present area fall in other 2 toposheets, viz. 79 A/1 and 73 M/13.

Data Gap Analysis: The broad objective of the data gap analysis is to have an idea about the underlying aquifer systems and data availability in terms of aquifer extension both laterally & vertically, aquifer characterization, development potential, etc. based on existing data and also further data requirement or the data gap in respect of not-at-all accessed areas or less accessed areas for the present study. Broadly, it includes to analyse the existing data already we have in different grids of study area laterally & vertically, compilation of the existing data, to have an idea of sub-surface aquifer geometry, identification of gap in terms of exploration, water level, water quality and geophysical data, followed by generation of data for the study.

Data Availability

The available data of existing exploratory tube wells & Observation wells constructed by CGWB in the respective blocks and topo-sheet within the study area has been compiled and tabulated in Table – 1 & the locations of exploratory wells have been shown in Fig. 1.

Table 1: Details of data in respect of exploratory wells in study area

Block	Location	Well Type	Drill Depth (mbgl)	Well Depth (mbgl)	Zone tapped/ Fractures encountered (mbgl)	Geology	SWL (mbgl)	Discharge (lps)	T (m2/day)
Raghunathganj-I	Rajnagar	EW	325.62	112	93-99,102-108	Alluvium	2.94	2	
Kandi	Gokarna (SEW)	SEW	275.9	129	53.0-62.0,90.0-126.0	Older Alluvium		12.9	655
Kandi	Jemo	EW	232.2	52	40.00-43.00,46.00-49.00	Older Alluvium/ Tertiary	9.06	5.5	756.2
Kandi	Jemo	OW	54.9	52	41-44,46-49	Older Alluvium/ Tertiary	8.8		
Kandi	Hometala (EW)	EW	190.4	29	16.60-19.60,22.60-25.60	Older Alluvium	6.07	4lps	210.82
Kandi	Sardarpukur	EW	251.4	89	35.00-44.00,56.00-59.00,80.00-86.00	Older Alluvium/ Tertiary	8.76	9.5lps	435.4
Kandi	Sardarpukur	OW	91.9	89	35-44,56-59,80-86	Older Alluvium	15.76	10	
Kandi Municipality	Rupur	EW	254	71	53.00-68.00	Older Alluvium/ Tertiary	9.03	8.50 lps	345.1
Kandi Municipality	Rupur	OW	74.6	41	32-38	Older Alluvium/ Tertiary			
Kandi Municipality	Kandi Atheletic Club	DEW	251.3	156	53.00-62.00,147.00-153.00	Older Alluvium/ Tertiary	11.93	7 lps	92.29
Kandi Municipality	Kandi Atheletic Club	SEW	91.9	62	44.00-59.00	Older Alluvium/ Tertiary			
Kandi Municipality	Kandi Jail Compound (SEW)	SEW	251.4	61	43.00-58.00	Older Alluvium/ Tertiary	10.74	4.88 lps	59.30m2/day-97m2/day
Kandi Municipality	Kandi Jail Compound (DEW)	DEW	251.5	182	46.00-58.00,173.00-179.00	Older Alluvium/ Tertiary	10.74	4.88	105.77
Farakka					42.00-46.00	Older Alluvium/ Tertiary	10.79	0.5 lps	

Farakka	Shallow well		115.57	106.5	37.00-43.00,44.00-55.00,91.50-103.50	Younger Alluvium	2.82 - 3.9	20.32	188.96 - 1486.73
Suti-I	Nayabahadurpur	EW-I	164.00	140	73-76, 82-85, 109-118, 134-137	Alluvium		5.5	
Suti-I	Nayabahadurpur (OW-I)	OW	163.10	140	73-76, 82-85, 109-118, 134-137				
Suti-I	Nayabahadurpur (OW-II)	OW	160.58	120	109-118	Alluvium		5.6	

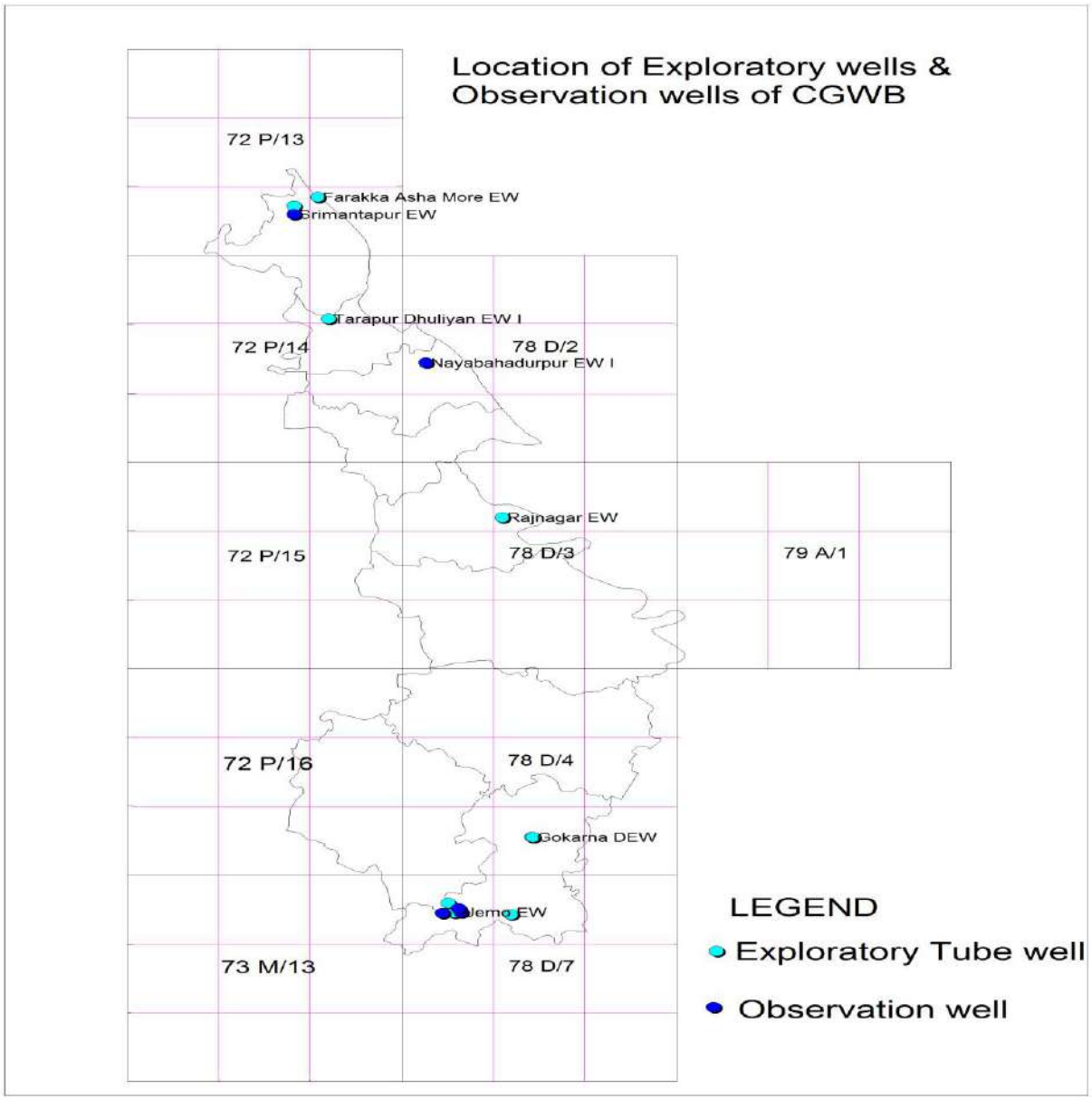


Fig. 1: Locations of CGWB exploratory wells in study area

The lithological and other data of deep tube well data of Agri-Irrigation Dept. & PHED, Govt. of West Bengal have also been collected from the concerned Depts. , The Tube wells have been tabulated in Table 2 & location of these wells have been shown in Fig. 2.

Sl. No.	Tube well	Latitude	Longitude	Block	Total Depth
1	Ahiran	24.51785	88.026464	Suti I	93.85
2	Andhua	24.58476389	88.01148056	Farakka	52.02
3	Ayra	24.25255	88.07358	Nabagram	91.46
4	Bagdanga	23.95100833	88.05083333	Kandi	180
5	Bhalkundi	24.12997	87.98392	Khargram	91.46
6	Chandanbati	24.27616	88.09796	Sagardighi	78
7	Chandni Daha	24.63289444	87.94998333	Samserganj	112.78
8	Dakshin Debagram	24.26741	88.08269	Sagardighi	85.4
9	Doheli Dangapara	24.2611	88.03287	Sagardighi	78
10	Fatellapur	24.52693611	88.068275	Suti I	118.73
11	Gazipur	24.61709	87.9928	Suti II	67.06
12	Gobarhati	24.03626111	88.10166667	Kandi	82.36
13	Gokarna	24.04632	88.11839	Kandi	106.77
14	Hafania	24.61368	88.01316	Suti II	56.39
15	Harua	24.52555	87.98972	Suti I	51.8
16	Hasimpur	24.62861111	88.00639722	Samserganj	70.13
17	Hilora	24.49724444	87.96652778	Suti I	59.44
18	Isanpur	24.15432	88.09055	Kandi	91.44
19	Kalinagar	24.47839444	87.9746	Suti I	54
20	Kusumgachi	24.52622778	87.94234167	Suti I	54.86
21	Mahalandi	24.07430833	88.12341111	Kandi	90
22	Mahesail	24.61272778	88.01446667	Suti II	56.39
23	Manigram	24.35077	88.1162	Sagardighi	152.36
24	Panchgram	24.20537	88.00939	Nabagram	100.65
25	Parulia	24.25802	88.08683	Sagardighi	88.69
26	Ratanpur	24.27692	88.00446	Sagardighi	85.65
27	Raturi	24.47358333	87.9813	Suti I	53.9
28	Khargram	24.52636	88.06814	Khargram	182.67

Table 2: Tube wells of Agri-Irrigation & PHED, Govt. of West Bengal

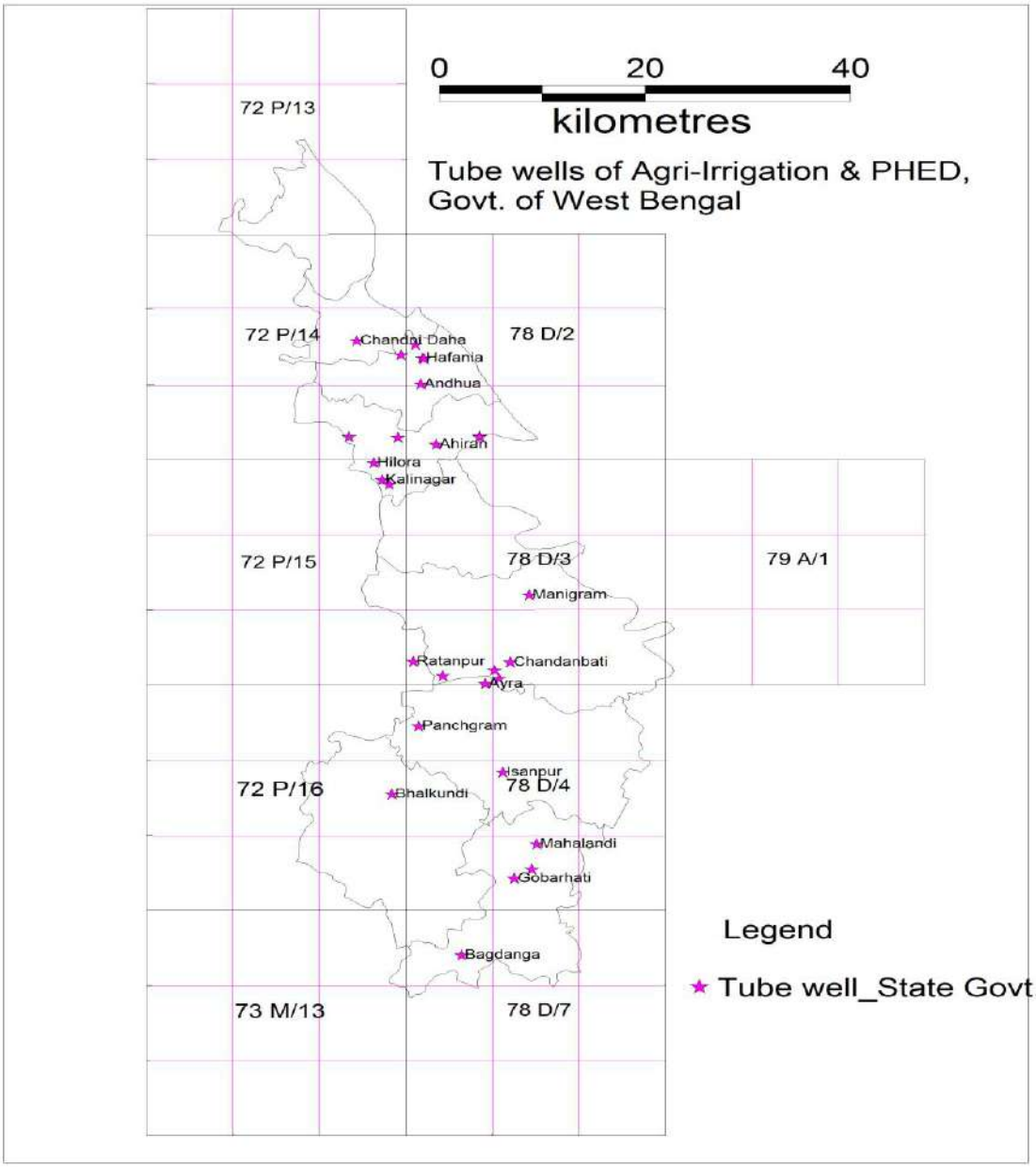


Fig. 2: Locations of Tube wells of State Govt. Depts. in study area

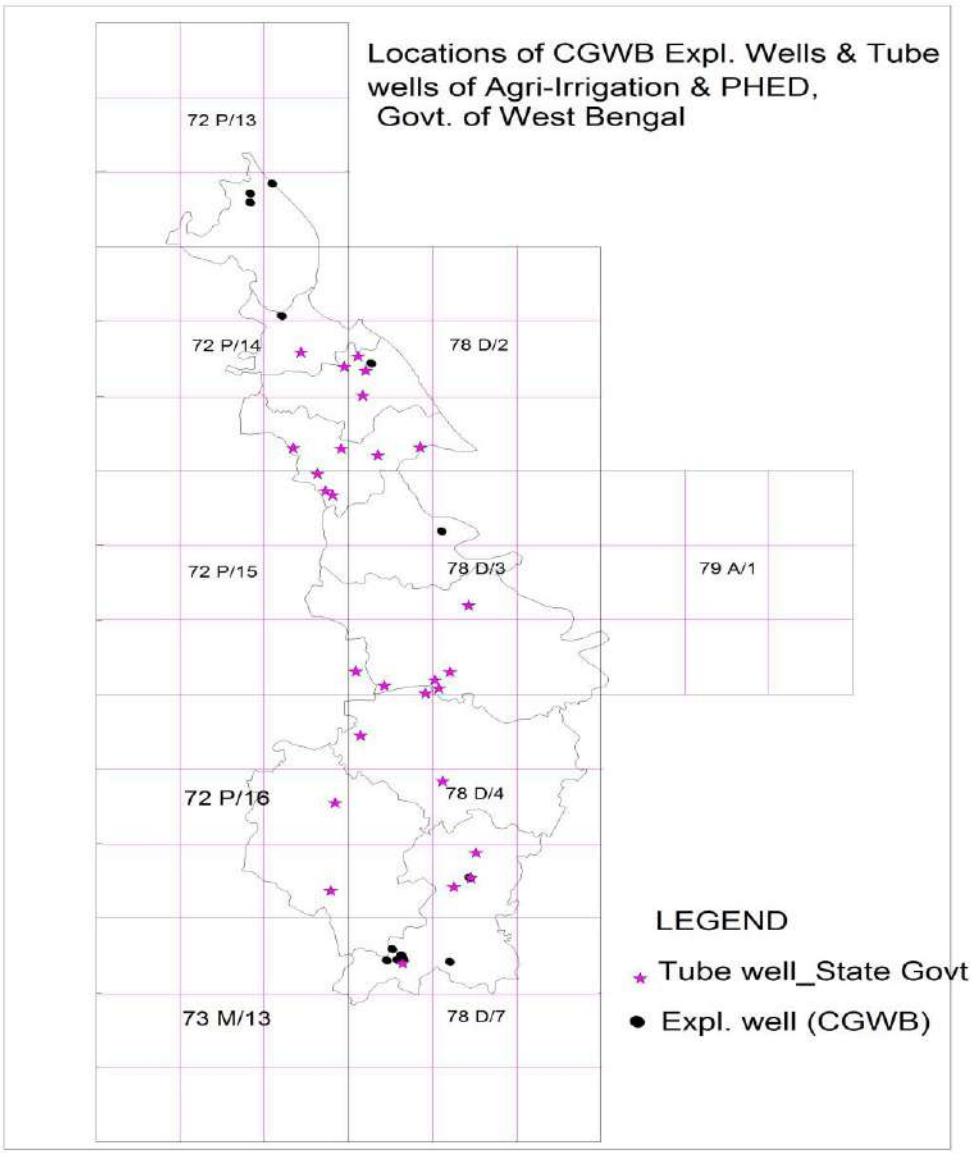


Fig. 3: Locations of existing CGWB exploratory wells & Tube wells of State Govt. Depts. under study

Approach of Data Gap for Exploratory Wells: For Data Gap Analysis, method suitable for the study area has been adopted. In the study area, existing data show that principally 2-aquifer system prevails in the sub-surface. For establishment of exploratory tube wells 2B quadrant (if area falls in it) has been considered as the centre and well field having 2 EWs and 2 OWs (considering Aquifer I up to 100 m depth & Aquifer II up to 200m depth) are required for present study; at places, where thick unconsolidated deposits are expected, eg. In Kandi, Khargram, Nabagram, Sagardighi and Raghunathganj I, in 4 Corner Quadrants of a Toposheet, if area falls in it, to study deep aquifer, i.e. Aquifer III, EW of 300 m are required. So, in one full Toposheet 8 wells are required. For arriving at nos. of wells of different depths required, above mentioned pre-requisites have been kept in mind and found that a total of 28 wells are required for present study (2 EWs & 2 OWs - 100 m depth, 2 EWs & 2 OWs - 200 m depth & 10 EWs & 10 OWs - 300 m depth).

However, there are already a few existing Exploratory & Observation Wells constructed by CGWB, as shown in Fig. 1. Also, data of some Tube wells have also been collected from State Govt Depts., Viz. Agri-Irrigation & PHED, Govt. of West Bengal, as shown in Fig. 2. Those wells have been considered as key wells representing the quadrant in which they fall and the nearby areas. **Finally, 18 wells, out of which 14 EWs – 7 of 200 m depth & other 7 of 300 m depth & 4 OWs of 300 m depth, have been proposed for construction by outsourcing. Tentative locations of wells by outsourcing as formulated is given in Table 3 and location of existing CGWB exploratory wells & proposed wells by outsourcing have been shown in Fig. 4.** Apart from this, a very few wells would be constructed in-house and those wells would be used for collection of additional data.

Table 3: List of tentative locations of wells to be constructed during 2017-18 through outsourcing in Murshidabad district West Bengal										
Sl no	**District Name**	**Block**	**Village**	**Proposed Well Site No. on Map**	**Latitude**	**Longitude**	**Toposheet no**	**Soft rock/Hard rock**	**Type of Well**	**Depth of Proposed well (m)**
1	Murshidabad	Farakka	Jigri Kulgachi	1	24.6991	87.9288	72P/14	Soft	EW	200
2	Murshidabad	Samserganj	Dogachhi	2	24.6204	87.9203	72P/14	Soft	EW	200
3	Murshidabad	Suti II	Khidirpur	3	24.5905	88.0443	78D/2	Soft	EW	300
4	Murshidabad	Suti II	Khidirpur	3	24.5905	88.0443	78D/2	Soft	OW	300
5	Murshidabad	Suti I	Panchigachhi	4	24.5266	87.9613	72P/14	Soft	EW	200
6	Murshidabad	RaghunathgaNJ i	Balighata	5	24.4841	88.0459	78D/3	Soft	EW	300
7	Murshidabad	RaghunathgaNJ i	Samyasidanpa	6	24.423	87.9891	72P/15	Soft	EW	200
8	Murshidabad	Sagardighi	Gayespur	7	24.3338	88.2019	78D/3	Soft	EW	300
9	Murshidabad	Sagardighi	Gayespur	7	24.3338	88.2019	78D/3	Soft	OW	300
10	Murshidabad	Sagardighi	Jalbanda	8	24.2959	88.0578	78D/3	Soft	EW	200
11	Murshidabad	Nabagram	Laskarpur	9	24.1621	88.2023	78D/4	Soft	EW	300
12	Murshidabad	Nabagram	Laskarpur	9	24.1621	88.2023	78D/4	Soft	OW	300
13	Murshidabad	Nabagram	Laskarpur	10	24.1857	88.0157	78D/4	Soft	EW	200
14	Murshidabad	Khargram	Jahangirpur sankarpur	11	24.1053	88.0493	78D/4	Soft	EW	300
15	Murshidabad	Khargram	Jahangirpur sankarpur	11	24.1053	88.0493	78D/4	Soft	OW	300
16	Murshidabad	Khargram	Parulia	12	24.0817	87.9107	72P/16	Soft	EW	200
17	Murshidabad	Kandi	Hijal	13	23.9546	88.1366	79A/1	Soft	EW	300
18	Murshidabad	Sagardighi	Nanoch	14	24.2357	88.1335	78D/4	Soft	EW	300

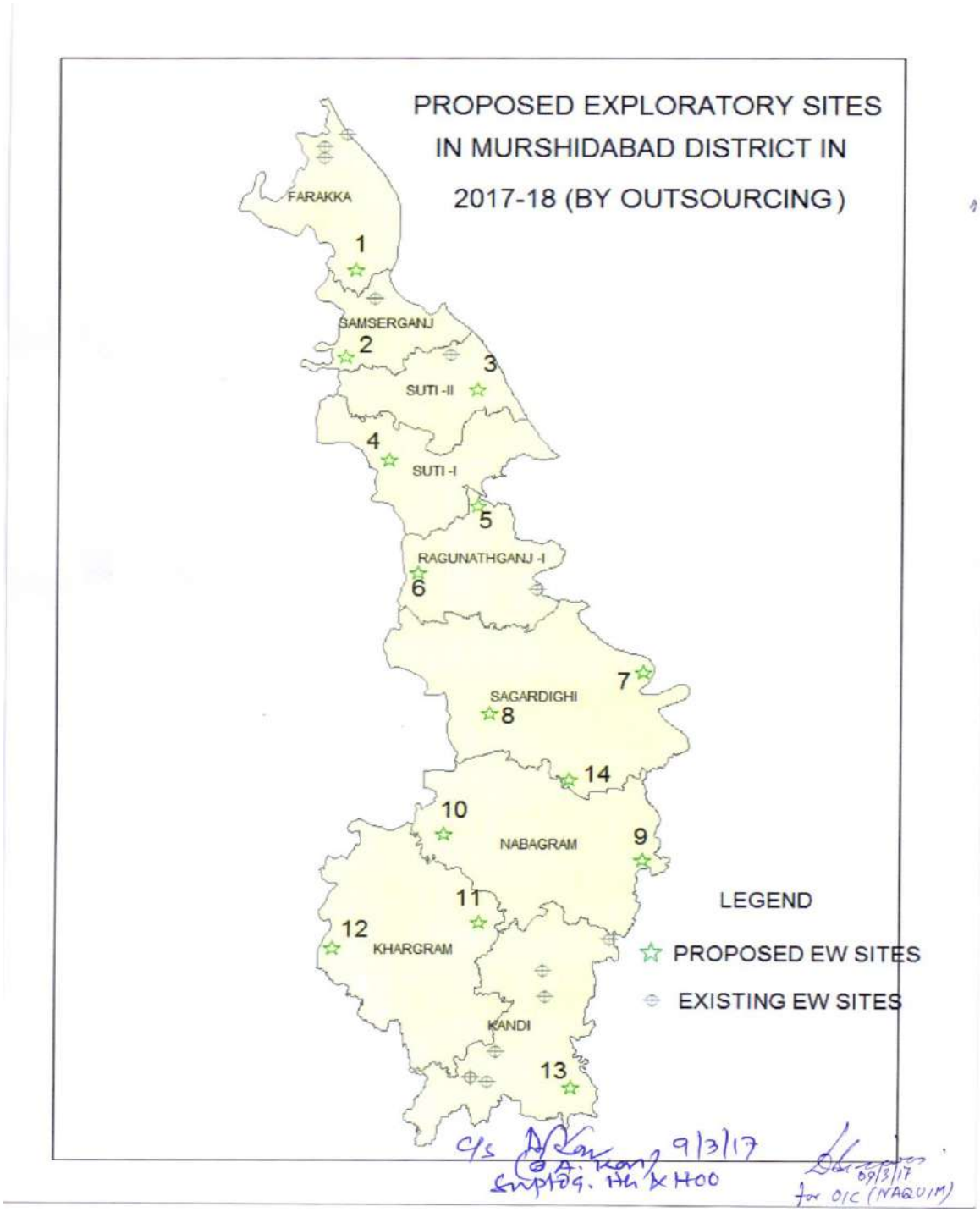


Fig. 3: Proposed exploratory sites & existing exploratory well sites in parts of Murshidabad district

Approach for Ground Water Monitoring Data:

Considering each topo-sheet as spatial scale -5' x 5' grids, as per the norms for shallow aquifer two observation wells in each quadrant are required. For deeper aquifers the existing exploratory data of CGWB wells and State Govt. Depts., eg. Agri-Irrigation & PHED, may be used for GW monitoring. For any gap, wells constructed in the Well field and Special Purpose wells should also be used.

Primarily, it is observed that, the nos. of existing monitoring wells, although not limited, but not well represented in some quadrants in a few blocks and in some quadrants more than 2 wells are there.

Study of pre-existing data show that Aquifer I is limited to Farakka, Samserganj, Suti II & Suti I, and in parts of Raghunathganj I & Sagardighi and in minor portion of Kandi & Khargram. Accordingly, the study area approximately comprises of 11quadrants. Therefore, 22 observation wells may be required to study Aquifer I.

On the other hand, Aquifer II occurs throughout the area. In the study area, there are more or less 25 quadrants. For study of this aquifer, about 50 wells are needed. 2 well field wells may be used for study purpose too.

Similarly, the occurrence of Aquifer III is restricted to Nabagram, Kandi, Samserganj and Suti I. For study of these aquifer, special purpose wells, 5 EWS & 5 OWs, of 300 m depth may be used for study of this aquiferAt least two time monitoring was proposed. Fig. 5 and Table 4. depicts the existing monitoring wells in different blocks of the study area. The water level monitoring wells are also considered for water quality monitoring stations.

Table 4: Existing monitoring wells (NHS) of CGWB

Sl. No.	Block	Location/ Village	Type of well	Lat	Long
1	Farakka	Arjunpur Pz	Piezometer	24.7178	87.9331
2	Farakka	Chaukigram	Dug Well	24.7807	87.9114
3	Farakka	Farakka	Dug Well	24.7709	87.9126
4	Farakka	Jorpukuria	Dug Well	24.7522	87.9014
5	Kandi	Basabari	Mark-II	23.9492	88.0447
6	Kandi	Gantla	Piezometer	24.08	88.0897
7	Kandi	Gobarhati	DTW*	24.0247	88.1403
8	Kandi	Gokarna	Mark-II	24.0347	88.1111

9	Kandi	Gokarna	Piezometer	24.0392	88.1153
10	Kandi	Jibanti	Cylindrical	24.0864	88.1703
11	Kandi	Kandi	Dug Well	23.9544	88.0458
12	Kandi	Manoharpur	Mark-II	23.9775	88.0569
13	Kandi	Nabagram	Mark-II	24.0647	88.1481
14	Kandi	Purandarpur	Mark-II	23.99639	88.073057
15	Kandi	Purandarpur Pz	Piezometer	23.9967	88.0733
16	Kandi	Ranagram	Mark-II	24.0206	88.0942
17	Kandi	Rasorah	Piezometer	23.9325	88.0508
18	Khargram	Jhilli	Piezometer	24.1786	87.9661
19	Khargram	Khargram	Piezometer	24.02882	87.97787
20	Khargram	Mahisar	Piezometer	23.9822	88
21	Khargram	Parulia	Piezometer	24.0822	87.9078
22	Khargram	Purapara	Piezometer	24.1244	87.9214
23	Khargram	Sherpur	Cylindrical	24.1281	88.0058
24	Nabagram	Chanak	STW	24.2186	88.1117
25	Nabagram	Daffarpur	Piezometer	24.132506	88.187306
26	Nabagram	Gurah - Pashla	Piezometer	24.2003	88.0667
27	Nabagram	Mahadipur	Mark II	24.1367	88.2025
28	Nabagram	Panchgram	Mark II	24.1983	88.0136
29	Nabagram	Polsanda Pz	Piezometer	24.1858	88.1494
30	Nabagram	Polsonda	Piezometer	24.1917	88.1542
31	Raghunathganj I	Barala	Cylindrical	24.4278	88.0086
32	Raghunathganj I	Barala	Piezometer	24.4281	88.0086
33	Raghunathganj I	Mirzapur Jain Colony	Dug Well	24.4084	88.069
34	Raghunathganj I	Raghunathganj	Dug Well	24.4608	88.065
35	Sagardighi	Manigram	Dug Well	24.34342	88.10837
36	Sagardighi	Megha - Sihara	Piezometer	24.1928	88.0769

37	Sagardighi	Sagardighi Pz	Piezometer	24.2928	88.0892
38	Samserganj	Dhulian Pz	Piezometer	24.678393	87.95264
39	Samserganj	Krishnanagar	Dug Well	24.65	87.94
40	Samserganj	Natun Malancha	Dug Well	24.6733	87.9303
41	Samserganj	Puratan Malancha	Dug Well	24.6714	87.9283
42	Samserganj	Putimari	Dug Well	24.6403	87.935
43	Suti I	Haroa	Piezometer	24.5211	87.9825
44	Suti I	Ramakantapur	STW*	24.56	88.08
45	Suti II	Ahiran	Dug Well	24.51649	88.03458
46	Suti II	Khapur	Dug Well	24.5723	88.0358

*STW – Shallow Tube Well, Deep Tube Well

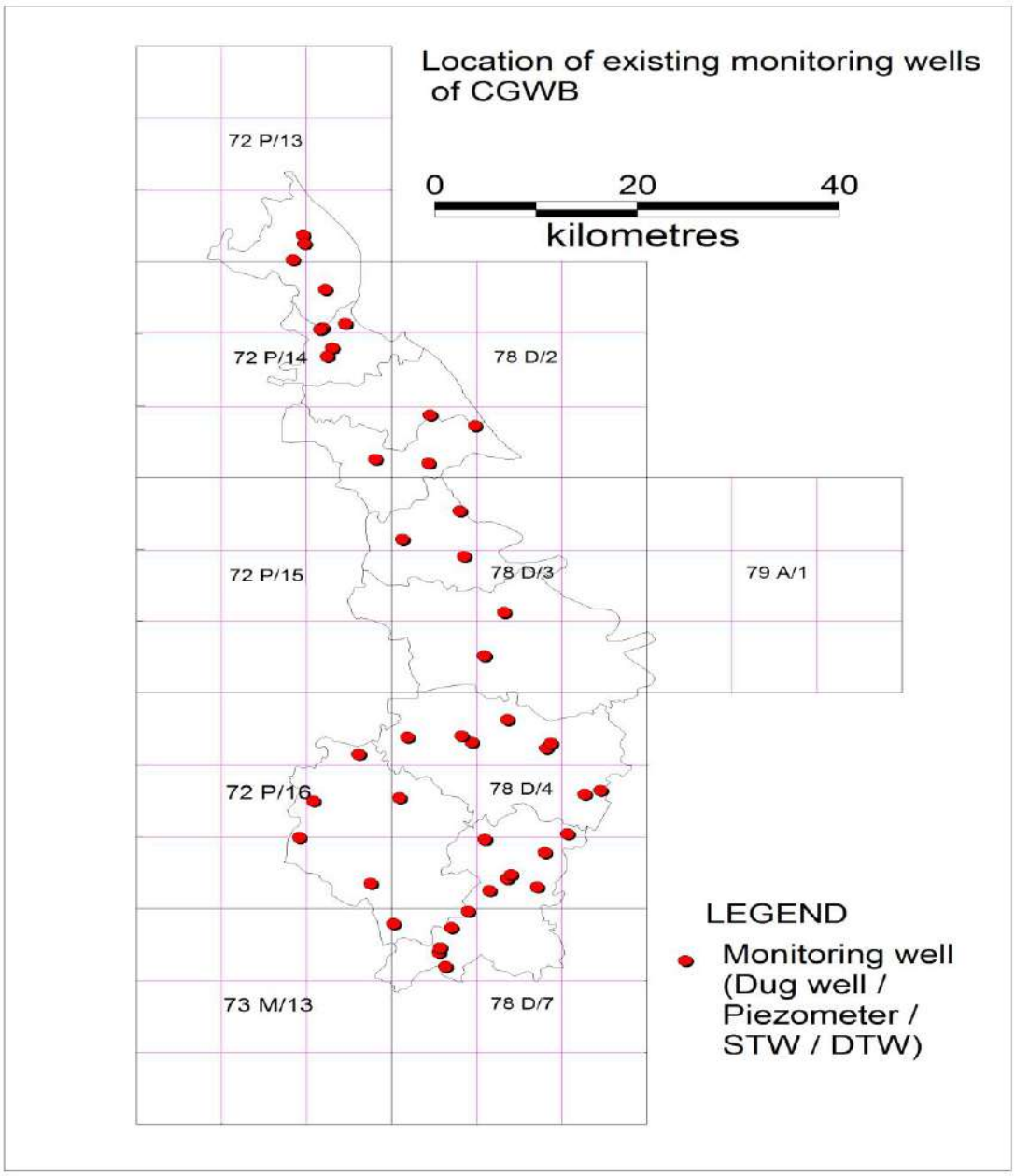


Fig. 5: Existing monitoring wells of CGWB

Geophysical Data: 2 or 3 Profiling/VES/TEM having 300 meter interpretation depth or as per the feasible spread in the field should be carried out in each of the nine quadrants. Therefore, one quadrant of a topo sheet needs 2 nos. VES and the area require about 50 VES. However, in the presence of sufficient existing and proposed exploration data the target of VES may be reduced accordingly.