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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

UTTAR DINAJPUR DISTRICT
WEST BENGAL

पूर्वी क्षेत्र, कोलकाता

Eastern Region, Kolkata

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

REPORT ON

AQUIFER MAPPING AND MANAGEMENT PLAN OF UTTAR DINAJPUR DISTRICT, WEST BENGAL

By

DEBASISH BAGCHI

CENTRAL GROUND WATER BOARD
Eastern Region, Kolkata

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FOREWORD

Aquifer Mapping and Management programme was taken up by the Central Ground Water Board during the XIIth Plan to characterize aquifers in three dimensions and formulate an aquifer management plan for benefit of the stakeholders. With this objective, Aquifer Mapping and Management study was taken up in Uttar Dinajpur district during Annual Action Plan: 2021-22. The management plans for nine Community Development Blacks of the district are prepared for sustainable management of groundwater resources through conjunctive use, increasing water use efficiency through novel methods and addressing the challenges of arsenic and fluoride contamination by critical analysis and interpretation of relevant data.

Hydrogeological, geophysical and hydrochemical data collected from field surveys was analyzed using dedicated software to prepare thematic maps on aquifer geometry and cross-correlation and to assess suitability of groundwater for drinking and irrigational use for the benefit of the local populace. Non-committed surface runoff was estimated block-wise for adoption of rainwater harvesting and augmentation of water resources through managed aquifer recharge. Seasonal, annual and decadal fluctuations in groundwater level were depicted through thematic maps. A Public Interaction Programme was organized for benefit of the stakeholders, wherein outcomes of aquifer mapping and management study were presented. The primary objective of the programme was to adopt participatory groundwater management by state government and the stakeholders with the philosophy *"Know Your Aquifer- Manage Your Aquifer".*

This report contains valuable information on aquifers of Uttar Dinajpur district brought out through 2-D cross-sections and 3-D models along with specific recommendations to tackle the challenging issues of arsenic and fluoride contamination. I appreciate the efforts made by Sh. Debasish Bagchi, Scientist-B (HG) in bringing out this report. I sincerely hope that it will be extremely useful to the policy makers, planners, administrators and groundwater data managers.

(Dr. Anadi Gayen)
Head of Office

EXECUTIVE SUMMARY

Aquifer Mapping and Management study was completed in 3056 km^2 area in Uttar Dinajpur district during the Annual Action Plan: 2021-22. The district falls in Survey of India degree sheet 78B, 78C, 72O and 72N. Economic development in the district is quite less, which has resulted in classifying it as a Backward District. The district has a monsoon sub-tropical climate having a normal rainfall of 2041 mm and annual temperature variation from 4 °C in winter to 41 °C in summer. The district is characterized by gentle topography with the master slope towards south. Four major geomorphologic types are recognized: Upper Alluvial Plain, Meander Flood Plain, Active flood Plain and Marshy Land (*Tal*). Mahananda, Fulahar, Kulik, Nagar, Tangon and Dahuk Rivers are the main natural drainage in the district.

Surface geology of Uttar Dinajpur district consists of quaternary alluvium in the fluvial deltaic plain of Bengal Basin. The quaternary sediments are further classified into Older alluvium and Younger alluvium. Older alluvium is exposed in southern part of the district falling in Itahar and Raiganj blocks, constituting the Barind Uplands. Younger alluvium occurs in the alluvial flood plains and shifting channels mostly in the south-eastern part of Mahananda basin. Periodic floods have resulted in deposition of fluvial silt, sand and clay in this zone. In Kaliaganj, Raiganj and Karandighi block, clay beds having thickness ranging from 3-5 m occur within fine to medium sand. In the northern part of the district (Goalpokhar-I, Goalpokhar-II, Islampur and Chopra block), predominantly arenaceous sediments (coarse sand and gravel) are found in the depth range of 110 to 250 m. The gravel beds are distinct at few locations like Milanpally and Durganagar. The gravels are well rounded and composed of quartzite and gneiss.

Major aquifers in the area are Younger Alluvium (Aquifer Code: AL 01) of Holocene age and Older Alluvium (Aquifer Code: AL 03) of Pleistocene age. Analysis of borehole logs of 75 wells (including exploratory wells of CGWB and production tube wells of PHED, Raiganj Division and Agri-irrigation Department, Raiganj) has revealed four to five aquifers in Raiganj, Hemtabad, Kaliaganj and Itahar block, three aquifers in Islampur, Goalpokhar-I and Karandighi block, two aquifers in Goalpokhar-II block and a single aquifer in Chopra block. In Barind Tract, thick clay layers (>10 m) have resulted in relatively poor groundwater potential of older alluvial aquifers as compared to younger alluvial aquifers. Aquifer Performance Test in one shallow and one deep exploratory well at Mohinipara

located in Barind Tract shows variation in transmissivity from 879.37 m^2/day to 1320.84 m^2/day. Storage co-efficient of shallow confined aquifer at Mohinipara in the depth range 36.0 – 55.0 m was 1.60 x 10^{-3}, which is about half the storage co-efficient (2.07 x 10^{-3}) of deeper confined aquifer in depth range 170.0 – 232.0 m. This indicates a considerable variation in yield potential of two distinct confined aquifers, one at <100 m depth while another at >150 m depth. High variation in well discharge was observed even in Barind Tract, as discharge in shallow exploratory well at Mohinipara (~32 m^3/day) was about 22.5 times lower compared to the discharge in deep exploratory well (720.58 m^3/day). Data Gap Analysis in Uttar Dinajpur district shows a requirement to construct 52 exploratory wells in addition to the existing 11 exploratory wells of CGWB as per the existing guidelines of aquifer mapping (CGWB 2013). A proposal to construct eight exploratory wells through outsourcing in Goalpokhar-I, Goalpokhar-II, Hemtabad, Karandighi and Itahar block (in Barind Tract) has been approved by the Ministry of Jal Shakti very recently. However, due to relatively less number of in-house exploratory wells (11 as on date), there is a need to take up intensive exploratory drilling in various blocks of the district in a phased manner over the next 4-5 years. The priority of well construction (in descending order) is suggested as: Chopra block, Goalpokhar-I block, Goalpokhar-II block, Karandighi block, Hemtabad block, Itahar block (Barind Tract), Raiganj block (Barind Tract) and Kaliaganj block. Even after construction of the proposed 8 exploratory wells, another 44 exploratory wells are still required to adequately characterize the aquifers for preparation of comprehensive aquifer management plans at block level and further fine tuning of existing block level aquifer management plans.

In addition to 29 active ground water monitoring wells (as on May 2022), 27 Key Observation Wells were established during the present survey. Thematic maps on depth to water level and water table contours during pre-monsoon and post-monsoon periods were prepared using special software like Rockworks and MapInfo. Assessment of dynamic groundwater resources (as on 31-3- 2013) indicates that all nine blocks were in Safe category with Stage of Ground Water Development varying from 37.25% in Chopra block to 83.41% in Hemtabad block. Itahar block has been categorized as fluoride contaminated by the Fluoride Task Force, Government of West Bengal. However, both historical and latest chemical analysis in NABL accredited lab of CGWB, ER has not shown any fluoride contamination having the highest fluoride concentration of 1.0 mg/L at Churamon.

However, seasonal variation in fluoride concentration in shallow aquifers needs to be assessed through regular groundwater quality studies from water supply tube wells, special purpose wells (Key Observation Wells) and ground water monitoring wells.

Due to low stage of groundwater development (<70%) at district level, demand side aquifer management may not be essential. However, due to rapid population growth and ever increasing demand of groundwater for irrigation, there is ample justification to increase the existing water use efficiency by using drip and sprinkler irrigation and adopting alternate cropping pattern. Crops like peanuts, sunflower, soybean and ginger needs to be grown instead of water-intensive paddy crop, especially during the summer. Water scarcity in Itahar block was reported by the farmers in the summer of 2022, which has been highlighted also by the print media. The issue should be addressed on priority by supply side management through construction of additional tube wells by the state government department. Cultivation of water intensive summer paddy (Boro) needs to be minimized and subsidy for alternate cropping is to be arranged by district administration to the marginal and small farmers in problematic areas of Itahar block.

Due to substantial monsoon rainfall in Uttar Dinajpur district, open area rainwater harvesting (OARWH) in rural areas and roof top rainwater harvesting (RTRWH) in urban and peri-urban areas can be taken up with financial and administrative support by the Government of West Bengal. In the Master Plan of Artificial Recharge (CGWB 2020), 30 RTRWH structures with unit cost of Rs. 40,000/- were proposed for three Census Towns (Kasba, Dalkhola and Nacchatrapur Katabari) and 75 RTRWH structures with unit cost of Rs. 80,000/- were proposed for three Municipalities (Raiganj, Islampur and Kaliaganj). The total cost for implementation of 105 RTRWH schemes was estimated at Rs. 72,00,000/- only. However, during the present survey, 14 sites were selected for implementation of rainwater harvesting, out of which 10 sites are in Raiganj block and two sites each in Islampur and Kaliaganj block.

An initiative on water conservation and harvesting in Uttar Dinajpur district has been taken up by the Government of West Bengal through the *Jal Dhoro Jal Bhoro* programme, which is being implemented by the Water Resources Investigation and Development Department. Under this programme, 786 water bodies are reported to be excavated in various blocks of the district. Possibility of expansion of this programme may be worked out by integrating the *Jal Dhoro Jal Bhoro* programme with centrally funded schemes like

Mahatma Gandhi National Employment Guarantee Scheme, *Pradhan Mantri Krishi Sinchai Yojana – Har Khet Ko Paani* and *Jal Shakti Abhiyan* – Catch The Rain initiative.

Village level aquifer mapping and management study was taken up in Birghai village of Raiganj block with an area of 451.66 ha. Based on type of tube wells, average running hour and average discharge of tube wells, groundwater requirement for cultivation of kharif crops, rabi crops and summer paddy (boro) were estimated at 500 m^3, 2497 m^3 and 122.37 m^3 respectively. Three India Mark-II tube wells were inventoried in Birghai village. Depth to water level in the tube wells were found to vary from 4.43 to 4.72 m bgl (November 2021) and from 5.15 to 5.59 m bgl (May 2022). Villagers of Birghai have installed low to medium discharge shallow tube wells (locally known as *Marshal*) fitted with submersible pumps (generally 5 HP capacity) for cultivation of two varieties of paddy (*Boro* and *Amon*) along with vegetables like cauliflower, potato and sunflower during winter season. For drinking and domestic work, cast iron tube wells of shallow depth (25 – 30 m) are primarily used. During the micro-level survey, two sites for open area rainwater harvesting were selected, one in the Primary School and another in Bhojo Gobindo Roy Madhyamik Shiksha Kendra. The cost estimate for implementation of open area rainwater harvesting has been worked out at Rs. 88,000/- only.

In order to share the local groundwater condition and outcomes of aquifer mapping and management study in the district by CGWB, a Public Interaction Programme (PIP) was organized in online mode on 20-5-2022 with wide participation from state government departments (PHED Raiganj Division, Agri-irrigation Department, SWID Geological Sub-division IV-C) and from the Raiganj University. Capacity building and awareness generation of the stakeholders may be planned in a phased manner by organization of training programmes and PIPs, where the outcomes of block level aquifer management plans can be shared. Participatory groundwater management is the key to a sustainable aquifer management as groundwater is a community resource. Outcomes of the present study will be shared through web portal for the benefit of the stakeholders.

CONTRIBUTORS

Data Acquisition	Debasish Bagchi, Scientist-B (HG)
Lithological Data (strata charts)	Public Health Engineering Directorate, Raiganj Division Agri-irrigation Department, Raiganj
Ground Water Level Data (state government)	State Water Investigation Directorate, Geological Sub-division IV-C, Raiganj
Ground Water Exploration Data	S.M. Hossain, Scientist-D (AHG)
Hydrometeorological Data	Dr. Nilamoni Barman, Scientist-B (HM) Dr. Indranil Roy, Scientist-D (HG)
Data Processing	Mahasweta Mukherjee (Young Professional) Rajyashree Nandy (Young Professional) Debasish Bagchi, Scientist-B (HG)
Data Compilation and Editing	Debasish Bagchi, Scientist-B (HG)
Hydrogeological Data Analysis and Interpretation	Dr. Indranil Roy, Scientist-D (HG) Debasish Bagchi, Scientist-B (HG)
Hydrochemical Data Analysis	Prashant Yentapalli, Asst. Chemist
Preparation of Thematic Maps and analysis in GIS	Mahasweta Mukherjee (Young Professional) Rajyashree Nandy (Young Professional)
Preparation of Report	Debasish Bagchi, Scientist-B (HG)
Scrutiny of Report	Dr. Indranil Roy, Scientist-D (HG)
Technical Guidance	Sandhya Yadav, Scientist-E (HG) Dr. S.K. Samanta, Regional Director (Retd.)
Report Processing and Publication	Chirashree Mohanty, Scientist-D (HG)
Overall Supervision	Dr. Anadi Gayen, Head of Office

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UTTAR DINAJPUR DISTRICT AT A GLANCE

S. No.	Items	Statistics
1.	**GENERAL INFORMATION**	
	Geographical Area	3142 km^2
	Area under aquifer mapping	3056 km^2
	Co-Ordinates	Latitude - $25^0$11' N to $26^0$49' N
		Longitude - 87^0 49' E to $90^0$00' E
	Administrative Setup	
	➢ District Head Quarter	Raiganj ($25^0$00'14" N, $88^0$11'20" E)
	➢ Nos. of Sub-Divisions	2 (Raiganj and Islampur)
	➢ Nos. of Blocks	9 (Raiganj, Itahar, Hemtabad, Karandighi, Goalpokhar-I, Goalpokhar-II, Kaliaganj, Islampur and Chopra)
	➢ Number of Gram Panchayat	98
	➢ Number of Gram Samsad	1632
	➢ Number of Mouza	1504
	➢ Number of Municipality	4 (Raiganj, Kaliaganj, Islampur and Dalkhola)
	➢ Number of Villages	1475
	(d) Population (Census, 2011)	**Total: 3007134**
	(with Population Density and Literacy %)	Male: 1551080 (51.58 % of total)
		Female: 1456054 (48.42 % of total)
		Rural: 1364175 (87.95 % of total)
		Urban: 1642959 (12.05 % of total)
		Population Density: 958 person per km^2
		Literacy: 59.07 %
		Male literacy: 65.52 %
		Female literacy: 52.17 %

	(e) Rainfall and Temperature	Normal Rainfall: 2041 mm (2013) Annual Rainfall: 1579 mm (2013) Temperature: Maximum – 41 ^{0}C Minimum – 4 ^{0}C
2.	**GEOMORPHOLOGY**	
	(a) Major Physiographic Units	(a) Active Flood Plain (b) Meander Flood Plain (c) Alluvial Plain – Upper (d) Marshy Land
	(b) Major Drainage	Perennial rivers: Mahananda, Kulik, Nagar, Dahuk, Gumari, Suin
3.	**LAND USE in km^2 (Year: 2020)**	
	Forest Area	5.80
	Pasture & other Grazing Land	0.40
	Cultivable Waste Land	0.50
	Land under Non-Agricultural Use	313.00
	Miscellaneous (Trees & Groves, not include in Net Sown Area)	34.70
	Current Fallow Land	1.50
	Other Fallow Land	1.00
	Net Sown Area	2767.30
4.	**MAJOR SOIL TYPE**	Sandy soil, Loam, Sandy loam soil, Clay loam soil
5.	**AREA UNDER PRINCIPAL CROPS in km^2 (Year: 2020)**	Rice (Aus, Aman, Boro) – 2268.0 Total Cereals: 3076.0 Total Pulses: 35.0 Total Food Grains: 3111.0 Total Oilseeds: 503.0 Total Fibers: 453.0 Total Miscellaneous Crops: 209.0
6.	**IRRIGATION**	**Areas & No. of Structures**

	Tube Wells	*High Discharge Tube Well (HDTW)* Number: 106, Area Irrigated: 43.30 km^2 *Medium Discharge Tube Well (MDTW)* Number: 7, Area Irrigated: 1.40 km^2 *Shallow Tube Well (STW)* Number: 12, Area Irrigated: 0.70 km^2
	Dug Wells	Number: 0, Area Irrigated: 0
	Tanks/Ponds (Year: 2012)	Number: 3403, Area Irrigated: 24.74 km^2
	Surface Lift Irrigation (RLI)	Number: 99, Area Irrigated: 14.60 km^2
7.	**NUMBER OF ACTIVE GROUND WATER MONITORING WELLS OF CGWB (as on 31-7-2022)**	29 Dug Well – 08 Piezometer – 02 Tube Well – 19
8.	**KEY WELLS (KOW) ESTABLISHED DURING NAQUIM STUDIES (2021-22)**	27 (India Mark-II Hand Pump operated Tube Wells)
9.	**GEOLOGICAL FORMATION**	Younger Alluvium and Older Alluvium (Barind Tract)
10.	**HYDROGEOLOGY**	
	Major Water Bearing Formation	Quaternary Alluvium
	Depth to Water Level	**Barind Tract (Older Alluvium)** Pre-monsoon 2022: 3.88 m bgl at Amlapara to 13.28 m bgl at Baidara Post-monsoon 2021: 1.61 m bgl at Amlapara to 7.25 m bgl at Churamon **Younger Alluvium** Pre-monsoon 2022: 2.89 m bgl at Kanki to 8.44 bgl at Kunore Post-monsoon 2021: 0.73 m bgl to 5.32 m bgl at Chopra (Dalua)
10.	**GROUND WATER EXPLORATION as on 31-7-2022**	
	No. of Wells Drilled by CGWB	15 (EW: 11, OW: 4)

Depth Range	Minimum: 61.20 m at Uttar Chirail (Kaliaganj block) Maximum: 307.80 m at Baghan (Kaliaganj block)
Discharge (75 wells including data of 15 wells drilled by CGWB)	Minimum: 197.5 m^3/hr at Majhok (Goalpokhar-I block) and Basantpur (Goalpokhar-II block) Maximum: 236.99 m^3/hr at Lakshmania (Raiganj block)
Transmissivity (T)	Minimum: 839.38 m^2/day at Durganagar (Islampur block) Maximum: 1816.85 m^2/day at Kaliaganj ITI (Kaliaganj block)
Storage Co-efficient (S)	Minimum: 5.29 x 10^{-5} at Goalpara Ward No. 1 (DEW) in Raiganj block Maximum: 2.07 x 10^{-3} at Mohinipara (Itahar block)

11. GROUND WATER QUALITY

(a) Presence of chemical constituents more than permissible limit	High iron in tube well samples at Chopra, Madaripur, Hemtabad, Lohagara, Baghan
(b) Type of water	Ca-Mg-HCO_3

12. DYNAMIC GROUND WATER RESOURCES (as on 31-3-2013)

(a) Net Annual Ground Water Availability	133514.83 ham
(b) Gross Ground Water Draft for all uses	82994.87 ham
(c) Projected demand for domestic use (up to 2025 AD)	7569.33 ham
(d) Stage of Ground Water Development	60.88 %

13. AWARENESS AND TRAINING ACTIVITY

(a) Number of Mass Awareness Programme Organized	One (organized on 14-2-2006 at Raiganj) Total participants: 119

(b) Number of Water Management Training Programme Organized	One (organized on 14-2-2006 at Raiganj) Total participants: 26
(c) Number of Public Interaction Programme organized during celebration of *Azadi Ka Amrit Mahotsav: Celebrating 75 Years of Indian Independence*	One (organized in online mode on 20-5-2022) Total participants: 54

14. EFFORTS OF ARTIFICIAL RECHARGE AND RAINWATER HARVESTING

Water conservation is being taken up by the Water Resources Investigation and Development Department in association with Department of Panchayati Raj and Rural Development, Government of West Bengal. During present study, 14 sites in Raiganj, Kaliaganj and Islampur Municipality were selected for implementation of Roof Top Rainwater Harvesting and/or Open Area Rainwater Harvesting.

15. GROUNDWATER CONTROL AND REGULATION

(a) No. of Over Exploited Blocks	Nil
(b) No. of Critical Blocks	Nil
(c) No. of Blocks Notified	Nil

16. MAJOR GROUND WATER RELATED PROBLEMS AND ISSUES

(1) Iron contamination in groundwater from tube well water samples collected from parts of Raiganj, Itahar, Kaliaganj, Hemtabad, Islampur and Chopra blocks

(2) Water scarcity problem in summer season in few areas of Itahar block, falling in the Barind Tract

1. INTRODUCTION

1.1 Objective of the study

The main objectives of the present study on Aquifer Mapping and Management can be summarized as follows:

- Delineation of aquifer geometry through analysis of borehole lithological data (both in house and state government departments) and correlation of aquifers, both regionally and locally
- Identification of aquifer groups based on depth of occurrence, aquifer parameters and variation in chemical quality, if any
- Identification of groundwater related issues and problems and presentation of the findings to the district administration for preparation of policies to the benefit of the stakeholders
- Preparation of Aquifer Management Plan for Uttar Dinajpur district and also for the nine Community Development Blocks
- Identification of a model village for development of village level Aquifer Management Plan based on existing database at micro-level, if any
- Identification of specific locations for implementation of rain water harvesting, both in urban, peri-urban and rural areas and presentation of the results to the district planners and administrators
- Suggesting suitable action based research programs within the scope of departmental activities and identification of areas of convergence by CGWB and state government departments working in water sector for sustainable management of groundwater resources of the district

1.2 Location and Accessibility

Uttar Dinajpur district, lying on the northern side of the River Ganga, was formed on 1st April 1992 after carving out from the West Dinajpur district. Uttar Dinajpur district is a multilingual district but is dominated by Bengali speaking people. The district is a gateway to hilly districts of North Bengal and is unique due to its geographical position connecting the Sub Himalaya to the north with Gangetic Alluvial Plain to the south. The district lies between north latitude 25^0 11' to 26^0 49 and east longitude 87^0 49' to $90^0$00'. Uttar Dinajpur district falls in Survey of India degree sheet nos. 78B, 78C, 72O and 72N, although Degree Sheet 72O and 72N covers a very small part of the geographical area.

The district is bounded by Bangladesh on the east (length of International Border is 227 km),

Kishanganj, Purnea and Katihar districts of Bihar on the west, Darjeeling district of West Bengal on the north and Malda district of West Bengal on the south. The National Highway (NH) No. 34 passes through Stalkuri, Itahar, Raiganj, Karandighi and Dalkhola before entering Purnea district of Bihar. National Highway 31, popularly known as Siliguri Road, passes through Kanki, Dhantola, Islampur and Chopra in the western and central parts of the district. Raiganj, the district headquarter, is about 425 km north of Kolkata, the State Capital. The nearest airport is at Bagdogra, which is about 149 km north of Raiganj. Apart from the National Highways, State Highways and a network of secondary and tertiary motorable roads connect various other prominent locations like Itahar, Hemtabad, Kaliaganj, Tungidighi, Dalkhola, Chakulia, Islampur, Chopra, Biprit, Dhantola, Kanki, Botolbari, Domohana, Rasakhowa etc. besides several large and small villages within the district.

1.3 Administrative Divisions and Demography

The district consists of nine Community Developmental Blocks, four Municipalities, 98 gram panchayats and 1475 villages (District Statistical Handbook, 2014). Raiganj and Islampur are the two sub-divisions in the district. Raiganj (25.6164 N, 88.1225 E) is the district headquarter, which is situated in the southern part of the district. Raiganj Municipality is the largest in the district, covering an area of 10.76 sq. km. Total population of Uttar Dinajpur district was 3007134 with male and female population being 1551080 and 1456054, respectively. 87.95% of total population is rural whereas only 12.05% is urban (Census 2011). The overall literacy rate in the district is also low when compared to other districts of West Bengal, being a dismal 59.07%, with female literacy rate lagging behind at 52.17% as compared to male literacy rate of 65.52% (Census 2011). Agriculture remains the main livelihood of the people, primarily due to the absence of any mineral resource in the district. Other relevant details on demographics of Uttar Dinajpur district are given in the District Summary. Administrative map of Uttar Dinajpur district is shown in **Fig. 1.1.**

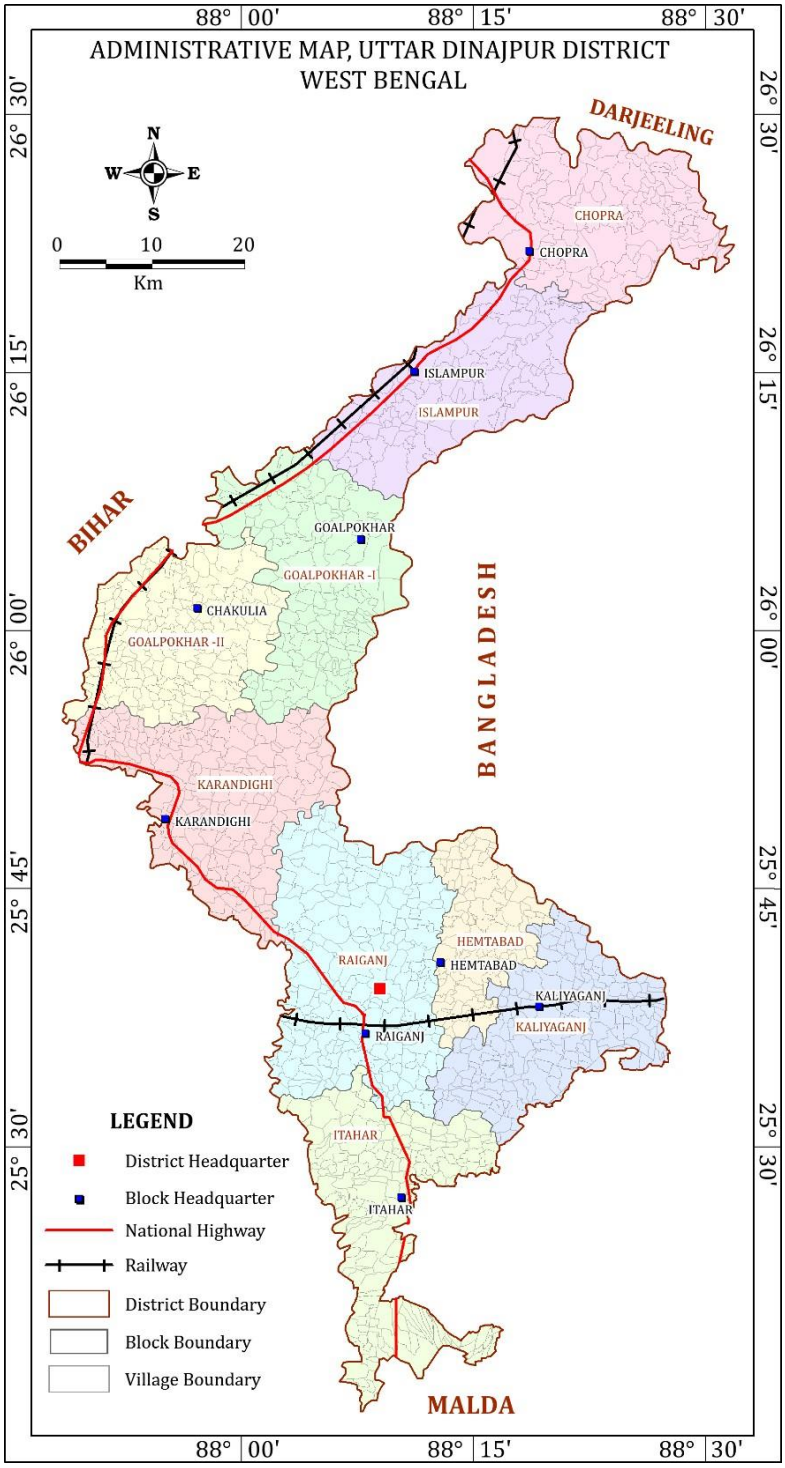


Fig. 1.1 Administrative map, Uttar Dinajpur district

1.4 Land use, Agriculture and Cropping Pattern

Land use pattern of urban and rural areas mainly depends on socio-economic and socio-cultural factors. The change in land use pattern can be explained as follows:

- The rapid growth of population demands for rapid increase in agricultural productions by bringing more and more areas under cultivation. In this regard, cropping pattern also plays a significant role as 'Boro' paddy cultivation is gaining importance at unprecedented level through bringing more areas under this.
- Rapid urbanization of the area is also changing the land use pattern regularly and more and more areas are being brought under urban activities and settlements.
- Another important change in land use is conversion of low-lying waterlogged areas into cultivable land (Multi Hazard District Disaster Management Plan, 2016-17).

Agricultural land is the most significant land use class in Uttar Dinajpur district. Almost entire cultivated land is under double cropping with only 0.5 km^2 area classified as Cultivable Waste Land (District Statistical Handbook). The Current Fallow Land and Other Fallow Land are also very less, covering an area of 1.5 km^2 and 1.0 km^2 respectively. Only 0.4 km^2 area has been classified as Pasture and Other Grazing Land. Total Forest Land in the district is 5.8 km^2, out of which 1.3 km^2 is under Raiganj Wildlife Sanctuary. Due to degraded land condition, 313 km^2 has been classified as Land under Non-agricultural Use. This is again attributed to poor economic development in the district.

Double cropping is a common practice, although more than two crops are harvested in few areas, which includes three varieties of paddy viz. *Aus, Amon* and *Boro*. *Boro* cultivation is causing a huge stress on the groundwater resources as the growing season coincides with the summer. Principal crops grown in the district are paddy, potato, wheat, pulses, mustard and other oilseed, jute, sugarcane and other Rabi crops. Among the food grains, paddy is the principal crop. *Boro* and *Amon* are the main types. The number of small cultivators in the district was 88536 while the number of marginal cultivators was 135827. Out of the paddy variety, *Amon* paddy is grown in 1770 km^2 area, followed successively by *Boro* paddy (496 km^2) and *Aus* paddy (2 km^2). Out of the oilseeds, rapeseed and mustard was cultivated to the largest extent, in an area of 484 km^2. Jute cultivation is done in 445 km^2 area. Tea cultivation is restricted in the northernmost part (Chopra block), with an

area of about 3 km^2 under the tea gardens, notable among these are the Debijhora Tea Estate in Chopra block. Total production of paddy (including *Aus, Amon* and *Boro*) in Uttar Dinajpur district was 573.8 thousand tonnes (TT) whereas total production of cereals including wheat and maize was 888 TT. Among the cash crops, annual production of potato, jute and sugarcane was 357.7 TT, 578.1 TT and 100.2 TT, respectively (District Statistical Handbook).

1.5 Irrigation

Uttar Dinajpur district is endowed with vast groundwater resources. Groundwater is mainly tapped by shallow and deep tube wells. However, this resource is limited in the Barind Uplands falling in Itahar block in the southernmost part of the district. Irrigation facilities are also created from surface water sources like rivers, ponds and tanks. Available data from Irrigation and Waterways Directorate, Government of West Bengal shows that irrigation facility can be categorized into the following types:

1.5.1 Surface Water Irrigation

Sources of surface water are mainly the perennial rivers and streams. Small water bodies like pond, tank, bils are also important sources of surface water irrigation particularly during Rabi and Boro crop seasons. Apart from tanks, irrigation is also being done by surface flow schemes like weirs, diversions etc. Latest available data indicates that area irrigated by government canals was 17 km^2 while area irrigated by tanks and ponds was 24.7 km^2. Total number of tanks and ponds was 3403 (District Statistical Handbook).

1.5.2 River Lift Irrigation

As per latest data of state government, a total of 99 River Lift Irrigation (RLI) schemes are operational in the district, where the water is drawn from Mahananda River. The area irrigated under the RLI scheme was 14.6 km^2 (Multi Hazard District Disaster Management Plan, 2016-17).

1.5.3 Groundwater Irrigation

High Discharge Deep Tubewell (HDTW), Medium Discharge Deep Tubewell (MDTW), Low Discharge Deep Tubewell (LDTW) and Shallow Tubewell (STW) are the sources for groundwater-based irrigation in Uttar Dinajpur district. This classification is widely followed by the Agri-irrigation Department, Raiganj Division. Available data shows that irrigation is done through 106 HDTW (area irrigated: 43.3 km^2), 7 MDTW (area irrigated: 1.4 km^2), 47 LDTW (area irrigated: 4.5 km^2) and 41700 STW (area irrigated: 1139.6 km^2) respectively. Surprisingly, the STWs were subsequently categorized as own and operated sources of irrigation and their number was drastically reduced from 41700 to 12 with area irrigated sharply decreasing from 1139.6 km^2 to merely 0.7 km^2 from 2011 to 2013 (District Statistical Handbook 2014).

1.6 Urban area, Industries and Mining Activities

The district has been categorized as a Backward District, as per the classification by the Ministry of Panchayati Raj in 2006. The district is receiving funds for economic development under the Backward Regions Grant Fund Programme. Rapid urbanization brings more and more areas under residential and industrial sector. However, in Uttar Dinajpur district, a total of 1215 Micro and Small Scale Enterprises exists giving an employment to 9276 person. Total number of factories was 56 having 3896 registered employees. The main industries in the district are food products, tobacco products, textiles, manufacture of wood products, fabricated metal products, nonmetallic mineral products, warehousing and support activities for transportation (District Statistical Handbook)

1.7 Economy of the District

Uttar Dinajpur district is one of the most backward districts in India. Poor economy is due to low per capita income, low yield per acre of land, backwardness in industrialization, shortage of capital and entrepreneurship and lack of infrastructure and large labour surplus. Sericulture is an important component of local economy. The Annual Average Consumer Price Index (CPI) for industrial workers in the district was 1126 in 2013 (Base

Year: 1982 with CPI of 100). Available data shows Mulberry production was 18.83 million tonnes with a production value of Rs. 23,54,130. Dalkhola town, which has become a municipality in 2003, is an important place for commercial and business activity. It is also the largest exporter of maize in West Bengal (District Statistical Handbook).

1.8 Previous Studies

Officers of the Central Ground Water Board (CGWB), Eastern Region, Kolkata have completed scientific studies on groundwater scenario of the district from time to time. Systematic hydrogeological surveys were taken up in the 1990s by Sh. Tapan Talukdar covering entire Uttar Dinajpur and parts of Darjeeling district (Talukdar 1998). Later on, Reappraisal Hydrogeological Survey was completed by Sh. D. Ghosh Dastidar and Sh. P.K. Das, who had brought out the hydrogeological scenario along with groundwater resource availability in the district (Ghosh Dastidar and Das 2006). District Ground Water Brochure of Uttar Dinajpur has been published and is available in official website of CGWB (Sen 2013). Basic hydrogeological data of the district is available in a state compilation on hydrogeology (Talukdar and Bandopadhyay 2017). Details of groundwater exploration in Uttar Dinajpur district has been brought out by CGWB (Guha 2009).

Impact analysis of Teesta Barage on groundwater regime of a part of Uttar Dinajpur district was studied by Sh. A.K. Ghosh during the Annual Action Plan: 2002-03 (Ghosh 2005). The report on Aquifer Systems of West Bengal deals with details of aquifer disposition and characteristics for all the districts of West Bengal, including Uttar Dinajpur (CGWB 2014). A pioneering study on regional geology of the district and surrounding area has been done by the Geological Survey of India (Ball 1877), which was followed up subsequently by workers who had focused on regional geological and tectonic framework of the Bengal Basin (Alam et al. 2003, Roy and Chatterjee 2015). Other related studies include delineation of groundwater potential zones using Remote Sensing and GIS (Biswas et al. 2020), development of multi hazard district disaster management plan (Government of West Bengal 2018) and a block level analysis of irrigation extension and development in Uttar Dinajpur district (Siddiqui et al. 2017).

2. HYDROMETEOROLOGY

2.1 General

Uttar Dinajpur district is characterized by a humid tropical climate, which is marked by extreme to very hot, oppressive and sultry summer, short and fairly cold winter and a protracted monsoon with plentiful rains and moisture in the air throughout the year. The district has a climate of type Cwa as per Köppen-Geiger classification indicating a monsoon sub-tropical climate. Four seasons are identifiable in the district in a year. The period from March to May is the summer season. The rainy season starts in June with the onset of southwest monsoon and continues till the middle or end of September. October and the first half of November constitutes the autumn season whereas the winter season starts in end of November and continues till end of February.

2.2 Rainfall

Main source of rainfall in Uttar Dinajpur district is the southwest monsoon. Maximum rainfall is recorded in July and August, whereas November, December and January are mostly dry. Sometimes torrential rain for short duration occurs from March to May. Normal rainfall in the district was 2041 mm, whereas the annual rainfall was 1579 mm (District Statistical Handbook 2014). In Goalpokhar-I and II, Islampur and Chopra blocks, higher normal annual rainfall (>2000 mm) is recorded whereas in rest of the district the normal annual rainfall is much lower, ranging between 1400 and 2000 mm.

The long-term rainfall data from 1981 to 2018, which was analyzed by the Climate Research and Services of the India Meteorological Department (IMD) reveals that the highest mean monthly rainfall was 418.8 mm in July. The mean Monsson Rainfall (from June to September) was 1296.9 mm and the mean Annual Rainfall was 1518.4 mm (IMD 2020). The IMD data also indicates a significant decreasing trend in monthly rainfall in September. However, no significant increase in dry days (daily rainfall <0.2 mm) was observed in Uttar Dinajpur district during the monsoon season.

The decadal rainfall data (period: 2006-2015) is available in the report of Multi Hazard

District Disaster Management Plan (2016-17), Government of West Bengal. The data reveals that lowest annual rainfall was 1169.00 mm in 2012 and highest annual rainfall was 1786.40 mm in 2011. The decadal average rainfall was 1447.26 mm. Month wise actual rainfall in 2015 and average monthly rainfall (from 2011 to 2015) in Uttar Dinajpur district is given in **Table 2.1.** Available rainfall data of Raiganj block shows a catastrophic flood event in August 2017, with monthly rainfall of 471.1 mm and the maximum daily rainfall of 158.0 mm on 12-8-2017, followed by 143.6 mm on 13-8-2017. The heavy rainfall has resulted in excessive water flow in the Kulik River, whose carrying capacity has been reduced due to encroachment and siltation.

Table 2.1 Monthly and average rainfall, Uttar Dinajpur district

Month	**Monthly Rainfall, 2015 (mm)**	**Average Rainfall (2011-15) (mm)**
January	29.10	10.90
February	8.70	10.80
March	84.73	16.60
April	54.33	59.80
May	165.15	183.80
June	174.96	346.50
July	215.10	515.60
August	360.80	408.40
September	150.55	364.30
October	3.10	106.00
November	0.0	10.90
December	0.0	8.30

(Source: Multi Hazard District Disaster Management Plan (2016-17), Government of West Bengal)

2.3 Temperature

As on date, there is no dedicated Meteorological Centre of the IMD in Uttar Dinajpur district. Therefore, available data from the nearby Meteorological Centre at Balurghat, Dakshin

Dinajpur district is used to study the pattern of temperature variation over the months. Temperature data at Balurghat for a five year period (from 2009 to 2013) shows that May is the warmest month while January is the coldest month. Highest mean monthly temperature was 41^0C in May 2009, May 2012 and April 2009. Generally, temperature starts rising from the beginning of March and day temperature becomes highest in April and May. The lowest mean monthly temperature was 4^0C in January 2013, followed by 5^0C in January 2011. The highest mean annual temperature (from 2009 to 2013) was 41^0C in 2009 and 2012 while the lowest mean annual temperature was 4^0C in 2013. The average ambient temperature at Raiganj, the district headquarters, is 24.9^0C with an annual variation ranging from 7^0C in winter to 36.8^0C in summer.

2.4 Humidity

The district has a humid climate throughout the year. Humid period commences in the last week of May and continues up to first week of October. The average relative humidity (RH) ranges between 31.6% in the winter season to 98.8% during the monsoon period. The average annual RH in the district is 78% having Dew Point varying from 3.9^0C to 28.9^0C. Average Dew Point temperature is 20.6^0C.

2.5 Wind Velocity

Wind velocity varies from month to month and attains maximum value during the winter months from November to January. Sometimes cyclonic wind and hailstorms lash the district in the months of March and April. Wind speed plays an important role in the evaporation and evapo-transpiration process. Simulation data indicates an average wind speed of 2.2 m/s having maximum speed of 8.2 m/s in Raiganj, the district headquarters. Wind pressure simulation results indicate a variation in pressure from 992.7 hecto Pascal (hPa) to 1024.2 hPa, with an average wind pressure of 1010.2 hPa.

2.6 Potential Evapotranspiration

Potential evapotranspiration (PET) is the maximum water loss or the upper limit of actual

evapotranspiration (AET). PET is a temperature-dependent quantity and is a measure of the moisture demand for a region. PET in Uttar Dinajpur district starts increasing from January (4.8±0.2 mm) to April (7.8±0.3 mm) and declines till September (5.1±0.2 mm). The lowest PET is observed in the monsoon season owing to the rainfall and cloudy weather condition. During post-humid period (after the first week of October), precipitation (P) is less than Potential Evapotranspiration (PET), which results in loss of soil moisture in the vadose zone.

2.7 Vapour Pressure

In meteorology, vapour pressure is used almost exclusively to denote the partial pressure of water vapour in the atmosphere and is expressed in Torricelli (torr). Vapour pressure at Raiganj starts increasing during peak winter (January) with value of 14.5±0.3 torr, becomes highest in the month of August (33.4±0.7 torr) and declines to a minimum in the month of December with mean value of 15.4±0.4 torr.

3. GEOMORPHOLOGY

3.1 Physiography

Uttar Dinajpur district is a part of Gangetic Alluvial Plain drained by the tributaries of Ganga River. The master slope of the district is towards south. The topography is gentle with average slope of land varying from 1 m/km to 3m/km in the northern part falling in Chopra and Islampurblock. In the southern part of the district comprising Raiganj, Hemtabad, Karandighi and Kaliaganj blocks, the average slope is about 1 m/km. However, in parts of Itahar block, the Barind Uplands is exposed, which has higher variation in surface slope on a scale of 1:50000 or larger. Based on variation in surface elevation, the district has been categorized into 11 elevation classes ranging from 20 - 25 m, >25 – 30 m, >35 – 40 m and so on. The elevation map (in metre above mean sea level) of Uttar Dinajpur district is shown in **Fig. 3.1.**

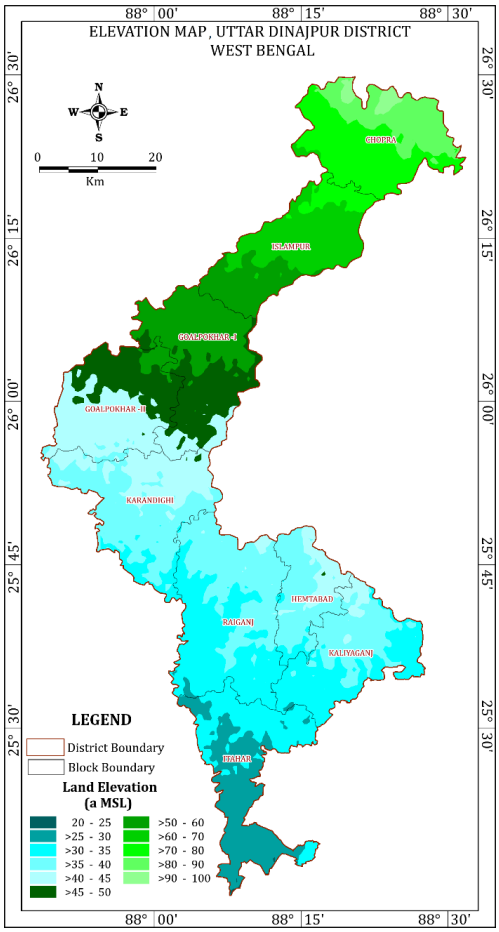


Fig. 3.1 Elevation map, Uttar Dinajpur district

A perusal of the elevation map reveals that highest elevation range of >90 to 100 m is present in entire Chopra block and northernmost part of Islampur block in the northern part of the district. The central part of the district covering parts of Goalpokhar-I and II blocks is a depressed area, where the surface elevation was minimum, ranging from 20 to 25 m amsl. In Karandighi, Raiganj, Hemtabad and Kaliaganj blocks, the elevation ranges from 30 to 35 m. Presence of the Barind Uplands (Older Alluvial tract) is conspicuous in entire Itahar block, except for its northern part. The elevation of the Barind Uplands has been found to be varying from ~45 m to 50 m. Based on regional geomorphology, four geomorphologic types have been recognized namely Upper Alluvial Plain, Active Flood Plain, Meander Flood Plain and Marshy Land (locally known as *Tal*). The geomorphological map of Uttar Dinajpur district is shown in **Fig. 3.2.**

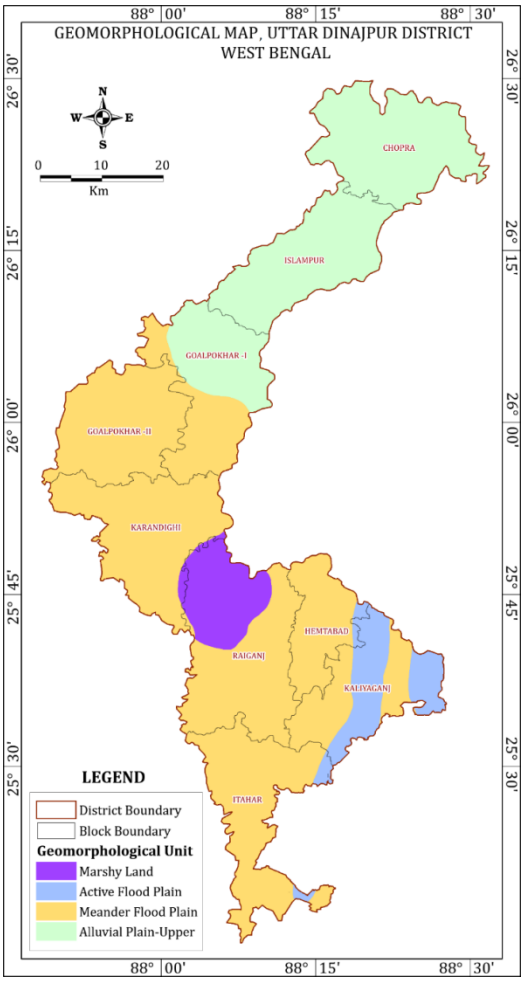


Fig. 3.2 Geomorphological map, Uttar Dinajpur district

A perusal of **Fig. 3.2** reveals that the Upper Alluvial Plain is exposed in the northern and north-central part of the district covering Chopra, Islampur and northern part of Goalpokhar-I block. Meander Flood Plain has been formed by meandering action of major perennial rivers like Mahananda, Kulik and Nagar River. Meander Flood Plain is the largest geomorphic unit by area in Uttar Dinajpur district. This unit is characterized by formation of point bars and oxbow lakes. Active Flood Plains are formed by overbank flow during flood events. This unit is mostly restricted to the eastern part of the district. The Active Flood Plains are conspicuous during post-monsoon period and are essentially related to breaching of embankments, which renders the fertile, cultivable land unsuitable for crop production due to deposition of sand and silt. The fourth geomorphic unit, Marshy Land, is restricted to the central part of the district covering parts of Raiganj block. This unit is locally known as the *Tal.* The marshy conditions developed here are genetically associated with the depression (or sagging) as described in the previous section. The sagging, developed locally, may be related to faulting and subsidence due to neo tectonic activity.

3.2 Land Use Land Cover

Land cover is the natural class of landform whereas land use is the usage pattern by human for a particular land cover type. Although these two terms are often used together, the natural classes like forest land, wetland, pastureland etc. are distinct from human made classes like built up area, agricultural land etc. Water bodies can be both natural like rivers and streams, large ponds (*Bils*) as well as artificial like irrigational tanks and ponds, canals etc. In Uttar Dinajpur district, major land use/land cover types are agricultural land, water body (rivers, streams and ponds), forest land and built-up area in the form of settlements. Major land use class in Uttar Dinajpur district is the agricultural land with two major agro-climatic zones namely Terai Zone and New and Old Alluvial Zone.

3.3 Drainage

The most important natural drainage in Uttar Dinajpur district is the Mahananda River having length of 360 km. The river is an important tributary of Ganga River. The river originates from

Nepal Himalaya, flows southwards through the district and enters Malda district. Kulik River is another perennial river, with Raiganj City situated on its left bank. Nagar River enters Uttar Dinajpur district from Bangladesh and flows towards south and south-east before entering Malda district to the south. The Dahuk River also enters the district from Bangladesh, flows towards west and joins Mahananda River in Kishanganj district of Bihar. Fulahar River, another tributary of Mahananda River, flows along the district border in Karandighi block and further southwards along the border of Malda district. Smaller natural drainage includes the Lona (or Nona) River, which is a tributary of Nagar River and Gunduri River, which enters Uttar Dinajpur district at Mahipur village and joins Nagar River. The drainage map of Uttar Dinajpur district is shown in **Fig. 3.3.**

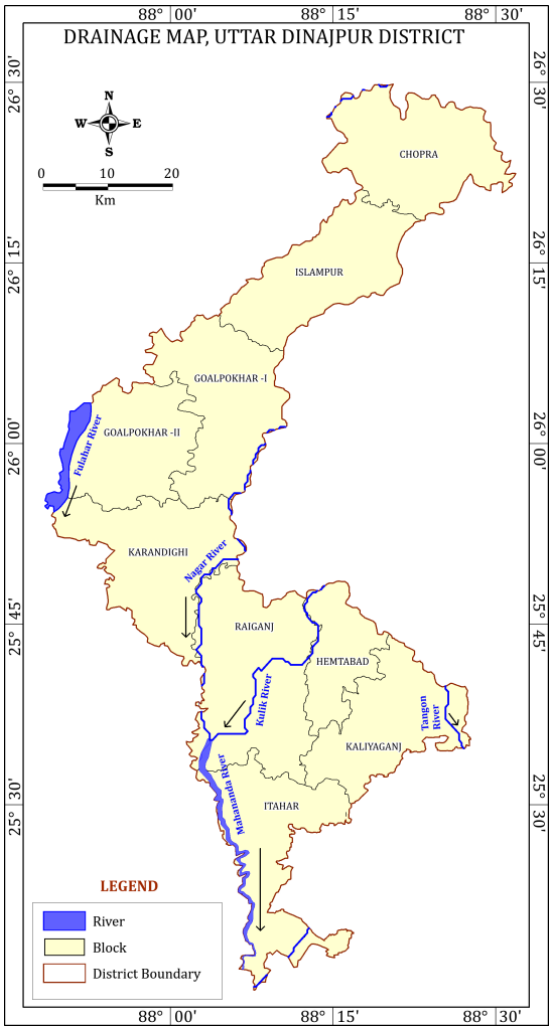


Fig. 3.2 Drainage map, Uttar Dinajpur district

Other smaller rivers flowing through Uttar Dinajpur district are Gumari River, Srimati River, Gobra River, Suin River, Berong River, Sudha River, Doloncha River and Sudhari River. These rivers are locally known as *Nadi.* Available hydrological data on some perennial rivers flowing through the district is summarized in **Table 3.1.**

Table 3.1 Hydrological data of some perennial rivers, Uttar Dinajpur district

Name of River	Location of River Gauge	Annual Average Flood Level (m)	Extreme Danger Level (m)
Kulik River	Kulik Railway Bridge	31.20	32.69
Nagar River	N.H. Road Bridge at Nagar	31.54	31.86
Gumari River	N.H. Road Bridge at Itahar	26.82	27.91
Suin River	Pajol	27.43	28.00
Suin River	Chakla Bridge at Kachna	25.49	26.06
Tangon river	Railway Bridge at Radhikapur	33.45	34.05
Mahananda River	N.H. Road Bridge at Sonapur	75.77	76.38
Dahuk River	N.H. Road Bridge at Chopra	69.46	70.07

(Source: Multi Hazard District Disaster Management Plan, 2016-17)

The data in **Table 3.1** indicates that Extreme Danger Levels in all the perennial rivers have exceeded the Extreme Danger Level during peak flood events. This indicates that Uttar Dinajpur district is highly vulnerable to damages caused by flooding.

3.4 Soil Type

Soils of Uttar Dinajpur district can be broadly classified into two types - alluvial soil and red soil. The alluvial soil is very fertile and is exposed almost throughout the entire district except for the southern part. In the southern part, non-alluvial red soil is found, which is derived from rocks of the Rajmahal Trap. The red soil has poor fertility. Based on soil texture and porosity, the alluvial soil has been classified as sandy to sandy-loam type. Due to leaching of base from this soil, the pH is relatively low. As a result, the soil is moderately to strongly acidic having pH varying from 4.5 to 6.2. Organic matter content of the alluvial soil is moderate to high whereas phosphorus and potassium content is low to medium. However, phosphate

fixation capacity is high, as observed by agronomists and pedologists.

Red soil is lower in organic matter and humus with less micro-nutrients as compared to alluvial soil. It is moderately to strongly acidic with pH varying from 5.0 to 6.3. The soil is not much suitable for cultivation due to the low water holding capacity and high leaching. However, soil fertility can be increased through crop rotation and crop diversification. In Uttar Dinajpur district, crops like wheat, pulses, tobacco and linseed are grown in red soil.

4. GEOLOGY

4.1 General

Surface geological setting of Uttar Dinajpur district is characterized by multiple Pleistocene terraces that separate the fluvio-deltaic region of the Foredeep Basin. Large scale sedimentation by the Himalayan Rivers has resulted in formation of Quaternary deposits in the fluvial Deltaic Plain of the Bengal Basin. The Quaternary sediments are classified into two distinct unit viz. the Older Alluvium of Pleistocene age and the Younger (Newer) Alluvium of Holocene age (Ball 1877).

Older alluvium of Pleistocene age occupies the southern part of the district covering a small part of Raiganj and major part of Itahar block, constituting the Barind Uplands. The Older Alluvium is well oxidized, massive, reddish and argillaceous in nature. The alluvium is yellow at the surface due to weathering and consists of calcareous concretions (kankar) and ferruginous concretions. The Barind Tract lies topographically above the Recent Alluvium (flood plain deposit) in the southern part of the district.

The Younger (or Recent) Alluvium of Holocene age occurs in the alluvial flood plains and shifting channels mostly in the south-eastern part of the Mahananda basin. Periodic floods have caused deposition of river borne silt, sand and clay in this zone. Thickness of the Younger Alluvium has not been established precisely. Presence of a north-south trending fault was indicated by geophysical survey conducted by the Oil and Natural Gas Corporation in 1961 (Ghosh Dastidar and Das 2004). The Younger and Older Alluvium have been clubbed as Bengal Alluvium (Roy and Chatterjee 2015).

The regional stratigraphy of Uttar Dinajpur district has been worked out by the Geological Survey of India (GSI 2009) and other workers (Alam et al. 2003, Roy and Chatterjee 2015). The Quaternary sediments are underlain by Precambrian crystalline basement, whose depth is variable at places. The Malda formation of Pleistocene age comprises ferrous shale, mudstone, limestone and sandstone. This is overlain by gravel, sand and clay of Shaugaon formation of Holocene age, which in turn is overlain by Recent Alluvium comprising sand, silt and clay. The generalized stratigraphic succession is given in **Table 4.1.**

Table 4.1 Generalized stratigraphic succession, Uttar Dinajpur district

Eon	Era	Period	Epoch	Formation	Lithology
Phanerozoic	Cenozoic	Quaternary	Holocene	Recent alluvium	Sand, silt, clay
			Pleistocene	Shaugaon formation	Stratified gravel, sand, clay
			Pleistocene	Malda formation	Shale, mudston limestone, sandstone
Precambrian crystalline basement					

4.2 Subsurface Geology

Subsurface geological data has been generated through construction of exploratory wells and observation wells by Central Ground Water Board, Eastern Region. As per available data, in-house exploratory drilling has been completed at seven sites in Uttar Dinajpur district viz. Bagan and Kaliaganj ITI (Kaliaganj block), Goalpara Ward No. 1 and Kasibati (Raiganj block), Milanpally High School and Durganagar (Islampur block) and Mohinipara (Itahar block). The borehole data indicates that in Kaliaganj, Raiganj and Karandighi blocks, clay beds having thickness ranging from 3-5 m occur within fine to medium sand. In the northern part of the district, falling in Goalpokhar-I, Goalpokhar-II, Islampur and Chopra blocks, predominantly arenaceous sediments (coarse sand and gravel) are found within the depth range of 110 to 250 m. The gravel beds are distinct at few locations like Milanpally and Durganagar, within a depth range of ~60 m to ~100 m and ~130 m to ~180 m. The gravels are well rounded and composed of quartzite and gneiss.

In the southern part of the district, falling in Raiganj and Itahar blocks, lateral facies variation has been interpreted based on borehole lithological data. Clay beds often merge laterally into fine sand and silt. The sediments are often intermixed and are deposited as silty or sandy clay or clayey sand. The clay beds are mostly lenticular at all depths. Presence of moderately thick coarse sand and gravel along with lenticular clay beds indicates frequent changes in the river courses throughout the depositional history of the fluvial sediments. The stratified layers of gravel, sand and clay of Shaugaon formation of Pleistocene age bears

testimony to such lateral variation in sedimentary facies during evolution of the Bengal Basin in the geographical extent of Uttar Dinajpur district.

5. HYDROGEOLOGY

5.1 Regional Hydrogeology

Hydrogeological condition at regional level is a result of configuration of aquifers consisting of Quaternary sedimentary deposits like Older Alluvium in Barind Uplands and the Younger Alluvium in gangetic alluvial plain. Groundwater occurs in porous formation comprising sands of variable grain size, silty sand, gravelly sand and gravels. The lateral and vertical distribution of the aquifers and their hydrological, hydrodynamic and hydrochemical properties control the quantity and quality of groundwater. As mentioned previously, the alluvial sediments are categorized into Older Alluvium (Aquifer Code: AL-03) of Pleistocene age and Younger Alluvium (Aquifer Code: AL-01) of Holocene age. Analysis of borehole lithological data has revealed two aquifer groups, Aquifer-I and Aquifer-II, except in parts of Itahar and Raiganj block where four to five aquifer groups (Aquifer- to Aquifer-V) have been interpreted based on the available data of exploratory and observation wells of CGWB and tube well data of state government departments.

From the lithological logs, it can be inferred that in the Barind Uplands (Barind Tract) in Itahar and southern part of Raiganj block, groundwater occurs under confined to semi-confined conditions in multiple aquifers exposed in various depth range of ~20 to ~50 m, ~70 to ~90 m, ~100 to ~140 m, ~170 to ~190 m and ~220 to ~230 m, the deepest aquifers being identified from in-house groundwater exploration by CGWB in Itahar and Kaliaganj block. In remaining parts of the district, the shallow aquifer (Aquifer-I) occurs under unconfined condition whereas the deeper aquifer (Aquifer-II) occurs under semi-confining to confining condition. In northern part of the district, falling in Chopra, Islampur, Goalpokhar-I and Goalpokhar-II block, aquifers are tapped by tube wells for drinking water supply and for agri-irrigational use within a maximum depth of ~100 m. Thin layers of clay alternating with layers of fine to coarse sand are exposed in the depth range of ~35 to ~50 m in the central and south-central part of the district, covering Raiganj, Hemtabad, Karandighi and Kaliaganj block. The clay layers pinch out towards north and thicken towards south, thereby creating aquifers under semi-confining condition.

5.2 Exploratory Drilling

Central Ground Water Board, Eastern Region has drilled eleven exploratory wells and four observation wells in Uttar Dinajpur district which includes Deep Exploratory Well (DEW) and Shallow Exploratory Well (SEW). Available data of in-house groundwater exploration in Uttar Dinajpur district are summarized in **Table 5.1**. Apart from the in-house data of Central Ground Water Board, Eastern Region, lithological logs (strata charts) were collected from Office of the Executive Engineer, Public Health Engineering Directorate (PHED) Raiganj Division and Office of the Executive Engineer, Raiganj Agri-irrigation Division, Water Resources Development Directorate (WRDD). The combined lithological data of 75 wells was analyzed to demarcate the aquifers up to block level for the first time. Analysis of aquifer parameters like transmissivity and storage co-efficient was made on data of Step Drawdown Test and Aquifer Performance Test carried out by CGWB during in-house groundwater exploration. Limited data on Yield Test carried out by PHED, Raiganj Division was used to study other parameters like static water level, drawdown and discharge of the production tube wells. Based on the available data, identification and characterization of aquifers was done for the first time for each of the nine Community Development Blocks of Uttar Dinajpur district. The database was also to generate thematic maps for preparation of the Aquifer Management Plans (AMP) at block level, whose details are given in a separate chapter.

Exploratory drilling at Mohinipara in Itahar block, falling in the Barind Tract, has revealed four aquifers in the depth range of 36.0-42.0 m (Aquifer-I), 49.0-55.0 m (Aquifer-II), 170.0-190.0 m (Aquifer-III) and 222.0-232.0 m (Aquifer-IV). These aquifers are separated from each other by clay layers having thickness varying from 7 m to 36 m. The thickest clay layer (thickness: 71.60 m) was identified in Mohinipara exploratory well in the depth range from 75.60 m to 147.20 m. Due to occurrence of persistently thick clay zones, groundwater potential in Barind Tract is much less compared to Younger Alluvium. For example, litholog of Lakshmania exploratory well (Raiganj block), drilled by CGWB has revealed very thin layers of clay with thickness varying from 3.05 m to 6.10 m only within the drilled depth of 122.86 m.

Relevant details of in-house groundwater exploration in Uttar Dinajpur district are given in **Annexure-I.** Groundwater exploration in the younger alluvial aquifer by Central Ground Water Board, Eastern Region reveals that deepest drilling of 337.36 m was done at

Baghan site in Kaliaganj block, whereas the shallowest drilled depth was 61.20 m (tapping only Aquifer-I) at Uttar Chirail site located in Kaliaganj Municipality. Well construction depth was found to be varying widely, from only 57.00 m at Uttar Chirail to a maximum of 248.00 m at Goalpara Ward No. 1 site in Raiganj Municipality. The data in **Annexure-I** also shows a wide variability in well discharge, ranging from 3.10 lps (267.84 m^3/day) at Milanpally High School in Islampur Municipality to a maximum of 58.86 lps (5085.50 m^3/day) at Baghan in Kaliaganj block (CGWB 2009). Drawdown in Deep Exploratory Wells (DEW) in younger alluvial aquifer was found to be varying from 3.39 m at Kaliaganj ITI (Mahadebpur) site to a maximum of 22.14 m at Milanpally High School, Ward No. 7 in Islampur Municipality. Transmissivity was found to be varying from 611 m^2/day at Goalpara site to 2045 m^2/day at Baghan site. Storage co-efficient (Storativity) of confined aquifers was ranging from $5.29x10^{-4}$ at Goalpara Ward No. 1 (Deep Exploratory Well) to 5.39×10^{-4} at Milanpally High School.

In Barind Tract, aquifers consisting of Older Alluvium have relatively poor groundwater potential as compared to aquifers consisting of Younger (Newer) Alluvium. Nonetheless, even in Barind Tract, a wide variation in discharge was observed at Mohinipara site, ~22 km south of Raiganj. Well construction depth of the Shallow Exploratory Well (SEW) was 57.00 m while it was 236.00 m in the Deep Exploratory Well (DEW). The DEW at Mohinipara recorded a discharge of only 0.37 lps (~32 m^3/day) whereas the SEW in the same site recorded a discharge of 8.34 lps (720.58 m^3/day), which was about 22.5 times higher than the discharge of DEW. The high variation in well discharge may be attributed to either improper well development or due to tapping of older alluvial aquifer occurring at deeper levels. Aquifer Performance Test in Mohinipara site has shown that transmissivity was ranging from 879.37 m^2/day to 1320.84 m^2/day. Storage co-efficient of shallow confined aquifer (1.6×10^{-3}) in depth range 36.0-55.0 m was about half the storage co-efficient of deeper confined aquifer (2.07×10^{-3}) in depth range 170.0-232.0 m. A fence diagram of Uttar Dinajpur district and southernmost part of Darjeeling district, based on data of exploratory and observation wells drilled by CGWB, is shown in **Fig. 5.1.**

Shallow tube wells are constructed within ~50 m depth by Agri-irrigation Department, Government of West Bengal. Such wells tap the shallow, unconfined aquifer (Aquifer-I). Available data indicates that discharge of such tube wells vary from 5 to 12 lps (432 to 1037

m^3/day), although drawdown is generally very less (0.09-0.58 m) after 80 minutes to 200 minutes of pumping with very fast recuperation. Groundwater abstraction from shallow tube wells is for agri-irrigational use by the farmers, who generally use submersible pump of 5 HP capacity. Relatively deeper tube wells (drilled depth: 50 to 100 m) have higher yield, varying from 10 to 20 lps (864 to 1728 m^3/day). The deep tube wells generally tap unconfined to semi-confined aquifers (Aquifer-I and Aquifer-II).

Although aquifer material in northern part of the district (Islampur and Chopra block) is coarser than the central part, a decrease in Specific Capacity of the tube wells has been reported (CGWB 2009). This was attributed to the nature of admixture of coarse sand with fine sand and silty sand, resulting in poor sorting and poor permeability of the aquifer material (Ghosh 2005).

5.2. Aquifer characteristics

In Uttar Dinajpur district, major aquifer system is restricted to porous formation only. As per standard classification code (CGWB 2013), two major aquifers are present in the district: Older Alluvium (Aquifer Code: AL03) covering the Barind Uplands and Younger Alluvium (Aquifer Code: AL01) covering the alluvial flood plains. The main water bearing formations (mostly confined and semi-confined aquifers) are Quaternary sediments of Recent (Holocene) and Pleistocene age. Aquifer materials consist of sands of variable grain size (very fine grained to coarse grained) and gravels. The nature of aquifer material in horizontal and vertical extent is non-uniform due to variation in lithofacies. Hydrogeological map of Uttar Dinajpur district is shown in **Fig. 5.2.**

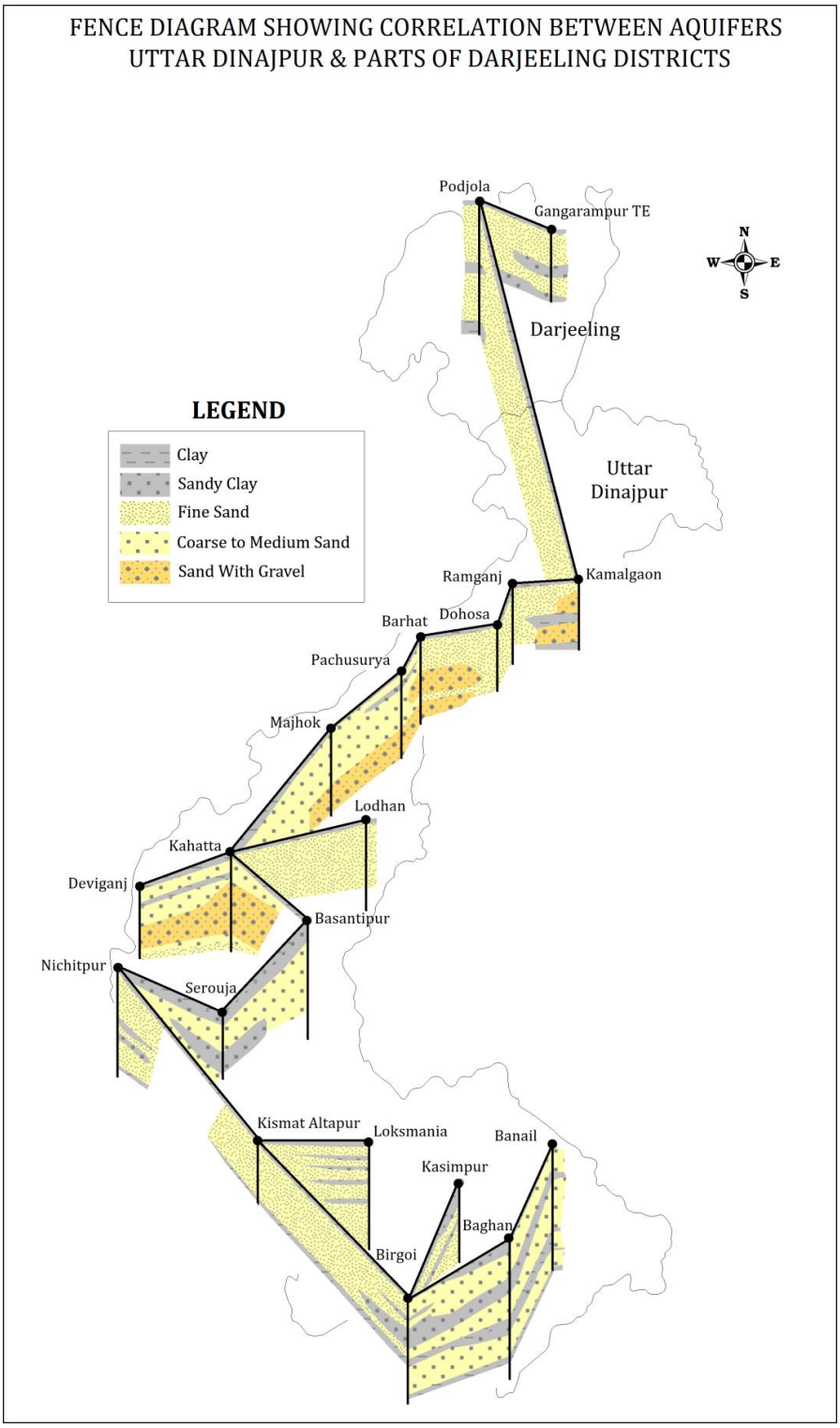


Fig. 5.1 Fence diagram showing aquifer disposition and correlation between aquifers in Uttar Dinajpur and southern most part of Darjeeling district

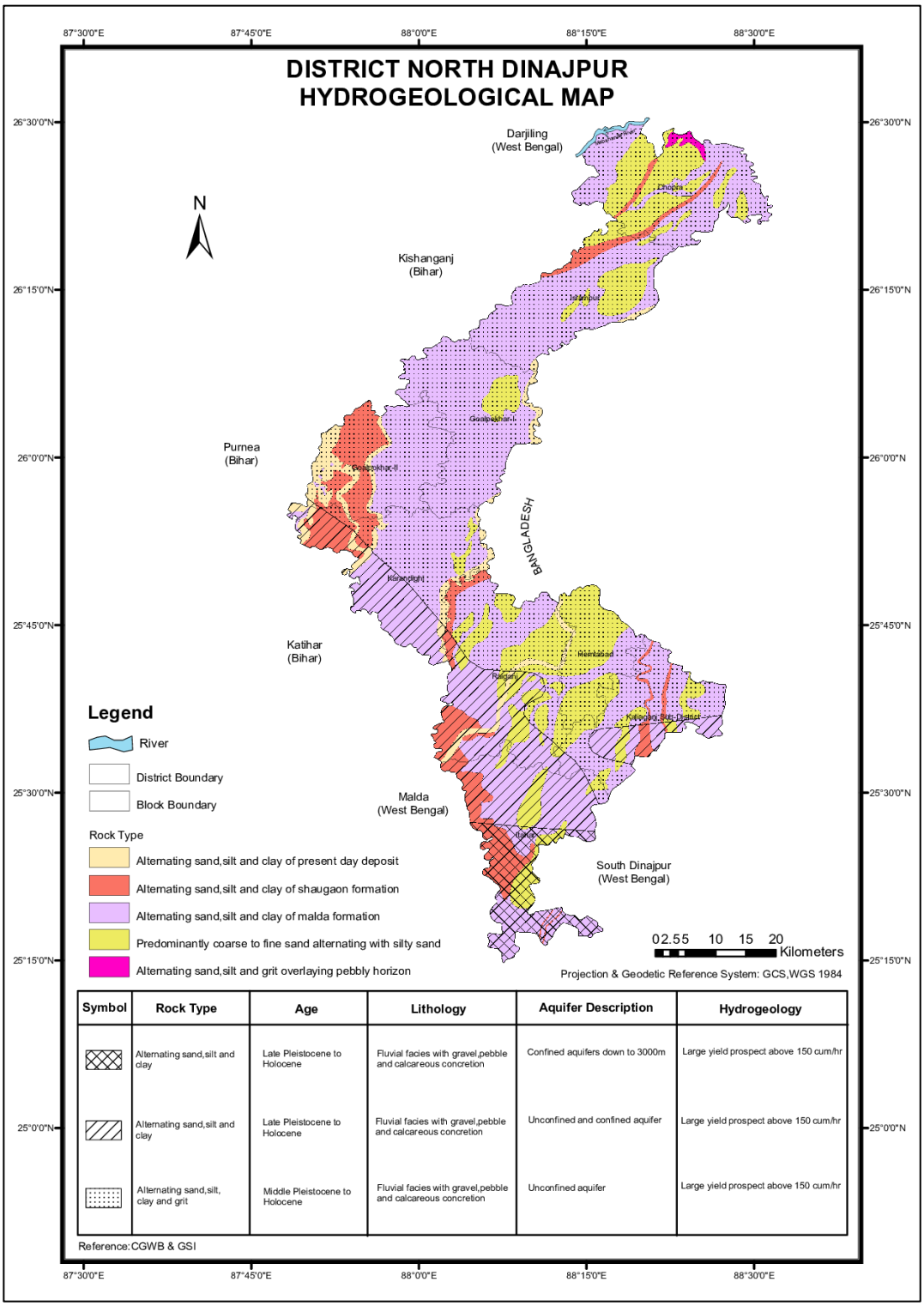


Fig. 5.2 Hydrogeological map, Uttar Dinajpur district

5.3 Groundwater potential

Well discharge data of Shallow Tube Wells (STW) constructed by Agri-irrigation Department, Government of West Bengal indicates a wide variation in discharge. Discharge of 5000 Imperial Gallon Per Hour (IGPH) or 545.52 m^3/day was recorded at Teliapokhar and Kichaktala (Goalpokhar-I block), Latmashid, Kamlagaon and Kuargaon (Islampur block), Binanpur and Goabari (Chopra block). Accordingly, these tube wells were categorized as Low Duty Tube Wells (LDTW) or more informally, as Shallow Tube Wells (STW) by the Agri-irrigation Department, Raiganj Division (pers. comm.). Available data indicates that drilled depth of the STWs was variable from 50 m to 100 m.

Data collected from Agri-irrigation Department, Raiganj Division reveals higher discharge of 17500 IGPH (1909.32 m^3/day) in Medium Duty Tube Wells (MDTW) and as high as 25000 IGPH (2727.60 m^3/day) in Heavy Duty Tube Wells (HDTW) in the younger alluvial aquifers (AL-01) of Uttar Dinajpur. The MDTWs are located at Sikar (Goalpokhar-II block), Raghabpur, Andharia and Damdoma (Karandighi block) whereas the HDTWs are located at Deogaon and Sahapur in Goalpokhar-II block.

Data of tube wells meant for drinking water supply were collected from the Public Health Engineering Directorate, Raiganj Division. Analysis of the data indicates that highest recorded discharge is 19500 GPH (2127.57 m^3/day) while drawdown was 4.88 m at Barua in Raiganj block during October, 2015. At Maslandpur (Raiganj block), discharge was 1771.57 m^3/day while drawdown was 3.20 m. Slightly lower discharge of 18600 GPH (1689.81 m^3/day) and drawdown of 4.57 m was recorded during yield test at Sherpur in Raiganj block (August, 2015). At Bamair site (Hemtabad block), yield test was conducted in March, 2014 using 4 Stage Vertical Turbine Pump. After eight hours of pumping, discharge was 27500 IGPH (3000.42 m^3/day) having maximum drawdown of 11.84 m. Yield test conducted by PHED, Raiganj Division at Gutin (Hemtabad block) has shown peak discharge of 26000 IGPH (2836.76 m^3/day) with 18" Head and peak drawdown of 17.23 m in September, 2016. A summary table on yield test conducted by PHED, Raiganj Division in six blocks of the district is given in **Table 5.1.**

Table 5.1 Summary of Yield Test by PHED, Raiganj Division, Uttar Dinajpur

Sl. No.	Block	Site Name	Date of Yield Test	Static Water Level (m bgl)	Peak Discharge (m^3/day)	Max. Drawdown (m)
1	Itahar	Kotar	27-12-2015	2.13	1838.44	4.27
2	Itahar	Chandanpur	08-2-2016	5.79	2029.37	5.18
3	Itahar	Purba Durlabhpur	07-12-2015	3.05	2127.57	4.27
4	Itahar	Surun	29-9-2015	3.05	1832.98	3.66
5	Itahar	Joyhat	09-1-2016	7.92	1832.98	7.01
6	Itahar	Sahavita (Shibrampur)	14-12-2015	4.27	2029.37	3.66
7	Kaliaganj	Majhiar	22-12-2015	3.66	1832.98	6.40
8	Kaliaganj	Shergram	02-11-2018	5.72	1772.98	3.20
9	Kaliaganj	Puria	11-6-2019	7.16	1772.98	6.45
10	Kaliaganj	Faridpur	07-5-2019	4.75	1772.98	5.28
11	Karandighi	Kamartor	25-12-2018	3.81	2318.51	11.07
12	Karandighi	Choprabari	29-6-2015	3.96	2029.37	3.35
13	Karandighi	Khowaspur	05-9-2019	5.74	1772.98	6.20
14	Islampur	Islampur Municipality	11-1-2014	5.90	1200.17	19.18
15	Islampur	Bhojpur	13-9-2019	3.30	1532.94	7.30
16	Islampur	Amalijhari	09-9-2019	3.55	1762.06	2.79
17	Goalpokhar-I	Biprit	24-1-2014	3.18	2673.10	7.75
18	Goalpokhar-I	Dehar	05-6-2019	4.80	1772.98	5.20
19	Goalpokhar-I	Intia	05-2-2015	3.96	2029.37	3.66
20	Goalpokhar-I	Dewan	15-2-2015	2.44	2029.37	2.44
21	Goalpokhar-I	Goagaon	24-1-2015	3.35	2291.23	3.35
22	Goalpokhar-I	Lodhan	10-8-2015	3.05	2029.37	5.18
23	Goalpokhar-II	Majlishpur	04-3-2015	3.05	2029.37	2.74

24	Goalpokhar-II	Amalbari	29-8-2019	6.22	1772.98	3.43
25	Chopra	Purba Chutiakhor	28-12-2018	2.10	1762.06	5.00

A perusal of T**able 5.2** indicates that static water level in the tube wells was ranging from 2.10 m at Purba Chutiakhor (Chopra block) to 7.92 m at Joyhat (Itahar block), the later falling in the Barind Tract, which is characterized by relatively deeper water table condition. Drawdown during the yield test was found to be varying widely, from 2.44 m at Dewan (Goalpokhar-I block) to 19.18 m in Islampur Municipality. Lowest discharge of 1532.94 m^3/day was recorded at Bhojpur in Islampur block, while the highest discharge of 2673.10 m^3/day was recorded at Biprit in Goalpokhar-I block.

5.4 Depth to groundwater level

Depth to groundwater level has been analyzed based on the data collected from active Groundwater Monitoring Wells (GWMW) in Uttar Dinajpur district. Due to unprecedented conditions arisen during COVID-19 virus outbreak, monitoring in pre-monsoon period (April-May 2021) was not possible. Due to COVID-19 situation in the previous year (pre-monsoon, 2020) also, very limited monitoring and water sample collection could be done. In spite of this challenging field conditions, depth to water level data in 5 piezometers or P-Tubes (fitted with Automatic Water Level Recorder) of State Water Investigation Directorate (SWID), Uttar Dinajpur Division and water level data in 39 tube wells of PHED, Raiganj Division were collected during the present study. In addition to this, groundwater level data for these 44 monitoring wells (39 tube wells and 5 piezometers) was collected from SWID and PHED, Government of West Bengal for post-monsoon period (November 2021) also. The data is given in **Annexure-I.**

Analysis of water level data reveals that deeper water level conditions are found in the Barind Uplands falling mainly in Itahar block. The Barind Uplands is a distinct hydrogeological unit, which separates the Younger Alluvium to the north. In the Barind Uplands, deepest water level (13.94 m bgl) was recorded in a tube well in Joyhat Gram Panchayat Office during pre-monsoon 2021 while the shallowest was 6.21 m bgl in a piezometer in Durgapur Gram Panchayat Office. In post-monsoon 2021, the deepest water

level (6.93 m) was again observed in Joyhat Gram Panchayat Office while the shallowest water level (2.86 m) was recorded in Block Seed Farm, Sripur.

In the younger alluvial tract, the shallowest depth to water level in pre-monsoon 2021 (3.03 m bgl) was recorded in a tube well at Elahi Baksh High School, Panjipara (Goalpokhar-I block) whereas the deepest (7.54 m) was recorded at Kamlabari-I Gram Panchayat Office at Karnojora (Raiganj block). During post-monsoon 2021, the shallowest water level in the younger alluvial tract was 1.01 m at Junior High School, Belan (Goalpokhar-II block) whereas the deepest was 5.60 m at Kamlabari-I Gram Panchayat Office at Karnojora.

During the present study, 27 Key Observation Wells (KOW) were established in Uttar Dinajpur district covering all development blocks. Out of these, two monitoring wells (India Mark-II hand pumps) were established as a part of the village level (micro level) aquifer mapping and management in Birghai village, Raiganj block during post-monsoon 2021 monitoring. Repeat survey was continued during pre-monsoon 2022 monitoring. Details of the KOW established during present study are given in A**nnexure-II** of this report.

A perusal of the data indicates that during monsoon period (September 2021), the deepest water level (8.28 m bgl) was recorded at Baidara in Itahar block, whereas the shallowest water level (0.85 m bgl) was observed at Bhelai in Kaliaganj block. Deeper water level conditions were observed in Itahar block, which falls in the Barind Uplands (Barind Tract), where Older Alluvium is exposed. In post-monsoon period (November 2021), the deepest water level was 7.25 m bgl at Churamon (Itahar block) while the shallowest was 1.09 m bgl, again at Bhelai. A perusal of the data also reveals that deeper water level was also recorded at Karnojora, ~3 km north-east of Raiganj, which indicates that this area also forms a part of the Barind Uplands.

During post-monsoon period (November 2021), in-house water level monitoring was completed in Uttar Dinajpur district, in spite of COVID-19 situation persisting. During monitoring, depth to water level in 27 monitoring wells (including 17 tube wells, 2 piezometers and 8 dug wells) of CGWB was measured. The measurement was continued during pre-monsoon 2022 also, as per the directives of the CGWB, CHQ, Faridabad. During

the pre-monsoon 2022 monitoring, depth to water level was measured in 29 monitoring wells including 7 dug wells, 2 piezometers and 20 tube wells. Two new Ground Water Monitoring Wells were inventoried at Biprit (WBWD-118) and Goagaon (WBWD-119) in Goalpokhar-I block. The data collected from twenty-eight active ground water monitoring wells in September and November, 2021 and from 29 active monitoring wells in May, 2022 is summarized in **Table 5.3.** A perusal of the data indicates that the shallowest depth to water level during post-monsoon (0.73 m) was recorded at Malon in Hemtabad block, while the deepest water level was 5.42 m at Baidara, located in the Barind Tract. Majority of ground water monitoring wells have recorded water level in the range of 2-4 m below ground level (bgl) in post-monsoon. During pre-monsoon 2022, the following depth to water level condition was observed:

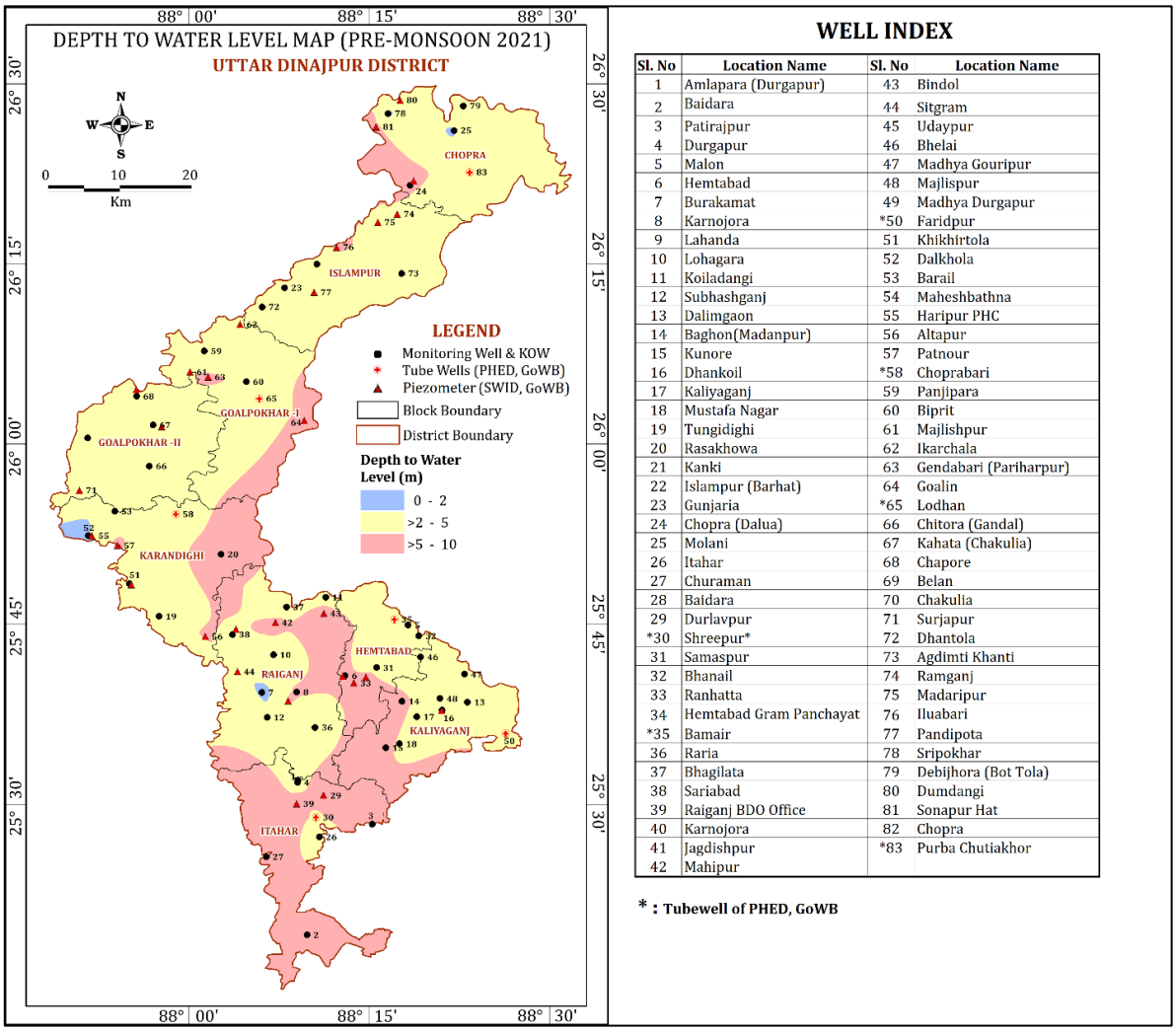
- In Barind Uplands: 3.88 m bgl at Amla Para (Durgapur) dug well to 13.28 m bgl at Baidara tube well
- In Younger Alluvium: 2.89 m bgl at Kanki dug well to 8.44 m bgl at Kunore tube well

Based on the depth to water level data of eighty-three wells, including ground water monitoring wells of CGWB and tube wells of PHED, Government of West Bengal, a depth to water level map has been prepared. The map is shown in **Fig. 5.3.** The map reveals that the deepest water level in the range 5-10 m is found in the southern, eastern and north-western part of the district. Almost entire Itahar block falls in this zone, which is characterized by occurrence of the Barind Tract. The shallowest water level in the range 0-2 m is observed in a small zone in the western part of Karandighi block.

Based on data of 28 ground water monitoring wells of CGWB, piezometers of State Water Investigation Directorate (SWID) and tube wells of PHED, Government of West Bengal, the depth to water level map for post-monsoon 2021 has been prepared. This map is shown in **Fig. 5.4.** A study of the map indicates that as compared to monsoon, the depth to water level in the range 2-5 m has spread even more widely and occupies a major part of the district. Deeper water level in the range 5-10 m has shrunk considerably and becomes restricted mainly to the southern part of Itahar block. The areal extent of the shallowest depth to water level zone in the range 0-2 m has increased substantially when compared to Fig. 5.2. This zone has become prominent in the west central and north eastern parts of the

district, occupying parts of Goalpokhar-I, Goalpokhar-II, Hemtabad, Raiganj and Karandighi blocks.

On the basis of depth to water level data of 29 monitoring wells and 2 Key Observation Wells (pre-monsoon 2022), the depth to water level map has been prepared, which is shown as **Fig. 5.5.** A perusal of the map reveals that deepest water level (> 10 m bgl) was observed in the southern part of Itahar block, falling in the Barind Uplands. Depth to water level ranging from >5 to 10 m was observed in central and northern parts of Itahar block, almost entire Raiganj block, western parts of Hemtabad and Kaliaganj blocks, south-eastern part of Karandighi block, in the south-western and northern parts of Islampur block and in the southern part of Chopra block. In remaining areas of the district, the shallowest depth to water level (2 to 5 m bgl) was observed in pre-monsoon 2022.

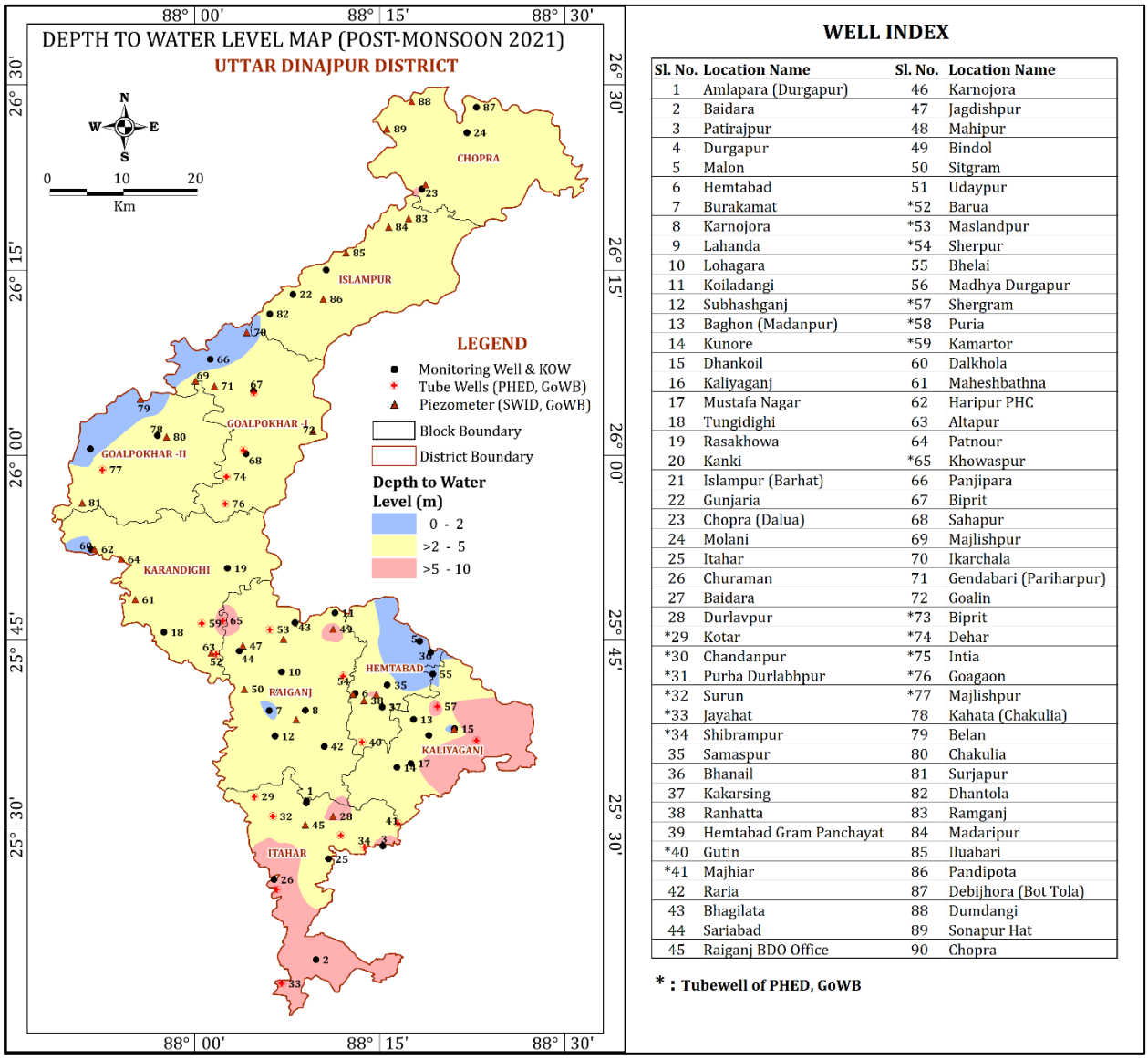


WELL INDEX

Sl. No	Location Name	Sl. No	Location Name
1	Amlapara (Durgapur)	43	Bindol
2	Baidara	44	Sitgram
3	Patirajpur	45	Udaypur
4	Durgapur	46	Bhelai
5	Malon	47	Madhya Gouripur
6	Hemtabad	48	Majlispur
7	Burakamat	49	Madhya Durgapur
8	Karnojora	*50	Faridpur
9	Lahanda	51	Khikhirtola
10	Lohagara	52	Dalkhola
11	Koiladangi	53	Barail
12	Subhashganj	54	Maheshbathna
13	Dalimgaon	55	Haripur PHC
14	Baghon(Madanpur)	56	Altapur
15	Kunore	57	Patnour
16	Dhankoil	*58	Choprabari
17	Kaliyaganj	59	Panjipara
18	Mustafa Nagar	60	Biprit
19	Tungidighi	61	Majlishpur
20	Rasakhowa	62	Ikarchala
21	Kanki	63	Gendabari (Pariharpur)
22	Islampur (Barhat)	64	Goalin
23	Gunjaria	*65	Lodhan
24	Chopra (Dalua)	66	Chitora (Gandal)
25	Molani	67	Kahata (Chakulia)
26	Itahar	68	Chapore
27	Churaman	69	Belan
28	Baidara	70	Chakulia
29	Durlavpur	71	Surjapur
*30	Shreepur*	72	Dhantola
31	Samaspur	73	Agdimti Khanti
32	Bhanail	74	Ramganj
33	Ranhatta	75	Madaripur
34	Hemtabad Gram Panchayat	76	Iluabari
*35	Bamair	77	Pandipota
36	Raria	78	Sripokhar
37	Bhagilata	79	Debijhora (Bot Tola)
38	Sariabad	80	Dumdangi
39	Raiganj BDO Office	81	Sonapur Hat
40	Karnojora	82	Chopra
41	Jagdishpur	*83	Purba Chutiakhor
42	Mahipur		

* : Tubewell of PHED, GoWB

Fig. 5.3 Depth to water level map (using data of ground water monitoring wells of CGWB and tube wells of PHED, Govt. of West Bengal), September 2021 (monsoon period), Uttar Dinajpur district

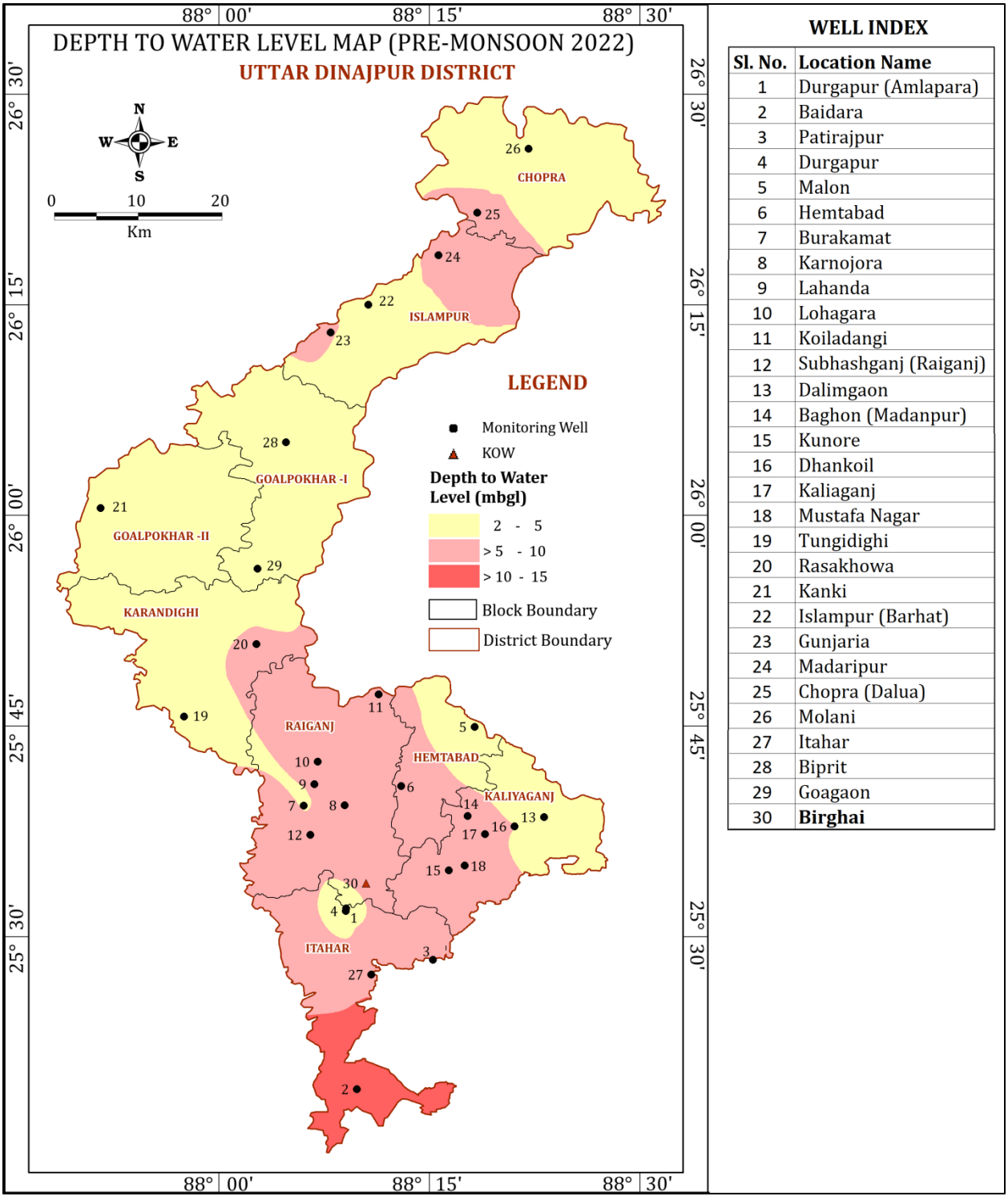


WELL INDEX

Sl. No.	Location Name	Sl. No.	Location Name
1	Amlapara (Durgapur)	46	Karnojora
2	Baidara	47	Jagdishpur
3	Patirajpur	48	Mahipur
4	Durgapur	49	Bindol
5	Malon	50	Sitgram
6	Hemtabad	51	Udaypur
7	Burakamat	*52	Barua
8	Karnojora	*53	Maslandpur
9	Lahanda	*54	Sherpur
10	Lohagara	55	Bhelai
11	Koiladangi	56	Madhya Durgapur
12	Subhashganj	*57	Shergram
13	Baghon (Madanpur)	*58	Puria
14	Kunore	*59	Kamartor
15	Dhankoil	60	Dalkhola
16	Kaliyaganj	61	Maheshbathna
17	Mustafa Nagar	62	Haripur PHC
18	Tungidighi	63	Altapur
19	Rasakhowa	64	Patnour
20	Kanki	*65	Khowaspur
21	Islampur (Barhat)	66	Panjipara
22	Gunjaria	67	Biprit
23	Chopra (Dalua)	68	Sahapur
24	Molani	69	Majlishpur
25	Itahar	70	Ikarchala
26	Churaman	71	Gendabari (Pariharpur)
27	Baidara	72	Goalin
28	Durlavpur	*73	Biprit
*29	Kotar	*74	Dehar
*30	Chandanpur	*75	Intia
*31	Purba Durlabhpur	*76	Goagaon
*32	Surun	*77	Majlishpur
*33	Jayahat	78	Kahata (Chakulia)
*34	Shibrampur	79	Belan
35	Samaspur	80	Chakulia
36	Bhanail	81	Surjapur
37	Kakarsing	82	Dhantola
38	Ranhatta	83	Ramganj
39	Hemtabad Gram Panchayat	84	Madaripur
*40	Gutin	85	Iluabari
*41	Majhiar	86	Pandipota
42	Raria	87	Debijhora (Bot Tola)
43	Bhagilata	88	Dumdangi
44	Sariabad	89	Sonapur Hat
45	Raiganj BDO Office	90	Chopra

* : Tubewell of PHED, GoWB

Fig. 5.4 Depth to water level map (using data of ground water monitoring wells of CGWB and tube wells of PHED, Govt. of West Bengal), November 2021 (post-monsoon), Uttar Dinajpur district



WELL INDEX

Sl. No.	Location Name
1	Durgapur (Amlapara)
2	Baidara
3	Patirajpur
4	Durgapur
5	Malon
6	Hemtabad
7	Burakamat
8	Karnojora
9	Lahanda
10	Lohagara
11	Koiladangi
12	Subhashganj (Raiganj)
13	Dalimgaon
14	Baghon (Madanpur)
15	Kunore
16	Dhankoil
17	Kaliaganj
18	Mustafa Nagar
19	Tungidighi
20	Rasakhowa
21	Kanki
22	Islampur (Barhat)
23	Gunjaria
24	Madaripur
25	Chopra (Dalua)
26	Molani
27	Itahar
28	Biprit
29	Goagaon
30	**Birghai**

Fig. 5.5 Depth to water level map, May 2022 (pre-monsoon), Uttar Dinajpur district

Table 5.3 Depth to water level in Ground Water Monitoring Wells, Uttar Dinajpur district

Sl. No.	Well No.	Location	Date	Type of Monitoring Well	M.P. (m)	DTW (m bgl)	Temp. (°C)
Monsoon period (September 2021)							
1	WBWD14A	Durgapur (Amlapara)	08-9-21	Dug Well	0.75	**1.69**	27.0
2	WBWD16B	Malan	09-9-21	Dug Well	0.80	**2.34**	27.0
3	WBWD23A	Itahar (Sripur)	08-9-21	Tube Well	0.30	**3.38**	27.0
4	WBWD24	Tungidighi	11-9-21	Dug Well	0.83	**1.96**	30.0
5	WBWD26	Kanki	12-9-21	Dug Well	0.83	**1.12**	NA
6	WBWD29A	Chopra	13-9-21	Tube Well	0.60	**3.93**	26.0
7	WBWD40B	Burakamat	11-9-21	Dug Well	1.25	**1.13**	27.0
8	WBWD42	Dalimgaon	10-9-21	Dug Well	0.72	**1.37**	30.0
9	WBWD45B	Molani	13-9-21	Dug Well	0.78	**1.96**	26.0
10	WBWD47	Panjipara	12-9-21	Dug Well	0.85	**0.57**	NA
11	WBWD65A	Baidara	08-9-21	Tube Well	0.50	**8.07**	29.0
12	WBWD66A	Patirajpur	08-9-21	TW Mark-II	0.60	**3.45**	27.0
13	WBWD67	Durgapur	08-9-21	Piezometer	1.20	**1.19**	NA
14	WBWD70A	Baghan (Madanpur)	10-9-21	TW Mark-II	0.70	**2.98**	26.0
15	WBWD73A	Madaripur	13-9-21	Dug Well	1.00	**1.42**	30.0
16	WBWD87	Lahanda	11-9-21	TW Mark-II	0.65	**3.27**	28.0
17	WBWD88	Lohagara	11-9-21	TW Mark-II	0.75	**3.86**	28.0
18	WBWD90	Koiladangi	11-9-21	TW Mark-II	0.50	**3.71**	27.0
19	WBWD91	Subhasganj (Raiganj Municipality)	14-9-21	TW Mark-II	0.75	**3.79**	27.0

20	WBWD93A	Kunore	10-9-21	TW Mark-II	0.70	**1.46**	30.0
21	WBWD110	Mustafa Nagar	10-9-21	TW Mark-II	0.60	**3.93**	29.0
22	WBWD111	Dhankoil	10-9-21	TW Mark-II	0.80	**1.89**	29.0
23	WBWD112	Hemtabad	09-9-21	TW Mark-II	0.40	**4.69**	26.0
24	WBWD113	Islampur	12-9-21	Tube Well	0.35	**1.57**	NA
25	WBWD114	Gunjaria	12-9-21	TW Mark-II	0.40	**3.38**	28.0
26	WBWD117	Rasakhowa	11-9-21	Tube Well	0.80	**2.77**	27.0
27	WBWD118	Karnojora (Raiganj)	09-9-21	TW Mark-II	0.60	**5.07**	26.0
28	WBWD119	Kaliaganj	10-9-21	TW Mark-II	0.80	**3.28**	30.0

Post-monsoon period (November 2021)

29	WBWD14	Amlapara (Durgapur)	19-11-21	Dug Well	0.88	**1.61**	25.0
30	WBWD16B	Malon	20-11-21	Dug Well	0.80	**0.73**	26.0
31	WBWD23A	Itahar (Sripur)	19-11-21	Tube Well	0.30	**3.31**	27.0
32	WBWD24	Tungidighi	21-11-21	Dug Well	0.83	**2.29**	26.0
33	WBWD26	Kanki	21-11-21	Dug Well	0.83	**1.64**	26.0
34	WBWD29A	Chopra	22-11-21	Tube Well	0.80	**5.32**	25.0
35	WBWD40B	Burakamat	23-11-21	Dug Well	1.25	**1.24**	24.0
36	WBWD42	Dalimgaon	20-11-21	Dug Well	0.72	**--**	--
37	WBWD45B	Molani	22-11-21	Dug Well	0.78	**2.44**	25.0
38	WBWD47	Panjipara	22-11-21	Dug Well	0.85	**--**	25.0
39	WBWD65A	Baidara	19-11-21	Tube Well	0.50	**5.42**	26.0
40	WBWD66A	Patirajpur	19-11-21	TW Mark-II	0.60	**3.49**	27.0
41	WBWD67	Durgapur	25-11-21	Piezometer	1.20	**1.18**	--
42	WBWD69A	Karnojora (Raiganj)	20-11-21	TW Mark-II	0.55	**4.62**	27.0

43	WBWD70A	Baghon (Madanpur)	23-11-21	TW Mark-II	0.70	**3.33**	24.0
44	WBWD73A	Madaripur	22-11-21	Dug Well	1.00	**2.83**	25.0
45	WBWD87	Lahanda	23-11-21	TW Mark-II	0.65	**3.59**	25.0
46	WBWD88	Lohagara	23-11-21	TW Mark-II	0.75	**3.93**	26.0
47	WBWD90	Koiladongi	23-11-21	TW Mark-II	0.50	**4.05**	25.0
48	WBWD91	Subhasganj	23-11-21	TW Mark-II	0.75	**3.66**	25.0
49	WBWD92A	Kaliaganj	20-11-21	TW Mark II	0.80	**3.05**	27.0
50	WBWD93A	Kunore	20-11-21	TW Mark-II	0.70	**2.52**	27.0
51	WBWD110	Mustafa Nagar	20-11-21	TW Mark-II	0.60	**4.87**	27.0
52	WBWD111	Dhankoil	20-11-21	TW Mark-II	0.80	**1.93**	26.0
53	WBWD112	Hemtabad	20-11-21	TW Mark-II	0.40	**4.97**	26.0
54	WBWD113	Islampur OW	22-11-21	OW/ PZ	0.35	**2.32**	NA
55	WBWD114	Gunjaria	22-11-21	TW Mark-II	0.40	**3.98**	25.0
56	WBWD117	Rasakhowa	21-11-21	TW Mark-II	1.30	**3.60**	26.0
Pre-monsoon period (May 2022)							
57	WBWD14	Amlapara (Durgapur)	01-5-22	Dug Well	0.88	**3.88**	27.0
58	WBWD16B	Malon	04-5-22	Dug Well	0.80	**3.46**	27.0
59	WBWD23A	Itahar (Sripur)	01-5-22	Tube Well	0.30	**9.34**	27.0
60	WBWD24	Tungidighi	04-5-22	Dug Well	0.83	**4.58**	28.0
61	WBWD26	Kanki	03-5-22	Dug Well	0.83	**2.89**	28.0
62	WBWD29A	Chopra	03-5-22	Tube Well	0.80	**5.51**	26.0
63	WBWD40B	Burakamat	04-5-22	Tube Well	0.88	**4.80**	31.0
64	WBWD42	Dalimgaon	04-5-22	Dug Well	0.72	**3.60**	27.0
65	WBWD45B	Molani	03-5-22	Dug Well	0.78	**2.91**	25.0
66	WBWD47	Panjipara	03-5-22	Dug Well	0.85	Dug Well abandoned	
67	WBWD65A	Baidara	01-5-22	Tube Well	0.50	**13.28**	28.0

68	WBWD66A	Patirajpur	01-5-22	TW Mark-II	0.60	**8.36**	27.0
69	WBWD67	Durgapur	05-5-22	Piezometer	1.20	**4.01**	NA
70	WBWD69A	Karnojora (Raiganj)	05-5-22	TW Mark-II	0.55	**7.08**	28.0
71	WBWD70A	Baghon (Madanpur)	04-5-22	TW Mark-II	0.70	**5.62**	30.0
72	WBWD73A	Madaripur	03-5-22	Dug Well	1.00	**5.27**	25.0
73	WBWD87	Lahanda	04-5-22	TW Mark-II	0.65	**5.33**	29.0
74	WBWD88	Lohagara	04-5-22	TW Mark-II	0.75	**5.84**	NA
75	WBWD90	Koiladongi	04-5-22	TW Mark-II	0.50	**6.18**	29.0
76	WBWD91	Subhasganj	05-5-22	TW Mark-II	0.75	**6.71**	27.0
77	WBWD92A	Kaliaganj	04-5-22	TW Mark II	0.80	**5.89**	27.0
78	WBWD93A	Kunore	05-5-22	TW Mark-II	0.70	**8.44**	26.0
79	WBWD110	Mustafa Nagar	04-5-22	TW Mark-II	0.60	**8.16**	27.0
80	WBWD111	Dhankoil	04-5-22	TW Mark-II	0.80	**5.03**	27.0
81	WBWD112	Hemtabad	04-5-22	TW Mark-II	0.40	**6.93**	27.0
82	WBWD113	Islampur OW	03-5-22	OW/ PZ	0.35	**3.50**	NA
83	WBWD114	Gunjaria	03-5-22	TW Mark-II	0.40	**5.26**	28.0
84	WBWD117	Rasakhowa	03-5-22	TW Mark-II	0.60	**5.26**	27.0
85	WBWD118	Biprit*	03-5-22	TW Mark-II	0.70	**3.85**	26.0
86	WBWD119	Goagaon*	03-5-22	TW Mark-II	0.60	**3.84**	25.0

5.5 Fluctuations in groundwater level

Fluctuations in groundwater level are of two types: short-term and long-term fluctuations. The short-term fluctuations show either annual rise or decline in groundwater level or the seasonal rise or decline in the level. Long-term fluctuation is calculated taking into consideration groundwater level data of at least 10 years (decadal data) or more. As mentioned in Section 5.4, calculation of fluctuation in groundwater level is done based on data collected during pre-monsoon and post-monsoon periods from the Ground Water Monitoring Wells. For calculation of seasonal fluctuation,

combined data of Ground Water Monitoring Wells and Key Observation Wells (established during aquifer mapping study) is used to quantify variation in groundwater level during pre-monsoon and post-monsoon period of a particular year. As the present study was taken up while COVID 19 virus outbreak was in full swing (in pre-monsoon 2021), groundwater monitoring was not possible.

5.5.1 Seasonal Fluctuation

The seasonal fluctuation has been calculated based on data collected during pre-monsoon 2022 and data collected during post-monsoon 2021. For calculation, depth to water level data of 27 monitoring wells including dug wells, tube wells and piezometers was utilized. A perusal of seasonal fluctuation data indicates that out of 27 wells, 11 wells (40.74 %) have shown seasonal rise ranging from 0-2 m, 13 wells (48.15 %) have shown seasonal rise from 2 to 4 m and only 3 wells (11.11 %) have recorded the highest seasonal rise (>4 m). Highest sesonal rise of 7.86 m was recorded in a tube well at Baidara in Itahar block (falling in Barind Tract), whereas the lowest seasonal rise of 0.19 m was observed in a tube well in Chopra Primary Health Centre at Dalua. The seasonal water level fluctuation map is shown in **Fig. 5.6.** A study of the map reveals that highest seasonal rise (>4 m) is found in the southernmost part of the district viz. in the southern part of Itahar block. Seasonal rise ranging from 2 to 4 m is observed in northern part of Itahar block, in Kaliaganj and Hemtabad block and in the central part of Islampur block. The lowest seasonal rise ranging from 0 to 2 m is observed in northern and central parts of Uttar Dinajpur district located in Chopra, Islampur, Goalpokhar-I, Goalpokhar-II and Karandighi block.

5.5.2 Annual Fluctuation

Due to unprecedented COVID situation in the years 2020 and part of 2021, pre-monsoon groundwater monitoring in the months of April and May was not possible, as already mentioned. To have consistency in analysis, pre-monsoon groundwater level data of 2018 and 2019 was used for analysis. Data of 19 ground water monitoring wells comprising dug wells, piezometers and tube wells was used for calculation. It is found that all the 19 wells have recorded annual rise in groundwater level ranging from 0 to 2 m. The highest annual rise of 0.82 m was recorded at

Durgapur in Raiganj block whereas the lowest annual rise was 0.11 m at Panjipara in Goalpokhar-I block. The pre-monsoon annual fluctuation map of Uttar Dinajpur district is shown in **Fig. 5.7.** Visual interpretation of the map indicates that annual rise in the range 0-2 m was recorded throughout the district.

During post-monsoon period, the annual fluctuation in Uttar Dinajpur district reveals a different scenario as compared to pre-monsoon. For post-monsoon, depth to water level data of 2020 and 2021 was used for analysis, as COVID 19 virus outbreak condition was much less severe during these periods. This has enabled completion of field survey in the district during the month of November. Data of 20 ground water monitoring wells was used for calculation, which shows 10 out of 20 wells (50 %) have shown post-monsoon rise in November 2021 when compared to November 2020. All the 10 wells have shown annual rise ranging from 0 to 2 m. The highest annual rise (post-monsoon) was 1.54 m at Panjipara in Goalpokhar-I block while the lowest was 0.14 m at Subhashganj in Raiganj Municipality. Out of 20 wells, 8 wells (40.0 %) have recorded annual decline ranging from 0 to 2 m, whereas only 2 wells (10.0 %) have recorded higher annual decline of 2 to 4 m in groundwater level. The lowest annual decline was 0.17 m in a tube well at Karnojora in Raiganj block whereas the highest decline was 2.40 m in another tube well at Mustafa Nagar in Kaliaganj block.

The map showing annual fluctuation in groundwater level in post-monsoon period is given in **Fig. 5.8.** A perusal of the map reveals that annual decline in the range 0-2 m was seen in the central part of the district covering Raiganj, Karandighi and western part of Kaliaganj blocks and in the eastern and western parts of Islampur block. Higher annual decline ranging from 2-4 m was seen in Chopra block in the northernmost part of the district and in a small sector falling in the central part of Kaliaganj block. In remaining part of the district, which is about 60% of the geographical area, annual rise ranging from 0-2 m was observed.

5.5.3 Decadal (Long-term) Fluctuation

As explained in Section 5.5.2, decadal fluctuation in groundwater level has been calculated based on the decadal data from 2009 to 2018 and comparing the decadal mean with corresponding depth to

water level in 2019, both during the pre-monsoon and post-monsoon period. Decadal fluctuation analysis for pre-monsoon was done with data of 21 ground water monitoring wells. The data indicates decadal rise in 18 wells (85.71 %) and decadal decline in only 3 wells (14.29 %) in post-monsoon. All the wells with decadal rising trend have shown rise in the range of 0 to 2 m. Only 1 well out of 21 (4.76 %) has shown decadal decline in the range 2-4 m, which is located at Patirajpur in Itahar block. The highest decadal rise of 1.44 m was observed at Karnojora in Raiganj block, whereas the lowest decadal rise was 0.21 m at Panjipara in Goalpokhar-I block. The lowest decadal decline recorded was 0.22 m at Madaripur in Islampur block. Pre-monsoon decadal fluctuation map of Uttar Dinajpur district is shown in **Fig. 5.9.** The map reveals that long-term decline is restricted only to southern and eastern parts of Itahar block, southern part of Kaliaganj block, in Chopra block and in the northern part of Islampur block. Decadal rise ranging from 0 to 2 m was observed in ~80% of the district area.

In post-monsoon period, long-term (decadal) fluctuation in groundwater level was carried out based on data of 22 ground water monitoring wells. It was found that one well at Baidara has shown neither rise nor decline, 14 wells have shown decadal rise and 7 wells have shown decadal decline in groundwater level. Decadal rise in the range of 0 to 2 m was recorded in 13 monitoring wells out of 22 (59.09 %) whereas rise in the range of 2 to 4 m was recorded at Dhankoil (2.02 m) in Kaliaganj block. Decadal decline was observed in 7 monitoring wells out of 22 (31.82 %) with all monitoring wells showing decline in the range of 0 to 2 m. The lowest decadal decline was 0.30 m at Hemtabad, whereas the highest decline was 1.82 m at Madaripur in Islampur block. The map showing post-monsoon decadal decline is given in **Fig. 5.10.** A perusal of the map indicates that long-term decline in the range 0-2 m was observed in the northern part of the district (Chopra and Islampur blocks), in the southern parts of Goalpokhar-I and Goalpokhar-II blocks, eastern part of Karandighi block, north western and eastern parts of Raiganj block, southern part of Hemtabad block and western part of Kaliaganj block. In remaining part of the district, only long-term rise in the range of 0-2 m was observed. Higher decadal rise of >2 - 4 m in groundwater level was observed in the central part of Kaliaganj block.

5.6 Water Table Contour Map

Using Garmin portable handheld GPS receiver, the elevation data of ground water monitoring wells of Uttar Dinajpur district was measured during the present study. The reduced level for each monitoring well was calculated using the elevation data and the depth to water level data of pre-monsoon and post-monsoon periods. Due to COVID situation, groundwater monitoring could not be taken up in pre-monsoon 2021. Hence, water table data for pre-monsoon 2022 and post-monsoon 2021 were used for preparation of water table contour maps of Uttar Dinajpur district. Based on disposition of water table contours, the groundwater flow direction on a regional scale has been deduced.

Water table contour map (pre-monsoon 2022) is shown in **Fig. 5.11** whereas that of post-monsoon 2021 is shown in **Fig. 5.12.** A perusal of the pre-monsoon map reveals that in the northern and central parts of the district, the regional groundwater flow direction is from north-east to south-west. Groundwater flow direction changed in the south-central and eastern parts covering Raiganj, Hemtabad and Kaliaganj block. In the northern part of Kulik River, flow direction is from north-west to south-east, whereas in the southern bank of Kulik River, flow direction is from north-east to south-west. In the southernmost part of the district, falling in the Barind Uplands of Itahar block, the flow direction appears to be controlled by the southerly flowing Mahananda River. Groundwater flow direction in pre-monsoon 2022 along Durgapur-Churamon-Sripur-Baidara section is from west to east. This indicates a westerly flow of groundwater both across the district boundary between Uttar Dinajpur and Dakshin Dinajpur in the eastern part of Itahar block and between Uttar Dinajpur and Malda district in the southern part of Itahar block.

In the post-monsoon period (November 2021), a variation in regional groundwater flow pattern has been observed, which is shown in **Fig. 5.12.** In Chopra block and northern part of Islampur block, regional groundwater flow direction was from north-east to south-west. In the central part of the district covering southern part of Islampur block, entire Goalpokhar-I, Goalpokhar-II and Karandighi blocks, regional groundwater flow direction was from north-west to south-east in the interfluve area between Fulahar River on the west and Nagar River on the east. Concavo-convex water table contours between Nagar River on the west and Kulik River on the east

indicates local change in groundwater flow direction, which may be attributed to constant interaction between surface water and groundwater in this area. This also indicates hydraulic connectivity between the rivers and shallow aquifers. However, in the southern part of the district, regional flow pattern appears to be controlled by the perennial Mahananda River draining through southern part of Raiganj block and along the western boundary of Itahar block. Water table contours in this area are spaced relatively wide apart in post-monsoon 2021, as compared to the pre-monsoon 2022. This indicates a sluggish regional flow in post-monsoon period. The easterly regional groundwater flow pattern is distinct across the border between Uttar Dinajpur district and Dakshin Dinajpur district along Sripur-Itahar-Patirajpur-Baidara section.

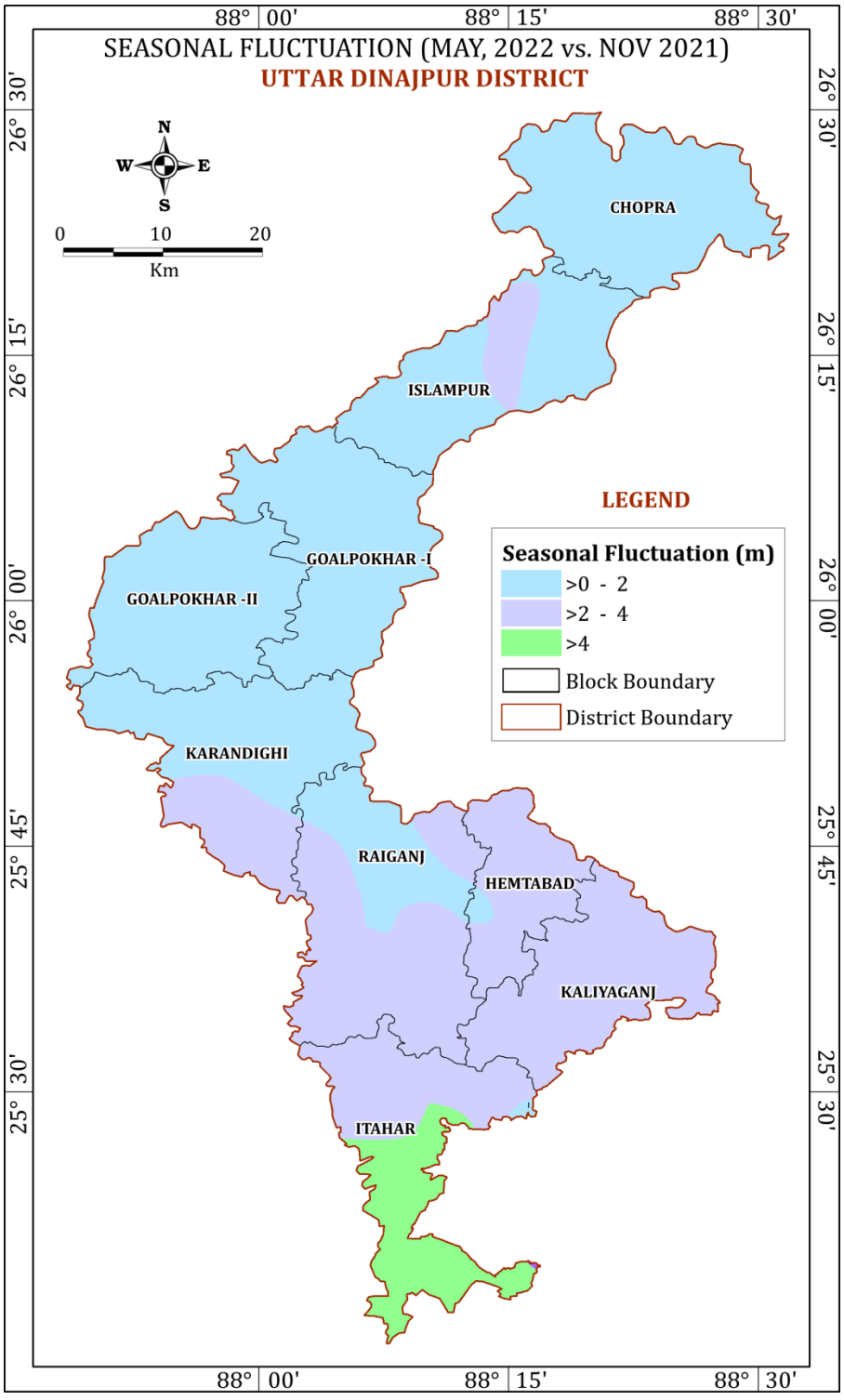


Fig. 5.6 Seasonal water level fluctuation map, Uttar Dinajpur district

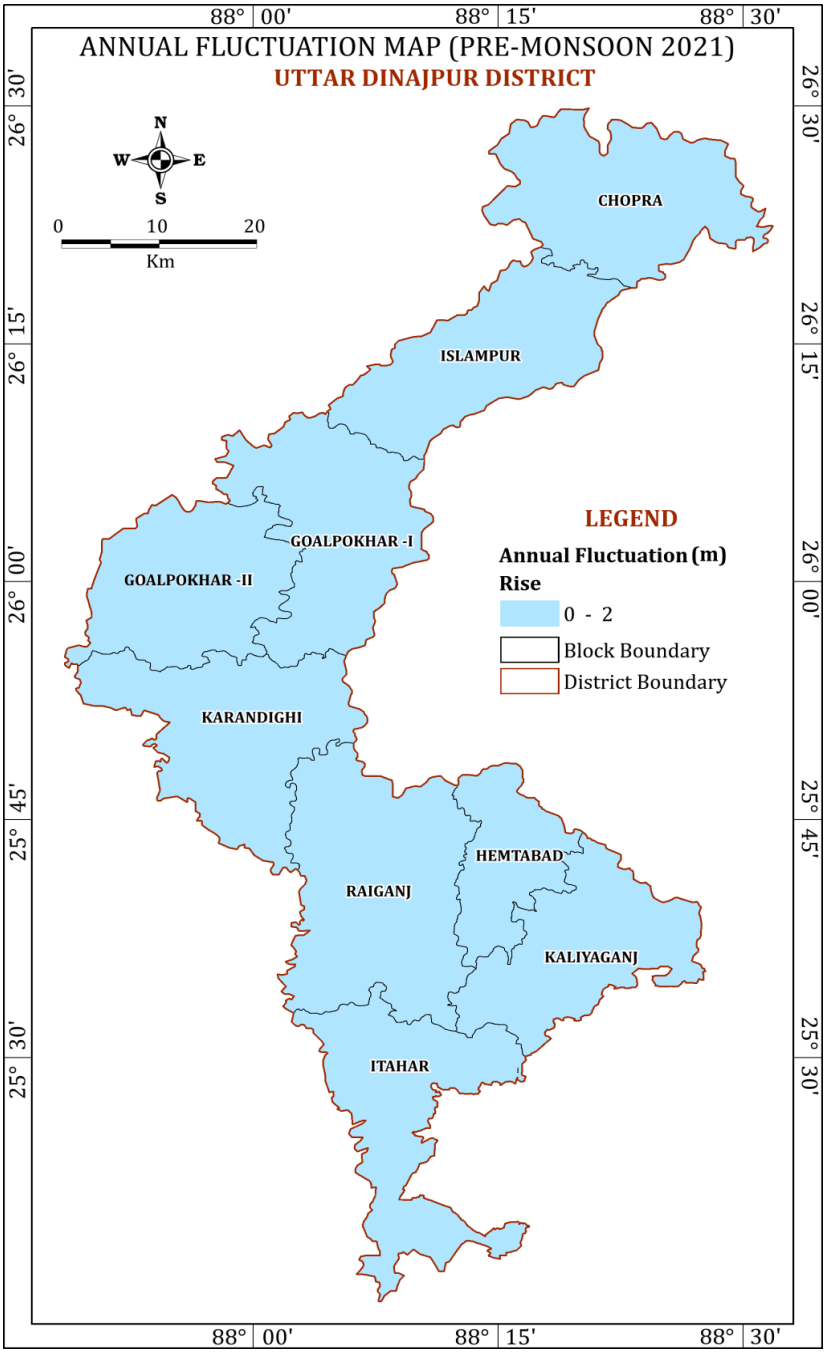


Fig. 5.7 Annual water level fluctuation map (pre-monsoon 2021), Uttar Dinajpur district

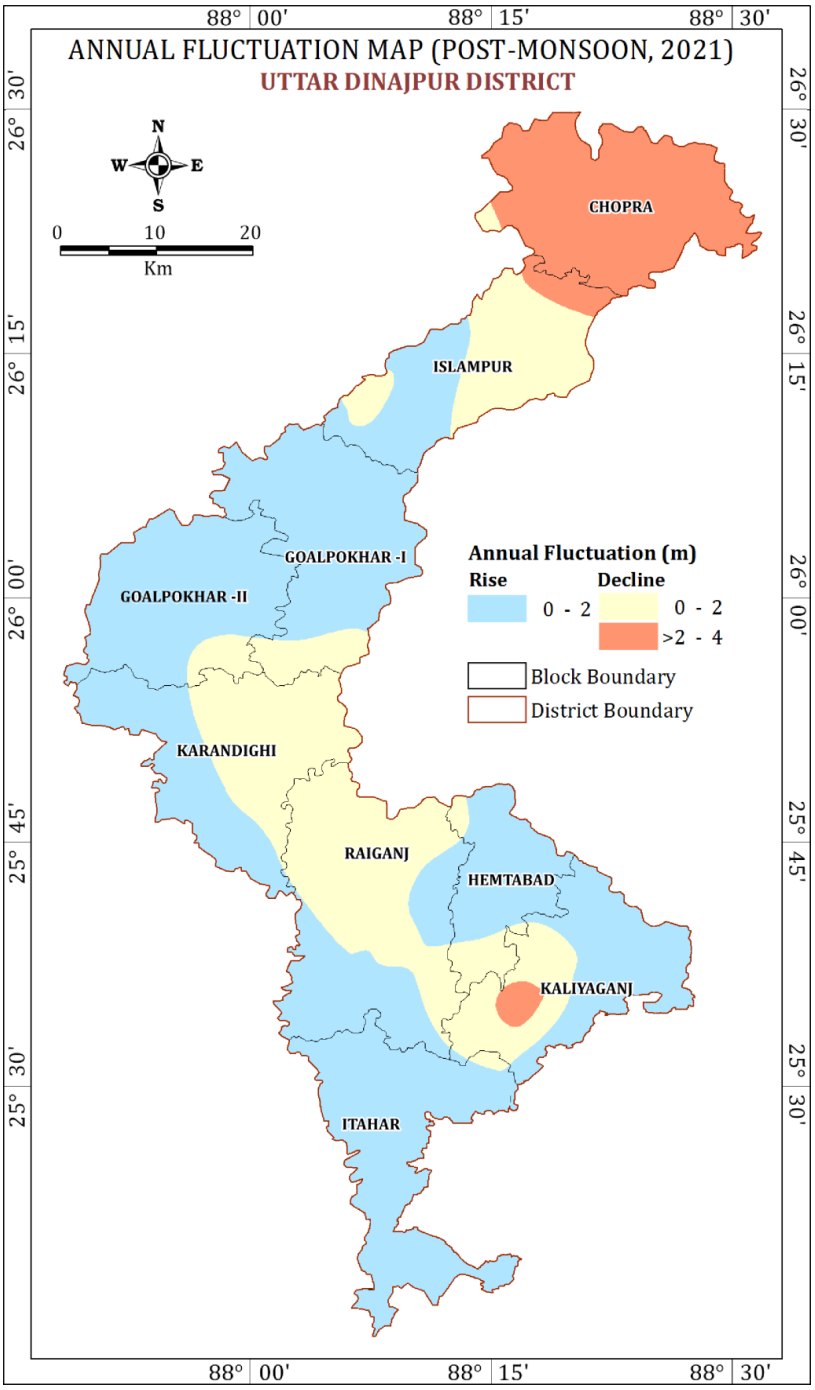


Fig. 5.8 Annual water level fluctuation map (post-monsoon 2021), Uttar Dinajpur district

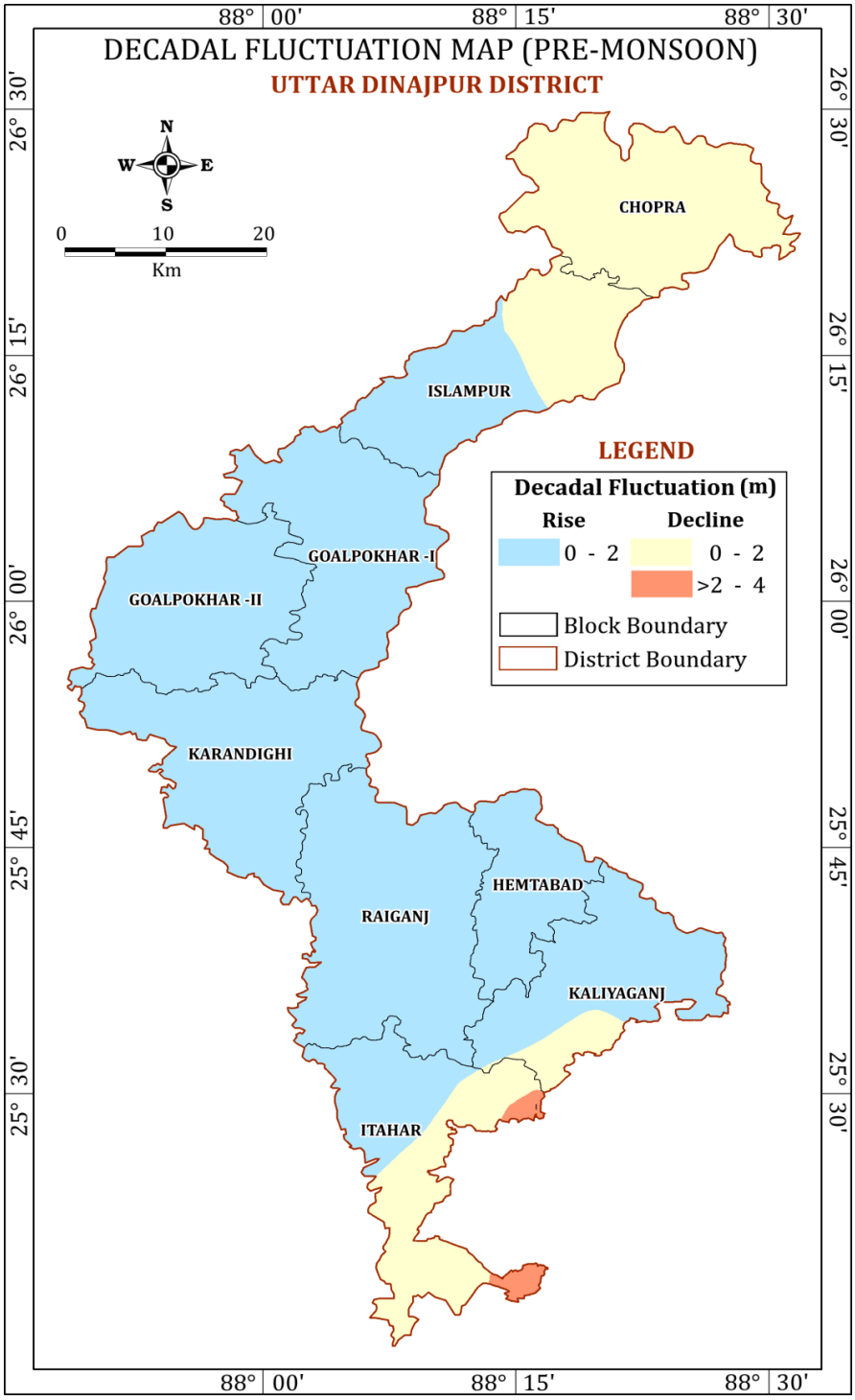


Fig. 5.9 Decadal water level fluctuation map (pre-monsoon), Uttar Dinajpur district

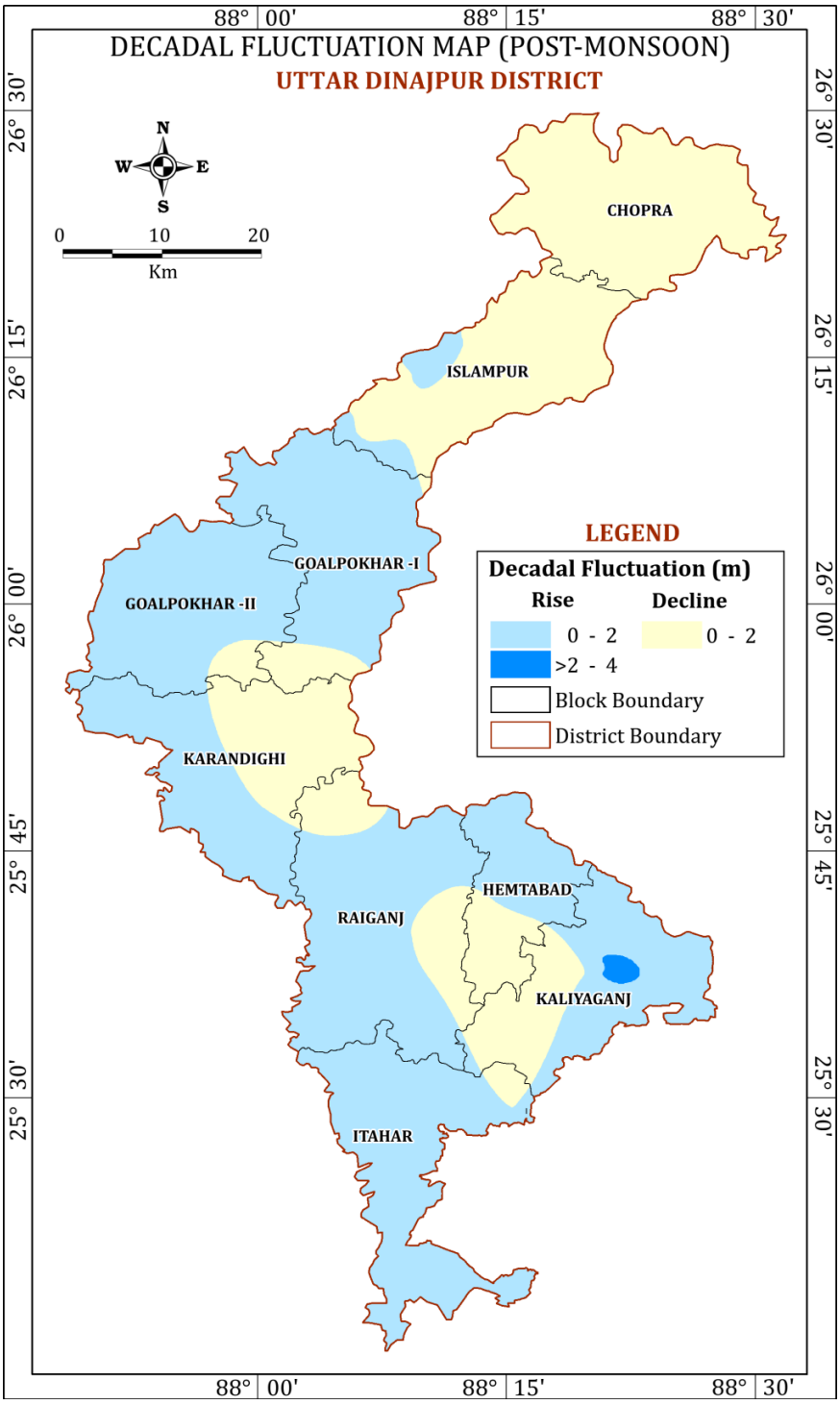


Fig. 5.10 Decadal water level fluctuation map (post-monsoon), Uttar Dinajpur district

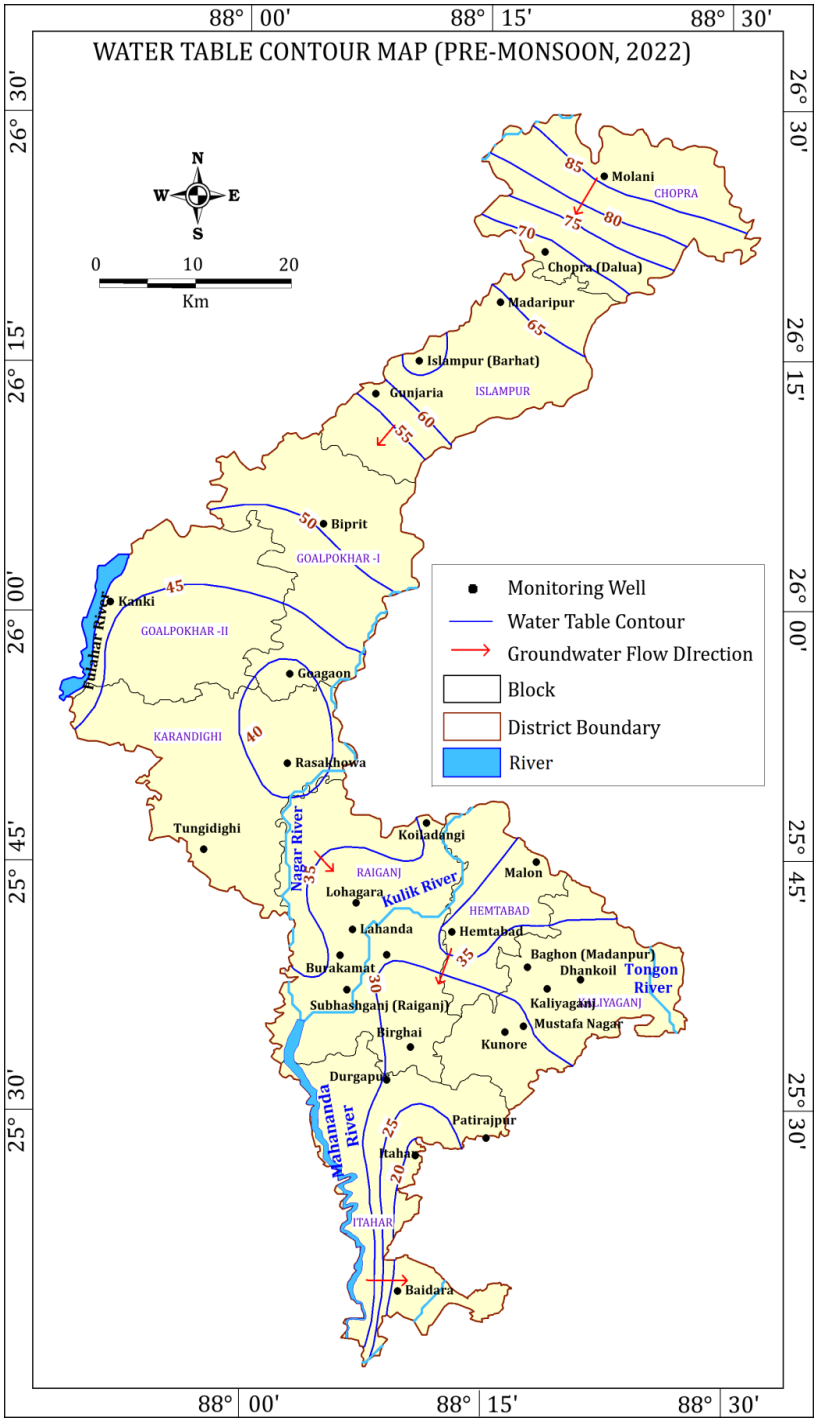


Fig. 5.11 Water table contour map (pre-monsoon 2022), Uttar Dinajpur district

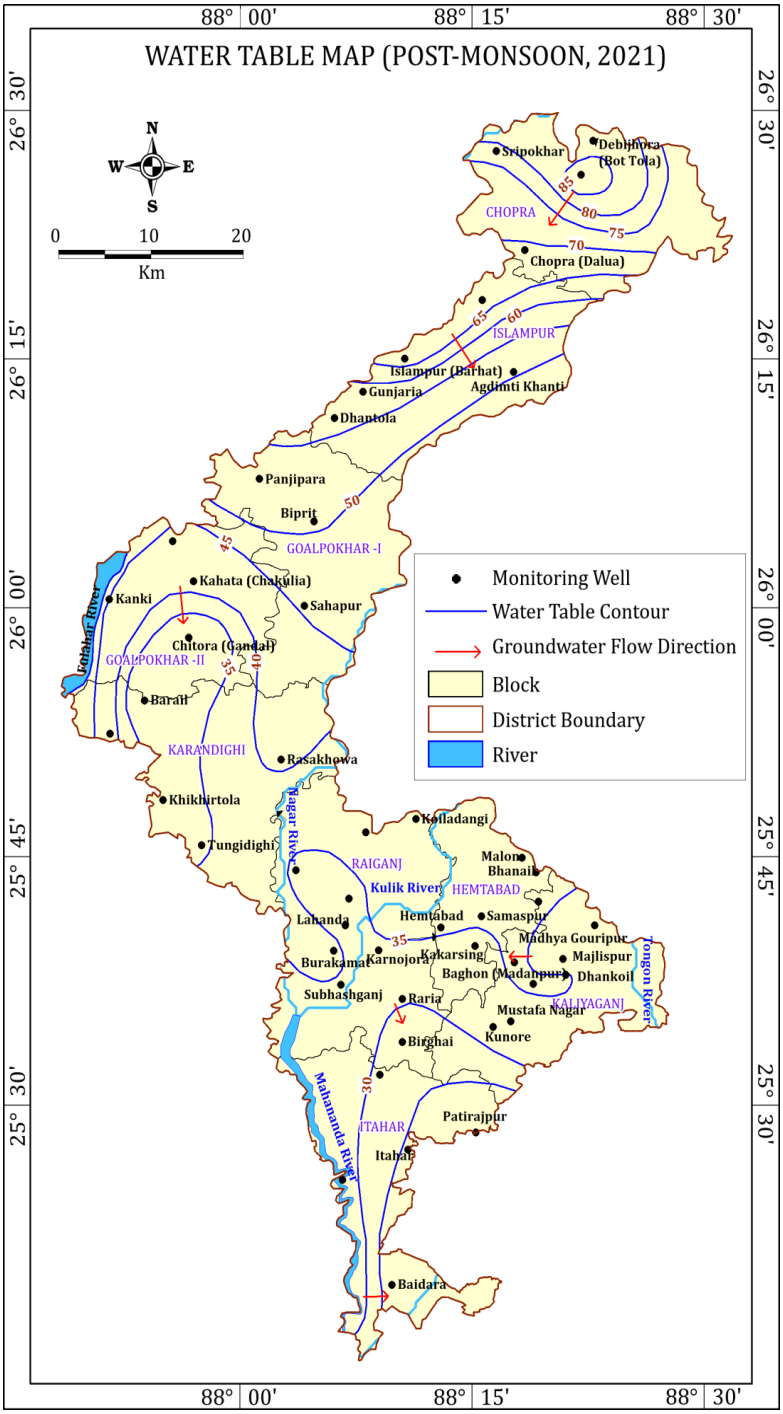


Fig. 5.12 Water table contour map (post-monsoon 2021), Uttar Dinajpur

5.6 Groundwater Resources

Dynamic groundwater resources of Uttar Dinajpur district (as on 31st March, 2013) were estimated jointly by CGWB and SWID, Government of West Bengal, following the methodology recommended by Groundwater Resources Estimation Committee (GEC, 1997). Dynamic groundwater resources have been estimated separately for both the command and non-command areas of the district. As per the assessment, no block was categorized as Semi-critical or Critical according to the Stage of Development. All blocks are in the Safe category, with the highest Stage of Development (SOD) of 83.41% for Goalpokhar-II block and the lowest SOD of 37.25% for Chopra block. Although the SOD was between 70 and 90% for Itahar, Raiganj and Goalpokhar-II block, these are categorized as Safe based on long-term groundwater level trend. A summary of the dynamic groundwater resources of Uttar Dinajpur district is given in **Table 5.4.**

Table 5.4 Summary of Dynamic Groundwater Resources, Uttar Dinajpur district (as on 31-3-2013)

1. Total Annual Ground Water Recharge	145529.34 ham
2. Provision for Natural Discharge	12014.51 ham
3. Net Annual Ground Water Availability	133514.83 ham
4. Existing Ground Water Draft for Irrigation	78133.60 ham
5. Existing Ground Water Draft for Domestic Use	3207.51 ham
6. Existing Ground Water Draft for Industrial Use	1603.76 ham
7. Existing Ground Water Draft for All Uses	82944.87 ham
8. Stage of Ground Water Development (SOD)	60.88 %
9. Annual Ground Water Allocation for Domestic use (as on 2025 AD)	7569.33 ham
10. Net Ground Water Availability for Future Irrigation Development	47811.90 ham
11. Categorization of Block	Safe: Nine blocks

A summary table of block wise dynamic groundwater resources of the district is given in **Table 4** of **Appendix-I**. The table shows a wide variation in Stage of Groundwater Development (SOD), ranging from 37.25% in Chopra block to 83.41% at Hemtabad block. However, based on long-term groundwater level trend, blocks with SOD of >70-90% (Hemtabad, Itahar and Raiganj) are categorized as Safe blocks.

6. GEOPHYSICAL STUDIES

As on date, no surface geophysical investigation (Vertical Electric Sounding, Gradient Profiling) has been carried out in Uttar Dinajpur district by Central Ground Water Board, Eastern Region. Borehole geophysical logging data is not available in Uttar Dinajpur district as per the published report (CGWB 2011). Hence, the depth to hard rock basement and demarcation of prominent granular zones (potential aquifers) could not be deciphered. Nine sites were selected for geophysical survey during the present study, whose details are given below:

1. In the office compound of the District Magistrate, Uttar Dinajpur at Karnojora (Raiganj block): In open ground opposite to Zila Parishad office on Raiganj-Hemtabad road, ~3 km NE of Raiganj
2. In open ground of Kendriya Vidyalaya, Gobindapur (Raiganj block): LHS of Raiganj-Bogram-Hemtabad road, ~7 km NE of Raiganj
3. In playground of Prahlad Chandra High School, Churamon (Itahar block): approachable from Itahar Chowk towards Churamon village, ~7.5 km SW of Itahar
4. In open ground within Block Seed Farm, Dhankoil (Kaliaganj block): On Kaliaganj-Dhankoil-Dalimgaon road, ~26 km East of Raiganj
5. Inside Sat Sang Vihar, Dalkhola (Karandighi block): On Raiganj-Tungidighi-Dalkhola old road, LHS of road before entering Dalkhola Market, ~43 km NW of Raiganj
6. In the Police Chowki at Kanki (Goalpokhar-II block): LHS of Dalkhola-Islampur-Siliguri road, adjacent to Weigh Bridge at Kanki; ~63 km NW of Raiganj
7. In the Block Seed Farm at Islampur (Islampur block): RHS of NH-27, on Gunjaria-Islampur old road, entry through Seed Farm Gate, ~88 km north of Raiganj
8. In the Chopra Sub-health Centre/Hospital at Dalua (Chopra block): LHS of NH-27, in the open ground on the back side of Health Centre, ~105 km north of Raiganj
9. In the playground of Chakulia High School (Goalpokhar-I block): Approach by Raiganj-Domohana-Janta Bazar Hat road, ~60 km NW of Raiganj.

It is proposed to complete the surface geophysical investigations in selected sites during the Annual Action Plan: 2022-2023.

7. HYDROCHEMISTRY

7.1 Groundwater Quality

In general groundwater of shallow aquifer in Uttar Dinajpur district is potable and by and large remains within the permissible limits of drinking water standard of BIS. Historical data of sample analysis is available separately both for pre-monsoon and post-monsoon periods, which was collected during the Annual Action Plan: 2000-2001 and brought out in a report (Ghosh Dastidar and Das 2004). The data is summarized in **Annexure-V.** A perusal of the data indicates that groundwater is mildly alkaline with pH varying from 7.3 to 7.9. During pre-monsoon period, Electrical Conductivity (EC) was found to vary from 125 to 392 µS/cm. In post-monsoon, EC was found to be ranging from 142 to 465 µS/cm. Highest TDS of 235 mg/L was recorded at Hemtabad during pre-monsoon period. The analysis result indicates that nitrate and fluoride contamination in groundwater was not reported. However, high iron in groundwater was reported from Sherpur (3.47 mg/L) during pre-monsoon but its concentration was much less (0.27 mg/L) during post-monsoon. The highest iron concentration recorded was 8.22 mg/L at Fatehpur in Kaliaganj block.

During Arsenic Special Drive in the year 2015, 19 samples were collected from Uttar Dinajpur district, which were analysed subsequently for iron, arsenic and uranium. Uranium was not detected in any groundwater sample. However, high iron was recorded at many locations like Chopra (8.81 mg/L), Madaripur (5.60 mg/L), Hemtabad (3.23 mg/L), Lohagara (2.21 mg/L), Baghan (1.61 mg/L), Sripur (1.53 mg/L) and Koiladangi (1.14 mg/L). Highest concentration of arsenic in groundwater was 6.11 ppb at Chopra, which was below the Permissible Limit (10 ppb) for arsenic (BIS, 2012). During Uranium Special Drive in the year 2019, analysis for arsenic and uranium was carried out once again. Analysis result of 31 groundwater samples collected during pre-monsoon 2019 reveals highest arsenic concentration of 2 ppb at Koiladangi in Raiganj block. Uranium was Below Detection Limit (BDL) in all the samples collected during this period.

During the present study, 53 groundwater samples were collected, out of which 27 samples were treated with either hydrochloric acid or nitric acid for analysis of heavy metals in groundwater. Analysis result of 26 groundwater samples collected during post-monsoon 2021 is

summarized in **Annexure-VI.**

The data given in **Annexure-VI** shows iron contamination in groundwater in many locations. Highest iron (9.197 mg/L) was recorded at Dhankoil in Kaliaganj block followed by 8.534 mg/L at Lohagara in Raiganj block. Iron concentration above Desirable Limit (1.0 mg/L) was also recorded at Chopra Hospital (7.042 mg/L), Karnojora in Raiganj block (3.337 mg/L), Baidara in Itahar block (3.115 mg/L), Hemtabad Hospital (3.038 mg/L), Kunore in Kaliaganj block (2.140 mg/L) and Subhashganj High School in Raiganj Municipality (1.306 mg/L).

According to report of Fluoride Task Force, Government of West Bengal, Itahar block was categorized as fluoride contaminated. Therefore, samples were collected both from Ground Water Monitoring Wells (GWMW) and Key Observation Wells (KOW) in Itahar block to validate the fluoride contamination in groundwater. Latest available data has indicated that fluoride contamination in groundwater is not observed in post-monsoon 2021 in Itahar block. The highest fluoride concentration was 1.00 mg/L in a KOW at Churamon, followed by 0.97 mg/L at Itahar GWMW and 0.85 mg/L at Baidara GWMW. Highest fluoride concentration in groundwater of Uttar Dinajpur district was 1.10 mg/L at Madaripur dug well in Islampur block, which is also below the permissible limit of fluoride. Historical data (2000-2001) has also shown absence of fluoride contamination in groundwater, as the highest fluoride concentration was 0.50 mg/L at Rajibpur in Kaliaganj block, followed by 0.43 mg/L at Sherpur in Hemtabad block.

Nitrate above permissible limit (45 mg/L) was recorded only at Baghon tube well (53 mg/L) in Kaliaganj block, which is attributed to anthropogenic contamination near the tube well. This tube well is located adjacent to a public toilet in the back side of Gram Panchayat office. Magnesium above permissible limit (30 mg/L) was found only at Kanki dug well (40 mg/L) in Goalpokhar-I block, which may cause a laxative effect. However, the dug well is not used for drinking but only occasionally for domestic work. Hence, there is no immediate concern regarding high magnesium in groundwater. Available data clearly indicates that groundwater in Uttar Dinajpur district is, in general, potable and suitable for domestic use.

8. AQUIFER MANAGEMENT PLAN

8.1 General

Management of aquifers goes hand in hand with aquifer mapping. It is a very important component of formulating a sustainable initiative on integrated groundwater resources management with people's participation. Major objectives of the National Aquifer Mapping and Management Programme (NAQUIM), as per Central Ground Water Board's Aquifer Information and Management System portal (http://aims-cgwb.org) are:

- Delineation and characterization of aquifers in three dimensions
- Identification and quantification of groundwater related issues
- Development of management plans to ensure sustainability of groundwater resources

As a part of the development of an Aquifer Management Plan (AMP), each aquifer system (Older Alluvial Aquifer, Younger Alluvial Aquifer) has been subdivided into Aquifer Groups (Aquifer-I, II, III, IV and so on) in Uttar Dinajpur district. For each of the nine developmental blocks, block-wise AMPs are being prepared with an objective to identify feasible areas for artificial recharge to groundwater and water conservation. This will help in arresting declining water levels besides demand side aquifer management option including crop diversification and increasing water use efficiency. Based on borehole logs of CGWB, ER, a 3-D map of Uttar Dinajpur district has been prepared using Rockworks software. The map is shown in Fig. 8.1.

As a follow up of development of block level AMP, Micro Level Aquifer Management Plan (MLAMP) has been taken up in Birghai village, Piyaltore mouza, Raiganj block. Although lack of base line data on desired scale (1:10000 scale) is not available, an effort was made to assess the crop water requirement for three seasons (Rabi, Kharif and Boro), decipher depth to water level condition in pre-monsoon and post-monsoon and select feasible sites for implementation of rainwater harvesting in the village. During the interaction with gram panchayat members, inputs were given to co-ordinate through the district and block administration to implement Jal Dharo Jal Bhoro programme for

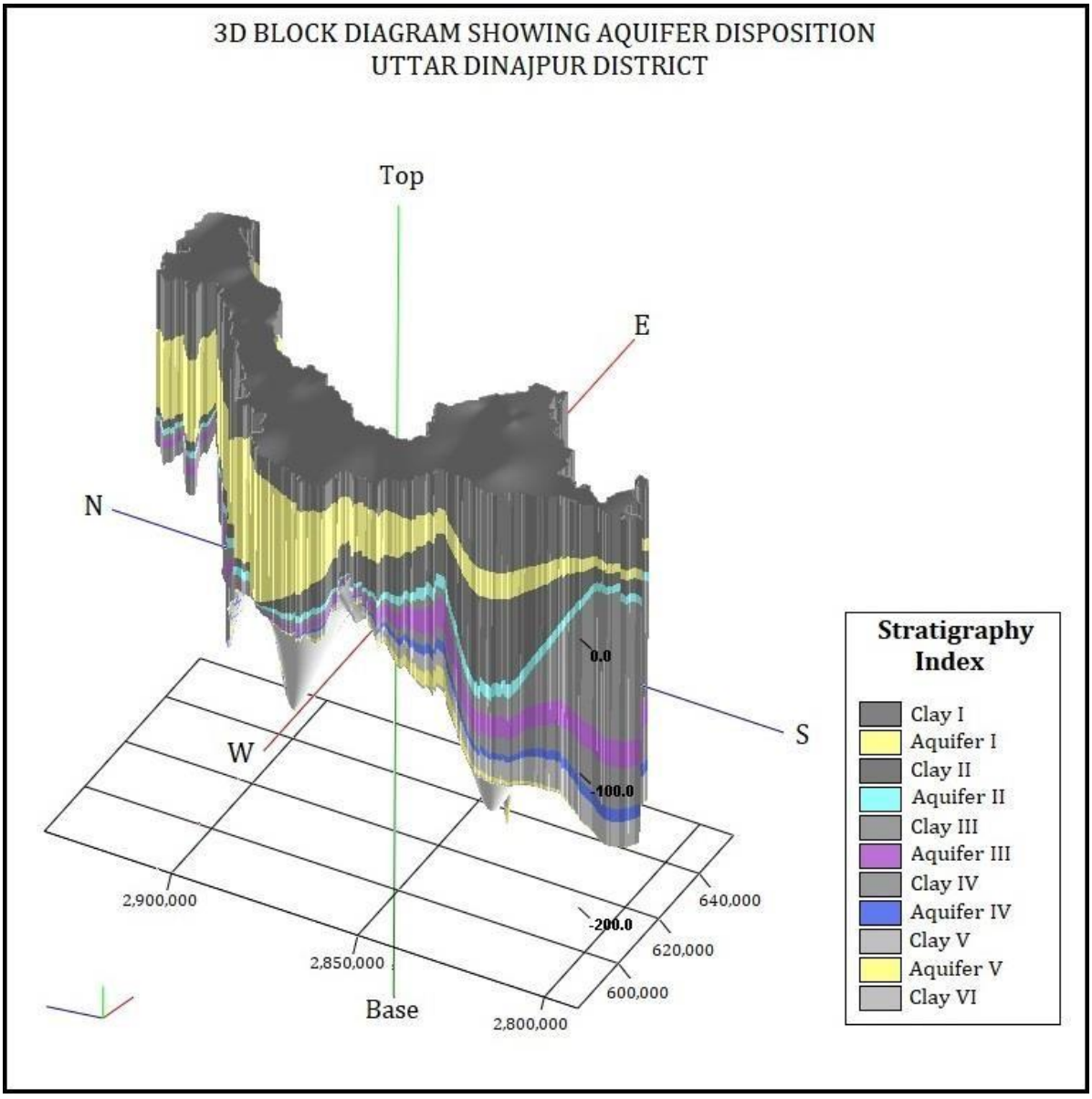


Fig. 8.1 Block Diagram Showing Aquifer Disposition in 3-D, Uttar Dinajpur district

conservation of water at village level. Although groundwater quality problem has not been reported by the villagers, high iron in groundwater has been observed from the individual shallow tube wells made of cast iron. The only deep tube well of PHED, Raiganj Division in Birghai village has been found disused for quite some time. The matter has been raised at an

appropriate level with PHED authorities in Karnjora, Raiganj block. From the village level survey in post-monsoon 2021 and pre-monsoon 2022, the plan for conducting a Public Interaction Programme with focus on Raiganj block was discussed. It was also planned to share the outcomes of the survey to the district administration once the report of the present survey is finalized and approved by the competent authority. As a follow up for organizing the PIP, one PIP was organized in online mode on 20-5-2022 with focus on Raiganj block having total 54 participants from state government departments (PHED, SWID, Agri-irrigation) and from Raiganj University. This PIP was organized as a part of celebrating Ajadi Ka Amrit Mahotsav commemorating 75 years of Indian independence.

8.2 Supply Side and Demand Side Aquifer Management

Supply side management of an Aquifer Management Plan (AMP) focuses on increasing the volume of water available through ways like a) finding new resources, b) increasing storage capacity, c) diverting water to increase water supply at a particular location and d) using technology to create clean, potable water from a previously unutilized source. Demand side management, on the other hand, can be defined as reducing the volume of water that is being used by the stakeholders for specific purpose like household use, farming, municipal or industrial needs. The main objective is to increase the Water Use Efficiency throughout the year.

Due to low Stage of Groundwater Development (60.88 %) in Uttar Dinajpur district and categorization of all the groundwater assessment units (developmental blocks) in “Safe” category, implementation of demand side management at district and block level may not be a priority at present.

However, supply side management interventions may be adopted through implementation of water resources augmentation like direct increase in storage potential through rain water harvesting or indirectly replenishing the shallow aquifers through artificial recharge in feasible areas. This envisages components of artificial recharge, rain water harvesting (either open area or roof top harvesting) and water conservation through construction of site-specific structures at block or village level. While demarcating feasible areas for artificial recharge, the following

factors have been taken into consideration as per the Master Plan of Artificial Recharge (CGWB 2020):

Areas having average depth to water level > 9 m bgl (post-monsoon) with or without falling trend

Long-term declining trend >10 cm/year in post-monsoon groundwater level

As per these criteria, no area in Uttar Dinajpur district was found to be feasible for artificial recharge to the shallow, unconfined aquifer. However, feasibility of roof top rainwater harvesting (RTRWH) for Census Towns and Municipalities as per Census 2011 has been worked out in the Master Plan. Three Census Towns (Dalkhola, Nacchhatrapur Katabari and Kasba) and three Municipalities (Islampur, Kaliaganj and Raiganj) were considered for calculating cost estimate, keeping unit cost at Forty Thousand Rupees only and unit roof area for Census Town as 100 m^2. For each Municipality, unit roof area was considered as 300 m^2 and unit cost of implementation at Rupees Eighty Thousand only. Relevant details are given in Table 8.1. The table shows that total cost of implementation of RTRWH in Uttar Dinajpur district is estimated at Rupees Seventy Two Lakh only. Out of this, the cost of implementing RTRWH in Census Towns is Rupees Twelve Lakh whereas the cost of implementing RTRWH in the Municipalities is Rupees Sixty Lakh.

Table 8.1 Roof Top Rainwater Harvesting Details, Uttar Dinajpur district

Type of Area	Number	Total no. of RTRWH structures proposed	Approximate roof area (m^2)	Total volume of rainwater available (MCM)	Unit Cost (Rs.)	Total Cost (Rs.)
Census Town	3	30	(@ 100 m^2 per roof) 3000	0.004	40000	1200000

Municipality (including Municipal Corporation)	3	75	(@ 300 m^2 per roof) 22500	0.036	80000	6000000

(Source: Master Plan of Artificial Recharge, CGWB 2020)

8.3 Site Specific Recommendations for Rain Water Harvesting

During the present study, field visits were taken up in Uttar Dinajpur district to explore the suitable sites for implementation of either Roof Top Rainwater Harvesting (RTRWH) or Open Area Rainwater Harvesting (OARWH), which are location specific. For implementing OARWH in the rural areas, runoff co-efficient of ~0.15 has been considered. For RTRWH, a runoff co-efficient of ~0.80 was used for calculation of runoff that can be harvested. During detailed survey at block level, 14 sites have been identified for implementation of rainwater harvesting, whose details are given in **Table 8.2.**

Table 8.2 Site specific details of rainwater harvesting, Uttar Dinajpur district

Sl No.	Block	Mouza	Name of site	Latitude	Longitude	Whether Roof Top or Open Area RWH feasible
1	Raiganj	Raiganj Municipality	Block Development Office, CollegePara	25.5015 N	88.1492 E	Roof top RWH
2	Raiganj	Karnojora	Suryodaya Children Home for Deaf and Dumb Boys and Girls	25.6561 N	88.1492 E	Roof top RWH
3	Raiganj	Udaipur	State Agricultural Research Farm	25.6437 N	88.1371 E	Open area RWH
4	Raiganj	Raiganj	Subhashganj Higher	25.6211 N	88.1084 E	Roof top

		Municipality	Secondary School			RWH
5	Raiganj	Karnojora	Office of the District Magistrate, Uttar Dinajpur	25.6551 N	88.1487 E	Roof top RWH
6	Raiganj	Maheshpur	Office of the Commandant, 174 BN, BSF	25.6497 N	88.1478 E	Both Roof top and Open area RWH
7	Raiganj	Raiganj Municipality	Raiganj Government Medical College and Hospital, Main Building	25.6095 N	88.1325 E	Roof top RWH
8	Raiganj	Kasba	S.A.P. 4th Battalion, Administrative Block	25.5881 N	88.1240 E	Roof top RWH
9	Raiganj	Ratanpur	Netaji Subhash Chandra Bose Teachers Training College	25.7637 N	88.1829 E	Open area RWH
10	Raiganj	Soharai	Raiganj Eco Park	25.6398 N	88.1177 E	Open area RWH
11	Islampur	Barhat	Block Seed Farm, Islampur	26.2502 N	88.1772 E	Open area RWH
12	Islampur	Islampur Municipality	Islampur Sadar Hospital, Main Building, Khudiram Pally	26.2573 N	88.1855 E	Roof top RWH
13	Kaliaganj	Kaliaganj Municipality	Block Development Office, Hospital	25.6354 N	88.3207 E	Roof top RWH

			Road, Kaliaganj			
14	Kaliaganj	Kaliaganj Municipality	Industrial Training Institute, Mahadebpur, Kaliaganj	25.6281 N	88.3190 E	Both Roof top and Open area RWH

8.4 Water Conservation Initiative by Government of West Bengal

The Water Resources Investigation and Development Department (WRIDD), Government of West Bengal has initiated *Jal Dharo Jal Bharo* programme for conservation of surface water and groundwater resources in Uttar Dinajpur district. The objective of this programme is to harvest rain water in tanks, ponds, reservoirs, canals and to implement artificial recharge and rain water harvesting in association with the Panchayati Raj and Rural Development (P&RD) Department, Government of West Bengal. It has been reported that different kinds of check dams, water harvesting tanks and surface flow schemes are being constructed for arresting surface run-off for utilization of stored water for irrigation and other purpose *(http://www.wbwridd.gov.in/index.php/wridd/jal_dharo_jal_bharo).*

Two schemes on roof top rainwater harvesting are proposed for implementation by the Surface Water Investigation Sub-Division V-A, Raiganj. They are located at the Industrial Training Institute (ITI), Raiganj and in ITI, Kaliaganj. Each scheme consists of a series of pipeline of 160 mm dia. In Raiganj ITI, the length of 160 mm dia. Pipeline is 100 m along with one Inspection Pit (0.6 m x 0.6 m x 0.6 m), one Control Unit Pit (0.6 m x 0.6 m x 0.6 m), one Recharge chamber (3.5 m x 3.0 m x 2.3 m), one Recharge Well and one Piezometer for monitoring of change in groundwater level due to impact of artificial recharge of harvested rainwater. The diagram is shown in **Fig. 8.2**. In Kaliaganj ITI, the length of proposed pipeline (160 mm dia.) is 120 m along with one Inspection Pit (0.6 m x 0.6 m x 0.6 m), one Control Unit Pit (1.2 m x 1.2 m x 0.6 m), one Recharge chamber (4.0 m x 3.0 m x 2.3 m), one Recharge Well and one Piezometer for monitoring of change in groundwater level due to impact of artificial recharge of harvested

rainwater. The diagram of recharge structure in Kaliaganj ITI (Mahadebpur) is shown in **Fig. 8.3.** However, no information is available on the depth and design aspects of the proposed recharge wells.

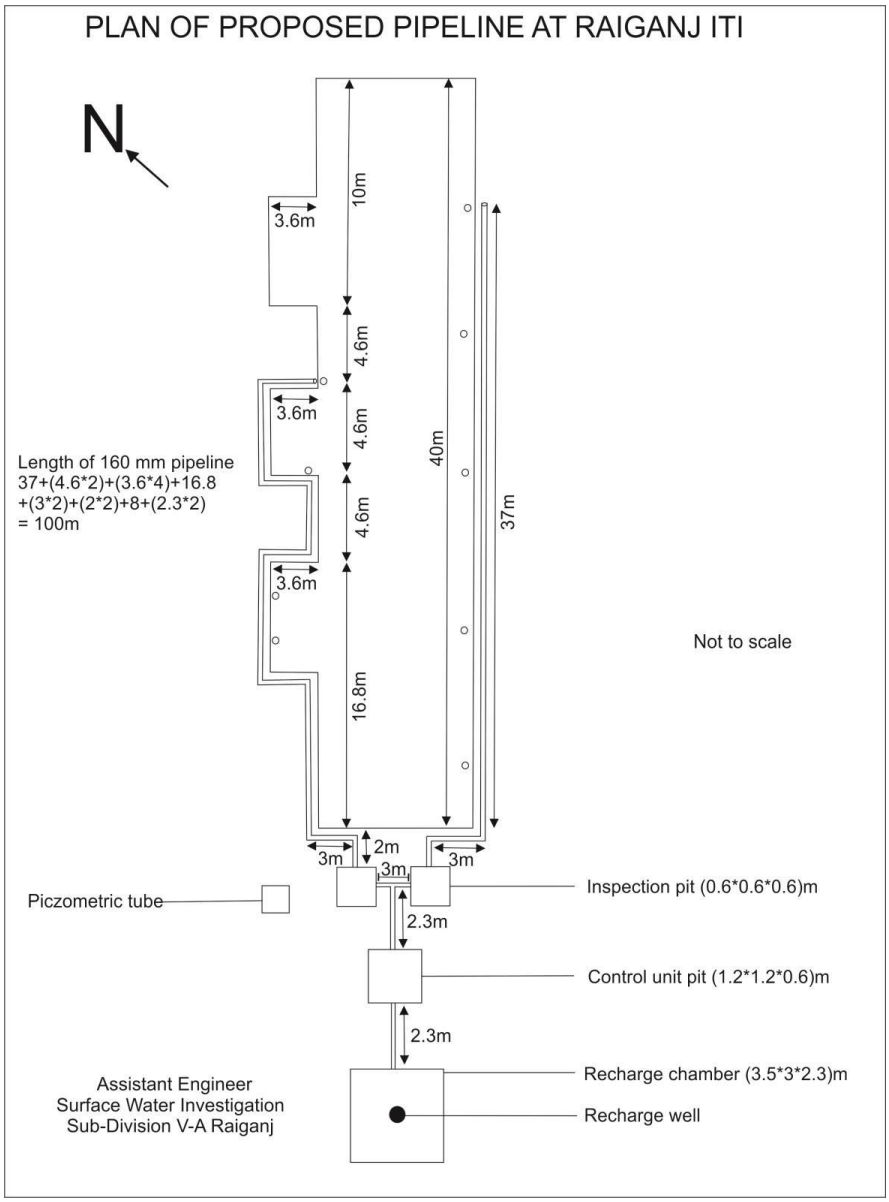


Fig. 8.2 Schematic Diagram of Rainwater Harvesting and Artificial Recharge, Industrial Training Institute,Raiganj

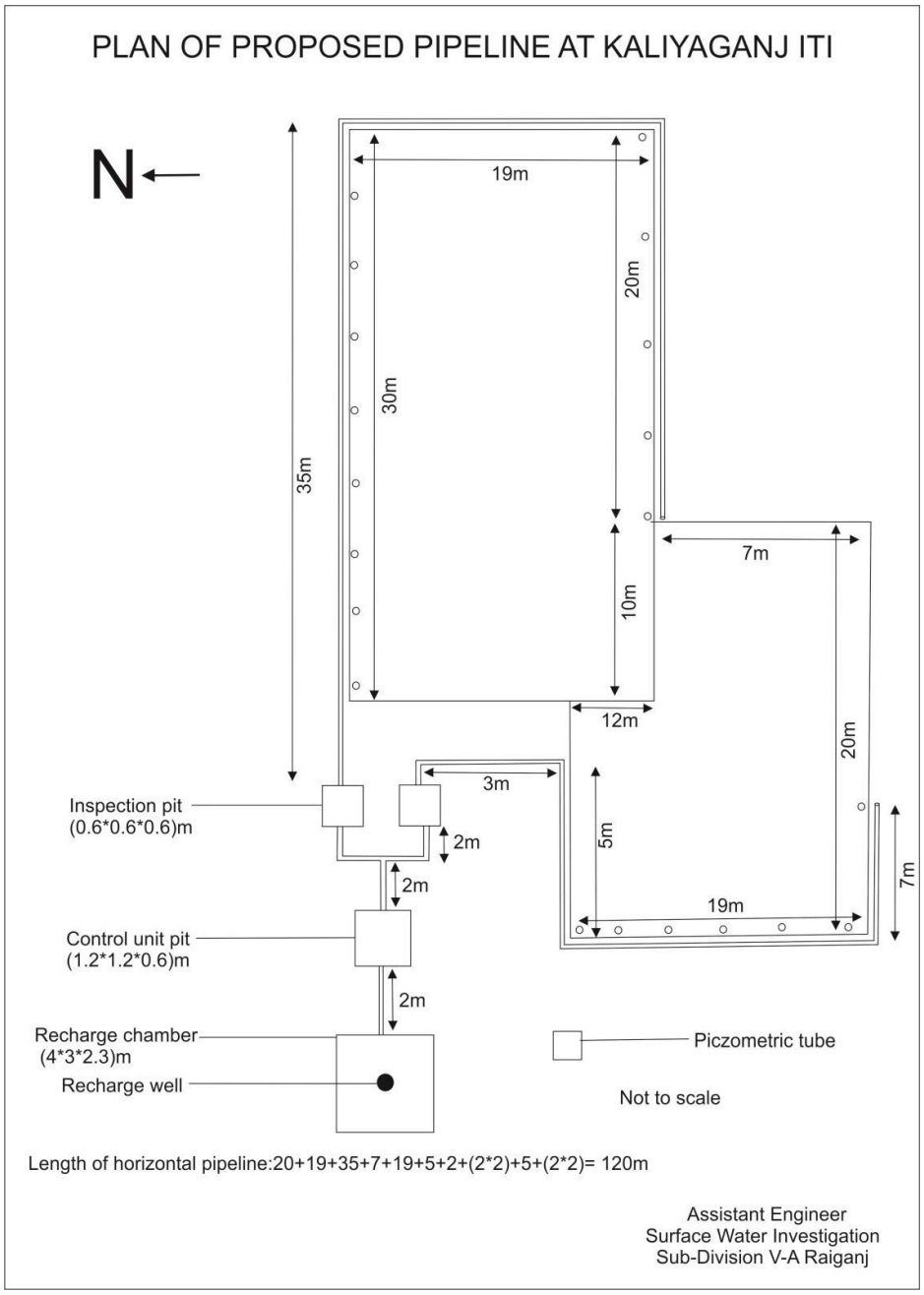


Fig. 8.3 Schematic Diagram of Rainwater Harvesting and Artificial Recharge, Industrial Training Institute,Kaliaganj

Roof top rainwater harvesting was implemented in 2015 in office of State Water Investigation Directorate (SWID), Division No. 5 Campus at Karnojora in Raiganj block. In this scheme, a recharge well was constructed to harvest roof top rainwater in the campus through a harvesting tank. The project was implemented by Hitec Engineers Co- operative Society at a cost of Rs. 3,72,000/- only. A piezometer of SWID was installed for monitoring of groundwater level under the National Hydrology Project. The piezometer is fitted with Automatic Water Level Recorder. Available data of the piezometer during the year 2021 were: 5.93 m bgl (13-4-2021), 4.50 m bgl (10-8-2021) and 4.95 m bgl (24-11-2021). The data reveals a seasonal rise of 0.98 m in groundwater level in 2021. Due to absence of long-term data of the SWID piezometer at Karnojora, the annual fluctuation due to impact of artificial recharge to the unconfined, shallow aquifer cannot be quantified. Photographs of the SWID piezometer are given in **Annexure-V.** Re-excavation of existing tanks and other water bodies are reported to be taken up under the Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) by the Water Resources Investigation and Development Department (WRI&DD) in association with the Panchayat Raj and Rural Development (P&RD) Department. As per available data, total 786 water bodies have been excavated for conservation of water resources as on December 2016 (Source: wbwridd.gov.in/wrdd/jal_dhoro_jal_bhoro.html). However, water conservation details under the MGNREGA scheme are awaited from the Office of the Executive Engineer, Jal Sampad Bhawan, Karnojora, Raiganj (as on 31-7-2022).

8.5 Participatory Ground Water Management

The objective of Participatory Ground Water Management (PGWM) is to ensure equitable, safe and sustainable management of groundwater resources in Uttar Dinajpur district through improved systems of aquifer mapping, utilization, awareness and governance. To this effect, one Water Management Training Programme and one Mass Awareness Programme were organized at Raiganj, the district headquarter. The theme of the training was “Ground Water Development and Management with special reference to Rain Water Harvesting”, which was organized on 14-2-2006 and was attended by 26 participants. The Mass Awareness Programme was organized on

13-2-2006 on the theme “Rain Water Harvesting”, in which 119 people had participated. The concept of employing Water Volunteers (Jal Doots) had emerged in the year 2019 by the Central Ground Water Board for an efficient and effective groundwater management at village level.

8.6 Village Level Aquifer Mapping and Management

Birghai village, falling in Piyaltore Mouza, Raiganj block has been considered for assessment of groundwater conditions and development of a Village Level Aquifer Management Plan. The village is ~12 km south-east of Raiganj having a total geographical area of 451.66 ha and total population of 2126 (Census 2011). The village can be approached via Taherpur from Dosti More near Raiganj (diversion from Raiganj-Malda road) and then via Dakshin Bajitpur road. Birghai village can also be reached from Durgapur bus stand via Kumardangi on Durgapur-Kunore-Kaliaganj road. The village is about 12 km west of Kunore and is bounded by Budhor village to the north, Mahisbathan to the west, Dharmadanga to the south, Kanaipur to the north-east and Basmanpara to the east. Map of Birghai village, available online through Google Earth, is shown in **Fig. 8.4.**

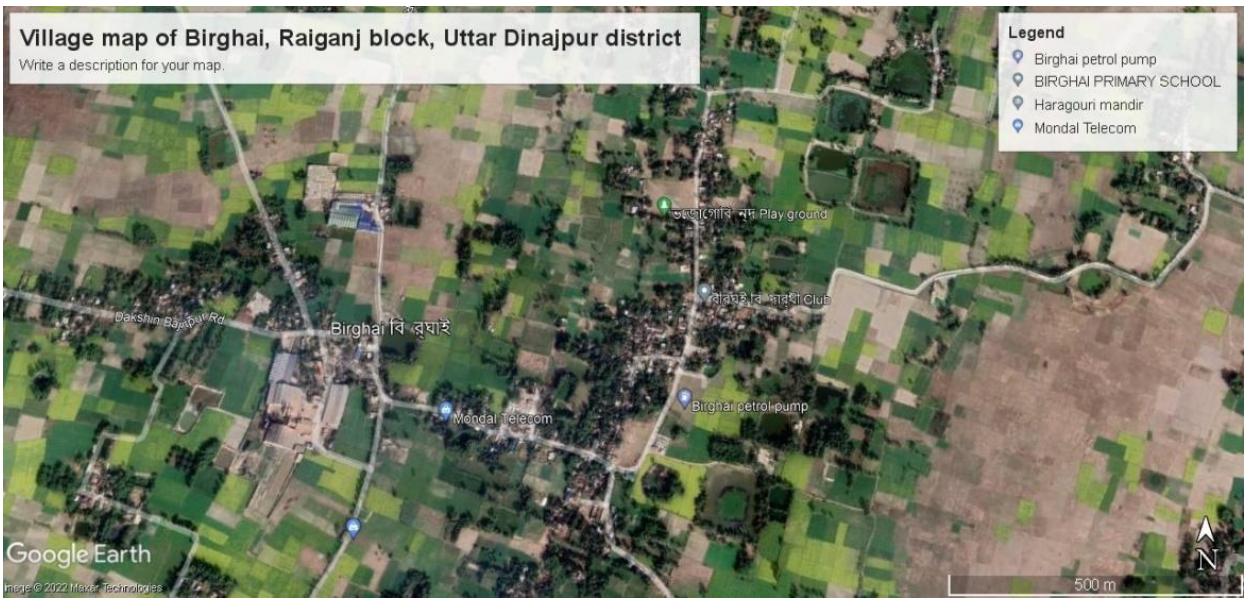


Fig. 8.4 Google Earth map of Birghai village, Raiganj block

During the micro-level survey, it was found that Birghai village has 466 households. The village has been categorized as Fully Covered by PHED, Raiganj Division. Salient points for development of village level aquifer management plan through micro-level study in Birghai village are given below:

- The soil is fertile and is of sandy to sandy loam variety. Due to cost factor, organic farming is not done by the villagers. Typically, nitrogeneous and phosphatic fertilizers are used for cultivation. Local products are being sold in village market, which sits once in a week regularly.
- No prominent surface water body exists in the village. Entire population is dependent on groundwater for drinking, domestic and agri-irrigational use.
- The farmers are generally small and marginal category, having typical land holding varying from 0.13 ha to 1.35 ha. Presently, only two varieties of paddy (Amon and Boro) are being cultivated. Mango orchards are present in the northern part of the village. During winter season, cauliflowers are cultivated along with sunflower.
- Most of villagers are using shallow tube wells fitted with submersible pump of 5 HP capacity (locally known as *Marshal*) for agriculture and irrigation. Discharge of the tube wells are reported to be varying from 200 to 250 LPM (12 to 15 m^3/hour). These submersible pumps have been installed by few affluent villagers as the cost of installation is relatively high, which ranges from Rs. 60000/- to Rs. 80000/- based on the capacity of the pump. Other villagers are using cast iron shallow tube wells (locally known as No. 6 tube wells) primarily for domestic use and rarely for drinking.
- Three India Mark-II hand pump fitted tube wells were surveyed in the village. They are located in the back side of village market while entering the village from Taherpur, in the compound of Primary School and in the compound of Bhojo Gobindo Roy Madhyamik Shiksha Kendra. Field photographs of the tube wells are given in **Annexure-II.** Depth to water level (DTW) and location of two tube wells are given below:

  Tube well (India Mark-II) in Birghai Primary School: 25.5637 N, 88.1746 E, DTW = 5.59 m bgl (on 05-5-2022)

Tube well (India Mark-II) in Bhojo Gobindo Roy Madhyamik Shiksha Kendra (MSK): 25.5679 N, 88.1752 E, DTW = 5.15 m bgl (on 05-5-2022)

- However, none of these tube wells were found to be operational during the field survey. Local people have informed that these tube wells are not being maintained by the government.
- An old deep tube well, constructed by the PHED, Government of West Bengal during the mid-1990s, has been found lying in disused condition. Field photograph of the abandoned, deep tube well is shown in **Annexure-V.**
- No active dug well exists in the village. The dug wells have been filled up and villagers have reported that these wells were causing diseases due to breeding of mosquitoes.
- During interaction with the villagers, it was found that individual small submersible pumps are used for irrigation since last five to six years. It has been reported that many farmers have left traditional farming practices and relocated to urban areas for alternative employment over the last three to four years.
- For cultivation of khariff crops, which depends mainly on rain water, groundwater requirement has been estimated at 500 m3 for 1 ha land. This calculation is done based on: average discharge of shallow tube well = 13.5 m3/hr, average daily pumping hours = 5 hours, total pumping hours in a week = 37 hours and average land area = 0.13 ha.
- For cultivation of rabi crops, groundwater requirement was estimated at 2497 m3 for 1 ha land. This is based on: average discharge of shallow tube well = 13.5 m3/hr, average daily pumping hours = 5 hours, total weekly pumping hours = 185 hours, number of tube wells for rabi cultivation = 5 and average land area = 0.13 ha.
- For cultivation of summer paddy (Boro), groundwater requirement has been estimated at 122.37 m3 for 1 ha land. This is based on: average discharge of shallow tube well = 13.5 m3/hr, average daily pumping = 3.5 hours, total weekly pumping hours = 906 hours, number of tube wells for boro cultivation = 35 and average land area = 0.13 ha.
- A small-scale industry (Sonar Bangla Food Products) is operational at the entry of the village when approaching via Taherpur-Dakshin Bajitpur road. However, details of

groundwater consumption by the industry are not available.

- Groundwater draft for drinking and domestic purpose is meager keeping in mind the rural water profile. Mainly small hand pump fitted shallow (28 to 35 m deep) tube wells made of cast iron (loosely called No. 6 tube wells) are used by majority of the villagers.
- Due to absence of functional deep tube well in Birghai, subsurface lithological data is not available. This precludes preparation of borehole lithologs and delineation of aquifer geometry at village level.
- Based on the micro-level survey, no major groundwater related issues and problems are observed in Birghai village.
- Villagers are generally found to be aware of the judicious use of village-level water resources. However, there is a need to raise awareness among them through capacity building and sensitizing them on possible decline in groundwater level and deterioration of groundwater quality due to rapidly increasing use of fertilizers.
- Inculcating the sense of ownership of village level water resources can be done through co-ordination between the block administration, gram panchayat and state government departments like PHED, Agriculture Department and Agri-irrigation Department. Participatory groundwater management appears to be the most feasible approach to adopt village level (micro-level) aquifer management in Birghai village.
- Two feasible sites for open area rainwater harvesting were selected in Birghai village. These are inside Primary School and Bhojo Gobindo Roy Madhyamik Shiksha Kendra. Following standard guidelines, the implementation cost in each of these sites has been worked out at Rs. 44,000/- only, which includes actual unit cost of Rs. 40,000/- and O&M cost of Rs. 4000/- (@10% of the unit cost) in each site. The total cost of implementation of open area rainwater harvesting would be Rs. 88,000/- only in two sites.
- The Gram Panchayat members of Birghai were encouraged to get the required funding either through district administration or through the special funds available under MLA Funding Scheme of the Government of West Bengal.

8.6 Block Level Aquifer Management Plan

Aquifer Management Plans at block level reveals the aquifer disposition and sustainable ways of managing the aquifers with active participation from the stakeholders. Block wise elevation maps, 2-D lithological cross sections, fence diagrams and 3-D block diagrams are prepared to show aquifer disposition. A summary of major groundwater related issues and problems at block level are given along with management interventions to address the issues and challenges. Aquifer Management Plans of nine Community Development Blocks of Uttar Dinajpur district are described in **PART-II** of this report.

PART - II

BLOCK WISE AQUIFER MANAGEMENT PLAN, UTTAR DINAJPUR DISTRICT

Aquifer Information and Management System
Chopra block, Uttar Dinajpur district, West Bengal
(381.0 km² area covered under NAQUIM)

GENERAL INFORMATION

State Name	West Bengal
District name	Uttar Dinajpur
Block Name	Chopra
Location	Located in northern most part of Uttar Dinajpur district, having Darjeeling district to the north, Islampur block (Uttar Dinajpur) to the south, Kishanganj district of Bihar to the west and bounded by International Border with Bangladesh to the east
Geographical Area	381.0 km²
Basin/Sub-basin	Ganga/ Bhagirathi
Principal Aquifer System	Alluvium (Aquifer Code: AL) Single Aquifer System
Major Aquifer System	Younger Alluvium of Holocene age (Aquifer Code- AL01) Aquifer-I: Depth range varies from 6.0 m to 27.0 and 15.0 m to 52.0 m (variable at different locations)
Monsoon Rainfall	2020: 1485.2 mm

AQUIFER DISPOSITION

Aquifer Disposition

Aquifer-I: Phreatic aquifer (shallow to moderately deep)
- Occurs throughout the block
- Aquifer material is Younger Alluvium of Holocene age

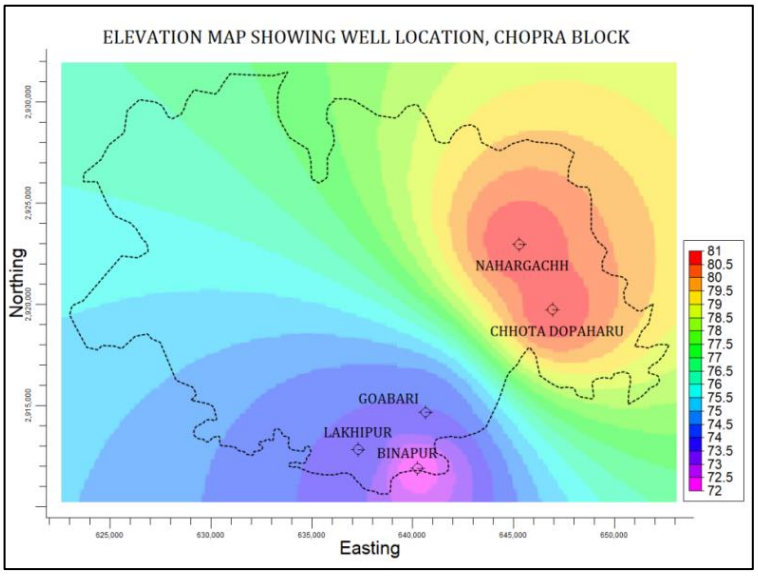


Fig. 1: Elevation map showing location of Tube Wells, Chopra block

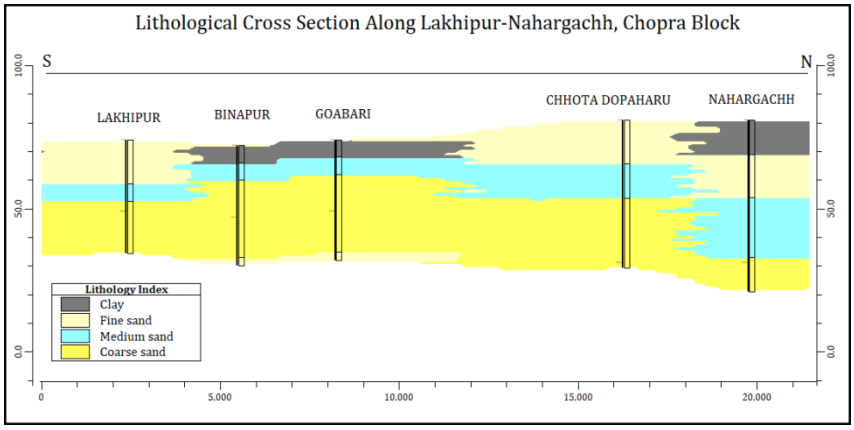


Fig. 2: Lithological cross section along Lakhipur-Nahargachh, Chopra block

Status of GW Exploration

Exploratory Wells of CGWB: 0
Observation Wells of CGWB: 0
Tube Wells of PHED/Agri-irrigation Department: 5
Monitoring Wells of State Water Investigation Directorate: 2

Aquifer Characteristics

AQUIFER	DEPTH RANGE (mbgl)	THICKNESS (m)	DISCHARGE (m^3/day)	Drawdown (m)
Aquifer-I	6.0-60.0	Max: 36.59 m at Chhota Dopaharu Min: 21.0 m at Binapur & Goabari	1762.06 at Purba Chutiakhor	5.0

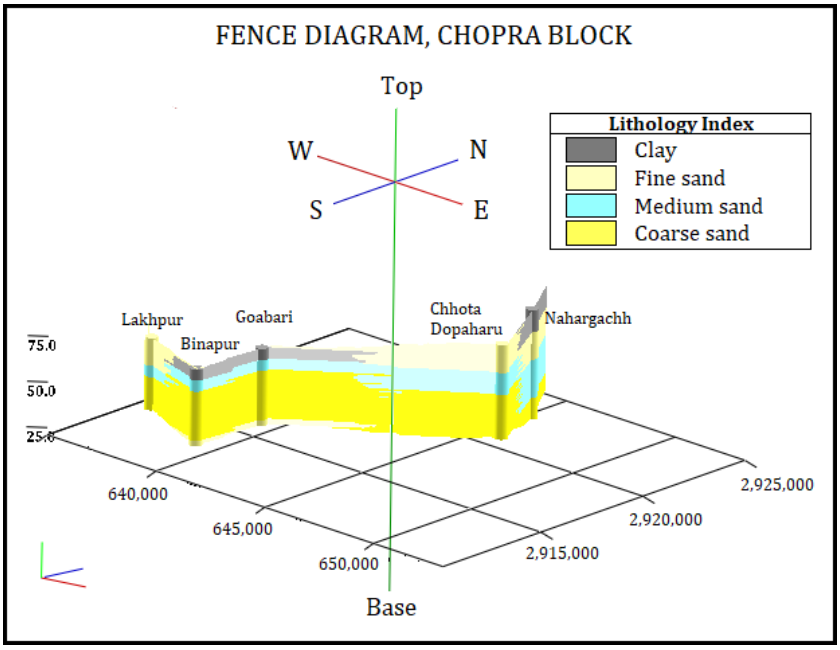


Fig. 3: Fence Diagram showing aquifer geometry, Chopra block

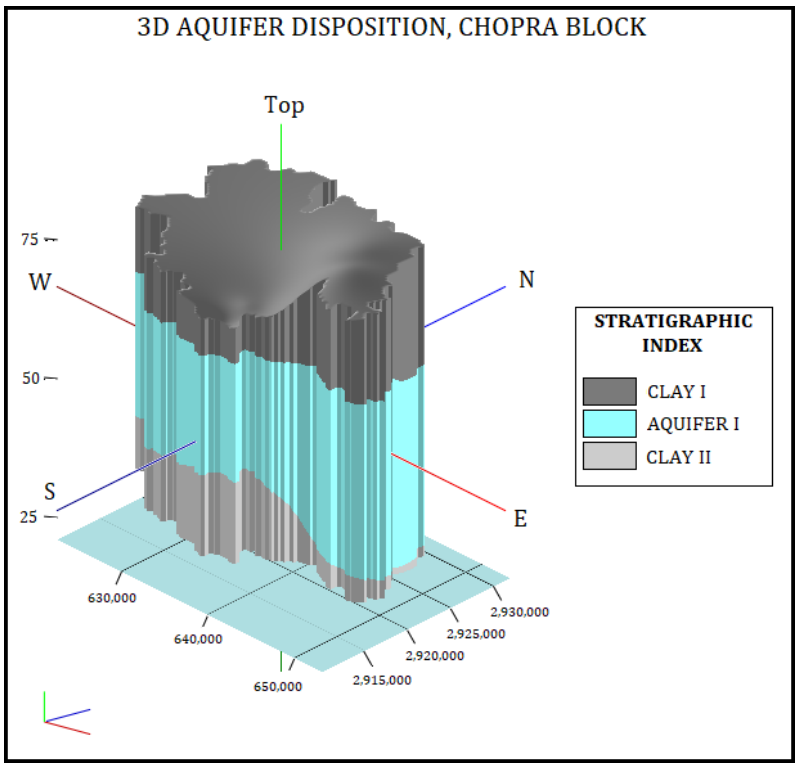


Fig. 4: Block Diagram showing aquifer disposition in 3-D, Chopra block

Groundwater Monitoring Status	As on March 2022, 2 ground water monitoring wells (Chopra, Molani) Key Observation Wells (KOW) established at Debijhora (Bottola) & Sripokhar during NAQUIM Study. Pre-monsoon monitoring in 2021 could not be done due to COVID-19 pandemic situation. However, survey completed during monsoon and post-monsoon periods. Average DTW (monsoon 2021): 2.785m bgl Average DTW (post-monsoon 2021): 3.225 m bgl Average water table elevation (monsoon 2021): 76.90 m amsl Average water table elevation (post-monsoon 2021): 78.31 m amsl
Groundwater Quality	NABL data of Chemical Lab in CGWB, ER reveals that groundwater is potable and can be safely used for drinking, domestic and irrigation purpose.
Groundwater Resource (as on 31-3-2013)	Net Annual Ground Water Availability: 11906.27 ham Existing Gross Ground Water Draft for All Uses: 4434.56 ham Stage of Ground Water Development: 37.25 % Category: Safe
Future Water Demand (as on 31-3-2013)	GW allocation for future domestic use (up to 2025 AD): 691.55 ham

Aquifer Management Plan

Groundwater Management Plan

<u>Groundwater management strategies</u>:

1. Participatory Ground Water Management to be implemented through Jal Doots for equitable, safe and sustainable management of groundwater resources, initially at block level

but subsequently at Village or gram panchayat level.

2. Taking up Pilot Studies on water conservation along Dahuk River and impact assessment on hydrological regime.
3. Installation of drip irrigation system, especially for cultivation of summer paddy (Boro) through government subsidy.
4. Convergence of *Jal Dhoro Jal Bhoro* programme with participation of farmers in centrally funded schemes like PMKSY-HKKP and MGNREGS.
5. Creating awareness on water conservation, design of policy for collection of village level data on groundwater level and rainfall in association with Self Help Groups, NGO and panchayat people.
6. Organization of Public Interaction Programme at Block level for capacity building of the stakeholder.

Artificial Recharge and Water Conservation	1. Implementation of artificial recharge scheme is not required due to very low Stage of Development (<70 %) in Chopra block. 2. Possibility of implementing sustainable and realistic schemes on open area rainwater harvesting at Chopra BDO Office and Dalua Hospital may be explored with funding from the State Government (District administration, Zila Parishad) as well as through funds available under MP/MLA schemes.

Aquifer Information and Management System
Islampur block, Uttar Dinajpur district, West Bengal
(329 km² area covered under NAQUIM)

GENERAL INFORMATION

State Name	West Bengal
District name	Uttar Dinajpur
Block Name	Islampur
Location	Located in north-central part of Uttar Dinajpur district, with Chopra block to the north, Goalpokhar-I block to the south, Kishanganj district of Bihar to the west and bounded by International Border with Bangladesh to the east
Geographical Area	329.0 km²
Basin/Sub-basin	Ganga/ Bhagirathi
Principal Aquifer System	Alluvium (Aquifer Code: AL) Single Aquifer System
Major Aquifer System	Younger Alluvium of Holocene age (Aquifer Code- AL01) Aquifer-I: Depth range varies from 13.0 m to 109.0 m Aquifer-II: Depth range varies from 178.0 m to 190.0 m Aquifer-III: Depth range varies from 196.0 m to 203.0 m Depth ranges are variable in different locations
Monsoon Rainfall	2020: 1485.2 mm

AQUIFER DISPOSITION

Aquifer Disposition

Aquifer-I: Phreatic aquifer (shallow to moderately deep)

- Occurs throughout the block
- Aquifer material is Younger Alluvium of Holocene age

Aquifer-II & Aquifer-III: Confined aquifer (moderately deep to deep)

- Deciphered on the basis of lithologs of deep exploratory wells of CGWB at Milanpally High School and Durganagar

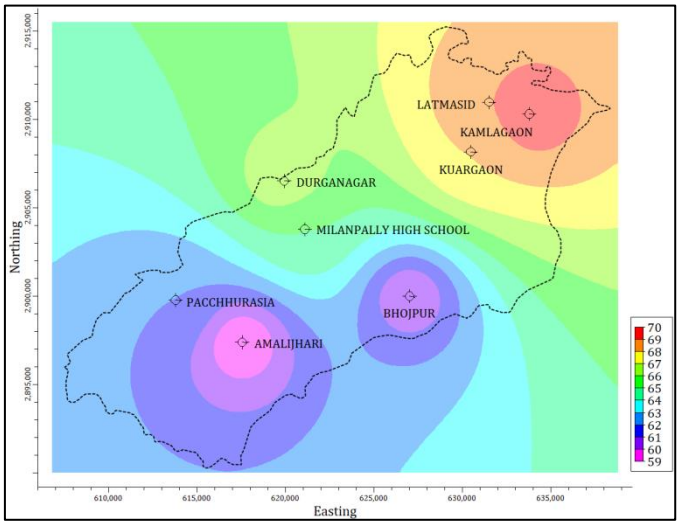


Fig. 2: Elevation map showing location of Tube Wells, Islampur block

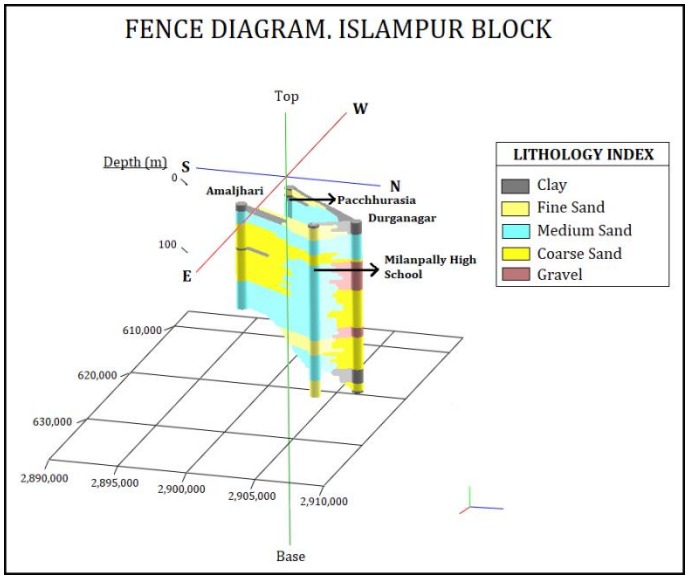


Fig. 2: Fence diagram showing disposition of aquifers, Islampur block

Status of GW Exploration

Exploratory Wells of CGWB: 2
Observation Wells of CGWB: 0
Tube Wells of PHED/Agri-irrigation Department: 6
Monitoring Wells of State Water Investigation Directorate: 6

Aquifer Characteristics

AQUIFER	DEPTH (mbgl)	DRAWDOWN (m)	T (m^2/day)	S
Aquifer-I	9.0-63.0	NA	NA	NA
Aquifer-II	178.0-190.0	3.347 – 3.98	839.37 – 1706.57	5.39×10^{-4}
Aquifer-III	196.0 – 203.0			

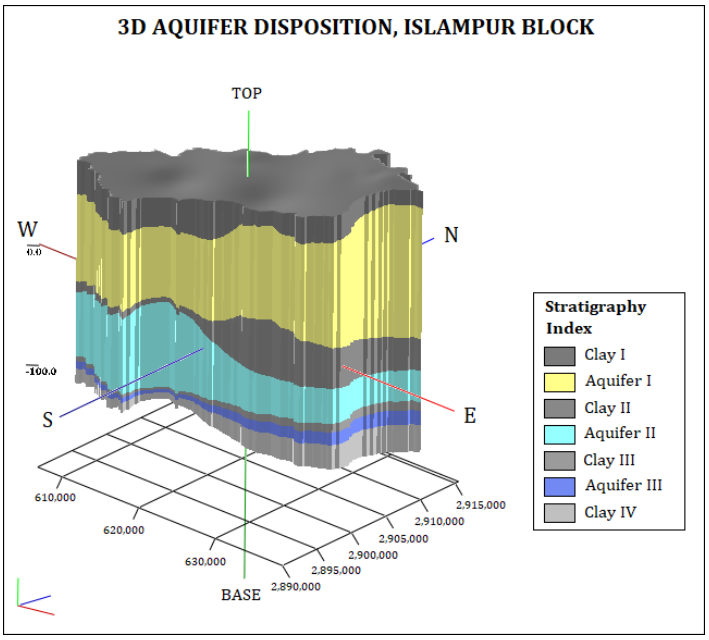


Fig. 3: Block Diagram showing aquifer disposition in 3-D, Islampur block

Groundwater Monitoring Status	Three ground water monitoring wells (Gunjaria, Islampur & Madaripur) exist & 2 Key Observation Wells (KOW) were established at Dhantola & Agdimti Khanti during the present NAQUIM Study. Average DTW (pre-monsoon 2022): 4.68m bgl Average DTW (post-monsoon 2021): 3.15 m bgl Average water table elevation (monsoon 2021): 76.90 m Average water table elevation (post-monsoon 2021): 63.03 m
Groundwater Quality	NABL data of CGWB, ER reveals that groundwater is potable and can be used for drinking, domestic and irrigation purpose.
Groundwater Resource (as on 31-3-2013)	Net Annual Ground Water Availability: 11399.31 ham Existing Gross Ground Water Draft for All Uses: 5321.62 ham Stage of Ground Water Development: 46.68 % Category: Safe
Future Water Demand (as on 31-3-2013)	GW allocation for future domestic use (up to 2025 AD): 913.77 ham

Aquifer Management Plan

Groundwater Management Plan

<u>Groundwater management strategies</u>:

7. Participatory Ground Water Management to be implemented through Jal Doots for equitable, safe and sustainable management of groundwater resources, initially at block level but subsequently at Village or gram panchayat level.
8. Taking up Pilot Studies on water conservation along Dahuk River and impact assessment on hydrological regime.
9. Installation of drip irrigation system, especially for cultivation of summer paddy (Boro) through government subsidy.
10. Convergence of *Jal Dhoro Jal Bhoro* programme with participation of farmers in centrally funded schemes like PMKSY-HKKP, Jal Shakti Abhiyan – Catch The Rain (JSA-CTR) 2022 programme & construction of *Amrit Sarovars* at designated sites by the district adminsitration.
11. Creating awareness on water conservation, design of policy for collection of village level data on groundwater level and rainfall in association with Self Help Groups, NGO and panchayat people.
12. Organization of Public Interaction Programme at Block level for capacity building of the stakeholder.

Artificial Recharge and Water Conservation

1. Implementation of artificial recharge scheme is not required due to very low Stage of Development (<70 %) in Islampur block.

2. Two feasible sites were selected at Block Seed Farm, Barhat (Islampur) for open area rain water harvesting and at Main Building, Islampur Sadar Hospital, Khudiram Pally for roof top rain water harvesting during NAQUIM field survey.

3. Convergence of centrally funded and state funded schemes is required for implementation of the pilot schemes in Islampur block.

Aquifer Information and Management System
Raiganj block, Uttar Dinajpur district, West Bengal
(472 km² area covered under NAQUIM)

GENERAL INFORMATION

State Name	West Bengal
District name	Uttar Dinajpur
Block Name	Raiganj
Location	Located in south-central part of the district, with Itahar block to the south, Kaliaganj & Hemtabad blocks to the east, Karandighi block to the north-west, Purnea district of Bihar to the west and International Border with Bangladesh to the north
Geographical Area	472.0 km²
Basin/Sub-basin	Ganga/ Bhagirathi
Principal Aquifer System	Alluvium (Aquifer Code: AL) Multiple Aquifer System (Older Alluvium & Younger Alluvium)
Major Aquifer System	Older Alluvium of Plesitocene age in the southernmost part (Aquifer Code – AL03) Younger Alluvium of Holocene age (Aquifer Code- AL01) in remaining parts of the block Aquifer-I: Depth range varies from 9.0 m to 21.0 m Aquifer-II: Depth range varies from 37.0 m to 75.0 m Aquifer-III: Depth range varies from 152.0 m to 180.0 m Aquifer-IV: Depth range varies from 215.0 m to 227.0 m Aquifer-V: Depth range varies from 233.0 m to 245.0 m Depth ranges are variable in different locations, the above categorization of aquifers was done on the basis of data of CGWB Eastern Region, PHED Raiganj Division and Agri-irrigation Department, Raiganj
Monsoon Rainfall	2020: 1485.2 mm

AQUIFER DISPOSITION

Aquifer Disposition

Aquifer-I: Phreatic aquifer (shallow)
- Occurs throughout the block
- Aquifer material is Younger Alluvium of Holocene age

Aquifer-II & Aquifer-III: Confined aquifer (moderately deep)
- Deciphered on the basis of lithologs of tube wells constructed by Public Health Engineering Directorate (PHED), Raiganj Division and Agri-irrigation Department, Raiganj

Aquifer-IV & Aquifer-V: Confined aquifer (deep, >200.0 m)
- Deciphered on the basis of lithologs of tube wells constructed by Central Ground Water Board, Eastern Region at Goalpara Ward No. 1

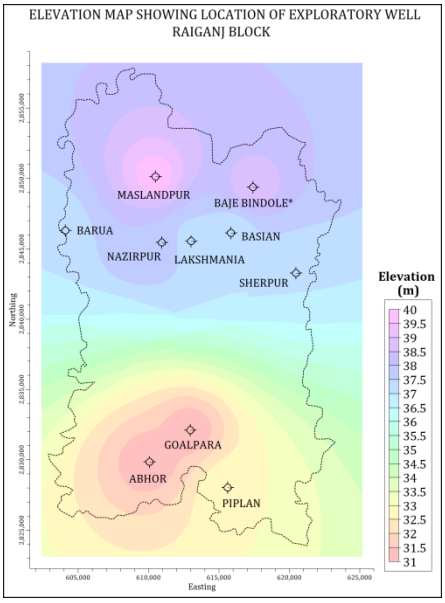


Fig. 3: Elevation map showing location of Tube Wells, Raiganj block

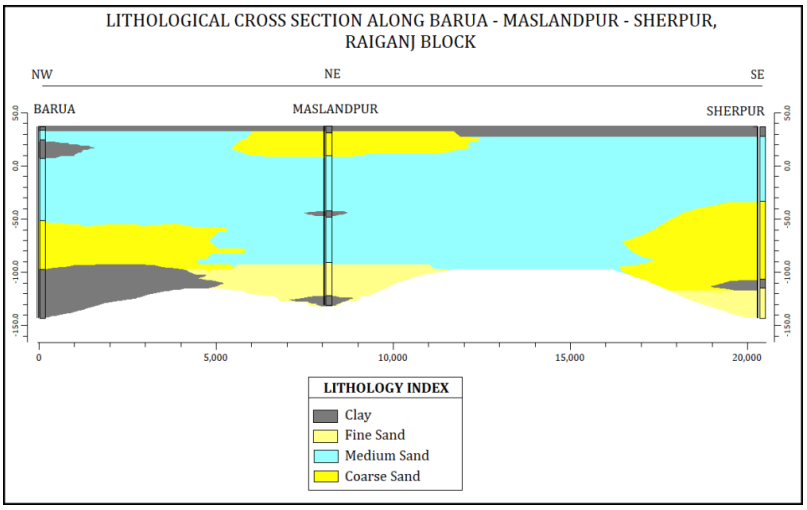


Fig. 2: Lithological cross-section along Barua-Sherpur, Raiganj block

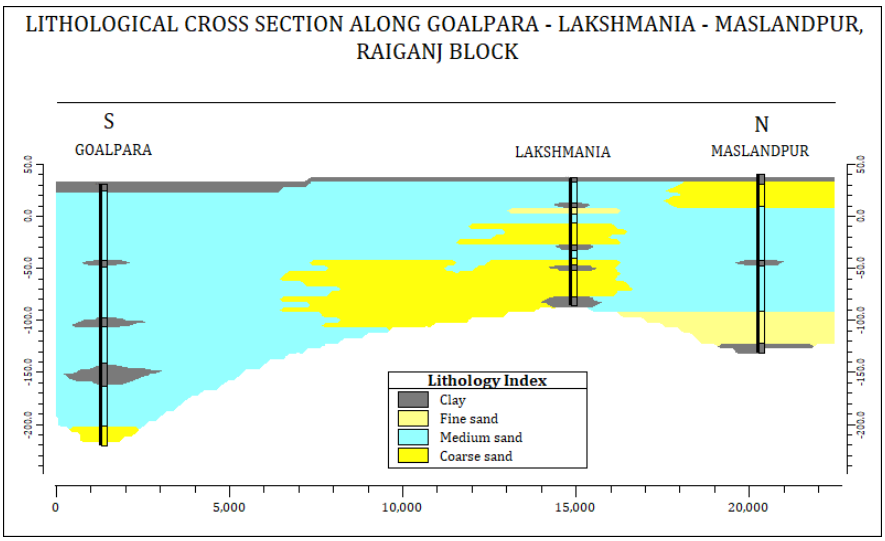


Fig. 3: Lithological cross-section along Goalpara-Maslandpur, Raiganj block

Status of GW Exploration

Exploratory Wells of CGWB: 3
Observation Wells of CGWB: 2
Tube Wells of PHED/Agri-irrigation Department: 8
Monitoring Wells of State Water Investigation Directorate: 6

Aquifer Characteristics

AQUIFER	Discharge (m^3/day)	DRAWDOWN (m)	T (m^2/day)	S
Aquifer-I	NA	NA	NA	NA
Aquifer-II	1689.91 – 2127.57	3.20-4.88	776.79	NA
Aquifer-III				
Aquifer-IV	811.30	11.617	611.00	5.29×10^{-5}
Aquifer-V				

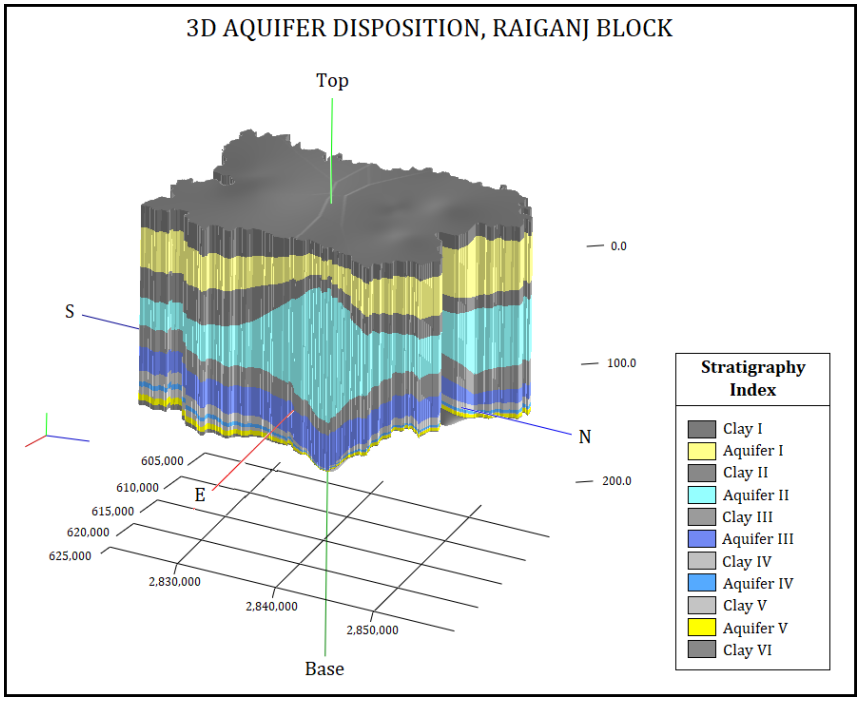


Fig. 3: Block Diagram showing aquifer disposition in 3-D, Raiganj block

Groundwater Monitoring Status

Six ground water monitoring wells of CGWB (Burakamat, Karnojora, Lahanda, Lohagara, Koiladangi & Subhashganj) are being monitored regularly. Additional five Key Observation Wells were established at Birghai (2 wells), Raria, Bhagilata & Sariabad during the present NAQUIM Study.

Average DTW (pre-monsoon 2022): 5.99 m bgl
Average DTW (post-monsoon 2021): 3.52 m bgl
Average water table elevation (pre-monsoon 2022): 32.01m
Average water table elevation (post-monsoon 2021): 34.49 m

Groundwater Quality

NABL data of CGWB, ER reveals that groundwater is potable and can

	be used for drinking, domestic and irrigation purpose. However, iron contamination in groundwater was observed in few locations like Lohagara (2.21 mg/L), Koiladangi (1.14 mg/L) & Sherpur (3.47 mg/L)
Groundwater Resource (as on 31-3-2013)	Net Annual Ground Water Availability: 22062.29 ham Existing Gross Ground Water Draft for All Uses: 17013.82 ham Stage of Ground Water Development: 77.12 % Category: Safe The Safe category has been defined on the basis of long-term water level trend in Raiganj block, as per the GEC-1997 methodology
Future Water Demand (as on 31-3-2013)	GW allocation for future domestic use (up to 2025 AD): 1634.95 ham
Water Supply Schemes of PHED, Govt. of West Bengal	Three Pipes Water supply Schemes (PWSS) exist in Raiganj block: Balia PWSS, Dwipnagar PWSS and Khalsi PWSS. Together, these schemes cover a design population of 47,574 (as on March, 2022)

Aquifer Management Plan

Groundwater Management Plan	➢ ➢ Village Level Aquifer Management at Birghai, Raiganj block: ➢ ➢ Possibility of developing village level Aquifer Management Plan was explored in Birghai village, Piyaltore Mouza of Raiganj block. Having 466 households, the village has been categorized as Fully Covered for drinking water supply by the Public Health Engineering Directorate, Raiganj Division. ➢ During interaction with the villagers, it was found that individual small submersible pumps are being used for irrigation since last five to six years. It has been reported by the locals that that many farmers have left the traditional farming practices and have shifted to urban areas for alternative employment over the last three to four years. ➢ Villagers are using shallow tube wells fitted with submersible pump of 5 HP capacity (locally called as Marshal) for agriculture and irrigation. Discharge of the tube wells are not available but reported to be varying from 200 to 250 LPM (12 to 15 m3/hour). These submersible pumps have been installed by few affluent villagers as the cost of installation is relatively high, which ranges from Rs. 60000/- to Rs. 80000/- ➢ The farmers are generally small and marginal category, having typical land holding varying from 0.13 ha to 1.35 ha. Presently, only two varieties of paddy (Amon and Boro) are being cultivated. Mango orchards are present in the northern part of the village. During winter season, cauliflowers are cultivated along with sunflower. ➢ No prominent surface water body exists in the village. Entire population is dependent on groundwater for drinking,

	domestic and agri-irrigational use. ➢ For cultivation of summer paddy (Boro), groundwater requirement has been estimated at 122.37 m3 for 1 ha land. The calculation is based on: ➢ Average discharge of shallow tube well = 13.5 m3/hr, average daily pumping = 3.5 hours, total pumping hours in a week = 906 hours, number of tube wells for Boro cultivation = 35 and average land area = 0.13 ha. ➢ A small-scale industry (Sonar Bangla Food Products) is operational exist at the entry of the village when approaching from Taherpur-Dakshin Bajitpur road. However, details of groundwater consumption by the industry are not made available. ➢ Three India Mark-II hand pump fitted tube wells were surveyed in the village. They are located in the back side of village market while entering the village from Taherpur, in the compound of Primary School and in the compound of Bhojo Gobindo Roy Madhyamik Shiksha Kendra. Depth to water level (DTW) and location of two tube wells are given below: ➢ Tube well (India Mark-II) in Birghai Primary School: 25.5637 N, 88.1746 E, DTW = 5.59 m bgl ➢ Tube well (India Mark-II) in Bhojo Gobindo Roy Madhyamik Shiksha Kendra (MSK): 25.5679 N, 88.1752 E, DTW = 5.15 m bgl
Artificial Recharge and Water Conservation	➢ Twelve feasible sites were selected in the block. Out of these, two sites were selected for open area rain water harvesting during micro-level survey in Birghai village of Piyaltore mouza. The two sites were located at Birghai Primary School and at Bhojogobindo Roy Madhyamik Shiksha Kendra, Birghai. ➢ Convergence of centrally funded and state funded schemes is required for implementation of the pilot schemes, both in Birghai village and in Raiganj block. Promising schemes include: PMKSY-HKKP-GW project, Jal Dhoro Jal Bhoro project and implementable schemes on rain water harvesting under Jal Shakti Abhiyan – Catch The Rain (JSA-CTR) 2022 programme and re-excavation, renovation and restoration of surface water bodies under the Amrit Sarovar programme as a part of celebration of 75 years of Indian Independence (Azadi Ka Amrit Mahotsav).

Aquifer Information and Management System
Goalpokhar-I block, Uttar Dinajpur district, West Bengal
(365 km² area covered under NAQUIM)

GENERAL INFORMATION

State Name	West Bengal
District name	Uttar Dinajpur
Block Name	Goalpokhar-I
Location	Located in central part of the district, with Islampur block to the north, Goalpokhar-II block to the west, Karandighi block to the south and bounded by International Border with Bangladesh to the east
Geographical Area	365.0 km²
Basin/Sub-basin	Ganga/ Bhagirathi
Principal Aquifer System	Alluvium (Aquifer Code: AL) Single Aquifer System
Major Aquifer System	Younger Alluvium of Holocene age (Aquifer Code- AL01) Single aquifer (Aquifer-I) has been identified at several locations; two aquifers (Aquifer-I & II) identified at Intia, Biprit, Lodhan, Teliapokhar, Kichaktola and three aquifers (Aquifer-I, II & III) at Goagaon Aquifer-I: Depth range varies from 3.0 m to 27.0 m Aquifer-II: Depth range varies from 43.0 m to 52.0 m Aquifer-III: Depth range varies from 76.0 m to 149.0 m Depth ranges are variable in different locations within the block
Monsoon Rainfall	2020: 1485.2 mm

AQUIFER DISPOSITION

Aquifer Disposition

Aquifer-I: Phreatic aquifer (shallow)
- Occurs throughout the block
- Aquifer material is Younger Alluvium of Holocene age

Aquifer-II & Aquifer-III: Confined aquifer (moderately deep)

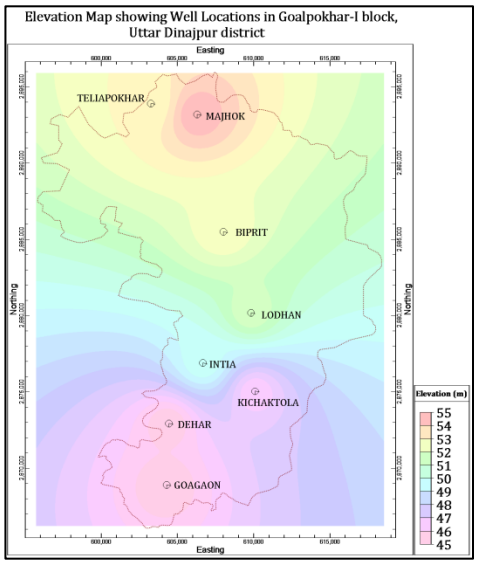


Fig. 4: Elevation map with location of Tube Wells, Goalpokhar-I block

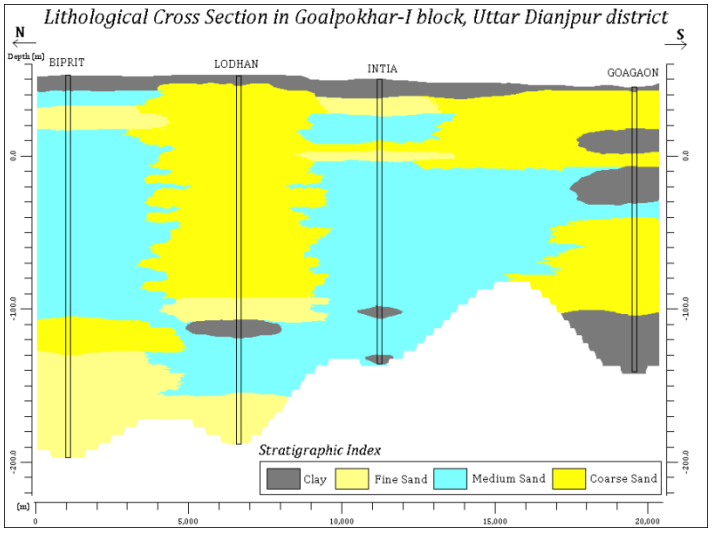


Fig. 2: Lithological cross section along Biprit-Goagaon, Goalpokhar-I block

Status of GW Exploration

Exploratory Wells of CGWB: 0
Observation Wells of CGWB: 0
Tube Wells of PHED/Agri-irrigation Department: 8
Monitoring Wells of State Water Investigation Directorate: 5

Aquifer Characteristics

AQUIFER	DISCHARGE (m^3/day)	DRAWDOWN (m)	T (m^2/day)	S
Aquifer-I	NA	NA	NA	NA
Aquifer-II	1772.98 – 2673.10	2.44 – 7.75	NA	NA
Aquifer-III				

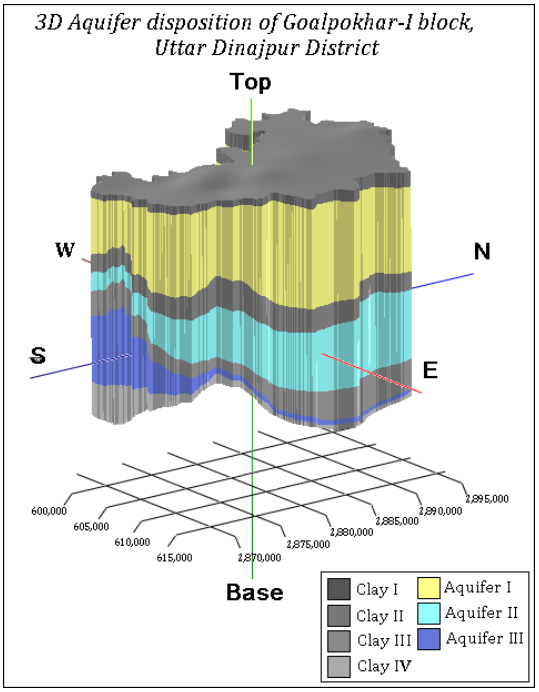


Fig. 3: Block Diagram showing aquifer disposition in 3-D, Goalpokhar-I block

Groundwater Monitoring

Two new ground water monitoring wells were established in pre-

Status	monsoon 2022 at Biprit and Goagaon. Two Key Observation Wells (KOW) were established at Panjipara Model Madrasa & at Sahapur during the present NAQUIM Study. Average DTW (pre-monsoon 2022): 3.85 m bgl Average DTW (post-monsoon 2021): 2.94 m bgl Average water table elevation (pre-monsoon 2022): NA Average water table elevation (post-monsoon 2021): 49.06 m
Groundwater Quality	NABL data of CGWB, ER reveals that groundwater is potable and can be used for drinking, domestic and irrigation purpose.
Groundwater Resource (as on 31-3-2013)	Net Annual Ground Water Availability: 13149.76 ham Existing Gross Ground Water Draft for All Uses: 5213.73 ham Stage of Ground Water Development: 39.65 % Category: Safe
Future Water Demand (as on 31-3-2013)	GW allocation for future domestic use (up to 2025 AD): 761.03 ham

Aquifer Management Plan

Groundwater Management Plan

<u>Groundwater management strategies</u>:

13. Installation of drip irrigation system, especially for cultivation of summer paddy (Boro) through government subsidy.
14. Design, development and installation of smart water supply measurement and monitoring system for real time monitoring of groundwater level and periodic assessment of groundwater quality, both during pre-monsoon and post-monsoon periods.
15. Convergence of *Jal Dhoro Jal Bhoro* programme with participation of farmers in centrally funded schemes like PMKSY-HKKP, Jal Shakti Abhiyan – Catch The Rain (JSA-CTR) 2022 programme & construction of *Amrit Sarovars* at designated sites with active participation from the district and block administration.
16. Creating awareness on water conservation, design of policy for collection of village level data on groundwater level and rainfall in association with Self Help Groups, NGO and panchayat people.
17. Organization of Public Interaction Programme in the block headquarter (Panjipara) for capacity building of the stakeholder.

Artificial Recharge and Water Conservation

1. Implementation of artificial recharge scheme is not required due to very low Stage of Development in Goalpokhar-I block.

2. Implementation of *Jal Dhoro Jal Bhoro* scheme needs to be taken up through renovation and restoration of existing surface water bodies. This scheme is being implemented by the Water Resources Investigation and Development Directorate (WRIDD) both as stand-

alone programme and as a component of the MGNREGS along with the Panchayat and Rural Development Department, Government of West Bengal.

Aquifer Information and Management System
Goalpokhar-II block, Uttar Dinajpur district, West Bengal
(299 km² area covered under NAQUIM)

GENERAL INFORMATION

State Name	West Bengal
District name	Uttar Dinajpur
Block Name	Goalpokhar-II
Location	Located in central part of the district, with Goalpokhar-I block to the north and east, Karandighi block to the south and Purnea district of Bihar to the west
Geographical Area	299.0 km²
Basin/Sub-basin	Ganga/ Bhagirathi
Principal Aquifer System	Alluvium (Aquifer Code: AL) Single Aquifer System
Major Aquifer System	Younger Alluvium of Holocene age (Aquifer Code- AL01) Single aquifer (Aquifer-I) has been identified at several locations; two aquifers (Aquifer-I & II) are identified at few locations Aquifer-I: Depth range varies from 3.0 m to 73.0 m Aquifer-II: Depth range varies from 82.0 m to 165.0 m Depth ranges are variable in different locations within the block
Monsoon Rainfall	2020: 1485.2 mm

AQUIFER DISPOSITION

Aquifer Disposition

Aquifer-I: Phreatic aquifer (shallow)
- Occurs throughout the block
- Aquifer material is Younger Alluvium of Holocene age

Aquifer-II: Confined aquifer (moderately deep)
- Demarcated at Majlishpur (82-165 m), Sikar (63-138 m), Deogaon & Sahapur (63-132 m)

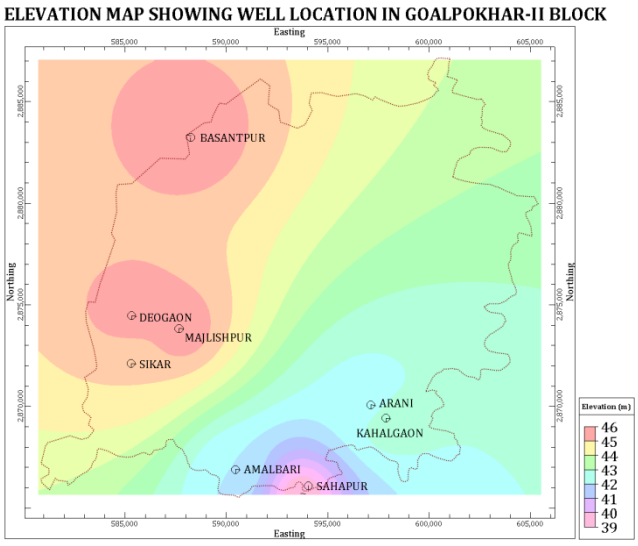


Fig. 5: Elevation map with location of Tube Wells, Goalpokhar-II block

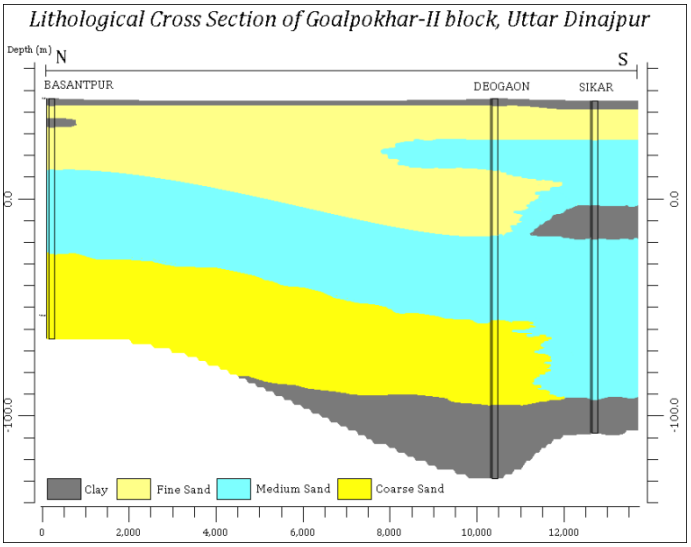


Fig. 2: Lithological cross section along Basantpur-Sikar, Goalpokhar-II block

Status of GW Exploration

Exploratory Wells of CGWB: 0
Observation Wells of CGWB: 0
Tube Wells of PHED/Agri-irrigation Department: 8
Monitoring Wells of State Water Investigation Directorate: 8

Aquifer Characteristics

AQUIFER	DISCHARGE (m^3/day)	DRAWDOWN (m)	T (m^2/day)	S
Aquifer-I	NA	NA	NA	NA
Aquifer-II	1772.98 – 2029.37	2.74 – 3.43	NA	NA

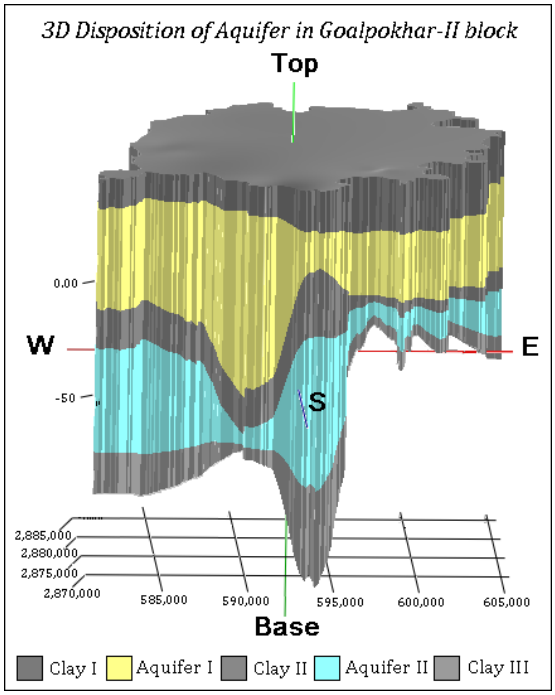


Fig. 3: Block Diagram showing aquifer disposition in 3-D, Goalpokhar-II block

Groundwater Monitoring Status	One ground water monitoring well exist at Kanki. Three Key Observation Wells were established at Chitora (Gandal), Kahata (Chakulia) and Chapore during the present NAQUIM Study. Average DTW (pre-monsoon 2022): 2.89 m bgl Average DTW (post-monsoon 2021): 2.52 m bgl Average water table elevation (pre-monsoon 2022): NA Average water table elevation (post-monsoon 2021): 37.81 m
Groundwater Quality	As per Arsenic Task Force (Govt. of West Bengal), Goalpokhar-II block is reported to have arsenic contamination in groundwater. However, available data of CGWB, ER indicates absence of arsenic contamination. High magnesium (40 mg/L) has been reported, but only in a single water sample. Except this, groundwater in the block is potable and safe for drinking, domestic and agri-irrigational use.
Groundwater Resource (as on 31-3-2013)	Net Annual Ground Water Availability: 12258.87 ham Existing Gross Ground Water Draft for All Uses: 8403.67 ham Stage of Ground Water Development: 68.55 % Category: Safe
Future Water Demand (as on 31-3-2013)	GW allocation for future domestic use (up to 2025 AD): 702.24 ham

Aquifer Management Plan

Groundwater Management Plan	**<u>Groundwater management strategies</u>:** ➢ Installation of drip irrigation system, especially for cultivation of summer paddy (Boro) through government subsidy. ➢ Design, development and installation of smart water supply measurement and monitoring system for real time monitoring of groundwater level and periodic assessment of groundwater quality, both during pre-monsoon and post-monsoon periods. ➢ Implementation of programmes like Jal Dhoro Jal Bhoro by state government along with convergence of state and centrally funded schemes: PMKSY-HKKP-GW scheme. ➢ Implementation of Jal Shakti Abhiyan – Catch The Rain (JSA-CTR) 2022 programme & construction of Amrit Sarovars at designated sites with active participation from the district and block administration for use by stakeholders. ➢ Creating awareness on water conservation, design of policy for collection of block/village level data on groundwater level and rainfall by Self Help Groups, NGO and Pachayati Raj Institutes. ➢ Organization of Public Interaction Programme in block headquarter (Chakulia) for capacity building of the stakeholder.
Artificial Recharge and	➢ Implementation of artificial recharge scheme is not required

Water Conservation	due to low Stage of Development in Goalpokhar-II block. ➢ Implementation of Jal Dhoro Jal Bhoro scheme needs to be taken up through renovation and restoration of existing surface water bodies. This scheme is being implemented by the Water Resources Investigation and Development Directorate (WRIDD), both as a stand-alone programme and as a component of MGNREGS along with Panchayat and Rural Development Department, Govt. of West Bengal.

Aquifer Information and Management System
Hemtabad block, Uttar Dinajpur district, West Bengal
(192 km² area covered under NAQUIM)

GENERAL INFORMATION

State Name	West Bengal
District name	Uttar Dinajpur
Block Name	Hemtabad
Location	Located in eastern part of the district, with International Border with Bangladesh to the north, Kaliaganj block to the east, Raiganj block to the west and Itahar block to the south
Geographical Area	192.0 km²
Basin/Sub-basin	Ganga/ Bhagirathi
Principal Aquifer System	Alluvium (Aquifer Code: AL) Single Aquifer System
Major Aquifer System	Younger Alluvium of Holocene age (Aquifer Code- AL01) Three aquifers (Aquifer-I, II & III) are identified has been identified at three locations; four aquifers (Aquifer-I to Aquifer-IV) are identified in few locations Aquifer-I: Depth range varies from 13.0 m to 44.0 m Aquifer-II: Depth range varies from 47.0 m to 65.0 m Aquifer-III: Depth range varies from 68.0 m to 105.0 m Aquifer-IV: Depth range varies from 122.0 m to 144.0 m Depth ranges are variable in different locations within the block
Normal Rainfall	2041.0 mm

AQUIFER DISPOSITION

Aquifer Disposition

Aquifer-I: Phreatic aquifer (shallow)
- Occurs throughout the block
- Aquifer material is Younger Alluvium of Holocene age

Aquifer-II, III & IV: Semi-confined to confined aquifer (moderately deep)
- Demarcated at Surangapur, Nehusara and Sona Bandh

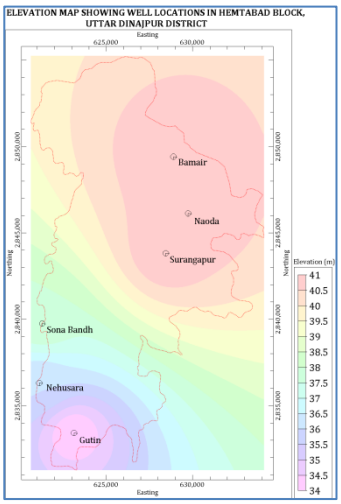


Fig. 6: Elevation map with location of Tube Wells, Hemtabad block

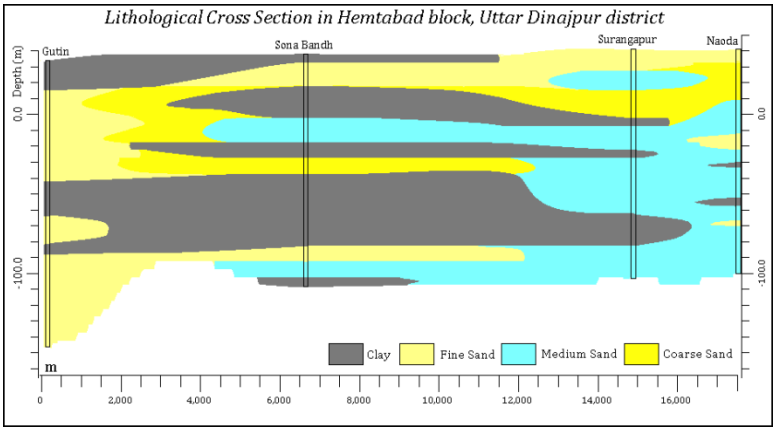


Fig. 2: Lithological cross section along Gutin-Naoda, Hemtabad block

Status of GW Exploration

Exploratory Wells of CGWB: 0
Observation Wells of CGWB: 0
Tube Wells of PHED/Agri-irrigation Department: 6
Monitoring Wells of State Water Investigation Directorate: 2

Aquifer Characteristics

AQUIFER	DISCHARGE (m^3/day)	DRAWDOWN (m)	SWL (m bgl)	T (m^2/day)
Aquifer-I	NA	NA	3.96 – 4.20	NA
Aquifer-II, Aquifer-III & Aquifer-IV	2836.76 – 3000.42	11.84 – 17.23	31.78	NA

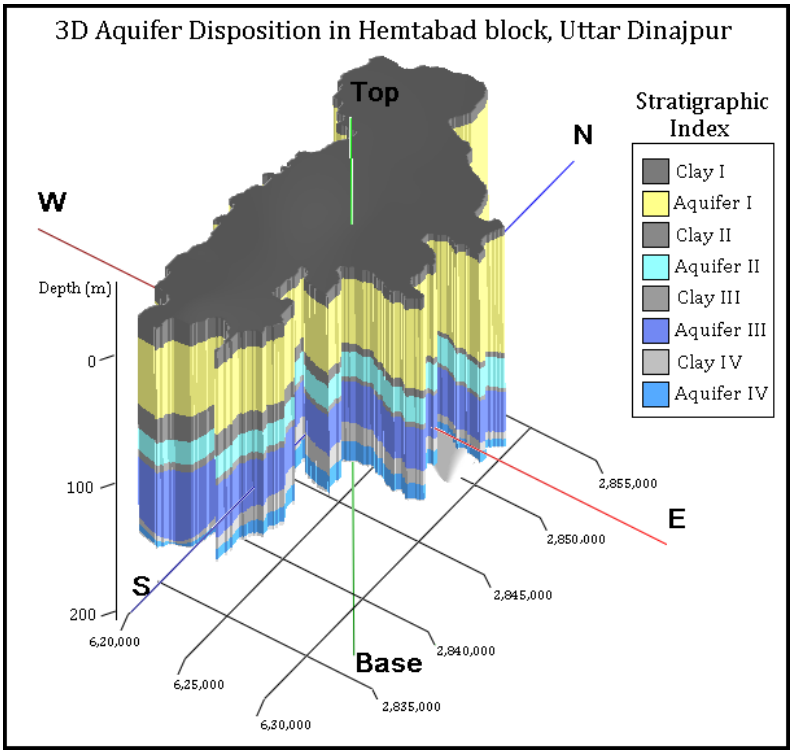


Fig. 3: Block Diagram showing aquifer disposition in 3-D, Hemtabad block

Groundwater Monitoring Status	Ground water monitoring is being done four times in a year through two monitoring wells at Hemtabad and Malon. Besides, three Key Observation Wells were established at Samaspur, Bhanail and Kakarsing during the present NAQUIM study. Average DTW (pre-monsoon 2022): 5.20 m bgl Average DTW (post-monsoon 2021): 2.85 m bgl Average water table elevation (pre-monsoon 2022): 37.31 m Average water table elevation (post-monsoon 2021): 39.65 m
Groundwater Quality	Available data of CGWB, ER indicates groundwater in Hemtabad block is potable and safe for drinking, domestic and agri-irrigational use. However, very iron contamination in groundwater was reported in locations Dhankoil (9.197 mg/L), Lohagara (8.534 mg/L), Chopra Hospital (7.042 mg/L), Karnojora (3.337 mg/L), Baidara (3.115 mg/L), Hemtabad Hospital (3.038 mg/L) etc.
Groundwater Resource (as on 31-3-2013)	Net Annual Ground Water Availability: 8757.31 ham Existing Gross Ground Water Draft for All Uses: 7304.71 ham Stage of Ground Water Development: 83.41 % Category: Safe The Safe category has been designed based on GEC, 1997 methodology due to absence of long-term declining trend in groundwater level.
Future Water Demand (as on 31-3-2013)	GW allocation for future domestic use (up to 2025 AD): 366.27 ham

Aquifer Management Plan

Groundwater Management Plan

<u>Groundwater management strategies</u>:

- Installation of drip irrigation system, especially for cultivation of summer paddy (Boro) through government subsidy.
- Design, development and installation of smart water supply measurement and monitoring system for real time monitoring of groundwater level and periodic assessment of groundwater quality, both during pre-monsoon and post-monsoon period.
- Implementation of programmes like Jal Dhoro Jal Bhoro by state government along with convergence of state and centrally funded schemes like PMKSY-HKKP-GW scheme.
- Implementation of Jal Shakti Abhiyan – Catch The Rain (JSA-CTR) 2022 programme & construction of Amrit Sarovars at designated sites with active participation from the district and block administration for use by stakeholders.
- Creating awareness on water conservation and formulation of policy for block/village level data collection on groundwater level & rainfall by Self Help Groups, NGO and Pachayati Raj Institutes.

	➢ Organization of Public Interaction Programme in block headquarter (Hemtabad) for raising awareness on sustainable groundwater management through participatory approach along with capacity building of the stakeholders.
Artificial Recharge and Water Conservation	➢ Due to categorization of Hemtabad block under Safe category, implementation of artificial recharge scheme is not required, as per the latest Master Plan on Artificial Recharge (CGWB 2020). ➢ Pilot studies on roof top and open area rain water harvesting may be taken up initially in government buildings like BDO Office, Hemtabad Hospital and BSF Camp at Govindpur. ➢ Implementation of Jal Dhoro Jal Bhoro scheme needs to be taken up through renovation and restoration of existing surface water bodies. This scheme is being implemented by the Water Resources Investigation and Development Directorate (WRIDD), both as a stand-alone programme and as a component of MGNREGS along with Panchayat and Rural Development Department, Govt. of West Bengal.

Aquifer Information and Management System
Karandighi block, Uttar Dinajpur district, West Bengal
(391 km² area covered under NAQUIM)

GENERAL INFORMATION

State Name	West Bengal
District name	Uttar Dinajpur
Block Name	Karandighi
Location	Located in south central part of the district, with International Border with Bangladesh to the east, Goalpokhar-I and Goalpokhar-II blocks to the north, Purnea district of Bihar to the west & south and Raiganj block to the south-east.
Geographical Area	391.0 km²
Basin/Sub-basin	Ganga/ Bhagirathi
Principal Aquifer System	Alluvium (Aquifer Code: AL) Single Aquifer System
Major Aquifer System	Younger Alluvium of Holocene age (Aquifer Code- AL01) Three aquifers (Aquifer-I, II & III) are identified at Choprabari and Andharia, two aquifers (Aquifer-I & II) are identified at Kamartor, Raghabpur and Damdama Aquifer-I: Depth range varies from 27.0 m to 40.0 m Aquifer-II: Depth range varies from 58.0 m to 149.0 m Aquifer-III: Depth range varies from 165.0 m to 171.0 m Depth ranges are variable in different locations within the block
Normal Rainfall	2041.0 mm

AQUIFER DISPOSITION

Aquifer Disposition

Aquifer-I: Phreatic aquifer (shallow)
- Occurs throughout the block with variable thickness
- Aquifer material is Younger Alluvium of Holocene age

Aquifer-II & III: Semi-confined to confined aquifer (moderately deep)
- Depth range of Aquifer-III: 96-153 m, 165-171 m

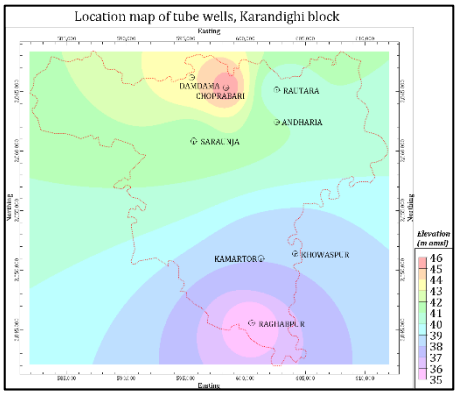


Fig. 7: Elevation map with location of Tube Wells, Karandighi block

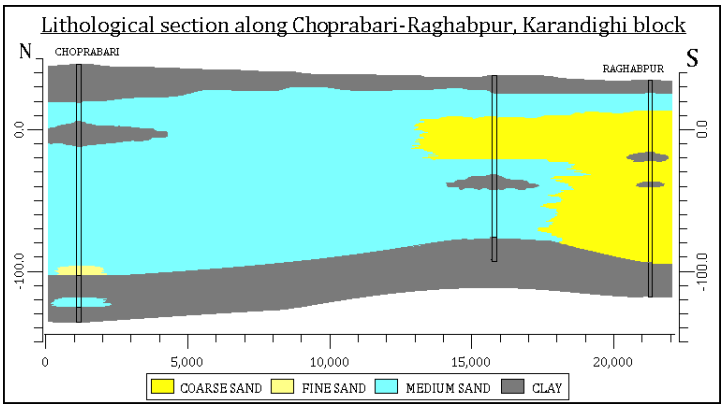


Fig. 2: Lithological cross section along Choprabari – Raghabpur, Karandighi block

Status of GW Exploration

Exploratory Wells of CGWB: 0
Observation Wells of CGWB: 0
Tube Wells of PHED/Agri-irrigation Department: 8
Monitoring Wells of State Water Investigation Directorate: 5

Aquifer Characteristics

AQUIFER	DISCHARGE (m^3/day)	DRAWDOWN (m)	SWL (m bgl)	T (m^2/day)
Aquifer-I	NA	NA	3.78 – 5.98	NA
Aquifer-II & Aquifer-III	1772.98 – 2318.51	3.35 – 11.07	NA	NA

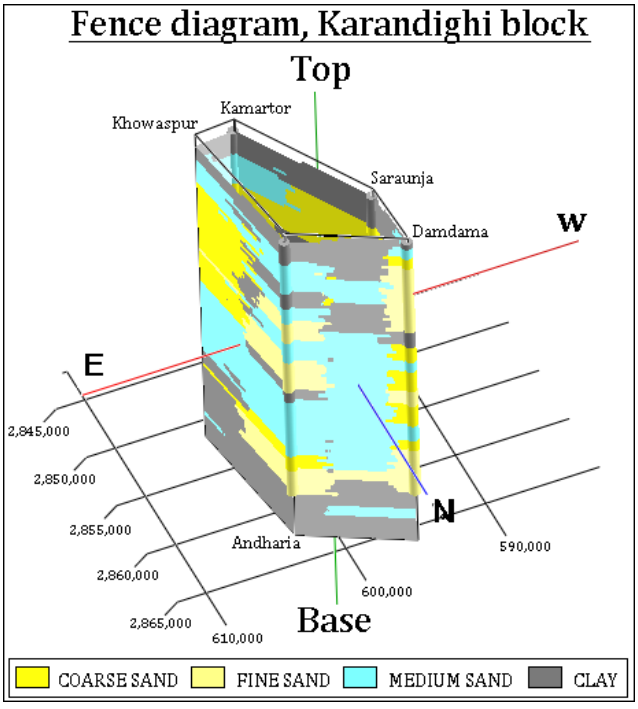


Fig. 3: Fence diagram showing aquifer disposition, Karandighi block

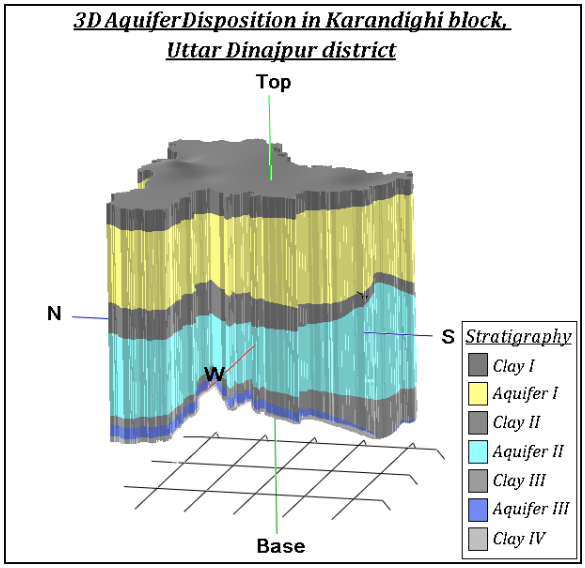


Fig. 3: Block diagram showing aquifer disposition, Karandighi block

Groundwater Monitoring Status	Groundwater monitoring is being done four times in a year through two monitoring wells at Tungidhighi and Rasakhowa. Besides, three Key Observation Wells were established at Khikhirtola, Dalkhola and Barail during the present NAQUIM study. Average DTW (pre-monsoon 2022): 4.92 m bgl Average DTW (post-monsoon 2021): 2.58 m bgl Average water table elevation (pre-monsoon 2022): 37.58 m Average water table elevation (post-monsoon 2021): 37.62 m
Groundwater Quality	Available data of CGWB, ER indicates groundwater in Karandighi block is potable and safe for drinking, domestic and agri-irrigational use. As per available data of CGWB, iron contamination in groundwater has not been reported in Karandighi block.
Groundwater Resource (as on 31-3-2013)	Net Annual Ground Water Availability: 17410.50 ham Existing Gross Ground Water Draft for All Uses: 9785.40 ham Stage of Ground Water Development: 56.20 % Category: Safe
Future Water Demand (as on 31-3-2013)	GW allocation for future domestic use (up to 2025 AD): 988.78 ham

Aquifer Management Plan

Groundwater Management Plan

Groundwater management strategies:

- Installation of drip irrigation system, especially for cultivation of summer paddy (Boro) through government subsidy.
- Design, development and installation of smart water supply measurement and monitoring system for real time monitoring of groundwater level and periodic assessment of groundwater quality, both during pre-monsoon and post-monsoon period.

	➢ Implementation of programmes like Jal Dhoro Jal Bhoro by state government along with convergence of state and centrally funded schemes like PMKSY-HKKP-GW scheme. ➢ Implementation of Jal Shakti Abhiyan – Catch The Rain (JSA-CTR) 2022 campaign & construction of Amrit Sarovars at feasible sites with active participation from the district and block administration. ➢ Creating awareness on water conservation and formulation of policy for block/village level data collection on groundwater level & rainfall by Self Help Groups, NGO and Pachayati Raj Institutes. ➢ Organization of Public Interaction Programme in block headquarters for raising awareness on sustainable groundwater management through participatory approach along with capacity building of the stakeholders.
Artificial Recharge and Water Conservation	➢ Due to categorization of Karandighi block under Safe category, implementation of artificial recharge scheme is not required, as per the latest Master Plan on Artificial Recharge (CGWB 2020). ➢ Pilot studies on roof top and open area rain water harvesting may be taken up initially in government buildings like BDO Office Karandighi, Dalkhola Rural Hospital etc. ➢ Generation of awareness on water resources management and conservation may be initiated in the urban areas (e.g. Dalkhola City), in association with the local administration and/or academic institutes. Such activities may be taken up subsequently in rural areas like Bagela, Bhulki, Rautara, Khanta, Gopalpur etc. ➢ Implementation of *Jal Dhoro Jal Bhoro* scheme needs to be taken up through renovation and restoration of existing surface water bodies. This scheme is being implemented by the Water Resources Investigation and Development Directorate, both as a stand-alone programme and as a component of MGNREGS along with Panchayat and Rural Development Department, Govt. of West Bengal.

Aquifer Information and Management System
Kaliaganj block, Uttar Dinajpur district, West Bengal
(302 km² area covered under NAQUIM)

GENERAL INFORMATION

State Name	West Bengal
District name	Uttar Dinajpur
Block Name	Kaliaganj
Location	Located in eastern part of the district, having International Border with Bangladesh to the north, east and south-east, Itahar block to the south, Hemtabad block to the west and north-west and Raiganj block to the south-west.
Geographical Area	302.0 km²
Basin/Sub-basin	Ganga/ Bhagirathi
Principal Aquifer System	Alluvium (Aquifer Code: AL) Single Aquifer System
Major Aquifer System	Younger Alluvium of Holocene age (Aquifer Code- AL01) Four aquifers (Aquifer-I, II, III & IV) are identified at Baghan, Atghara, Dhankoil & Dalimgaon, three aquifers (Aquifer-I, II & III) are identified at Kaliaganj ITI (Mahadebpur) & Shergram, single aquifer (Aquifer-I) is demarcated at Uttar Chiral and Puria in Shallow Exploratory Wells (depth: <140 m) of CGWB, ER and Tube Wells of PHED and Agri-irrigation Department, Govt. of West Bengal Aquifer-I: Depth range varies from 32.0 m to 38.1 m Aquifer-II: Depth range varies from 42.7 m to 51.8 m Aquifer-III: Depth range varies from 67.0 m to 91.5 m Aquifer-IV: Depth range varies from 128.0 m to 143.3 m Aquifer-V is exposed at deeper level (213.5 m – 221.5 m) at Kaliaganj ITI (Mahadebpur) site of CGWB, ER Depth range of aquifers are variable in different locations within the block
Normal Rainfall	2041.0 mm

AQUIFER DISPOSITION

Aquifer Disposition

Aquifer-I: Phreatic aquifer (shallow)

- Occurs throughout the block with variable thickness
- Aquifer material is Younger Alluvium of Holocene age

Aquifer-II, III & IV:

- Generally occurs under confining condition (moderately deep)
- Aquifer-III is exposed at deeper levels (>200 m) at Kaliaganj ITI Exploratory Well
- In other locations, Aquifer-III is exposed in the depth range ~60 m to ~120 m
- Strata chart of PHED, Raiganj Division reveals highest thickness of 97.5 m for Aquifer-I at Puria site

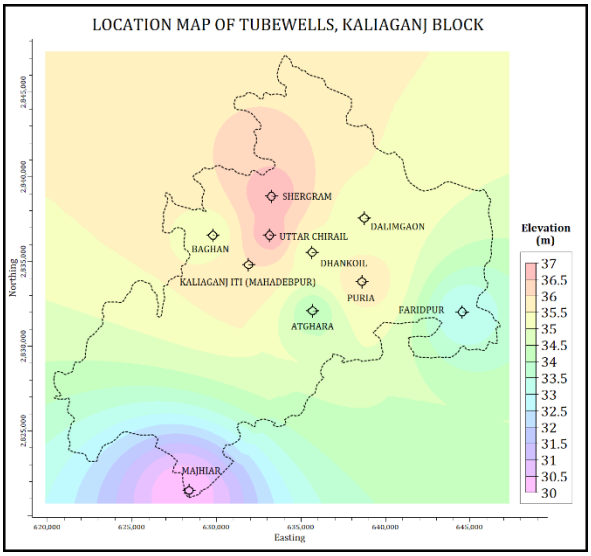


Fig. 1: Location map of Tube Wells, Kaliaganj block

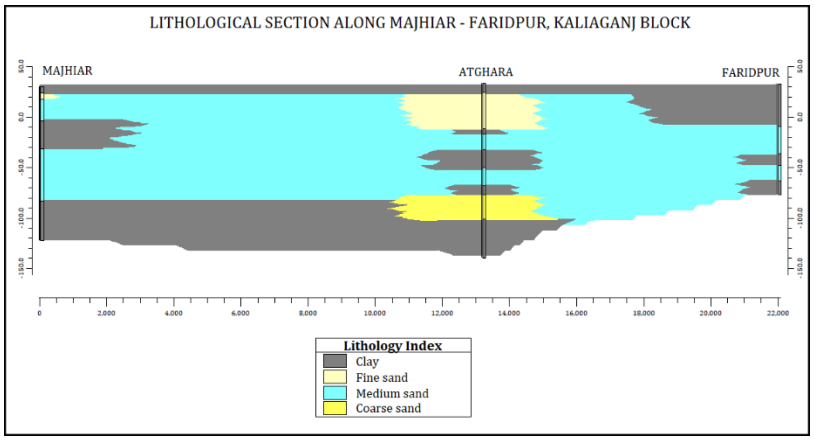


Fig. 2: Lithological cross section along Majhiar–Atghara-Faridpur, Kaliaganj block

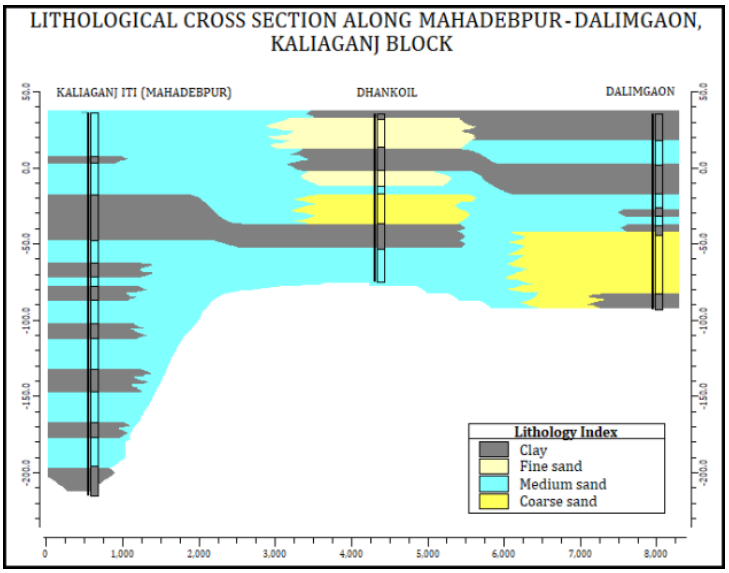


Fig. 3: Lithological cross section along Kaliaganj ITI (Mahadebpur)–Dhankoil-Dalimgaon, Kaliaganj block

Status of GW Exploration

Exploratory Wells of CGWB: 4
Observation Wells of CGWB: 0
Tube Wells of PHED/Agri-irrigation Department: 7
Monitoring Wells of State Water Investigation Directorate: 3

Aquifer Characteristics

AQUIFER	DISCHARGE (m^3/day)	DRAWDOWN (m)	SWL (m bgl)	T (m^2/day)
Aquifer-I	1772.98	3.20 - 6.45	3.66 – 8.34	NA
Aquifer-II, Aquifer-III & Aquifer-IV	1772.98 – 5085.50	3.02 – 4.63	3.28 – 5.22	1004.0 – 2045.0

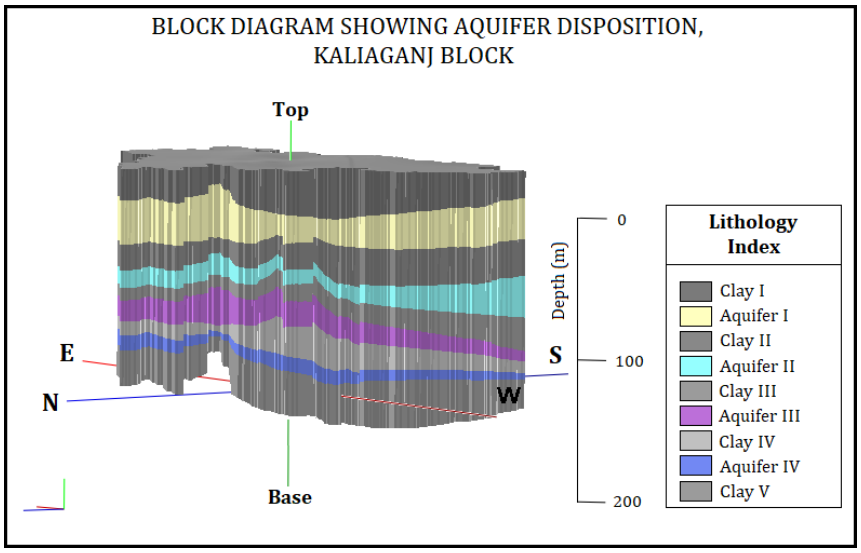


Fig. 4: Block Diagram showing aquifer disposition, Kaliaganj block

Groundwater Monitoring Status

Ground water monitoring is being done four times in a year through six monitoring wells at Dalimgaon, Baghon, Kaliaganj, Kunore, Dhankoil & Mustafa Nagar. Besides, three Key Observation Wells were established at Madhya Gouripur, Bhelai and Majlispur during the present study on aquifer mapping and management.

Average DTW (pre-monsoon 2022): 6.12 m bgl
Average DTW (post-monsoon 2021): 2.72 m bgl
Average water table elevation (pre-monsoon 2022): 32.04 m
Average water table elevation (post-monsoon 2021): 34.66 m

Groundwater Quality

Available data of CGWB, ER indicates groundwater in Kaliaganj block is generally potable and safe for drinking, domestic and agri-irrigational use. Available data (post-monsoon 2021) from groundwater samples collected during the present study has shown high nitrate (53 mg/L) in Baghon tube well, which is due to anthropogenic source. High iron in groundwater is observed at Dhankoil (9.197 mg/L) and Kunore (2.14 mg/L).

Groundwater Resource (as on 31-3-2013)	Net Annual Ground Water Availability: 18127.84 ham Existing Gross Ground Water Draft for All Uses: 10504.13 ham Stage of Ground Water Development: 57.94 % Category: Safe
Future Water Demand (as on 31-3-2013)	GW allocation for future domestic use (up to 2025 AD): 736.96 ham

Aquifer Management Plan

Groundwater Management Plan

<u>Groundwater management strategies</u>:

- Installation of drip irrigation system, especially for cultivation of summer paddy (Boro) through government subsidy.
- Design, development and installation of smart water supply measurement and monitoring system for real time monitoring of groundwater level and periodic assessment of groundwater quality, both in pre-monsoon and post-monsoon period.
- Implementation of Jal Dhoro Jal Bhoro scheme by Government of West Bengal for protection and conservation of water resources, especially rainwater in surface water bodies.
- Proactive role needs to be taken by district and block administration for implementation of schemes like Pradhan Mantri Krishi Sinchai Yojana – Har Khet Ko Paani scheme and Jal Shakti Abhiyan – Catch The Rain (JSA-CTR) 2022 campaign.
- Creating awareness on water conservation and formulation of policy for block/village level data collection on groundwater level & rainfall by Self Help Groups, NGO and Pachayati Raj Institutes.
- Organization of Public Interaction Programme in block headquarter (Kaliaganj) for raising awareness on sustainable groundwater management through participatory approach along with capacity building of the stakeholders.

Artificial Recharge and Water Conservation

- Due to categorization of Kaliaganj block under Safe category, implementation of artificial recharge scheme is not required as per latest Master Plan on Artificial Recharge (CGWB 2020).
- Pilot studies on roof top and open area rain water harvesting may be taken up initially in government buildings like BDO Office at Karandighi, Dalkhola Rural Hospital etc.
- Generation of awareness on water resources management is needed in urban areas like Dalkhola City, in association with the local administration and/or academic institutes.
- Construction of Amrit Sarovars at feasible sites with active participation from the district and block administration.

GENERAL INFORMATION

State Name	West Bengal
District name	Uttar Dinajpur
Block Name	Itahar
Location	Located in the southern part of the district, bounded by Raiganj & Kaliaganj blocks to the north, Harirampur block (Dakshin Dinajpur district) to the east, Gazole block (Malda district) to the south and Chanchal-I, Chanchal-II blocks (Malda district) & Katihar district of Bihar to the west.
Geographical Area	362.0 km^2
Basin/Sub-basin	Ganga/ Bhagirathi
Principal Aquifer System	Alluvium (Aquifer Code: AL) Single Aquifer System
Major Aquifer System	Older Alluvium of Pleistocene age (Aquifer Code-AL03) Four aquifers (Aquifer-I, II, III & IV) are identified at Mohinipara Deep Exploratory Well and Shallow Exploratory Well during in-house exploration by CGWB, ER (depth of construction: 236 m & 57 m) Aquifer-I: Depth range varies from 36.0 m to 42.0 m Aquifer-II: Depth range varies from 49.0 m to 55.0 m Aquifer-III: Depth range varies from 170.0 m to 190.0 m Aquifer-IV: Depth range varies from 222.0 m to 232.0 m
Normal Rainfall	2041.0 mm

AQUIFER DISPOSITION

Aquifer Disposition

Aquifer-I & Aquifer-II: Shallow aquifer

- Occurs throughout the block with variable thickness
- Aquifer material is Older Alluvium of Pleistocene age

Aquifer-III & Aquifer-IV: Generally occurs under confining condition (moderately deep to deep)

- Four aquifers are identified at Mohinipara and Surun.
- Three aquifers are identified at Kotar, Purba Durlabhpur, Dakhinal, Sonapur and Basudebpur
- Aquifer-III is exposed at variable depth (range: 70.1 m to 162.0 m) as per in house data and data of tube wells of state government (PHED, Raiganj Division)
- Aquifer-IV is exposed at Surun (103.63 m to 158.50 m) & at Mohinipara Deep Exploratory Well (222.0 m to 232.0 m)

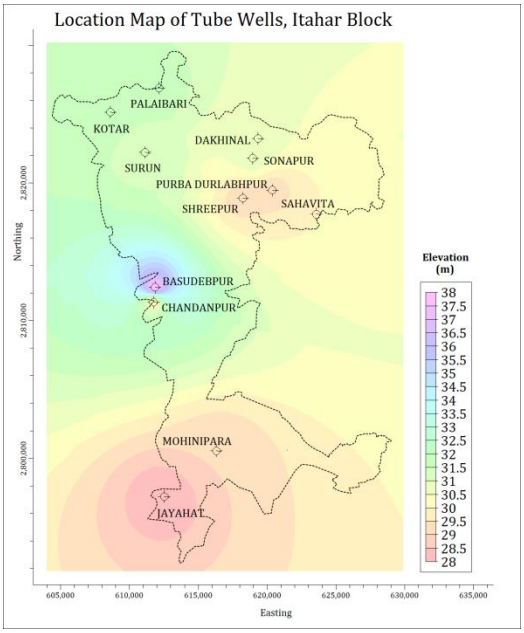


Fig. 1: Elevation map with location of Tube Wells, Itahar block

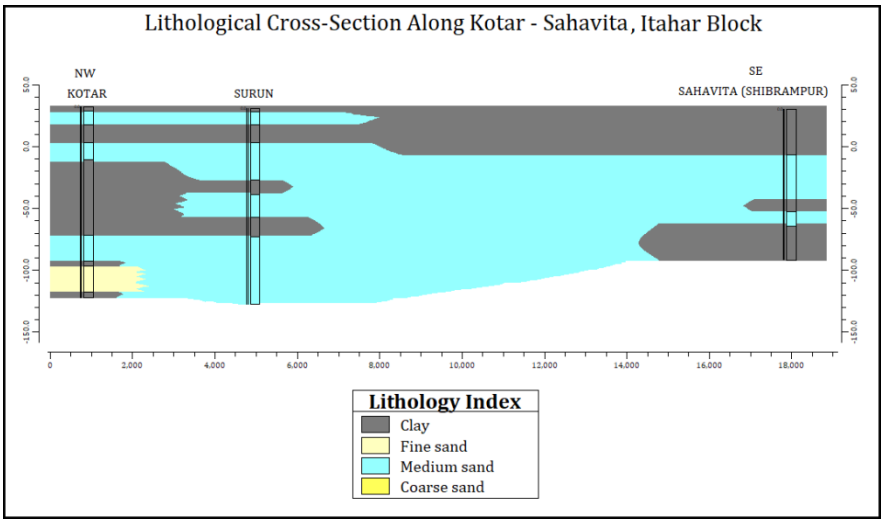


Fig. 2: Lithological cross section along Kotar-Surun-Sahavita (Shibrampur)

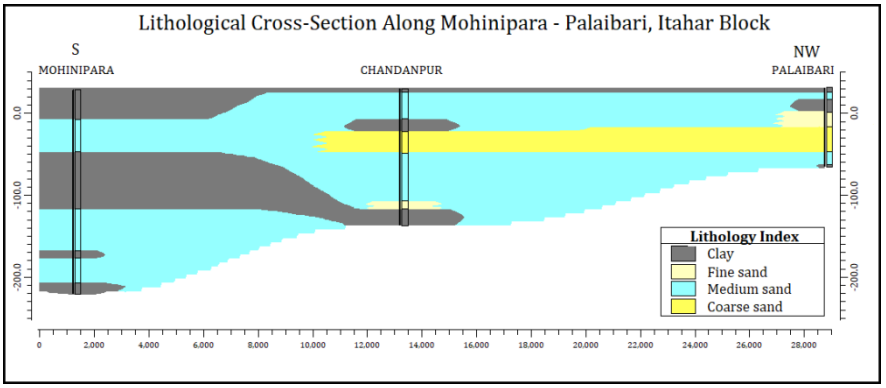


Fig. 3: Lithological cross section along Mohinipara-Chandanpur-Palaibari

Status of GW Exploration

Exploratory Wells of CGWB: 2
Observation Wells of CGWB: 1
Tube Wells of PHED/Agri-irrigation Department: 11
Monitoring Wells of State Water Investigation Directorate: 5

Aquifer Characteristics

AQUIFER	DISCHARGE (m^3/day)	DRAWDOWN (m)	T (m^2/day)	S
Aquifer-I	720.60	1.70	879.37	2.07×10^{-3}
Aquifer-II, Aquifer-III & Aquifer-IV	31.97 – 2127.57	3.20	1320.84	1.60×10^{-3}

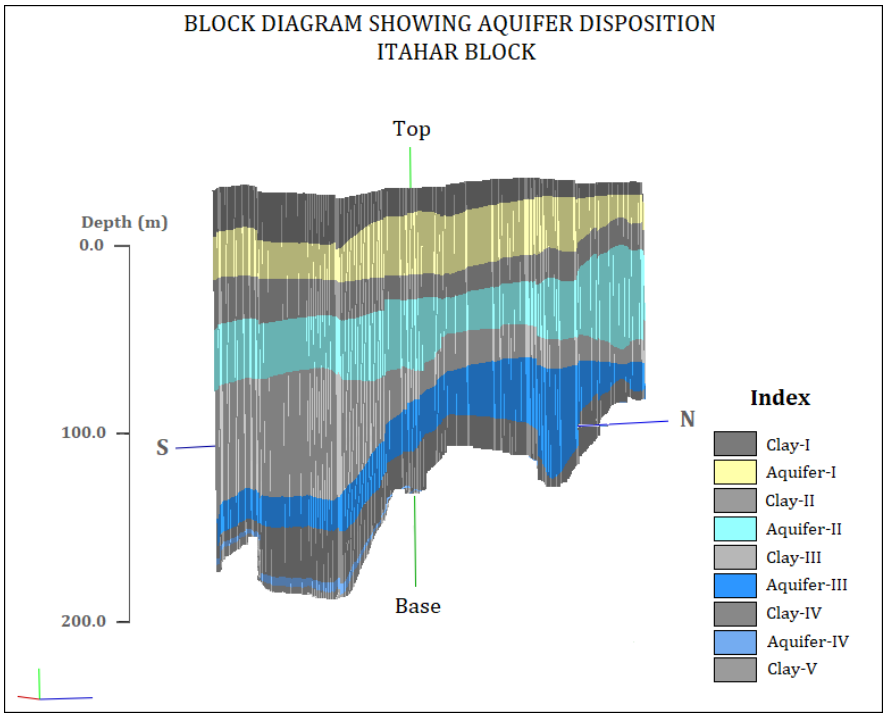


Fig. 4: Block diagram showing aquifer disposition in 3-D, Itahar block

Groundwater Monitoring Status

Ground water monitoring is being done four times in a year through four monitoring wells at Amlapara, Durgapur, Patirajpur & Sripur (Itahar). Besides, two Key Observation Wells were established at Churamon & Angardighi (Itahar) during the present NAQUIM study.
Average DTW (pre-monsoon 2022): 7.77 m bgl
Average DTW (post-monsoon 2021): 4.08 m bgl
Average water table elevation (pre-monsoon 2022): 24.03 m
Average water table elevation (post-monsoon 2021): 27.72 m

Groundwater Quality

As per Fluoride Task Force of Govt. of West Bengal, Itahar block has been declared as fluoride contaminated. However, CGWB data has shown fluoride above permissible limit (1.5 mg/L) was not observed

	in Itahar block, as highest fluoride concentration reported was 1.0 mg/L in Churamon, followed by 0.97 mg/L at Itahar.
Groundwater Resource (as on 31-3-2013)	Net Annual Ground Water Availability: 18442.69 ham Existing Gross Ground Water Draft for All Uses: 14963.23 ham Stage of Ground Water Development: 81.13 % Category: Safe Safe category has been assigned due to absence of long-term decline in groundwater level, as per the GEC-1997 methodology
Future Water Demand (as on 31-3-2013)	GW allocation for future domestic use (up to 2025 AD): 773.78 ham

Aquifer Management Plan

Groundwater Management Plan

<u>Groundwater management strategies</u>:

- Due to occurrence of Barind Tract with thick clay layers, aquifer potential in Itahar block is comparatively less. Water scarcity problem has been reported during summer season due to intensive cultivation of summer paddy (Boro), which is to be addressed through alternate cropping like peanuts, jute, maize, sunflower & soybean having higher water use efficiency and lower crop water requirement.
- Design, development and installation of smart water supply measurement and monitoring system for real time monitoring of groundwater level and periodic assessment of groundwater quality, both in pre-monsoon and post-monsoon period.
- Implementation of Jal Dhoro Jal Bhoro scheme by Government of West Bengal for protection and conservation of water resources, especially rainwater in traditional surface water bodies (ponds and bils).
- Proactive role needs to be taken by the district and block administration for ground implementation of centrally funded schemes like Pradhan Mantri Krishi Sinchai Yojana – Har Khet Ko Paani (PMKSY-HKKP) – Ground Water scheme and successful outcome of Jal Shakti Abhiyan – Catch The Rain (JSA-CTR) 2022 campaign.
- Organization of Public Interaction Programme in block headquarter (Itahar) for raising awareness on sustainable groundwater management through participatory approach along with capacity building of the stakeholders.

Artificial Recharge and Water Conservation

- Due to categorization of Itahar block under Safe category, implementation of artificial recharge scheme is not required as per latest Master Plan on Artificial Recharge (CGWB 2020).
- Pilot studies on roof top and open area rain water harvesting may be taken up as Pilot Projects in few government buildings like BDO Office at Itahar, Itahar Rural Hospital and

Government ITI near Durgapur.

- Generation of awareness on water resources management and conservation may be initiated in urban and peri-urban areas like Itahar and Sripur. This is to be done with active co-operation by the block administration and the stakeholders.
- Construction of Amrit Sarovars at feasible sites with active participation from the district and block administration, as an integral component of Jal Shakti Abhiyan – Catch The Rain (2022) campaign.

PART – III

DATA GAP ANALYSIS, UTTAR DINAJPUR DISTRICT

10.1 GENERAL

In the context of aquifer mapping, Data Gap Analysis (DGA) has the following major objectives (CGWB 2013)

- Identification of gaps in the existing data on various aspects of the aquifer being mapped.
- Optimization of additional data requirements for a realistic depiction of the aquifer system and management of its groundwater resources.

The process of identification of data gap involves the following steps:

- Compilation of the available data on the aquifer being studied.
- Compilation of the data collected in a common standardized format.
- Interpretation/analysis of each data layer.
- Identification of data gaps with respect to thematic layers, sub-surface data and data on groundwater recharge and draft.

10.2 DATA GAP ANALYSIS ON GROUNDWATER EXPLORATION

As per the guidelines on aquifer mapping, 3 to 4 "Special Purpose Wells (SPW)" need to be constructed in the corner quadrants of each topographic sheet (on 1:50000 scale) at suitable locations to get the subsurface lithological details (CGWB 2013). In addition to this, a "Well Field" comprising two Exploratory Wells (EW) and two Observation Wells (OW), totalling four wells, tapping each aquifer (Aquifer-I, II etc.) should be constructed to find out the aquifer disposition. To sum up, there should be total eight wells, including four SPW and four EW and OW, in each of the topographic sheets.

As more than 95% of the mappable area of Uttar Dinajpur district is covered by seven Survey of India topographic sheets (78 B/4, 78 B/7, 78 C/2, 78 C/3, 78 C/5, 78 C/6 and 72 O/13), there should be at least 56 wells in the district to adequately represent the aquifer disposition following the standard guidelines. However, existing data on in-house groundwater exploration in the district reveals only 15 wells, including 11 EW and 4 OW. This indicates a need to construct another 41 wells (including SPW) in the district. Already a proposal has been under consideration to construct 11 wells including 8 EW and 3 OW in Uttar Dinajpur district through outsourcing exploration. However, due to budgetary constraint, the remaining 30 wells could not be taken up for construction in the immediate

future (AAP: 2022-23). Therefore, presently there will be 30 wells (including EW, OW) that may be considered as Data Gap. In the present time (August 2022), the Data Gap in Uttar Dinajpur district would be 41 wells as the 11 wells through outsourcing exploration are yet to be constructed. The wells proposed for construction need to be constructed keeping in mind the variation in number of wells in each of the nine Community Developmental Blocks. An order of priority of construction of the wells identified after Data Gap Analysis in the nine blocks may be as follows (in descending order of priority):
Chopra block, Goalpokhar-I block, Goalpokhar-II block, Karandighi block, Hemtabad block, Itahar block (falling in Barind Tract), Raiganj block (falling in Barind Tract) and Kaliaganj block.

Toposheet wise and quadrant wise location of eight exploratory wells drilled by CGWB in Uttar Dinajpur district (updated as on 30-6-2022) is shown in **Fig. 10.1.** A perusal of **Fig. 10.1** indicates that maximum number of exploratory wells of CGWB exists in Kaliaganj block and reasonably sufficient number in Islampur block, but the number of such wells is much less in Raiganj and Itahar block. As on date, there are no exploratory well in Goalpokhar-I, Goalpokhar-II, Hemtabad, Karandighi and Chopra blocks. As such, these five blocks are virgin area as far as in house groundwater exploration is concerned.

10.3 DATA GAP ANALYSIS ON GEOPHYSICAL DATA

As per the guidelines on aquifer mapping, considering the case of Uttar Dinajpur district having two main aquifer groups (Aquifer-I and Aquifer-II), the recommended number of Profiling/Vertical electrical Sounding (VES)/Transient Electromagnetic Survey (TEM) should be three in each of the nine quadrants of a topographic sheet (on 1:50000 scale). Therefore, for each topographic sheet, the total number of Profiling/VES/TEM should be 27. Considering nine toposheets, the total number of Profiling/VES/TEM desirable is 9x27 = 243 Profiling/VES/TEM. Therefore, the present Data Gap is 243 such survey having 300 m interpretation depth in Uttar Dinajpur district. Since this is a huge number, it is proposed to adopt outsourcing geophysical survey to fulfil the Data Gap in respect of geophysical survey in a time bound manner. Considering the budgetary constraint and other issues, at least 50% of this number, viz. about 120 such VES/TEM survey could be completed in a time bound manner through accelerated geophysical

survey or outsourcing geophysical survey during the remaining part of AAP: 2022-23 and also possibly during the AAP: 2023-24.

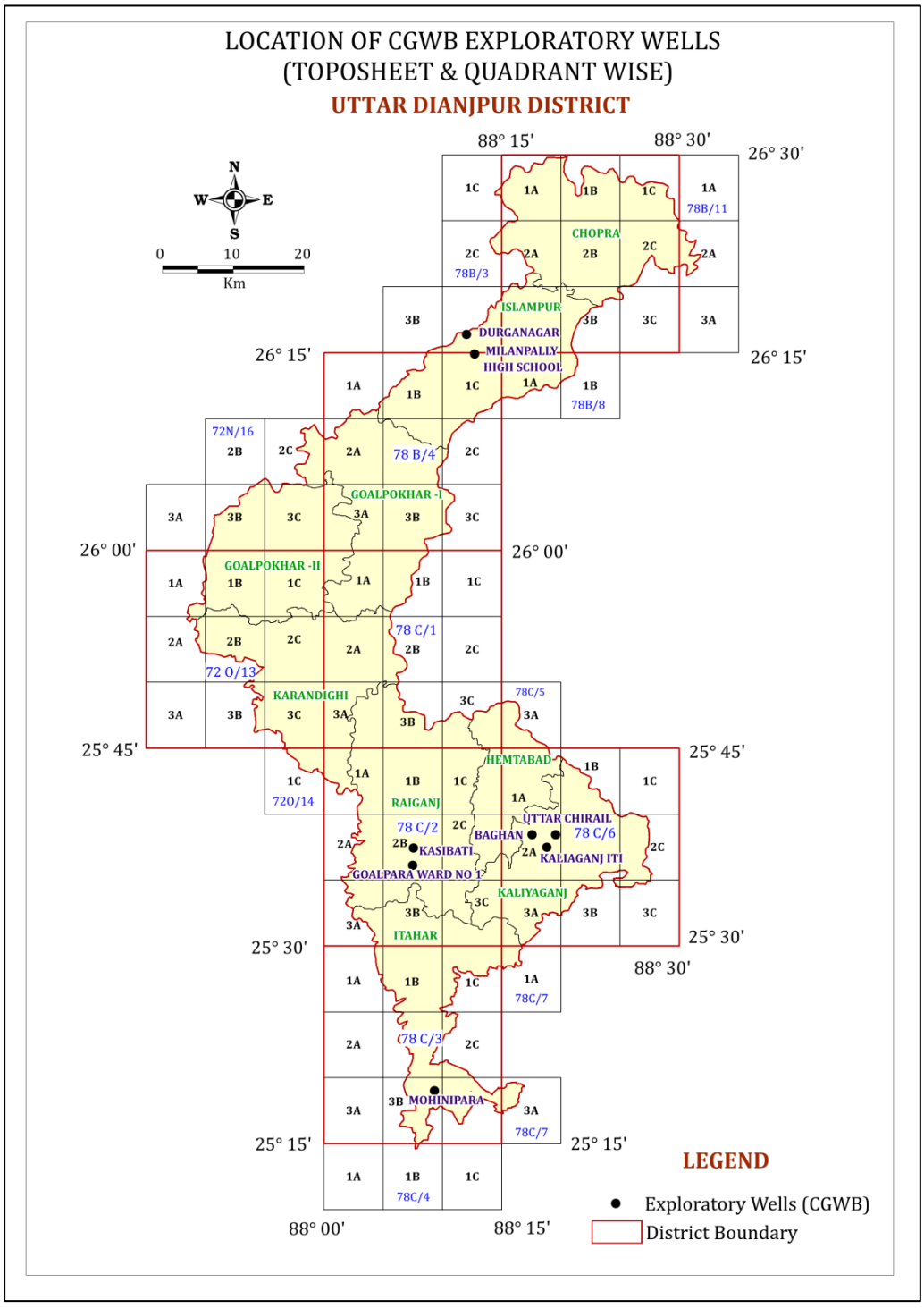


Fig. 10.1 Toposheet wise and Quadrant wise Data Gap Analysis for Groundwater Exploration, Uttar Dinajpur district (as on 30-6-2022)

10.4 DATA GAP ANALYSIS ON GROUNDWATER MONITORING

Data required for groundwater monitoring as per the Manual on Aquifer Mapping (CGWB 2013) are as follows:

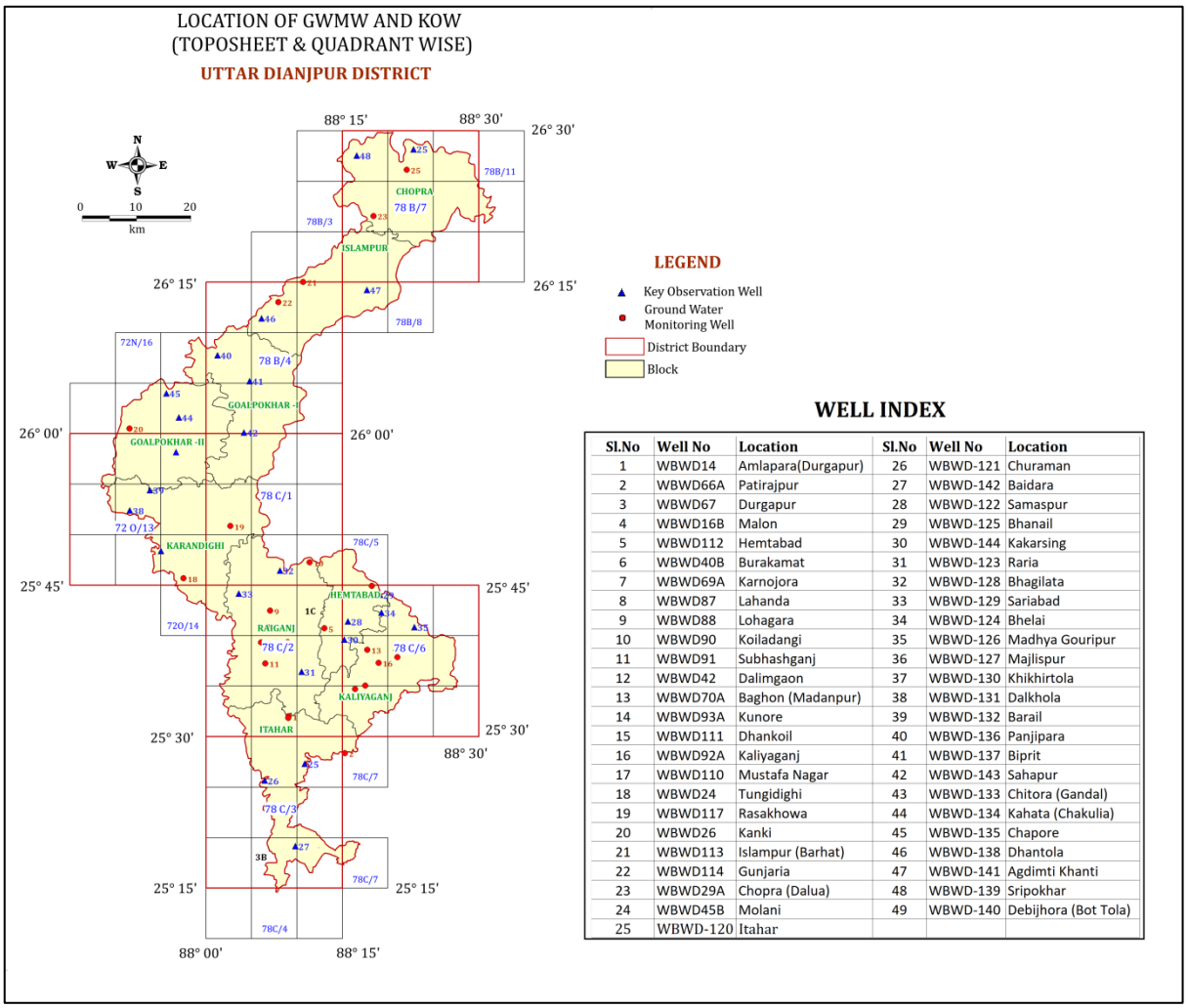
- For unconfined aquifer (Aquifer-I), two open wells/Dug Wells are recommended for each of the nine quadrants of a topographic sheet (on 1:50000 scale)
- For 2nd and 3rd aquifer (Aquifer-II, Aquifer-III and so on), Special Purpose Wells (SPW)/Piezometers (PZ) may be constructed in the central quadrant and one each in four corner quadrants.

This indicates that to adequately represent the groundwater regime in Uttar Dinajpur district, there should be 5 SPW/PZ and 18 DW in one topographic sheet. The total number of monitoring wells in one topographic sheet would be 23 (18 DW and 5 PZ/SPW), which is an ideal condition and not achievable in the present situation. For nine topographic sheets, the total number of monitoring wells should be 9 x 23 = 207 monitoring wells. This includes 162 Dug Wells (DW) and 45 Piezometers (PZ) for the entire district. During the present study, 25 Ground Water Monitoring Wells (GWMW) were measured. Apart from this, 27 Key Observation Wells (KOW) were inventoried during the aquifer mapping study. The break-up of DW and PZ and Tube Well (TW) is as follows (as on May 2022):

- Dug Well: 6 (at Durgapur, Malon, Tungidighi, Kanki, Madaripur, Dalimgaon)
- Piezometers and Tube Wells: 48 including two Piezometers (at Durgapur and Islampur) and 46 tube wells (19 GWMW and 27 KOW)
- Total number of Dug Wells, Piezometers and Tube Wells: 54
- Data Gap: 207 – 54 = 153 Monitoring Wells/Special Purpose Wells

Monitoring data from 44 Tube Wells and Piezometers was collected during the field survey from State Water Investigation Directorate (SWID), Raiganj for pre-monsoon and post-monsoon 2021. However, as the SWID Piezometers are invariably covered from top and fitted with Automatic Water Level Recorders, quarterly monitoring (manually by CGWB hydrogeologists) is not possible every year. There is a proposal to construct one Piezometer (150 m deep) at Dakshin Ariagaon, Chopra block through outsourcing drilling during the AAP: 2022-23. However, considering the huge Data Gap of 153 monitoring wells, in the first phase, at least 100 dedicated Special Purpose Wells/Piezometers need to be constructed through outsourcing drilling so that the data may be utilized to analyse the variation in groundwater level and both short-term and

long-term fluctuations. Fulfilling the Data Gap for groundwater monitoring would be a real challenge, considering the substantial expenditure and time required to complete, albeit partially, the requirement of having sufficient number of monitoring stations (in house) in Uttar Dinajpur district. Location of 49 Ground Water Monitoring Wells and Key Observation Wells in Uttar Dinajpur district (as on May 2022) is shown in **Fig. 10.2.** The map shows locations of only 49 wells out of 54 previously mentioned as few monitoring wells of varying types (Dug Well, Tube Well, Piezometer) are located so closely that they cannot be visually represented in the district level location map.



WELL INDEX

Sl.No	Well No	Location	Sl.No	Well No	Location
1	WBWD14	Amlapara(Durgapur)	26	WBWD-121	Churaman
2	WBWD66A	Patirajpur	27	WBWD-142	Baidara
3	WBWD67	Durgapur	28	WBWD-122	Samaspur
4	WBWD16B	Malon	29	WBWD-125	Bhanail
5	WBWD112	Hemtabad	30	WBWD-144	Kakarsing
6	WBWD40B	Burakamat	31	WBWD-123	Raria
7	WBWD69A	Karnojora	32	WBWD-128	Bhagilata
8	WBWD87	Lahanda	33	WBWD-129	Sariabad
9	WBWD88	Lohagara	34	WBWD-124	Bhelai
10	WBWD90	Koiladangi	35	WBWD-126	Madhya Gouripur
11	WBWD91	Subhashganj	36	WBWD-127	Majlispur
12	WBWD42	Dalimgaon	37	WBWD-130	Khikhirtola
13	WBWD70A	Baghon (Madanpur)	38	WBWD-131	Dalkhola
14	WBWD93A	Kunore	39	WBWD-132	Barail
15	WBWD111	Dhankoil	40	WBWD-136	Panjipara
16	WBWD92A	Kaliyaganj	41	WBWD-137	Biprit
17	WBWD110	Mustafa Nagar	42	WBWD-143	Sahapur
18	WBWD24	Tungidighi	43	WBWD-133	Chitora (Gandal)
19	WBWD117	Rasakhowa	44	WBWD-134	Kahata (Chakulia)
20	WBWD26	Kanki	45	WBWD-135	Chapore
21	WBWD113	Islampur (Barhat)	46	WBWD-138	Dhantola
22	WBWD114	Gunjaria	47	WBWD-141	Agdimti Khanti
23	WBWD29A	Chopra (Dalua)	48	WBWD-139	Sripokhar
24	WBWD45B	Molani	49	WBWD-140	Debijhora (Bot Tola)
25	WBWD-120	Itahar			

Fig. 10.2 Toposheet wise and Quadrant wise Data Gap Analysis for Groundwater Monitoring, Uttar Dinajpur district (May 2022)

10.5 DATA GAP ANALYSIS ON GROUNDWATER QUALITY

As per Manual on Aquifer Mapping (CGWB 2013), the following requirements for chemical sampling points are mentioned:

- For unconfined aquifer/first aquifer (Aquifer-I): One sample from open wells/Dug Wells for each of the nine quadrants of a topographic sheet
- For confined aquifer/second aquifer (Aquifer-II, Aquifer-III and so on): Sample to be collected from wells constructed in the well fields (as mentioned in groundwater exploration) and also from the Special Purpose Wells (SPW). One sample each to be collected from four corner quadrants and one sample from the central quadrant.

Considering each topographic sheet, the required number of groundwater samples to be collected from shallow aquifer (unconfined aquifer or Aquifer-I) would be nine. For seven such topographic sheets (Sheet No. 78 B/4, 78 B/7, 78 C/2, 78 C/3, 78 C/5, 78 C/6 and 72 O/13), there should be at least 63 sampling locations in Uttar Dinajpur district. For water sample collection from the deeper (confined) aquifer, there should be five samples from each topographic sheet. Therefore, for seven such sheets, total number of water samples from deeper aquifer would be: 7 x 5 = 35 samples. The break-up of desirable number of water samples for chemical quality study in Uttar Dinajpur district is as follows:

- For shallow aquifer (Aquifer-I): 63 water samples from nine blocks
- For deeper aquifer (Aquifer-II, Aquifer-III and so on): 35 water samples from nine blocks
- Total desirable number of water samples: 98 water samples from the district

During the present study, 53 samples were collected from the shallow aquifer, taking the Ground Water Monitoring Wells and Key Observation Wells as the sample collection points. Sample collection during pre-monsoon 2021 was severely hampered due to COVID-19 virus outbreak, which also hampered the field surveys during the period from April 2021 to September 2021. Water sample collection from deep tube wells is another issue as almost all the tube wells are fitted with pumps and only treated water samples meant for drinking are available for analysis. Without knowing the nature of aquifer (unconfined/confined), it is very difficult to ensure that water samples are being collected from the confined aquifers only. Therefore, it was not possible to ensure sample collection from the deeper aquifer in Uttar Dinajpur district during the

present study. However, considering chemical analysis of groundwater samples that are collected from Aquifer-I (shallow, unconfined aquifer) only, the existing Data Gap would be: 63 – 53 = 10 samples. For the confined aquifer, the Data Gap would be 35 samples. Therefore, based on data availability and data requirement, the total Data Gap for chemical quality is 45 samples (10 samples for unconfined aquifer and 35 samples from deeper, confined aquifer).

In reality, the actual field condition does not permit to have the desirable density of water quality sampling locations due to various issues like:

- Location of PHED Head Work Sites in places that does not follow the gridded pattern of the topographic sheet.
- Non-existence of ideal (desirable) density of Ground Water Monitoring Wells and Key Observation Wells of CGWB and Special Purpose Wells of state government departments.

REFERENCES

Alam, M., Alam, M.M., Curray, J.R., Chowdhury, M.L.R., Gani, M.R. (2003) An overview of the sedimentary geology of the Bengal Basin in relation to the regional tectonic framework and basin-fill history, *Sedimentary Geology,* 155(3-4), pp. 179-208

Ball, V. (1877) Geology of the Rajmahal Hills, Memoir of the Geological Survey of India, vol. 13(II), pp. 155-248

Biswas, S., Mukhopadhyay B.P. and Bera, A. (2020) Delineating groundwater potential zones of agriculture dominated landscapes using GIS based AHP techniques: a case study from Uttar Dinajpur district, West Bengal, *Environmental Earth Sciences,* 79:302

Bureau of Applied Economics and Statistics (2014), District Statistical Handbook, Uttar Dinajpur, Department of Statistics and Programme Implementation, Government of West Bengal

Central Ground Water Board (2011), Status Report on Geophysical Activities (on both Surface and Sub-surface) in West Bengal, conducted by Eastern Region, Kolkata, 298 p.

Central Ground Water Board (2013) Manual on Aquifer Mapping, Ministry of Water Resources, Govt. of India, Faridabad, 72 p.

Central Ground Water Board (2014), Aquifer Systems of West Bengal, CGWB, Eastern Region, Kolkata, Ministry of Water Resources, Govt. of India

Central Ground Water Board (2020), Master Plan for Artificial Recharge to Ground Water in India, CGWB, Ministry of Jal Shakti, Govt. of India, Faridabad

Climate Research and Services, Observed Rainfall Variability and Changes over West Bengal State, India Meteorological Department, Pune (2020) Met. Monograph No. ESSO/IMD/HS/Rainfall Variability/29(2020)/53, 29 p.

Geological Survey of India (2009) News, Geological Survey of India, Eastern Region, Kolkata, vol. 30, no. 1-2

Ghosh Dastidar, D. and Das, P.K. (2004) Report on Reappraisal Hydrogeological Survey in Dakshin Dinajpur and parts of Uttar Dinajpur District, West Bengal, Central Ground Water Board, Eastern Region, Kolkata; Technical Report Series-D, No. 167

Guha, R.K. (2009) Ground Water Exploration in West Bengal, Central Ground Water Board, Eastern Region, Kolkata; Technical Report Series-D, No. 219

Multi Hazard District Disaster Management Plan 2016-17 of Uttar Dinajpur District (2018), Office of the District Magistrate, Uttar Dinajpur, 125 p.

Roy, A.B. and Chatterjee, A. (2015) Tectonic framework and evolutionary history of the Bengal Basin in the Indian subcontinent, *Current Science,* 109:271-279

Sen, G. (2013) District Ground Water Brochure: Uttar Dinajpur, West Bengal; Scientific Report Series: E, Sl. No. 48

Siddiqui S.H., Afzal, F. and Hoque, A. (2017) Assessment of Irrigation Extension and Development in Uttar Dinajpur district of West Bengal: A Block Level Analysis, *Asian Profile,* 45(5): 422-435

Talukdar, T. (1998) Report on Reappraisal Hydrogeological Survey in Parts of Mahananda Sub-basin in Uttar Dinajpur and Darjeeling Districts, West Bengal, Technical Report Series-D, No. 138

Talukdar T. and Bandopadhyay S. (2017) Hydrogeological Framework and Ground Water Resources of West Bengal State, Central Ground Water Board, Ministry of Water Resources, River Development and Ganga Rejuvenation, Govt. of India

ANNEXURE-I

Details of Exploratory Drilling (In House), Uttar Dinajpur district

Sl No.	Location	Block/ Year of construction	Co-ordinate (in DD)	Drilled Depth (m)	Well Construction Depth (m)	Zones Tapped (mbgl)	SWL (mbgl)	Discharge (lps)	Drawdown (m)	Transmissivity, T (m2/day)	Storativity (S)	Chemical quality
1.	Baghan EW	Kaliaganj	25.6409 N 88.2931 E	337.36	NA	34.45-41.00 45.93-55.77 72.18-98.42 137.19-154.19	NA	58.86	4.63	2045.00 m^2/day	NA	Potable
2.	Kaliaganj ITI (SEW)	Kaliaganj (2006-2007)	25.6250 N 88.3139 E	149.48	96.00	78.0-93.0	8.34	20.0 (330 min of pumping)	3.39	1816.85 m^2/day	NA	Potable
3.	Kaliaganj ITI (DEW)	Kaliaganj (2006-2007)	NA	251.13	224.50	185.5-193.5 213.5-221.5	Dry	NA	NA	NA	NA	NA
4.	Uttar Chirail	Kaliaganj (2006-2007)	25.6406 N 88.3264 E	61.20	57.00	33.0-54.0	3.28	19.05	3.02	1004.00 m^2/day	NA	Potable
5.	Goalpara Ward No. 1 (DEW)	Raiganj (2006-07)	25.6022 N 88.1250 E	251.93	248.00	215.0-227.0 233.0-245.0	3.684	9.39	11.617	611.00 m^2/day	$5.29x10^{-5}$	Potable
6.	Goalpara	Raiganj	25.6022 N	247.65	246.00	216.0-225.0	NA	NA	NA	NA	NA	NA

	Ward No. 1 (DOW)	(2006-07)	88.1250 E			234.0-243.0						
7.	Goalpara Ward No. 1 (SEW)	Raiganj	25.6022 N 88.1250 E	115.00	113.00	86.0-110.0	3.88	12.12	2.59	1518.00 m^2/day	$1.10x10^{-3}$	NA
8.	Goalpara Ward No. 1 (SOW)	Raiganj	25.6022 N 88.1250 E	NA	111.00	90.0-108.0	NA	NA	NA	NA	NA	NA
9.	Kasibati EW	Raiganj	25.6240 N 88.1462 E	240.30	157.00	91.0-109.0 148.0-154.0	5.03	2.19	8.45	776.79 m^2/day (J) 785.93 m^2/day (T)	NA	NA
10.	Milanpally High School, Ward No. 7 (EW)	Islampur (2006-2007)	26.2486 N 88.2125 E	215.54	205.00	155.0-173.0 178.0-190.0 196.0-202.0	3.10	22.14	3.98	1706.57 m^2/day	$5.39x10^{-4}$	Potable
11.	Milanpally High School, Ward No. 7 (OW)	Islampur (2006-2007)	26.2486 N 88.2125 E	203.85	210.00	160.0-169.0 180.0-186.0 197.0-200.0	3.17	24.16	1.10	NA	NA	Potable
12.	Durganagar Ward No. 1 (EW)	IslampurMunicipality (2006-2007)	26.2456 N 88.2706 E	248.59	206.00	158.0-164.0 178.0-190.0 193.0-203.0	3.65	11.35	3.35	839.38 m^2/day (J) 751.36 m^2/day (T)	NA	Potable
13.	Mohinipara/Kasba	Itahar (2005-	25.3167 N 88.1556 E	250.00	236.00	170.0-190.0 222.0-232.0	6.40	0.37	3.20	879.37 m^2/day	$2.07x10^{-3}$	Potable

	(DEW)	2006)										
14.	Mohinipa ra/Kasba (SEW)	Itahar (2005-2006)	25.3167 N 88.1556 E	58.00	57.00	36.0-42.0 49.0-55.0	3.52	8.34	1.70	1320.84 m^2/day	$1.60x10^{-3}$	Potable
15.	Mohinipa ra/Kasba (SOW)	Itahar (2005-2006)	25.3167 N 88.1556 E	57.60	55.00	36.0-42.0 48.0-54.0	11.50	6.70	NA	NA	NA	NA

ANNEXURE-II

Depth to Water Level and Other Relevant Data of Piezometers and Tube Wells of State Water Investigation Directorate (SWID), Raiganj

Sl. No.	Block	Name of Water Level Monitoring Station	Type of Well	Latitude	Longitude	Date of measurement (April & November)	DTW (April 2021) in m bgl	DTW (November 2021) in m bgl	Remarks
1	Chopra	Sadhuramgachh Block Seed Farm	PZ	26.3583	88.3078	05-4-2021 16-11-2021	5.48	3.13	SWID PZ
2	Chopra	Sonapur Oil India Limited, Dumdangi	PZ	26.4777	88.2925	05-4-2021 16-11-2021	3.98	2.87	SWID PZ
3	Chopra	M. G. High School, Sonapur Hat	Tube Well	26.4407	88.2594	05-4-2021 16-11-2021	5.36	3.27	
4	Islampur	Chopra High School	Tube Well	26.3656	88.3114	05-4-2021 16-11-2021	5.38	3.23	
5	Islampur	Ramganj High School	Tube Well	26.3197	88.2886	06-4-2021 17-11-2021	4.37	3.43	
6	Islampur	Barhat Block Seed Farm	Tube Well	26.2502	88.1772	06-4-2021 17-11-2021	4.42	1.39	
7	Islampur	Madaripur High School	Tube Well	26.3083	88.2619	06-4-2021 17-11-2021	4.94	3.19	
8	Islampur	Islampur State Farm Colony High School	PZ	26.2737	88.2042	06-4-2021 17-11-2021	5.01	2.45	SWID PZ
9	Islampur	Pandipota Madrasa	Tube Well	26.2112	88.1733	06-4-2021 17-11-2021	4.67	3.44	
10	Islampur	Gunjaria Gram Panchayat Office	Tube Well	26.2173	88.1322	06-4-2021 17-11-2021	4.84	3.29	

11	Goalpokhar-I	Majlishpur Seed Godown	Tube Well	26.1006	88.0011	07-4-2021 22-11-2021	4.88	2.78
12	Goalpokhar-I	Ikarchala Junior Basic School	Tube Well	26.1664	88.0703	07-4-2021 22-11-2021	3.20	1.20
13	Goalpokhar-I	Parialpur Gandhapara F. P. School	Tube Well	26.0936	88.0264	07-4-2021 22-11-2021	5.17	4.23
14	Goalpokhar-I	Elahi Baksh High School, Panjipara	Tube Well	25.6319	88.1300	07-4-2021 22-11-2021	3.03	1.24
15	Goalpokhar-I	Biprit Free High School	Tube Well	26.0863	88.0808	07-4-2021 22-11-2021	4.72	4.33
16	Goalpokhar-I	Goalin Free Primary School	Tube Well	26.0331	88.1594	07-4-2021 22-11-2021	5.47	3.64
17	Goalpokhar-II	Majra Seed Godown	Tube Well	26.0279	87.9458	12-4-2021 23-11-2021	4.41	2.41
18	Goalpokhar-II	Kanki Police Station	Tube Well	26.0095	87.8583	12-4-2021 23-11-2021	3.73	3.73
19	Goalpokhar-II	Belan Junior High School	Tube Well	26.0762	87.9267	12-4-2021 23-11-2021	3.05	1.01
20	Goalpokhar-II	Chakulia High School	Tube Well	26.0249	87.9617	12-4-2021 23-11-2021	3.52	2.74
21	Goalpokhar-II	Surjapur High School	Tube Well	25.9363	87.8478	12-4-2021 23-11-2021	3.33	2.91
22	Karandighi	Mahesh Bathan A-I Farm House	Tube Well	25.8054	87.9197	13-4-2021 24-11-2021	4.30	3.15
23	Karandighi	Dalkhola PHC, Haripur	Tube Well	25.8732	87.8647	13-4-2021 24-11-2021	3.78	2.77
24	Karandighi	Rasakhowa Gram Panchayat (GP) Office,	Tube Well	25.8477	88.0349	13-4-2021 24-11-2021	5.98	3.84

		Kismat							
25	Karandighi	Altapur GP Office	Tube Well	25.7335	88.0222	13-4-2021 24-11-2021	5.78	3.43	
26	Karandighi	Patnour Free Primary School	Tube Well	25.8599	87.9003	13-4-2021 24-11-2021	5.72	3.09	
27	Raiganj	Raiganj Block Development Office, College Para	Tube Well	25.5015	88.1492	13-4-2021 24-11-2021	5.98	4.15	
28	Raiganj	Kamlabari-I G.P. Office, Karnojora	Tube Well	25.6769	88.2450	13-4-2021 24-11-2021	7.54	5.60	
29	Raiganj	Halalpur G.P. Office, Jagdishpur	P-Tube	25.7434	88.0650	13-4-2021 24-11-2021	4.79	4.09	SWID PZ
30	Raiganj	Mahipur G.P. Office	Tube Well	25.7525	88.1197	13-4-2021 24-11-2021	5.71	2.88	
31	Raiganj	Bindol G.P. Office	Tube Well	25.7655	88.1867	13-4-2021 24-11-2021	6.07	5.42	
32	Raiganj	Sitgram Bidya Bhawan	Tube Well	25.6847	88.0672	13-4-2021 24-11-2021	3.79	2.99	
33	Raiganj	SWID Div. No. V Campus, Karnojora	Tube Well	25.6545	88.1522	13-4-2021 24-11-2021	5.93	4.95	
34	Raiganj	SARF, Raiganj	P-Tube	25.6437	88.1371	13-4-2021 24-11-2021	5.04	4.70	
35	Hemtabad	Block Seed Farm, Hemtabad	Tube Well	25.6691	88.2283	19-4-2021 25-11-2021	6.10	3.31	
36	Hemtabad	Hemtabad G.P. Office	Tube Well	25.6781	88.2133	19-4-2021 25-11-2021	6.34	4.16	
37	Kaliaganj	Block Seed Farm, Durgapur	Tube Well	25.6306	88.3503	19-4-2021 25-11-2021	4.77	1.11	
38	Kaliaganj	Bhandar G.P. Office	Tube Well	25.6432	88.2950	19-4-2021	5.43	3.50	

						25-11-2021		
39	Kaliaganj	Health Sub-centre, Kunore	Tube Well	25.5790	88.2731	19-4-2021	8.33	2.46
						25-11-2021		
40	Itahar	Block Seed Farm, Sripur	Tube Well	25.4943	88.1758	19-4-2021	6.68	2.86
						25-11-2021		
41	Itahar	Durgapur G.P. Office	Tube Well	25.5309	88.1506	19-4-2021	6.21	3.69
						25-11-2021		
42	Itahar	Durlavpur G.P. Office	Tube Well	25.5130	88.1865	19-4-2021	6.81	5.31
						25-11-2021		
43	Itahar	Patirajpur G.P. Office	Tube Well	25.4172	88.2529	19-4-2021	7.09	6.39
						25-11-2021		
44	Itahar	Joyhat G.P. Office	Tube Well	25.3178	88.1633	19-4-2021	13.34	6.93
						25-11-2021		

Source: State Water Investigation Directorate, Government of West Bengal

ANNEXURE-III

Key Observation Wells (KOW) Established During Aquifer Mapping and Management Study, Uttar Dinajpur district

Sl. No.	KOW No.	Location with Co-ordinates	Height of M.P. (m)	Depth to Water Level (m bgl)		Atmospheric & Water Temperature (^{0}C)		Date of Installation/ Survey	Remarks
				Monsoon	Post-monsoon	Monsoon	Post-monsoon		
1	WBWD-120	At Angardighi, ~200 m from Itahar Chowk on Itahar-Patirajpur road, LHS of road, in front of the house of Sh. Sanjay Shil 25.4553 N, 88.1807 E	0.72	3.21	3.31	A: 34.0 W: 29.0	A: 25.0 W: 27.0	I: 2014 AD S: 08-9-2021, 19-11-2021	Used extensively for drinking and domestic work, cast iron tube well
2	WBWD-121	At Churamaon in Itahar block, ~8 km west of Itahar, inside Churamon P.C. High School, in front of Rabindra Bhawan 25.4276 N, 88.1071 E	0.85	8.10	7.25	A: 34.0 W: 28.0	A: 24.0 W: 26.0	I: 2000 AD S: 08-9-2021, 19-11-2021	Used extensively for drinking, samples collected in post-monsoon for basic and heavy metal analysis
3	WBWD-122	At Samaspur (Hemtabad block), ~5 km east of Hemtabad on Malon road, LHS of road, in front of the house of Sh. M. Rahaman 25.6902 N, 88.2599 E	0.75	2.81	2.25	A: 32.0 W: 28.0	A: 28.0 W: 26.0	I: 2021 AD S: 09-9-2021, 20-11-2021	Drilled depth: 300 feet (reported), installed by Gram Panchayat Samaspur, used for drinking; TDS = 65 mg/L on 09-9-21

4	WBWD-123	At Raria (Raiganj block), ~10 km south-east of Raiganj via Sijgaon-Malgaon road towards Kaliaganj, LHS of road, in front of Kali Temple 25.6072 N, 88.1747 E	0.80	3.43	3.36	A: 32.0 W: 29.0	A: 26.0 W: 24.0	I: 2016 AD S: 10-9-2021, 25-11-2021	Used extensively for drinking, India Mark-II hand pump, installed by 12 No. Barua Gram Panchayat, samples collected in post-monsoon for basic and heavy metal analysis
5	WBWD-124	At Bhelai (Kaliaganj block), ~8 km north of Kaliaganj on Bidisoil-Nischintapur road, LHS of road, in front of the house of Sh. Bartholi Murmu 25.7048 N, 88.3212 E	0.70	0.85	1.09	A: 31.0 W: 28.0	A: 27.0 W: 25.0	I: 2020 AD S: 10-9-2021, 20-11-2021	Used extensively for drinking, India Mark-II hand pump, located in tribal area, TDS = 53 mg/L on 10-9-21
6	WBWD-125	At Bhanail (Kaliaganj block), inside Bhanail Free Primary School, ~12 km north of Kaliaganj, LHS of Kaliaganj-Nischintapur-Malon road 25.7342 N, 88.3186 E	0.80	1.25	1.81	A: 31.0 W: 27.0	A: 28.0 W: 27.0	I: 2018 AD S: 10-9-2021, 20-11-2021	Used occasionally for drinking, India Mark-II hand pump, TDS = 80 mg/L on 10-9-21
7	WBWD-126	At Madhya Gauripur (Kaliaganj block), near Radha Krishna Temple, ~5 km north of Dalimgaon, via Shankarpur-Pandara-Pachakandar road, RHS of road 25.6810 N, 88.3819 E	0.75	3.13	2.89	A: 34.0 W: 28.0	A: 27.0 W: 26.0	I: 2001 AD S: 10-9-2021 20-11-2021	Used extensively for drinking, India Mark-II hand pump, drilled depth: 300 feet (reported), TDS = 56 mg/L on 10-9-21

8	WBWD-127	At Majlispur (Kaliaganj block), ~3 km north-east of Kaliaganj, ~50 m from Sitapur Bridge More, approach via Kaliaganj-Saharullahpur road 25.6472 N, 88.3479 E	0.85	2.70	2.04	A: 34.0 W: 28.0	A: 27.0 W: 28.0	I: 2021 AD S: 10-9-2021 20-11-2021	Used extensively for drinking, India Mark-II hand pump, adjacent to the shop of Sh. Suresh Deb Sharma, drilled depth: 60 feet (reported)
9	WBWD-128	At Bhagilata (Raiganj block), near village more, ~7 km west of Bindol on Bhatol road, in front of Bagha's Tuition Centre, RHS of road 25.7743 N, 88.1351 E	0.30	2.57	2.94	A: 32.0 W: 27.0	A: 24.0 W: 26.0	I: 2011 AD S: 11-9-2021 21-11-2021	Installed by Majlispur Gram Panchayat, India Mark-II hand pump, not used frequently
10	WBWD-129	At Sariabad (Raiganj block), ~4 km north of Nagar on Bhatol road, LHS of road towards Nagar Bridge, in front of Anganbari and Haque Sar Beej Bhandar 25.7362 N, 88.0598 E	0.80	2.57	2.94	A: 34.0 W: 28.0	A: 22.0 W: 25.0	I: 2011 AD S: 11-9-2021 21-11-2021	Installed by Block Development Office, Raiganj; drilled depth: 350 feet (reported), TDS = 99 mg/L on 11-9-21
11	WBWD-130	At Khikhirtola (Karandighi block), ~10 km south-east of Dalkhola, inside Nilkamal Industries, ~20 m from main road 25.8068 N, 87.9168 E	0.85	2.43	2.39	A: 32.0 W: 28.0	A: 25.0 W: 25.0	I: NA S: 11-9-2021 21-11-2021	Used for drinking, owner: Sh. Dulal Kundu, resident of Siliguri
12	WBWD-131	At Dalkhola (Karandighi block), inside Satsang Vihar and in front of temple, ~4 km before reaching Purnea More,	0.75	1.42	1.74	A: 31.0 W: 27.0	A: 24.0 W: 25.0	I: 1990 AD S: 11-9-2021 21-11-2021	Used extensively for drinking, cast iron tube well, TDS = 236 mg/L on 11-9-21

		LHS of Raiganj-Dalkhola road 25.8734 N, 87.8598 E							
13	WBWD-132	At Barail (Karandighi block), on Dalkhola-Chakulia road, ~6 km from Dalkhola Satsang Vihar, RHS of village road, in front of the house of Sh. Badruddin 25.9070 N, 87.8968 E	0.80	3.22	2.89	A: 34.0 W: 27.0	A: 25.0 W: 26.0	I: 2021 AD S: 12-9-2021 21-11-2021	Used for domestic work, water with high iron, cast iron tube well, TDS = 95 mg/L on 12-9-21
14	WBWD-133	At Chitora Gandal (Goalpokhar-II block), in front of Chitora Netaji Club, ~18 km north-east of Dalkhola via Amlabari-Lalganj-Chakulia road, RHS of road 25.9699 N, 87.9445 E	0.65	1.75	1.54	A: 35.0 W: NA	A: 26.0 W: NA	I: 2018 AD S: 12-9-2021 21-11-2021	Mark-II tube well, installed by Zila Parishad, Raiganj
15	WBWD-134	At Kahata (Chakulia) in Goalpokhar-II block, approachable by Lalganj-Chakulia-Lahil road, LHS of hospital road, in front of the house of Md. Ismail 26.0270 N, 87.9497 E	0.60	2.77	3.53	A: 31.0 W: 26.0	A: 23.0 W: 25.0	I: 2011 AD S: 12-9-2021 21-11-2021	India Mark-II tube well, used for drinking, TDS = 60 mg/L on 12-9-21
16	WBWD-135	At Chapore (Goalpokhar-II block), ~7 km north-west of Chakulia, near road diversion towards Bilatbari, in front of Kali Temple 26.0669 N, 87.9270 E	0.80	2.78	2.49	A: 31.0 W: 27.0	A: 23.0 W: 26.0	I: 2019 AD S: 12-9-2021 21-11-2021	Cast iron tube well, used for drinking, two such tube wells installed nearby, TDS = 76 mg/L on 12-9-21

17	WBWD-136	At Panjipara (Goalpokhar-I block), inside Model Madrasa, ~4 km south of Goalpokhar-I Block Office, approachable by right turn from NH-27 at Panjipara More 26.1296 N, 88.0208 E	0.47	1.66	1.87	A: 31.0 W: NA	A: 23.0 W: NA	I: 2019 AD S: 12-9-2021 22-11-2021	Submersible tube well, used occasionally for drinking
18	WBWD-137	At Biprit (Goalpokhar-I block), in front of Kali Temple, LHS of Panjipara-Biprit Chowk-Debiganj road, approachable also by Goagaon-Dhantola road 26.0870 N, 88.0793 E	0.70	1.77	2.57	A: 32.0 W: 27.0	A: 24.0 W: 25.0	I: NA S: 12-9-2021 22-11-2021	India Mark-II tube well, used occasionally for domestic work, water with high iron content, TDS = 66 mg/L on 12-9-21
19	WBWD-138	At Dhantola (Islampur block), in front of Kali Temple, near Dhantola Market, RHS of Dhantola-Rasakhowa-Botolbari-Raiganj road, ~13 km south-west of Islampur 26.1907 N, 88.1014 E	0.60	2.98	2.52	A: 31.0 W: 28.0	A: 23.0 W: 25.0	I: 2019 AD S: 12-9-2021 22-11-2021	India Mark-II tube well, used occasionally for domestic work, water with high iron content, installed by Dhantola Gram Panchayat, TDS = 61 mg/L on 12-9-21
20	WBWD-139	At Sripokhar (Chopra block), LHS of Sonapur Hat-Borobila-Haptia road, near Sripokhar SSK School, ~16 km north-west of Chopra, ~30 m from village road, near Sripokhar SKS 26.4591 N, 88.2760 E	0.60	1.72	1.47	A: 32.0 W: 28.0	A: 24.0 W: 25.0	I: 2018 AD S: 13-9-2021 22-11-2021	India Mark-II tube well, used occasionally for domestic work, installed by Block Development Office, Chopra

21	WBWD-140	At Debijhora Bottola (Chopra block), ~20 km north-east of Chopra via Chopra-Molani-Kachakali road, adjacent to Kali Temple and Debijhora Tea Estate 26.4696 N, 88.3801 E	0.75	3.53	3.67	A: 31.0 W: 26.0	A: 22.0 W: NA	I: 2013 AD S: 13-9-2021 22-11-2021	India Mark-II tube well, extensively used for drinking, installed by Block Development Office, Chopra
22	WBWD-141	At Agdimti Khanti (Islampur block), ~13 km east of Islampur Bus Stand via Islampur-Patagora road, LHS of road 26.2373 N, 88.2947 E	0.70	4.29	4.08	A: 31.0 W: 27.0	A: 21.0 W: 23.0	I: 2006 AD S: 13-9-2021 22-11-2021	India Mark-II tube well, extensively used for drinking
23	WBWD-142	At Baidara (Itahar block), ~22 km north of Gazole, LHS of Gazole-Raiganj road, in front of a dhaba owned by Sh. Majibur Rahaman 25.3194 N, 88.1636 E	0.29	8.28	5.63	A: 29.0 W: 30.0	A: 26.0 W: 30.0	I: 2019 AD S: 08-9-2021 19-11-2021	Submersible tube well, used for drinking, drilled depth is 150 feet (reported)
24	WBWD-143	At Shahpur (Goalpokhar-I block), in front of Junior High School, ~8.5 km north of Goagaon on Raiganj-Botolbari-Rudel-Dhantola road, LHS of village road 26.0020 N, 88.0692 E	0.70	--	3.31	--	A: 23.0 W: 25.0	I: 2015 AD S: -- 22-11-2021	India Mark-II tube well, used for domestic work, this is older tube well among the two, drilled depth is 150 feet (reported)
25	WBWD-144	At Kakarsing (Hemtabad block), near Sri Sri Utmai Chandi Mata Temple, ~4 km south-east of Hemtabad, LHS	0.75	--	2.39	--	A: 23.0 W: 25.0	I: 2020 AD S: -- 22-11-2021	India Mark-II tube well, used for drinking and domestic work, installed by Tabad

		of Raiganj-Hemtabad-Kaliaganj road 25.6604 N, 88.2532 E							Gram Panchayat Office
26	WBWD-145	At Birghai (Raiganj block), inside Birghai Primary School compound, ~11.5 km south-east of Raiganj via Dosti More-Taherpur-Dakshin Bajitpur-Paschim Manoharpur-Sahebghata road, LHS of village road 25.5637 N, 88.1746 E	0.66	4.72	5.59	A: 22.0 W: NA	A: 28.0 W: NA	I: 2014 AD (reported) S: 24-11-21 & 05-5-2022	India Mark-II tube well, not in working condition due to broken chain
27	WBWD-146	At Birghai (Raiganj block), inside Bhojo Gobindo Roy Madhyamik Siksha Kendra (MSK), Birghai, ~12 km south-east of Raiganj via Dosti More-Taherpur-Dakshin Bajitpur-Paschim Manoharpur-Sahebghata road, LHS of village road 25.5679 N, 88.1752 E	0.70	4.43	5.15	A: 23.0 W: NA	A: 28.0 W: NA	I: 2017 AD (reported) S: 24-11-21 & 05-5-2022	India Mark-II tube well, not in working condition due to broken chain

ANNEXURE-IV

Block Wise Ground Water Resource, Uttar Dinajpur district (as on 31-3-2013)

Name of Groundwater Assessment Unit	Recharge worthy area (ha)	Recharge from Rainfall (ham)		Recharge from Other Sources (ham)		Total Annual Ground Water Recharge (ham)	Total Natural Discharge (ham)	Net Annual Ground Water Avail-ability (ham)	Existing Ground Water Draft for Irrigation (ham)	Existing Ground Water Draft for Domestic Use (ham)	Existing Ground Water Draft for Industrial Use (ham)	Existing Gross Ground Water Draft for All Uses (ham)	Annual Ground Water allocation for Domestic Use as on 2025 (ham)	Net Ground Water Availability for future use (ham)	Stage of Ground Water Development (%)
		Monsoon	Non-monsoon	Monsoon	Non-monsoon										
Chopra	38082	9343.19	2580.44	367.39	938.17	13229.19	1322.92	11906.27	3995.00	293.04	146.52	4434.56	691.55	7219.72	37.25
Goalpokhar-I	35510	9900.19	2734.27	468.38	1508.00	14610.84	1461.08	13149.76	4730.00	322.49	161.24	5213.73	761.03	7658.73	39.65
Goalpokhar-II	29870	8327.76	2299.99	749.30	2243.92	13620.97	1362.10	12258.87	7957.30	297.58	148.79	8403.67	702.24	3599.33	68.55
Hemtabad	19182	5054.51	1299.77	673.58	2190.36	9218.22	460.91	8757.31	7071.90	155.21	77.60	7304.71	366.27	1319.14	83.41
Islampur	34343	8425.85	2327.08	489.28	1423.69	12665.90	1266.59	11399.31	4740.80	387.21	193.61	5321.62	913.77	5744.74	46.68
Itahar	36240	12124.45	2232.38	1412.36	4722.69	20491.88	2049.19	18442.69	14471.40	327.89	163.94	14963.23	773.78	3197.51	81.13
Kaliaganj	31357	13113.49	2414.49	1016.35	3597.72	20142.05	2014.21	18127.84	10035.70	312.29	156.14	10504.13	736.96	7355.18	57.94
Karandighi	39052	11811.59	3007.00	851.18	2657.07	18326.84	916.34	17410.50	9156.90	419.00	209.50	9785.40	988.78	7264.82	56.20
Raiganj	48277	13366.39	3271.25	1513.61	5072.21	23223.46	1161.17	22062.29	15974.60	692.81	346.41	17013.82	1634.95	4452.74	77.12
TOTAL DISTRICT		**91467.43**	**22166.67**	**7541.41**	**24353.83**	**145529.34**	**12014.51**	**133514.83**	**78133.60**	**3207.51**	**1603.76**	**82944.87**	**7569.33**	**47811.90**	**60.88**

ANNEXURE-V

Range of Chemical Parameters (Basic Analysis) During Pre-monsoon and Post-monsoon, Uttar Dinajpur district (after Ghosh Dastidar and Das, 2004)

Sl. No.	Location	Block	Concentration (mg/L)													EC (µS/cm)	pH
			SiO_2	Fe	Ca	Mg	Na	K	HCO_3	Cl	F	SO_4	NO_3	TDS	TH		
Pre-monsoon (AAP: 2000-2001)																	
1	Fatehpur	Kaliaganj	44	8.22	16	4.8	15	5.4	55	39	0.24	1.2	BDL	121	60	201	7.5
2	Tangul Bilpara	Kaliaganj	37	BDL	8	4.8	9.6	1.9	43	18	0.09	1.2	BDL	75	40	125	7.6
3	Beltor	Kaliaganj	31	0.67	22	3.6	37	18	110	50	BDL	10	BDL	206	70	348	7.7
4	Hemtabad	Hemtabad	46	0.39	30	18	19	7.7	122	67	0.27	BDL	BDL	235	150	392	7.4
5	Sherpur	Hemtabad	39	3.47	16	7.2	16	1.7	116	11	0.15	BDL	BDL	121	70	202	7.5
6	Raiganj	Raiganj	33	0.58	30	3.6	30	4.3	122	21	0.11	BDL	BDL	186	90	310	7.9
Post-monsoon (AAP: 2000-2001)																	
7	Rajibpur	Kaliaganj	--	0.44	52	17	13	1.9	220	18	0.50	22	0.1	--	52	465	7.5
8	Sherpur	Hemtabad	--	0.27	12	6.1	4.6	0.5	73	5.3	0.43	1.0	6.5	--	55	142	7.7
9	Raiganj	Raiganj	--	0.36	30	15	24	5.4	195	14	0.19	14	2.2	--	135	396	7.3

ANNEXURE-VI

Analysis Result of Groundwater (post-monsoon 2021), Uttar Dinajpur district

Sl. No.	Location	Block	Date of sampling	pH	EC (µS/cm)	Concentration (mg/L)											
						TH as $CaCO_3$	Ca	Mg	Na	K	Cl	TA as $CaCO_3$	HCO_3	SO_4	NO_3	F	TDS	Fe
1	Mustafa Nagar	Kaliaganj	20-11-21	7.44	311.5	105	22	12	26.5	6.1	35	90	110	18.63	3.68	0.25	192	0.267
2	Dalimgaon	Kaliaganj	20-11-21	7.03	203.1	85	14	12	16.3	5.9	25	70	85	1.45	0.28	0.66	128	0.526
3	Hemtabad	Hemtabad	20-11-21	7.63	163.4	60	18	4	15.6	1.8	11	85	104	0.63	0.85	0.86	115	3.038
4	Malon	Hemtabad	20-11-21	7.12	254.9	60	14	6	21.1	16.8	46	50	61	8.23	2.96	0.77	153	1.787
5	Karnojora	Raiganj	20-11-21	7.30	144.8	65	12	9	12.0	2.0	11	75	92	5.82	0.41	0.78	108	3.337
6	Patirajpur	Itahar	19-11-21	7.72	321.9	130	20	19	26.4	1.6	21	155	189	3.75	1.48	0.72	210	BDL
7	Durgapur	Itahar	19-11-21	7.86	646.1	210	42	26	56.5	14.7	50	235	287	18.12	5.83	0.90	388	BDL
8	Kanki	Goalpokhar-II	21-11-21	7.68	1129	395	92	40	62.1	16.7	78	290	354	75.12	32.0	0.79	613	0.084
9	Tungidighi	Karandighi	21-11-21	7.44	574.7	220	54	21	31.4	13.1	46	200	244	3.12	24.48	0.84	343	0.209
10	Chopra (Dalua)	Chopra	22-11-21	7.35	145.4	45	16	0	10.8	1.8	18	50	61	1.17	0.00	0.75	87	7.042
11	Molani	Chopra	22-11-21	7.00	603.4	115	30	1	64.9	32.4	89	140	171	0.94	0.67	0.70	332	0.122
12	Burakamat	Raiganj	23-11-21	6.71	175.4	65	14	1	7.3	4.8	32	50	61	0.65	0.29	0.73	104	8.534
13	Lahanda	Raiganj	23-11-21	7.42	182.6	60	20	0	16.8	1.9	25	70	85	0.88	1.21	0.97	121	0.170
14	Lohagara	Raiganj	23-11-21	7.30	322.7	85	22	1	30.4	3.9	43	65	79	5.41	41.94	0.67	203	8.544
15	Koiladangi	Raiganj	23-11-21	7.53	99.1	30	8	0	8.2	1.7	11	35	43	0.68	BDL	0.66	58	0.132
16	Subhashganj	Raiganj	23-11-21	7.74	256.4	50	12	0	40.7	1.6	21	125	153	0.51	BDL	0.98	175	1.306
17	Itahar	Itahar	19-11-21	7.72	671.5	170	38	2	64.9	19.8	92	125	153	13.10	43.04	0.97	383	0.247

18	Baidara	Itahar	19-11-21	7.56	283.9	105	32	1	21.9	1.1	18	135	165	1.18	1.30	0.85	183	3.115
19	Madaripur	Islampur	22-11-21	7.40	625.8	220	38	3	39.3	28.6	57	210	256	17.50	2.81	1.10	371	0.815
20	Baghon	Kaliaganj	23-11-21	7.05	785.4	215	38	2	59.0	19.3	110	80	98	45.60	53.00	1.00	415	0.878
21	Kaliaganj	Kaliaganj	20-11-21	7.61	293.1	100	22	11	27.0	1.6	25	135	165	0.63	2.13	0.92	190	0.769
22	Kunore	Kaliaganj	20-11-21	7.69	262.4	95	26	7	17.4	1.7	14	110	134	1.05	BDL	0.77	150	2.140
23	Gunjaria	Islampur	20-11-21	7.36	126.2	30	10	1	16.2	1.2	18	45	55	1.85	BDL	0.60	82	7.731
24	Dhankoil	Kaliaganj	22-11-21	7.80	219.8	70	16	7	13.5	2.0	18	75	92	1.41	BDL	0.80	114	9.197
25	Churamon	Itahar	19-11-21	8.02	459.1	45	12	4	74.1	1.0	21	195	238	1.23	BDL	1.00	259	BDL
26	Raria	Raiganj	25-11-21	7.71	163.8	50	16	2	15.8	1.8	11	75	92	1.06	BDL	0.82	104	0.118

ANNEXURE-VII

FIELD PHOTOGRAPHS

Roof top rainwater harvesting and artificial recharge project in SWID Division-V Campus, Karnojora, Raiganj block. SWID piezometer with AWLR system is seen in the foreground.

Close up view of recharge well and rainwater harvesting tank in SWID Division-V Campus, Karnojora, Raiganj block.

Village level aquifer mapping survey, Primary School, Birghai village, Piyaltore mouza, Raiganj block (pre-monsoon 2022)

Deep tube well installed by PHED, Raiganj Division in Birghai village (Co-ordinate: 25.5666 N, 88.1762 E) during village level aquifer mapping (post-monsoon 2021)

Inventory of India Mark-II tube well at Bhojo Gobindo Roy Madhyamik Shiksha Kendra, Birghai village (Raiganj block) during village level aquifer mapping survey