केन्द्रीय भूमि जल बोर्ड

जल संसाधन, नदी विकास और गंगा संरक्षण

विभाग, जल शक्ति मंत्रालय

भारत सरकार

Central Ground Water Board

Department of Water Resources, River Development and Ganga Rejuvenation,

Ministry of Jal Shakti

Government of India

AQUIFER MAPPING AND MANAGEMENT OF GROUND WATER RESOURCES

Jehanabad District
Bihar

मध्य पूर्वी क्षेत्र, पटना

Mid Eastern Region, Patna

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FOREWORD

Government of India is committed to accord high priority to water conservation and its management. National Aquifer mapping is one of the efforts which include delineation of lateral and vertical disposition of aquifers and their characterization including potential, to analyze the variation in quality of ground water, & sustainability of the aquifer. In this Report on "**Aquifer Maps and Ground Water Management Plan of Jehanabad district, Bihar**" all the scientific studies like geological, geophysical, hydrogeological and chemical has been undertaken.

In the year 2009, all the blocks of Jehanabad district faced severe draught condition due to inadequate rainfall, and after more than one decade same picture reflects in resource calculation 2020, all blocks of the district found water stressed, even one block is under "over-exploited" category. The major ground water issues have been highlighted such as over exploitation of ground water in certain blocks and some quality issue in few locations etc. Mainly artificial recharge structures have been proposed as per suitability. Block-wise distribution and management plan has also been given for drinking water security and irrigation coverage.

The report is a sincere effort of Smt Sulekha Bhaya, Sc B, under the guidance of Dr. Sudhanshu Shekhar, Sc-D, and Dr. Indranil Roy, Sc.-D Nodal Officer (NAQUIM). Continuous and sincere works by Shri Suresh Kumar, Asst Chemist are acknowledged.

I am of firm conviction that the present report will go a long way to help the planners and executors, in the ground water sector for ground water development and management plans in the district.

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Last but not the least; I am very much thankful to my entire colleagues for their help and support.

Sulekha Bhaya

Sc. B

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CHAPTER- 1

INTRODUCTION

The vagaries of rainfall, inherent heterogeneity, over exploitation of once copious aquifers, lack of regulation mechanism etc. has a detrimental effect on ground water scenario of the Country in last decade or so. Thus, prompting the paradigm shift from "Traditional Groundwater Development concept" to "Modern Groundwater Management concept". Varied and diverse hydrogeological settings demand precise and comprehensive mapping of aquifers down to the optimum possible depth at appropriate scale to arrive at the robust and implementable ground water management plans. This leads to concept of Aquifer Mapping and Ground Water Management Plan. Aquifer mapping is a process wherein a combination of geologic, geophysical, hydrologic and chemical analyses is applied to characterize the quantity, quality and sustainability of ground water in aquifers. The proposed management plans will provide the "Road Map" for ensuring sustainable management and equitable distribution of ground water resources, thereby primarily improving drinking water security and irrigation coverage. Thus the crux of NAQUIM is not merely mapping, but reaching the goal-that of ground water management through community participation.

During XII five year plan (2012-17) National Aquifer Mapping (NAQUIM) study was initiated by CGWB to carry out detailed hydrogeological investigation. The Aquifer Mapping programme has been continued till 2023 to cover whole country. The present studies of Jehanabad district, Bihar have been taken up in AAP 2019-20 as a part of NAQUIM Programme. The aquifer maps and management plans will be shared with the administration of Jehanabad district and other user agencies for its effective implementation.

1.1 Objective and Scope

The major objectives of aquifer mapping are

- Delineation of lateral and vertical disposition of aquifers and their characterization
- Quantification of ground water availability and assessment of its quality to formulate aquifer management plans to facilitate sustainable management of ground water resources at appropriate scales through participatory management approach with active involvement of stakeholders.

The groundwater management plan includes Ground Water recharge, conservation, harvesting, development options and other protocols of managing groundwater. These

protocols will be the real derivatives of the aquifer mapping exercise and will find a place in the output i.e. the aquifer map and management plan.

The main activities under NAQUIM are as follows:

a). Identifying the aquifer geometry

b). Aquifer characteristics and their yield potential

c). Quality of water occurring at various depths

d). Aquifer wise assessment of ground water resources

e). Preparation of aquifer maps and

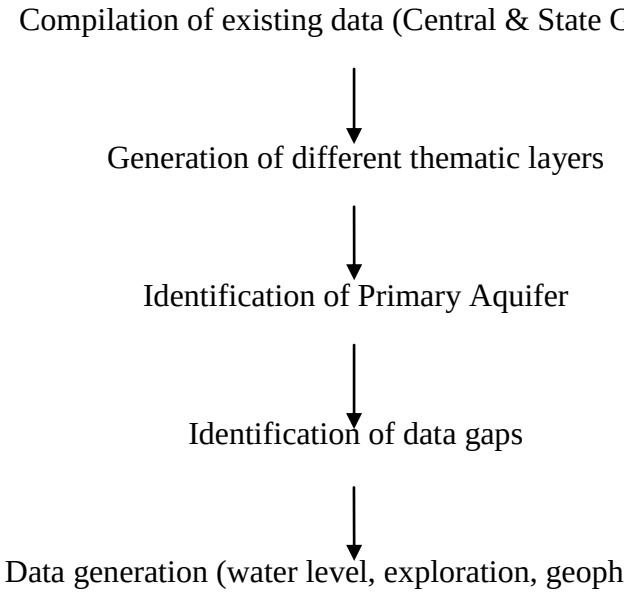
f). Formulate ground water management plan.

The demarcation of aquifers and their potential will help the agencies involved in water supply in ascertaining, how much volume of water is under their control. The robust and implementable ground water management plan will provide a "Road Map" to systematically manage the ground water resources for equitable distribution across the spectrum.

1.2 Approach and methodology

The ongoing activities of NAQUIM include hydrogeological data acquisition supported by geophysical and hydro-chemical investigations supplemented with ground water exploration down to the depths of 200 meters in hard rocks and 300m in soft rock

Considering the objectives of the NAQUIM, the data on various components was segregated, collected and brought on GIS platform by geo-referencing the available information for its utilization for preparation of various thematic maps. The approach and methodology followed for Aquifer mapping is as given below:



hydrochemical, hydrogeological etc.

↓

Aquifer Maps with 3D disposition

↓

Preparation of Aquifer Management Plan

↓

Capacity building in all aspects of ground water through IEC Activties

1.3 Area Detalis

In phase VI aquifer mapping area covered Jehanabad district. Jehanabad district located in south Bihar. The district occupies an area of 932 square kilometers, covering 7 administrative blocks. The district is bounded in the north by the district Patna, in the south by the district Gaya in the west by the Arwal, and in the east by the district Nalanda. Jehanabad district is located on global map between 24°99' and 25°32' North latitude and 84°82' and 85°22'East longitude, comes under Survey of India Toposheet No. 72 C/15,16,G/3,4. D/13, & H/1. The location of the study area is shown in ***Fig.1***. The population density of the district is 1200 persons per sq. km. The salient demographic details of the administrative blocks falling in the area are given in ***Table 1.1.***

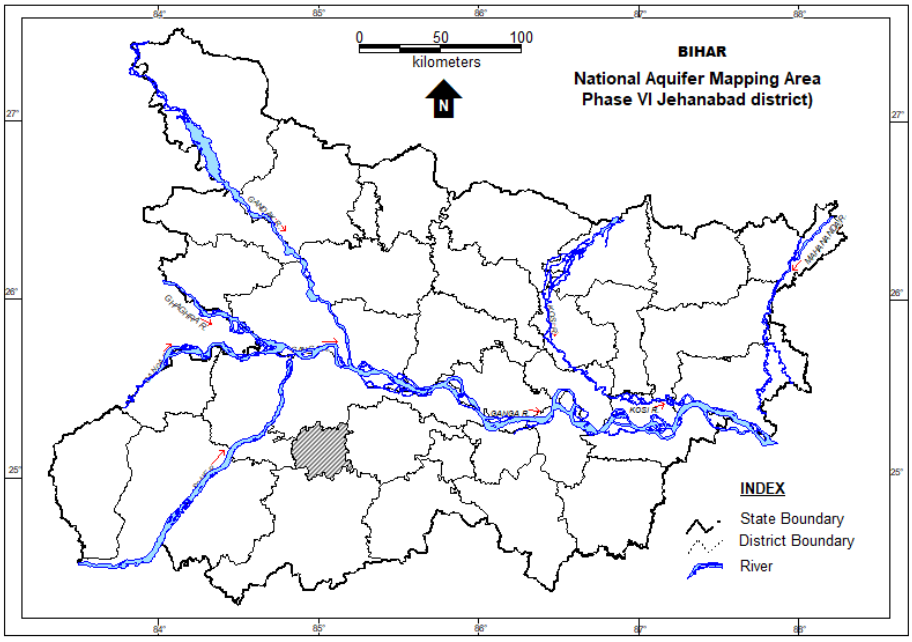


Figure 1: Aquifer Mapping area- Jehanabad district

Table 1.1: Demographic details of the administrative blocks falling under NAQUIM area (Ref. Census of India 2011)

District	*Block*	*Total area (sq.Km)*	*Rural Population*	*Urban Population*	*Total Population*
Jehanabad	Ratni Faridpur	127.14	146586	0	146586
	Jehanabad	162.51	151551	103202	254753
	Kako	132.54	173487	0	173487
	Modanganj	79.95	87718	0	87718
	Ghoshi	92.49	108130	0	108130
	Makhdumpur	243.85	228160	31994	260154
	Hulasganj	97.1	94485	0	94485
		931	990117	135196	**1125313**

(As per census 2011)

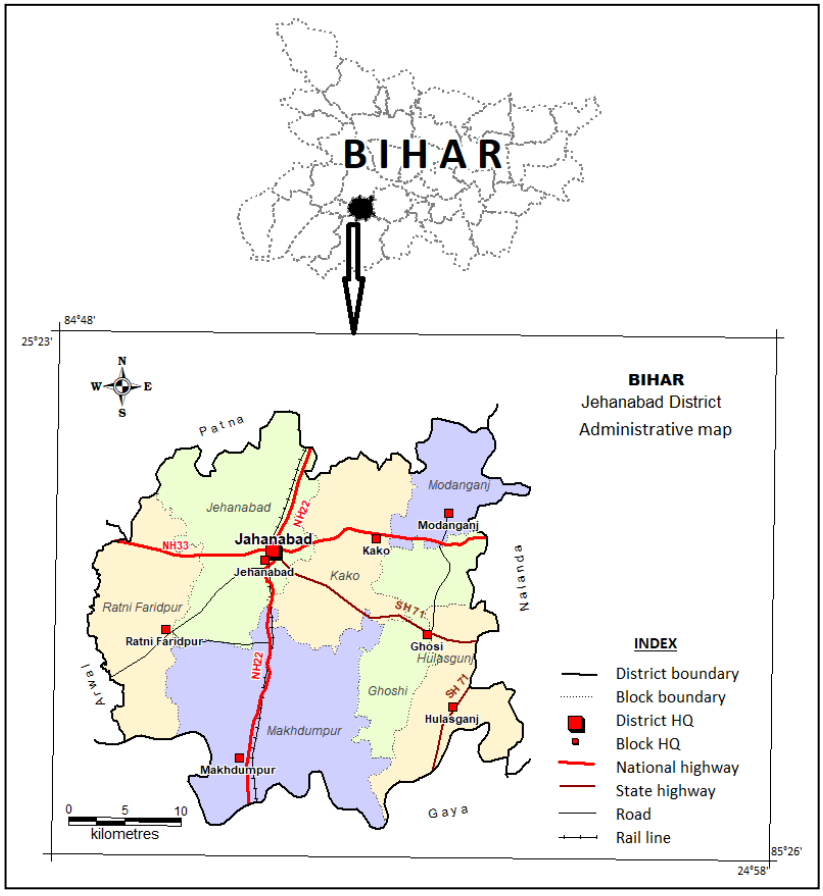


Figure 2: Administrative Map

1.4 Brief Description

The administrative map (***Fig. 2.***) of the area shows that main cities of Jehanabad district are Jahanabad, Makhdumpur, Kako, Ghosi, Hulasganj, Modanganj, and Ratnifaridpur. Two national highways are passing through the district. NH22 connecting Jahanabad and Patna, NH33 connecting Jahanabad and Sheikhpura. Other Major city Ghosi and Hulasganj are connected by SH71 and other roads. Railways through Makhdumpur and Jahanabad connected to Patna, the capital of Bihar.

1.4.1 Data availability

Central Ground Water Board has carried out systematic and reappraisal hydrogeological surveys, exploratory drilling under groundwater exploration programme and depth to water level monitoring under "ground water regime monitoring" etc. In Bihar state, data available in the aquifer mapping area from the previous works of CGWB, Public Health Engineering Department, Govt. of Bihar, Minor Water Resource Department, Govt. of Bihar, etc. have been compiled and data gap analysis has been carried out for working out the need for additional data generation in the study area. Though, the data generation through in-house and outsourcing exploration drilling is in progress and this has been incorporated as far as possible.

1.4.2 Data adequacy and data gap analysis and data generation

As per the existing data availability on March 2019, data gap analysis has been carried out. On the basis of this data gap analysis, fresh data has been generated. The block wise total number of NHS wells has been given in ***Table 1.2***.

Table 1.2: Block wise number of NHS wells (2019)

SN	District	Block	Area (sq Km)	Total numbers NHS monitoring locations
1	Jehanabad	Ratni Faridpur	127.14	0
2	Jehanabad	Jehanabad	162.51	3
3	Jehanabad	Kako	132.54	1
4	Jehanabad	Modanganj	79.95	1
5	Jehanabad	Ghoshi	92.49	2
6	Jehanabad	Makhdumpur	243.85	2
7	Jehanabad	Hulasganj	97.1	1

1.4.3 Climate & Rainfall spatial and temporal distribution

The district comes under the "Sub-tropical" type i.e. mild and dry winter and hot summer. The area experiences a continental monsoon type of climate owing to its great distance from the sea. The climate is extreme and comprises three broad seasons-the summer, the monsoon and the winter. The summer months from the middle of March to May are characterized by hot blasts of westerly winds commonly known as 'loo'. The peak of summer is in May. The cold spell starts from December and continues till end of February. During this period the mercury drops down to as low as 4°C.

The rainfall in the southwest monsoon season constitutes about 89% of the annual normal rainfall. The average annual rainfall in the Jehanabad district is 1074.50mm. The months of July and August are the rainiest months, receiving normal monthly rainfall to the tune of 269.8 and 304.6 mm. Due to changing climatic situation; the district faces erratic monsoon behavior. Frequent draught due to low rainfall (700-900) is witnessed every alternate year. More than 90% of total precipitation occurs during monsoon season (June-September). 5 years monthly rainfall is given in ***Table 1.3***

Table 1.3: Rainfall Departure

Year	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
	RF	%D	RF	%D	RF	%D	RF	%D	RF	%D	RF	%D	RF	%D	RF	%D	RF	%D	RF	%D	RF	%D	RF	%D
2014	17.2	34	21.1	178	5.9	-16	0	-100	40.6	76	37.4	-67	247.8	-3	371.3	45	117.1	-40	14.4	-63	0	-100	1.2	-79
2015	7.5	-42	0	-100	5.1	-28	6.9	-47	4.6	-80	192.9	71	186.2	-27	216.8	-15	114	-42	0.7	-98	0	-100	0	-100
2016	16.2	27	0	-100	3.6	-49	0	-100	10.4	-55	77.4	-31	278.9	9	178.2	-30	436.4	122	57.8	48	0	-100	0	-100
2017	0	-100	0	-100	0.8	-89	0	-100	21	-9	133.5	19	314.2	23	128.3	-50	146.5	-25	0	-100	0	-100	0	-100
2018	0	-100	0	-100	0	-100	0	-100	3	-87	59.6	-47	228.8	-10	113.6	-56	83.5	-58	0.7	-98	0	-100	8	38

1.4.4 Physiographic Set up

The district is Part of South Bihar Plane, basement made up of Archaean formations overlain by Quaternary Alluviums. Major Drainages Phalgu, Dardha, Punpun, Morhar, Jamuna flowing from south to north direction.

1.4.5 Physiography/DEM

Elevation of the area ranges from 56 m and 312.5 m above mean sea level (SRTM data with WGS 84 Spheroid). The generated elevation map by SRTM map is given in ***Fig.3.***

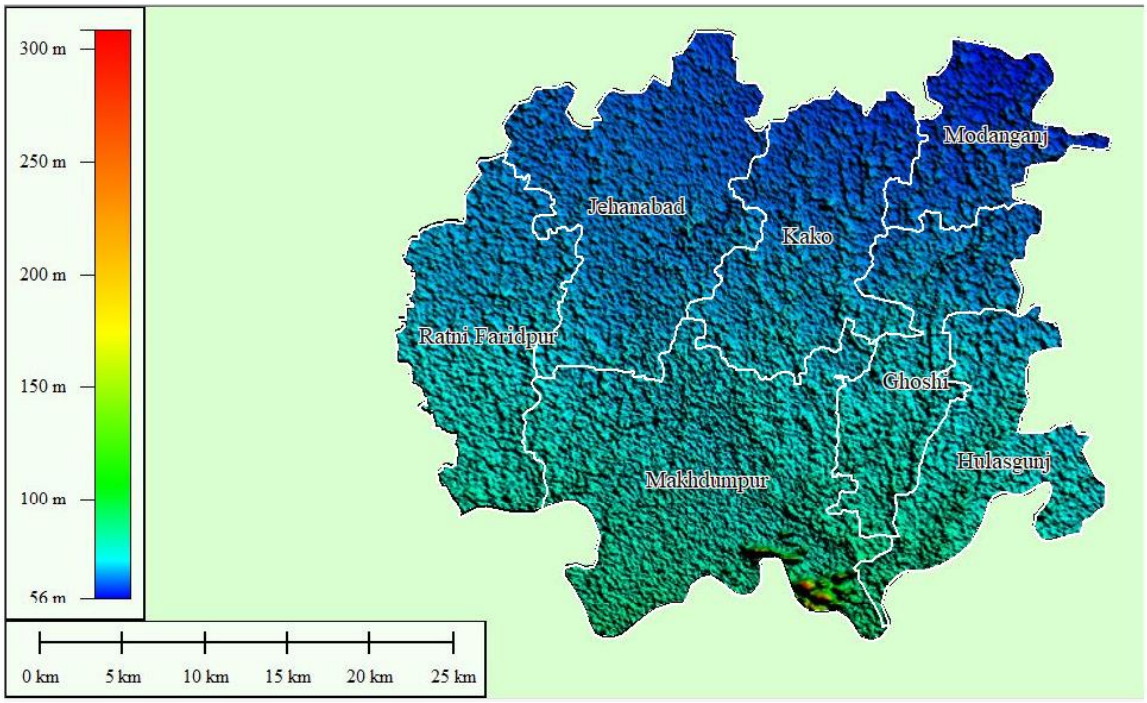


Figure 3: Digital Elevation Model of the area based on SRTM Data

1.4.6 Geomorphology

Jehanabad district is located within the Mid-Ganga basin, in the southern margin of the Gangetic plains. The district mainly represents flat alluvium terrain except hills in the south. The maximum elevation of is around 312.5 m above MSL. Surrounding the hills there is pediplane area in southern part of the district. The general slope of the district is N/NE. The main rivers of the district flow from south towards north/ northeast. (***Fig 4***)

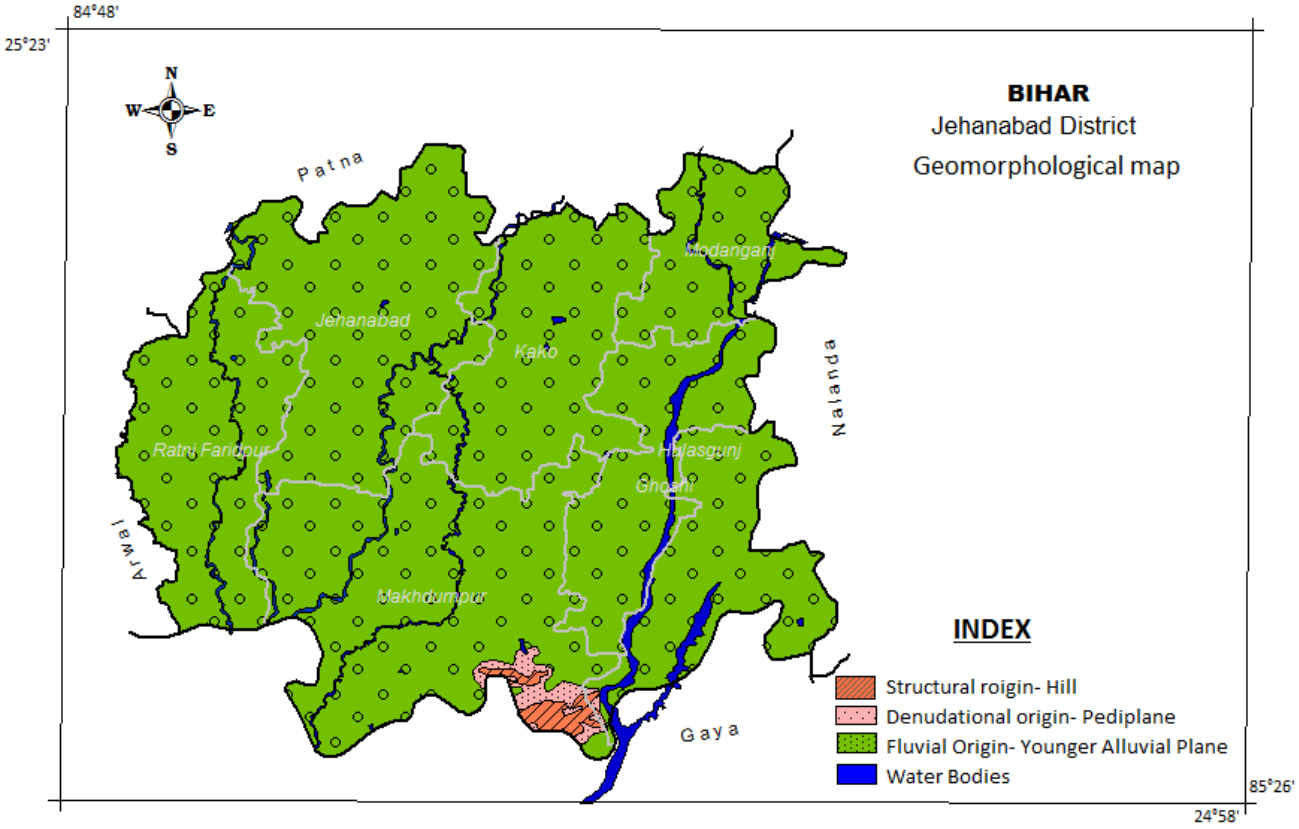


Figure 4: Geomorphology

1.4.7 Land-Use Pattern

Land use is the term used to describe the human use of land. It represents the economic and cultural activities (e.g., agricultural, residential, industrial, mining, and recreational uses) that are practiced at a given place. Looking into the different land use patterns of Jehanabad distict, the maximum area (about 90%) is being utilized in agricultural purpose followed by built up rural area. A very small percentage area is under mining. ***Fig 5*** shows the different land use patterns of Jehanabad district and also their graphical representations. ***Table 1.4*** shows the area under different land use patterns and their percentages. Amongst all land use patterns water use involved mainly in agriculture, mining and urban areas. As maximum area is under agricultural use therefore there is maximum water utilization for irrigation purpose.

Table 1.4: Percentage of area under different Land use patterns

SN	Land use Pattern	Area (sq km)	% Area
1	Agricultural land	1360.53	86.71
2	Built up Rural	92.01	5.86

3	River/Lake/Pond/water bodies	74.97	4.78
4	Forest	6.12	0.39
5	Built up Urban	4.62	0.29
6	Barren unculturable/waste land	23.84	1.52
7	Built up Mining	6.91	0.44
	Total Area	1569	100

As maximum land utilization is under agricultural purpose, the further break up of agricultural use given in ***Table 1.5*** for this some important nomenclatures are as follows:

Net Irrigated Area: It is the area irrigated through any source once in a year for a particular crop.

Total/Gross Irrigated Area: It is the total area under crops, irrigated once and/or more than once in a year. It is counted as many times as the number of times the areas are cropped and irrigated in a year.

Net Area Sown: This represents the total area sown with crops and orchards. Area sown more than once in the same year is counted only once.

Gross Cropped Area: This represents the total area sown once and/or more than once in a particular year, i.e. the area is counted as many times as there are sowings in a year. This total area is also known as total cropped area or total area sown.

Cropping Intensity: (Gross cropped Area / Net Cropped Area) * 100

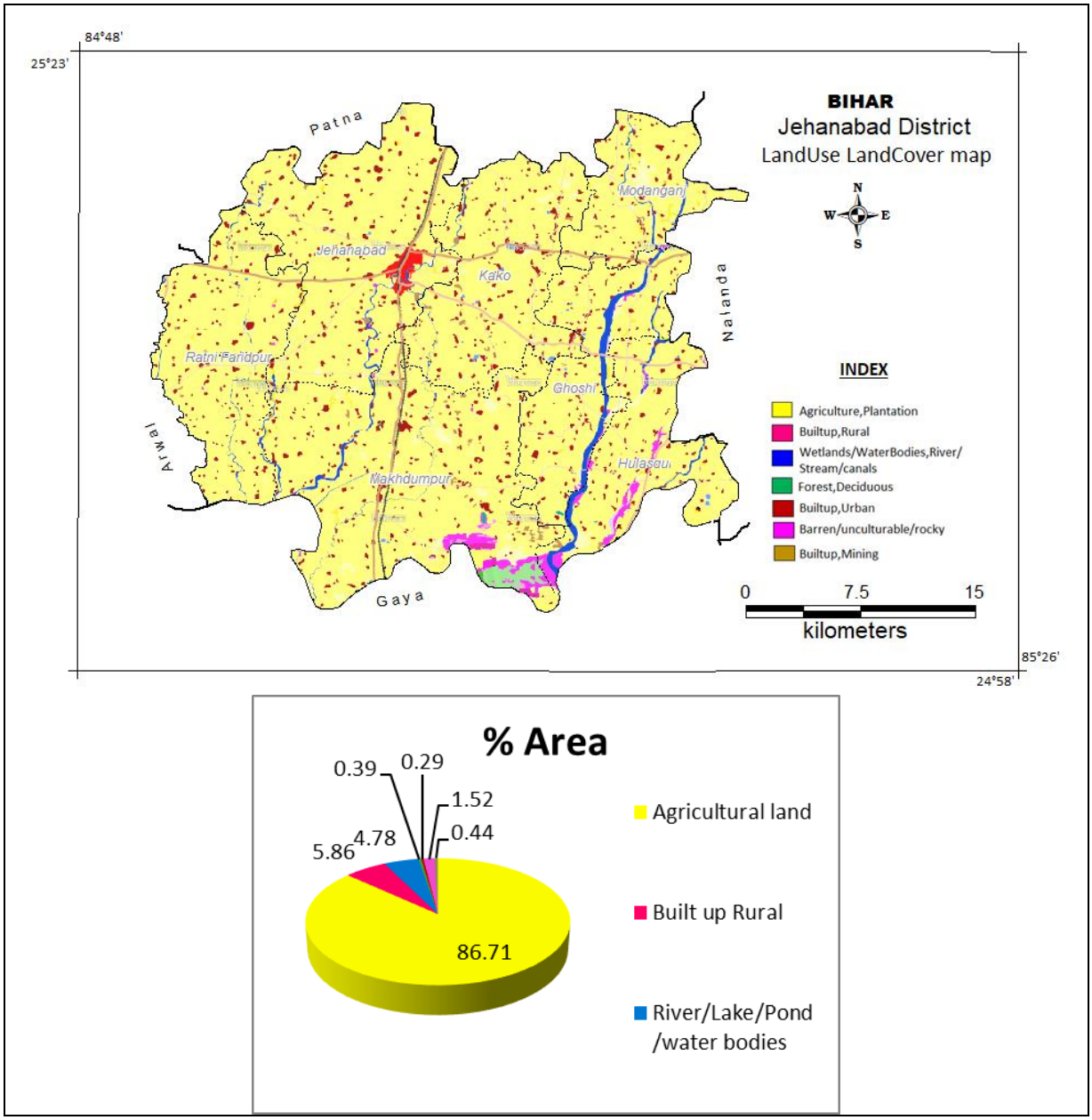


Figure 5: Land use

Table 1.5: Lans Use Statistics

SN	Block	Block area	Gross cropped area	Net sown area	Area sown more than once (1-2)	Cropping intensity (%)	Area under forest	Area under Waste land	Area under other uses
1	Jehanabad	16251	25350	13580	11770	187	0	884	1787
2	Ratni Faridpur	12714	23142	11643	11499	199	0	428	644
3	Kako	13254	20661	11887	8774	174	0	785	582
4	Modanganj	7995	12159	7484	4675	162	0	190	321

5	Ghoshi	9249	13955	8239	5716	169	0	196	814
6	Makhdumpur	24385	36753	19056	17697	193	317	2247	2765
7	Hulasganj	9710	8632	8574	58	101	321	62	753
	Total	93558	140652	80464	60188	175	638	4792	7665

Source: District irrigation Plan, Jehanabad: Department of Agriculture, Pmksy Cell, Patna (Bihar)

1.4.8 Soil

Soil texture and structure impacts water holding capacity and infiltration rate through specific formation. Soil texture refers to the composition of the soil in terms of the proportion of small, medium, and large particles (clay, silt, and sand, respectively) in a specific soil mass. For example, a coarse soil is sand or loamy sand, a medium soil is loam, silt loam, or silt, and a fine soil is a sandy clay, silty clay, or clay. Soil structure refers to the arrangement of soil particles (sand, silt, and clay). Coarse soils have a higher infiltration rate than fine soils. Coarse soils with granular subsoils have higher permeability. Slow permeability is characteristic of moderately fine subsoil with angular to subangular blocky structure. Soil with a high percentage of silt and clay particles, has a higher water-holding capacity. The soil consists mainly of loam with a small proportion of sand and clay ***Fig 6***. Area under major soil type in the district is being presented in ***Table 1.6.***

Table 1.6: Soil distribution in Jehanabad district

SN	Block	Major soil type			Total (ha)
		Clay (ha)	Clay loam (ha)	Sandy loam (ha)	
1	Jehanabad	1625	5688	5688	13001
2	Ratni Faridpur	1290	4686	5721	11697
3	Kako	1723	5302	4639	11664
4	Modanganj	2399	2399	1999	6796
5	Ghosi	1387	4162	2312	7862
6	Makhdumpur	2488	9705	8535	20727
7	Hulasganj	388	4855	3399	8642
Total		8900	39195	32292	80388

Source: District irrigation Plan, Jehanabad: Department of Agriculture, Pmksy Cell, Patna (Bihar)

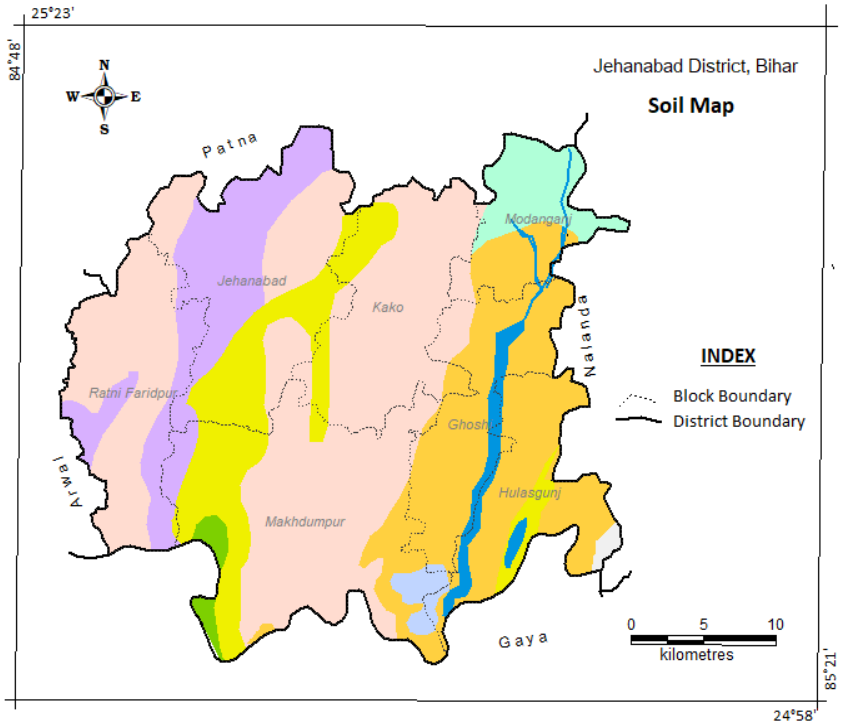


Figure 6: Soil

Source: District irrigation Plan, Jehanabad: Department of Agriculture, Pmksy Cell, Patna (Bihar)

Fine-loamy, Typic Ustifluvents, Typic Haplustalfs
Fine, Typic Ustochrepts, Fine aeric Haplaquepts
River
Fine-loamy, Fluvetic Ustochrepts, Fine-loamy, typic ustifluvents
Fine, aeric ochraqualfs, Fine-loamy, typic ustochrepts
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1.4.9 Hydrology and Drainage

Jehanabad district falls under Harohar Basin. The general slope of the area is towards northeast. The Major rivers are Lokain, Phalgu (Nonain, and Morhar) river. One main river of the state, Punpun, flows along west boundary of the district. All rivers flow towards NE and meets Ganges towards North. The Phalgu Nadi originates in Jharkhand, near Chatra, other branch originates near Chouparan, both flows towards north enterns in Bihar state, meet near Bodh Gaya. Falgu nadi enters in Jehanabad district from south near Sultanpur, Hulasganj block, flows through Ghosi and Modanganj block and enters Patna district towards north. Morhar river originates near Sherghati, Gaya district, Bihar, flows towards north enters

Jehanabad district from south of Makhdumpur block, flows through Jehanabad block and enters Patna towards north. ***Fig 7*** representing drainage of Jehanabad district.

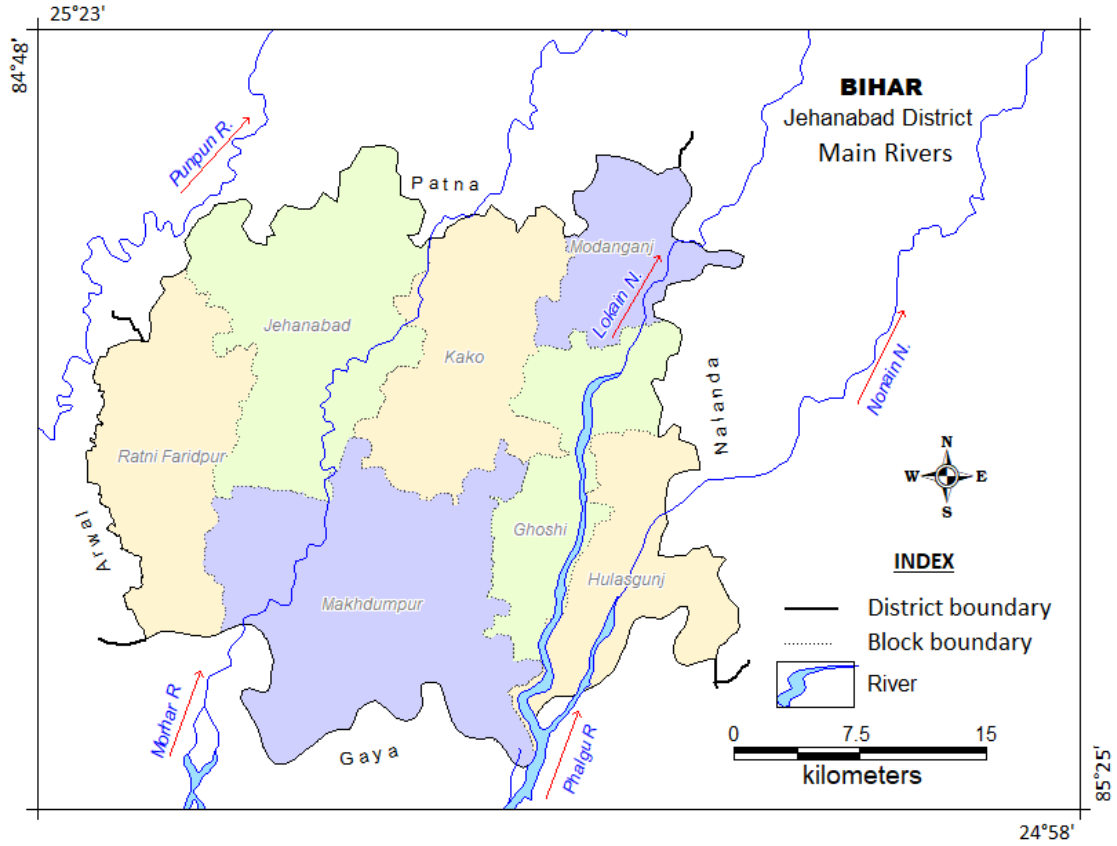


Figure 7: Drainage Map

1.4.10 Agriculture

Jehanabad district falls under agro climatic zone III. Agricultural activity in the area is confined to the traditional kharif cultivation depending primarily on monsoon rainfall and rabi cultivation in localized patches where irrigation facilities are available. The major kharif crops grown are paddy, while among the rabi crops wheat, pulses are important. ***Table 1.7*** shows season-wise crop cultivated in Jehanabad district.

Table 1.7: Season-wise crop cultivated in Jehanabad district

District	Type of Crop	Year	Season	Area (Hectare)
Jehanabad	Barley, Jowar, Bazra, Ragi & Small Millets	2018-19	Whole year	210
	Oil Seeds	2018-19	Whole year	279
	Kharif Pulses	2018-19	Kharif	235
	Rabi Pulses	2018-19	Rabi	14088
	Maize	2018-19	Whole year	234
	Rice	2018-19	Kharif	34098
	Wheat	2018-19	Rabi	23195

(Bihar statistical Handbook 2018) http://dse.bihar.gov.in/

1.4.11 Irrigation

Irrigation is the process of applying water to the crops artificially to fulfil their water requirements. The different sources of surface irrigation are cannal, aharpyne, lift irrigation, and perennial source of water. Sources of irrigation through ground water is open well, deep tube well, medium tube well and shallow tube well. To understand the irrigation practices some terminologies are there.

(i) Net Irrigated Area: It is the area irrigated through any source once in a year for a particular crop.

(ii) Total Net Un-Irrigated Area: It is the area arrived at by deducting the net irrigated area from net sown area.

(iii)Total/Gross Irrigated Area: It is the total area under crops,irrigated once and/or more than once in a year. It is counted as many times as the number of times the areas are cropped and irrigated in a year.

Blockwise area irrigated and area rainfed have shown ***Table 1.8.***

Table 1.8: Area Irrigated and rainfed *Area in hectare*

Block	Irrigated		Gross Rainfed area		
	Gross Irrigated Area	Net Irrigated Area	Partially irrigated/ protective irrigation	Un-Irrigated or Totally Rainfed	Total
Jehanabad	10053	5021	3824	11473	15297
Ratni Faridpur	10089	7257	3263	9790	13053
Kako	14591	6524	1518	4553	6070
Modanganj	6458	4127	1425	4276	5701
Ghosi	5477	3100	2120	6359	8478
Makhdumpur	17462	8427	4823	14468	19291
Hulasganj	1727	1461	1726	5179	6905
Total	65857	35917	18699	56096	74795

Table 1.9: Distribution of dugwells as in 4th MI and comparison with 5 th MI

Number of dug wells				
Block	4th MI			5th MI
	0-20 m	>20 m	Total	
Hulasganj	1	0	1	_
Jehanabad	11	51	62	1

Makhdumpur	7	0	7	1
Modnganj	2	0	2	1
Ratni Faridpur	0	5	5	
			77	**3**

As per the 4th and 5th MI Census data ***Table 1.8*** the number of dug wells has been decreased from 77 to 3 only, which indicate that the use of water of unconfined aquifer has been decreased.

Table 1.10: Distribution and comparison of number of Shallow tube Wells of Jehanabad district according to depth (m)

Block	0-20 mts		20-40 mts		40-60 mts		60-70 mts		>70 mts		Total	
	4th MI	5th MI	4th MI	5th MI	4th MI	5th MI	4th MI	5th MI	4th MI	5th MI	4th MI	5th MI
Ghosi	91	149	17	560	3	0	0	0	1774	0	1885	709
Hulasganj	146	204	15	148	1117	0	1	0	353	0	1632	352
Jehanabad	277	80	21	940	1208	0	279	0	560	0	2345	1020
Kako	223	1	20	846	2	0	0	0	2521	0	2766	847
Makhdumpur	2065	59	313	1999	449	0	2	0	494	0	3323	2058
Modanganj	155	73	567	704	436	0	0	0	55	0	1213	777
Ratni Faridpur	319	13	10	1754	1973	0	60	0	114	0	2476	1767
Total	3276	579	963	6951	5188	0	342	0	5871	0	15640	7530

Table 1.11: Distribution and comparison of number of Deep tube Wells of Jehanabad district according to depth (m)

Block	70-90 mts		90-110 mts		110-130 mts		130-150 mts		>150 mts		Total	
	4th MI	5th MI	4th MI	5th MI	4th MI	5th MI	4th MI	5th MI	4th MI	5th MI	4th MI	5th MI
Ghosi	0	0	440	1	0	0	0	0	0	0	440	1
Hulasganj	2	0	0	0	0	0	0	0	0	0	2	0
Jehanabad	2	0	0	1	0	0	0	0	0	2	2	3
Kako	13	0	22	14	0	0	0	0	0	0	35	14
Makhdumpur	1	0	0	0	0	0	0	2	0	0	1	2
Modanganj	1	0	0	0	0	0	0	0	0	2	1	2
Ratni Faridpur	0	0	0	0	0	0	0	0	0	0	0	0
Total	19	0	462	16	0	0	0	2	0	4	481	22

Compared the number of shallow tube well and deep tube well ***Table 1.9*** & ***Table 1.10.*** of 4th and 5th MI cencus, both the number has been decreased, The number of shallow tube well of depth range of 0 to 20 mts, has been decreased in almost all blocks and depth range of 20 to 40 mts has been increased, and in deeper range 40 to 70 m the number has been decreased, indicating the shallow aquifer has been developed more, compared to deeper.

1.4.12 Cropping Patterns

The main crops of the district are rice, maize, wheat, gram, maize, pulses (masoor) and potato (***Table 1.11***). The district occupies a prominent position in the state in the production of potato.

Table 1.12: Cropping Pattern

Area in ha

Type of Crop	Season	Area (Ha)	Net Area Sown	Cropped Area	Area Sown More Than Once
Barley, Jowar, Bazra, Ragi & Small Millets	Whole year	210	41706	77317	35609
Oil Seeds	Whole year	279			
Kharif Pulses	Kharif	235			
Rabi Pulses	Rabi	14088			
Maize	Whole year	234			
Rice	Kharif	34098			
Wheat	Rabi	23195			

Source: state.bihar.gov.in (Agriculture Department)

1.4.13 Prevailing Water Conservation/Recharge Practices

In Jehanabad district, Injection well, tank and ponds, Ahar-pyne system etc are the main traditional water conservation structures present. Apart from these, village ponds and tanks used for irrigation in agriculture field acts as water conservation structures.

1.5 Geology

The maximum part of Jehanabad district is mainly occupied by Quarternary sediments, which occur mainly in eastern part. The western part is covered by sediments of Fatwa formation of middle Holocene age made up of alternate sequence of sand silt and clay. Small part of eastern side of the district contains soft loose sediments of flood plain of streams i.e. sediments of Diara formation of late Holocene age. A small portion in South occupied by metasediments of Munger group belonging to middle Proterozoic age. The metasediments include highly folded and fractured quartzite, phyllite and schiest with intrusive granite and pegmatites. Very small portion in south contains lateritic soil. (***Fig 8***)

Ground water occurs both in Alluvium and metasediments. In alluvium ground water is in unconfined condition whereas in metasediments ground water present in the formation due to secondary porosity that is between fault and fractures within rocks.

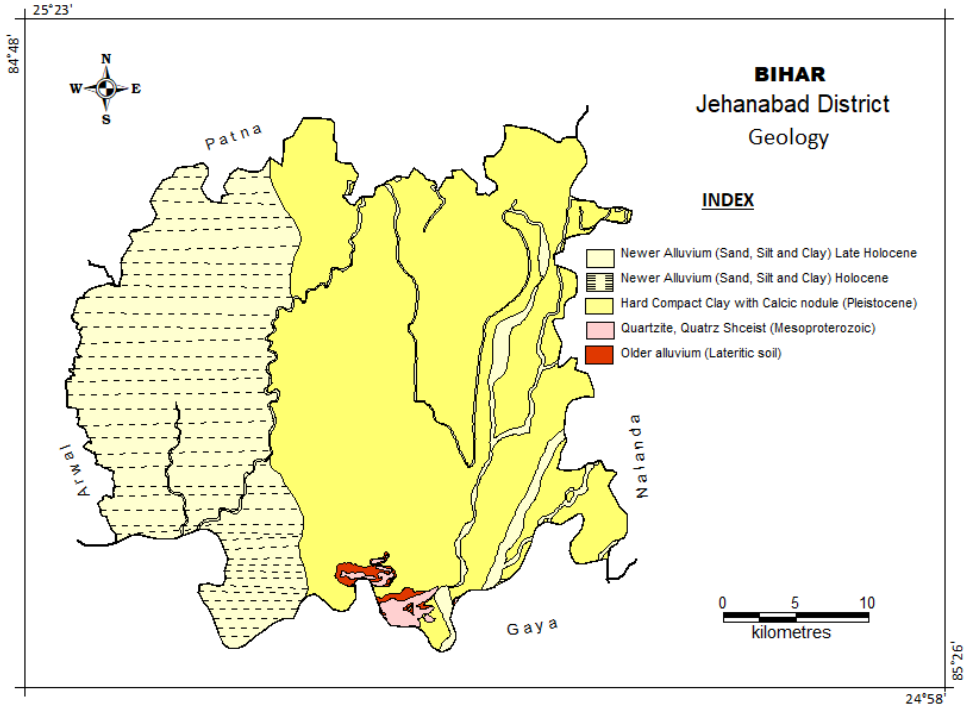


Figure 8: Geology Map

CHAPTER- 2

DATA COLLECTION AND GENERATION

The water level and quality data are being collected and recorded regularly from National hydrograph monitoring Stations. The data gap analysis has been done and new data has been generated for more information. Exploration data has also been complied. To understand the sub–surface geology, identify the various water bearing horizons including their depth, thickness and compute the hydraulic characteristics such as transmissivity and storativity of the aquifers, exploratory drilling programme was carried out by Central Ground Water Board.

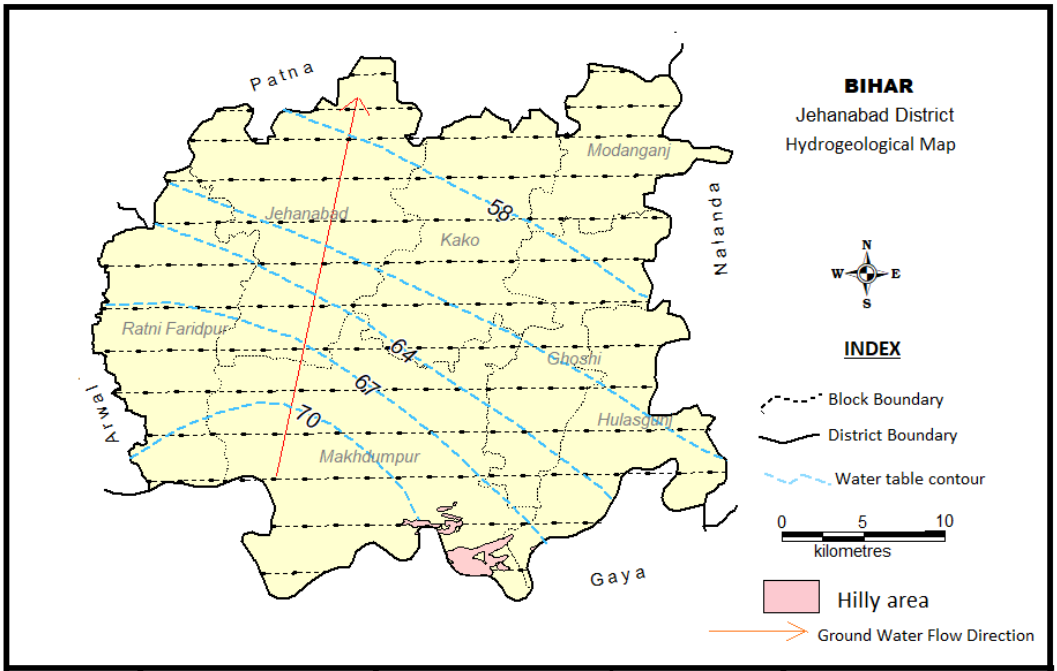
2.1 Hydrogeology

Jehanabad district falls under Harohar basin. Major part of the district made up of sediment of Quaternary and Holocene age with small part of metasediments of Proterozoic age.

Ground water occurs both in Alluvium and metasediments. In alluvium ground water is in unconfined condition whereas in metasediments ground water present in the formation due to secondary porosity that is between fault and fractures within rocks.

The Quaternary alluvium consisting of alluvial sediments, made up of gravels, sands, silt and clays constitute the main water bearing formation. The gravel and medium to coarse-grained sand layers are good groundwater repositories. The depth of the basement varies from 120 to 150 m below land surface. The alluvial formation overlying the basement holds good aquifers; however, in some parts of this district clays are prominent. The shallow aquifers can be tapped for a discharge of 20m3/hr, while the deep aquifers can be tapped by wells drilled up to the bed rock yielding about more than 50 m3/hr. Based on the previous studies by CGWB and the State agencies, the salient hydrogeological information is presented as under. ***Fig 9***

Depth ranges of shallow aquifers (in m bgl)	*Jehanabad Bazar: 30-50 (in general)*
Yield potential (discharge) of tube wells tapping shallow aquifer	*15-20 m^3/hr*
Depth ranges of deeper aquifers (in m bgl)	*Jehanabad Bazar: 97-107,113-125,129-140 (in general)*
Yield potential (discharge) of tube wells tapping deeper aquifer (discharge)	*77 m^3/hr at a drawdown of 9.0 m*
Transmissivity of deeper aquifers	*121 m^2/day*



Age Group	Lithology	Hydrogeology	Groundwater Structure	Poteltial
Quarternary	Recent alluvium, Clay, Silt, fine-medium to coarse sand with Kankar	Fairly thick regionally extensiveinterconnected semiconfined to confined aquifer down to 0 depth of 140 m	Shallow tube well Medium capacity tubewell Heavy duty tubewell	Depth Discharge 30 to 40 mbgl 15-20m3/hr 50 to 80 mbgl 30-50m3/hr 100-150 mbgl100-200 m3/hr

Figure 9: Hydrogeological Map.

2.1.1 Depth to Water Level

To study the ground water behavior, all over the district total 8 National Hydrograph Monitoring Stations (***Fig 10***) are being monitored four times a year, May19, August19, November19 and January'20. The pre and post monsoon data for the year 2019 and details of of 8 monitoring stations have shown in ***Annexure I.***

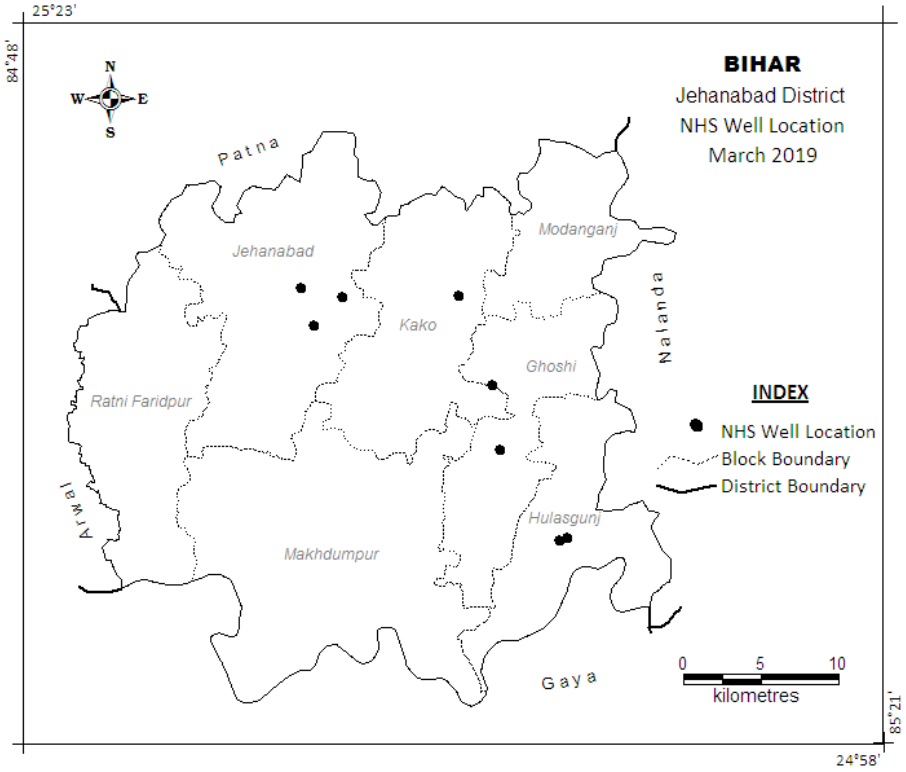


Figure 10: Location of National Hydrograph Monitoring Stations.

Premonsoon 2019

The premonsoon depth to water level data varies from 3.49 m bgl (Tenibigha) and 10.4 m bgl (Gaurakshini). The depth to water level map premonsoon 2019 (***Fig 11***) shows maximum area of the district shows depth to water level 5 to 10 mbgl, small portotion of north western and south western part shows depth to water level within 2 to 5 mbgl during premonsoon season. Very small portion in central part shows depth to water level more than 10 m.

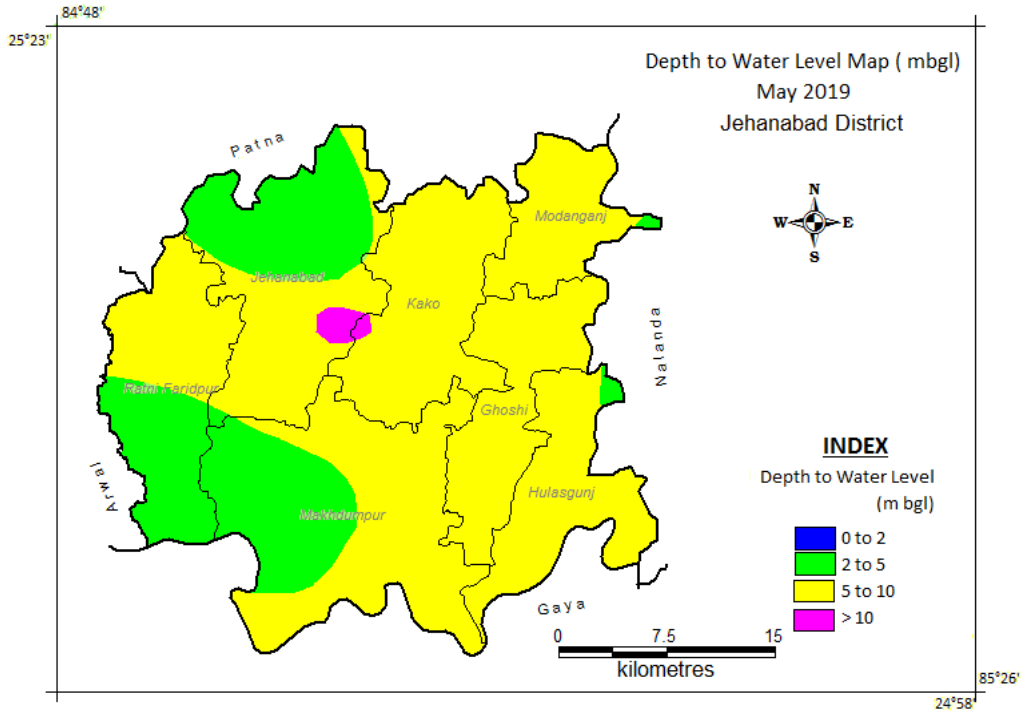


Figure 11: Depth to Water Level Map- Premonsoon 2019

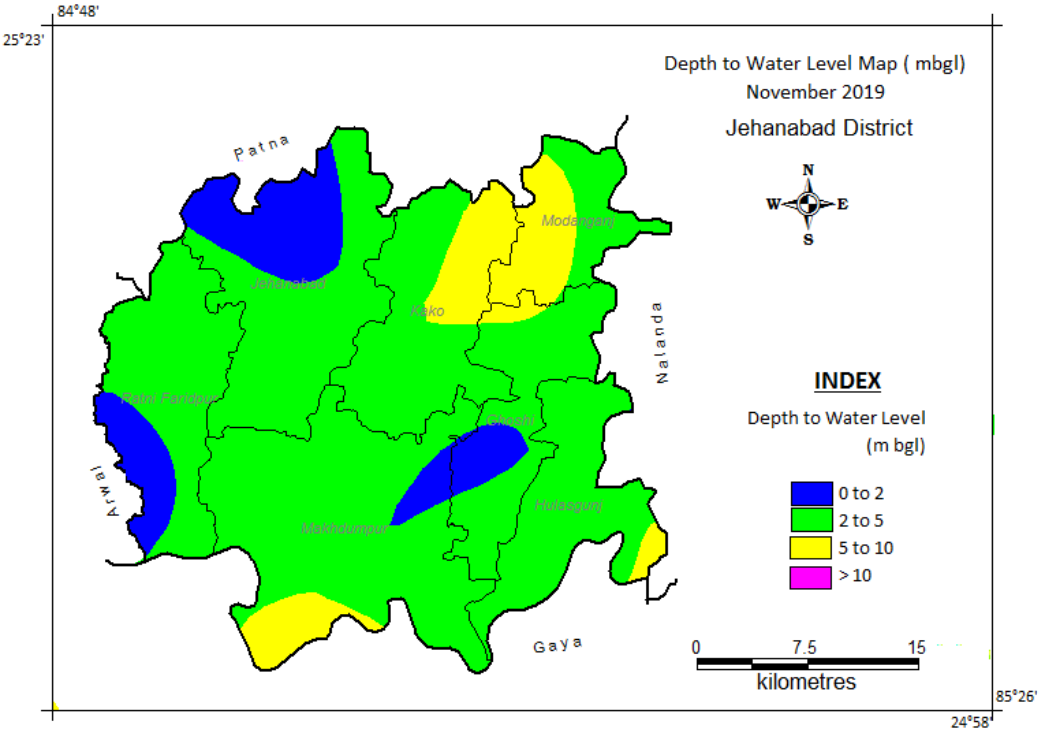


Figure 12: Depth to Water Level Map- Post-monsoon 2019

Postmonsoon 2019

The post monsoon depth to water level varies from 1.62 (Lakhwar) and 4.94 (Gaurakshini). The depth to water level map of post monsoon (***Fig 12***) shows that maximum area shows 2 to 5 m bgl range of depth to water level. Small part of north and south western

side and central small part shows depth to water level within the range of 0 to 2 mbgl. Part of north eastern side and southern side of the district shows depth to water level 5 to 10 mbgl.

Water level fluctuation of November 2019 wrt May 2019:

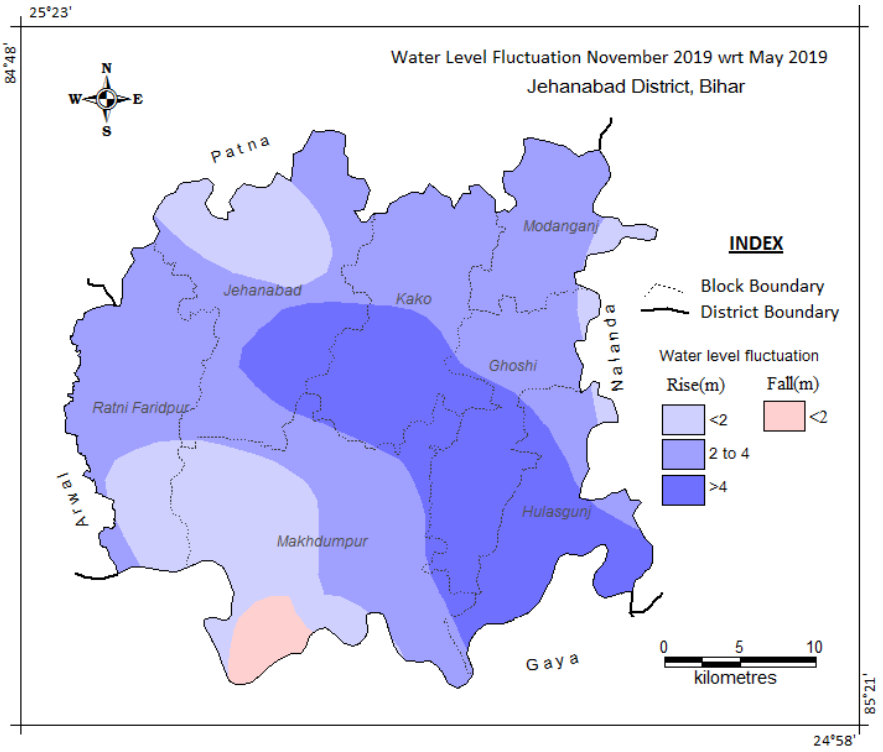


Figure 13: Water Level Fluctuation Map Postmonsoon 2019 wrt Premonsoon 2019

The water level fluctuation map (***Fig 13***) shows that in maximum part of the district there is rise in water level when compared post monsoon to premonsoon 2019. Water level rise varies from 1.68m (Tenibigha, Jehanabad) to 5.46 m (Gaurakshini, Jehanabad). Maximum area of the district shows water level rise within the range of 2 to 4 m. Central and south eastern part of the district shows water level rise more than 4m. a very small part in south shows fall of water level within 2m.

Long term water level trend:

The long-term water level data and hydrograph of Kurtha, Karpi, Makhdumpur and Jehanabad block of Jehanabad district has been shown in ***Fig.14 (i), Fig.14(ii), Fig.14(iii) and Fig.14(iv).*** Except the hydrograph of post-monsoon of Kurtha block (fliing 0.4 mm/yr) the other hydrograph showing rising trend both in premonsoon and postmonsoon period. In Giriak block hydrograph showing rising trend in both pre and post monsoon. Premonsoon rising trend varies from 0.18 mm/yr to 2.03 mm/yr, post monsoon rising trend varies from 0.02 mm/yr to 1.55 mm/yr.

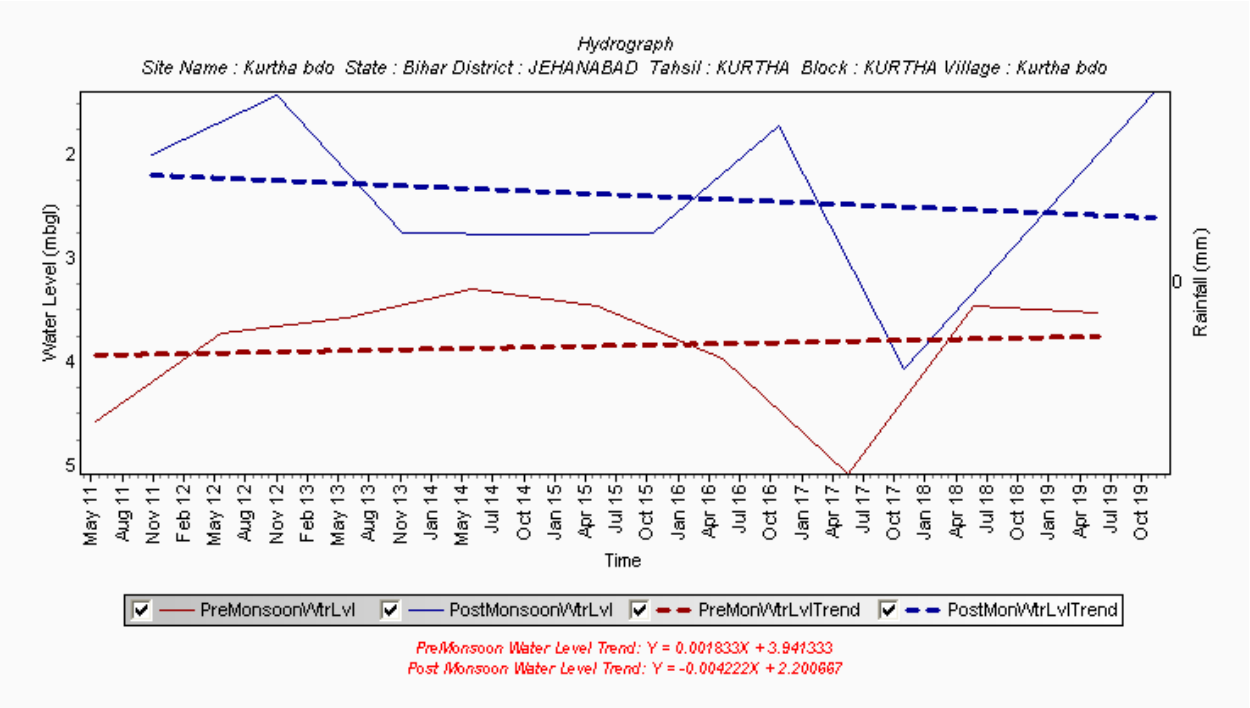


Figure 14 (i): Water Level Trend – Hydrograph1

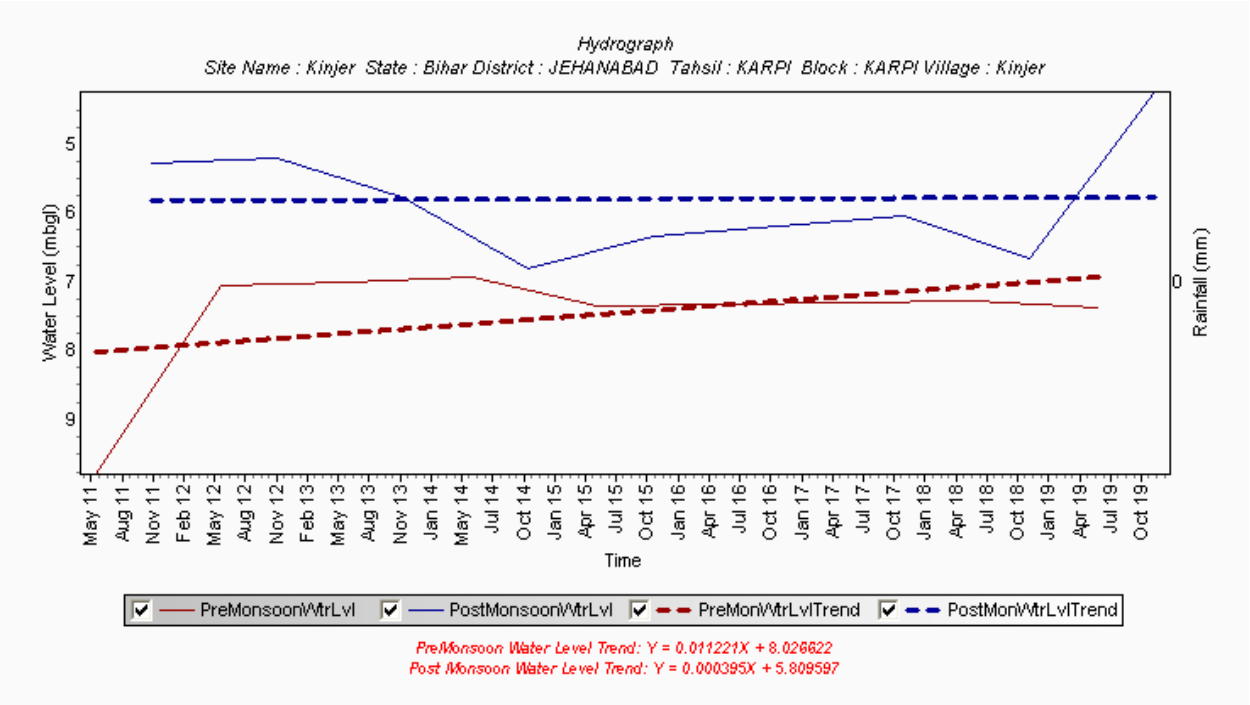


Figure 14 (ii): Water Level Trend – Hydrograph2

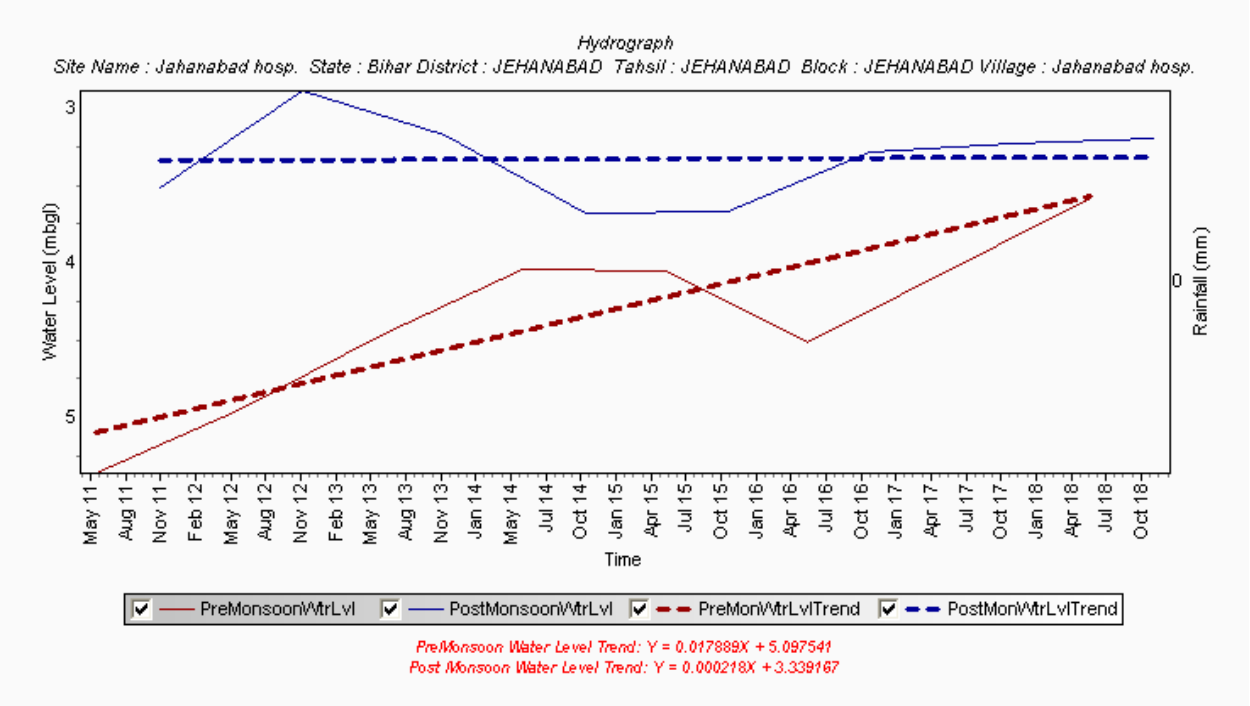


Figure 14 (iii): Water Level Trend – Hydrograph3

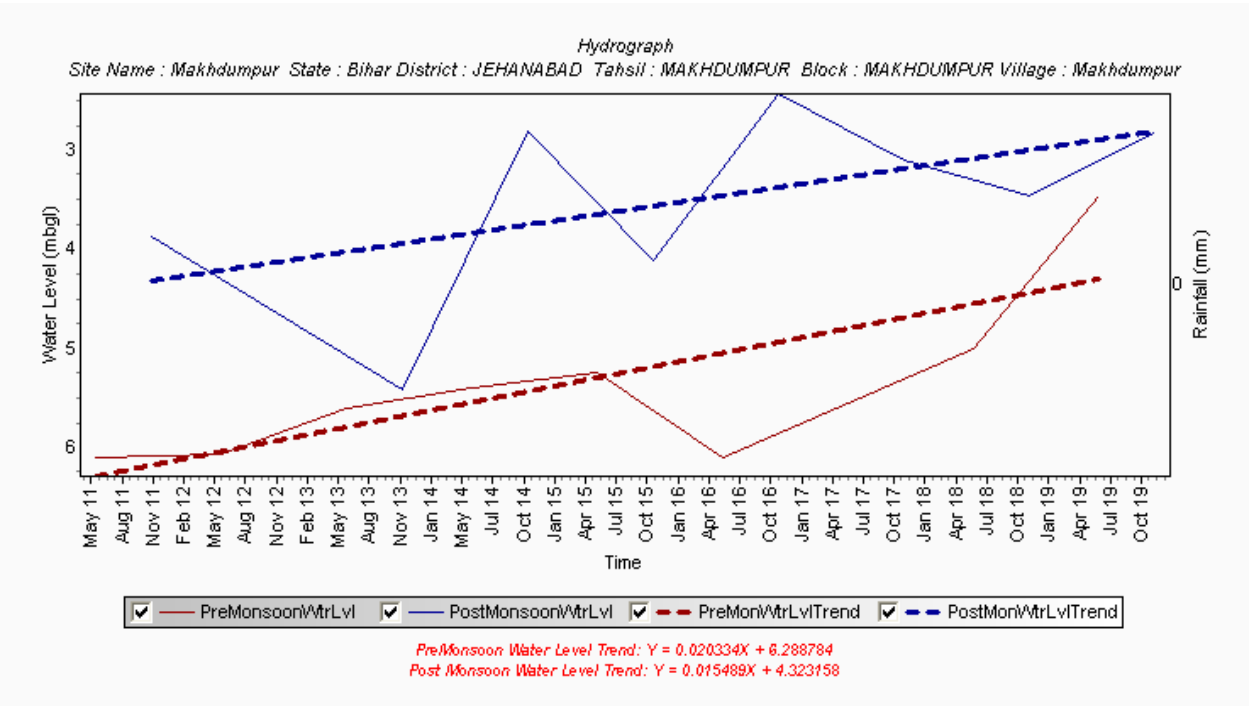


Figure 14 (iv): Water Level Trend – Hydrograph4

Water Table Contour:

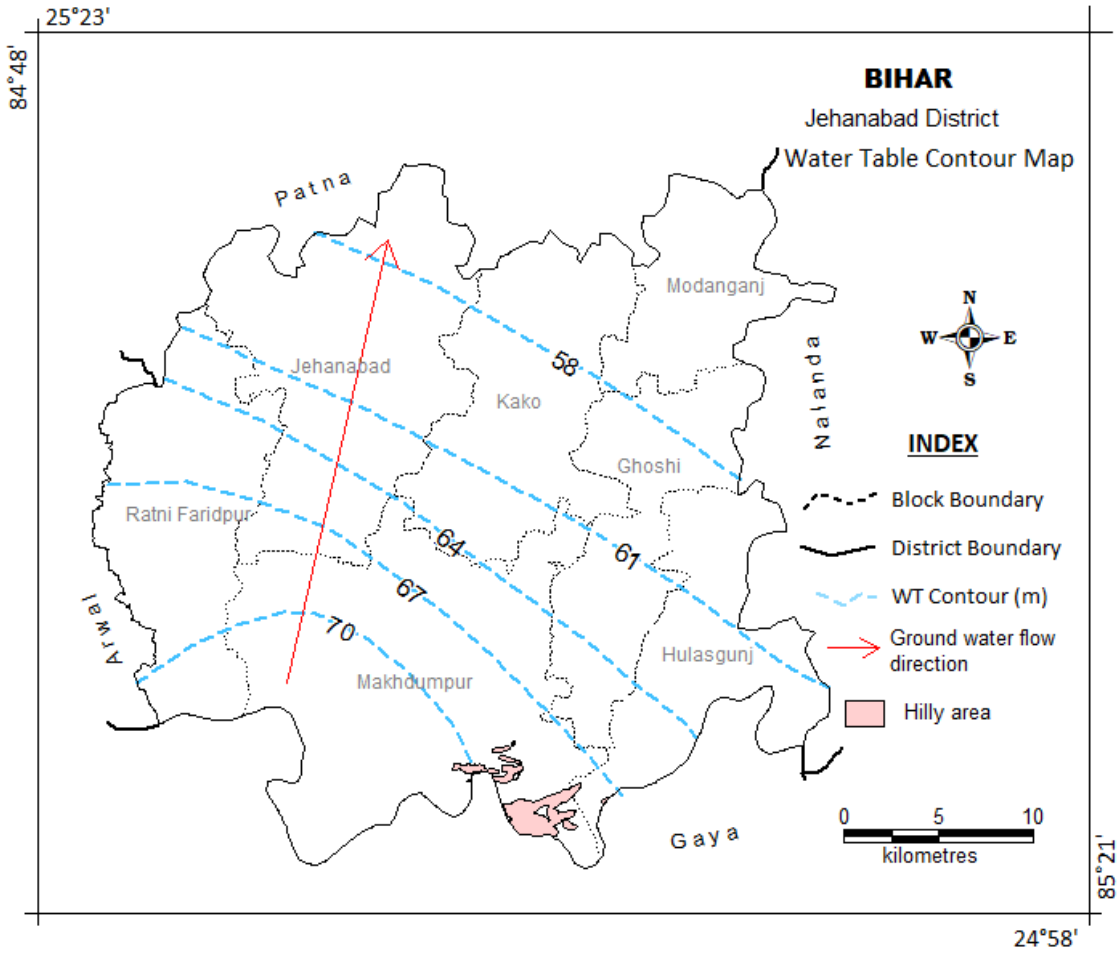


Figure 15: Water Table Contour Map

The water table contour map (***Fig.15***) shows the height of water table varies from 60 m to 70 m above MSL. As shown in map, water table become shallower in NE direction, therefore the ground water flow direction is towards NE, which is following the general slope of the area.

2.1.2 Exploratory drilling:

In Jehanabad district 14 exploratory wells and 1 observation wells have been constructed (***Fig.16***). Out of 15, 5 wells are in alluvium area and 9 well is in hard rock area. The exploratory drilling has been done down to a depth upto 147.3 m below ground level.

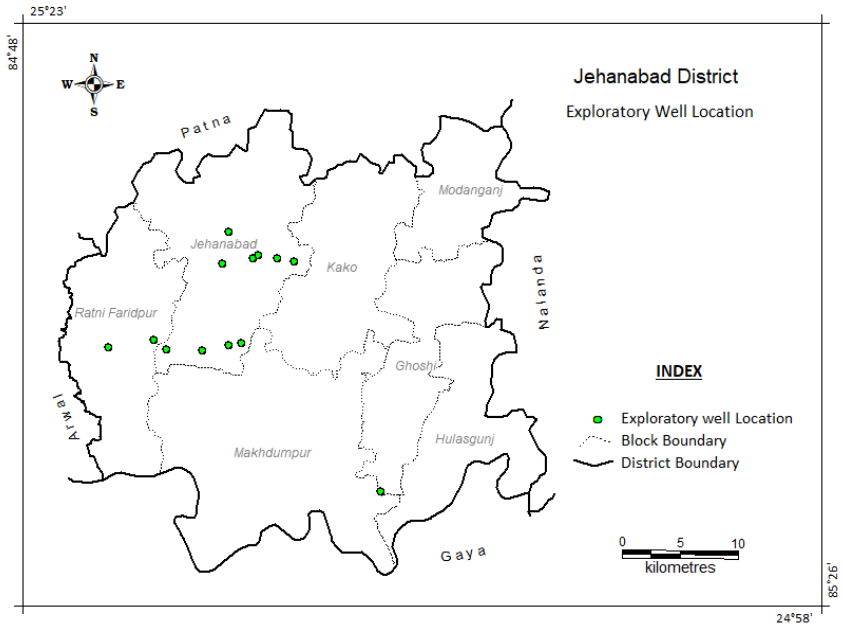


Figure 16: Location of exploratory wells

Major part of the district covered by thick quaternary alluvium, showing both single or double sand zones grading from fine medium to coarse, with alternate clay lenses. As per CGWB and other drilling data, in the western part contains thick upper clay layer with sand lenses; however there is thick bottom sand layer as per data. In the middle part of the district, top clay layer is become less thick and sand proportion increases compared to western side. Drilling data in southern part shows thick sand layers with very thin top clay layers. Subsurface lithological information extracted from exploration data has been shown ***Table 2.2.*** Data showing the depth of drilling of each location and granular zone/ fracture tapped. Tabulated data shows that within 150 m depth 2 to 3 granular/fracture zone is present.

Table 2.2: Subsurface granular zone/fracture tapped

Sl.	Block	Location	Depth drilled m bgl	Granular zone/ fracture tapped (m)		Thickness
				From	To	
1	Jehanabad	Jehanabad	147.3	97	107	10
				113	125	12
				129	140	11
2	Jehanabad	Jehanabad Bazar Samiti	153.4	93	99	6
				111	123	12

2.1.3 Pumping tests:

Total 14 exploratory wells (***Table 2.1***) have been constructed. The transmissivity calculated is 120.82 m2/ day. Details of exploratory well has been given in Annexure II.

Table 2.1: List of Exploratory and observation wells of CGWB

SN	Block	Location	EW & OW constructed	Latitude	Longitude
1	Jehanabad	Jehanabad	Only EW	25.211	84.958
2	Jehanabad	Jehanabad Bazar Samiti	Both	25.215	84.982
3	Ghosi	Ghosi	Only EW	25.048	85.083
4	Jehanabad	Parasbigha	Only EW	25.154	84.973
5	Jehanabad	Kalpa	Only EW	25.234	84.963
6	Jehanabad	Dhangwan	Only EW	25.213	85.015
7	Kako	Kako	Only EW	25.215	85.001
8	Ratni Faridpur	Sikaria	Only EW	25.151	84.867
9	Ratni Faridpur	Imadpur	Only EW	25.157	84.903
10	Jehanabad	Karouta	Only EW	25.150	84.913
11	Jehanabad	Sundarpur	Only EW	25.149	84.942
12	Jehanabad	Karpi	Only EW	25.153	84.963
13	Jehanabad	Parasbigha	Only EW	25.154	84.973
14	Jehanabad	Kasaisen	Only EW	25.217	84.986

2.2 Hydrogeochemical Investigation

2.2.1 Water quality sampling, numbering of samples and analysis mechanism

During Premonsoon 2019 total 9 nos of Ground water samples were collected from dug wells in all over the district. The result in Table 2.3 gives an idea of quality of phreatic aquifer in this district.

Table 2.3: Chemical Quality of Phreatic aquifer

SN	Block	location	pH	EC	TH	Ca	Mg	Na	K	HCO3	Cl	SO4	NO3	Fl	TDS
1	Makhdumpur	Alubikha	8.44	2110	835	8	198	3.9	0.6	683	128	6.2	0.08	0.05	1266
2	Jehanabad	Gaurakhni	8.1	1209	400	52	66	3.2	0.9	506	89	1.2	0.09	0.00	725
3	Ghoshi	Ghoshi	8.31	491	165	40	16	1.3	0.3	250	14	0.3	0.11	0.00	295
4	Hulhasganj	Hulasganj	8.23	973	280	52	36	3.7	0.5	421	43	1.5	0.11	0.04	584
5	Jehnabad	Jehnabad	8.15	1460	500	70	79	4.3	0.3	451	57	5.1	0.44	0.03	876
6	Kako	Kako	7.94	4560	1975	144	392	4.8	1.3	848	323	7.4	15.29	0.00	2736
7	Ghosi	Lakhwar	8.05	743	245	54	27	2.2	0.3	287	39	1.0	0.51	0.04	446
8	Makhdumpur	Makhdumpur	8.53	772	170	8	36	3.9	0.4	342	43	0.8	0.09	0.00	463
9	Jehanabad	Teni Bigha	8.13	2390	880	60	177	5.6	0.6	726	170	6.5	0.30	0.05	1434

BIS 2012	Minimum	7.94	491.00	165.00	8.00	15.80	1.30	0.26	250.10	14.20	0.30	0.08	0.00	294.60
	Maximum	8.53	4560	1975	144	392.445	5.57	1.28	847.90	323.05	7.38	15.29	0.05	2736.00
	Average	8.21	1634.22	605.56	54.22	114.21	3.64	0.57	501.56	100.58	3.32	1.89	0.02	980.53
	Acceptable limit	**<6.5**	500	**200**	**75**	**30**	_	**1.9**	**200**	**250**	**200**	**NA**	**1**	_
	Permissible limit (in absence of alternate source)	**>8.5**	2000	**600**	**200**	**100**	_	**50**	**600**	**1000**	**400**	**45**	**1.5**	_

From the above values of different parameters, it is clear that the water all over the district is portable, except in Kako, Makhdumpur and Tenibigha where EC, TH, MG and HCO3 value is beyond permissible limit.

Hardness *(mg/l) as* $caco_3$		*Water Class*
0-75	-	Soft
75-150	-	Moderate
150-300	-	Hard
300-600	-	Very hard
>600	-	Extremely

As per the sample collected and analysed, In Jehanabad district hardness of ground water varies from 165 (Ghosi) to 1975 (Kako). According to the scale of hardness 2 samples are “extremely hard”, and rest 2 samples are “very hard”.

Suitability for Irrigation

The suitability of groundwater for irrigation purpose is based on its chemical characteristics which create soil condition hazardous to crop growth and yield. It depends on the following prevailing criteria: -

Salinity: - Total concentration of soluble salt

Sodicity: Concentration of sodium relative to calcium and magnesium.

Relative proportion of carbonates + bicarbonate to calcium + magnesium.

Based on the above, many methods have been suggested by the scientist/chemist to check its suitability. Some of them are as under:

(i) Sodium Adsorption Ratio (SAR): It is a measure of the amount of sodium (Na) relative to calcium (Ca) and magnesium (Mg) in the water. It is the ratio of the Na concentration divided by the square root of one-half of the Ca + Mg concentration.

Excessive sodium in irrigation water promotes soil dispersion and structural breakdown but only if sodium exceeds calcium by more than a ratio of about 3:1. Such a relatively high sodium content (>3:1) often results in a water infiltration problem due to soil dispersion and plugging and sealing of the surface pores. In other words higher the SAR lower the rate of infiltration which leads to the problem with crop production.

(ii) Sodium Soluble Percentage (SSP): It is a parameter for classifying irrigation water in terms of soil permeability. Sodium ion in groundwater tends to be exchanged by Mg2+ and Ca2+ of clay particles. This exchange process reduces the permeability of soil. Sodium also combines with chloride and carbonates generating salinity and alkalinity in soil.

(iii) Residual Sodium Carbonate (RSC): It indicates the hazardous effect of carbonate and bicarbonate on the quality of water for agricultural purpose. RSC determines how much unreacted Ca and Mg remain available to counteract any Na present. When Na is present, no residual Ca and Mg remains, but residual carbonates are present, the RSC determines how much additional Ca amendments is required to react with the unreacted carbonate to prevent accumulation of sodium carbonate.

(iv) Kelly's Index: It is measurement of Na+ against Ca2+ and Mg2+ in meq/1. A Kelley's index more than 1, indicates an excess level of sodium in water.

(vi) Magnesium Ratio: In general, $Ca2^{+}$ and $Mg2^{+}$ maintain a state of equilibrium in water. But the level $Mg2^{+}$ will be high if exchangeable Na^{+} is present in irrigated soil. In equilibrium, more $Mg2^{+}$ tends to make the soil alkaline. Thus, it affects the soil quality for crops.

(v) Permeability Index: Permeability of soil is greatly influenced by Na^{+}, $Ca2^{+}$, $Mg2^{+}$, and Cl^{-} contents of soil, and is affected by long-term use of irrigation water, with high salt content.

The above suggested method wise suitability of groundwater of the area for irrigation purpose is given in the ***Table 2.4***: -

Table 2.4: Suitability of ground water for irrigation

SN	Block	location	Sodium Adsorption Ratio	Sodium Soluble Percentage	Kelley's Index	Magnesium Ratio	Permeability Index
			Na/sqrt(Ca+Mg/2)	***Na*100/Ca+Mg+Na***	***Na/(Ca+Mg)***	***(Mg*100)/(Ca+Mg)***	***Na+sqrtHCo3)/(Ca +Mg+Na)*100***
1	Makhdumpur	Alubikha	0.37	1.84	0.02	96.12	14.30
2	Jehanabad	Gaurakhni	0.34	2.63	0.03	55.79	21.26
3	Ghoshi	Ghoshi	0.19	2.28	0.02	28.31	29.98
4	Hulhasganj	Hulasganj	0.44	4.01	0.04	41.21	26.28
5	Jehnabad	Jehnabad	0.41	2.78	0.03	53.01	16.65
6	Kako	Kako	0.26	0.89	0.01	73.16	6.27
7	Ghosi	Lakhwar	0.27	2.67	0.03	33.11	23.09
8	Makhdumpur	Makhdumpur	0.76	8.01	0.09	82.00	46.26
9	Jehanabad	Teni Bigha	0.46	2.29	0.02	74.73	13.38
		Minimum	0.19	0.89	0.01	28.31	6.27
		Maximum	17.18	62.19	3.51	96.12	70.08
		Average	2.25	9.70	0.42	55.34	28.24
		Suitable	<10	<50	<1	<50	25-75
		Marginal	NA	NA	1.2	NA	NA
		Not suitable	>10	>50	>2	>50	>75

In six locations (in Makhdumpur, Jehanabad and Hulasganj block), the high values of Mg ratio (>50) indicates that ground water may cause some problem for crop production. In rest locations, values of all parameters indicates that ground water is suitable for irrigation.

Piper diagram:

A Piper diagram is a graphic procedure proposed by Arthur M. Piper in 1944 for presenting water chemistry data to help in understanding the sources of the dissolved constituent salts in water. This procedure is based on the premise that cations and anions in water are in such amounts to assure the electroneutrality of the dissolved salts, in other words the algebraic sum of the electric charges of cations and anions is zero. A Piper diagram is a graphical representation of the chemistry of a water sample or samples. The plot below **(*Fig.17)*** shows the cation-anion proportion of water samples of Jehanabad district. Most of

the sample shows relatively high carbonate (anion) proportion and high Na-K-Mg (cation) proportion.

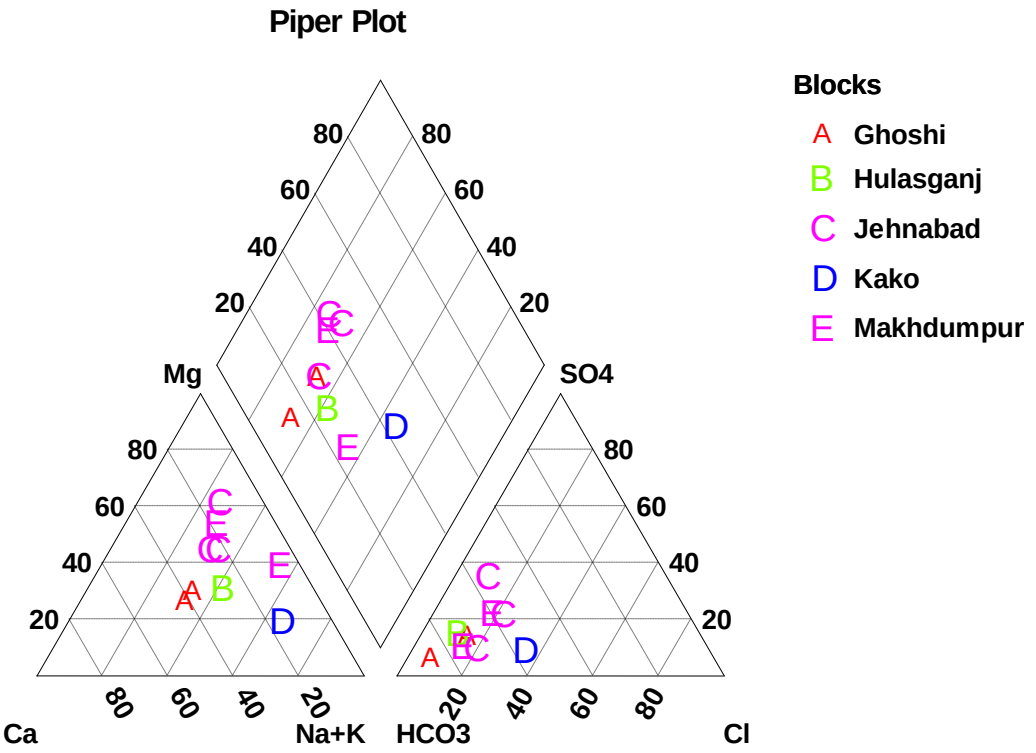


Figure 17: Piper Plot

USSL diagram:

The United States Soil Laboratory Staff's (USSLS's) diagram classifies the water quality into 16 zones to assess the degree of suitability of water for irrigation (***Fig 18***) in which waters have been divided into C1, C2 C3 and C4 types on the basis of salinity hazard and S1, S2, S3, S4 types on the basis of sodium hazard. Most of the ground water sample of Jehanabad district analyzed comes under low salinity hazard zone, except one which is under medium salinity hazard zone.

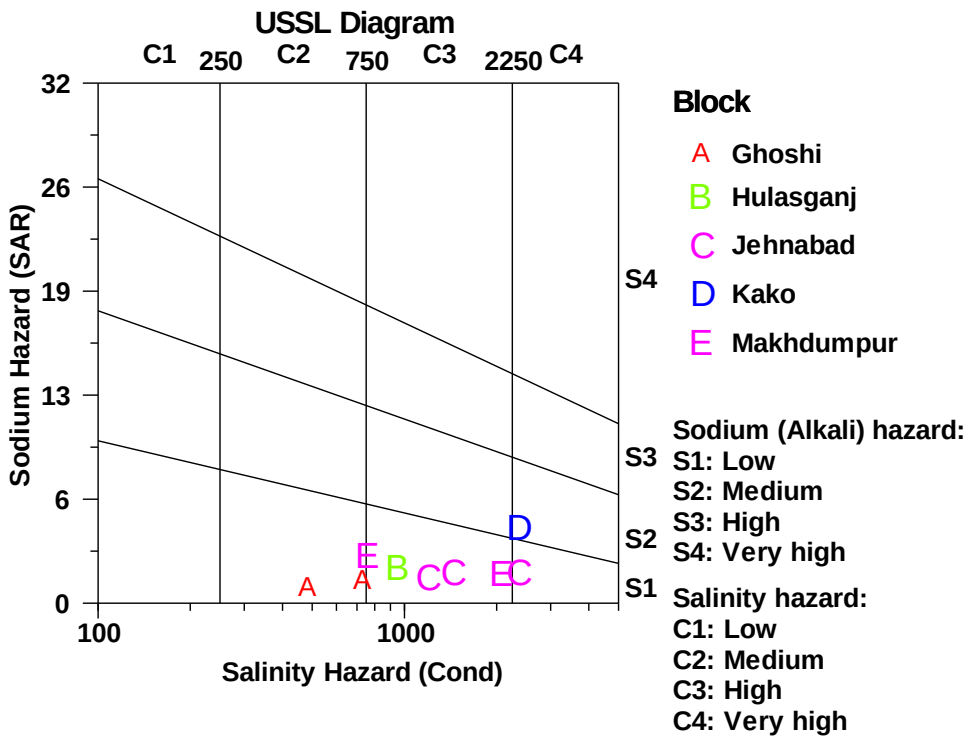
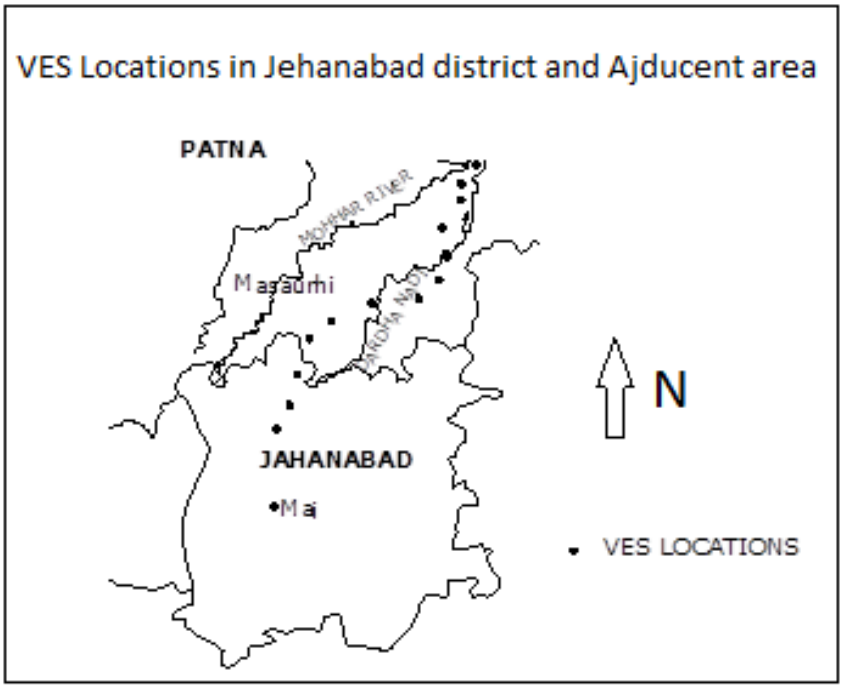


Figure 18: USSL Diagram

2.3 Geophysical Investigation

Central ground Water Board has conducted geophysical survey along Patna-Jahanabad traverse. There are total 4 locations in Jehanabad district where In Vertical Electrical Sounding (VES), has been carried out. The interpreted results were correlated with the existing Geological data as well as the existing drilling data. On the basis of interpreted results, geoelectrical sections have been prepared and vertical and horizontal disposition of granular zones of various grades are analysed within the investigated area. The overall section runs from north (Patna) to south (Jahanabad) with three linear sections. Section from Gopalpur Mathia to Mai in north south direction prepared which passing through Jahanabad district. ***Fig 19***



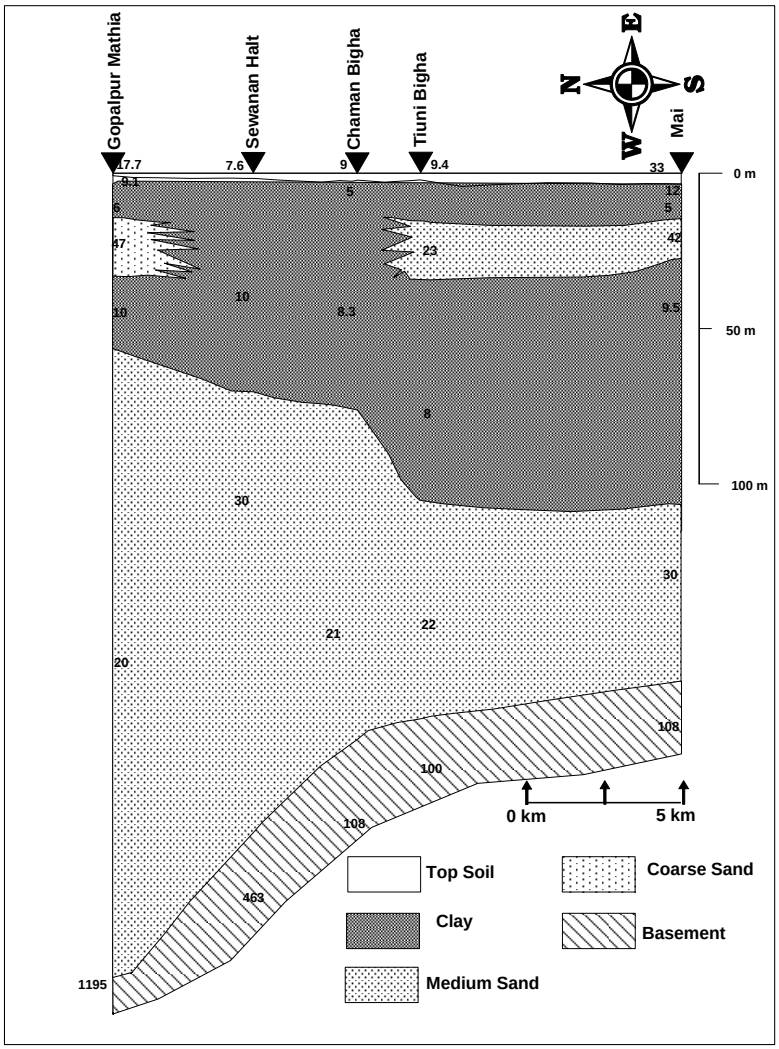


Figure 19: Geological Cross Section Gopalpur Mathia to Mai

This geo-electrical cross section is providing following information

I) The basement is dipping towards north as expected

II) Sediments are sandy, may be medium sand, above this basement. The thickness of the sand bed is increasing from south to north.

III) Above this sandy layer, a predominantly clay bed is present and patches of coarser sand material is present from Mai to Tuini Bigha at Gopalpur Mathia however this bed is absent in rest of the profile.

CHAPTER- 3

GENERATION OF AQUIFER MAPS

3.1 Aquifer Disposition

Jehanabad district is a part of Harohar sub-basin. Maximum part of the district occupied by Quarternary sediments, A small portion in South occupied by metasediments of Munger group belonging to middle Proterozoic age.

Ground water occurs both in Alluvium and metasediments. In alluvium ground water is in unconfined condition whereas in metasediments ground water present in the formation due to secondary porosity that is between fault and fractures within rocks.

The northern part of the districts made up of mainly alluvium and southern small part covered by hilly area. The lithological sections from drilling data shows double aquifer system in West and southern part of the district, in eastern and southern part, single aquifer system shown by the pannels. All aquifer systems contain thick clay layers.

Aquifer disposition of the area has been studied by different data of drilling sites. From the drilling data different lithology has been prepared which depicts the vertical and lateral orientation of aquifer of the area. Presence of both single and double layered aquifer has been reviled from different panels and litholog. Aquifer made up of fine medium and coarse sand layers.

3.1.1 Hydrogeological Section along A-A1

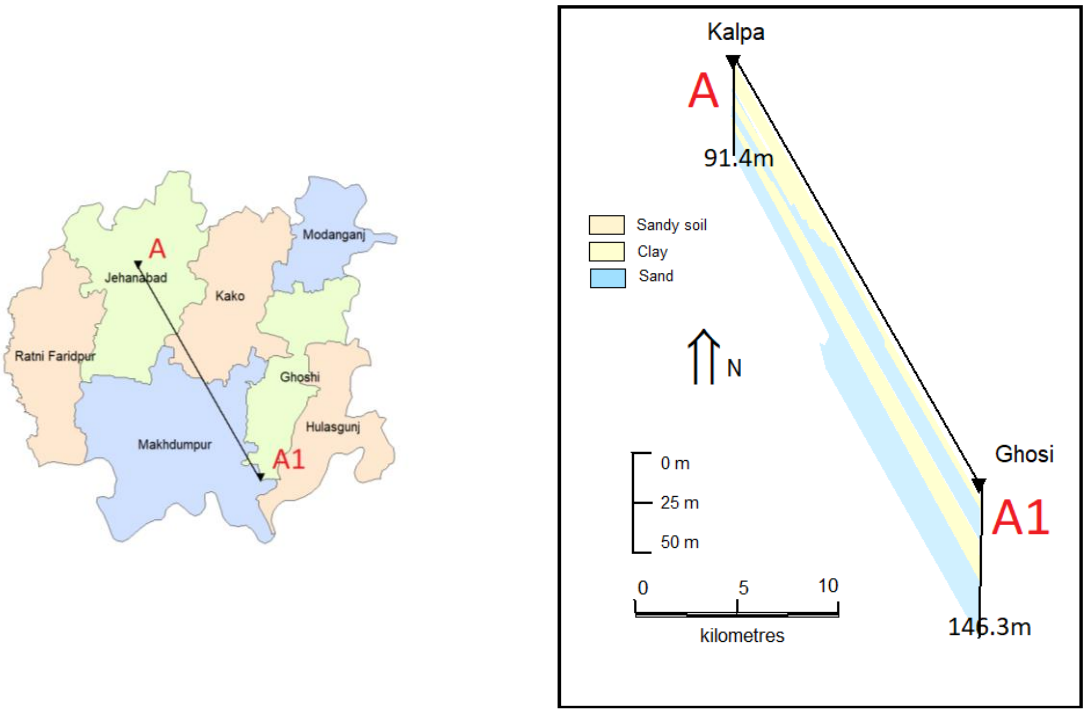


Figure 20: Hydrogeological Section along A-A1

3.1.2 Hydrogeological Section along B-B1

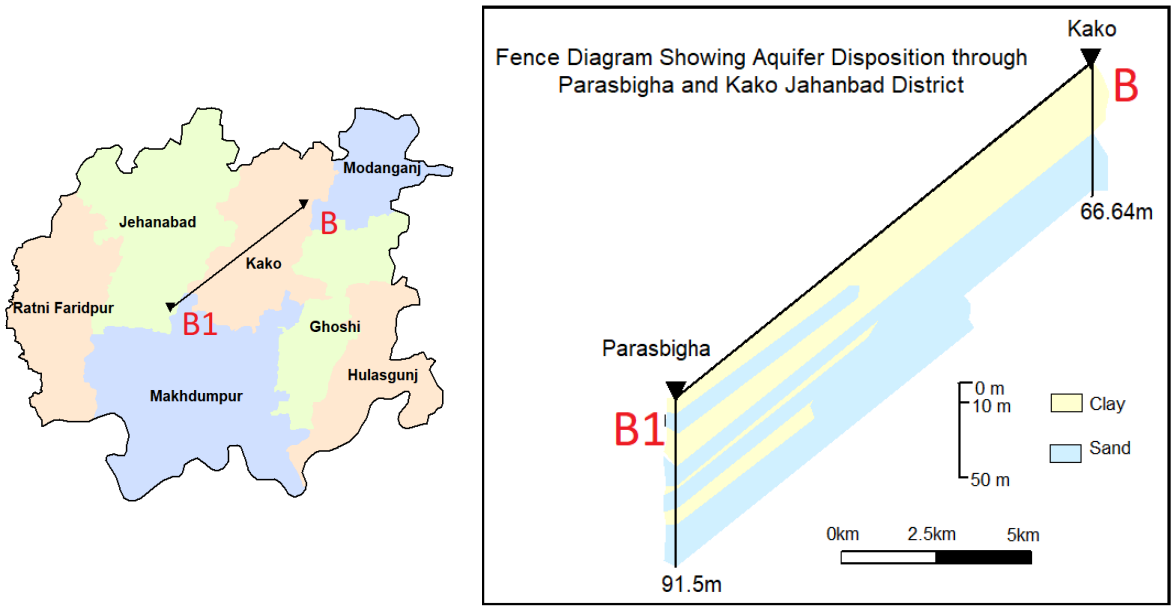


Figure 21: Hydrogeological Section along B-B1

3.1.3 Hydrogeological Section along B1-A1

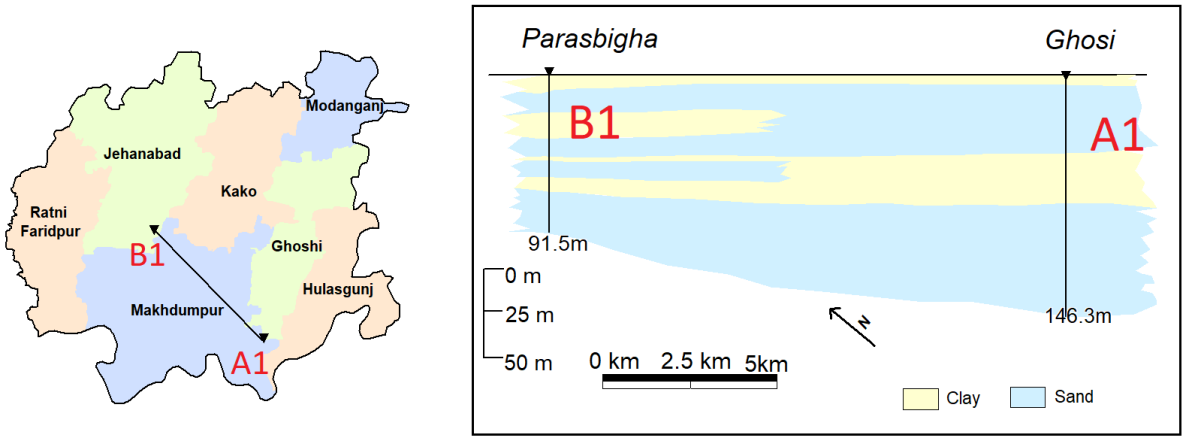
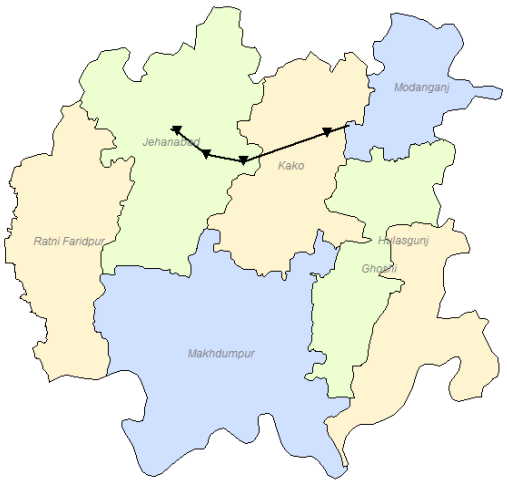


Figure 22: Hydrogeological Section along B1-A1

Using the the litholog of exploratory well drilled at Parasbigha and Ghosi, a cross section through Makhdumpur block has been prepared. Cross section shows several alternate sand-clay layers are there in Jehanabad, while moving towards Makhdumpur the sand and clay patches end out and towards Ghosi, finally it showing two layer aquifer system, which are separated by two clay layers. The average thichness of 1st aquifer is 40 m and average thickness of 2nd aquifer is 35 m. thickness of 2nd aquifer is about 15 m at Jehanabad and gradually more thick (about 75 m) in Ghosi. The two aquifers are separated by about 30 m thick clay layer, whereas the top clay layers is of thickness of less than 10m.

3.1.4 Aquifer disposition (Pannel diagrams)



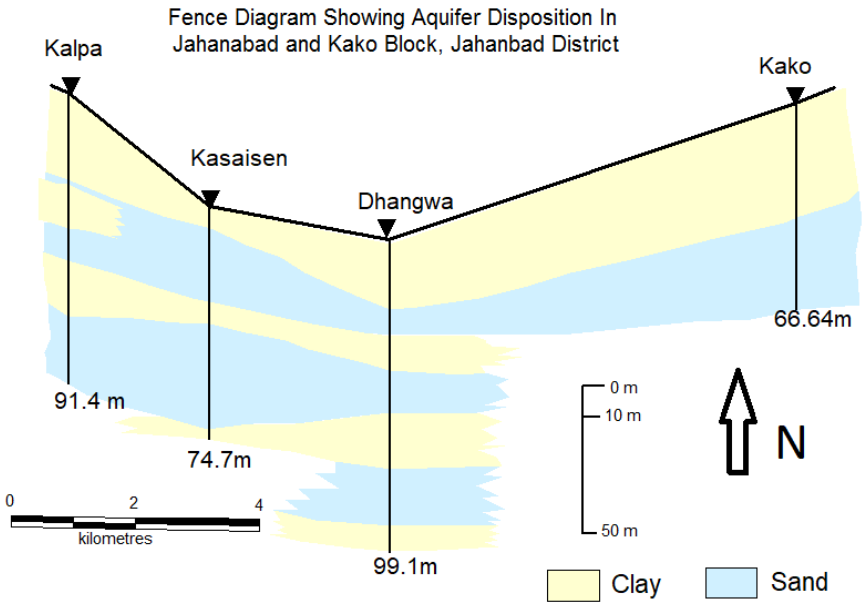
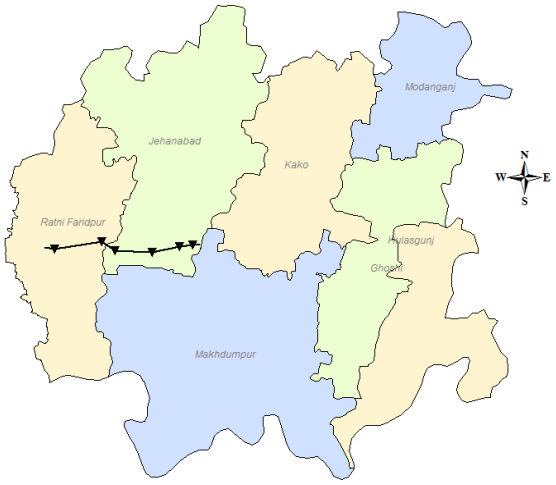


Figure 23: Pannel Diagram 1

Pannel ***Fig 23*** has been prepared from the exploration data of four drilling sites at Kalpa, Kasaisen, Dhangwan and Kako. The pannel shows that there are two layers of aquifer separated by a clay layers. The first layer of sand becomes finer towards east direction, i.e. towards Kako block. Among the four wells, well of Dhangwan is of maximum depth (99.1 m). Average thickness of 1st and 2nd aquifer is 21 m and 28 m respectively. The two aquifer layers are separated by a 12 m thick clay layer. The 1st aquifer layer become thin (8m) towards Kasaisen and again thick towards east (Dhangwan). Towards Kako the average thickness of 1st aquifer is 26 m. towards eastern side the 2nd layer aquifer may present. Lithologs of different locations are presented in Annexture II.



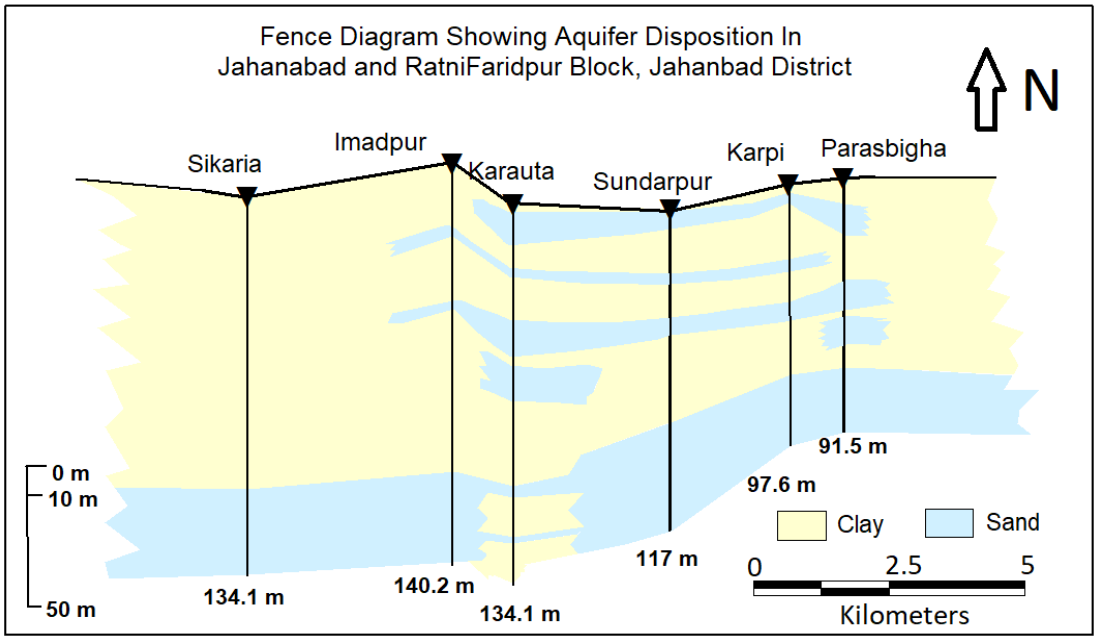


Figure 24: Pannel Diagram 1

Using the exploration drilling data of Sikaria, Imadpur, Karouta, Sundarpur, Karpi and Parasbigha, a panel ***Fig 24*** has been prepared through Jehanbad and RatniFaridpur block, which shows that there is a layer of aquifer with top clay layer, with thin sand lenses. The average thickness of aquifer is 32 m. the top clay layer is about 75 m thick. Thickness of sand lenses present in the clay layers varies from 10m to 12 m. in every drilling data shows that the sand is fining upward. The west side i.e. in Ratnifaridpur block, there is about 59 m thik clay layer, with no sand patches.

3.2 Aquifer Parameters/Pumping Test Results

Aquifer Performance Test (APT) was conducted in exploratory wells in order to determine the aquifer parameters. APT was conducted at constant discharge, and drawdown has been measured at regular intervals. Also the residual drawdown has been measured periodically during recovery. The time-drawdown data has been plotted by using Cooper-Jacob's Straight Line method and using Theis's Recovery Method and transmissivity values are approximated. T value has been calculated for one well in Jehanabad block in ***Table 3.1***. T value calculated is 120.82 m2/day. In Jehanabad district, shallow tube wells in the depth range of 30-50 m are capable of yielding 15-20 m3/hr discharges. The deeper aquifers are capable of yielding 50-100 m3/hr.

Table 3.1: Aquifer Parameters calculated from APT (Existing Data)

Sl.	Block	Location	Depth (mbgl)	Discharge m3/hr	Drawdown (m)	Transmissivity (m2/day)
1	Jehanabad	Jehanabad Bazar Samiti	147.3	76.78	9.44	120.82

3.3 Aquifer Characteristics

Total 15 exploratory wells and 1 observation well have been constructed in Jehanabad district. All bore wells were drilled in quaternary alluvial formation except at one site at Ghosi which is in quartzite zone belonging to Mesoproterozoic age.

One exploratory and one observation well (fig-12) have been drilled at Jehanabad proper, down to a depth of 147 m (Table-11). The drilling data show that three potential zones have been encountered; at different depths below 90 m . The well is yet to be tested. The ground water occurs under confined to semi confined conditions in deeper aquifer whereas in shallow aquifer; comes under water table condition. The study reveals that the water table elevation generally ranges from 50 to 70 m above MSL.

In Jehanabad district, shallow tube wells in the depth range of 30-50 m are capable of yielding 15-20 m3/hr discharges. The deeper aquifers are capable of yielding 50-100 m3/hr. The detailed exploration data has been attached in ***Annexture II.***

3.4 Aquifer Map:- Based on Hydrogeology, Pumping test, Lithologs.

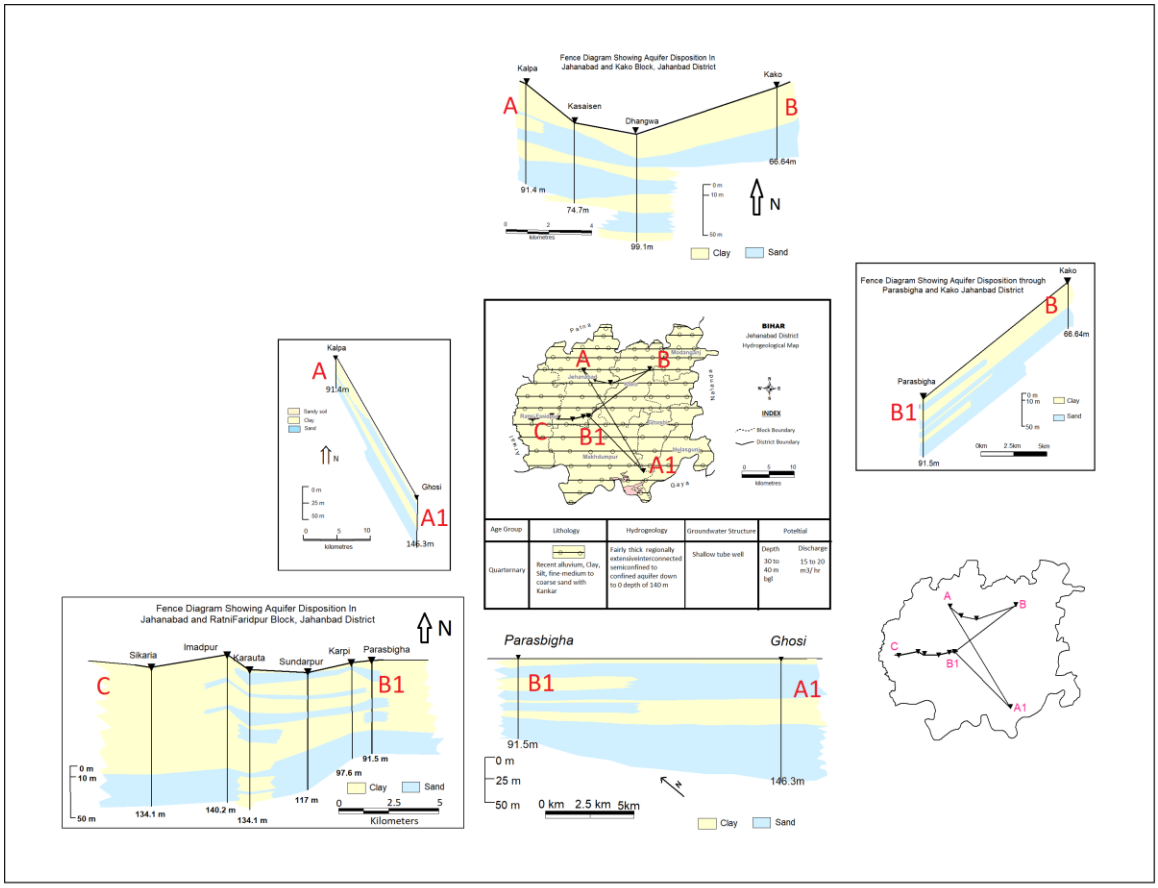


Figure 25: Aquifer Maps, Jehanabad District, Bihar

CHAPTER- 4

GROUND WATER RESOURCES

4.1 Dynamic Ground Water Resources (as per resource 2020)

Ground Water Resource of the area has been estimated block wise based on for base year as on 2020. In the present report GEC 2015 methodology has been used and based on the assessment has been made using appropriate assumptions. This methodology recommends aquifer wise ground water resource assessment of both the Ground water resources components, i.e., replenishable ground water resources or Dynamic Ground Water Resources and In-storage Resources or Static Resources. The assessment of ground water includes assessment of dynamic and in-storage ground water resources, but the development planning should mainly depend on dynamic resource only as it gets replenished every year. Changes in static or in-storage resources reflect impacts of ground water mining. Such resources may not be replenishable annually and may be allowed to be extracted only during exigencies with proper recharge planning in the succeeding excess rainfall years.

Assessment of Annually Replenishable or Dynamic Ground Water Resources (Unconfined Aquifer i. e Aquifer-I)

The methodology for ground water resources estimation is based on the principle of water balance as given below –

Inflow – Outflow = Change in Storage (of an aquifer)

The equation can be further elaborated as

$\Delta S = RRF+RSTR+RC+RSWI+RGWI+RTP+RWCS \pm VF \pm LF - GE - T - E - B$

Where,

ΔS – Change is storage, RRF – Rainfall recharge, RSTR- Recharge from stream channels

RC – Recharge from canals, RSWI – Recharge from surface water irrigation

RGWI- Recharge from ground water irrigation, RTP- Recharge from Tanks & Ponds

RWCS – Recharge from water conservation structures, VF – Vertical flow across the aquifer system, LF- Lateral flow along the aquifer system (through flow), GE-Ground Water Extraction, T- Transpiration, E- Evaporation, B-Base flow

The dynamic Ground Water Resources has been assessed by CGWB, MER, Patna in association with State Ground Water Direcorate, Bihar based on GEC, Methodology 2015. The summarized detail of Annually Replenishable or Dynamic Ground Water Resources of Jehanabad district is in ***Table 4.1*** and ***Table 4.2.***

Table 4.1: Block-wise Net Annual Ground Water Availability (as on 2020)

SN	*Block*	*Recharge from Rainfall*		*Recharge from Other Sources*		*Total Annual Ground Water Recharge*	*Provision for Natural Discharges*	*Net Annual Ground Water Availability*
		Monsoon	*Non-monsoon*	*Monsoon*	*Non-monsoon*			
		(ham)	*(ham)*	*(ham)*	*(ham)*	*(ham)*	*(ham)*	*(ham)*
1	Ghoshi	2220.2	58.74	793.8	509.44	3582.18	358.22	96.21
2	Hulhasganj	2332.34	61.7	426.23	502.07	3322.34	332.24	178.35
3	Jehanabad	3902.52	103.25	590.46	612.17	5208.4	520.84	360.11
4	Kako	3182.39	84.19	550.18	528.1	4344.86	434.49	652.63
5	Madanganj	1919.57	50.78	339.61	399.75	2709.71	270.97	266.15
6	Makhdumpur	5851.86	154.82	1094.59	1097.19	8198.46	819.84	961.16
7	Ratni Faridpur	2984.52	78.96	720.49	747.03	4531	453.1	0
	Total	**22393.4**	**592.44**	**4515.36**	**4395.75**	**31896.95**	**3189.7**	**2514.61**

Table 4.2: Blockwise Stage of Ground Water Development (as per resource calculation 2020)

SN	*Administrative Units*	*Net Annual Ground Water Availability*	*Existing Gross Ground Water Draft for irrigation*	*Existing Gross Ground Water Draft for Domestic Uses*	*Existing Gross Ground Water Draft for Industrial Uses*	*Existing Gross Ground Water Draft for All Uses*	*Provision for Domestic and Industrial Requirement for Next 25 years*	*Net GW Availability for Future Irrigation Development*	*Stage of Ground Water Development*
		(ham)	*(ham)*	*(ham)*	*(ham)*	*(ham)*	*(ham)*	*(ham)*	*(%)*
1	Ghoshi	96.21	2711.5	186.29	207.00	3104.78	209.26	96.21	96.30
2	Hulhasganj	178.35	2493.9	162.78	135.00	2791.68	182.85	178.35	93.36
3	Jehanabad	360.11	3210	794.48	225.00	4229.48	892.45	360.11	90.23
4	Kako	652.63	2715	298.88	207.00	3220.88	335.74	652.63	82.37
5	Madanganj	266.15	1903.84	151.12	99.00	2153.96	169.75	266.15	88.32
6	Makhdumpur	961.16	5475.17	558.43	315.00	6348.6	627.29	961.16	86.04
7	Ratni Faridpur	0	3915	252.54	261.00	4428.54	283.68	0	108.60
	Total	2514.61	22424.41	2404.5178	1449	26277.92	2701.02	2514.61	91.54

As per the "Dynamic ground water resource" calculation of Bihar, 2020, the figures for Jehanabad district are in the Table 4.1 and Table 4.2. As per the data the SOD (Sage of development) of the district is 91.54%. Block-wise SOD value varies from 82.37% (Kako block) to 108.60% (RatniFaridpur). Among 7 blocks 3 are of 'semi critical' (Ghosi, Hulasganj and Jehanabad) category, 3 are 'critical' (Kako, Modanganj and Makhdumpur) category and 1 is 'over exploited' (Ratni Faridpur) category.

4.2 Static Ground water Resources

In-storage groundwater resource of unconfined aquifer has been estimated and given in ***Table 4.3.*** The exercise has been carried out block-wise based on available data. Specific yield has been taken as per the prescribed norms in GWRE-2020. Static resource of Jehanabad district is estimated to be 1.48 BCM. Highest static resource is estimated in the prolific aquifers of Makhdumpur block, while low static resource is estimated in Modanganj block.

Table 4.3: Estimated In-storage resource of first aquifer in Jehanabad district

Sl. No.	Block	Lithology	GW Worthy Area (ha)	Bottom of Unconfined Aquifer (m bgl)	Pre-Monsoon Water Level (m bgl)	Specific Yield	In-Storage Resource (ham)	In-Storage Resource (BCM)
1	Ghoshi	Alluvium	9246	55	6.5	0.06	26905.86	0.27
2	Hulhasganj	Alluvium	9713	55	8.37	0.04	18116.69	0.18
3	Jehanabad	Alluvium	16252	25	6.95	0.06	17600.92	0.18
4	Kako	Alluvium	13253	50	9.38	0.04	21533.47	0.22
5	Madanganj	Alluvium	7994	35	6.5	0.04	9113.16	0.09
6	Makhdumpur	Alluvium	24370	45	5.9	0.04	38114.68	0.38
7	Ratni faridpur	Alluvium	12429	40	5.6	0.04	17102.3	0.17
Total								1.48

CHAPTER- 5

GROUND WATER RELATED ISSUES

5.1 Identification of issues

The net ground water availability of Jehanabad district is 2514..61 ham and stage of ground water development is 91.54%, when look into block-wise stage of development, there are no “safe” category block in the district, 3 “semi-critical”, 3 “critical” and 1 “over exploited” block is there as on resource 2020.

It says that there is abundant use of ground water of in the district, and it also reflects in the MI Cencus data. the comparison of MI Cencus data of 5th with respect to 4th shows vast decrease of number of Dug wells, Medium tube wells and Deep tube wells in function in almost all blocks. Number of dug wells decreased to 3 from 77, number of medium tube well deceased to 7530 from 15640, whereas number of Deep tube wells decreased to 22 from 481. From MI Census data and resource data, it may be said that the aquifers are developed enough and there is minimum or no scope of ground water development except a few places of the district.

In quality point of view ground water is suitable for irrigation. Magnesium ratio is above permissible limit in 6 blocks of the district. There may be some issue when ground water used for irrigation in these blocks.

5.2 Major Ground Water Issues

Use of deeper tube wells Medium tube wells and Dug wells has been decreased when compared to 5th MI Census data with respect to 4th MI Census data.

there is no “safe” category block in the district, 3 “semi-critical”, 3 “critical” and 1 “over exploited” block is there as on resource 2020. In semi critical blocks there is a very little or no scope of development of ground water for future use, in critical category there should be some conjunctive use of ground water, and for overexploited category there is no scope of development of ground water for future at all and also there needed some management strategies.

Limited extension of less thickened aquifer layers with thick clay layers, in eastern and southern part of the district. Lowering of water level and use of deeper tube wells in irrigation and other purposes.

Quality issues: Except in very few places the ground water is potable but some parameters like sodium adsorption ratio, sodium soluble percentage shows that there may be some quality issue of crops if water is being use for irrigation purpose.

CHAPTER- 6

MANAGEMENT STRATEGIES

6.1 Supply side management plan

There are no “safe” category block in the district. There are 3 “semi-critical”, 3 “critical” and 1 “over exploited” block in the district as on resource 2020, therefore there is minimum or no scope of ground water development except a few places of the district.

6.1.1 Artificial recharge to ground water

As per ground water resource 2020 There are no “safe” category block in the district, 3 “semi-critical”, 3 “critical” and 1 “over exploited” block in Jehanabad distrct based on SOD. SOD value of Ratni faridpur is 108.60% means ground water exploited over its availability. This may cause stress to aquifer. Land use data says the district have high cropping intensity value in almost each block, implies frequent irrigation all over the district. Irrigation data shows in Kako and Modanganj block, there is higher percentage of irrigated area than rainfed area, means more development of ground water. In other blocks also irrigation done by using ground water. From MI Cencus data it was compared that number of dug wells and shallow tube wells and Deep tube wells have drastically been decreased. All the data concludes that phreatic aquifer being dried out gradually and deeper aquifer is being exploited to meet all industrial, irrigation and domestic needs of Jehanabad district. Therefore, artificial recharge may be implemented for aquifer management or to balance aquifer stress. Details norms given in ***Table 6.1.***

Table 6.1 Details of Norms adopted for Artificial Recharge Structures in Bihar

Terrain Type	Recharge Structure Type	Recharge %	Unit Cost (inLakh)
Hard Rock Area	Percolation Tank	20%	30
	Gully Plug	20%	0.4
	Contour Bunding&Trenching	40%	2
	Check Dam	30%	20
Marginal Alluvial Area	NalaBunding	20%	1
	Contour Bunding& Trenching	20%	2
	Recharge Shaft	25%	5
	Percolation Tank	35%	30
Alluvial Area	De-silting of existing tank /pond /talao	50%	5
	De-silting of Mauns (Ox-bow Lake)	<1%	100.0 /100 ha
	Injection Well in Village Tank	10%	4
	Renovation of traditional Ahar-Pyne System	40%	20.0 / Km
Urban Areas	Roof-top Rain Water Harvesting Structures	80%	1
	De-silting and revival of existing ponds	20%	10

Source: Master Plan for Artificial Recharge to ground water in India 2020 (http://cgwb.gov.in/Master%20Plan%20to%20GW%20Recharge%202020.pdf)

Table 6.2 Further Scope of Artificial Recharge in Jehanabad district

Area of District (Sq.Km.)	Area Identified for AR (Sq.Km.)	Volume of Unsaturated Zone (MCM)	Available Subsurface Space for AR (MCM)	Water Required for Recharge (MCM)	Surplus Available for Recharge (MCM)
932.57	932.57	2113.2	169.06	260.36	594.5

Source: Master Plan for Artificial Recharge to ground water in India 2020 (http://cgwb.gov.in/Master%20Plan%20to%20GW%20Recharge%202020.pdf)

Artificial Recharge and Cost Estimates:

Rural Areas

Considering hydrogeological diversities among different areas of Jehanabad district, a simplified and generalised norm has been adopted where design and efficiency of individual artificial recharge structure has been defined specific to the existing terrain types in the district. Terrainwise norms adopted along with unit cost estimates for different types of structures are given in ***Table 6.1*** In Jehanabad district there are alluvium and hard rock area. Different type of artificial recharge structure may be used as per area type, amongst all recharge by AharPyne system is very common in South Bihar. These structures, if revitalized would assist immensely in water conservation as groundwater recharge in South Bihar.

The proposed plan envisages utilization of 260.36 MCM (***Table 6.2***) of source water for recharge purpose through different structures. On the basis of the norm, number of structures has been worked out based on gross storage capacity of individual structure. Numbers of various types of artificial recharge structures and cost Estimate in Jehanabad district are given in Table 6.4. As per estimate, 5 NalaBunding, 41 Contour Bunding & Trenching, 81 Recharge Shaft and 4 Percolation Tank may be created to enhance groundwater recharge. On the other hand, in vast alluvial tract of Jehanabad, augmentation of groundwater resource may be achieved through renovation of natural and man-made surface water structures. It is proposed that, De-silting of existing 148 village tanks /ponds /talaos, Injection Well creation in 197 Village Tanks, and Renovation of 55 km of traditional aharpyne System may result in expected rise in water table. However, actual numbers of structures implementable may vary significantly based on scale of implementation. Total cost of work has been estimated to be Rs. 3240 Lakhs

Urban Areas

In urban areas, two aspects are considered, viz., revival of urban water bodies and roof top rainwater harvesting. Total cost for revival of 4 existing surface water bodies (ponds) with an estimated cost of Rs. 40 Lakhs, whereas construction of 800 rainwater harvesting structures costs Rs. 800 lakh. The total cost estimate for artificial recharge in Jehanabad district is Rs 4080 Lakh with a break up of Rs 3240 Lakh for rural areas & Rs 800 Lakhs for urban areas (***Table 6.3***).

Table 6.3 Number of Artificial recharge structures and Cost Estimates in Jehanabad district

Districr -Jehanabad	Number of Artificial Recharge Structures	Cost of Artificial Recharge Structures (Lakh)
Percolation Tank	0	0
Gully Plug	0	0
Contour Bunding& Trenching	0	0
Check Dam	0	0
NalaBunding	5	5
Contour Bunding& Trenching	41	82
Recharge Shaft	81	405
Percolation Tank	4	120
De-silting of existing tank /pond /talao	148	740
De-silting of Mauns (Ox-bow Lake)	0	0
Injection Well in Village Tank	197	788
Renovation of traditional Ahar-Pyne	55	1100
Roof-top Rain Water Harvesting Structures	800	800
De-silting and revival of existing ponds	4	40
Total		**4080**

Source: Master Plan for Artificial Recharge to ground water in India 2020 (http://cgwb.gov.in/Master%20Plan%20to%20GW%20Recharge%202020.pdf)

6.2 Demand side management plan

The Stage of development of all 7 blocks of Jehanabad district is above 80%, one of the block is under ‘over exploited’ category. As per census data water of shallow aquifer is being used more. Micro irrigation practices may be adopted, and at the same time coordinated use of surface and ground water for irrigation purpose is required for management. Crop rotation may be applied in Agriculture.

CHAPTER- 7

SUM UP – DISTRICT FINDINGS

- Jehanabad district is a part of Magadh Division. The territory of the present-day district became Jehanabad sub-division of Gaya district in 1872. The district came into existence on 1 August 1986. It is surrounded by Patna in north, Arwal in east, Nalanda in west and Gaya in south. Jehanabad district occupies an area of 932 square kilometres including 7 administrative blocks.

- The district is located on global map between 24º59′37″ and 25º18′00″ North Latitude and 84º49′47″ and 85º13′06″ East longitude, comes under Survey of India Toposheet No. 63C/15,16, 63D/13, 63G/3,4, 63H/1. Elevation of the area ranges from 56 m and 312.5 m above mean sea level.

- Jehanabad district is located within the Mid-Ganga basin, in the southern margin of the Gangetic plains. The Major rivers are Lokain, Phalgu (Nonain, and Morhar) river. One main river of the state, Punpun, flows along west boundary of the district. The general slope of the area is towards northeast. The district mainly represents flat alluvium terrain except hills in the south. Maximum land is under agriculture use. The major kharif crops grown are paddy, while among the rabi crops wheat, pulses are important. Maximum irrigation done by using ground water.

- The water level behavior has been analyzed from NHS monitoring data. Pre-monsoon depth to water level varies from 3.49 to 10.4 m bgl whereas post-monsoon depth to water level varies from 1.62 to 4.94 m bgl. Looking into long term water level trend most of the data shows rising trend both pre and post monsoon. Ground water flow direction is towards N- NE direction.

- Coming to Geologic and hydrogeologic point of view the district contains alluviums of Quarternary and Holocene age containing sand silt and clay and metasediments of munger group of middle Proterozoic age containing highly folded and fractured quartzite, phyllite and schiest with intrusive granite and pegmatites. Ground water occurs both in Alluvium and metasediments. Exploration data shows the characteristics of aquifer in both formations.

- In Jehanabad district, shallow tube wells in the depth range of 30-50 m are capable of yielding 15-20 m3/hr discharges. The deeper aquifers are capable of yielding 50-100 m3/hr. T value calculated is 120.82 m2/day.

- Aquifer maps shows presence of both single and double layered aquifer has been reviled from different panels and litholog. Aquifer made up of fine medium and coarse sand layers. The northern part of the districts made up of mainly alluvium and southern small part covered by hilly area. The lithological sections from drilling data shows double aquifer system in West and southern part of the district, in eastern and southern part, single aquifer system shown by the pannels. All aquifer systems contain thick clay layers.

- As per "Ground Water Resource Estimation 2020", ground water has been used drastically in this district as all the block are showing SOD value above 80%, even one block is in 'over exploited' category. As per MI Census data for shallow tube wells, the number has been decreased for shallower depth and increased for deeper depth range. Number of dug wells has also been decreased, which is reflecting that shallow aquifer is being developed more than deeper one. Micro irrigation practices may be adopted, and at the same time coordinated use of surface and ground water for irrigation purpose is required for management. The ground water is potable for drinking and irrigation purposes except some few places.

- As stage of development percentage is very high in all blocks artificial recharge plan has been proposed in the district. Construction of total 800 roof top rain water harvesting structure, 197 injection wells, 148 pond, and 186 other artificial recharge structures has been proposed, with total cast of 4080 lakhs.

CHAPTER- 8

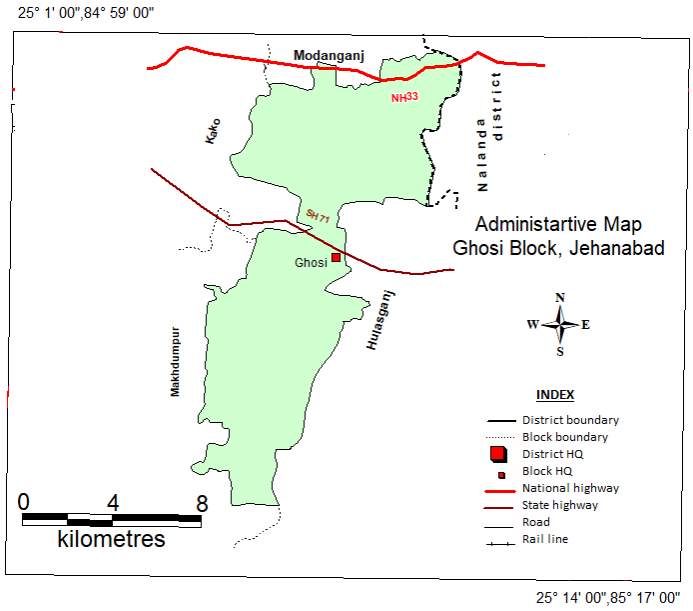
BLOCK-WISE AQUIFER MAPS AND MANAGEMENT PLAN.

8.1 Ghosi block

8.1.1 Salient Information

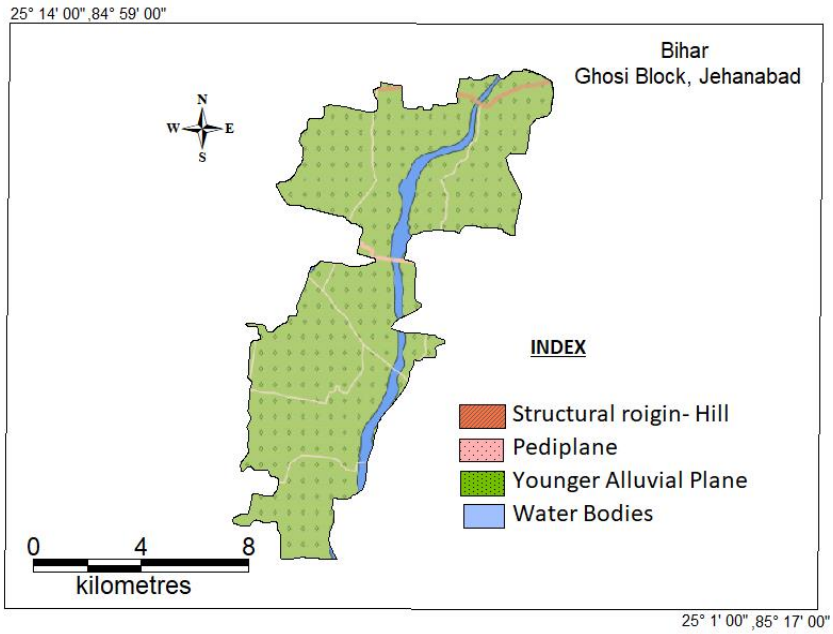
1.	Name of the block and area			Ghosi - 92.49 Sq. Km
2.	District/State			Jehanabad/ Bihar
3.	Population (2011)	Total	:	108130
		Rural		108130
		Urban		0
4.	Normal rainfall (District)	(mm)	:	1051.9
5.	Agriculture and irrigation			Main crops are Paddy, Wheat, oil seeds etc. Gross irrigated area: 5477Ha Rainfed area: 6359 Ha GW Extraction structure: (5th MI) DW : Nil STW : 709 DTW : 1
6.	Ground water resource availability and extraction	As per 2020 Resource Calculation	:	Net GW Availability: 96.21 ham Gross GW Draft : 3104.78 ham
7.	Existing and future water demand		:	For next 25 years: 209.26 ham
8.	Water level behaviour	Depth to water level		Pre-monsson : 5 to 10 m bgl Post-monsoon : 0 to 5 mbgl
9.	Basin / Sub-basin		:	Gandak and others

The Ghosi block of Jehanabad district is surrounded by Modanganj block in the North, Kako and Makhdumpur block in the West, Hulasganj block in the south-east Nalanda district boundary, in the East.



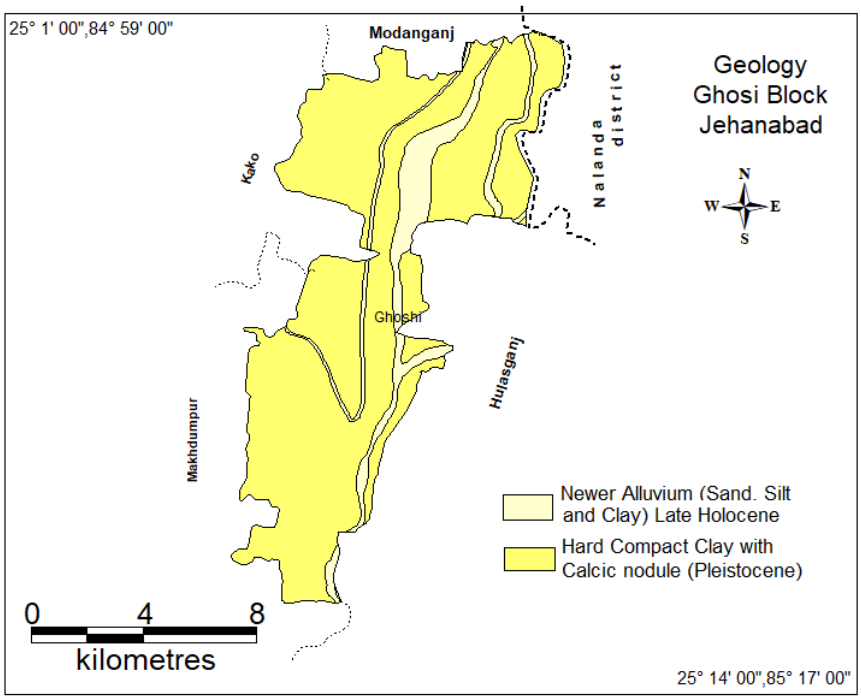
Geomorphology

The Ghosi block is in part of Mid-Ganga basin. Major part of the block made up of younger alluvium. A small part south to north made up of water bodies.



Geology

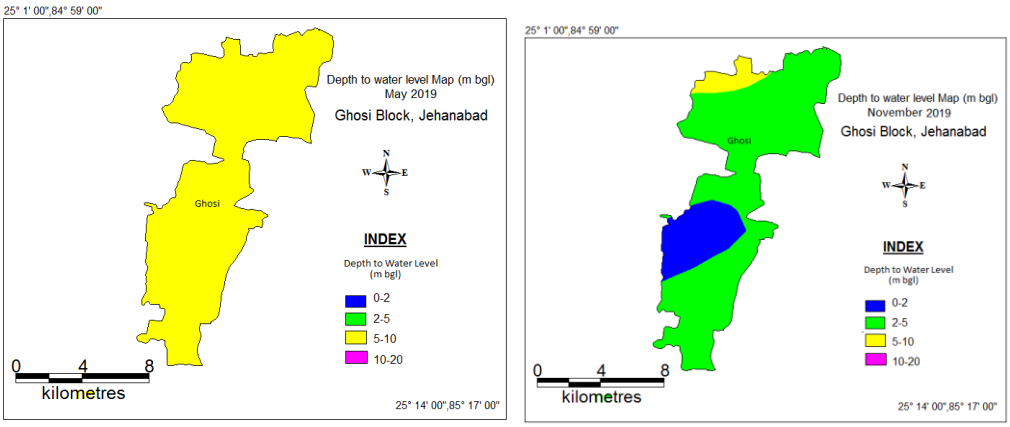
Major part of the block is covered by hard compact clay with calcic nodule of Pleistocene age. Small part of the block surrounding the water bodies the block made up of younger alluvium.of late Holocene age.



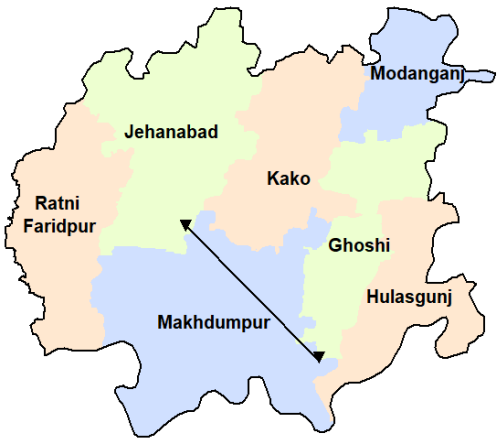
Depth to Water Level

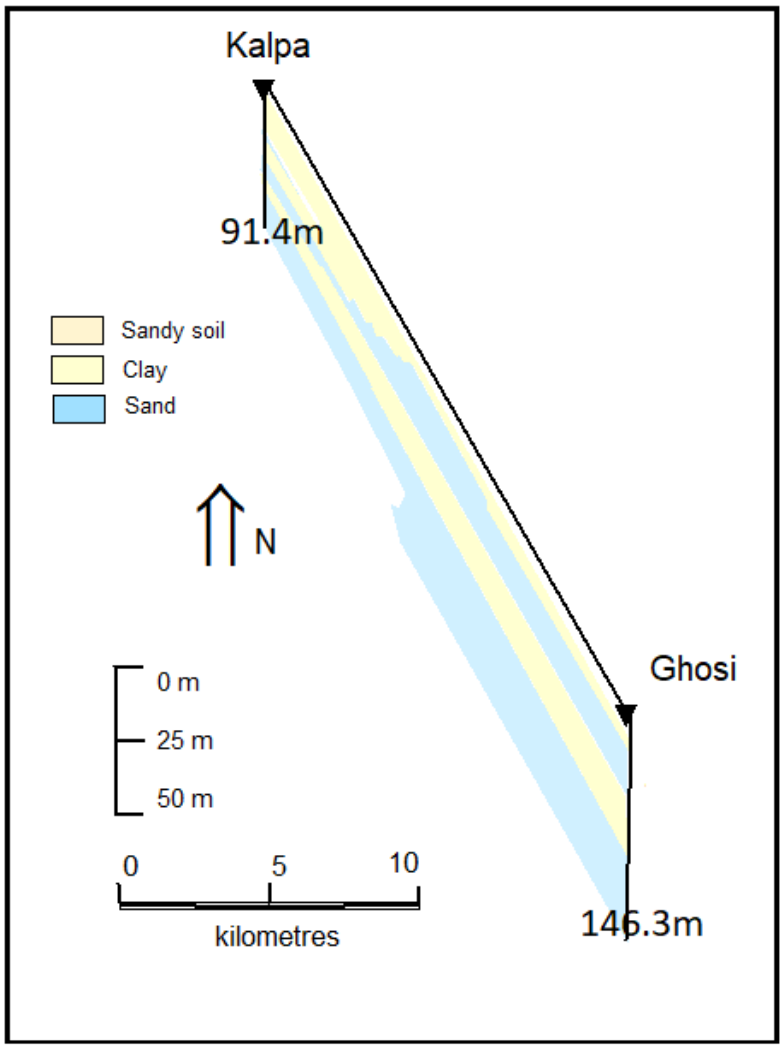
There are two National hydrograph monitoring stations in Ghosi block. CGWB NHS monitoring data shows that during the pre-monsoon period (2019-20), the block is under 5 to 10 m bgl depth to water level range. During the post-monsoon period, major part of the block shows 2-5 m bgl depth to water level, except north western part with 5-10 m bgl and small south western part 0 to 2 m bgl depth to water level range.

SN	Block	Location	Latitude	Longitude	Depth to Water Level (m bgl)		Elevation (m)	Fluctuation	Depth	RL
					May-19	Nov-19				
1	Ghoshi	Ghoshi	25.174	85.100	7.5	3.77	69	3.73	7.5	61.5
2	Ghoshi	Lakhwar	25.137	85.105	4.9	1.62	72	3.28	4.9	67.1



8.1.2 Aquifer Disposition and Characteristics





Aquifer disposition has been shown in the cross section prepared through Kalpa and Ghosi. By usig the drilling data of the two wells cross section has been prepared. The cross section shows that in southern part of Ghosi block there are two layers of aquifer, separated by two impermeable clay layers. 1st aquifer at a depth of 6 m and of 30m thick, whereas 2nd aquifer occurs at 36 m depth and of 60 m thick. Proceeding towards north the 1st aquifer become thin.

8.1.3 Ground water resource, extraction, contamination and other issues

Ground Water Resources - 2020

About 3.83% of the net ground water availability of Jehanabad district is available in Ghosi block. The SOD is 96.30 % whereas of the district SOD is 91.54 %. The block is in “Critical” category. So there is no scope for further development of ground water.

Block	*Recharge from Rainfall*		*Recharge from Other Sources*		*Total Annual Ground Water Recharge*	*Provision for Natural Discharges*	*Net Annual Ground Water Availability*
	Monsoon	*Non-monsoon*	*Monsoon*	*Non-monsoon*			
	(ham)	*(ham)*	*(ham)*	*(ham)*	*(ham)*	*(ham)*	*(ham)*
Ghoshi	2220.2	58.74	793.8	509.44	3582.18	358.22	96.21

Administrative Units	*Net Annual Ground Water Availability*	*Existing Gross Ground Water Draft for irrigation*	*Existing Gross Ground Water Draft for Domestic Uses*	*Existing Gross Ground Water Draft for Industrial Uses*	*Existing Gross Ground Water Draft for All Uses*	*Provision for Domestic and Industrial Requirement for Next 25 years*	*Net GW Availability for Future Irrigation Development*	*Stage of Ground Water Development*
	(ham)	*(ham)*	*(ham)*	*(ham)*	*(ham)*	*(ham)*	*(ham)*	*(%)*
Ghoshi	96.21	2711.5	186.29	207.00	3104.78	209.26	96.21	96.30

Chemical quality of Ground Water

Result of chemical analysis of ground water of shallow aquifer is given in the table below. The TDS ranged from 295 to 446 ppm. In general chemical quality of ground water of shallow aquifer is potable and also suitable for irrigation purpose. Result of chemical analysis is given in the table below.

SN	**Block**	**location**	**pH**	**EC**	**TH**	**Ca**	**Mg**	**Na**	**K**	**HCO3**	**Cl**	**SO4**	**NO3**	**Fl**	**TDS**
1	Ghoshi	Ghoshi	8.31	491	165	40	16	1.3	0.3	250	14	0.3	0.11	0.00	295
2	Ghosi	Lakhwar	8.05	743	245	54	27	2.2	0.3	287	39	1.0	0.51	0.04	446
BIS 2012		*Acceptable limit*	**<6.5**	500	**200**	**75**	**30**	_	**1.9**	**200**	**250**	**200**	**NA**	**1**	_
		Permissible limit (in absence of alternate source)	**>8.5**	2000	**600**	**200**	**100**	_	**50**	**600**	**1000**	**400**	**45**	**1.5**	_

SN	**Block**	**location**	Sodium Adsorption Ratio	Sodium Soluble Percentage	Kelley's Index	Magnesium Ratio	Permeability Index
			Na/sqrt(Ca+Mg/2)	***Na*100/Ca+Mg+Na***	***Na/(Ca+Mg)***	***(Mg*100)/(Ca+Mg)***	***Na+sqrtHCo3)/(Ca+Mg+Na)*100***
1	Ghoshi	Ghoshi	0.19	2.28	0.02	28.31	29.98
2	Ghosi	Lakhwar	0.27	2.67	0.03	33.11	23.09
		Suitable	<10	<50	<1	<50	25-75
		Marginal	NA	NA	1.2	NA	NA
		Not suitable	>10	>50	>2	>50	>75

8.1.4 Supply side management

Ghosi block is under 'critical' category, SOD is 96.30%. Therefore for ground water management, some artificial structure may be constructed in Ghosi block. Based on the, geology, geomorphology, depth to water level and surface water availability, the types and number of the artificial recharge structures has been worked out for Ghosi block and given in the table below. Based on available literature and previous experiences, unit cost of above structures is also worked out. As per Master plan of artificial recharge 2020, the table is as follows

Ghosi Block			
Recharge Structure		Cost (in Lakh)	Total Cost (Lakh)
Type	Number		
Percolation Tank	0	0	203
Gully Plug	0	0	
Contour Bunding & Trenching	0	0	
Check Dam	0	0	
Nala Bunding	0	0	
Contour Bunding & Trenching	0	0	
Lateral Recharge Shaft	4	8	
Recharge Shaft	8	40	
Percolation Tank	0	0	
De-silting of existing tank /pond /talao	15	75	
Injection Well in Village Tank	20	80	

8.1.5 Demand side management Plan

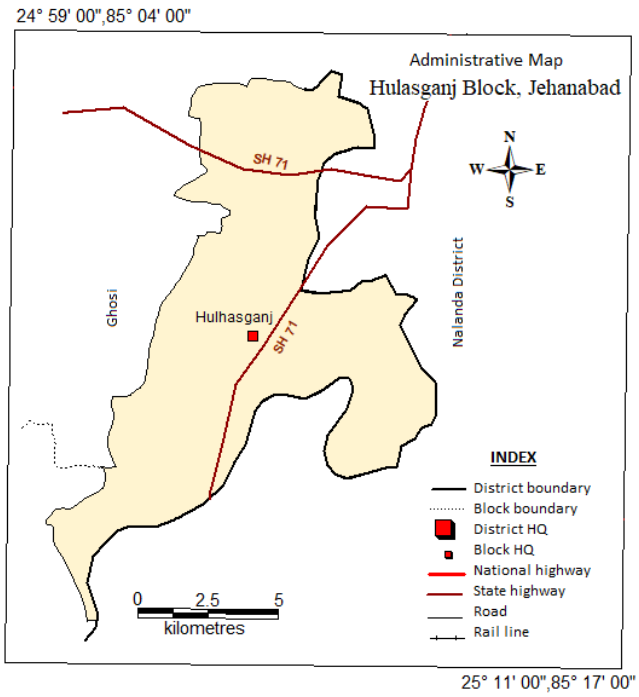
Some advance irrigation practices may be adopted such as drip/sprinkle irrigation etc. lining of field channels, change of cropping pattern also may be taken up for conservation purpose.

8.2 Hulasganj block

8.2.1 Salient Information

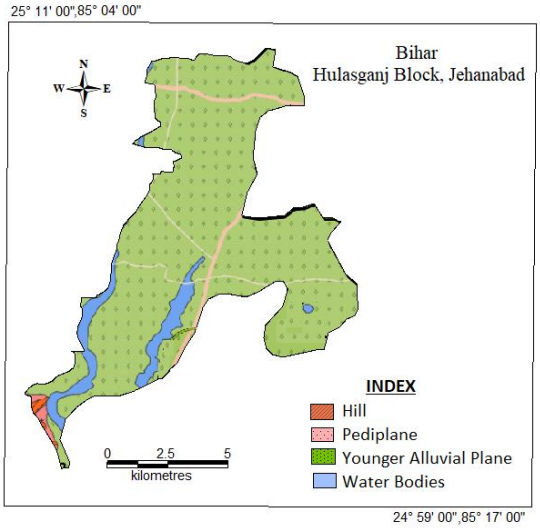
1.	Name of the block and area			Hulasganj - 97.1 Sq. Km
2.	District/State			Jehanabad/ Bihar
3.	Population (2011)	Total	:	94485
		Rural		94485
		Urban		0
4.	Normal rainfall (District)	(mm)	:	1051.9
5.	Agriculture and irrigation			Main crops are Paddy, Wheat, oil seeds, Maize etc. Gross irrigated area: 1727 Ha Rainfed area: 5179 Ha GW Extraction structure: (5th MI) DW : Nil STW : 352 DTW : 0
6.	Ground water resource availability and extraction	As per 2020 Resource Calculation	:	Net GW Availability: 178.35 ham Gross GW Draft : 2791.68 ham
7.	Existing and future water demand		:	For next 25 years: 182.85 ham
8.	Water level behaviour	Depth to water level		Pre-monsson : 5 to 10 m bgl Post-monsoon : 2 to 5 mbgl
9.	Basin / Sub-basin		:	Gandak and others

The Hulasganj block of Jehanabad district is surrounded by Ghosi Block in the West, Sharing East boundary with Nalanda district and South boundary with Gaya district.



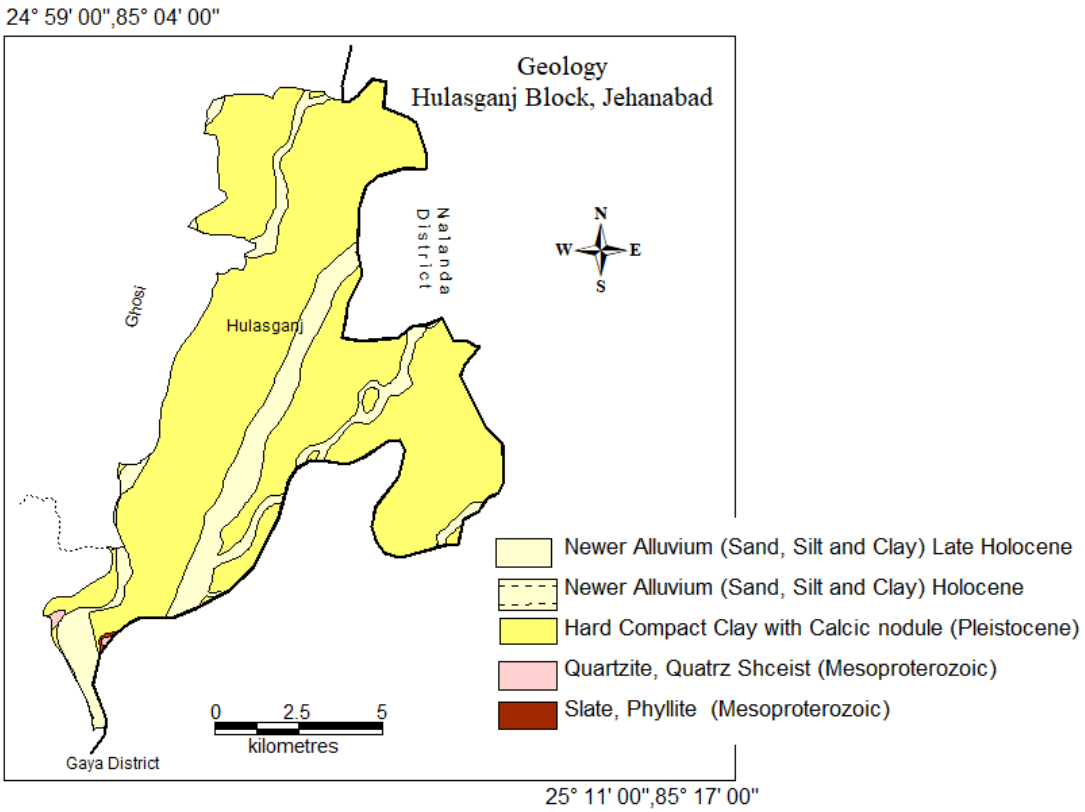
Geomorphology

The Hulasganj block is in part of Mid-Ganga basin. Major part of the block made up of younger alluvium, except very small part in south consisting of hilly and pediplane. In southern part there are part of area covered by water bodies.



Geology

Major part of the block is covered by hard compact clay with calcic nodule of Pleistocene age. Small part of the block surrounding the water bodies the block made up of younger alluvium. Of late Holocene age.

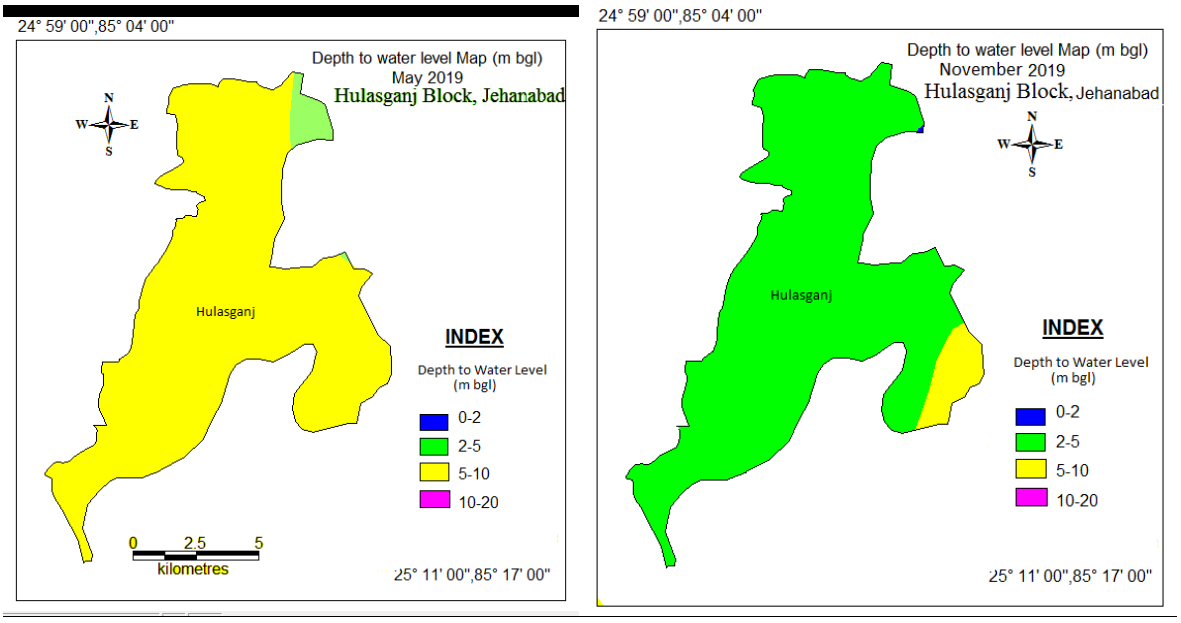


Depth to Water Level

CGWB NHS monitoring data shows that during the pre-monsoon period (2019-20), depth to water level is 5 to 10 m bgl. But during post-monsoon period, well show the water level 0 to 5 m bgl.

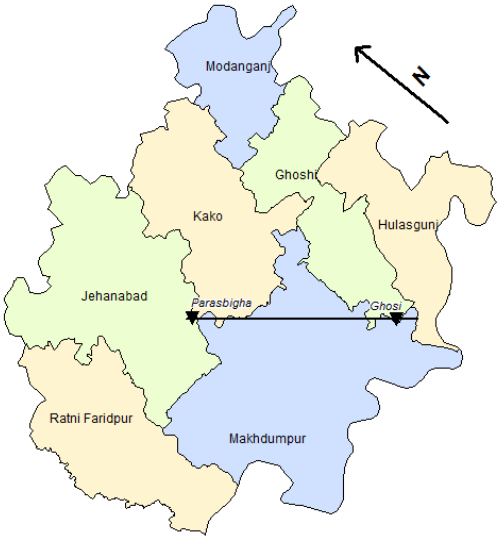
Depth to water level map of pre-monsoon 2019 shows major part of the block comes under depth to water level range 5 to 10 m bgl except small northern part with depth to water level range 2 to 5 m bgl, whereas map of post-monsoon 2019 shows major part of the block comes under depth to water level range 2 to 5 m bgl except small eastern part with depth to water level range 0 to 2 m bgl.

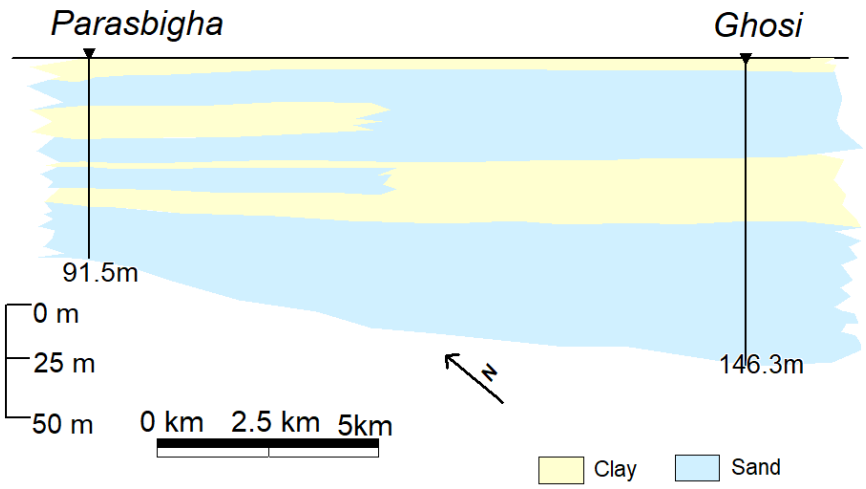
SN	Block	Location	Latitude	Longitude	Depth to Water Level (m bgl)		Elevation (m)	Fluctuation	Depth	RL
					May-19	Nov-19				
1	Hulasganj	Bholakpur	25.084	85.143	6.35	6.25	77.9	0.1	6.35	71.55
2	Hulasganj	Hulasganj	25.086	85.148	8.37	3.28	80.5	5.09	6.5	72.13



8.2.2 Aquifer Disposition and Characteristics

Using the the litholog of exploratory well drilled at Parasbigha and Ghosi, a cross section through nearby block Ghosi has been prepared. The south part of hulasganj block may show the same two aquifer system as in Ghosi. Cross section shows two aquifer layers occurs at 6 m and 78 m depth. These two are separated by 30 m clay layer. The top clay layer is 6m thick.





8.2.3 Ground water resource, extraction, contamination and other issues

Ground Water Resources - 2020

About 7.09% of the net ground water availability of Jehanabad district is available in Hulasganj block. The SOD is 96.36 % whereas of the district SOD is 91.54 %. The block is in "Critical" category. So there is no scope for further development of ground water.

Block	*Recharge from Rainfall*		*Recharge from Other Sources*		*Total Annual Ground Water Recharge*	*Provision for Natural Discharges*	*Net Annual Ground Water Availability*
	Monsoon	*Non-monsoon*	*Monsoon*	*Non-monsoon*			
	(ham)	*(ham)*	*(ham)*	*(ham)*	*(ham)*	*(ham)*	*(ham)*
Hulhasganj	2332.34	61.7	426.23	502.07	3322.34	332.24	178.35

Administrative Units	*Net Annual Ground Water Availability*	*Existing Gross Ground Water Draft for irrigation*	*Existing Gross Ground Water Draft for Domestic Uses*	*Existing Gross Ground Water Draft for Industrial Uses*	*Existing Gross Ground Water Draft for All Uses*	*Provision for Domestic and Industrial Requirement for Next 25 years*	*Net GW Availability for Future Irrigation Development*	*Stage of Ground Water Development*
	(ham)	*(ham)*	*(ham)*	*(ham)*	*(ham)*	*(ham)*	*(ham)*	*(%)*
Hulhasganj	178.35	2493.9	162.78	135.00	2791.68	182.85	178.35	93.36

Chemical quality of Ground Water

Result of chemical analysis of ground water of shallow aquifer is given in the table below. In general chemical quality of ground water of shallow aquifer is potable and also suitable for irrigation purpose. Result of chemical analysis is given in the table below.

Block	**location**	**pH**	**EC**	**TH**	**Ca**	**Mg**	**Na**	**K**	**HCO3**	**Cl**	**SO4**	**NO3**	**Fl**	**TDS**
Hulhasganj	Hulasganj	8.23	973	280	52	36	3.7	0.5	421	43	1.5	0.11	0.04	584
BIS 2012	*Acceptable limit*	**<6.5**	500	**200**	**75**	**30**	_	**1.9**	**200**	**250**	**200**	**NA**	**1**	_
	Permissible limit (in absence of alternate source)	**>8.5**	2000	**600**	**200**	**100**	_	**50**	**600**	**1000**	**400**	**45**	**1.5**	_

Block	**location**	Sodium Adsorption Ratio	Sodium Soluble Percentage	Kelley's Index	Magnesium Ratio	Permeability Index
		Na/sqrt(Ca+Mg/2)	***Na*100/Ca+Mg+Na***	***Na/(Ca+Mg)***	***(Mg*100)/(Ca+Mg)***	***Na+sqrtHCo3)/(Ca +Mg+Na)*100***
Hulhasganj	Hulasganj	0.44	4.01	0.04	41.21	26.28
	Suitable	<10	<50	<1	<50	25-75
	Marginal	NA	NA	1.2	NA	NA
	Not suitable	>10	>50	>2	>50	>75

8.2.4 Supply side management

Hulasganj block is under 'critical' category, SOD is 96.36%. Therefore for ground water management, some artificial structure may be constructed in Hulasganj block. Based on the geology, geomorphology, depth to water level and surface water availability, the types and number of the artificial recharge structures has been worked out for Hulasganj block and given in the table below. Based on available literature and previous experiences, unit cost of above structures is also worked out. As per Master plan of artificial recharge 2020, the table is as follows:

Hulasganj Block			
Recharge Structure		Cost (in Lakh)	Total Cost (Lakh)
Type	Number		
Percolation Tank	0	0	208
Gully Plug	0	0	
Contour Bunding & Trenching	0	0	
Check Dam	0	0	
Nala Bunding	1	1	
Contour Bunding & Trenching	0	0	
Lateral Recharge Shaft	4	8	
Recharge Shaft	8	40	
Percolation Tank	0	0	
De-silting of existing tank /pond /talao	15	75	
Injection Well in Village Tank	21	84	

8.2.5 Demand side management Plan

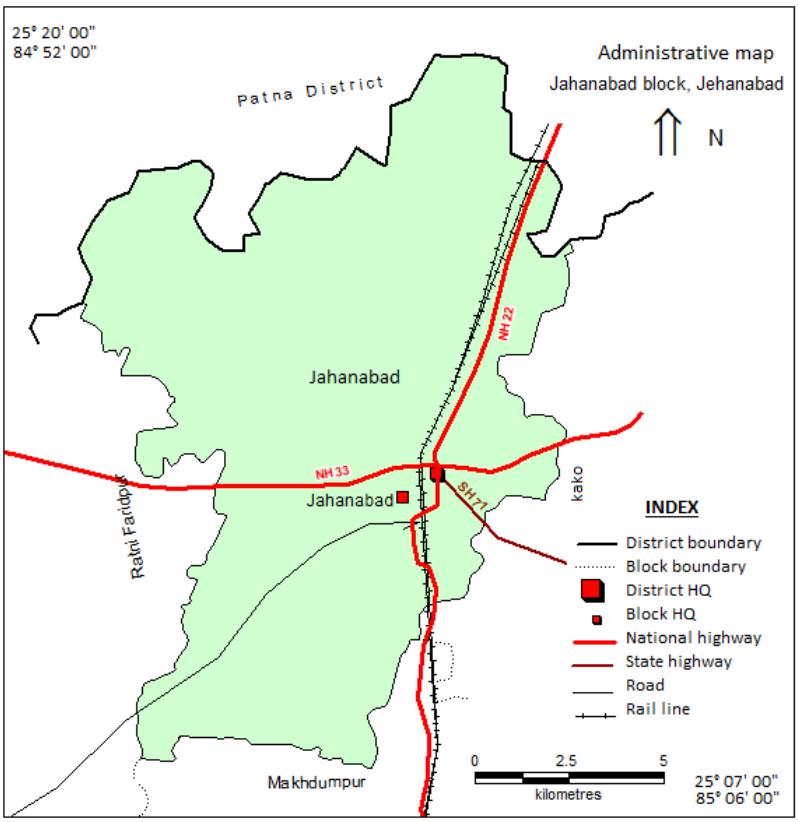
Some advance irrigation practices may be adopted such as drip/sprinkle irrigation etc. lining of field channels, change of cropping pattern also may be taken up for conservation purpose.

8.3 Jahanabad block

8.3.1 Salient Information

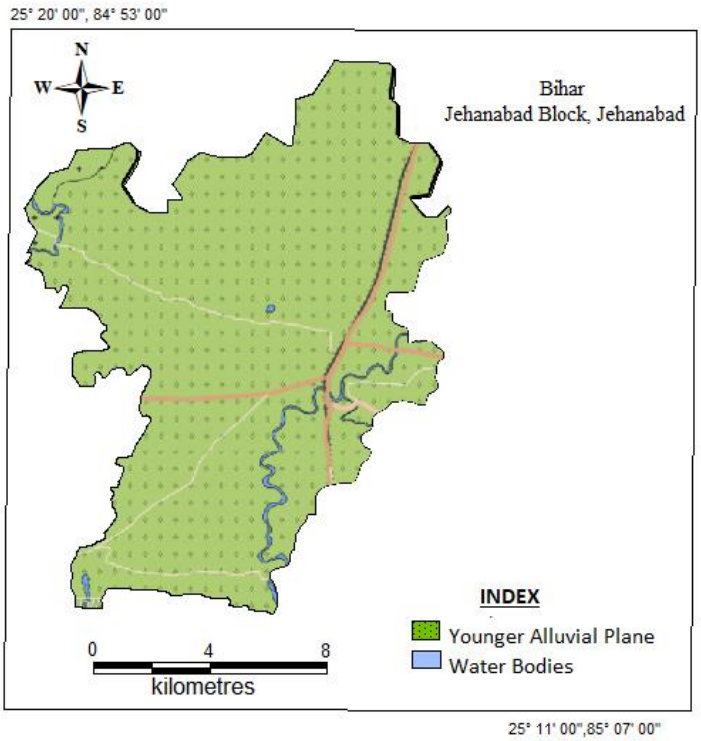
1.	Name of the block and area			Jehanabad - 162.51Sq. Km
2.	District/State			Jehanabad/ Bihar
3.	Population (2011)	Total	:	254753
		Rural		151551
		Urban		103202
4.	Normal rainfall (District)	(mm)	:	1051.9
5.	Agriculture and irrigation			Main crops are Paddy, Wheat, Jowar, Oil seeds etc. Gross irrigated area: 10053 Ha Rainfed area: 11473 Ha GW Extraction structure: (5^{th} MI) DW : 1 STW : 1020 DTW : 3
6.	Ground water resource availability and extraction	As per 2020 Resource Calculation	:	Net GW Availability: 360.11 ham Gross GW Draft : 4229.48 ham
7.	Existing and future water demand		:	For next 25 years: 892.45 ham
8.	Water level behaviour	Depth to water level		Pre-monsson : 0 to >10 m bgl Post-monsoon : 0 to 5 mbgl
9.	Basin / Sub-basin		:	Gandak and others

The Jehanabad block of Jehanabad district is surrounded by Patna district in the Norht, Kako Block in the East, Makhdumpur Block in the South and Ratnifaridpur block in the West.



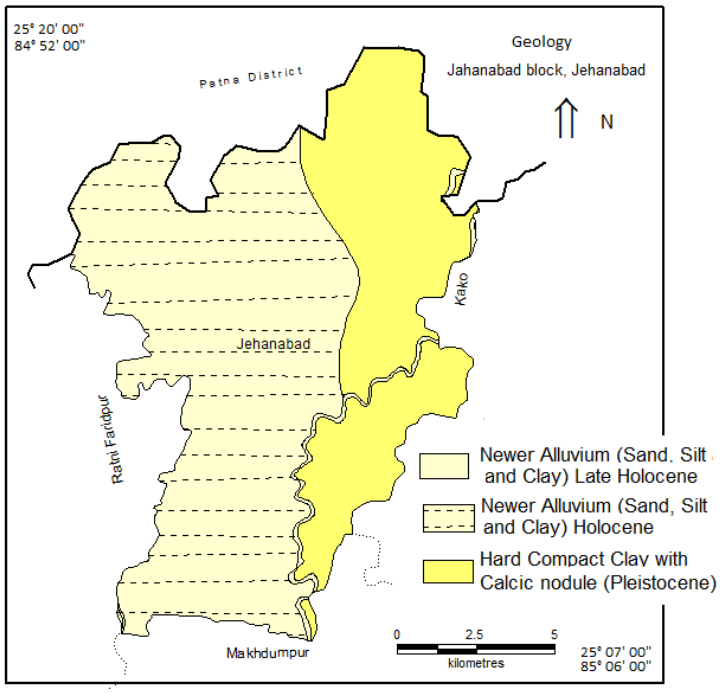
Geomorphology

The Jehanabad block is in part of Mid-Ganga basin. Major part of the block made up of younger alluvium. In southern part there are part of area covered by water bodies.



Geology

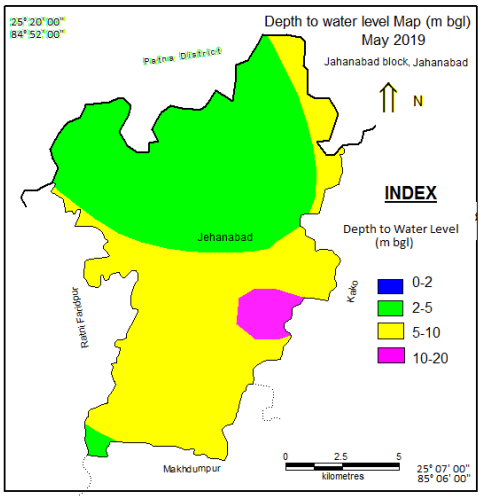
Major part of the block is covered by newer alluvium of Holocene age composed of sand silt and clay. Eastern part of the block covered by hard compact clay with calcic nodule of Pleistocene age. Very small part in south-eastern part of the block surrounding the water bodies the block made up of younger alluvium of late Holocene age.

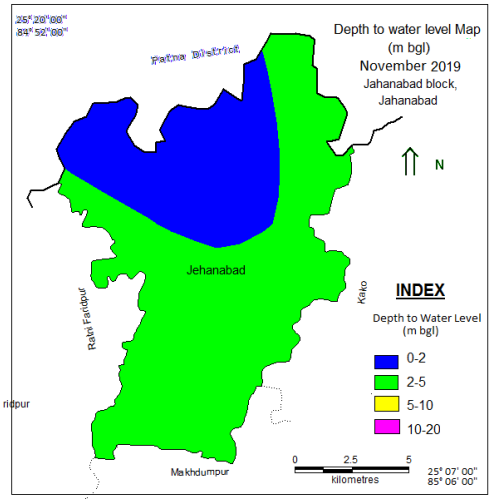


Depth to Water Level

There are 3 National hydrograph monitoring stations in Jehanabad block. CGWB NHS monitoring data and depth to water level map shows that during the pre-monsoon period (2019-20), the northern part of the block shows 2 to 5 m bgl depth to water level and southern part shows 5 to 10 m bgl water level except small eastern part showing >10 m bgl depth to water level. The post monsoon depth to water level map shows maximum part of the block comes under 2-5 m bgl depth to water level range rest in 0 to 2 m bgl depth to water level range.

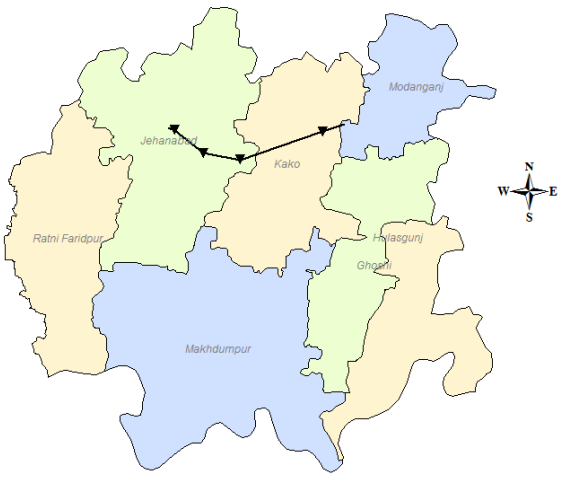
SN	Block	Location	Latitude	Longitude	Depth to Water Level (m bgl)		Elevation (m)	Fluctuation	Depth	RL
					May-19	Nov-19				
1	Jehanabad	Gaurakhini	25.209	84.986	10.4	4.94	70.7	5.46	9.2	60.3
2	Jehanabad	Jahanabad hosp.	25.225	85.004	6.4	6.2	67	0.2	6.4	60.6
3	Jehanabad	Teni Bigha	25.230	84.978	3.49	1.81	67.3	1.68	5	63.81

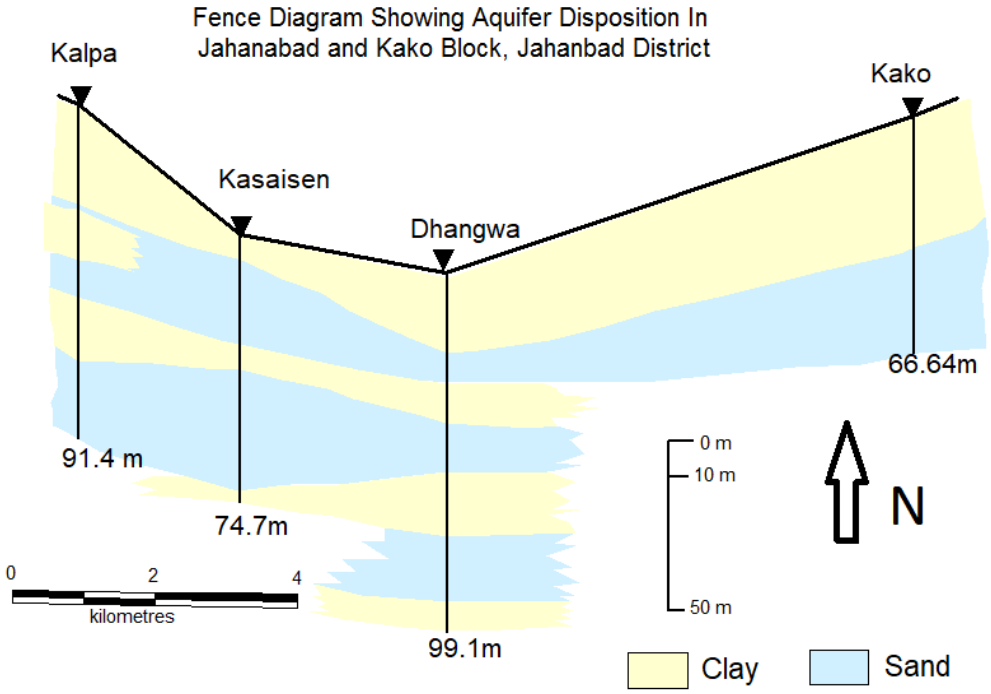




8.3.2 Aquifer Disposition and Characteristics

Using the the exploration data of four drilling at Kalpa, Kasaisen, Dhangwan and Kako, litholog of Jehanbad and Kako block has been prepared, which shows that there are two layers of aquifer (sand) separated by a clay layers. The first layer of sand becomes finer towards east direction, i.e. towards Kako block. 1st aquifer depth is 10m, whereas 2nd aquifer occurs at a depth of 22m. Average thickness of 1st and 2nd aquifer is 21 m and 28 m respectively. The two aquifer layers are separated by a 12 m thick clay layer.





8.3.3 Ground water resource, extraction, contamination and other issues

Ground Water Resources - 2020

About 14.32% of the net ground water availability of Jehanabad district is available in Jehanabad block. The SOD is 90.23 % whereas of the district SOD is 91.54 %. The block is in "Critical" category. So there is no scope for further development of ground water.

Block	*Recharge from Rainfall*		*Recharge from Other Sources*		*Total Annual Ground Water Recharge*	*Provision for Natural Discharges*	*Net Annual Ground Water Availability*
	Monsoon	*Non-monsoon*	*Monsoon*	*Non-monsoon*			
	(ham)	*(ham)*	*(ham)*	*(ham)*	*(ham)*	*(ham)*	*(ham)*
Jehanabad	3902.52	103.25	590.46	612.17	5208.4	520.84	360.11

Administrative Units	*Net Annual Ground Water Availability*	*Existing Gross Ground Water Draft for irrigation*	*Existing Gross Ground Water Draft for Domestic Uses*	*Existing Gross Ground Water Draft for Industrial Uses*	*Existing Gross Ground Water Draft for All Uses*	*Provision for Domestic and Industrial Requirement for Next 25 years*	*Net GW Availability for Future Irrigation Development*	*Stage of Ground Water Development*
	(ham)	*(ham)*	*(ham)*	*(ham)*	*(ham)*	*(ham)*	*(ham)*	*(%)*
Jehanabad	360.11	3210	794.48	225.00	4229.48	892.45	360.11	90.23

Chemical quality of Ground Water

Result of chemical analysis of ground water of shallow aquifer is given in the table below. In general chemical quality of ground water of shallow aquifer is potable and also suitable for irrigation purpose. In some places EC, TH, Mg and HCO3 value are in higher side. The magnesium ratio of the ground water of the block shows higher values which indicates that it is not suitable for irrigation, therefore there may be some quality issues if ground water used for irrigation purpose. Result of chemical analysis is given in the table below.

SN	Block	location	pH	EC	TH	Ca	Mg	Na	K	HCO3	Cl	SO4	NO3	Fl	TDS
1	Jehanabad	Gaurakhni	8.1	1209	400	52	66	3.2	0.9	506	89	1.2	0.09	0.00	725
2	Jehnabad	Jehnabad	8.15	1460	500	70	79	4.3	0.3	451	57	5.1	0.44	0.03	876
3	Jehanabad	Teni Bigha	8.13	2390	880	60	177	5.6	0.6	726	170	6.5	0.30	0.05	1434
BIS 2012		*Acceptable limit*	**<6.5**	500	**200**	**75**	**30**	_	**1.9**	**200**	**250**	**200**	**NA**	**1**	_
		Permissible limit (in absence of alternate source)	**>8.5**	2000	**600**	**200**	**100**	_	**50**	**600**	**1000**	**400**	**45**	**1.5**	_

SN	Block	location	Sodium Adsorption Ratio	Sodium Soluble Percentage	Kelley's Index	Magnesium Ratio	Permeability Index
			Na/sqrt(Ca+Mg/2)	***Na*100/Ca+Mg+Na***	***Na/(Ca+Mg)***	***(Mg*100)/(Ca+Mg)***	***Na+sqrtHCo3)/(Ca+Mg+Na)*100***
1	Jehanabad	Gaurakhni	0.34	2.63	0.03	55.79	21.26
2	Jehnabad	Jehnabad	0.41	2.78	0.03	53.01	16.65
3	Jehanabad	Teni Bigha	0.46	2.29	0.02	74.73	13.38
		Suitable	<10	<50	<1	<50	25-75
		Marginal	NA	NA	1.2	NA	NA
		Not suitable	>10	>50	>2	>50	>75

8.3.4 Supply side management

Jehanabad block is under 'critical' category, SOD is 90.23%. Therefore for ground water management, some artificial structure may be constructed in Jehanabad block. Based on the geology, geomorphology, depth to water level and surface water availability, the types and number of the artificial recharge structures has been worked out for Jehanabad block and given in the table below. Based on available literature and previous experiences, unit cost of

above structures is also worked out. As per Master plan of artificial recharge 2020, the table is as follows

Jehanabad Block			
Recharge Structure		Cost (in Lakh)	Total Cost (Lakh)
Type	Number		
Percolation Tank	0	0	381
Gully Plug	0	0	
Contour Bunding & Trenching	0	0	
Check Dam	0	0	
Nala Bunding	1	1	
Contour Bunding & Trenching	0	0	
Lateral Recharge Shaft	7	14	
Recharge Shaft	14	70	
Percolation Tank	1	30	
De-silting of existing tank /pond /talao	26	130	
Injection Well in Village Tank	34	136	

8.3.5 Demand side management Plan

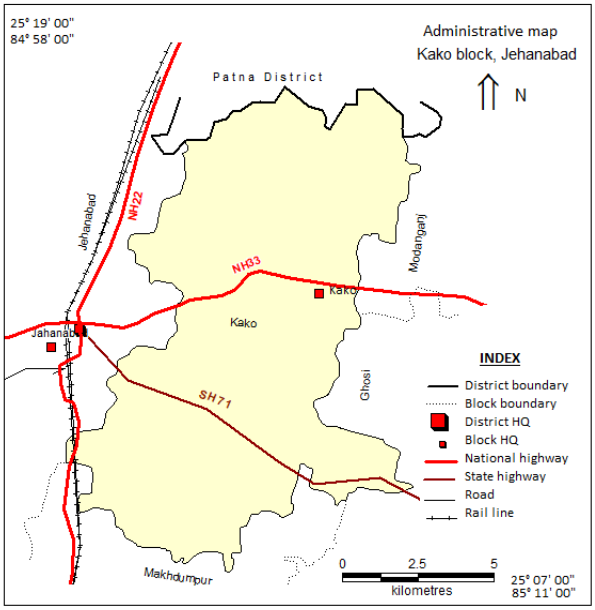
Some advance irrigation practices may be adopted such as drip/sprinkle irrigation etc. lining of field channels, change of cropping pattern also may be taken up for conservation purpose.

8. 4 Kako block

8.4.1 Salient Information

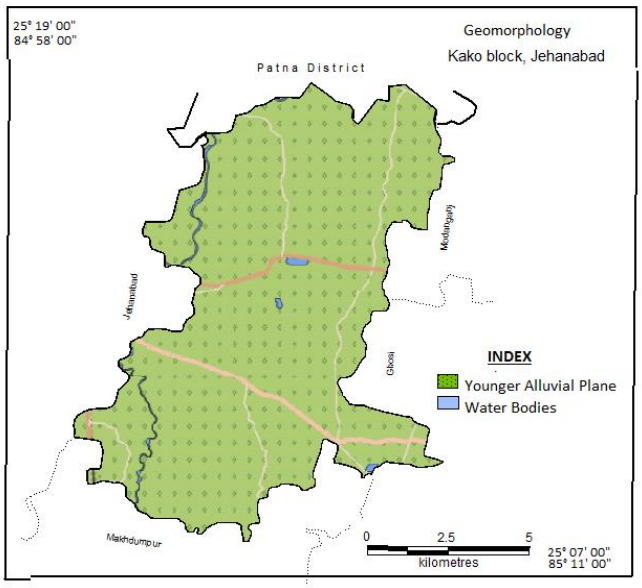
1.	Name of the block and area			Kako - 132.54 Sq. Km
2.	District/State			Jehanabad/ Bihar
3.	Population (2011)	Total	:	173487
		Rural		173487
		Urban		0
4.	Normal rainfall (District)	(mm)	:	1051.9
5.	Agriculture and irrigation			Main crops are Paddy, Wheat, Jowar, Oil seeds, Millets etc. Gross irrigated area: 14591 Ha Rainfed area: 4553 Ha GW Extraction structure: (5th MI) DW : NIL STW : 847 DTW : 14
6.	Ground water resource availability and extraction	As per 2020 Resource Calculation	:	Net GW Availability: 652.63 ham Gross GW Draft : 3220.88 ham
7.	Existing and future water demand		:	For next 25 years: 335.74 ham
8.	Water level behaviour	Depth to water level		Pre-monsson : 5 to >10 m bgl Post-monsoon : 2 to 10 mbgl
9.	Basin / Sub-basin		:	Gandak and others

The Kako block of Jehanabad district is surrounded by Ghosi and Modanganj Block in the East, Jehanabad Block in the West, Makhdumpur Block in the North and one District Boundary, Patna in North.



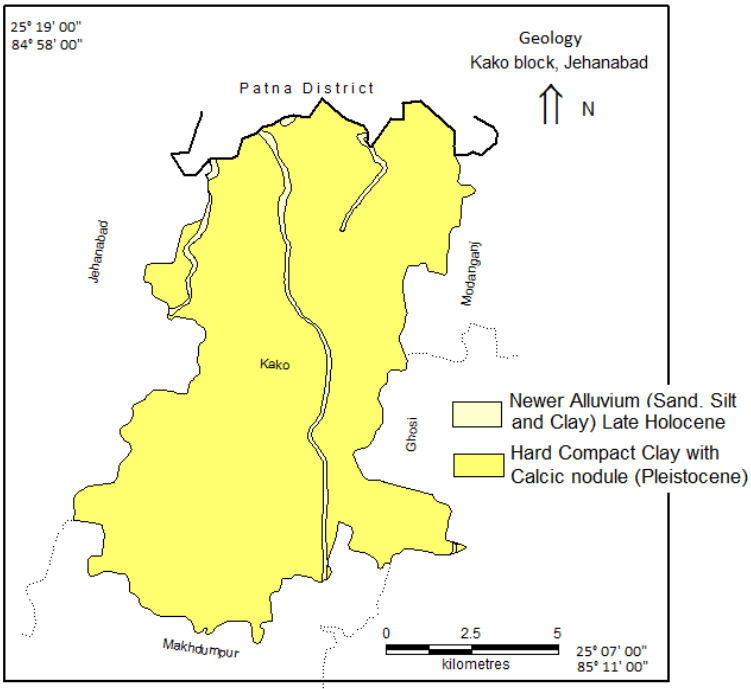
Geomorphology

The Kako block is in part of Mid-Ganga basin. Major part of the block made up of younger alluvium. Very small central part of the block covered by water bodies.



Geology

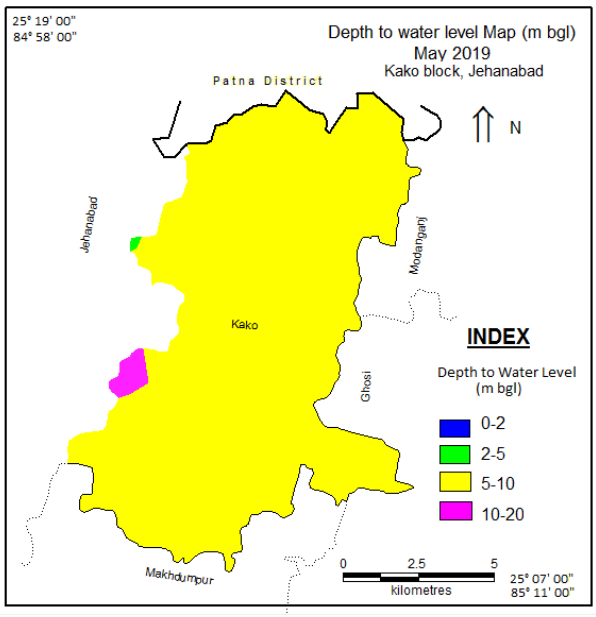
Major part of the block is covered by hard compact clay with calcic nodule of Pleistocene age. Small part of the block along the water bodies the block made up of younger alluvium of late Holocene age.

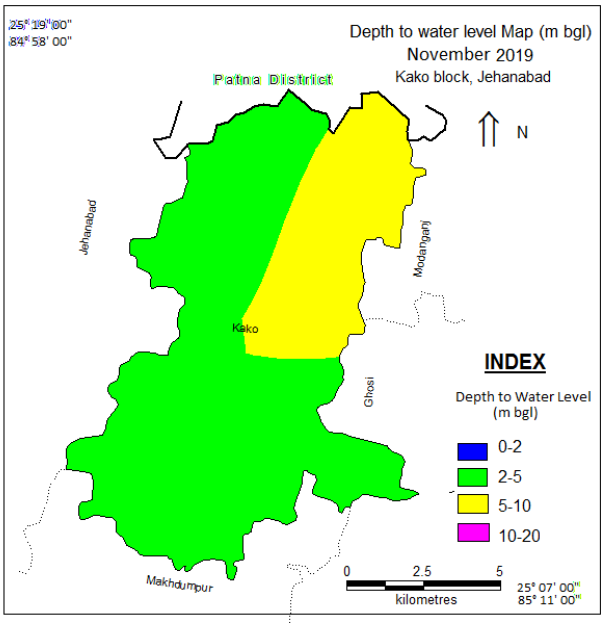


Depth to Water Level

There is only 1 National hydrograph monitoring station in Jehanabad block. CGWB NHS monitoring data and depth to water level map shows that during the pre-monsoon period (2019-20), maximum part of the block shows 5 to 10 m bgl depth to water level. The post monsoon depth to water level map shows maximum part of the block comes under 2-5 m bgl depth to water level range rest in 5 to 10 m bgl depth to water level range in north-eastern part.

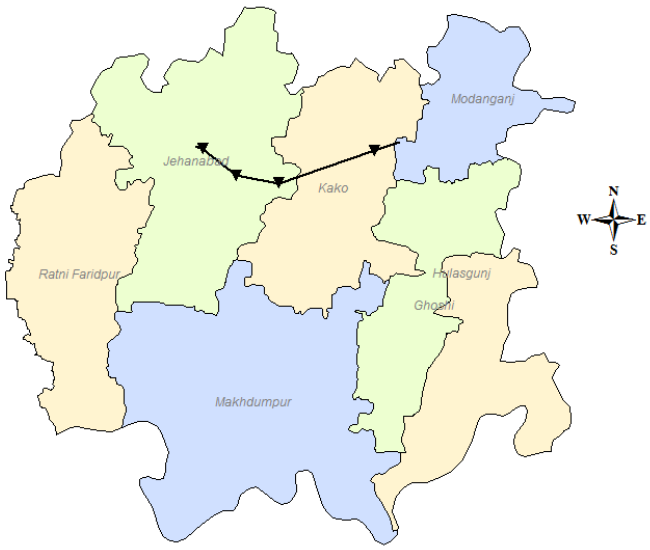
Block	Location	Latitude	Longitude	Depth to Water Level (m bgl)		Elevation (m)	Fluctuation	Depth	RL
				May-19	Nov-19				
Kako	Kako	25.226	85.079	9.38	5.7	65.9	3.68	5.2	56.52



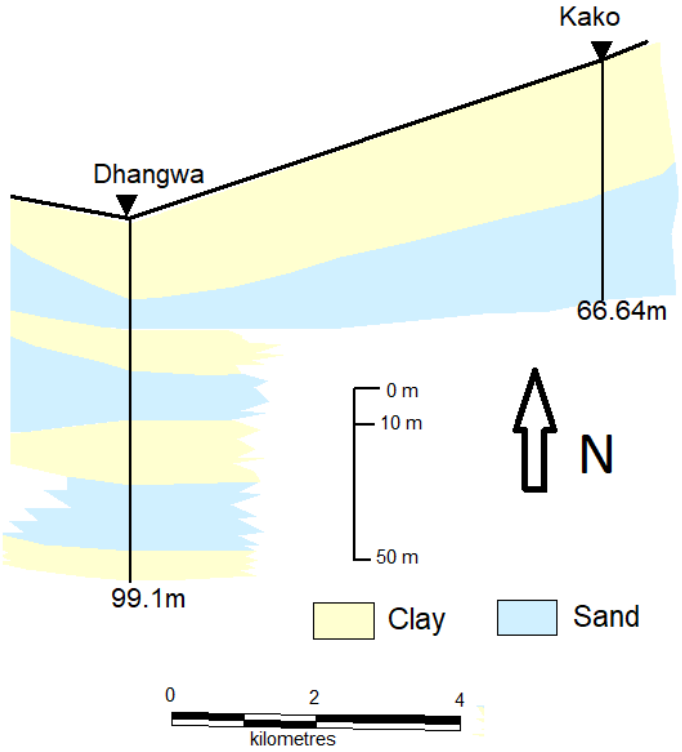


8.4.2 Aquifer Disposition and Characteristics

Using the exploration data of, Dhangwan and Kako, a cross section has been prepared, which shows the aquifer disposition of Kako block. The data shows that there is single layer of aquifer occurs approximately at 27m deph. The aquifer layer is overlain by 33 m clay layer. The thickness of aquifer layer is less towards west and more towards east.



Fence Diagram Showing Aquifer Disposition In Jahanabad and Kako Block, Jahanbad District



8.4.3 Ground water resource, extraction, contamination and other issues

Ground Water Resources - 2020

About 25.95% of the net ground water availability of Jehanabad district is available in Kako block. The SOD is 82.37 % whereas of the district SOD is 91.54 %. The block is in

"Semicritical" category. So there is limited or no scope for further development of ground water.

Block	*Recharge from Rainfall*		*Recharge from Other Sources*		*Total Annual Ground Water Recharge*	*Provision for Natural Discharges*	*Net Annual Ground Water Availability*
	Monsoon	*Non-monsoon*	*Monsoon*	*Non-monsoon*			
	(ham)	*(ham)*	*(ham)*	*(ham)*	*(ham)*	*(ham)*	*(ham)*
Kako	3182.39	84.19	550.18	528.1	4344.86	434.49	652.63

Administrative Units	*Net Annual Ground Water Availability*	*Existing Gross Ground Water Draft for irrigation*	*Existing Gross Ground Water Draft for Domestic Uses*	*Existing Gross Ground Water Draft for Industrial Uses*	*Existing Gross Ground Water Draft for All Uses*	*Provision for Domestic and Industrial Requirement for Next 25 years*	*Net GW Availability for Future Irrigation Development*	*Stage of Ground Water Development*
	(ham)	*(ham)*	*(ham)*	*(ham)*	*(ham)*	*(ham)*	*(ham)*	*(%)*
Kako	652.63	2715	298.88	207.00	3220.88	335.74	652.63	82.37

Chemical quality of Ground Water

Result of chemical analysis of ground water of shallow aquifer is given in the table below. EC, TH, Mg, HCO3 value are some higher side. In general chemical quality of ground water of shallow aquifer is potable and also suitable for irrigation purpose. Result of chemical analysis is given in the table below.

SN **Block**	**location**	**pH**	**EC**	**TH**	**Ca**	**Mg**	**Na**	**K**	**HCO3**	**Cl**	**SO4**	**NO3**	**Fl**	**TDS**
Kako	Kako	7.94	4560	1975	144	392	4.8	1.3	848	323	7.4	15.29	0.00	2736
BIS 2012	*Acceptable limit*	**<6.5**	500	**200**	**75**	**30**	_	**1.9**	**200**	**250**	**200**	**NA**	**1**	_
	Permissible limit (in absence of alternate source)	**>8.5**	2000	**600**	**200**	**100**	_	**50**	**600**	**1000**	**400**	**45**	**1.5**	_

Block	**location**	Sodium Adsorption Ratio	Sodium Soluble Percentage	Kelley's Index	Magnesium Ratio	Permeability Index

		Na/sqrt(Ca+Mg/2)	*Na*100/Ca+Mg+Na*	*Na/(Ca+Mg)*	*(Mg*100)/(Ca+Mg)*	*Na+sqrtHCo3)/(Ca +Mg+Na)*100*
Kako	Kako	0.26	0.89	0.01	73.16	6.27
	Suitable	<10	<50	<1	<50	25-75
	Marginal	NA	NA	1.2	NA	NA
	Not suitable	>10	>50	>2	>50	>75

8.4.4 Supply side management

Kako block is under 'Semicritical' category, SOD is 82.37%. Therefore for ground water management, some artificial structure may be constructed in Kako block. Based on the geology, geomorphology, depth to water level and surface water availability, the types and number of the artificial recharge structures has been worked out for Kako block and given in the table below. Based on available literature and previous experiences, unit cost of above structures is also worked out. As per Master plan of artificial recharge 2020, the table is as follows

Kako Block			
Recharge Structure		Cost (in Lakh)	Total Cost (Lakh)
Type	Number		
Percolation Tank	0	0	320
Gully Plug	0	0	
Contour Bunding & Trenching	0	0	
Check Dam	0	0	
Nala Bunding	1	1	
Contour Bunding & Trenching	0	0	
Lateral Recharge Shaft	6	12	
Recharge Shaft	12	60	
Percolation Tank	1	30	
De-silting of existing tank /pond /talao	21	105	
Injection Well in Village Tank	28	112	

8.4.5 Demand side management Plan

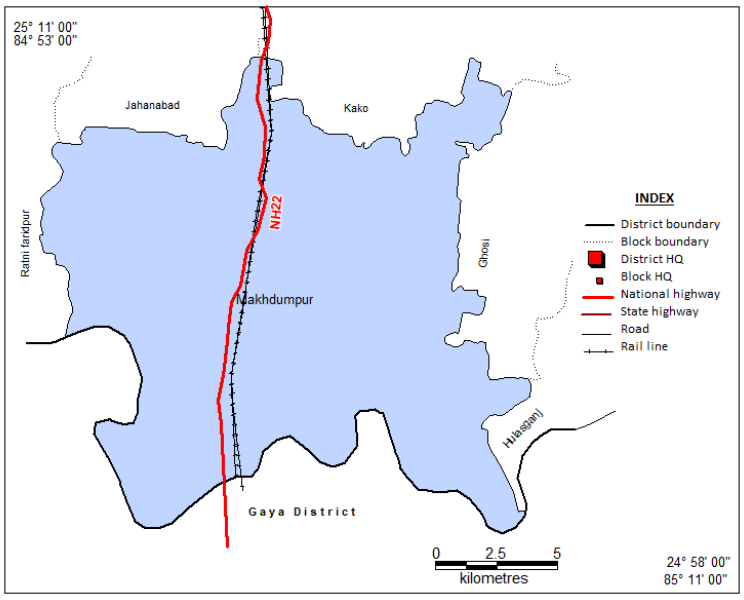
Some advance irrigation practices may be adopted such as drip/sprinkle irrigation etc. lining of field channels, change of cropping pattern also may be taken up for conservation purpose.

8.5 Makhdumpur block

8.5.1 Salient Information

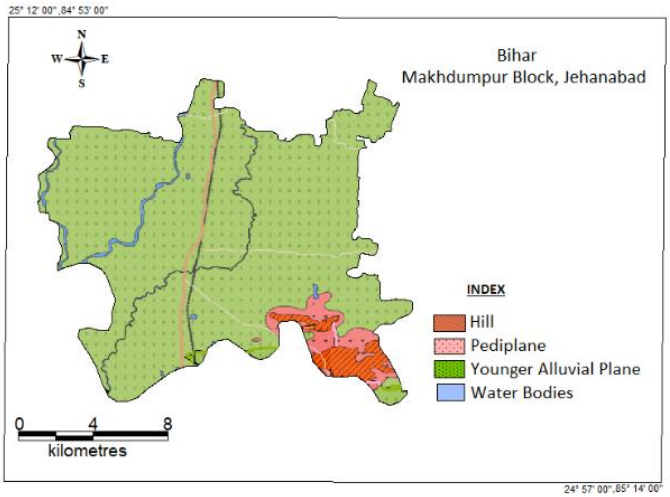
1.	Name of the block and area			Makhdumpur - 243.85Sq. Km
2.	District/State			Jehanabad/ Bihar
3.	Population (2011)	Total	:	260154
		Rural		228160
		Urban		31994
4.	Normal rainfall (District)	(mm)	:	1051.9
5.	Agriculture and irrigation			Main crops are Paddy, Wheat, Maize, Oil seeds, Millets etc. Gross irrigated area: 17462 Ha Rainfed area: 14468 Ha GW Extraction structure: (5th MI) DW : 1 STW : 2058 DTW : 2
6.	Ground water resource availability and extraction	As per 2020 Resource Calculation	:	Net GW Availability: 961.16 ham Gross GW Draft : 6348.6 ham
7.	Existing and future water demand		:	For next 25 years: 627.29 ham
8.	Water level behaviour	Depth to water level		Pre-monsson : 2 to 10 m bgl Post-monsoon : 0 to 5 mbgl
9.	Basin / Sub-basin		:	Gandak and others

The Makhdumpur block of Jehanabad district is surrounded by Jehanabad and Kako Block in the Norht, Ghosi Block in the East, Ratnifaridpur Block in the West and District Boundary, Gaya in South and Arwal in the West.



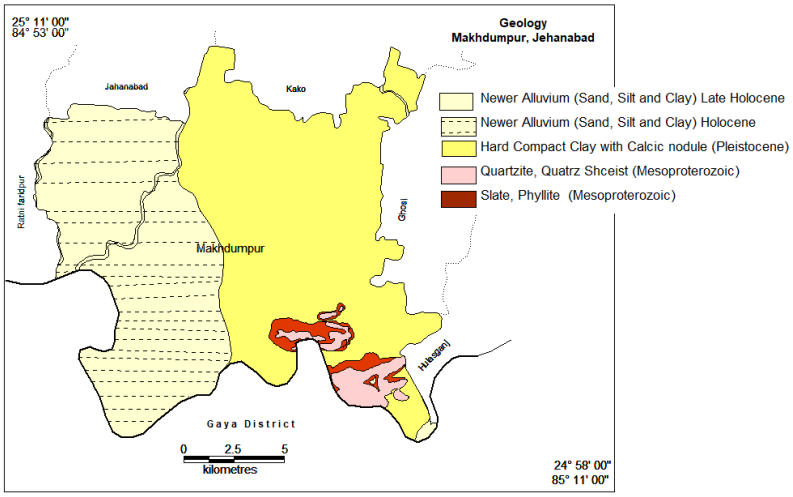
Geomorphology

The Ghosi block is in part of Mid-Ganga basin. Major part of the block made up of younger alluvium. The small south-eastern part covered by hilly region, surrounded by pediplane. Very small part of the block occupied by water bodies.



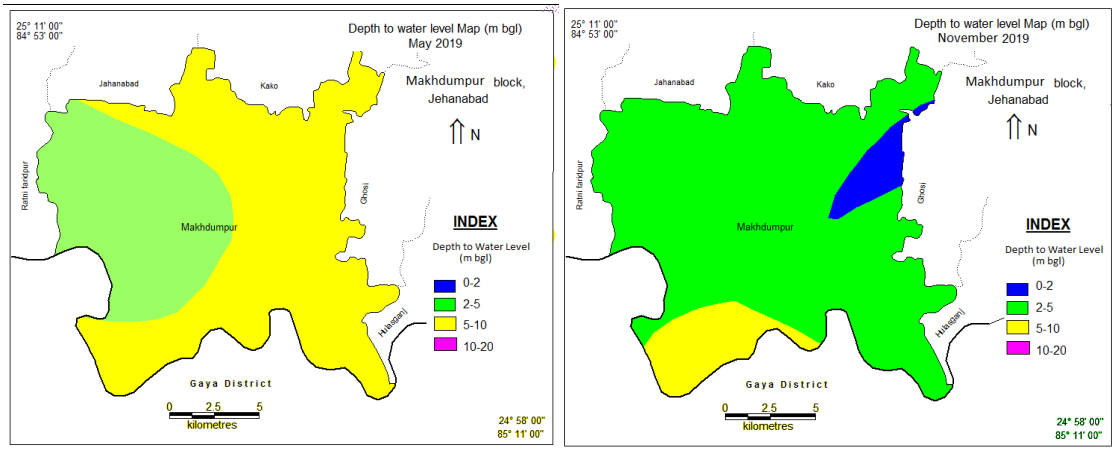
Geology

Major part of the block is covered by hard compact clay with calcic nodule of Pleistocene age. Western part of the block covered by newer alluvium of Holocene age composed of sand silt and clay. Very small part in south-eastern side of the block made up of metamorphosed rock like quartzite, quartz shceist of Mesoproterozoic age surrounded by slate phyllite of same age. Part of the block made up of younger alluvium of late Holocene age.



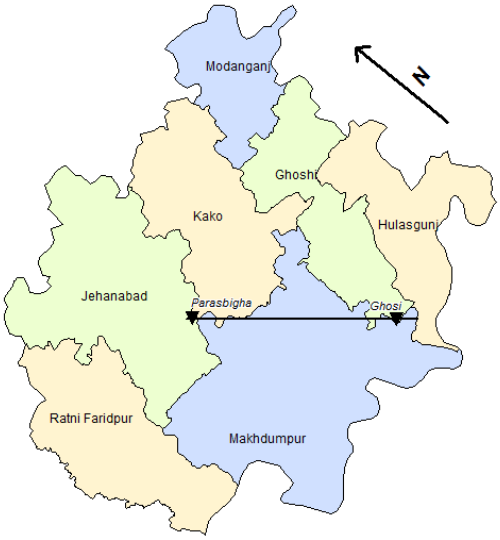
Depth to Water Level

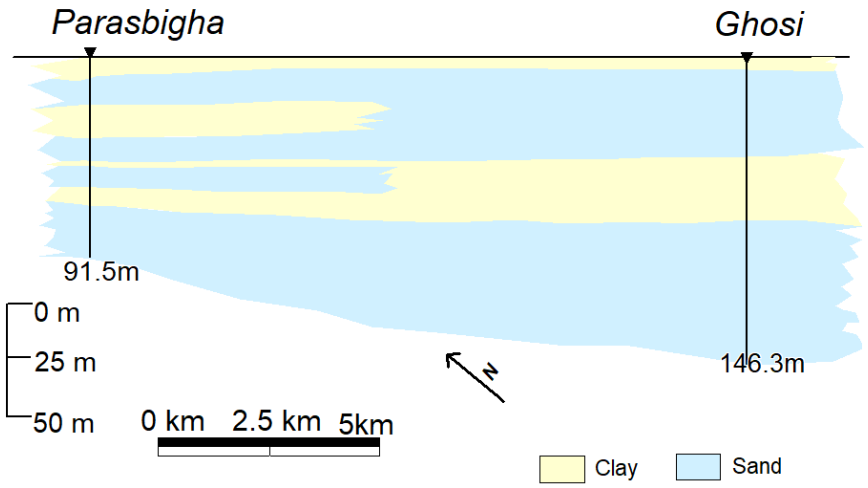
CGWB NHS monitoring data and depth to water level map shows that during the pre-monsoon period (2019-20), major part of the block shows 5 to 10 m bgl depth to water level and smaller western part shows 2 to 5 m bgl water level. The post monsoon depth to water level map shows maximum part of the block comes under 2-5 m bgl depth to water level range except north eastern part 0 to 2 m bgl depth to water level range and southern part 5 to 10 m bgl depth to water level range.



8.5.2 Aquifer Disposition and Characteristics

Using the litholog of exploratory well drilled at Parasbigha and Ghosi, a cross section through Makhdumpur block has been prepared. Cross section shows several alternate sand-clay layers are there in Jehanabad, while moving towards Makhdumpur the sand and clay patches end out and towards Ghosi, finally it showing two layer aquifer system, which are separated by two clay layers. The average thichness of 1st aquifer is 40 m and average thickness of 2nd aquifer is 35 m. thickness of 2nd aquifer is about 15 m at Jehanabad and gradually more thick (about 75 m) in Ghosi. The two aquifers are separated by about 30 m thick clay layer, whereas the top clay layers is of thickness of less than 10m.





8.5.3 Ground water resource, extraction, contamination and other issues

Ground Water Resources - 2020

About 38.22% of the net ground water availability of Jehanabad district is available in Makhdumpur block. The SOD is 86.04 % whereas of the district SOD is 91.54 %. The block is in "Semicritical" category. So there is limited or no scope for further development of ground water.

Block	*Recharge from Rainfall*		*Recharge from Other Sources*		*Total Annual Ground Water Recharge*	*Provision for Natural Discharges*	*Net Annual Ground Water Availability*
	Monsoon	*Non-monsoon*	*Monsoon*	*Non-monsoon*			
	(ham)	*(ham)*	*(ham)*	*(ham)*	*(ham)*	*(ham)*	*(ham)*
Makhdumpur	5851.86	154.82	1094.59	1097.19	8198.46	819.84	961.16

Administrative Units	*Net Annual Ground Water Availability*	*Existing Gross Ground Water Draft for irrigation*	*Existing Gross Ground Water Draft for Domestic Uses*	*Existing Gross Ground Water Draft for Industrial Uses*	*Existing Gross Ground Water Draft for All Uses*	*Provision for Domestic and Industrial Requirement for Next 25 years*	*Net GW Availability for Future Irrigation Development*	*Stage of Ground Water Development*
	(ham)	*(ham)*	*(ham)*	*(ham)*	*(ham)*	*(ham)*	*(ham)*	*(%)*
Makhdumpur	961.16	5475.17	558.43	315.00	6348.6	627.29	961.16	86.04

Chemical quality of Ground Water

Result of chemical analysis of ground water of shallow aquifer is given in the table below. EC, TH, Mg, HCO3 value are some higher side. In general chemical quality of ground water of shallow aquifer is potable and as Magnesium ratio is higher so there may be some issue in quality in crops if ground water used for irrigation purpose. Result of chemical analysis is given in the table below.

SN	**Block**	**location**	**pH**	**EC**	**TH**	**Ca**	**Mg**	**Na**	**K**	**HCO3**	**Cl**	**SO4**	**NO3**	**Fl**	**TDS**
1	Makhdumpur	Alubikha	8.44	2110	835	8	198	3.9	0.6	683	128	6.2	0.08	0.05	1266
2	Makhdumpur	Makhdumpur	8.53	772	170	8	36	3.9	0.4	342	43	0.8	0.09	0.00	463
BIS 2012		*Acceptable limit*	**<6.5**	500	**200**	**75**	**30**	_	**1.9**	**200**	**250**	**200**	**NA**	**1**	_
		Permissible limit (in absence of alternate source)	**>8.5**	2000	**600**	**200**	**100**	_	**50**	**600**	**1000**	**400**	**45**	**1.5**	_

SN	**Block**	**location**	Sodium Adsorption Ratio	Sodium Soluble Percentage	Kelley's Index	Magnesium Ratio	Permeability Index
			Na/sqrt(Ca+Mg/2)	***Na*100/Ca+Mg+Na***	***Na/(Ca+Mg)***	***(Mg*100)/(Ca+Mg)***	***Na+sqrtHCo3)/(Ca +Mg+Na)*100***
1	Makhdumpur	Alubikha	0.37	1.84	0.02	96.12	14.30
8	Makhdumpur	Makhdumpur	0.76	8.01	0.09	82.00	46.26
		Suitable	<10	<50	<1	<50	25-75
		Marginal	NA	NA	1.2	NA	NA
		Not suitable	>10	>50	>2	>50	>75

8.5.4 Supply side management

Makhdumpur block is under 'Semicritical' category, SOD is 82.37%. Therefore for ground water management, some artificial structure may be constructed in Makhdumpur block. Based on the geology, geomorphology, depth to water level and surface water availability, the types and number of the artificial recharge structures has been worked out for Makhdumpur block and given in the table below. Based on available literature and previous experiences, unit cost of above structures is also worked out. As per Master plan of artificial recharge 2020, the table is as follows

Makhdumpur Block			
Recharge Structure		Cost (in Lakh)	Total Cost (Lakh)
Type	Number		
Percolation Tank	0	0	557
Gully Plug	0	0	
Contour Bunding & Trenching	0	0	
Check Dam	0	0	
Nala Bunding	0	0	
Contour Bunding & Trenching	0	0	
Lateral Recharge Shaft	4	8	
Recharge Shaft	7	35	
Percolation Tank	0	0	
De-silting of existing tank /pond /talao	13	65	
Injection Well in Village Tank	17	68	

8.5.5 Demand side management Plan

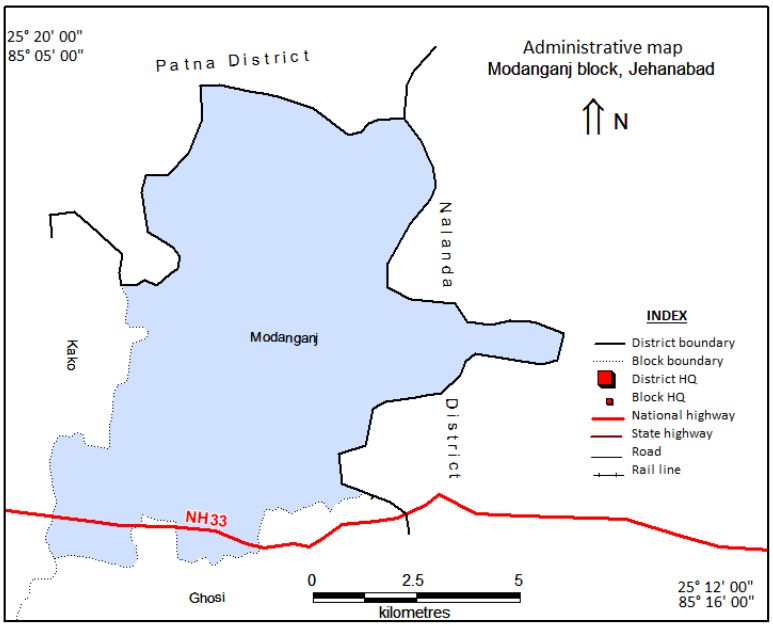
Some advance irrigation practices may be adopted such as drip/sprinkle irrigation etc. lining of field channels, change of cropping pattern also may be taken up for conservation purpose.

8. 6 Modanganj block

8.6.1 Salient Information

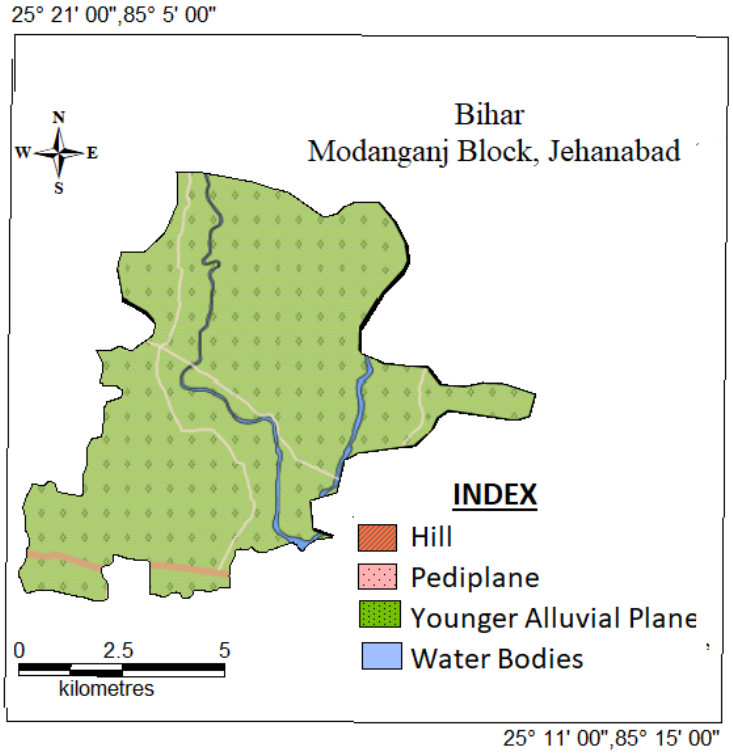
1.	Name of the block and area			Modanganj - 79.95 Sq. Km
2.	District/State			Jehanabad/ Bihar
3.	Population (2011)	Total	:	87718
		Rural		87718
		Urban		0
4.	Normal rainfall (District)	(mm)	:	1051.9
5.	Agriculture and irrigation			Main crops are Paddy, Wheat, Maize, Oil seeds, Millets etc. Gross irrigated area: 6458 Ha Rainfed area: 4276 Ha GW Extraction structure: (5th MI) DW : 1 STW : 777 DTW : 2
6.	Ground water resource availability and extraction	As per 2020 Resource Calculation	:	Net GW Availability: 266.15ham Gross GW Draft : 2153.96ham
7.	Existing and future water demand		:	For next 25 years: 169.75 ham
8.	Water level behaviour	Depth to water level		Pre-monsson : 5 to 10 m bgl Post-monsoon : 2 to 10 mbgl
9.	Basin / Sub-basin		:	Gandak and others

The Modanganj block of Jehanabad district is surrounded by Kako Block in the West, Makhdumpur Block in the South, Patna district in the North and Nalanda District in the East.



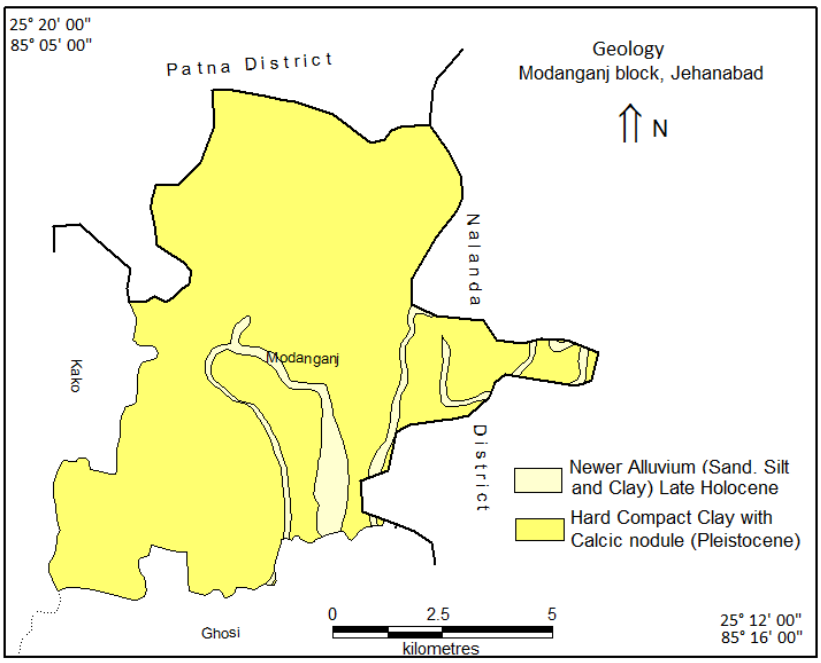
Geomorphology

The Modanganj block is in part of Mid-Ganga basin. Major part of the block made up of younger alluvium. In southern part there are part of area covered by water bodies.



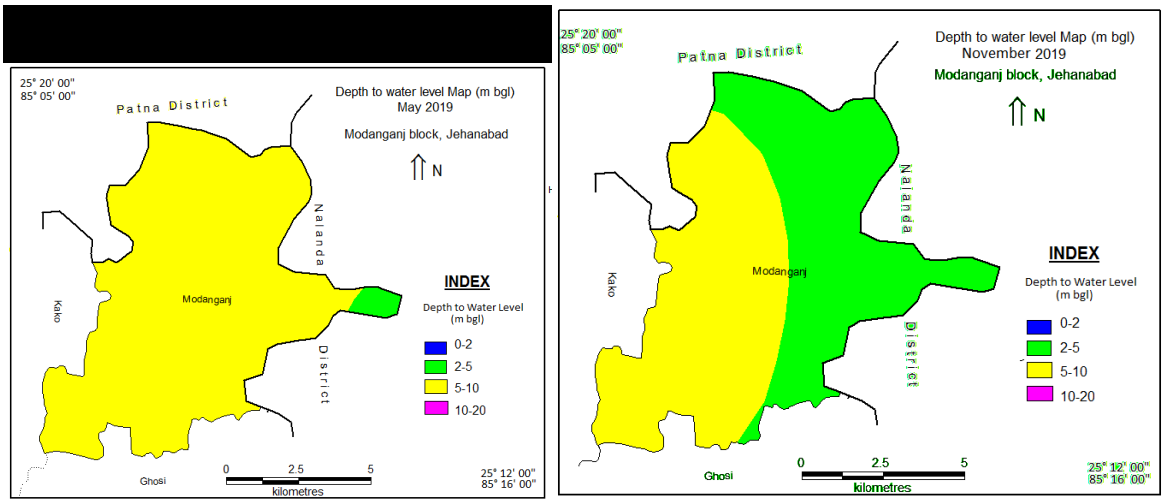
Geology

Major part of the block is covered by hard compact clay with calcic nodule of Pleistocene age. Small part of the block surrounding the water bodies the block made up of younger alluvium. Of late Holocene age.



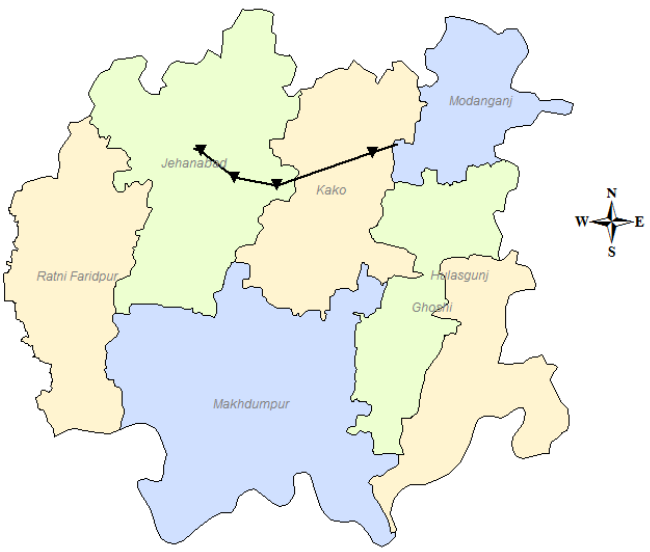
Depth to Water Level

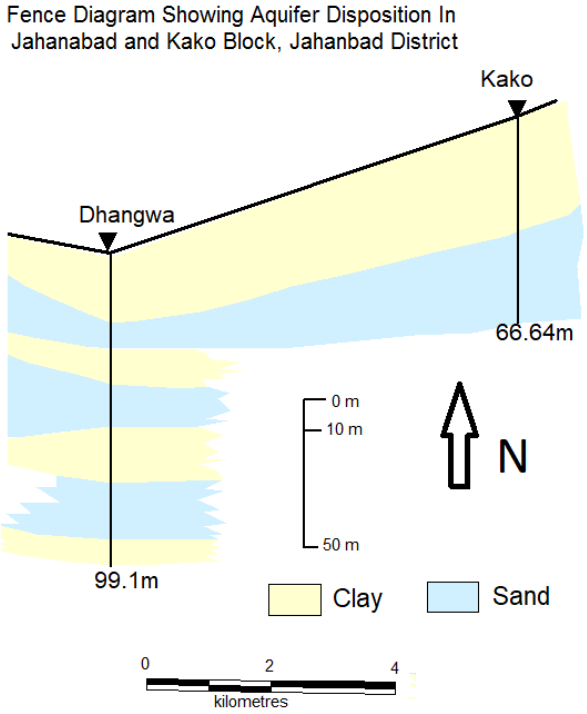
CGWB NHS monitoring data shows that during the pre-monsoon period (2019-20), depth to water level is 5 to 10 m bgl all through the block. But during post-monsoon period, the block shows two depth to water level range 2 to 5 m bgl covering eastern part of the block and 5 to 10 m bgl covering western part of the block.



8.6.2 Aquifer Disposition and Characteristics

Using the exploration data of, Dhangwan and Kako, a cross section has been prepared, which shows the aquifer disposition of adjacent block Kako. The data shows that there is single layer of aquifer occurs approximately at 27m deph. The aquifer layer is overlain by 33 m clay layer. The thickness of aquifer layer is less towards west and more towards east. the south part of Modanganj block may show the same aquifer disposition.





8.6.3 Ground water resource, extraction, contamination and other issues

Ground Water Resources - 2020

About 10.58% of the net ground water availability of Jehanabad district is available in Modanganj block. The SOD is 88.32 % whereas of the district SOD is 91.54 %. The block is in "Semicritical" category. So there is limited or no scope for further development of ground water.

Block	*Recharge from Rainfall*		*Recharge from Other Sources*		*Total Annual Ground Water Recharge*	*Provision for Natural Discharges*	*Net Annual Ground Water Availability*
	Monsoon	*Non-monsoon*	*Monsoon*	*Non-monsoon*			
	(ham)	*(ham)*	*(ham)*	*(ham)*	*(ham)*	*(ham)*	*(ham)*
Madanganj	1919.57	50.78	339.61	399.75	2709.71	270.97	266.15

Administrative Units	*Net Annual Ground Water Availability*	*Existing Gross Ground Water Draft for irrigation*	*Existing Gross Ground Water Draft for Domestic Uses*	*Existing Gross Ground Water Draft for Industrial Uses*	*Existing Gross Ground Water Draft for All Uses*	*Provision for Domestic and Industrial Requirement for Next 25 years*	*Net GW Availability for Future Irrigation Development*	*Stage of Ground Water Development*
	(ham)	*(ham)*	*(ham)*	*(ham)*	*(ham)*	*(ham)*	*(ham)*	*(%)*
Madanganj	266.15	1903.84	151.12	99.00	2153.96	169.75	266.15	88.32

Chemical quality of Ground Water

Result of chemical analysis of ground water of shallow aquifer of surrounding area shows in general Chemical quality of shallow aquifer is potable and also suitable for irrigation purpose.

8.6.4 Supply side management

Modanganj block is under 'Semicritical' category, SOD is 88.32%. Therefore for ground water management, some artificial structure may be constructed in Modanganj block. Based on the geology, geomorphology, depth to water level and surface water availability, the types and number of the artificial recharge structures has been worked out for Modanganj block and given in the table below. Based on available literature and previous experiences, unit cost of above structures is also worked out. As per Master plan of artificial recharge 2020, the table is as follows

Modanganj Block			
Recharge Structure		Cost (in Lakh)	Total Cost (Lakh)
Type	Number		
Percolation Tank	0	0	176
Gully Plug	0	0	
Contour Bunding & Trenching	0	0	
Check Dam	0	0	
Nala Bunding	0	0	
Contour Bunding & Trenching	0	0	
Lateral Recharge Shaft	4	8	
Recharge Shaft	7	35	
Percolation Tank	0	0	
De-silting of existing tank /pond /talao	13	65	
Injection Well in Village Tank	17	68	

8.6.5 Demand side management Plan

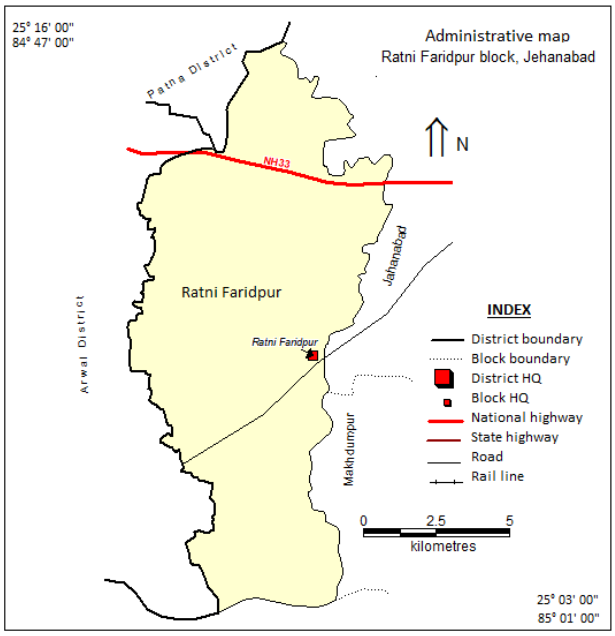
Some advance irrigation practices may be adopted such as drip/sprinkle irrigation etc. lining of field channels, change of cropping pattern also may be taken up for conservation purpose.

8. 7 Ratni Faridpur block

8.7.1 Salient Information

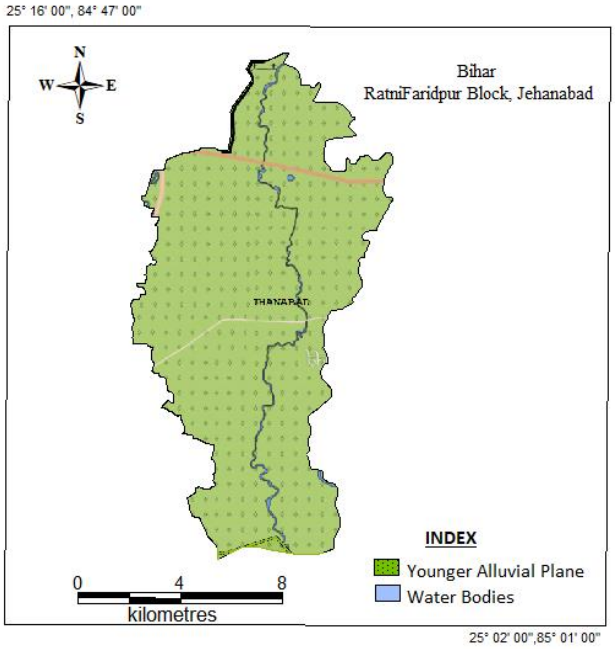
1.	Name of the block and area			Ratnifaridpur - 127.14 Sq. Km
2.	District/State			Jehanabad/ Bihar
3.	Population (2011)	Total	:	146586
		Rural		146586
		Urban		0
4.	Normal rainfall (District)	(mm)	:	1051.9
5.	Agriculture and irrigation			Main crops are Paddy, Wheat, Maize, Oil seeds, Millets etc. Gross irrigated area: 10089 Ha Rainfed area: 9790 Ha GW Extraction structure: (5th MI) DW : Nil STW : 1767 DTW : 0
6.	Ground water resource availability and extraction	As per 2020 Resource Calculation	:	Net GW Availability: 0 ham Gross GW Draft : 4428.54 ham
7.	Existing and future water demand		:	For next 25 years: 283.68 ham
8.	Water level behaviour	Depth to water level		Pre-monsson : 2 to 10 m bgl Post-monsoon : 0 to 5 mbgl
9.	Basin / Sub-basin		:	Gandak and others

The Ratni Faridpur block of Jehanabad district is surrounded by Parwalpur block in the norht, Jehanabad and Makhdumpur block in the east and one district boundary, Arwal in south-west.



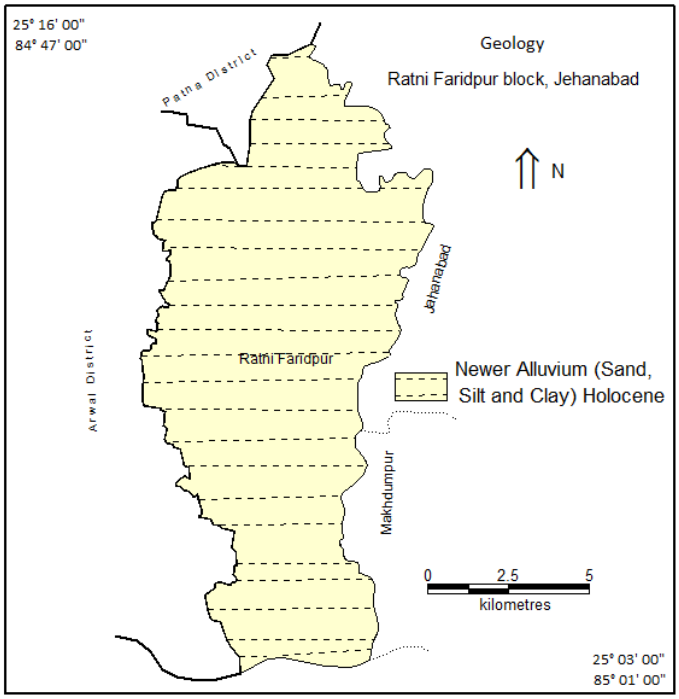
Geomorphology

The Jehanabad block is in part of Mid-Ganga basin. Major part of the block made up of younger alluvium. In mid part there are part of area covered by water bodies.



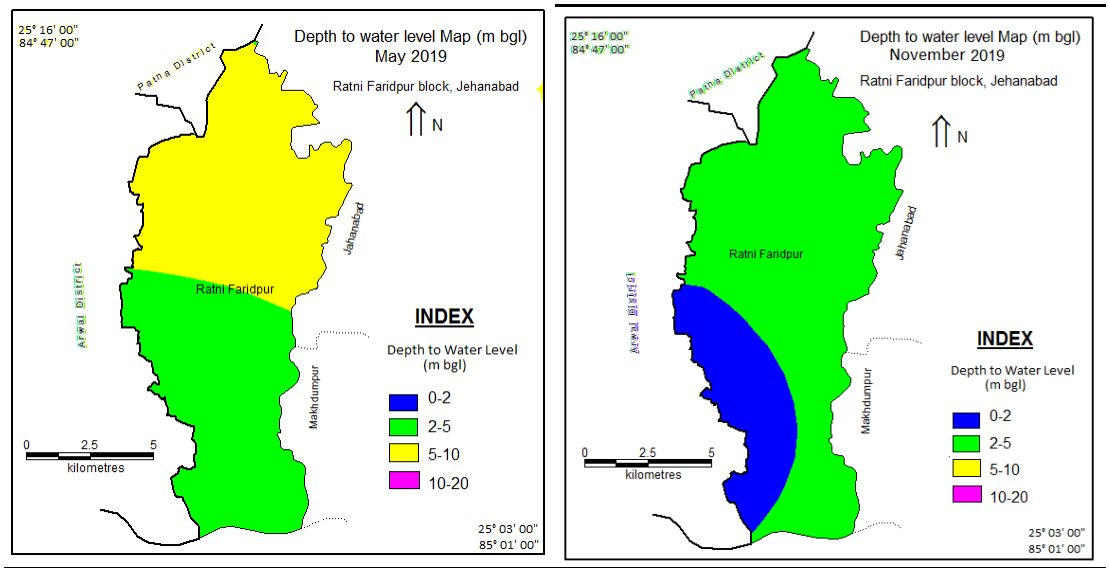
Geology

The total area of the block is covered by newer alluvium of Holocene age composed of sand silt and clay.

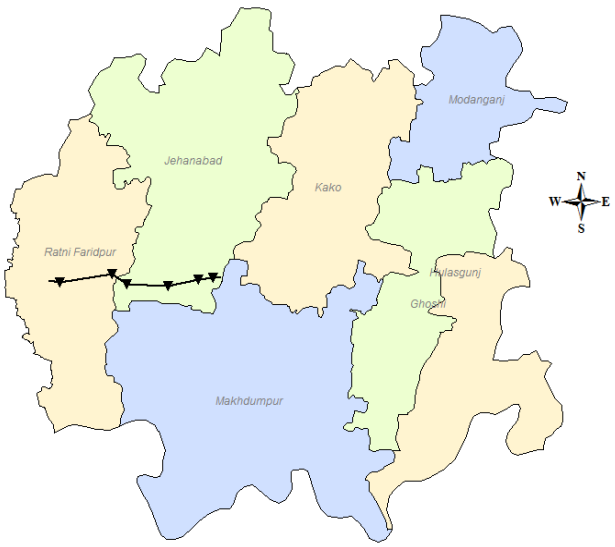


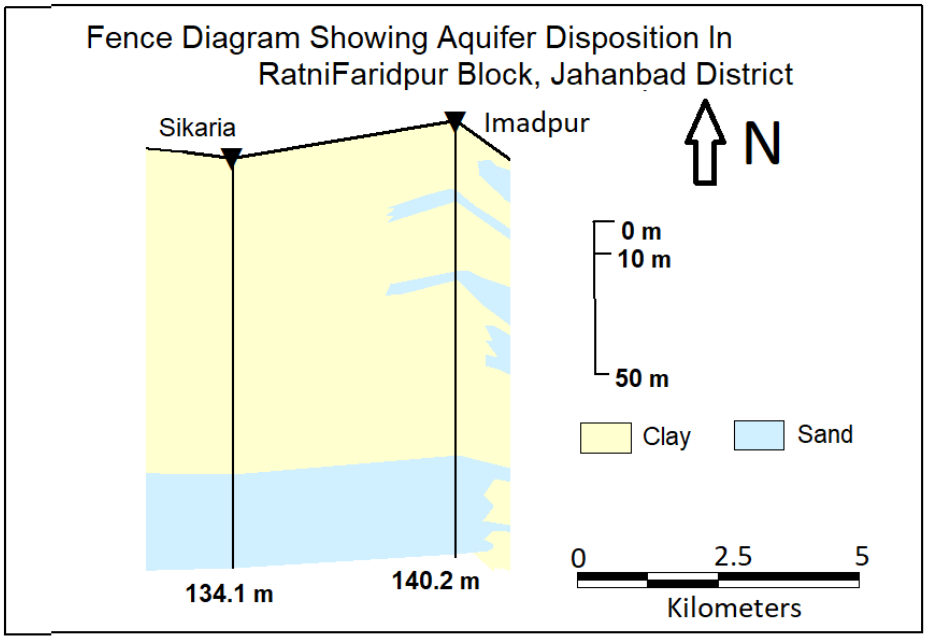
Depth to Water Level

CGWB NHS monitoring data and map shows that in pre-monsoon period, two range of depth to water level, 2 to 5 m bgl and 5 to 10 m bgl covering almost equal area of the block. During post-monsoon period, major part of the block shows 2 to 5 m bgl depth to water level, except small south western part with depth to water level within 2 m bgl.



8.7.2 Aquifer Disposition and Characteristics





Using the exploration drilling data of Sikaria, Imadpur, litholog of Ratnifaridpur block has been prepared, which shows that there is a layers of aquifer (sand) with top clay layer, with thin sand lenses in eastern side of the block. The average thickness of aquifer is 30 m. the top clay layer is about 104 m thick. Thickness of sand lenses present in the clay layers varies from 10m to 12 m. The drilling data shows that the sand is fining upward.

8.7.3 Ground water resource, extraction, contamination and other issues

Ground Water Resources - 2020

The SOD of the block is 108.60 % whereas of the district SOD is 91.54 %. Hence the net ground water availability is 0. The block is in "Over-exploited" category. So there is no any scope for further development of ground water.

Block	*Recharge from Rainfall*		*Recharge from Other Sources*		*Total Annual Ground Water Recharge*	*Provision for Natural Discharges*	*Net Annual Ground Water Availability*
	Monsoon	*Non-monsoon*	*Monsoon*	*Non-monsoon*			
	(ham)	*(ham)*	*(ham)*	*(ham)*	*(ham)*	*(ham)*	*(ham)*
Ratni Faridpur	2984.52	78.96	720.49	747.03	4531	453.1	0

Administrative Units	*Net Annual Ground Water Availability*	*Existing Gross Ground Water Draft for irrigation*	*Existing Gross Ground Water Draft for Domestic Uses*	*Existing Gross Ground Water Draft for Industrial Uses*	*Existing Gross Ground Water Draft for All Uses*	*Provision for Domestic and Industrial Requirement for Next 25 years*	*Net GW Availability for Future Irrigation Development*	*Stage of Ground Water Development*
	(ham)	*(ham)*	*(ham)*	*(ham)*	*(ham)*	*(ham)*	*(ham)*	*(%)*
Ratni Faridpur	0	3915	252.54	261.00	4428.54	283.68	0	108.60

Chemical quality of Ground Water

Result of chemical analysis of ground water of shallow aquifer of surrounding area shows In general Chemical quality of shallow aquifer is potable and also suitable for irrigation purpose.

8.7.4 Supply side management

Ratnifaridpur block is under 'Over-Exploited' category, SOD is 108.60%. Therefore for ground water management, some artificial structure may be constructed in Ratnifaridpur block. Based on the geology, geomorphology, depth to water level and surface water availability, the types and number of the artificial recharge structures has been worked out for Ratnifaridpur block and given in the table below. Based on available literature and previous experiences, unit cost of above structures is also worked out. As per Master plan of artificial recharge 2020, the table is as follows

Ratni Faridpur Block			
Recharge Structure		Cost (in Lakh)	Total Cost (Lakh)
Type	Number		
Percolation Tank	0	0	300
Gully Plug	0	0	
Contour Bunding & Trenching	0	0	
Check Dam	0	0	
Nala Bunding	1	1	
Contour Bunding & Trenching	0	0	
Lateral Recharge Shaft	5	10	
Recharge Shaft	11	55	
Percolation Tank	1	30	
De-silting of existing tank /pond /talao	20	100	
Injection Well in Village Tank	26	104	

8.7.5 Demand side management Plan

Some advance irrigation practices may be adopted such as drip/sprinkle irrigation etc. lining of field channels, change of cropping pattern also may be taken up for conservation purpose.

ANNEXURES

Annexture I

SN	Block	Location	Latitude	Longitude	Depth to Water Level (m bgl)		Elevation (m)	Fluctuation (m)	Depth (m)	RL
					May-19	Nov-19				
1	Hulasganj	Bholakpur	25.084	85.143	6.35	6.25	77.9	0.1	6.35	71.55
2	Jehanabad	Gaurakhini	25.209	84.986	10.4	4.94	70.7	5.46	9.2	60.3
3	Ghoshi	Ghoshi	25.174	85.100	7.5	3.77	69	3.73	7.5	61.5
4	Hulasganj	Hulasganj	25.086	85.148	8.37	3.28	80.5	5.09	6.5	72.13
5	Jehanabad	Jahanabad hosp.	25.225	85.004	6.4	6.2	67	0.2	6.4	60.6
6	Kako	Kako	25.226	85.079	9.38	5.7	65.9	3.68	5.2	56.52
7	Ghoshi	Lakhwar	25.137	85.105	4.9	1.62	72	3.28	4.9	67.1
8	Jehanabad	Teni Bigha	25.230	84.978	3.49	1.81	67.3	1.68	5	63.81

Annexture II

Drilling data for lithologs and pannel diagrams showing aquifer disposition:

Name:- Kalpa (Lat 25.234, Long 84.963)	District: Jehanabad Block : Jahanabad	
Depth Range (m)	Lithology	Thickness (m)
00.00-25.9	Hard clay	25.9
25.9-27.4	Fine sand	1.5
27.4-41.2	Clay	13.8
41.2-51.2	Coarse sand	10.0
51.2-69.5	Clay	18.3
69.5-91.4	Coarse sand	21.9

Name:- Kasaisen (Lat 25.217, Long 84.986)	District: Jehanabad Block : Jahanabad	
Depth Range (m)	Lithology	Thickness (m)
00.00-6.7	Clay	6.7
6.7-30.5	Medium sand	23.8
30.5-37.2	Clay	6.7
37.2-71.6	Coarse sand	34.4
71.6-74.7	Clay	3.1

Name:- Dhangwan (Lat 25.213, Long 85.015)	District: Jehanabad Block : Jahanabad	
Depth (m)	Lithology	Thickness (m)
00.00-21.3	Clay	21.3
21.3-30.5	Fine sand	9.2
30.5-42.4	Clay	11.9
42.4-55.2	Coarse sand	12.8
55.2-72.9	Clay	17.7
72.9-91.4	Coarse sand	18.5
91.4-99.1	Clay with Kankar	7.7

Name:- Kako (Lat 25.215, Long 85.001)	District: Jehanabad Block : Kako	
Depth (m)	Lithology	Thickness (m)
00.00-33.76	Clay	33.76
33.76-66.4	Fine sand	32.64

Name:- Sikaria (Lat 25.1511, Long 84.8671)	District: Jehanabad Block : Ratni Faridpur

Depth (m)	Lithology	Thickness (m)
00.00- 58.8	Clay	58.8
58.8-59.4	Coarse sand	0.6
59.4-103.7	Hard clay	44.3
103.6-109.7	Medium sand	6.1
109.7-134.1	Coarse sand	24.4

Name:- Imadpur (Lat 25.1568, Long 84.9033)	District: Jehanabad Block: Ratni faridpur	
Depth (m)	Lithology	Thickness (m)
00.00-22.9	Clay	22.9
22.9-25.9	Medium sand	3
25.9-48.7	Clay	22.8
48.7-51.2	Medium sand	2.5
51.2-67.1	Clay	15.9
67.1-97.6	Clay	30.5
97.6-140.2	Coarse sand	42.6

Name:- Karouta (Lat 25.1495, Long 84.9133)	District: Jehanabad Block : Jahanabad	
Depth (m)	Lithology	Thickness (m)
00.00-3.05	Surface clay	3.05
3.05-6.1	Fine sand	3.05
6.1-12.5	Medium sand	6.4
12.5-15.2	Coarse sand	2.7
15.2-22.8	Hard clay	7.6
22.8-26.2	Coarse sand	3.4
26.2-41.2	Hard clay	15
41.2-47.6	Coarse sand	6.4
47.6-101.2	Hard clay	53.6
101.2-114.6	Coarse sand	13.4
114.6-117.4	Sandy clay	2.8
117.4-130.1	Coarse sand	12.7
130.1-134.1	Sandy clay	4

Name:- Sundarpur (Lat 25.1487, Long 84.9418)	District: Jehanabad Block : Jahanabad	
Depth (m)	Lithology	Thickness (m)
00.00-2.13	Surface clay	2.13
2.13-8.2	Fine sand	6.07

8.2-19.2	Coarse sand	11.00
19.2-25.3	Clay with Kankar	6.1
25.3-30.5	Coarse sand	5.2
30.5-50.3	Clay	19.8
50.3-59.5	Coarse sand	9.2
59.5-64.9	Clay	5.4
64.9-74.4	Coarse sand	9.5
74.9-79.6	Clay	4.7
79.6-111.3	Coarse sand	31.7
111.3-117.0	Weathred rock	5.7

Name:- Karpi (Lat 25.1526, Long 84.9627)	District: Jehanabad Block : Jahanabad	
Depth (m)	Lithology	Thickness (m)
00.00- 3.05	Clay	3.05
3.05-6.4	Fine sand	3.35
6.4-25.9	Clay	19.5
25.9-30.5	Medium sand	4.6
30.5-41.2	Clay	10.7
41.2-47.6	Coarse sand	6.4
47.6-66.8	Clay	19.2
66.8-92.1	Coarse sand	25.3
92.1-97.6	Clay	5.5

Name:- Parasbigha (Lat 25.1542, Long 84.9725)	District: Jehanabad Block : Jahanabad	
Depth (m)	Lithology	Thickness (m)
00.00-9.2	Clay	9.2
9.2-19.8	Fine sand	10.6
19.8-35.9	Clay	16.1
35.9-46.6	Coarse sand	10.7
46.6-48.7	Sandy clay	2.1
48.7-58.5	Coarse sand	9.8
58.5-66.4	Sandy clay	7.9
66.4-69.5	Coarse sand	3.1
69.5-78.9	Sandy clay	9.4
78.9-89.0	Coarse sand	10.1
89.0-91.5	Clay	2.5

Name:- Ghosi (Lat 25.048, Long 85.083)	District: Jehanabad Block : Ghosi	
Depth (m)	Lithology	Thickness (m)
00.00-6.1	Clay	6.1
6.1-42.7	Medium sand	36.6
42.7-45.7	Clay	3.0
45.7-49.4	Coarse sand	3.7
49.4-79.3	Clay	29.9
79.3-103.0	Coarse sand with incalation of clay	23.7
103.0-146.3	Coarse sand	43.3

Name:- Parasbigha (Lat 25.1542, Long 84.9725)	District: Jehanabad Block : Jahanabad	
Depth (m)	Lithology	Thickness (m)
00.00-9.2	Clay	9.2
9.2-19.8	Fine sand	10.6
19.8-35.9	Clay	16.1
35.9-46.6	Coarse sand	10.7
46.6-48.7	Sandy clay	2.1
48.7-58.5	Coarse sand	9.8
58.5-66.4	Sandy clay	7.9
66.4-69.5	Coarse sand	3.1
69.5-78.9	Sandy clay	9.4
78.9-89.0	Coarse sand	10.1
89.0-91.5	Clay	2.5

Name:- Ranisarai (Lat 25.45548, Long 85.55036)	District: Barh Block : Patna	
Depth (m)	Lithology	Thickness (m)
0-2.29	Clay	2.29
2.29-3.72	Fine sand	1.433
3.72-5.88	Coarse sand	2.17

Name:- Ghosi2 (Lat 25.16695, Long 85.10888)	District: Jehanabad Block : Ghosi	
Depth (m)	Lithology	Thickness (m)
00.00-9.00	Clay	9
9.00-60.5	Sand	51.5

60.5-115.5	Clay	51
115.5-143.2	Sand	27.7

Name:- Kena (Lat 24.96978, Long 85.50114)	District: Nawada Block : Nawada	
Depth (m)	Lithology	Thickness (m)
00.00-18.03	Clay	18.03
18.03-28.47	Fine sand	10.44
28.47-51.01	Clay	22.54
51.01-64.65	Coarse sand	13.64
64.65-68.03	Sandy clay	8.38

Annexture III

Sl.No.	Location/ Block	Depth Drilled mbgl.	Length of Casing pipe/ Depth const. m.	Granular/ Zone/ fracture Tapped m.	Static Water level m. bgl.	Discharge m^3/hr.	Drawdown m.	Specific Capacity m^3/hr./m.	Trans- missivity m^2/day	Storativity	Diameter of assembly mm.	Formation
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
1	JEHANABAD $25^0$12'40" $84^0$57'30" EW	147.3	-	097.00-107.00 113.00-125.00 129.00-140.00	4.57	76.78	9.44	-	120.82	-	-	-
2	JEHANABAD BAZAR SAMITI OW	129	127	093.00-099.00 111.00-123.00	4.57	76.78	9.44	-	120.82	-	-	-

References:

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