



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

**IN PARTS OF BHAGALPUR DISTRICT,
BIHAR**

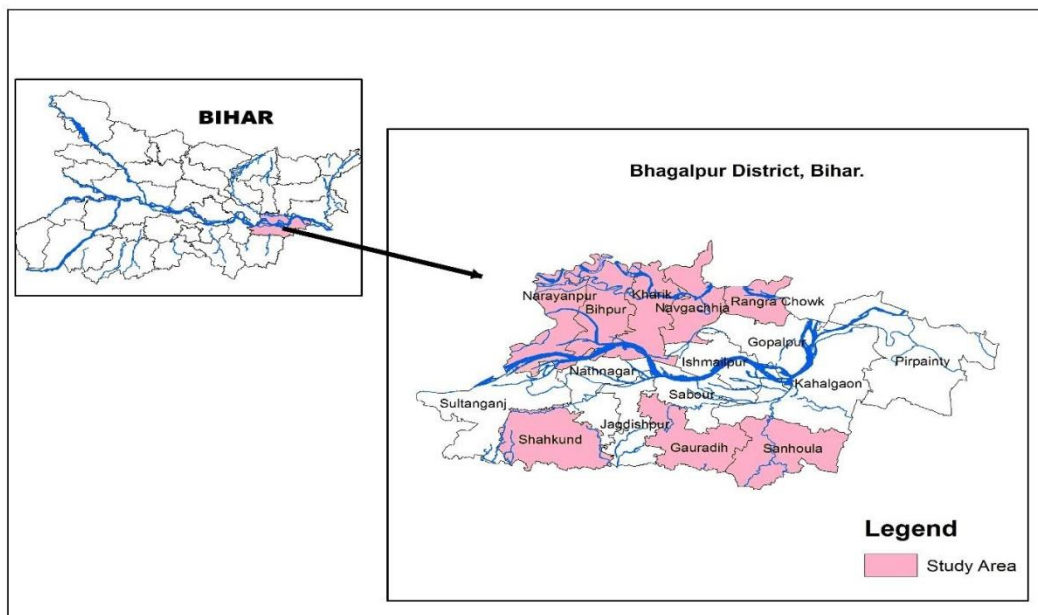
मध्य पूर्वी क्षेत्र, पटना
Mid Eastern Region, Patna



**Government of India
Ministry of Jal Shakti**

**DEPARTMENT OF WATER RESOURCES, RIVER
DEVELOPMENT & GANGA REJUVENATION**

**AQUIFER MAPPING AND MANAGEMENT PLAN IN PARTS
OF BHAGALPUR DISTRICT, BIHAR (AAP 2019-20)**



**CENTRAL GROUND WATER BOARD
MID-EASTERN REGION, PATNA**

AUGUST 2022

Contributors Page

Principal Contributors

Sanjib Chakraborty
Arya Mishra
Shipra Kumari
Md. Amin Rashid

Scientist-B
Young Professional
Young Professional
Young Professional

Technical Supervision

Dr. I.Roy

Scientist-C

Overall Supervision

Shri A.K. Agarwal
Shri T. B. N. Singh

RD, MER
Scientist-E & RD, MER

CONTENTS

CHAPTER	PAGE NO.
Aquifer Maps and Management Plan of Bihpur Block	2-19
Aquifer Maps and Management Plan of Goradih Block	20-36
Aquifer Maps and Management Plan of Kharik Block	37-54
Aquifer Maps and Management Plan of Narayanpur Block	55-72
Aquifer Maps and Management Plan of Naugachhia Block	73-89
Aquifer Maps and Management Plan of Rangrachowk Block	90-106
Aquifer Maps and Management Plan of Shahkund Block	107-124
Aquifer Maps and Management Plan of Sonhaura Block	124-140

Introduction

Bhagalpur district of Bihar situated on both northern and southern banks of the river Ganges, includes the 2nd largest city of Bihar by population. Bhagalpur is known as the Silk City of Bihar.

The district Bhagalpur is located in the eastern part of the state and extends between the north latitudes of 25⁰-03'-40" and 25⁰-30'-00" and east longitudes of 86⁰-30'-00" and 87⁰-29'-45". The district forms a part of the mid-Gangetic alluvium plain covering an area of 2603 sq.km.

Geo-morphologically and geologically the district is characterized by flat alluvial plains of Quaternary sediments and few isolated uplands of crystalline gneissic rocks in the eastern parts of the district. The district is rural one and people are largely depending on agriculture. The district represents alluvial plain with abundant land and water resources. The porous formation in alluvial tracts broadly constitutes the hydrogeological frame work of the district. So far, the scope for irrigation development in the district is moderate.

Total geographical area of the district is 2603 sq km. National Aquifer Mapping in Bhagalpur district was undertaken by CGWB, MER, Patna during 2016-2017 and 2017-18 under phase III and phase IV&V where 1472 sq km was covered. Under the Annual Action Plan of 2019-20 of CGWB, MER, Patna, aquifer mapping program and subsequent formulation of management plan were undertaken in the remaining 8 blocks comprising an area of 1132 sq km.

The present report is a compilation of block wise picture of geology, geomorphology, water level, ground water development, aquifer disposition and management plan for further sustainable development of water resources in the district. In absence of exploratory well data in few blocks of the district, the aquifer dispositions of the adjacent blocks have been presented. There exists further scope for detail aquifer disposition in prevalence of sufficient lithological data.

AQUIFER MAPS AND MANAGEMENT PLAN OF BIHPUR BLOCK, BHAGALPUR DISTRICT, BIHAR

1. Salient Information

Name of the Block/Area	Bihpur/152.08 sq km
District/State	Bhagalpur/Bihar
Population	Total- 145631 Rural- 145631 Urban- 0
Rainfall	Normal Monsoon- 977.3 Non-monsoon rainfall- 231
Agriculture and Irrigation	Principal crops - Rice – Wheat, Rice – Gram, Rice – Pulses, Rice – Rai. Gross cropped area- 13477.03 Net sown area- 11051.28 Irrigation practices- Surface water by canal -Ground water by tube well and DW Cropping intensity- 121.95 %, Number and types of abstraction structures – DW- 185, STW- 626, MDTW-9, DTW- 1
Geology	Quaternary alluvium- Diara and Ganga-Kosi Formation
Geomorphology	Major Physiographic units- Alluvial plain Major Drainage- Ganga, Bagmati
Ground water resource availability and extraction	Annual Ground Water Resource (Ham)-4059.64 Net Ground Water Availability for future use (Ham)- 2907.5 Ground water extraction (Ham)- 1131.54
Existing and future water demand	1131.57 Ham/187.63 Ham (annual GW allocation for domestic as on 2025)
Water level behaviour	Pre-monsoon SWL- 5.73-6.75 mbgl Post-monsoon SWL- 2.30-3.27 mbgl

2. Aquifer Disposition

Number of Aquifers	03; up to the explored depth of 100 m
Aquifer disposition and basic characteristics	1st aquifers within 20 m depth fine sand mostly phreatic 2nd aquifers within 40-60 m depth and 3rd or deeper aquifers within 60-100 m depth medium to coarse sand, semi-confined to confined.

3. Ground water resource, extraction, contamination and other issues

Ground water Safe

Resource/Categorization

Availability

Chemical quality of ground water and contamination Potable, As contamination reported from few sporadic area

4. Supply Side Interventions

Ground Water Development Strategies- Number of STW and DTW may be proposed for irrigation uses- STW-534, DTW-82

Aquifer wise space available for recharge and proposed interventions As per ARMP, 2020, for Bihpur block 11.58 sq km is suitable for recharge.
Lateral Recharge Shaft-3, Recharge shaft- 3, Desilting of existing tanks-5, Nala bunding-2 and injection well-5 etc. are some suitable structures in the area

5. Demand side interventions

Advanced Irrigation Practices Project based drip/sprinkler irrigation, lining of field channels etc.

Change in cropping pattern Water intensive and less water intensive crop like pulses, oilseeds may be encouraged.

Alternate water sources Conjunctive uses of groundwater/surface water sources,

Regulation and Control Capacity building for awareness generation for arsenic contamination

1. 0 General Information

1.	Area	in Sq. Km	:	2.08
2.	No. of revenue village		:	30
3.	Population (2011)	Total	:	1,45,631
		Rural	:	1,45,631
		Urban	:	—
4.	Normal annual rainfall (District)	(mm)	:	1268
5.	Basin / Sub-basin		:	Bagmati-Kosi Sub basin
6.	Location		:	
	Latitude		:	25°17'37.854"N to 25°29'37.07"N
	Longitude		:	86°52'10.761"E to 86°59'27.5"E

The Bihpur block of Bhagalpur district is surrounded in the east by Kharik block, in the north by Madhepura district, in the south and in west by Narayanpur block, (Fig:1). Block headquarter of Bihpur is Bihpur town. It belongs to Bhagalpur division. Naugachhia city, Bhagalpur city, Sultanganj city, Gogri Jamalpur city are the nearby cities to Bihpur. Bihpur block consist of 30 villages and 13 Panchayats. Gobindpur is the smallest village and Bihpur is the biggest village of Bihpur block. Bhagalpur (Bhagdattapuram), Munger, Sahibganj, Deoghar (Baba Dham), Pakur (Pakaur) are the nearby important tourist destinations. Maithili is the local language , people also speaks Hindi, Urdu.

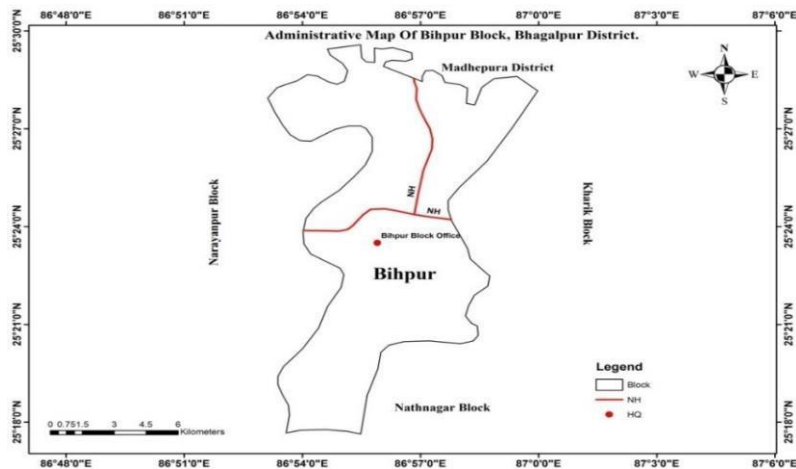


Fig-1, Administrative Map of Bihpur block, Bhagalpur District

1.1 Basic Demographic Detail of Bihpur Block as per 2011 census data

Total population of Bihpur block is 145631 among which 65664 is male population, 57722 is female population and 22245 is child population. Number of household is 23503. There are 13 gram panchayats and 30 villages in the Bihpur block, (Table-2)

Table-1: Demographic distribution of Bihpur Block

Block	No. of Household	Males	Females	Child	Total
Bihpur	23503	65664	57722	22245	145631

Source: Census 2011

Table-2: Panchayat wise village in Bihpur Block

S.No.	Panchayat	Villages
1	Hario	6
2	DharampurRatti	3
3	Marwa West	1
4	Marwa East	1
5	Jhandapur West	2
6	Jhandapur East	3
7	BihpurJamalpur	2
8	Bihpur Middle	1
9	Bihpur East	1
10	Bihpur South	4
11	Babhangama	2
12	Lattipur North	2
13	Lattipur South	2
	Total	30

Source: Census 2011

1.2 Distribution of persons engaged in agriculture and other workers/ non workers in the block

In Bihpur block, 71.2% of total population is non workers. It is evident from diagram given below, that 14% of the total population in the block is engaged in agriculture, 5% engaged as cultivator, 1% comprises household industrial workers and 8% comprises other worker, (Fig-2).

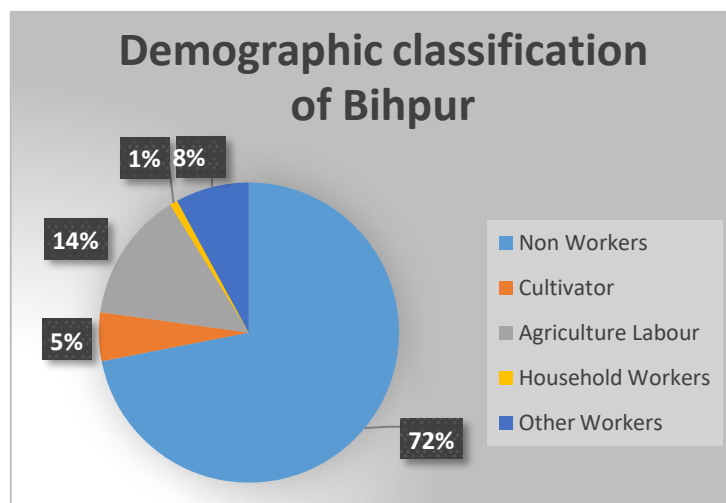


Fig-2, Demographic classification of Bihpur Block, Bhagalpur District

Source: Census 2011

1.3 Rainfall and Temperature

Normal annual rainfall of Bihpur block is 1268 mm of which 80% occurs during the monsoon season. The normal rainfall during monsoon season is 977.3 mm and during non-monsoon season is 231 mm. The temperature varies from 45 to 50°C.

1.4 Soil

Bihpur block contains mainly fine sandy loamy soil.

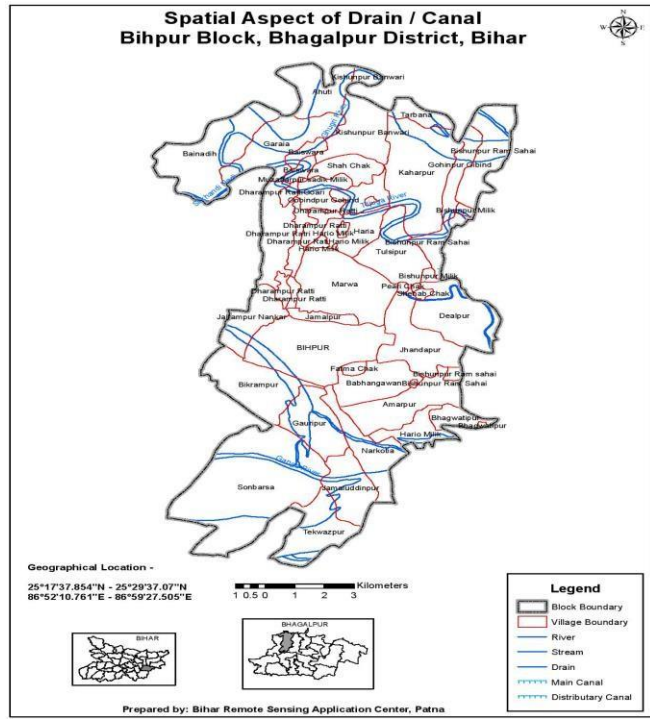
Table-3: Soil type

Block	Soil Type
Bihpur	Fine sandy loamy Soils, Clayey Soils

Source: District Irrigation Plan, 2019

1.5 Physiography, Basin/sub-basin, Drainage

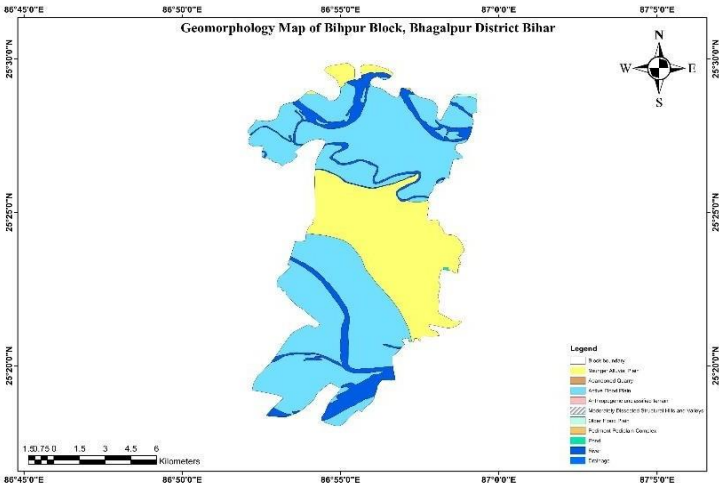
The Bihpur block is situated in north-west part of Bhagalpur District. Bihpur forms part of Badua-Koa Sub-basin. Dendritic and parallel to sub-parallel drainage patterns are dominating in this region. Bihpur block has average elevation 45 m. Sikhandi Nadi, Ghugri, Tiljuga Rivers are flowing through this block.



(Fig-3: Drainage and canal network in Bihpur Block)
 Source: District Irrigation Plan, 2019

1.6 Geomorphology

The Bihpur block is a part of Indo-Gangetic alluvium plain, having gentle slope. Quaternary alluvium plain of fluvial (deposited by flood during rainy season) origin covers the major part of the block. A small part of the block is covered by water bodies.



(Fig-4: Geomorphological map of Bihpur Block)

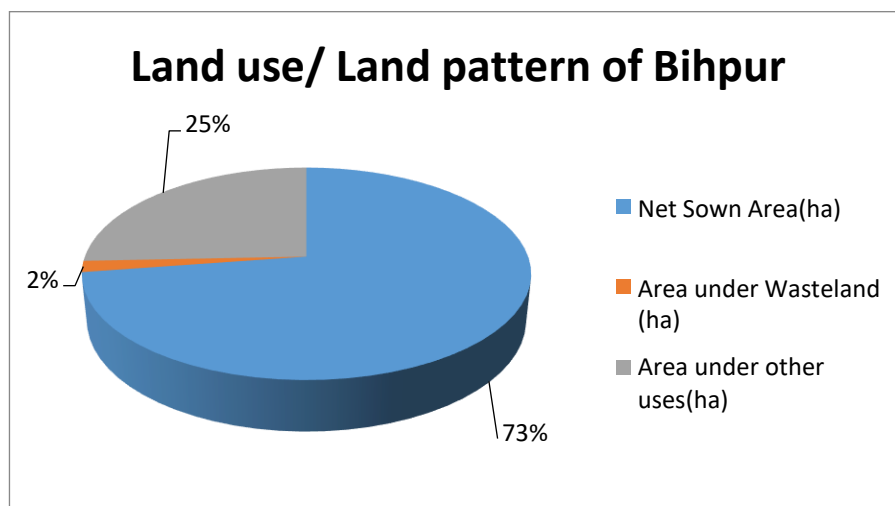
1.7 Land use / Land Cover

Total geographical area of the Bihpur block is 15208.00 ha. Bihpur block has net sown area is 11051.28 ha and gross cropped area is 13477.03 ha. Therefore area under multiple cultivation is 2425.75 ha area. 258.39 ha area is under wasteland. It is evident that net sown area is 72.66%, area under multiple cultivation is 15.95 % and wasteland is 1.69% of total geographical area. The cropping intensity of the block is 121.95%.

Table-4: Land use/Land Pattern of Bihpur Block

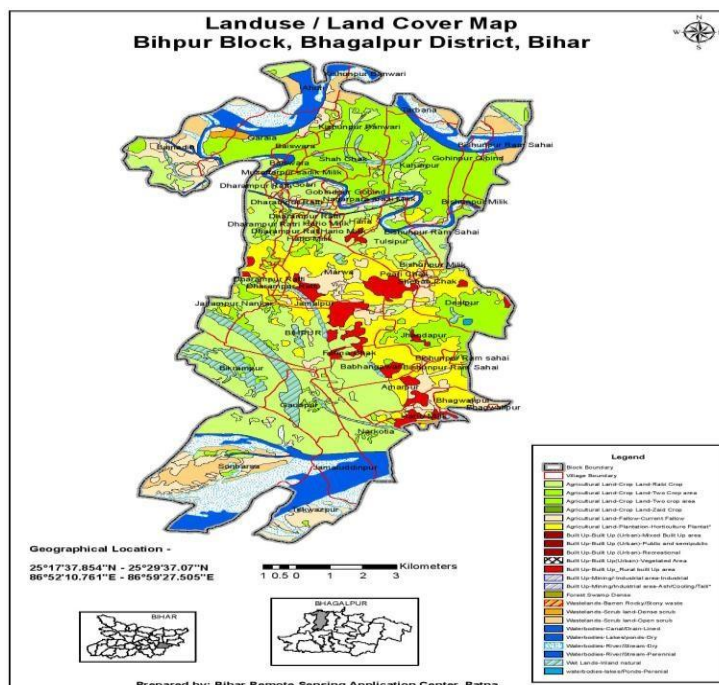
Name of the Block	No. of Gram Panchayat	Total Geographical Area (ha)	Gross cropped Area (ha)	Net Sown Area (ha)	Area Sown more than once (ha)	Area under Forest (ha)	Area under Wasteland (ha)	Cropping Intensity (%)
Bihpur	13	15208	13477.03	11051.28	2425.75	0	258.39	121.95

Source: District Irrigation Plan, 2019



(Fig-5: Land use and Land cover of in Bihpur Block)

Source: District Irrigation Plan, 2019



(Fig-6: Land use and Land cover of in Bihpur Block)

Source: District Irrigation Plan,2019

1.8 Agriculture and Irrigation

Agriculture is the main stay of the people living in Bihpur block, which is evident from census figures of 2011. Bihpur block falls in the Agro-climatic Zone III A. Bihpur block is producer of several crops such as paddy, maize, arhar, mung and urad during Kharif season. Wheat, maize, barely, pulses and oil seeds during Rabi season and summer season. Cereals are the major crops in the block.

Table-5: Area under different crops in Bihpur Block

Crops	Cropped Area (ha)	Kharif (ha)	Rabi (ha)	Summer Rabi (ha)
Coarse Cereal	13334.4	6734.4	5040	1560
Pulses	1495.2	619.2	264	612
Oil Seeds	355	25	330	0

Source: District Irrigation Plan,2019

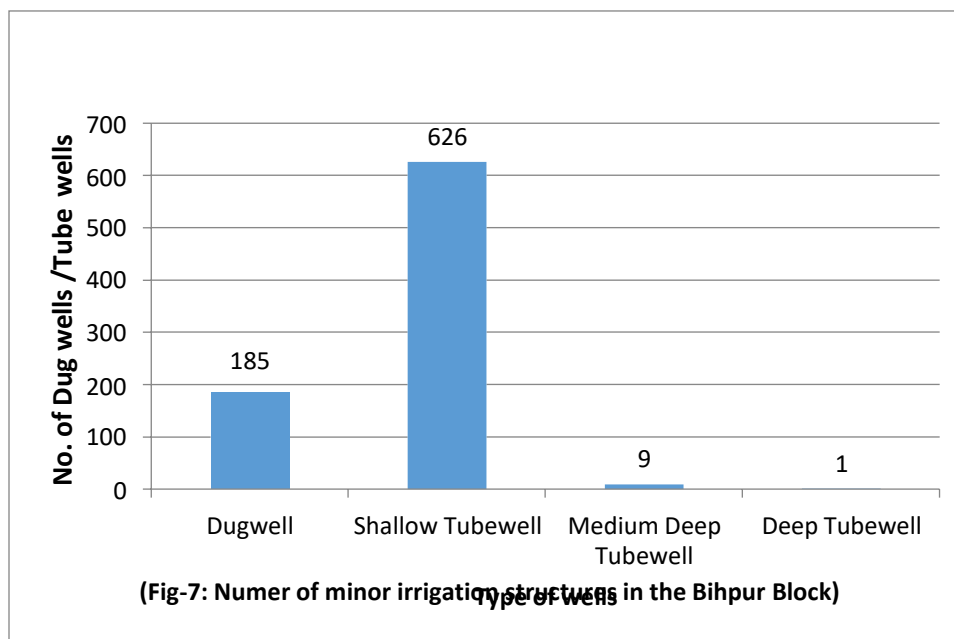
Surface irrigation network comprises canal irrigation, tanks, surface flow and lift irrigation. A considerable area is brought under irrigation by numbers of tanks.

Ground water irrigation is limited and is accomplished mainly through dug wells, shallow tube wells, medium deep tube wells and limited numbers of deep tube wells. Shallow tube wells are limited to the depth of 0-35 m bgl. Ground water extraction for irrigation use is 910.5 ham.

Table-6: Block level statistics of no. of tubewells for irrigation use as per 5th MI Census

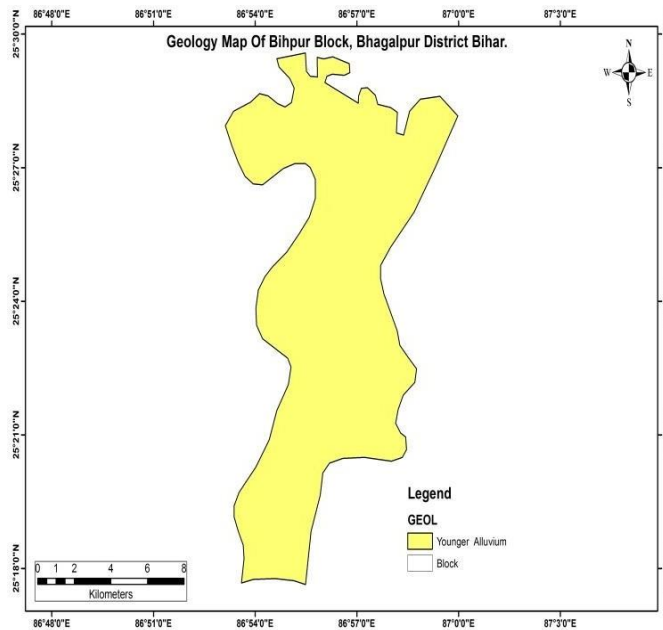
Block Name	Dug well	Shallow Tube well			Medium Deep Tube well	Deep Tube well
	No.	0-20 m depth	20-35 m depth	35-40 m depth	No.	No.
Bihpur	185	355	271	-	9	1

Source: 5th Minor Irrigation Census, 2013-14)



2.0 Geology

Major part of the block is covered by Diara and Ganga-kosi formation of Late Holocene age. The Diara formation is represented by unoxidised grey sand, silt and clay of the present day flood plain, channel bares, levees and back swamps and the Ganga-kosi formation is represented by fine to medium sand, silt and clay inundated in rainy season, bank erosion and re deposition.



(Fig-8: Geology of Bihpur Block)

3.0 Hydrogeology

Considerably thick sand layers with intermittent clay in the Quaternary Alluvium (mostly younger) of Late Holocene age form the main source of ground water in the block. Based on the strata logs and hydrogeological properties, the aquifer system in the district can be divided into three categories,

- i. The 1st aquifers within 20 m depth.
- ii. The 2nd aquifers within 40-60 m depth.
- iii. The 3rd or deeper aquifers within 60-100 m depth.

In shallow aquifers, the ground water occurs under unconfined condition and in deeper under semi- confined conditions. The shallow aquifers consist of fine to medium sand with clay. The deeper aquifers mainly consist of sand with alternating layers of clay.

Hydrogeologically the Bihpur block is underlain by porous, unconsolidated formation. The unconsolidated formation comprises clay, silt and different grades of sand down to depth of 155 m. The thick granular sand zone constitute potential aquifer system. The shallow aquifer is mainly under phreatic condition whereas differ part is under semi-confined to confined condition. The exploratory well data of CGWB, reveals that tube wells of 50 m depth yield at 52.4 m³/hr with drawdown 19.52 m. The transmissivity of the aquifer varies 209.52m²/day, specific capacity 2.68 m³/hr/m and storativity is 1.1 x 10⁻³.

3.1 Aquifer Disposition and Characteristics

Aquifer disposition of the area has been studied from the existing lithological data. The lithological cross section, across the block represents multiple aquifer system up to depth of 162m.

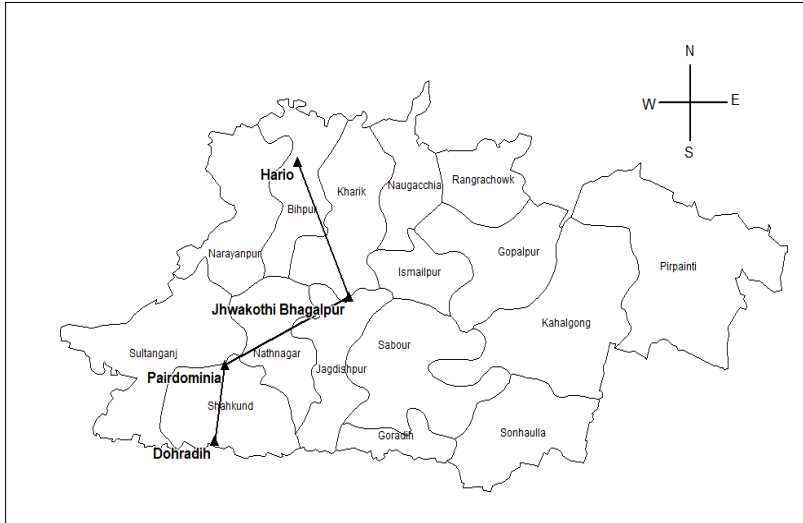


Figure-9(a): Location of Bore holes, Bhagalpur District

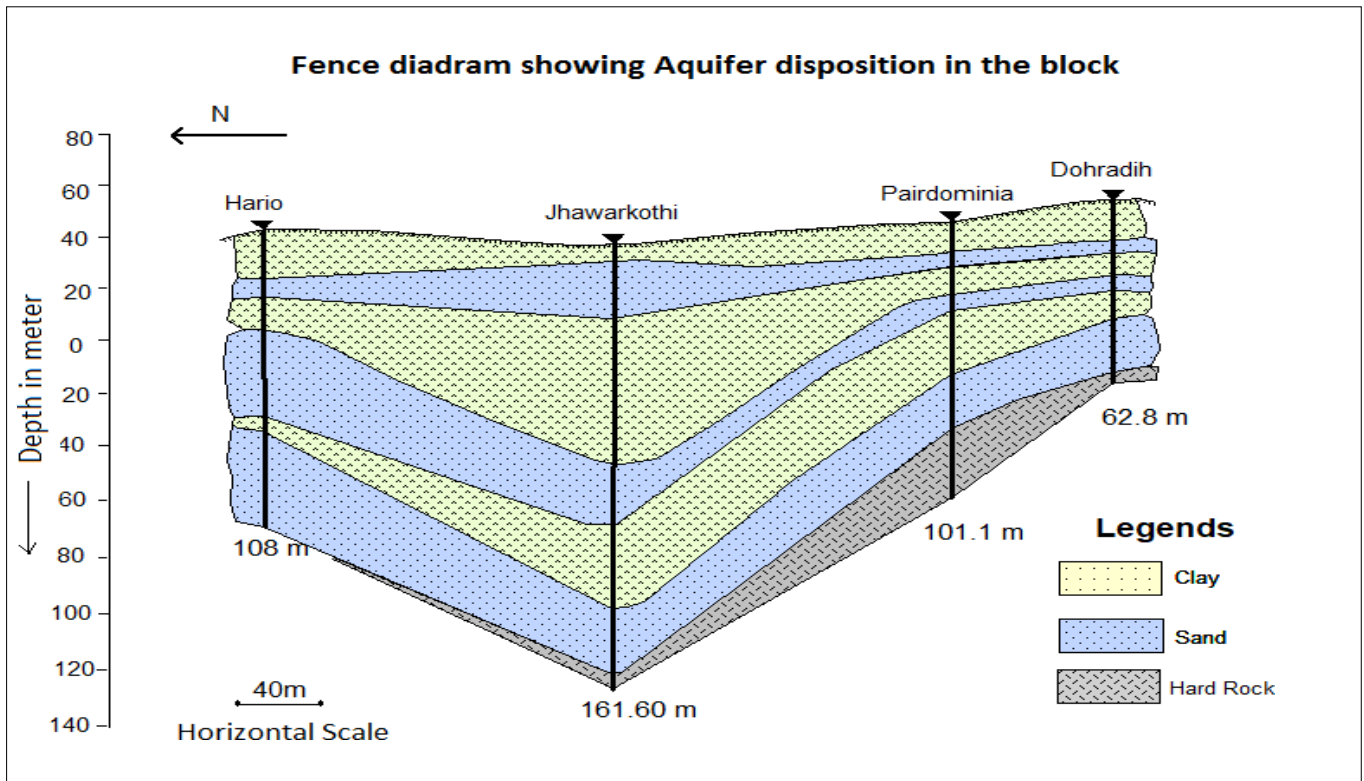


Figure-9(b): Fence diagram showing Aquifer disposition in the Block

3.2 Depth to Water Level

The groundwater regime of the block has been monitored from the existing network monitoring wells and inventoried observation wells. Observation wells are private, dug wells, piezometer of minor irrigation department, Government of Bihar. The average depth of dug wells is 9.5 m bgl. Piezometers are on an average 50 m bgl depth whereas the PHED deep tube wells are in general, deeper 155 m. The pre monsoon water level in dug well zone 5.73-6.75 m bgl and in post monsoon water level varies from 2.30-3.27 m bgl (Fig 10 a&b). Comparatively deeper water level 5.03-7.15 m bgl is reported from the deep tube wells of PHED. Ground water level fluctuation 3-3.5 m in general reflects more or less uniform and low fluctuation, (Fig-10 c). Water table map has been prepared from the elevation and depth to water level data of the observation wells, (Fig-11a &b).

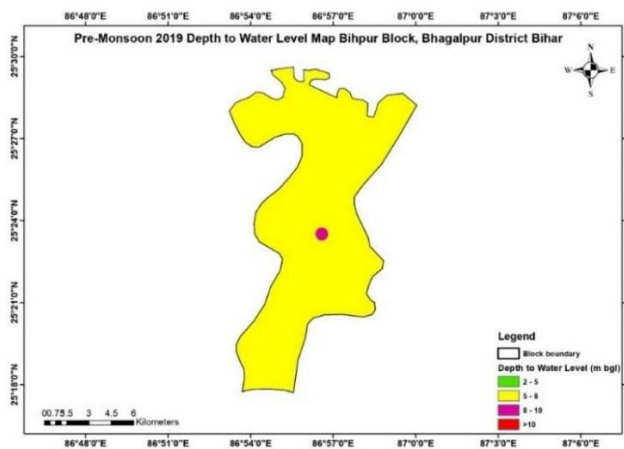


Figure-10(a): Pre monsoon water level

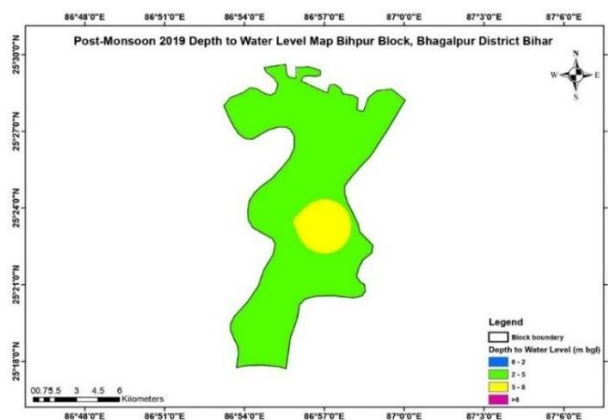


Figure-10(b): Post monsoon water level

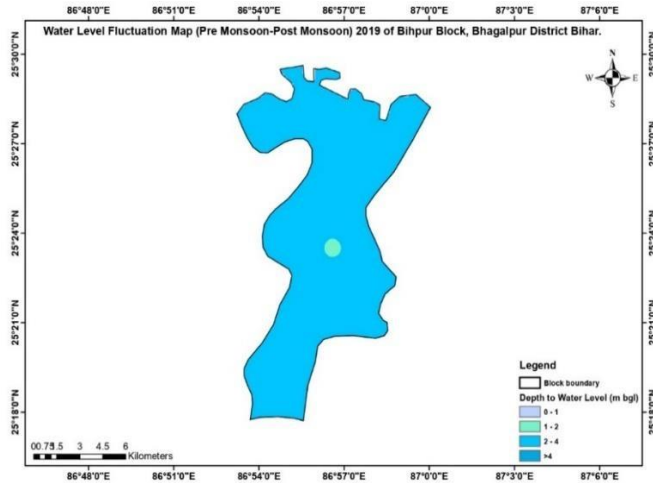


Figure-10(c): Fluctuation of water level

3.3 Ground Water Flow

Water table map has been prepared from the elevation and depth to water level data of the observation wells. In a groundwater regime, equipotential lines, the line joining points of the equal head on the potentiometric surface, were drawn based on the area of variation of the head of an aquifer. Based on the water table elevation, ground water flow directions (from S-N) are determined (Fig-11). It has been observed that the ground water flow directions follow the major drainage channels and topography of the area. This indicates the topographic control for the ground water movement.

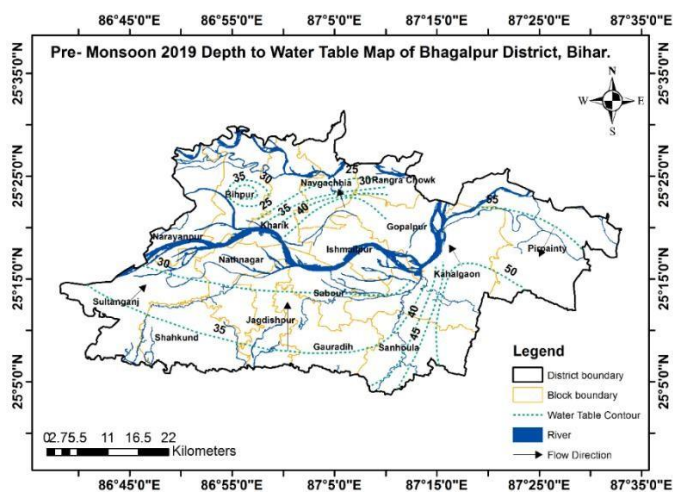


Figure-11(a): Pre monsoon water table

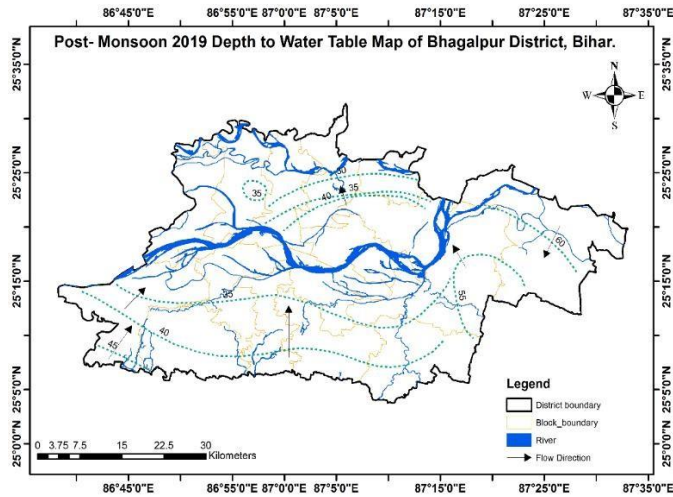


Figure-11(b): Post monsoon water table

Table-7: Depth to water level of pre monsoon and post monsoon of Bihpur Block

Block	Type of well	Location	Latitude	Longitude	Depth of well (m)	RL(m)	Depth to Water Level (m bgl)		Fluctuation (m)	Water Table (amsl)	
							Pre monsoon	Post monsoon		Pre monsoon	Post monsoon
Bihpur	NHS	Menenth chowk	25.3989	86.9222	9.5	37.4	5.73	2.30	3.43	31.67	35.1
Bihpur	PHED	Naugachhia	25.4049	86.9224	155	40.9	6.75	3.27	3.48	34.15	37.63
Bihpur	PZ	BDO office	25.2561	87.2395	50	45.6	7.15	5.03	2.12	38.45	40.57

4.0 Ground Water Resources

About 5.94% of the net ground water availability of Bhagalpur district is available in Bihpur block only. Total ground water resource of the block is 4510.71 ham and the total ground of draft of the block is 1134.54 ham. The SOD is 28.66% whereas of the district SOD is 27.87%. The block comes under “Safe” category, says that there are sufficient scope for ground water development.

Table-8: Ground Water Resources estimation -2020

District	Block	Recharge from Rainfall during Monsoon season (ham)	Recharge from Rainfall during Non-Monsoon season (ham)	Recharge from Other Sources during Monsoon season (ham)	Recharge from Other Sources during Non-Monsoon season (ham)	Total Annual Ground Water Recharge (ham)	Total Natural Discharges	Annual Extractable GW Resource (ham)	GW Extraction for Irrigation (ham)	GW Extraction for Industrial (ham)	GW Extraction for Domestic (ham)	Total Extraction (ham)	Net GW Availability for Future Development (ham)	Stage of Ground Water Development(ham)	Category: Safe / Semi-critical/ Critical/ Over-exploited
Bhagalpur	Bihpur	3751.26	402.11	189.83	167.51	4510.71	451.07	4059.64	910.5	54.00	167.03	1131.54	2907.5	27.87	Safe

5.0 Chemical quality of Ground Water

Result of chemical analysis (2019) of ground water (sample collected during May 2019) of shallow aquifer is given in the table below. In general water of shallow aquifer is potable. Total Hardness value shows that at Bihpur, water is very hard. As per report on Arsenic contamination in ground water, arsenic contamination above permissible limit, 42 ppb has been reported from Marwa village in Bihpur block.

Table-9: Chemical quality of Ground Water of Bihpur Block

Location	pH	EC	TH	Ca	Mg	Na	K	HCO3	Cl	SO4	NO3	F	TDS
Bihpur	7.9	797	355	110	19	8.58	0.3	311	32	54	34	0.19	478

6.0 Management Plan

6.1. Supply side intervention in Agriculture and Irrigation

From the existing land/agriculture and irrigation practices it is understood that the Bihpur block is principally dependent on agriculture. However, the average cropping intensity is recorded as 121.95 %. It reveals that considerable cropped area is not under assured irrigation coverage. The dynamic ground water resource reports stage of development is 27.87 % which indicates there exists further scope of ground water development in the block both for agriculture and drinking/domestic purposes. 5th MI Census data shows that majority of irrigation tube wells accompanied within the depth of 50-70 m. Therefore, along with the present exploration depth, further development may be planed from the deeper part.

Considering projected 70% development, 1710.21 ham further resources may be developed safely for generation of additional irrigation potential. This balance resource is recommended for development through STW/DTW as per the prevailing terrain condition and hydrogeology of the area. Considering unit draft of 2.4 and 5.2032 ham for STW and DTW respectively following number of irrigation structures have been proposed. Thus, in Bihpur block 534 STW and 82 DTW may be constructed. (Table10).

Table-10(a): Additional resource for 70% development

Assessment Unit Name	Total Area of Assessment Unit (Ha)	Recharge Worthy Area (Ha)	Annual Extractable Ground Water Resource (Ham)	Total Extraction (Ham)	(Ha Draft for 70% m) development	Additional resource available for 70% development (Ham)
BIHPUR	15208	15208	4059.64	1131.54	2841.748	1710.208

Table-10(b): Recommended number of structures for further irrigation development

Additional resource available for 70% development (Ham)	Resource allocated for development by STW (Ham)	Resource allocated for development by DTW (Ham)	Unit draft of STW (Ham)	Unit draft of DTW (Ham)	No. of STW proposed	No. of DTW proposed
1710.208	1282.656	427.552	2.4	5.2032	534	82

6.2 Supply side intervention through Artificial Recharge and rain water harvesting

Based on post monsoon water level, long term water level trend, local geological and geomorphological settings and availability and non-committed surplus runoff, the feasibility of artificial recharge to augment ground water resources in the Bihpur block has been worked out (Artificial Recharge Management Plan, 2019). An area of 11.58 Sq. km has been found as suitable for artificial recharge.

Based on the local geology/hydrogeology and underlying lithological disposition percolation tank, recharge shaft, injection wells in village tank, de-silting of existing tank/talao/pond may be practiced in Bihpur block. The tentative numbers of the above structures are as follows.

Table-10: Proposed AR structure and RWH

Bihpur Block	
Recharge Structure	
Type	Number
Lateral Recharge Shaft	3
Recharge Shaft	3
Nala bunding	2
De-silting of existing tank /pond /talao	5
Injection Well in Village Tank	5

Source: ARMP, 2019

6.3 Demand side intervention

Considering the area being high potential in terms of ground water resources, the additional resources may be utilized for more water intensive crops like paddy, cereals etc. along with the other crops. Crop rotation for diversification of agriculture practices may be encouraged. This may create further irrigation potential in the block and at the same time an attempt for more development may reduce the water logging and flooding.

Arsenic contamination beyond permissible limit has been reported from Marwa village in the block. Hence, to combat this challenges ground water from the tube wells may be tested before utilization. Deeper aquifer may be explored with the techniques of cement sealing to avoid percolation of contaminated water from shallower depth. Domestic and community based As removal plant may be installed as short term measures.

AQUIFER MAPS AND MANAGEMENT PLAN OF GORADIH BLOCK, BHAGALPUR DISTRICT, BIHAR

1. Salient Information

Name of the Block/Area	Goradih/134.25 sq km
District/State	Bhagalpur/Bihar
Population	Total- 174964 Rural- 174964 Urban- 0
Rainfall	Normal Monsoon- 977.3 Non-monsoon rainfall- 231
Agriculture and Irrigation	Principal crops - Rice – Wheat, Rice – Gram, Rice – Pulses, Rice – Rai. Gross cropped area- 13308.16 Net sown area- 10930.73 Irrigation practices- Surface water by canal -Ground water by tube well and DW Cropping intensity- 121.75 %, Number and types of abstraction structures – DW- 387, STW- 655, MDTW-129, DTW- 9
Geology	Late Pleistocene alluvium- Diara and Sutadih formation
Geomorphology	Major Physiographic units- Alluvial plain Major Drainage- Ganga, Badua-Koa Sub basin
Ground water resource availability and extraction	Annual Ground Water Resource (Ham)-3636.7 Net Ground Water Availability for future use (Ham)- 2757.21 Ground water extraction (Ham)- 855.56
Existing and future water demand	855.56 Ham/218 Ham (annual GW allocation for domestic as on 2025)
Water level behaviour	Pre-monsoon SWL- 4.32-6.55 mbgl Post-monsoon SWL- 2.00-3.10 mbgl

2. Aquifer Dispositions

Number of Aquifers	02; up to the explored depth of 70 m
Aquifer disposition and basic characteristics	1st aquifers within 30 m depth fine sand mostly phreatic 2nd aquifers within 30-70 m depth medium to coarse sand, semi-confined to confined.

3. Ground water resource, extraction, contamination and other issues

GW Resource/Categorization Safe

Availability

Chemical quality of ground water and contamination Potable

4. Supply Side Interventions

Ground Water Development Strategies- Number of STW and DTW may be proposed for irrigation uses- STW-528, DTW-126

Aquifer wise space available for recharge and proposed interventions As per ARMP, 2020, for Bhagalpur district 385.41 sq km is suitable for recharge.
Percolation tank-8, Gully plug-471, Contour bunding & Trenching-764, Check dam-22, Nala bunding-37, Recharge shaft-86, Desilting of existing tanks-157 and injection well-210 etc. are some suitable structures in the district

5. Demand side interventions

Advanced Irrigation Practices Project based drip/sprinkler irrigation, lining of field channels etc

Change in cropping pattern Less water intensive crop like pulses, oilseeds may be encouraged.

Alternate water sources Conjunctive uses of groundwater/surface water sources,

Regulation and Control Capacity building for awareness generation for fluoride/arsenic contamination.(if needed)

1.0 General Information

1. Area	in Sq. Km	:	134.25
2. No. of revenue village		:	121
3. Population (2011)	Total	:	1,74,964
	Rural	:	1,74,964
	Urban	:	—
4. Normal annual rainfall (District)	(mm)	:	1208
5. Basin / Sub-basin		:	Badua-Koa Sub-basin
6. Location		:	
Latitude		:	25°05'21.54" N to 25°14'8.25" N
Longitude		:	86°59'6.58" E to 87°8'23.63" E

The Goradih block of Bhagalpur district is surrounded in east by Sonhaila block, in the north by Sabour block, in the west by Jagdishpur block and in the south by Banka district (Fig:1). Block headquarter of Goradih is Goradih town. It belongs to Bhagalpur division. Bhagalpur city, Amarpur city, Colgong city, Naugachhia city are the nearby cities to Goradih. Hajjudih is the smallest village and Amarpur is the biggest village. Bhagalpur (Bhagdattpuram), Sahibganj, Munger, Deoghar (Baba Dham), Pakur (Pakaur) are the nearby important tourist destinations. Maithili is the local language, people also speaks Hindi, Urdu.

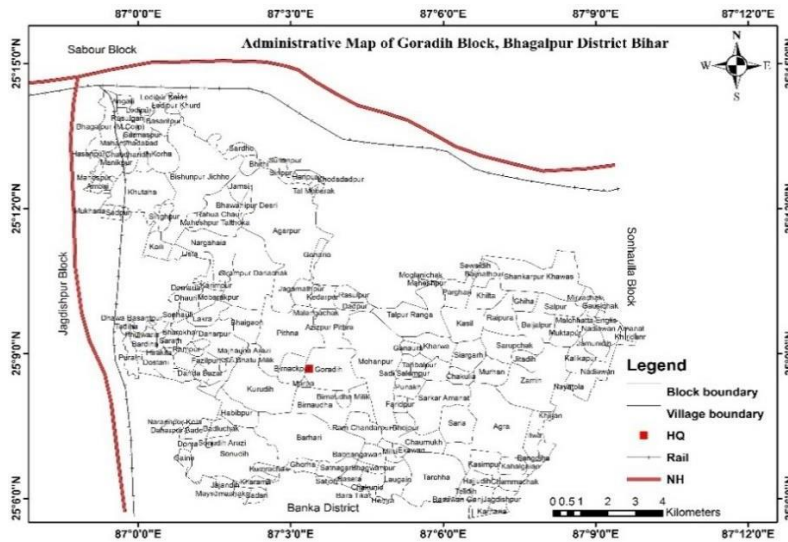


Fig-1, Administrative Map of Goradih Block, Bhagalpur District

1.1 Basic Demographic Detail of Goradih Block as per 2011 census data

Total populations of Goradih block is 174964 among which 77684 is male population, 68526 is female population and 28754 is child population. Number of household is 27813. There are 15 gram panchayats and 131 villages in the Goradih block, (Table-1 and 2).

Table-1: Demographic distribution of Goradih Block

Block	No. of Household	Males	Females	Child	Total
Goradih	27813	77684	68526	28754	174964

Source: Census 2011

Table-2: Panchayat wise village in Goradih Block

S.No.	Panchayat	Villages
1	Sonudih Satjori	15
2	Mohanpur	12
3	Tarcha Damuchak	11
4	Kasimpur	14
5	Sarathdaharpur	16
6	Pithana	6
7	Salpur	8
8	Ustu	4
9	Murahanjamin	4
10	Ndiyama	8
11	Goradih	5
12	Khutaha	4
13	Bishunpur Jicho	7
14	Agarpur	3
15	Manchhipur	4
	Total	121

Source: Census 2011

1.2 Distribution of persons engaged in agriculture and other workers/ non workers in the Block

In Goradih block, 65% of total population is non workers. It is evident from diagram given below, that 23% of the total population in the block is engaged in agriculture, 6% engaged as cultivator, 1% comprises household industrial workers and 5% comprises other worker, (Fig-2).

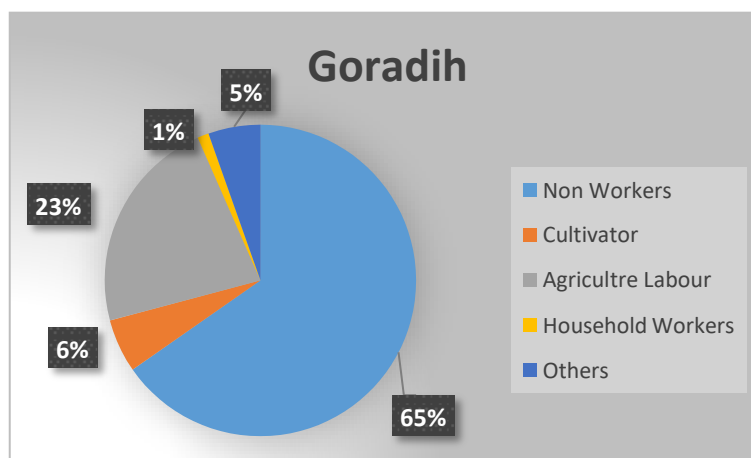


Fig-2, Demographic classification of Goradih Block, Bhagalpur District

Source: Census 2011

1.3 Rainfall and Temperature

Normal annual rainfall of Goradih block is 1208 mm of which 80% occurs during the monsoon season. The normal rainfall during monsoon season is 977.3 mm and during non-monsoon season is 231 mm. The temperature varies from 45 to 50°C.

1.4 Soil

Goradih block contains mainly fine sandy loamy soil.

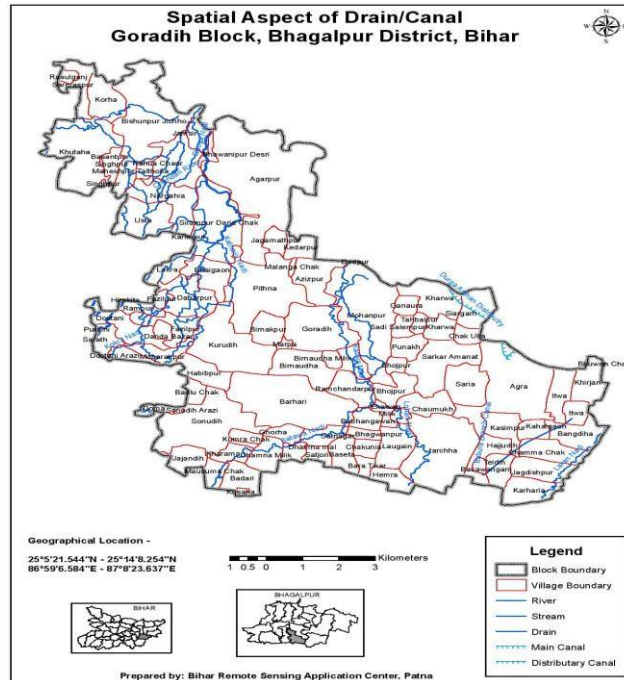
Table-3: Soil type

Block	Soil Type
Goradih	Fine sandy loamy Soils, Clayey Soils

Source: District Irrigation Plan, 2019

1.5 Physiography, Basin/sub-basin, Drainage

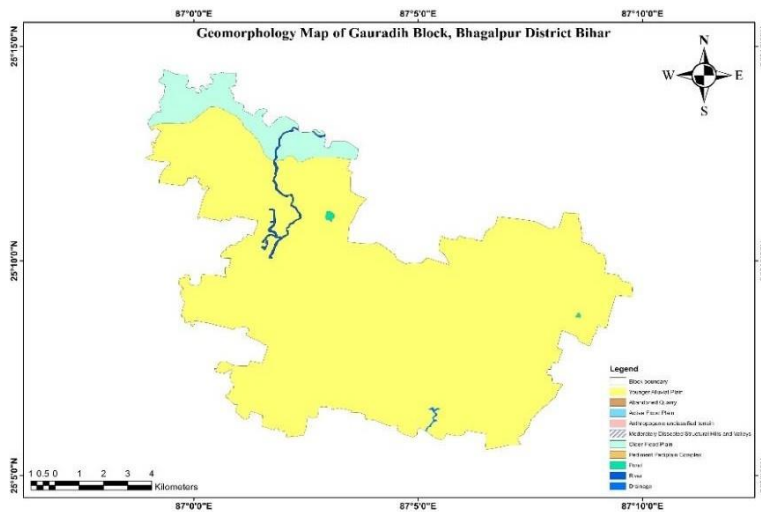
The Goradih block is situated in south part of Bhagalpur District. Goradih forms part of Badua-Koa Sub-basin. Dendritic and parallel to sub-parallel drainage patterns are dominating in this region. Goradih block has average elevation 42m. Chandan, Ghogha, Kokra, Katharia, Kodwa, Lohari and Batawa Rivers are flowing in this block.



(Fig-3: Drainage and canal network in Goradih Block)
 Source: District Irrigation Plan, 2019

1.6 Geomorphology

The Goradih block is a part of Indo-Gangetic alluvium plain, having flat or gentle slope. Quaternary alluvium plain of fluvial origin covers the major part of the block. A small part of the block covered under water bodies.



(Fig-4: Geomorphological map of Goradih Block)

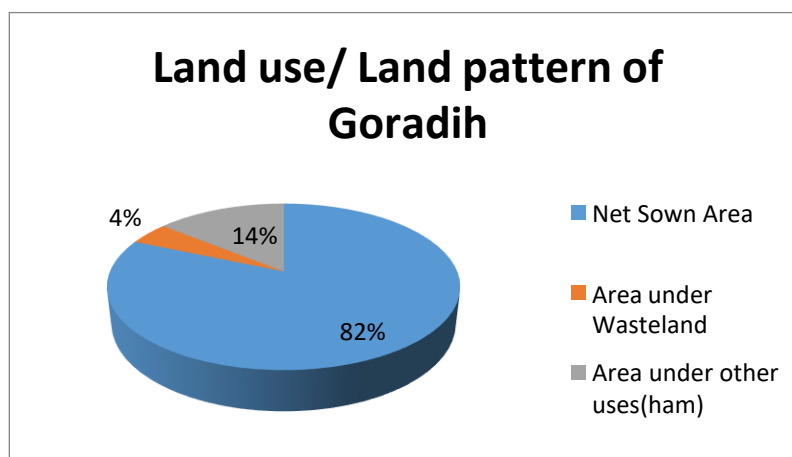
1.7 Land use / Land Cover

Total geographic area of the Goradih block is 12100 ha. Goradih block has net sown area is 10930.73 ha and gross cropped area is 13477.03 ha. Therefore area under multiple cultivation is 2377.43 ha area and 595 ha area is under wasteland. It is evident that net sown area is 82.42 %, area under multiple cultivation is 14.14 % and wasteland is 4.40 % of total geographical area. The cropping intensity of the block is 121.75%.

Table-4: Land use/Land Pattern of Goradih Block

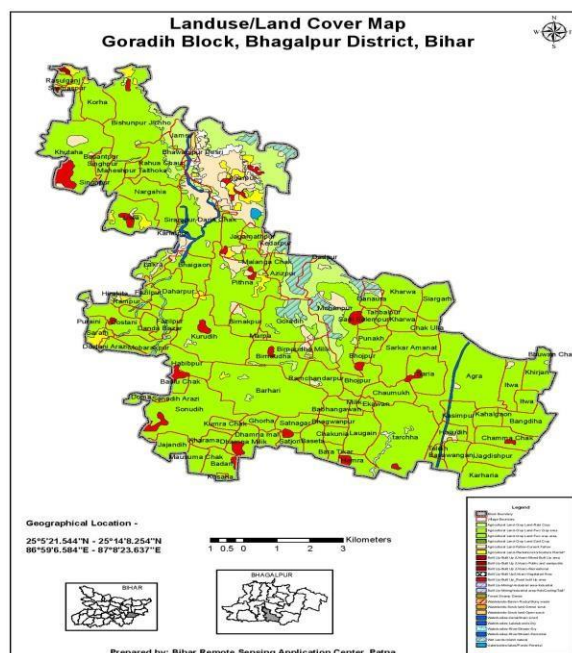
Name of the Block	No. of Gram Panchayat	Total Geographical Area (ham)	Gross cropped Area (ham)	Net Sown Area (ham)	Area Sown more than once (ham)	Area under Forest (ham)	Area under Wasteland (ham)	Cropping Intensity (%)
Goradih	15	121	13308.16	10930.73	2377.43	0	595	121.75

Source: District Irrigation Plan, 2019



(Fig-5: Land use and Land cover of in Goradih Block)

Source: District Irrigation Plan, 2019



(Fig-6: Land use and Land cover of in Gordih Block)

Source: District Irrigation Plan,2019

1.8 Agriculture and Irrigation

Agriculture is the main stay of the people living in Gordih block, which is evident from census figures of 2011. Gordih block falls in the Agro-climatic Zone III A. Goradiah block is producer of several crops such as paddy, maize, arhar, mung and urad during Kharif season, wheat, maize, barely, pulses and oil seeds during Rabi season and summer season. Cereals are the major crops in the block.

Table-5: Area under different crops in Goradiah Block

Crops	Cropped Area (ha)	Kharif (ha)	Rabi (ha)	Summer Rabi (ha)
Coarse Cereal	21143.28	9754.8	4430.4	6958.08
Pulses	1336.8	420	264	652.8
Oil Seeds	352	22	330	0

Source: District Irrigation Plan,2019

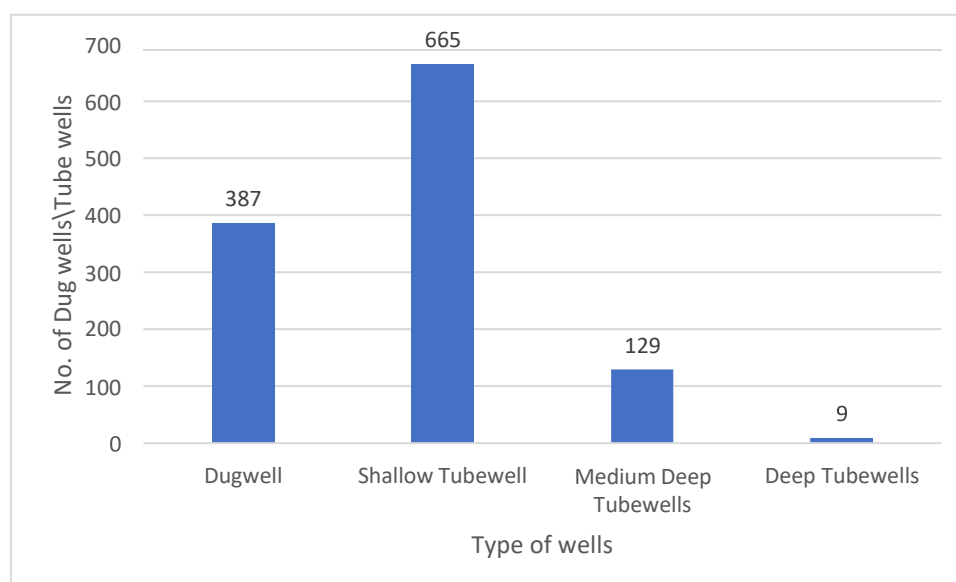
Surface irrigation network comprises canal irrigation, tanks, surface flow and lift irrigation. A considerable area is brought under irrigation by numbers of tanks.

Ground water irrigation is limited and is accomplished mainly through dug wells, shallow tube wells, medium deep tube wells and limited numbers of deep tube wells. Shallow tube wells are limited to the depth of 0-35 m bgl. Ground water extraction for irrigation use is 616.5 ham.

Table-6: Block level statistics of no. of tubewells for irrigation use as per 5th MI Census

Block Name	Dug well	Shallow Tube well			Medium Deep Tube well	Deep Tube well
	No.	0-20 m depth	20-35 m depth	35-40 m depth	No.	No.
Goradih	387	175	490	-	129	9

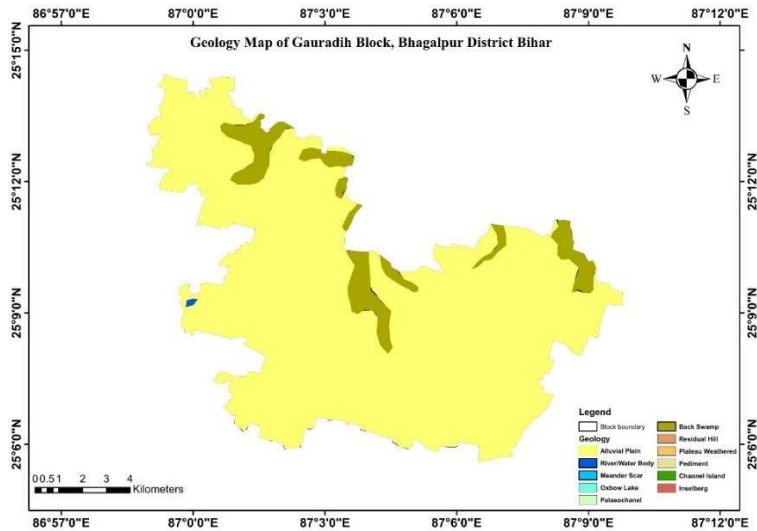
Source: 5th Minor Irrigation Census, 2013-14)



(Fig-7: Number of minor irrigation structures in the Goradih Block)

2.0 Geology

Major part of the block is covered by Diara and Sautadih formation of Late Pleistocene to Holocene age. The Diara formation is represented by unoxidised grey sand, silt and clay of the present day flood plain, channel bares, levees and back swamps and the Sautadih formation is represented by Khaki green clay with brown silt and sand, highly oxidized, impregnated with caliche nodules.



(Fig-8: Geology of Goradih Block)

3.0 Hydrogeology

Considerably thick sand layers with intermittent clay in the Quaternary Alluvium (mostly younger) of Late Holocene age form the main source of ground water in the block. Based on the strata logs and hydrogeological properties, the aquifer system in the district can be divided into two categories,

- i) The shallow aquifers within 30 m depth.
- ii) The deep aquifers within 40-70 m depth.

In shallow aquifers, the ground water occurs under unconfined condition and in deeper under semi-confined conditions. The shallow aquifers consisting of fine to medium sand with clay. The deeper aquifers mainly consist of sand with alternating layers of clay.

Hydrogeologically the Goradih block is underlain by porous, unconsolidated formation. The unconsolidated formation comprises clay, silt and different grades of sand down to depth of 68 m. The thick granular sand zone constitute potential aquifer system. The shallow aquifer is mainly under phreatic condition whereas differ part is under semi-confined to confined condition. The exploratory well data of CGWB, reveals that tube wells of 64.7 m depth yield at 12.9 m³/hr with drawdown 27.46 m. The specific capacity 0.47 m³/hr/m and storativity is 0.9 x 10⁻³.

3.1 Aquifer Disposition and Characteristics

Aquifer disposition of the area has been studied from the existing lithological data. The lithological cross section, across the block represents multiple aquifer system up to depth of 68 m. In general hard crystalline rocks are encountered at a depth of 60-65 mbgl.

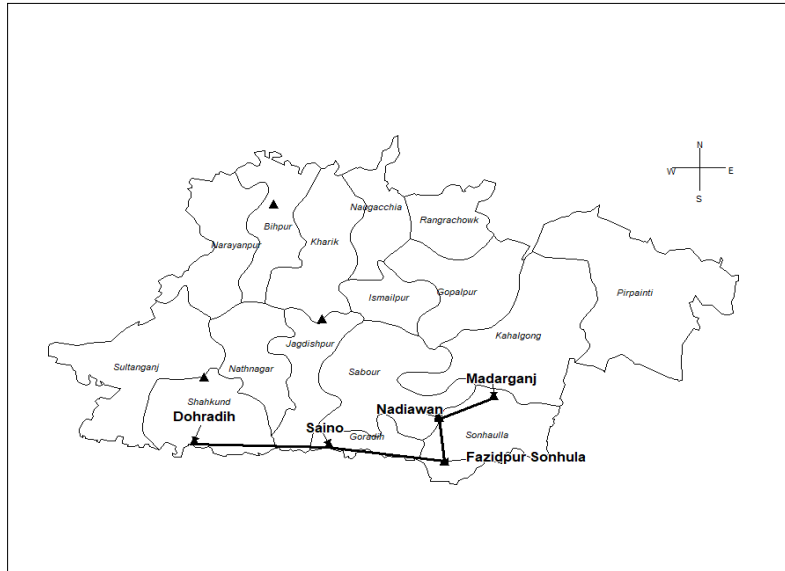


Figure-9(a): Location Map, Bhagalpur District

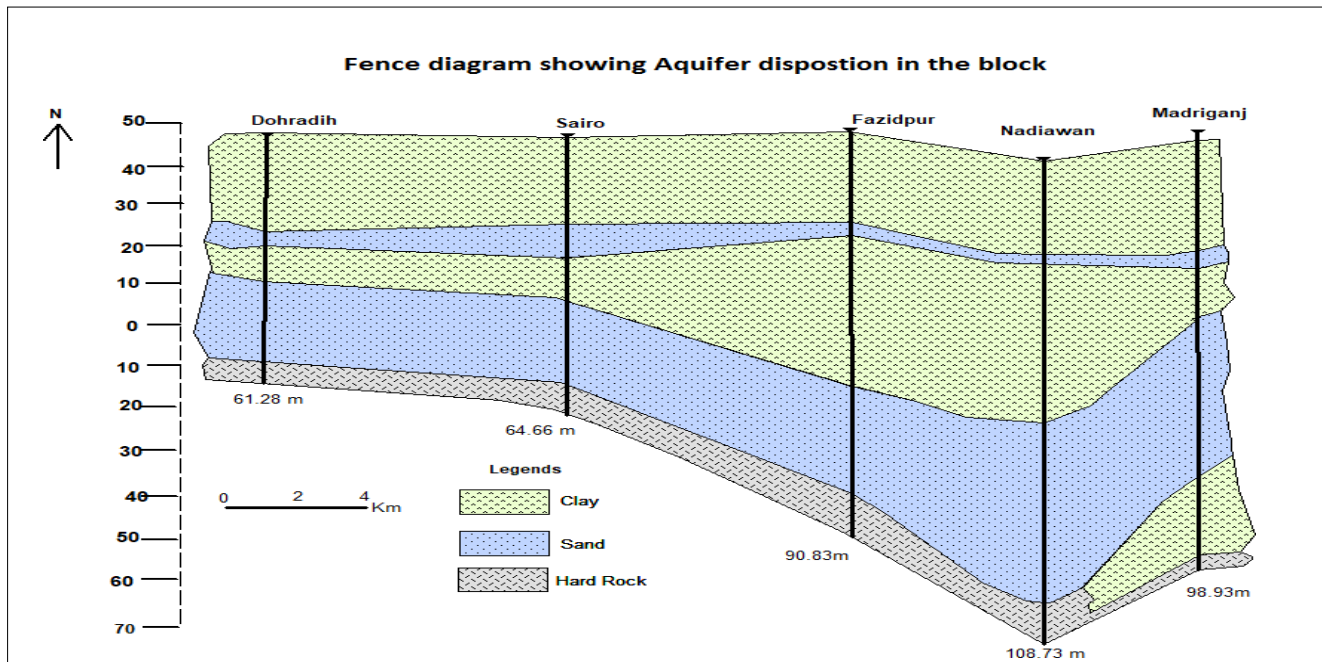


Figure-9(b): Fence diagram showing Aquifer disposition in the Block

3.2 Depth to Water Level

The groundwater regime of nearby area of the Goradih block has been monitored from the existing network monitoring wells and inventoried observation wells. Observation wells are private, dug wells, piezometer of minor irrigation department, Government of Bihar. The average depth of dug wells is 9 to 10 m bgl. Piezometers are on an average 50 mbgl depth whereas the PHED deep tubewells are in general, deeper (155 m bgl). The pre monsoon water level in dug well zone 4.32-6.65 m bgl and in post monsoon water level varies from 2.00-3.10 m bgl (Fig10a &b). Comparatively deeper water level 4-8 m bgl is reported from the deep tube wells of PHED. Ground water level fluctuation 2-4 in general reflects more or less uniform and moderate fluctuation(Fig-10c).

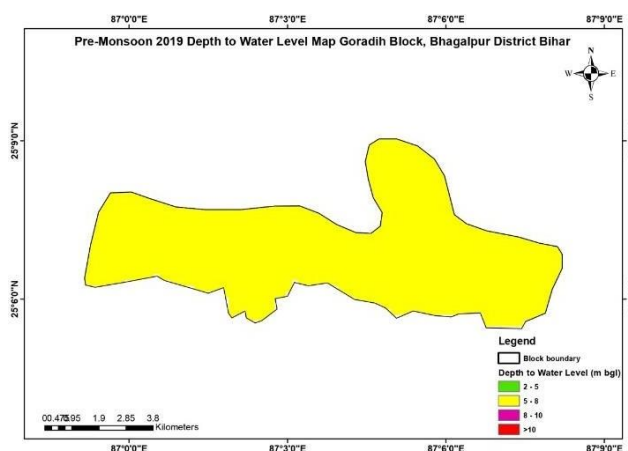


Figure-10(a): Pre monsoon water level

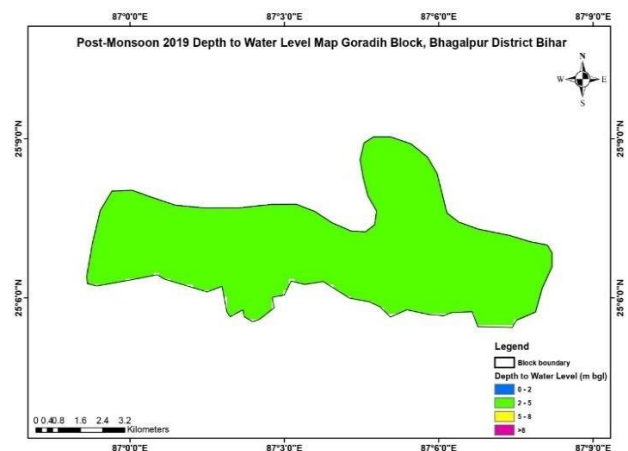


Figure-10(b): Post monsoon water level

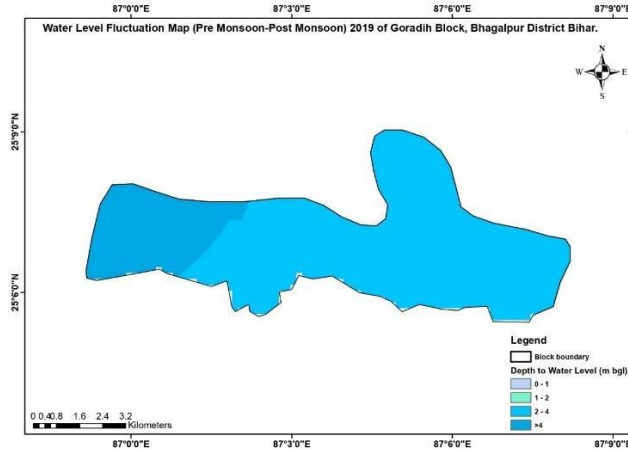


Figure-10(c): Fluctuation of water level

3.3 Ground Water Flow

Water table map has been prepared from the elevation and depth to water level data of the observation wells. In a groundwater regime, equipotential lines, the line joining points of the equal head on the potentiometric surface, were drawn based on the area of variation of the head of an aquifer. Based on the Water table elevation, ground water flow directions (from S-N) are demarcated in Fig.11a & b. It has been observed that the ground water flow directions (from S-N) are demarcated in Fig.11a & b. It has been observed that the ground water flow directions follow the major drainage channels and topography of the area. This indicates the topographic control for the ground water movement.

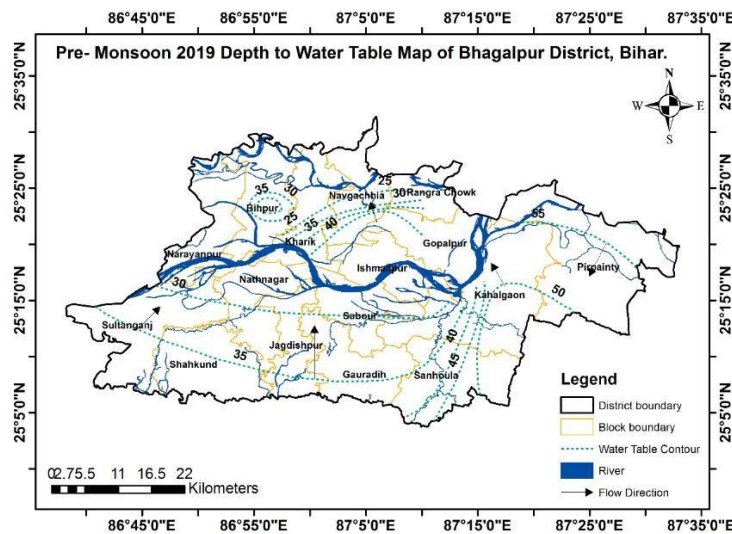


Figure-11(a): Pre monsoon water table

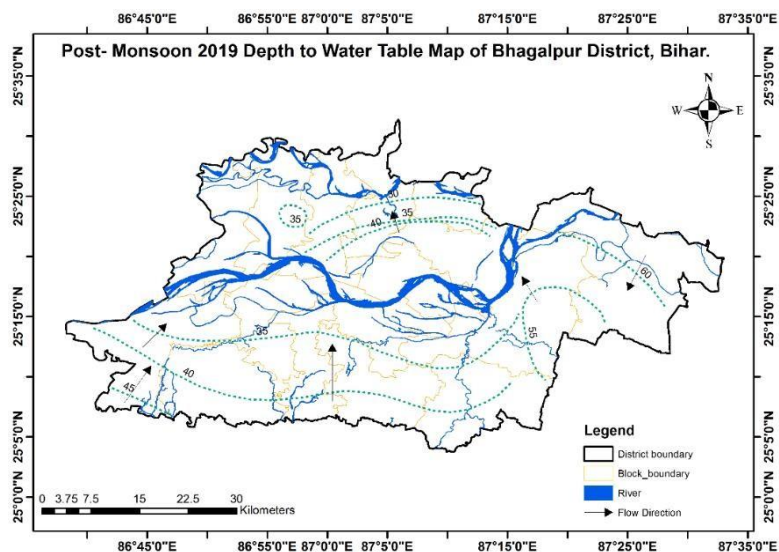


Figure-11(b): Post monsoon water table

Table-7: Depth to water level of pre monsoon and post monsoon of nearby Blocks of Goradih Block

Block	Type of well	Location	Latitude	Longitude	Depth of well (m)	RL(m)	Depth to Water Level (m bgl)		Fluctuation (m)	Water Table (amsl)	
							Pre monsoon	Post monsoon		Pre monsoon	Post monsoon
Jagdishpur	DW/N HS	L.N. High School	25.1187	86.9864	6.5	44.2	3.73	1.10	2.63	40.47	43.1
Sonhaulla	DW	LHS of Ghoga road from Dhauriya	25.1442	87.1652	9	39.2	5.75	2.3	3.45	33.45	36.9
Sonhaulla	CGWB_OW	School Ground, NHS well	25.1822	87.1649	115	39.8	7.15	4.2	2.95	32.65	35.6

4.0 Ground Water Resources

About 5.63 % of the net ground water availability of Bhagalpur district is available in Goradih block only. Total ground water resource of the block is 4040.77 ham and the total ground of draft of the block is 855.56 ham. The SOD is 23.53 % whereas of the district SOD is 27.87%. The Block come under "Safe" category, says that there are sufficient scope for ground water development.

Table-8: Ground Water Resources estimation -2020

District	Block	Recharge from Rainfall during Monsoon season (ham)	Recharge from Rainfall during Non-Monsoon season (ham)	Recharge from Other Sources during Monsoon season (ham)	Recharge from Other Sources during Non-Monsoon season (ham)	Total Annual Ground Water Recharge (ham)	Total Natural Discharges	Annual Extractable GW Resource (ham)	GW Extraction for Irrigation (ham)	GW Extraction for Industrial (ham)	GW Extraction for Domestic (ham)	Total Extraction (ham)	Net GW Availability for Future Development (ham)	Stage of Ground Water Development(ham)	Category: Safe / Semi-critical/ Critical/ Over-exploited
Bhagalpur	Goradih	3311.46	354.9	180.98	193.3	4040.77	404.07	3636.7	616.5	45.00	194.07	855.56	2757.21	23.53	Safe

5.0 Chemical quality of Ground Water

Result of chemical analysis (2019) of ground water (sample collected during May 2019) of shallow aquifer is given in the table below. In general water of shallow aquifer is potable. However, Fluoride contamination of groundwater has been reported from the Goradih block (as per GW Resource Assessment of Bihar as on March 2022).

Table-9: Chemical quality of Ground Water of nearby Blocks of Goradih Block

Location	pH	EC	TH	Ca	Mg	Na	K	HCO3	Cl	SO4	NO3	F	TDS
Jagdishpur	7.6	2112	408	59	72	288	19.2	701	249.0	91.0	27.0	1.01	1373
Sabour	7.5	555	122	36	8	75	2.2	132	58.0	92.0	27.0	0.49	361

6.0 Management Plan

6.1. Supply side intervention in Agriculture and Irrigation

From the existing land/agriculture and irrigation practices it is understood that the block is principally agricultural depending. However, the average cropping intensity is recorded as 121.75 %. It reveals that considerable cropped area is not under assured irrigation coverage. The dynamic ground water resource reports stage of development is 23.53 % which indicate there exists further scope of ground water development in the block both for agriculture and drinking/domestic purposes. 5th MI Census data shows that majority of irrigation tube wells are within the depth of 50-70 m. Therefore further development may be planned from the deeper part as well.

Considering projected 70% development 1690.13 ham further resources may be developed safely for irrigation development. This balance resource is recommended for development through STW/DTW as per the prevailing terrain condition and hydrogeology of the area. Considering unit draft of 2.4 and 3.36 for ham for STW and DTW respectively following number of irrigation structures have been proposed. Thus in Goradih block 528 STW and 126 DTW may be constructed. (Table10).

Table-10(a): Additional resource for 70% development

Assessment Unit Name	Total Area of Assessment Unit (Ha)	Recharge Worthy Area (Ha)	Annual Extractable Ground Water Resource (Ham)	Total Extraction (Ham)	(Ha Draft for 70% m) development	Additional resource available for 70% development (Ham)
GORADIH	13425	13425	3636.7	855.56	2545.69	1690.13

Table-10(b): Recommended number of structures for further irrigation development

Additional resource available for 70% development (Ham)	Resource allocated for development by STW (Ham)	Resource allocated for development by DTW (Ham)	Unit draft of STW (Ham)	Unit draft of DTW (Ham)	No. of STW proposed	No. of DTW proposed
1690.13	1267.598	422.5325	2.4	3.36	528	126

6.2 Supply side intervention through Artificial Recharge and rain water harvesting

As per the proposed ARMP of Bihar state, considering the post monsoon water level and long term water level trend, no such area has been delineated for implementation of AR structures in the block. However, based on the local hydrological situation and site specific development scenario artificial recharge and water harvesting techniques may be practiced for efficient and sustainable management of ground water resources in the block. In Goradih urban area, roof top rain water harvesting may be practiced for water conservation. The gram panchayat buildings, schools. Govt buildings etc. may be shortlisted, in phases, for implementation of roof top rain water harvesting.

6.3 Demand side intervention

Considering the area being high potential in terms of ground water resources, the additional resources may be utilized for more water intensive crops like paddy, cereals etc. along with the other crops. This may create further irrigation potential in the block. Suitable crop rotation may be practiced. Conjunctive use of surface and ground water may be practiced.

Sporadic occurrences of Fluoride marginally above permissible limit have been reported from few area in the block. Therefore, suitable mitigation measures may be taken to schedule water quality testing of each well in the block before uses. Domestic fluoride removal techniques, dilution of F affected water with F free water may be suitable to mitigate the issue in short term measures.

AQUIFER MAPS AND MANAGEMENT PLAN OF KHARIK BLOCK, BHAGALPUR DISTRICT, BIHAR

1. Salient Information

Name of the Block/Area	Kharik/131.57 sq km
District/State	Bhagalpur/Bihar
Population	Total- 158184 Rural- 158184 Urban- 0
Rainfall	Normal Monsoon- 977.3 Non-monsoon rainfall- 231
Agriculture and Irrigation	Principal crops - Rice – Wheat, Rice – Gram, Rice – Pulses, Rice – Rai. Gross cropped area- 9195.32 Net sown area- 7356.26 Irrigation practices- Surface water by canal -Ground water by tube well and DW Cropping intensity- 125 %, Number and types of abstraction structures – DW- 231, STW- 133, MDTW-29
Geology	Quaternary alluvium- Diara and Ganga-Kosi Formation
Geomorphology	Major Physiographic units- Alluvial plain Major Drainage- Ganga, Bagmati Sub basin
Ground water resource availability and extraction	Annual Ground Water Resource (Ham)-3337.22 Net Ground Water Availability for future use (Ham)- 2850.14 Ground water extraction (Ham)- 465.23; SOD- 14%
Existing and future water demand	465.23 Ham/199.08 Ham (annual GW allocation for domestic as on 2025)
Water level behaviour	Pre-monsoon SWL-6.7 mbgl Post-monsoon SWL- 3-4 mbgl

2. Aquifer Disposition

Number of Aquifers	03 ;up to the explored depth of 100 m
---------------------------	---------------------------------------

Aquifer disposition and basic characteristics	1st aquifers within 20 m depth fine sand mostly phreatic 2nd aquifers within 40-60 m depth and 3rd or deeper aquifers within 60-100 m depth medium to coarse sand, semi-confined to confined.
3. Ground water resource, extraction, contamination and other issues	
GW Resource/Categorization	Safe
Availability	
Chemical quality of ground water and contamination	Potable
4. Supply Side Interventions	
Ground Water Development Strategies-	Number of STW and DTW may be proposed for irrigation uses- STW-585, DTW-96
Aquifer wise space available for recharge and proposed interventions	As per ARMP, 2020, for Kharik block 85.95 sq km is suitable for recharge. Check Dam-1, Percolation Tank-2, lateral Recharge shaft-24, Recharge shaft-20, Nala bunding-15, Desilting of existing tanks-35 and injection well-45 etc. are some suitable structures in the area
5. Demand side interventions	
Advanced Irrigation Practices	Project based drip/sprinkler irrigation, lining of field channels etc.
Change in cropping pattern	Water intensive crops like paddy, wheat as well as less water intensive crops like pulses, oilseeds may be encouraged.
Alternate water sources	Conjunctive uses of groundwater/surface water sources,
Regulation and Control	Capacity building for awareness generation for fluoride/arsenic contamination.(if needed)

1.0 General Information

1.	Area	in Sq. Km	:	131.57
2.	No. of revenue village		:	25
3.	Population (2011)	Total	:	1,58,184
		Rural	:	1,58,184
		Urban	:	—
4.	Normal annual rainfall (District)	(mm)	:	1226
5.	Basin / Sub-basin		:	Bagmati-Kosi Sub-basin
6.	Location		:	
	Latitude		:	25°17'2.996" N to 25°28'56.56" N
	Longitude		:	86°55'55.368" E to 87°4'8.687" E

The Kharik block of Bhagalpur district is surrounded in the east by Naugachhia block, in the north by Madhepura district, in the south-west by Nathnagar block, in the west by Bihpur block, in the south by Nathnagar block and in the south-east by Islampur Block. (Fig:1). Block headquarter of Kharik block is Kharik Bazar. It belongs to Bhagalpur division. Naugachhia city, Bhagalpur city, Colgong city, Sultanganj city are the nearby cities to Kharik Block. Kharik block consist of 28 villages and 13 panchayats. Baluachak is the smallest village and Kharik is the biggest village of Kharik block. Bhagalpur (Bhagdattpuram), Munger, Sahibganj, Deoghar (Baba Dham), Pakur (Pakaur) are the nearby important tourist destinations. Maithili is the local language, people also speaks Hindi, Urdu.

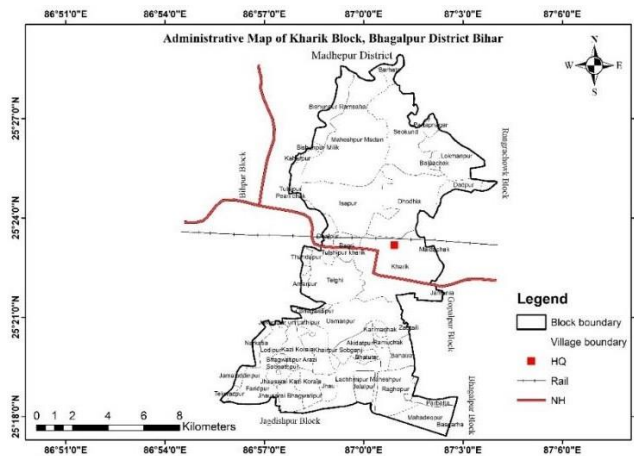


Fig-1, Administrative Map of Kharik Block, Bhagalpur District

1.1 Basic Demographic Detail of Kharik block as per 2011 census data

Total population of Kharik block 158184 among which evident that 70573 is male population, 62025 is female population and 25586 is child population. Number of household is 25629. There are 13 gram panchayats and 28 villages in the Kharik block, (Table-2).

Table-1: Demographic distribution of Kharik Block

Block	No. of Household	Males	Females	Child	Total
Kharik	25629	70573	62025	25586	158184

Source: Census 2011

Table-2: Panchayat wise village in Kharik Block

S.No.	Panchayat	Villages
1	Bhavanpura	1
2	Lokmanpur	3
3	Tulsipur	2
4	Dhruvganj	2
5	Telghi	2
6	Kharik Bazar	1
7	Gotkharik	3
8	Akidatpur	4
9	Chorhar	2
10	Dhoria Dadpur	3
11	Khairpur	3
12	Raghopur	1
13	Ushmanpur	1
	Total	28

Source: Census 2011

1.2 Distribution of persons engaged in agriculture and other workers/ non workers in the block

In Kharik block, 68% of total population is non workers. It is evident from diagram given below, that 22% of the total population in the block is engaged in agriculture, 4% engaged as cultivator, 2% comprises household industrial workers and 4% comprises other worker, (Fig-2).

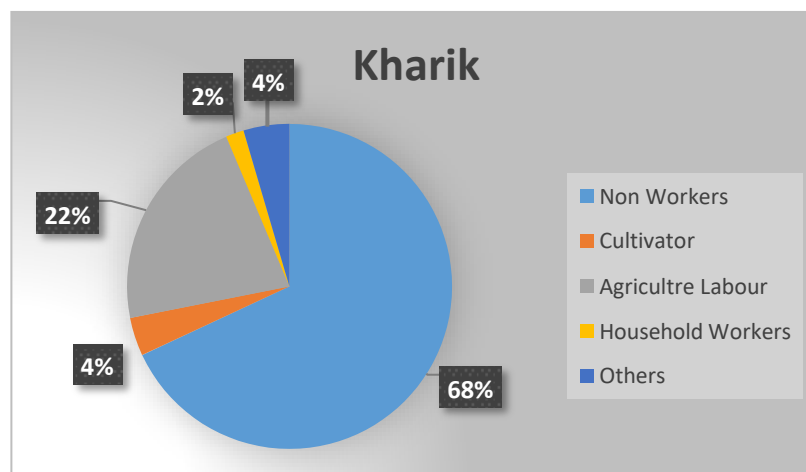


Fig-2, Demographic classification of Kharik Block, Bhagalpur District

Source: Census 2011

1.3 Rainfall and Temperature

Normal annual rainfall of Kharik block is 1226 mm of which 80% occurs during the monsoon season. The normal rainfall during monsoon season is 977.3 mm and during non-monsoon season is 231 mm. The temperature varies from 45 to 50°C.

1.4 Soil

Kharik block contains mainly fine sandy loamy soil.

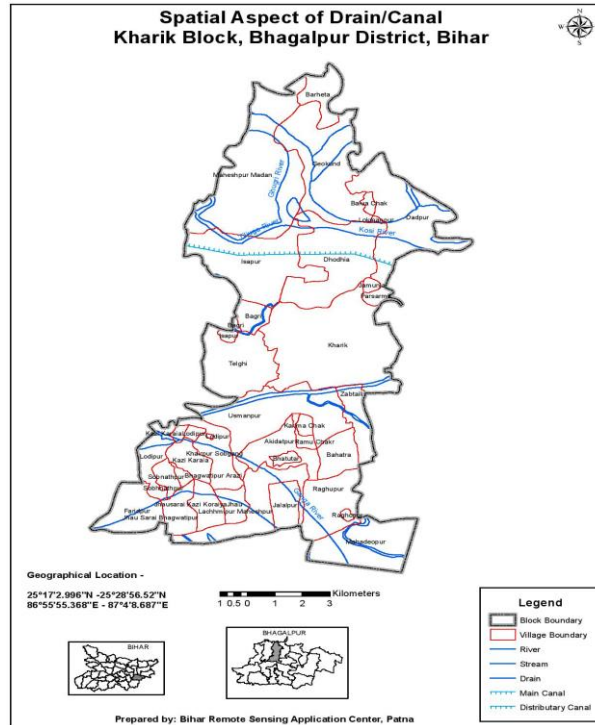
Table-3: Soil type

Block	Soil Type
Kharik	Fine sandy loamy Soils, Clayey Soils

Source: District Irrigation Plan, 2019

1.5 Physiography, Basin/sub-basin, Drainage

The Kharik block is situated in northern part of Bhagalpur District. Kharik forms part of Bagmati-Kosi Sub-basin. Dendritic and parallel to sub-parallel drainage patterns are dominating in this region. Kharik block has average elevation 45m. Ghugri, Tiljuga, Kosi and Ganga Rivers are flowing in this block.

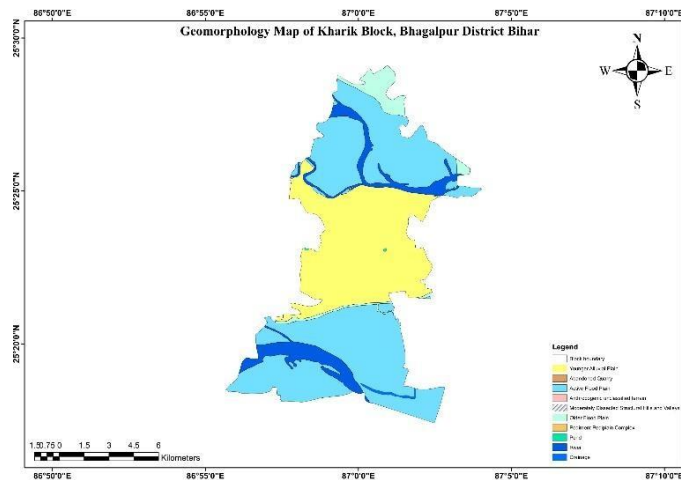


(Fig-3: Drainage and canal network in Kharik Block)

Source: District Irrigation Plan, 2019

1.6 Geomorphology

The Kharik block is a part of Indo-Gangetic alluvium plain, having gentle slope. Quaternary alluvium plain of fluvial (deposited by flood during rainy season) origin covers the major part of the block. A small part of the block covered by water bodies.



(Fig-4: Geomorphological map of Kharik Block)

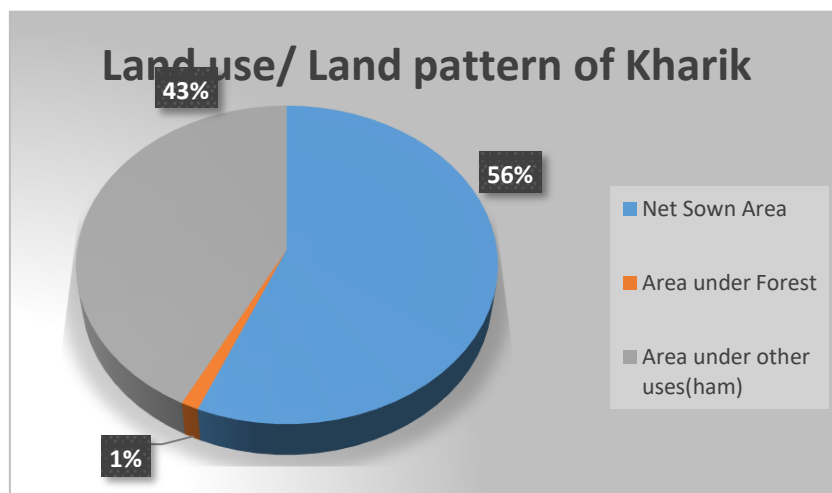
1.7 Land use / Land Cover

Total geographic area of the Kharik block is 13157.00 ha. Block as net sown area is 7356.26 ha and gross cropped area is 9195.32 ha. Therefore area under multiple cultivation is 1839.06 ha area and 162.22 ha area is under forest. It is evident that net sown area is 56%, area under multiple cultivation is 13.97 % and wasteland is 1.23% of total geographical area. The cropping intensity of the block is 125%.

Table-4: Land use/Land Pattern of Kharik Block

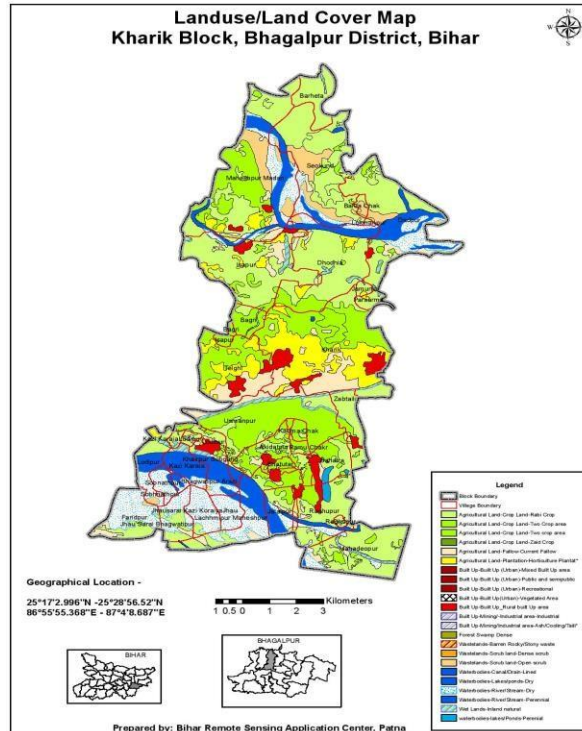
Name of the Block	No. of Gram Panchayat	Total Geographical Area (ham)	Gross cropped Area (ham)	Net Sown Area (ham)	Area Sown more than once (ham)	Area under Forest (ham)	Area under Waste land (ham)	Cropping Intensity (%)
Kharik	13	13157	9195.32	7356.26	1839.06	162.22	0	125

Source: District Irrigation Plan, 2019



(Fig-5: Land use and Land cover of in Kharik Block)

Source: District Irrigation Plan, 2019



(Fig-6: Land use and Land cover of in Kharik Block)

Source: District Irrigation Plan, 2019

1.8 Agriculture and Irrigation

Agriculture is the main stay of the people living in Kharik block, which is evident from census figures of 2011. Kharik block falls in the Agro-climatic Zone III A. Kharik block is producer of several crops such as paddy, miازه, arhar, mung and urad during Khaif season. Wheat, maize, barely, pulses and oil seeds during Rabi season and summer season. Cereal are the major crops in the block.

Table-5: Area under different crops in Kharik Block

Crops	Cropped Area (ha)	Kharif (ha)	Rabi (ha)	Summer Rabi (ha)
Coarse Cereal	12399.6	6315.6	4524	1560
Pulses	1185	441	132	612
Oil Seeds	340	22	318	0

Source: District Irrigation Plan, 2019

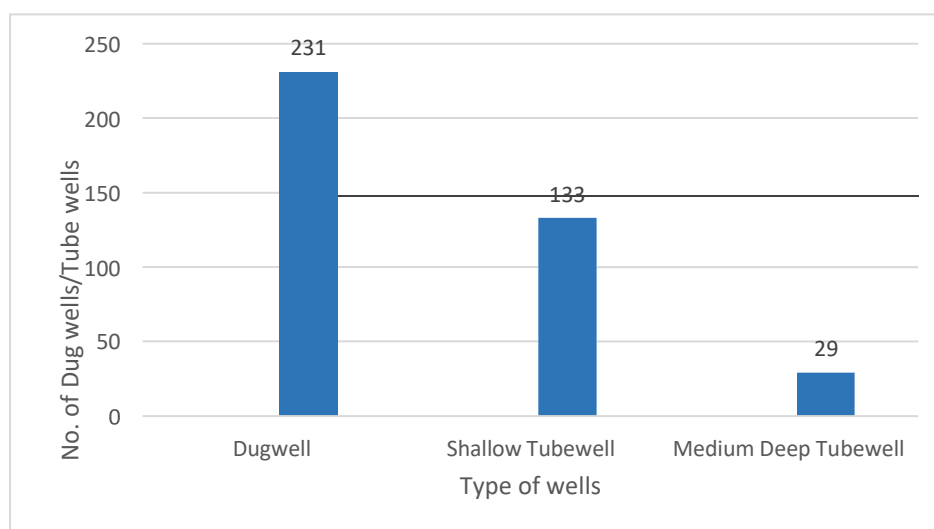
Surface irrigation network comprises canal irrigation, tanks, surface flow and lift irrigation. A considerable area is brought under irrigation by numbers of tanks.

Ground water irrigation is limited and is accomplished mainly through dug wells, shallow tube wells, medium deep tube wells and limited numbers of deep tube wells. Shallow tube wells are limited to the depth of 0-35 m bgl. Ground water extraction for irrigation use is 270.00 ham.

Table-6: Block level statistics of no. of tube wells for irrigation use as per 5th MI Census

Block Name	Dug well	Shallow Tube well			Medium Deep Tube well	Deep Tub well
	No.	0-20 m depth	20-35 m depth	35-40 m depth	No.	No.
Kharik	231	2	131	-	29	-

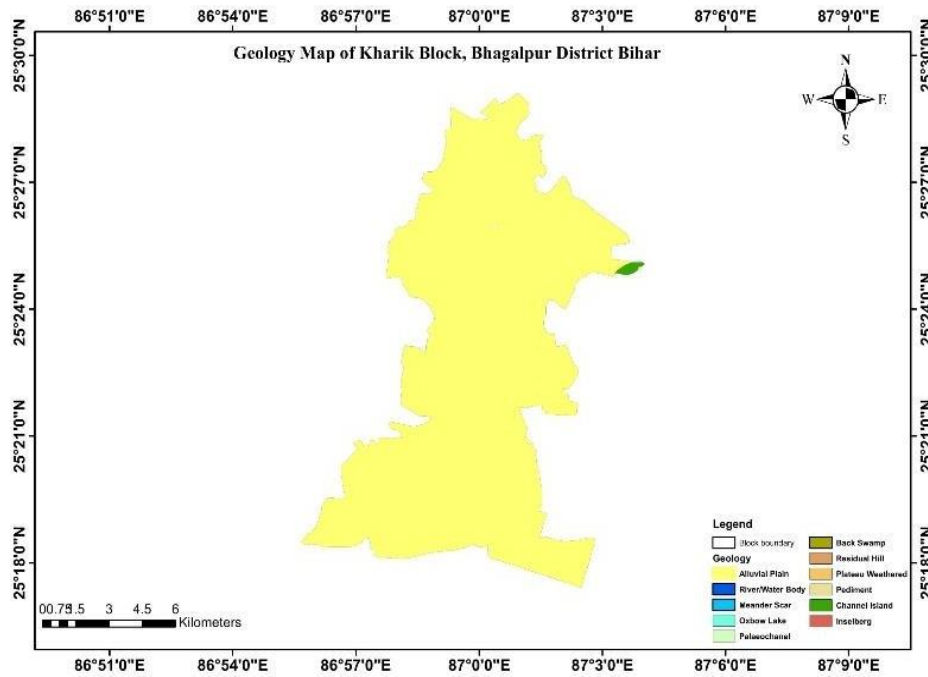
Source: 5th Minor Irrigation Census, 2013-14)



(Fig-7: Number of minor irrigation structures in the Kharik Block)

2.0 Geology

Major part of the block is covered by Diara formation, Ganga-kosi formation and Belhar formation of Middle to Late Holocene age. The Diara formation is represented by unoxidised grey sand, silt and clay of the present day flood plain, channel bares, levees and back swamps, The Ganga-kosi formation is represented by fine to medium sand, silt and clay inundated in rainy season, bank erosion and redeposition and The Belhar formation is represented by silty loam with sand, feebly oxidized.



(Fig-8: Geology of Kharik Block)

3.0 Hydrogeology

Considerably thick sand layers with intermittent clay in the Quaternary Alluvium (mostly younger) of Late Holocene age form the main source of ground water in the block. Based on the strata logs and hydrogeological properties, the aquifer system in the district can be divided into three categories,

- i. The 1st aquifers within 20 m depth.
- ii. The 2nd aquifers within 40-60 m depth.
- iii. The 3rd or deeper aquifers within 60-100 m depth.

In shallow aquifers, the ground water occurs under unconfined condition and in deeper under semi-confined conditions. The shallow aquifers consisting of fine to medium sand with clay. The deeper aquifers mainly consist of sand with alternating layers of clay.

Hydrogeologically the Kharik block is underlain by porous, unconsolidated formation. The unconsolidated formation comprises clay, silt and different grades of sand down to depth of 110 m. The thick granular sand zone constitute potential aquifer system. The shallow aquifer is mainly under phreatic condition whereas differ part is under semi-confined to confined condition. The exploratory well data of CGWB, reveals that tube wells of 50 m depth yield at 50.8 m³/hr with drawdown 18.84 m. The transmissivity of the aquifer varies 205.57 m²/day, specific capacity 2.64 m³/hr/m and storativity is 1.0 x 10⁻³.

3.1 Aquifer Disposition and Characteristics

Aquifer disposition of the area has been studied from the existing lithological data. The lithological cross section, across the block represents multiple aquifer system up to depth of 110 m.

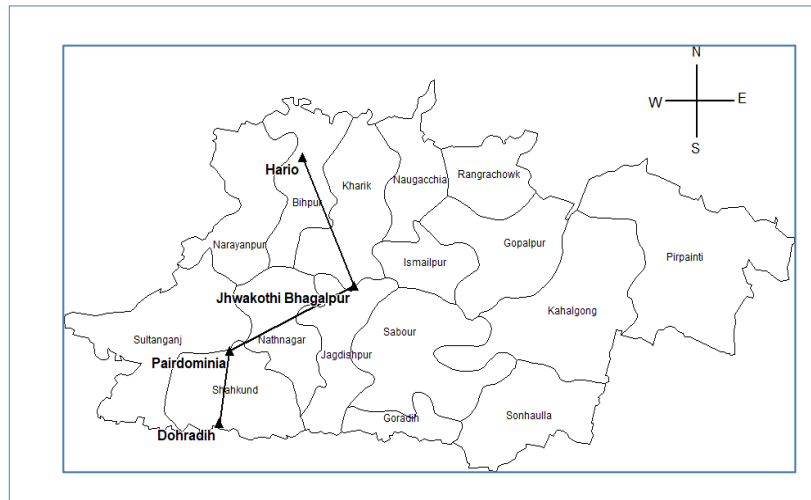


Figure-9(a): Location of bore holes, Bhagalpur District

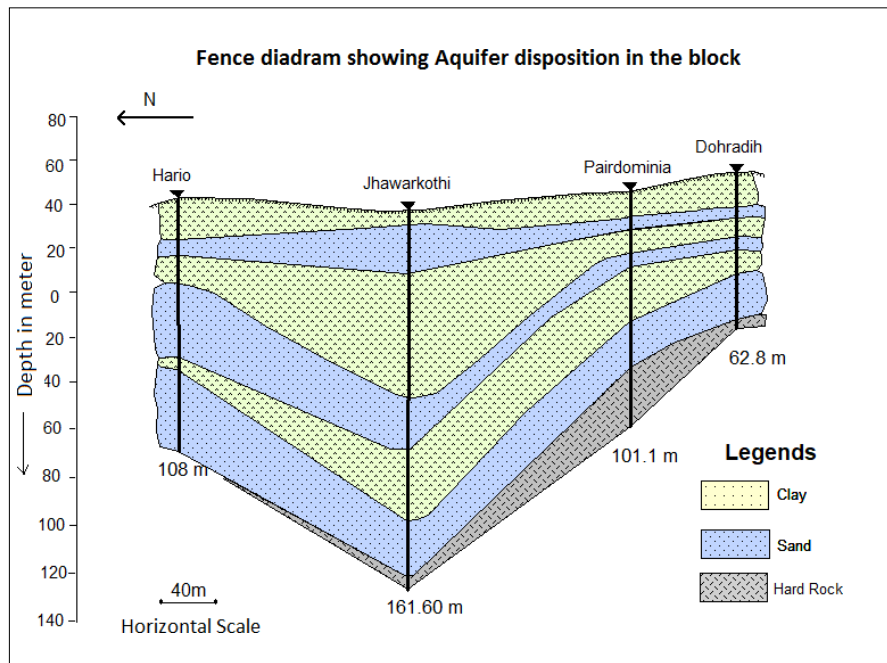


Figure-9(b): Fence diagram showing Aquifer disposition in the Block

3.2 Depth to Water Level

The groundwater regime of the block has been monitored from the existing network monitoring wells and inventoried observation wells. Observation wells are private, dug wells, piezometer of minor irrigation department, Government of Bihar. The average depth of dug wells is 8 m bgl. Piezometers are on an average 50 m bgl depth whereas the PHED deep tubewells are in general, deeper 120 m bgl. The pre monsoon water level in dug well zone 6-7 m bgl and in post monsoon water level varies from 3-4 m bgl. Comparatively deeper water level 4-8 m bgl is reported from the deep tubewells of PHED. Ground water level fluctuation 2-4 m in general reflects more or less uniform and low fluctuation, (Fig-10a-c).

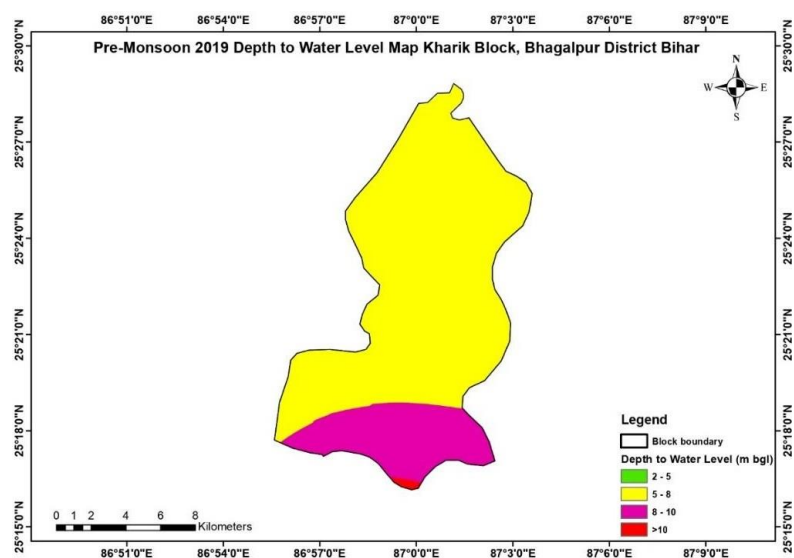


Fig 10(a): Pre monsoon water level

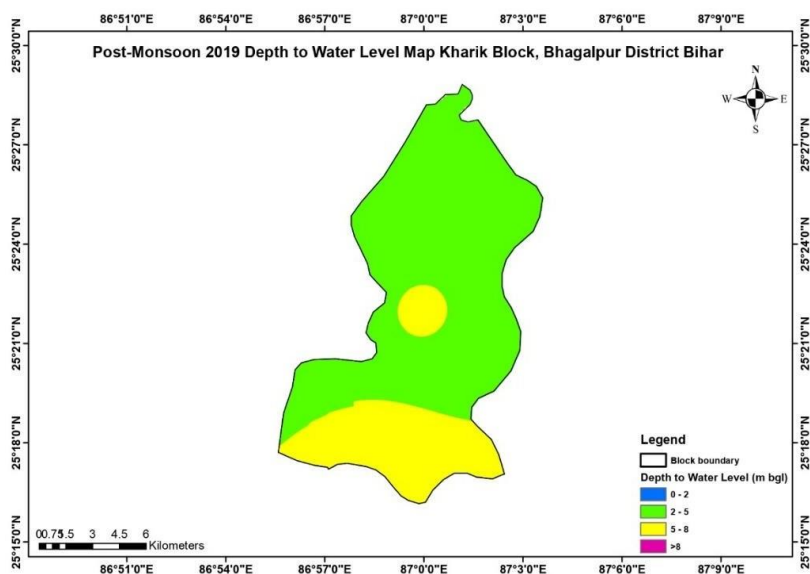


Figure-10(b): Post monsoon water level

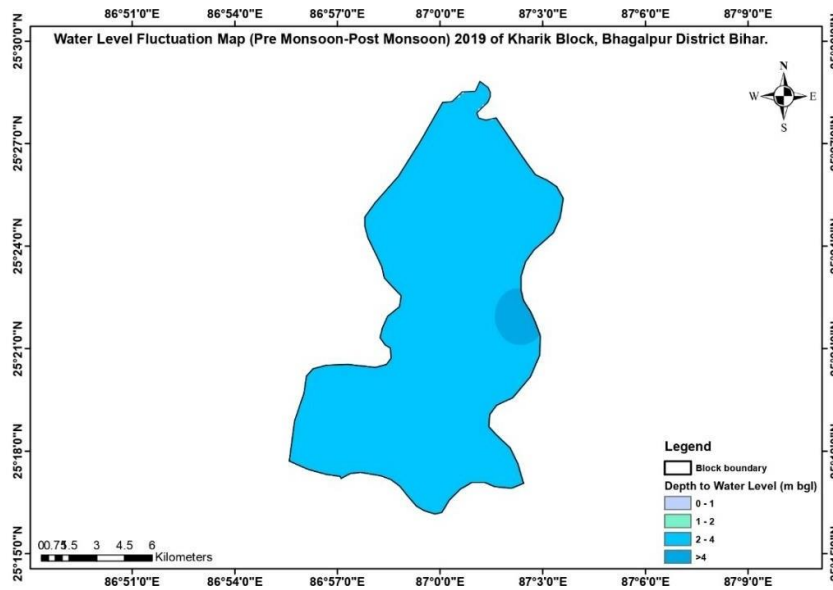


Figure-10(c): Fluctuation of water level

3.3 Ground Water Flow

Water table map has been prepared from the elevation and depth to water level data of the observation wells. In a groundwater regime, equipotential lines, the line joining points of the equal head on the potentiometric surface, were drawn based on the area of variation of the head of an aquifer. Based on the Water table elevation, ground water flow directions (from S-N) are demarcated in *Fig-11*. It has been observed that the ground water flow directions follow the major drainage channels and topography of the area. This indicates the topographic control for the ground water movement.

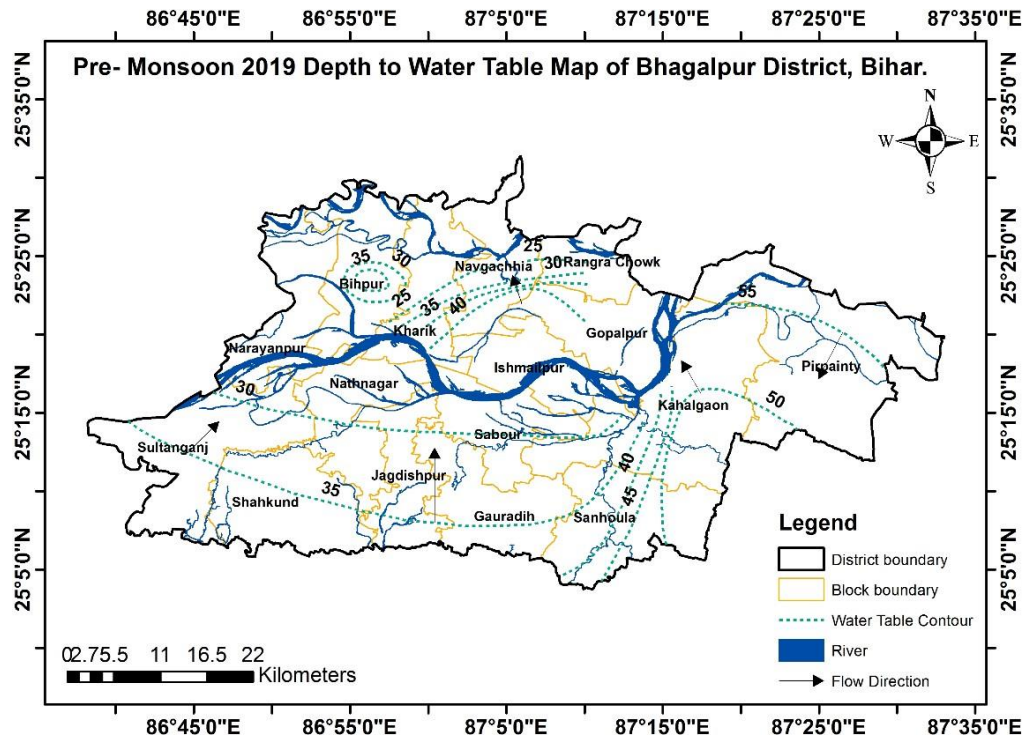


Figure-11(a): Pre monsoon water table

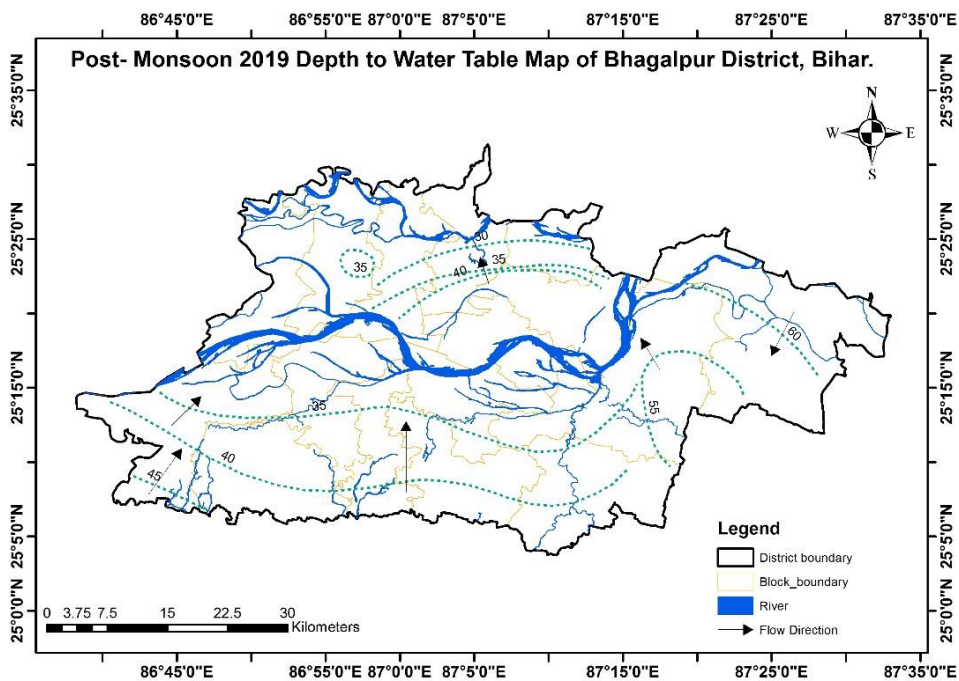


Figure-11(b): Post monsoon water table

Table-7: Depth to water level of pre monsoon and post monsoon of Kharik Block

Block	Type of well	Location	Latitude	Longitude	Depth of well (m)	RL(m)	Depth to Water Level (m bgl)		Fluctuation (m)	Water Table (amsl)	
							Pre monsoon	Post monsoon		Pre monsoon	Post monsoon
Kharik	PHED_DTW	Near Kedar house	25.3989	86.9222	120	39.4	8.27	4.20	4.07	31.13	35.20
Kharik	DW	Hatia Chak	25.3661	87.0377	8	39.6	7.2	3	420	32.4	36.60
Kharik	PZ	BDO office	25.3669	87.0024	50	36.8	7.79	5.07	2.72	29.01	31.73

4.0 Ground Water Resources

About 5.82 % of the net ground water availability of Bhagalpur district is available in Kharik block only. Total ground water resource of the block is 3708.02 ham and the total ground of draft of the block is 465.23 ham. The SOD is 13.9 % whereas of the district SOD is 27.87%. The Block comes under “Safe” category, says that there are sufficient scope for ground water development.

Table-8: Ground Water Resources estimation -2020

District	Block	Recharge from Rainfall during Monsoon season (ham)	Recharge from Rainfall during Non-Monsoon season (ham)	Recharge from Other Sources during Monsoon season (ham)	Recharge from Other Sources during Non-Monsoon season (ham)	Total Annual Ground Water Recharge (ham)	Total Natural Discharges	Annual Extractable GW Resource (ham)	GW Extraction for Irrigation (ham)	GW Extraction for Industrial (ham)	GW Extraction for Domestic (ham)	Total Extraction (ham)	Net GW Availability for Future Development (ham)	Stage of Ground Water Development(ham)	Category: Safe / Semi-critical/ Critical/ Over-exploited
Bhagalpur	Kharik	324 5.3 5	347 .88	60.38	54.4 1	3708. 02	370. 8	3337. 22	270	18.00	177. 23	465.2 3	285 0.14	13.9 4	Safe

5.0 Chemical quality of Ground Water

Result of chemical analysis (2019) of ground water (sample collected during May 2019) of shallow aquifer of nearby block of Kharik block is given in the table below. In general water of shallow aquifer is potable. However, Fluoride contamination of groundwater has been reported from the Kharik block (asper GW Resource Assessment of Bihar as on March 2022).

Table-9: Chemical quality of Ground Water of nearby Block of Kharik block

Location	pH	EC	TH	Ca	Mg	Na	K	HCO ₃	Cl	SO ₄	NO ₃	F	TDS
Bihpur	7.9	797	355	110	19	8.58	0.3	311	32	54	34	0.19	478
Navgachhia	8.1	1004	450	138	26	24	1.4	372	39	62	50	0.88	602

6.0 Management Plan

6.1. Supply side intervention in Agriculture and Irrigation

From the existing land/agriculture and irrigation practices it is understood that the Block is principally agricultural depending. However, the average cropping intensity is recorded as 125 %. It reveals that considerable cropped area is not under assured irrigation coverage. The dynamic ground water resource reports reveals stage of development is 13.94 % which indicates very limited development and further scope of ground water development both for agriculture and drinking/domestic purposes may be encouraged. 5th MI Census data shows that majority of irrigation tube wells accompanied within the depth of 50 m. Therefore further development may be planned from the deeper part as well.

Considering projected 70% development 1870.824 ham further resources may be developed safely for irrigation development. This balance resource is recommended for development through STW/DTW as per the prevailing terrain condition and hydrogeology of the area. Considering unit draft of 2.4 and 4.8768 ham for STW and DTW respectively following

number of irrigation structures have been proposed. Thus in Kharik block 585 STW and 96 DTW may be constructed. (Table10). These tube wells will enhance the irrigation potential in the district.

Table-10(a): Additional resource for 70% development

Assessment Unit Name	Total Area of Assessment Unit (Ha)	Recharge Worthy Area (Ha)	Annual Extractable Ground Water Resource (Ham)	Total Extraction (Ham)	Draft for 70% development (Ha m)	Additional resource available for 70% development (Ham)
KHARIK	13157	13157	3337.22	465.23	2336.054	1870.824

Table-10(b): Recommended number of structures for further irrigation development

Additional resource available for 70% development (Ham)	Resource allocated for development by STW (Ham)	Resource allocated for development by DTW (Ham)	Unit draft of STW (Ham)	Unit draft of DTW (Ham)	No. of STW proposed	No. of DTW proposed
1870.824	1403.118	467.706	2.4	4.8768	585	96

6.2 Supply side intervention through Artificial Recharge and rain water harvesting

Based on post monsoon water level, long term water level trend, local geological and geomorphological settings and availability, non-committed surplus runoff, the feasibility of artificial recharge to augment ground water resources in the Kharik block has been worked out (Artificial Recharge Management Plan, 2019). An area of 85.95 Sq. km has been found as suitable for artificial recharge.

Based on the local geology/hydrogeology and underlying lithological disposition percolation tank, recharge shaft, injection wells in village tank, de-silting of existing tank/talao/pond may be practiced in Kharik block. The tentative numbers of the above structures are as follows

Table-11: Proposed AR structure and RWH

Kharik Block	
Recharge Structure	
Type	Number
Check Dam	1
Percolation Tank	2

Lateral Recharge Shaft	24
Recharge Shaft	20
Nalabunding	15
De-silting of existing tank /pond /talao	35
Injection Well in Village Tank	45

Source: ARMP, 2019

6.3 Demand side intervention

Considering very limited development for irrigation , so far in the block additional resources may be utilized for more water intensive crops like paddy, cereals etc. along with the other crops. This may create further irrigation potential in the block and at the same time the increase in development in ground water may reduce the chances of water logging. Ground water irrigation may be promoted in the block. Suitable crop rotation may be practiced.

To mitigate the fluoride contamination of ground water periodic testing of ground water quality may be made mandatory. Domestic fluoride removal techniques, dilution of F affected water with F free water may be suitable to mitigate the issue in short term measures.

AQUIFER MAPS AND MANAGEMENT PLAN OF NARAYANPUR BLOCK, BHAGALPUR DISTRICT, BIHAR

1. Salient Information

Name of the Block/Area	Narayanpur/144.27 sq km
District/State	Bhagalpur/Bihar
Population	Total- 126950 Rural- 126950 Urban- 0
Rainfall	Normal Monsoon- 977.3 Non-monsoon rainfall- 231
Agriculture and Irrigation	Principal crops - Rice – Wheat, Rice – Gram, Rice – Pulses, Rice – Rai. Gross cropped area- 4341.48 Net sown area- 3473.19 Irrigation practices- Surface water by canal -Ground water by tube well and DW Cropping intensity- 125 %, Number and types of abstraction structures – DW- 56, STW- 502, MDTW-78, DTW-3
Geology	Quaternary alluvium- Diara and Ganga-kosi formation
Geomorphology	Major Physiographic units- Alluvial plain Major Drainage- Ganga, Bagmati Sub basin
Ground water resource availability and extraction	Annual Ground Water Resource (Ham)-3843.83 Net Ground Water Availability for future use (Ham)- 2516.56 Ground water extraction (Ham)- 1117.67; SOD -31%
Existing and future water demand	1117.67 Ham/158.59 Ham (annual GW allocation for domestic as on 2025)
Water level behaviour	Pre-monsoon SWL-5.73-675 mbgl Post-monsoon SWL- 2.30-3.27 mbgl

2. Aquifer Disposition

Number of Aquifers	03; up to the explored depth of 100 m
---------------------------	---------------------------------------

Aquifer disposition and basic characteristics	1st aquifers within 20 m depth fine sand mostly phreatic 2nd aquifers within 40-60 m depth and 3rd or deeper aquifers within 60-100 m depth medium to coarse sand, semi-confined to confined.
3. Ground water resource, extraction, contamination and other issues	
GW	Safe
Resource/Categorization	
Availability	Potable
Chemical quality of ground water and contamination	
4. Supply Side Interventions	
Ground Water Development Strategies-	Number of STW and DTW may be proposed for irrigation uses- STW-450, DTW-71
Aquifer wise space available for recharge and proposed interventions	As per ARMP, 2020, for Bhagalpur district 385.41 sq km is suitable for recharge. Percolation tank-8, Gully plug-471, Contour bunding & Trenching-764, Check dam-22, Nala bunding-37, Recharge shaft-86, Desilting of existing tanks-157 and injection well-210 etc. are some suitable structures in the area
5. Demand side interventions	
Advanced Irrigation Practices	Project based drip/sprinkler irrigation, lining of field channels etc.
Change in cropping pattern	Water intensive crops like paddy, wheat may be practiced; crop rotation.
Alternate water sources	Conjunctive uses of groundwater/surface water sources,
Regulation and Control	Capacity building for awareness generation for fluoride/arsenic contamination.(if needed)

AQUIFER MAPS AND MANAGEMENT PLAN OF NARAYANPUR BLOCK, BHAGALPUR DISTRICT, BIHAR

1.0 General Information

1.	Area	in Sq. Km	:	144.27
2.	No. of revenue village		:	24
3.	Population (2011)	Total	:	1,26,950
		Rural	:	1,26,950
		Urban	:	-
4.	Normal annual rainfall (District)	(mm)	:	1236
5.	Basin / Sub-basin		:	Bagmati-Kosi Sub-basin
6.	Location		:	
	Latitude		:	25°15'53.17 " N to 25°27'59.56" N
	Longitude		:	86°46'33.30" E to 86°55'10.34" E

The Narayanpur block of Bhagalpur district is surrounded in the east and north by Bihpur block, in the north by Madhepura District, in the south by Sultanganj block, in the south-east by Nathnagar and in the west by Khagaria district. (Fig:1). Block headquarter of Kharik Block is Narayanpur. It belongs to Bhagalpur division. Naugachhia city, Bhagalpur city, Sultanganj city and Gogri Jamalpur city are the nearby cities to Narayanpur Block. Narayanpur block consist of 24 Villages and 11 Panchayats. Gangapur is the smallest village and Sihpur is the biggest village of Narayanpur block. Bhagalpur (Bhagdattapuram), Munger, Sahibganj, Deoghar (Baba Dham), Pakur (Pakaur) are the nearby important tourist destinations. Maithili is the local language , people also speaks Hindi, Urdu.

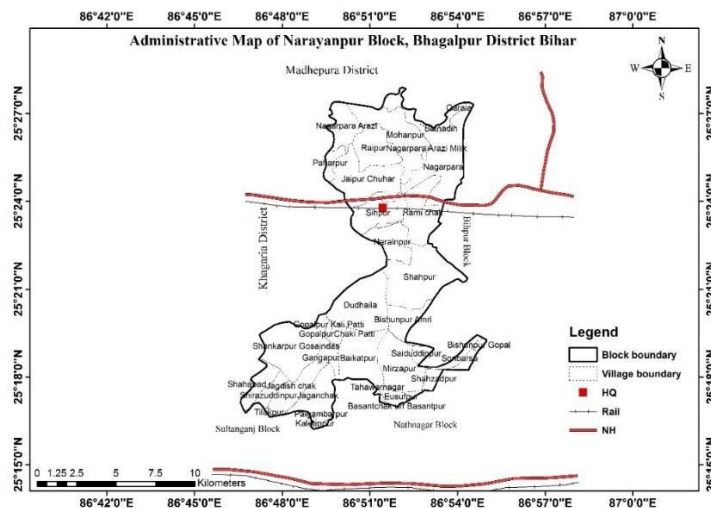


Fig-1, Administrative Map of Narayanpur Block, Bhagalpur District

1.1 Basic Demographic Detail of Narayanpur Block as per 2011 census data

Total population of Narayanpur block 126950 among which 57127 is male population, 49574 is female population and 20249 is child population. Number of household is 19620. There are 11 gram panchayats and 24 villages in the Narayanpur block, (Table-2).

Table-1: Demographic distribution of Narayanpur Block

Block	No. of Household	Males	Females	Child	Total
Narayanpur	19620	57121	49574	20249	126950

Source: Census 2011

Table-2: Panchayat wise village in Narayanpur Block

S.No.	Panchayat	Villages
1	Raipur	2
2	Bhawanipur	2
3	Nagarpara North	1
4	Nagarpara South	1
5	Nagarpara East	1
6	Jaipurchar West	4
7	Singhpur West	1
8	Singhpur East	1
9	Jaipurchar East	1
10	Baikathpur Dudhaaila	7
11	Shahjadpur	3
	Total	24

Source: Census 2011

1.2 Distribution of persons engaged in agriculture and other workers/ non workers in the Block

69 % of total population is non workers in Narayanpur block,. It is evident from diagram given below, that 17% of the total population in the block is engaged in agriculture, 7% engaged as cultivator, 1% comprises household industrial workers and 6% comprises other worker, (Fig-2).

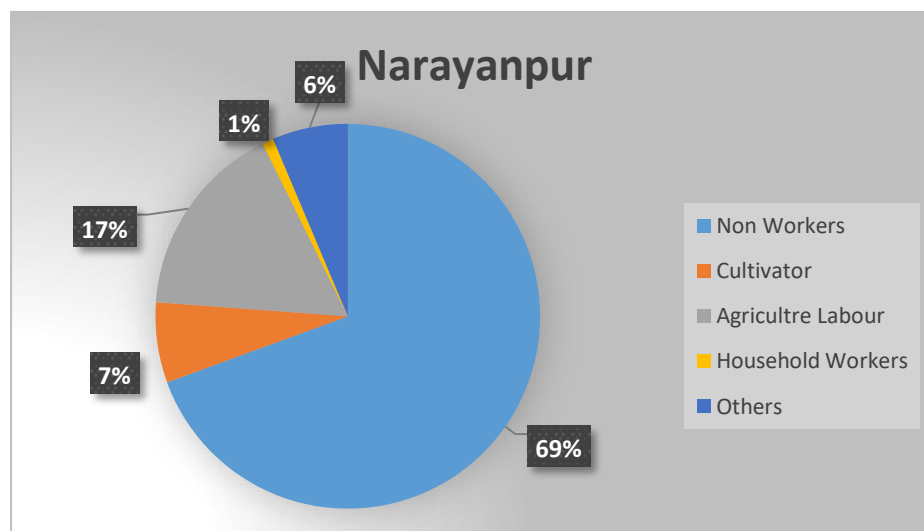


Fig-2, Demographic classification of Narayanpur Block, Bhagalpur District
Source: Census 2011

1.3 Rainfall and Temperature

Normal annual rainfall of Narayanpur block is 1236 mm of which 80% occurs during the monsoon season. The normal rainfall during monsoon season is 977.3 mm and during non-monsoon season is 231 mm. The temperature varies from 45 to 50°C.

1.4 Soil

Narayanpur block contains mainly fine sandy loamy soil.

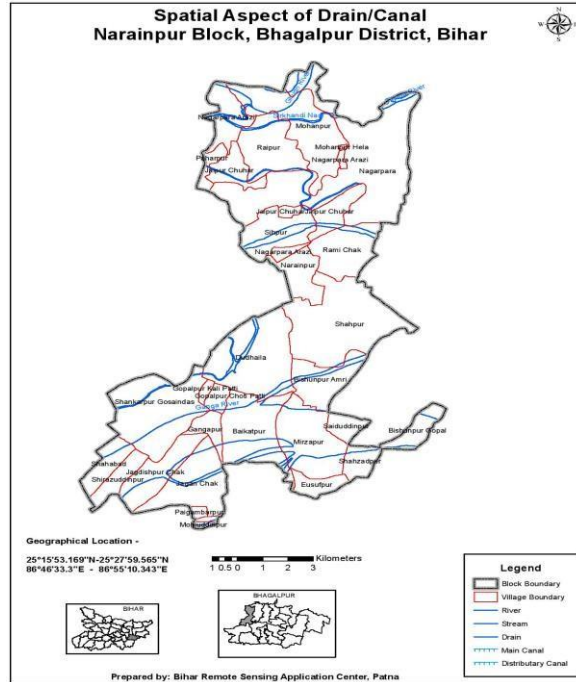
Table-3: Soil type

Block	Soil Type
Narayanpur	Fine sandy loamy Soils, Clayey Soils

Source: District Irrigation Plan, 2019

1.5 Physiography, Basin/sub-basin, Drainage

The Narayanpur block is situated in northern part of Bhagalpur District. Narayanpur forms part of Bagmati-Kosi Sub-basin. Dendritic and parallel to sub-parallel drainage patterns are dominating in this region. Narayanpur block has average elevation 45m. Ghugri, Sirkhandi and Ganga Rivers are flowing in this block.

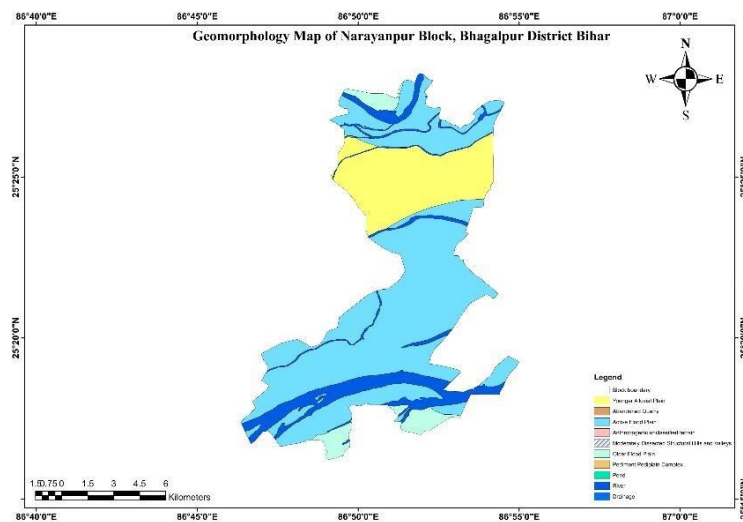


(Fig-3: Drainage and canal network in Narayanpur Block)

Source: District Irrigation Plan, 2019

1.6 Geomorphology

The Narayanpur block is a part of Indo-Gangetic alluvium plain, having gentle slope. Quaternary alluvium plain of fluvial (deposited by flood during rainy season) origin covers the major part of the block. A small part of the block covered by water bodies.



(Fig-4: Geomorphological map of Narayanpur Block)

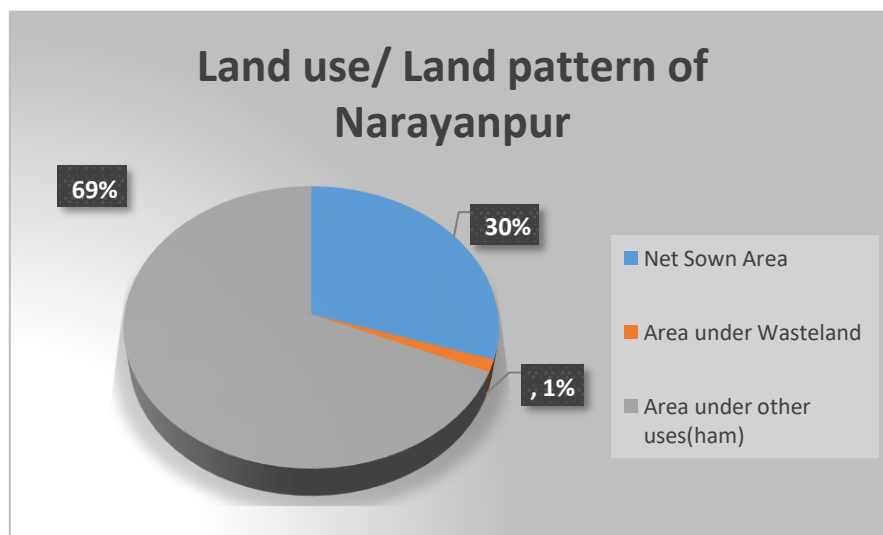
1.7 Land use / Land Cover

Total geographic area of the Narayanpur block is 14427 ha. Narayanpur block has net sown area is 3473.19 ha and gross cropped area is 4341.48 ha. Therefore area under multiple cultivation is 868.29 ha area and 205.77 ha area is under wasteland. It is evident that net sown area is 24.07 %, area under multiple cultivation is 6.01 % and wasteland is 1.43% of total geographical area. The cropping intensity of the block is 125%.

Table-4: Land use/Land Pattern of Narayanpur Block

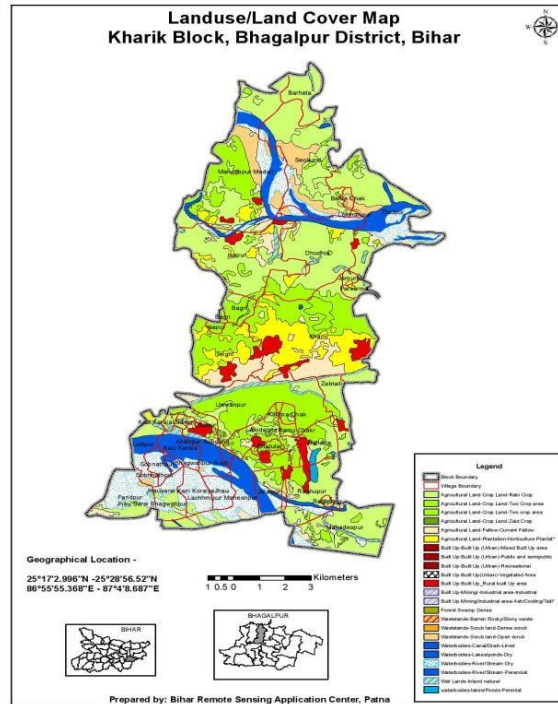
Name of the Block	No. of Gram Panchayat	Total Geographical Area (ham)	Gross cropped Area (ham)	Net Sown Area (ham)	Area Sown more than once (ham)	Area under Forest (ham)	Area under Wasteland (ham)	Cropping Intensity (%)
Narayanpur	11	14427.00	4341.48	3473.19	868.29	0	205.77	125

Source: District Irrigation Plan,2019



(Fig-5: Land use and Land cover of in Narayanpur Block)

Source: District Irrigation Plan,2019



(Fig-6: Land use and Land cover of in Narayanpur Block)

Source: District Irrigation Plan, 2019

1.8 Agriculture and Irrigation

Agriculture is the main stay of the people living in Narayanpur block, which is evident from census figures of 2011. Narayanpur block falls in the Agro-climatic Zone III A. Narayanpur block is producer of several crops such as paddy, miaze, arhar, mung and urad during Khaif season. Wheat, maize, barely, pulses and oil seeds during Rabi season and summer season. Cereal are the major crops in the block.

Table-5: Area under different crops in Narayanpur Block

Crops	Cropped Area (ha)	Kharif (ha)	Rabi (ha)	Summer Rabi (ha)
Coarse Cereal	11300.4	5786.4	3954	1560
Pulses	1257	447	198	612
Oil Seeds	340	22	318	0

Source: District Irrigation Plan, 2019

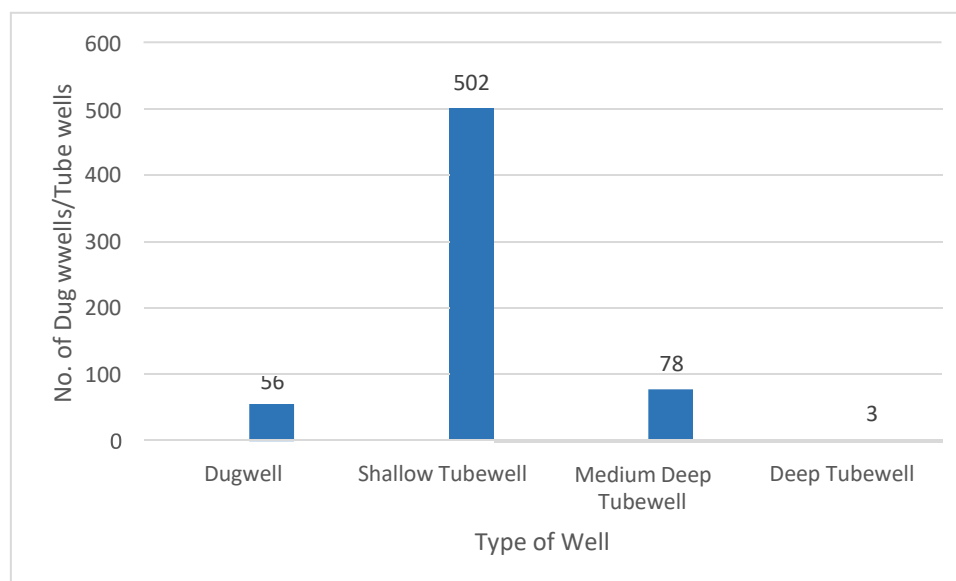
Surface irrigation network comprises canal irrigation, tanks, surface flow and lift irrigation. A considerable area is brought under irrigation by numbers of tanks.

Ground water irrigation is limited and is accomplished mainly through dug wells, shallow tube wells, medium deep tube wells and limited numbers of deep tube wells. Shallow tube wells are limited to the depth of 0-35 m bgl. Ground water extraction for irrigation use is 931.5 ham.

Table-6: Block level statistics of no. of tubewells for irrigation use as per 5th MI Census

Block Name	Dug well	Shallow Tube well			Medium Deep Tube well	Deep Tube well
	No.	0-20 m depth	20-35 m depth	35-40 m depth	No.	No.
Narayanpur	56	122	380	-	78	3

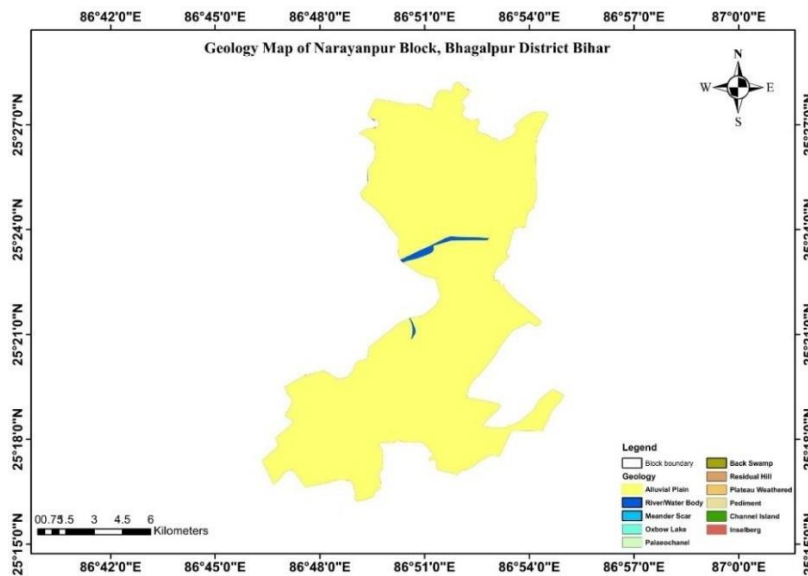
Source: 5th Minor Irrigation Census, 2013-14)



(Fig-7: Number of minor irrigation structures in the Narayanpur Block)

2.0 Geology

Major part of the block is covered by Diara formation and Ganga-kosi formation of Late Holocene age. The Diara formation is represented by unoxidised grey sand, silt and clay of the present day flood plain, channel bares, levees and back swamps and The Ganga-kosi formation is represented by fine to medium sand, silt and clay inundated in rainy season, bank erosion and re-deposition.



(Fig-8: Geology of Narayanpur Block)

3.0 Hydrogeology

Considerably thick sand layers with intermittent clay in the Quaternary Alluvium (mostly younger) of Late Holocene age form the main source of ground water in the block. Based on the strata logs and hydrogeological properties, the aquifer system in the district can be divided into three categories,

- i. The 1st aquifers within 20 m depth.
- ii. The 2nd aquifers within 40-60 m depth.
- iii. The 3rd or deeper aquifers within 60-100 m depth.

In shallow aquifers, the ground water occurs under unconfined condition and in deeper under semi-confined conditions. The shallow aquifers consisting of fine to medium sand with clay. The deeper aquifers mainly consist of sand with alternating layers of clay.

Hydrogeologically the Narayanpur block is underlain by porous, unconsolidated formation. The unconsolidated formation comprises clay, silt and different grades of sand down to depth of 155 m. The thick granular sand zone constitute potential aquifer system. The shallow aquifer is mainly under phreatic condition whereas differ part is under semi-confined to confined condition. The exploratory well data of CGWB, reveals that tube wells of 50 m depth yield at 52.6 m³/hr with drawdown 19.50 m. The transmissivity of the aquifer varies 209.55 m²/day, specific capacity 2.64 m³/hr/m and storativity is 1.1 x 10⁻³.

3.1 Aquifer Disposition and Characteristics

Aquifer disposition of the area has been studied from the existing lithological data. The lithological cross section, across the block represents multiple aquifer system up to depth of 155 m.

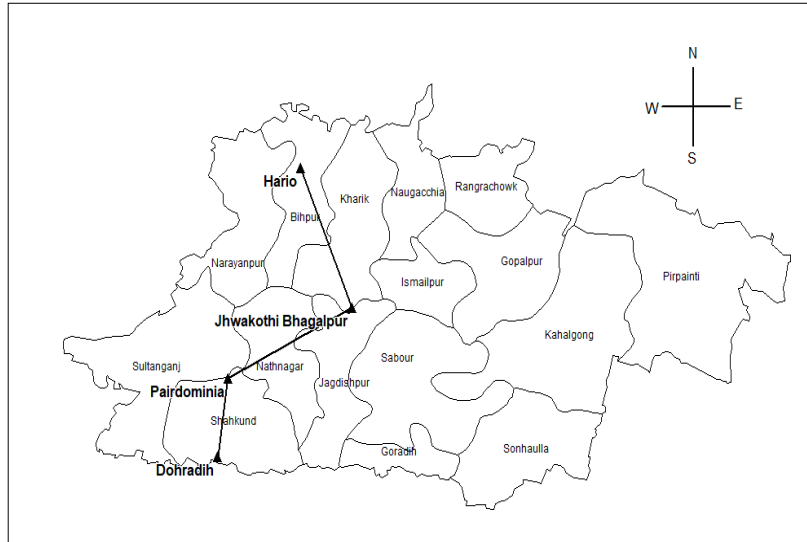


Figure-9(a): Location of bore holes, Bhagalpur District

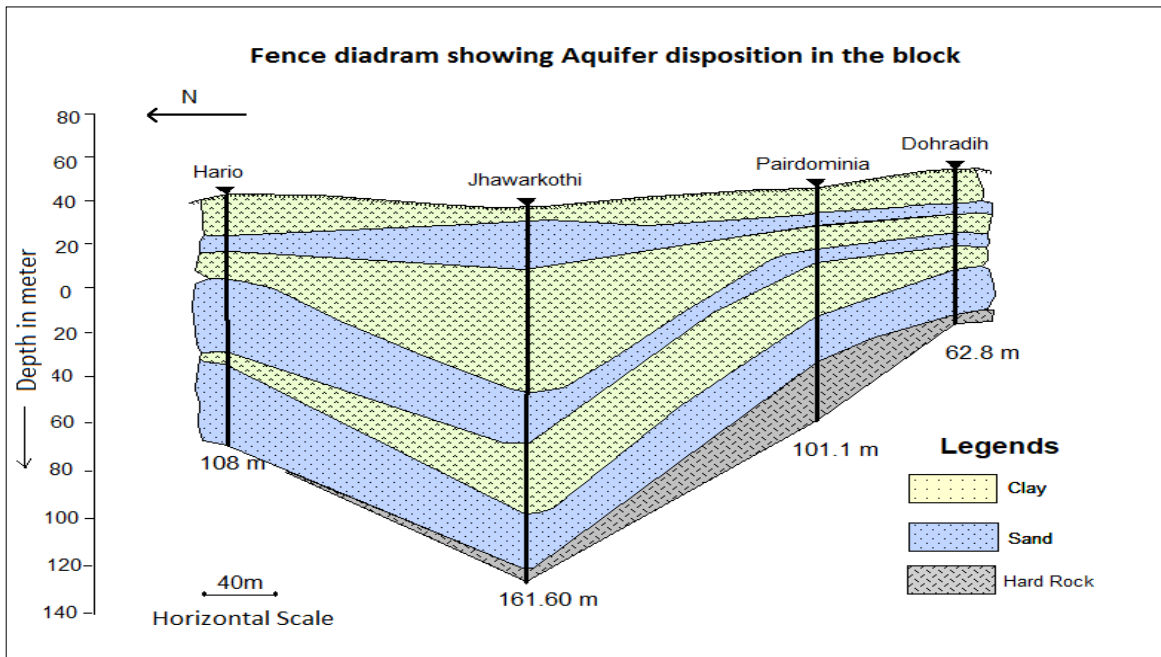


Figure-9(b): Fence diagram showing Aquifer disposition in the Block

3.2 Depth to Water Level

The groundwater regime nearby block of the Narayanpur block has been monitored from the existing network monitoring wells and inventoried observation wells. Observation wells are private, dug wells, piezometer of minor irrigation department, Government of Bihar. The average depth of dug wells is 9.5m bgl. Piezometers are on an average 50 m bgl depth whereas the PHED deep tube wells are in general, deeper 155m. The pre monsoon water level in dug well zone 5.73-6.75 m bgl and in post monsoon water level varies from 2.30-3.27 m bgl. Comparatively deeper water level 5.03-7.15 m bgl is reported from the deep tube wells of PHED. Ground water level fluctuation 3-3.5 m in general reflects more or less uniform and low fluctuation, (Fig-10a-c).

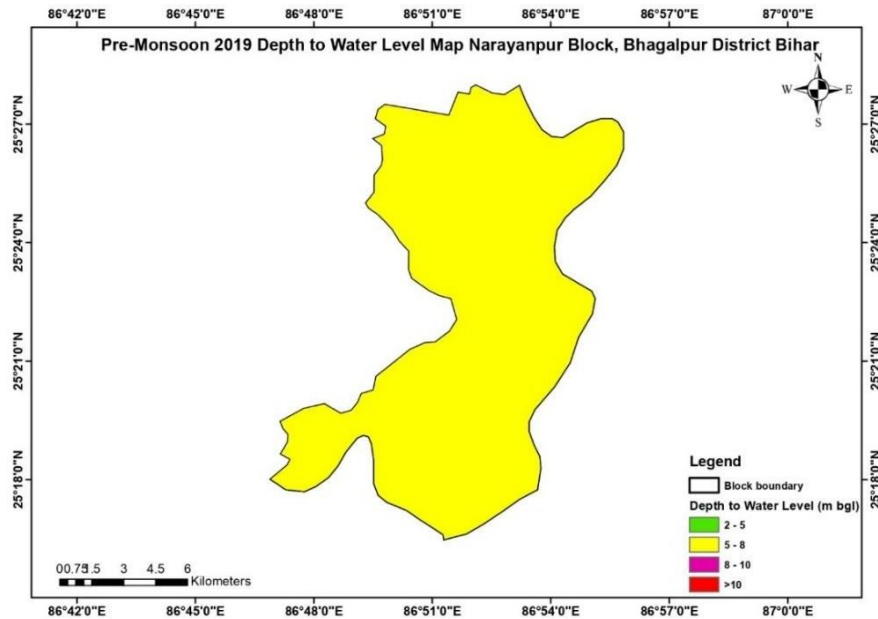


Figure-10(a): Pre monsoon water level

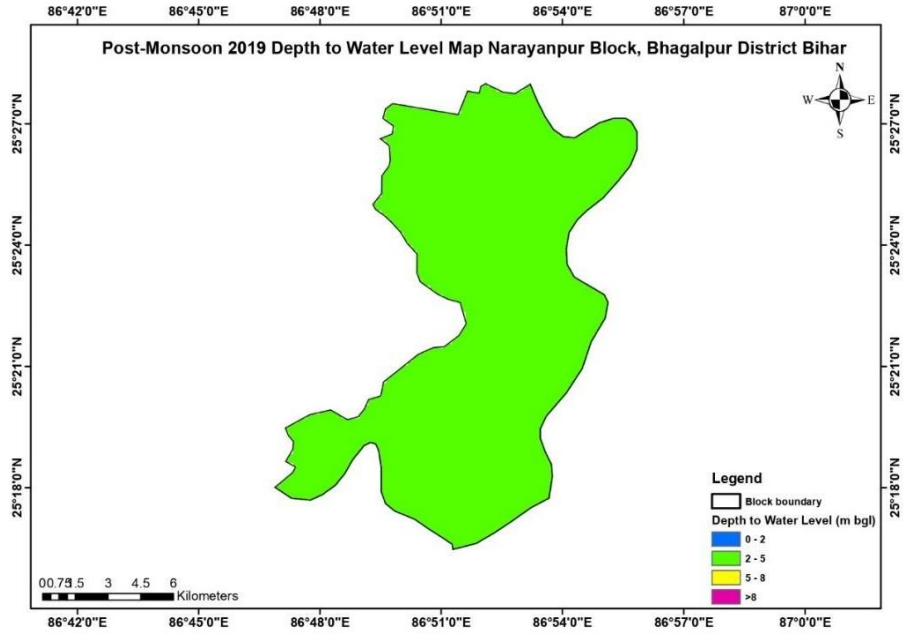


Figure-10(b): Post monsoon water level

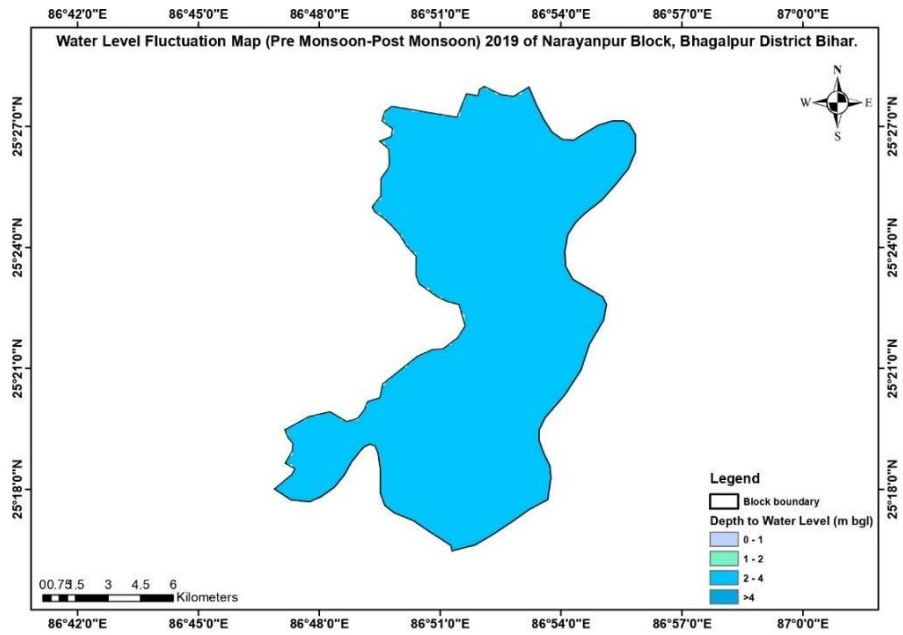


Figure-10(c): Fluctuation of water level

3.3 Ground Water Flow

Water table map has been prepared from the elevation and depth to water level data of the observation wells. In a groundwater regime, equipotential lines, the line joining points of the equal head on the potentiometric surface, were drawn based on the area of variation of the head of an aquifer. Based on the Water table elevation, ground water flow directions (from S-N) are demarcated in Fig-11. It has been observed that the ground water flow directions follow the major drainage channels and topography of the area. This indicates the topographic control for the ground water movement.

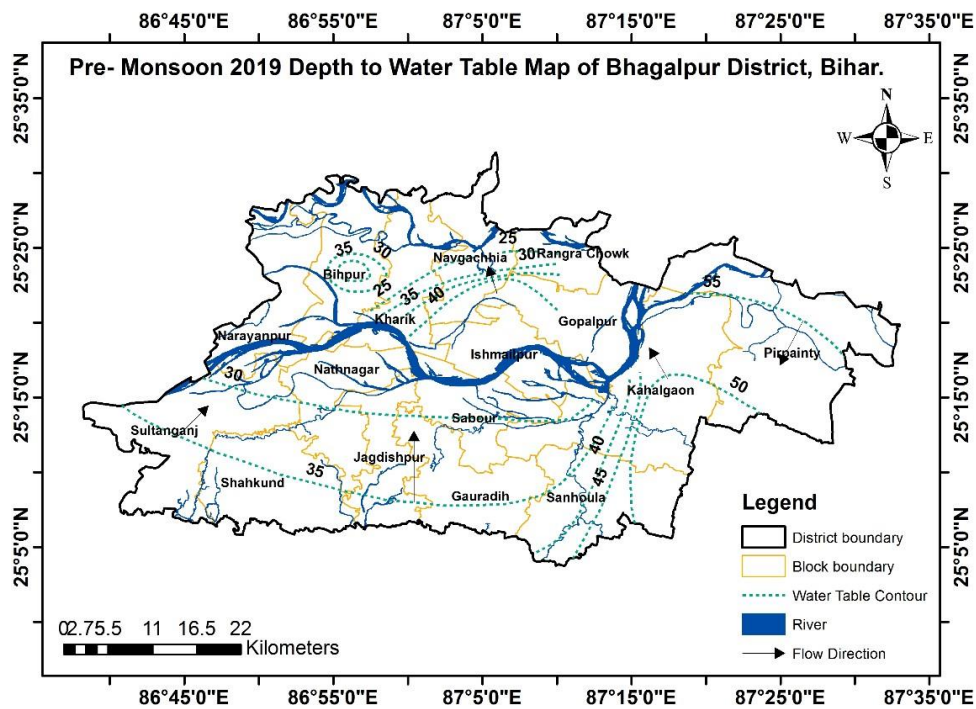


Figure-11(a): Pre monsoon water table

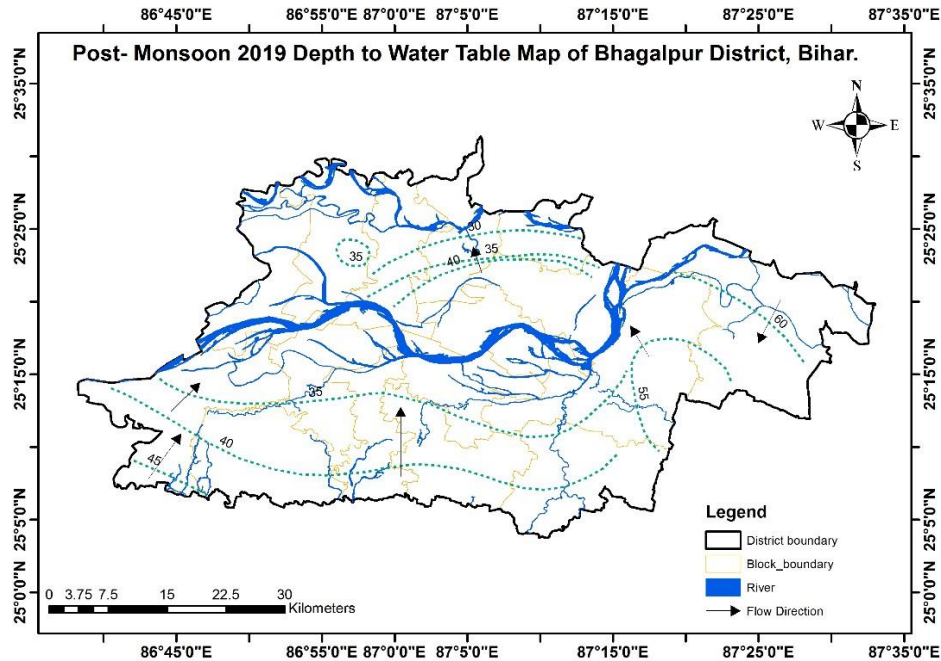


Figure-11(b): Post monsoon water table

Table-7: Depth to water level of pre monsoon and post monsoon of nearby block of Narayanpur block

Block	Type of well	Location	Latitude	Longitude	Depth of well (m)	RL(m)	Depth to Water Level (m bgl)		Fluctuation (m)	Water Table (amsl)	
							Pre monsoon	Post monsoon		Pre monsoon	Post monsoon
Bihpur	NHS	Menenth chowk	25.3989	86.9222	9.5	37.4	5.73	2.30	3.43	31.67	35.1
Bihpur	PHED	Naugachhia	25.4049	86.9224	155	40.9	6.75	3.27	3.48	34.15	37.63
Bihpur	PZ	BDO office	25.2561	87.2395	50	45.6	7.15	5.03	2.12	38.45	40.57

4.0 Ground Water Resources -2020

About 5.13 % of the net ground water availability of Bhagalpur district is available in Narayanpur block only. Total ground water resource of the block is 3843.83 ham and the total ground of draft of the block is 1117.67 ham. The SOD is 30.61 % whereas of the district SOD is 27.87%. The block comes under “Safe” category, says that there are sufficient scope for ground water development.

Table-8: Ground Water Resources estimation -2020

District	Block	Recharge from Rainfall during Monsoon season (ham)	Recharge from Rainfall during Non-Monsoon season (ham)	Recharge from Other Sources during Monsoon season (ham)	Recharge from Other Sources during Non-Monsoon season (ham)	Total Annual Ground Water Recharge (ham)	Total Natural Discharges	Annual Extractable GW Resource (ham)	GW Extraction for Irrigation (ham)	GW Extraction for Industrial (ham)	GW Extraction for Domestic (ham)	Total Extraction (ham)	Net GW Availability for Future Development (ham)	Stage of Ground Water Development(ham)	Category: Safe / Semi-critical/ Critical/ Over-exploited
Bhagalpur	Narayanpur	3059	381	211.7	191.	3843	192	3651	931	45	141	1117	2516	31	Safe

5.0 Chemical quality of Ground Water

Result of chemical analysis (2019) of ground water (sample collected during May 2019) of shallow aquifer of nearby block of Narayanpur block is given in the table below. In general water of shallow aquifer is potable.

Table-9: Chemical quality of Ground Water of nearby block of Narayanpur Block

Location	pH	EC	TH	Ca	Mg	Na	K	HCO3	Cl	SO4	NO3	F	TDS
Bihpur	7.9	797	355	110	19	8.58	0.3	311	32	54	34	0.19	478

6.0 Management Plan

6.1. Supply side intervention in Agriculture and Irrigation

From the existing land/agriculture and irrigation practices it is understood that the block is principally agricultural depending. However, the average cropping intensity is recorded as 125 %. It reveals that considerable cropped area is not under assured irrigation coverage. As per the the dynamic ground water resource stage of development is 30.16 % which indicates there exist further scope of ground water development in the block both for agriculture and drinking/domestic purposes. 5th MI Census data shows that majority of irrigation tube wells accompanied within the depth of 50 m. Therefore further development may be planed from the deeper part as well

Considering projected 70% development 1438.478 ham further resources may be developed safely for irrigation development. This balance resource is recommended for development through STW/DTW as per the prevailing terrain condition and hydrogeology of the area. Considering unit draft of 2.4 and 5.0496 ham for STW and DTW respectively following number of irrigation structures have been proposed. Thus in Narayanpur block 450 STW and 71 DTW may be constructed. (Table10). These tube wells will create additional irrigation potential in the block.

Table-10(a): Additional resource for 70% development

Assessment Unit Name	Total Area of Assessment Unit (Ha)	Recharge Worthy Area (Ha)	Annual Extractable Ground Water Resource (Ham)	Total Extraction (Ham)	(Ha Draft for 70% m) development	Additional resource available for 70% development (Ham)
NARAYANPUR	14427	14427	3651.64	1117.67	2556.148	1438.478

Table-10(b): Recommended number of structures for further irrigation development

Additional resource available for 70% development (Ham)	Resource allocated for development by STW (Ham)	Resource allocated for development by DTW (Ham)	Unit draft of STW (Ham)	Unit draft of DTW (Ham)	No. of STW proposed	No. of DTW proposed
1438.478	1078.859	359.6195	2.4	5.0496	450	71

6.2 Supply side intervention through Artificial Recharge and rain water harvesting

As per the proposed ARMP of Bihar state, considering the post monsoon water level and long term water level trend, no such area has been delineated for implementation of AR structures in the block. However, based on the local hydrological situation and site specific development scenario artificial recharge and water harvesting techniques may be practiced for efficient and sustainable management of ground water resources in the block. In Narayanpur urban area, roof top rain water harvesting may be practiced for water conservation. The gram panchayat buildings, schools, Govt buildings etc. may be shortlisted, in phases, for implementation of roof top rain water harvesting.

6.3 Demand side intervention

Considering the area being high potential in terms of ground water resources and limited development scenario in the block, the additional resources may be utilized for more water intensive crops like paddy, cereals etc. along with the other crops. This may create further irrigation potential in the block. Suitable crop rotation may be practiced.

AQUIFER MAPS AND MANAGEMENT PLAN OF NAUGACCHIA BLOCK, BHAGALPUR DISTRICT, BIHAR

1. Salient Information

Name of the Block/Area	Naugachhia/106.70 sq km
District/State	Bhagalpur/Bihar
Population	Total- 124857 Rural- 85177 Urban- 39680
Rainfall	Normal Monsoon- 977.3 Non-monsoon rainfall- 231
Agriculture and Irrigation	Principal crops - Rice – Wheat, Rice – Gram, Rice – Pulses, Rice – Rai. Gross cropped area- 9197.04 Net sown area- 7447 Irrigation practices- Surface water by canal -Ground water by tube well and DW Cropping intensity- 123.5 %, Number and types of abstraction structures – DW- 112, STW- 345, MDTW-310, DTW-1
Geology	Quaternary alluvium- Diara and Ganga-Kosi Formations
Geomorphology	Major Physiographic units- Alluvial plain Major Drainage- Ganga, Bagmati Sub basin
Ground water resource availability and extraction	Annual Ground Water Resource (Ham)-2973.6 Net Ground Water Availability for future use (Ham)- 1603.86 Ground water extraction (Ham)- 1327.4; SOD-23%
Existing and future water demand	1327.4 Ham/385.74 Ham (annual GW allocation for domestic as on 2025)
Water level behaviour	Pre-monsoon SWL- 4-7 mbgl Post-monsoon SWL- 2-3 mbgl

2. Aquifer Disposition

Number of Aquifers	03; up to the explored depth of 100 m
Aquifer disposition and basic characteristics	1st aquifers within 20 m depth fine sand mostly phreatic 2nd aquifers within 40-60 m depth and 3rd or deeper aquifers within 60-100 m depth medium to coarse sand, semi-confined to confined.

3. Ground water resource, extraction, contamination and other issues

GW	Safe
Resource/Categorization	
Availability	Potable
Chemical quality of ground water and contamination	

4. Supply Side Interventions

Ground Water Development Strategies-	Number of STW and DTW may be proposed for irrigation uses- STW-236, DTW-39
Aquifer wise space available for recharge and proposed interventions	As per ARMP, 2020, for Naugachhia block 4.19 sq km is suitable for recharge. De-silting of existing tanks-2 and injection well-2 etc. are some suitable structures in the area

5. Demand side interventions

Advanced Irrigation Practices	Project based drip/sprinkler irrigation, lining of field channels etc.
Change in cropping pattern	Water intensive crop like paddy, wheat may be encouraged; crop rotation
Alternate water sources	Conjunctive uses of groundwater/surface water sources,
Regulation and Control	Capacity building for awareness generation for fluoride/arsenic contamination.(if needed)

1.1 General Information

1. Area	in Sq. Km	:	106.70
2. No. of revenue village		:	15
3. Population (2011)	Total	:	1,24,857
	Rural	:	1,24,857
	Urban	:	—
4. Normal annual rainfall (District)	(mm)	:	1188
5. Basin / Sub-basin		:	Bagmati-Kosi Sub-basin
6. Location		:	
Latitude		:	25°5'21.544 "N to 25°14'8.254"N
Longitude		:	86°59'6.584"E to 87°8'23.637"E

The Naugachhia block of Bhagalpur district is surrounded in the east by Ramgarhchowk block, in the north by Madhepura and Purnia district, in the west by Kharik block, in the south by Islampur block and in the south-east by Gopalpur block. (Fig:1). Block headquarter of Naugachhia block is Naugachhia town. It belongs to Bhagalpur division. Naugachhia city, Bhagalpur city, Colgong city, Sultanganj city are the nearby cities to Naugachhia block. Naugachhia block consist of 15 villages and 10 panchayats. Barwa is the smallest village and Partapnagar is the biggest village of Naugachhia block. Bhagalpur (Bhagdattpuram), Munger, Sahibganj, Deoghar (Baba Dham), Pakur (Pakaur) are the nearby important tourist destinations. Maithili is the local language, people also speaks Hindi, Urdu.

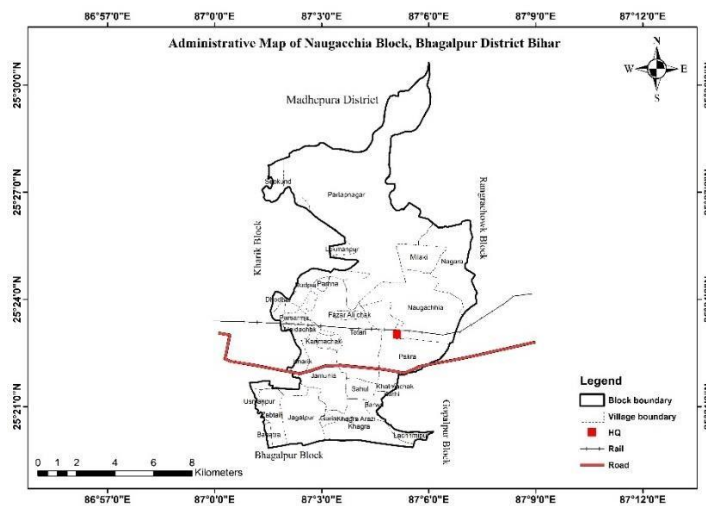


Fig-1, Administrative Map of Naugachhia Block, Bhagalpur District

1.2 Basic Demographic Detail of Naugachhia block as per 2011 census data

Total population of Naugachhia block 124857 among which 55994 is male population, 49365 is female population and 19498 is child population. Number of household is 18970. There are 10 gram panchayats and 15 villages in the Naugachhia block, (Table-2).

Table-1: Demographic distribution of Naugachhia Block

Block	No. of Household	Males	Females	Child	Total
Naugachhia	18970	55994	49365	19498	124857

Source: Census 2011

Table-2: Panchayat wise village in Naugachhia Block

S.No.	Panchayat	Villages
1	Dholbajja	1
2	Khairpur Kadwa	1
3	Kadwa Diara	1
4	Punama Pratapnagar	2
5	Nagrah	1
6	Pakra	1
7	Tetri	1
8	Yamuna	2
9	Jagatpur	3
10	Khagra	2
	Total	15

Source: Census 2011

Distribution of persons engaged in agriculture and other workers/ non workers in the block

In Naugachhia Block, 68% of total population is non workers. It is evident from diagram given below, that 10% of the total population in the block is engaged in agriculture, 6% engaged as cultivator, 1% comprises household industrial workers and 10% comprises other worker, (Fig-2).

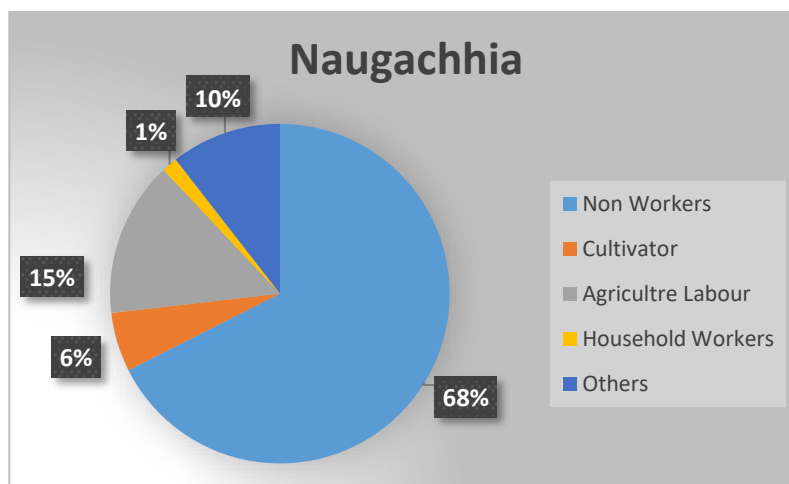


Fig-2, Demographic classification of Naugachhia block, Bhagalpur District

Source: Census 2011

1.3 Rainfall and Temperature

Normal annual rainfall of Naugachhia block is 1188 mm of which 80% occurs during the monsoon season. The normal rainfall during monsoon season is 977.3 mm and during non-monsoon season is 231 mm. The temperature varies from 45 to 50°C.

1.4 Soil

Naugachhia block contains mainly fine sandy loamy soil.

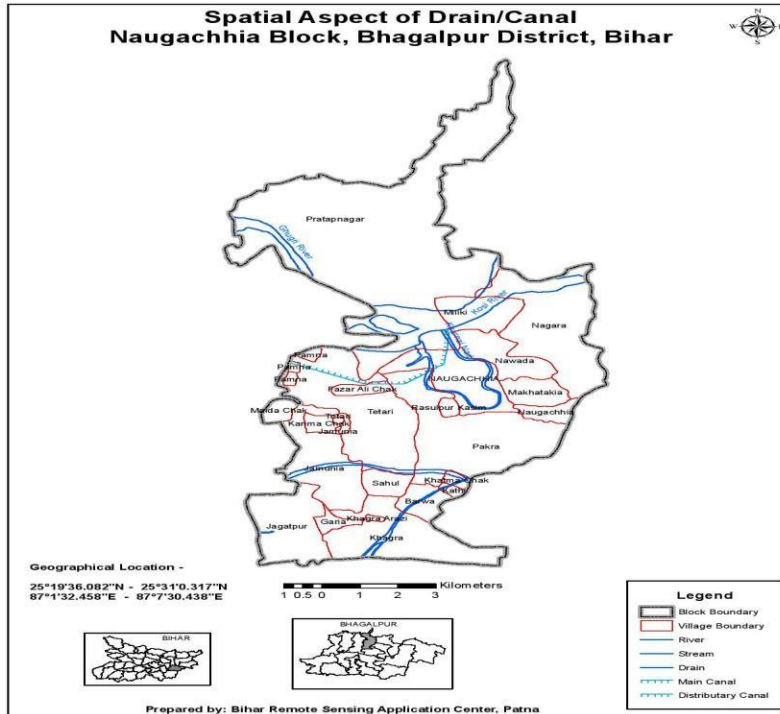
Table-3: Soil type

Block	Soil Type
Naugachhia	Fine sandy loamy Soils, Clayey Soils

Source: District Irrigation Plan, 2019

1.5 Physiography, Basin/sub-basin, Drainage

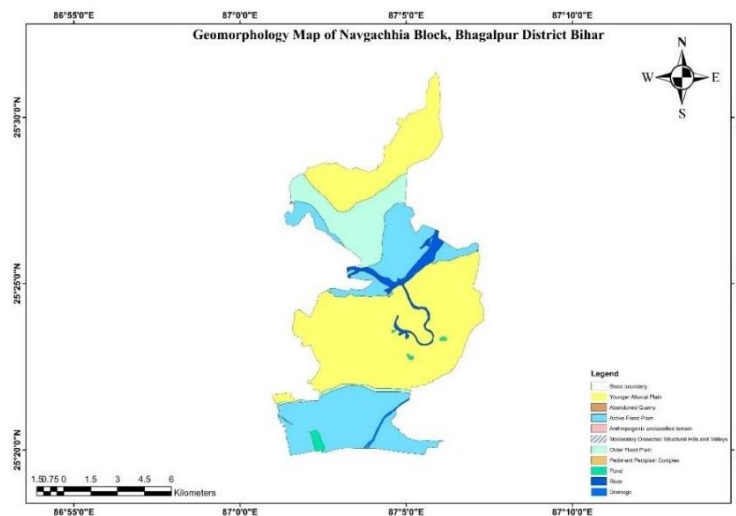
The Naugachhia block is situated in northern part of Bhagalpur District. Naugachhia forms part of Bagmati-Kosi Sub-basin. Dendritic and parallel to sub-parallel drainage patterns are dominating in this region. Naugachhia block has average elevation 45m. Ghugri and Kosi and Ganga Rivers are flowing in this block.



(Fig-3: Drainage and canal network in Naugachhia Block)
 Source: District Irrigation Plan, 2019

1.6 Geomorphology

The Naugachhia block is a part of Indo-Gangetic alluvium plain, having gentle slope. Quaternary alluvium plain of fluvial (deposited by flood during rainy season) origin covers the major part of the block. A small part of the block covered by water bodies.



(Fig-4: Geomorphological map of Naugachhia Block)

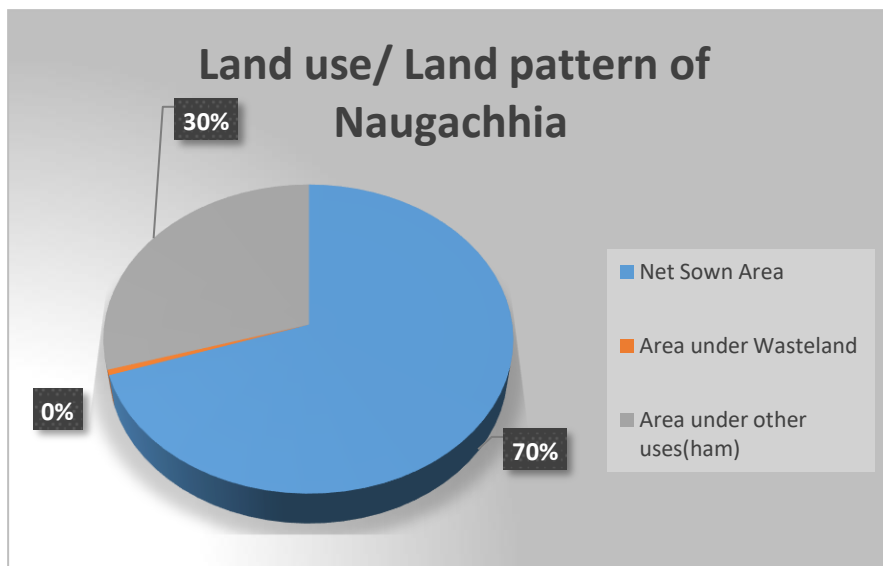
1.7 Land use / Land Cover

Total geographic area of the Naugachhia block is 10670.00 ha. Naugachhia block has net sown area is 7447.00 ha and gross cropped area is 9197.00 ha. Therefore area under multiple cultivation is 1750.04 ha area and 60.00 ha area is under wasteland. It is evident that net sown area is 69.79 %, area under multiple cultivation is 16.40 % and wasteland is 0.56 % of total geographical area. The cropping intensity of the block is 123.5%.

Table-4: Land use/Land Pattern of Naugachhia Block

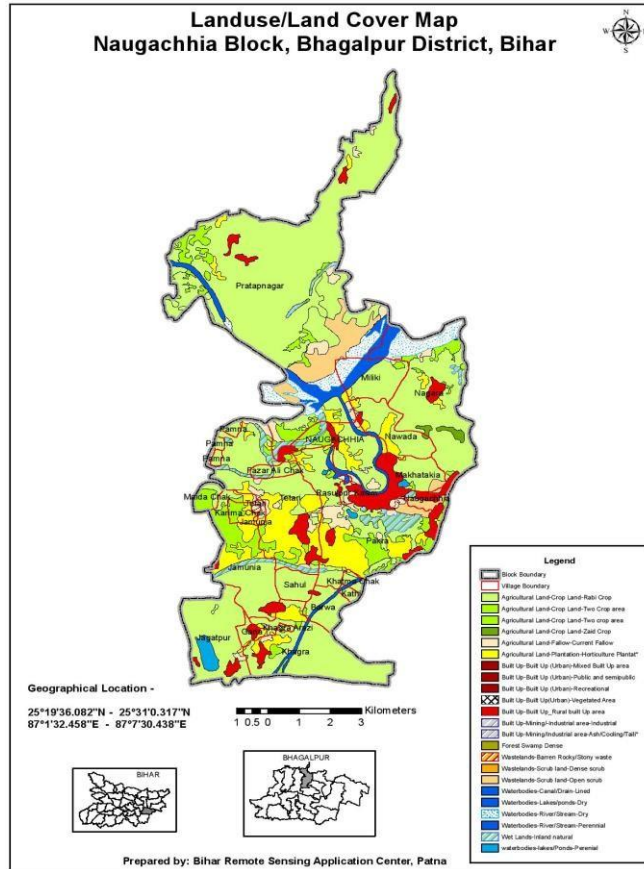
Name of the Block	No. of Gram Panchayat	Total Geographical Area (ham)	Gross cropped Area (ham)	Net Sown Area (ham)	Area Sown more than once (ham)	Area under Forest (ham)	Area under Wasteland (ham)	Cropping Intensity (%)
Naugachhia	10	10670	9197.04	7447	1750.04	60	0	123.5

Source: District Irrigation Plan, 2019



(Fig-5: Land use and Land cover of in Naugachhia Block)

Source: District Irrigation Plan, 2019



(Fig-6: Land use and Land cover of in Naugachhia Block)

Source: District Irrigation Plan, 2019

1.8 Agriculture and Irrigation

Agriculture is the main stay of the people living in Naugachhia block, which is evident from census figures of 2011. Naugachhia block falls in the Agro-climatic Zone III A. Naugachhia block is producer of several crops such as paddy, miaze, arhar, mung and urad during Kharif season. Wheat, maize, barely, pulses and oil seeds during Rabi season and summer season. Cereals are the major crops in the block.

Table-5: Area under different crops in Naugachhia Block

Crops	Cropped Area (ha)	Kharif (ha)	Rabi (ha)	Summer Rabi (ha)
Coarse Cereal	14060.4	7010.4	5490	1560
Pulses	1432.8	622.8	198	612
Oil Seeds	364	22	342	0

Source: District Irrigation Plan, 2019

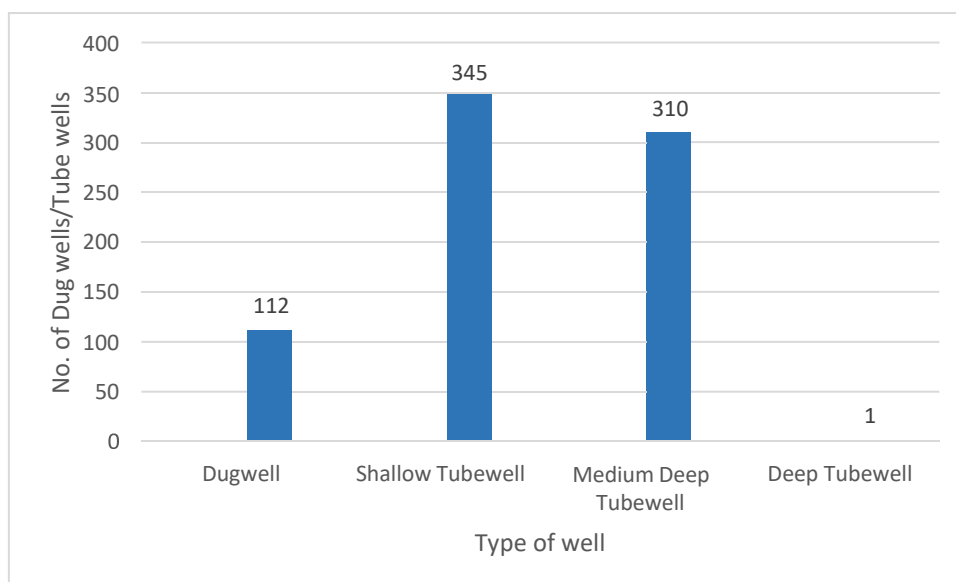
Surface irrigation network comprises canal irrigation, tanks, surface flow and lift irrigation. A considerable area is brought under irrigation by numbers of tanks.

Ground water irrigation is limited and is accomplished mainly through dug wells, shallow tube wells, medium deep tube wells and limited numbers of deep tube wells. Shallow tube wells are limited to the depth of 0-35 m bgl. Ground water extraction for irrigation use is 903.00 ham.

Table-6: Block level statistics of no. of tubewells for irrigation use as per 5th MI Census

Block Name	Dug well	Shallow Tube well			Medium Deep Tube well	Deep Tube well
	No.	0-20 m depth	20-35 m depth	35-40 m depth	No.	No.
Naugachhia	112	208	137	-	310	1

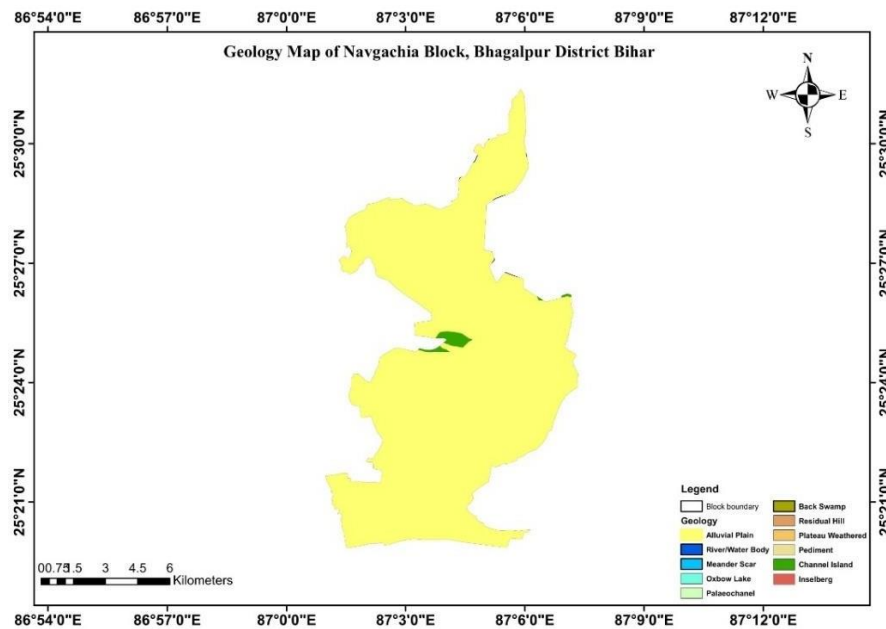
Source: 5th Minor Irrigation Census, 2013-14)



(Fig-7: Number of minor irrigation structures in the Naugachhia Block)

2.0 Geology

Major part of the block is covered by Diara formation, Ganga-kosi formation and Belhar formation of Middle to Late Holocene age. The Diara formation is represented by unoxidised grey sand, silt and clay of the present day flood plain, channel bares, levees and back swamps, The Ganga-kosi formation is represented by fine to medium sand, silt and clay inundated in rainy season, bank erosion and redeposition and The Belhar formation is represented by silty loam with sand, feebly oxidized.



(Fig-8: Geology of Naugacghia Block)

3.0 Hydrogeology

Considerably thick sand layers with intermittent clay in the Quaternary Alluvium (mostly younger) of Late Holocene age form the main source of ground water in the block. Based on the strata logs and hydrogeological properties, the aquifer system in the district can be divided into three categories,

- i. The 1st aquifers within 20 m depth.
- ii. The 2nd aquifers within 40-60 m depth.
- ii. The 3rd or deeper aquifers within 60-100 m depth.

In shallow aquifers, the ground water occurs under unconfined condition and in deeper under semi-confined conditions. The shallow aquifers consisting of fine to medium sand with clay. The deeper aquifers mainly consist of sand with alternating layers of clay.

Hydrogeologically the Naugachhia block is underlain by porous, unconsolidated formation. The unconsolidated formation comprises clay, silt and different grades of sand down to depth of 110 m. The thick granular sand zones constitute potential aquifer system. The shallow aquifer is mainly under phreatic condition whereas differ part is under semi-confined to confined condition. The exploratory well data of CGWB, reveals that tube wells of 50 m depth yield at 50.8 m³/hr with drawdown 18.84 m. The transmissivity of the aquifer varies 205.57 m²/day, specific capacity 2.64 m³/hr/m and storativity is 1.0 x 10⁻³.

3.1 Aquifer Disposition and Characteristics

Aquifer disposition of the area has been studied from the existing lithological data. The lithological cross section, across the block represents multiple aquifer system up to depth of 110 m.

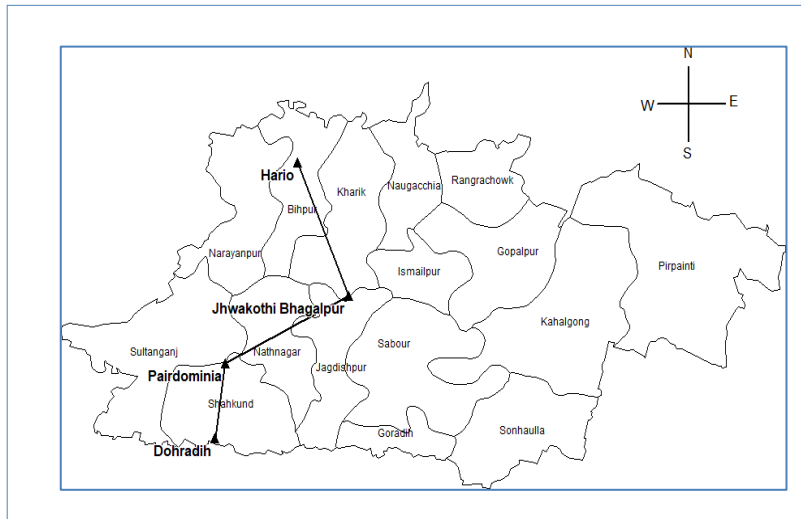


Figure-9(a): Location Map of the bore holes in Bhagalpur District

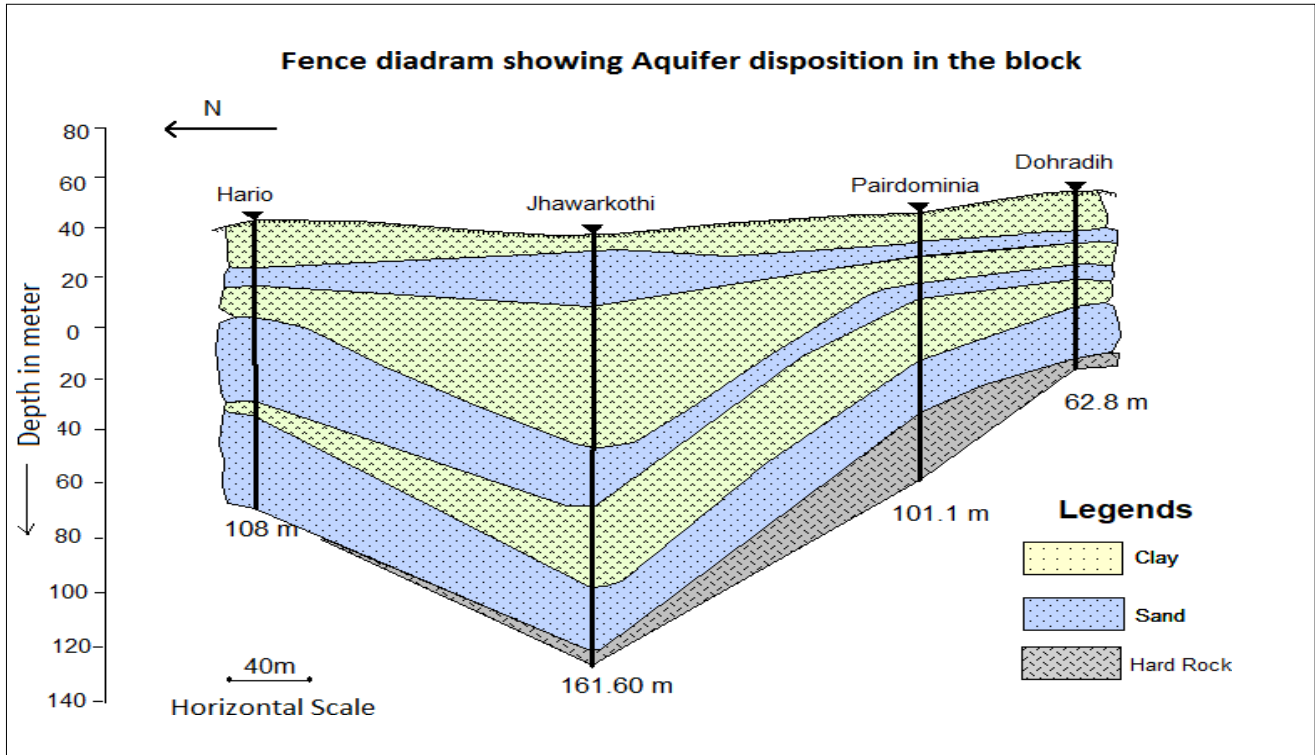


Figure-9(b): Fence diagram showing Aquifer disposition in the Block

3.2 Depth to Water Level

The groundwater regime of the block has been monitored from the existing network monitoring wells and inventoried observation wells. Observation wells are private, dug wells, piezometer of minor irrigation department, Government of Bihar. The average depth of dug wells is 9 m bgl. Piezometers are on an average 50 m bgl depth. The pre monsoon water level in dug well zone 4-7 m bgl and in post monsoon water level varies from 2-3 m bgl. Ground water level fluctuation 2-4 m in general reflects more or less uniform and low fluctuation, (Fig-10a-c).

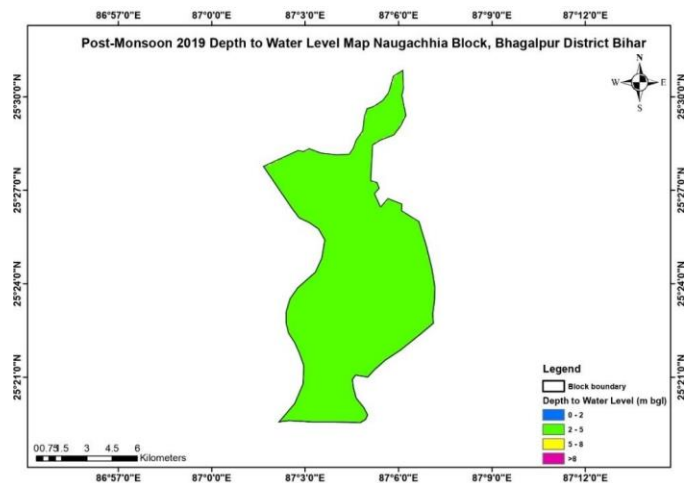


Fig -10(b): Post monsoon water level

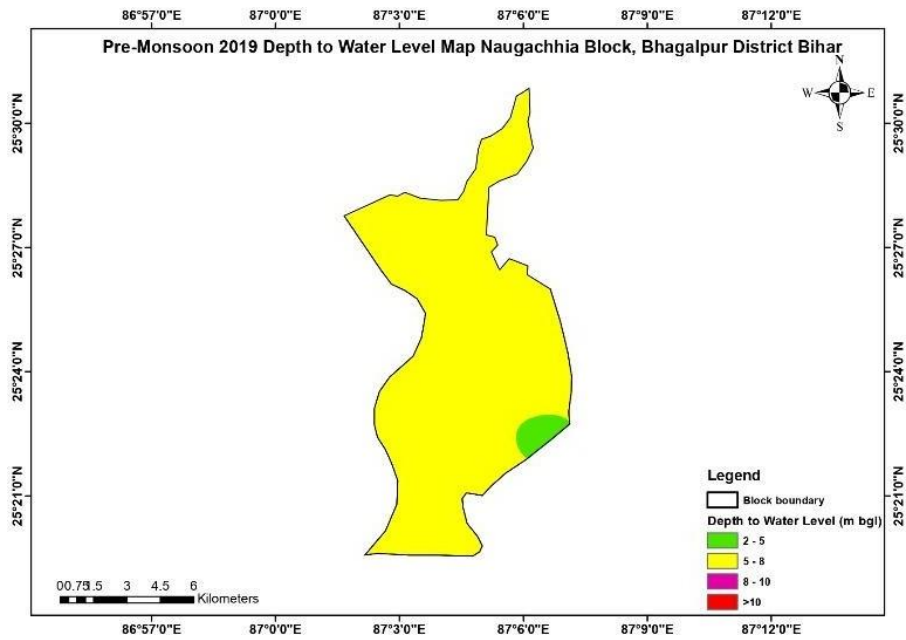


Figure-10(a): Pre monsoon water level

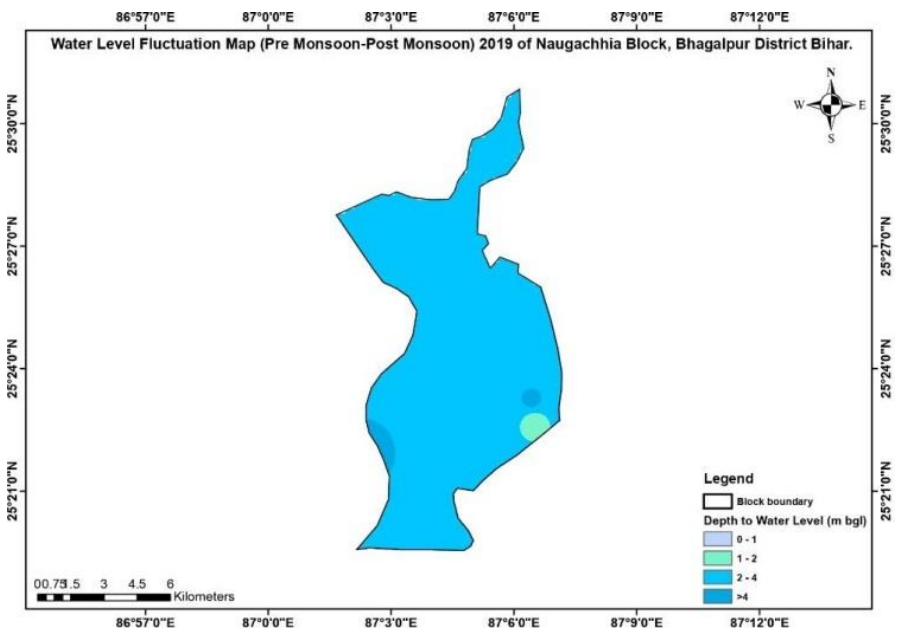


Figure-10(c): Fluctuation of water level

3.3 Ground Water Flow

Water table map has been prepared from the elevation and depth to water level data of the observation wells. In a groundwater regime, equipotential lines, the line joining points of the equal head on the potentiometric surface, were drawn based on the area of variation of the head of an aquifer. Based on the Water table elevation, ground water flow directions (From S-N) are demarcated in Fig-11. It has been observed that the ground water flow directions follow the major drainage channels and topography of the area. This indicates the topographic control for the ground water movement.

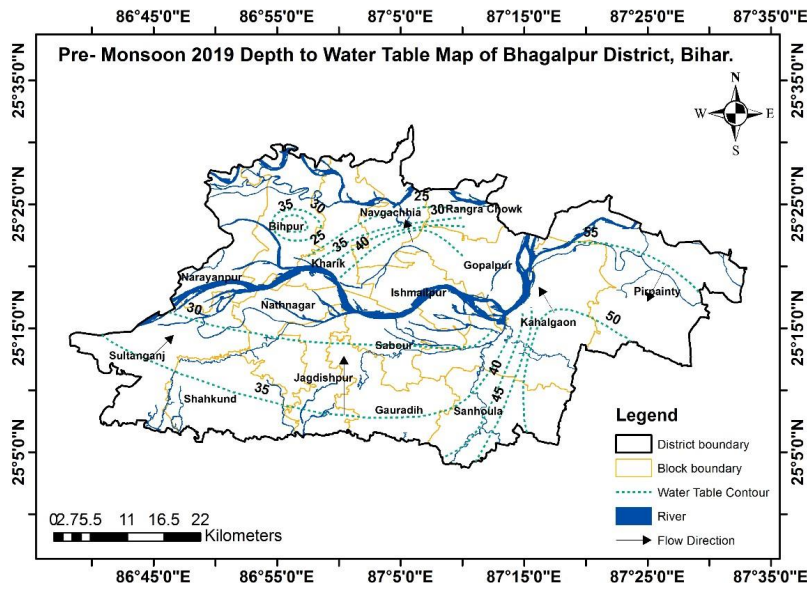


Figure-11(a): Pre monsoon water table

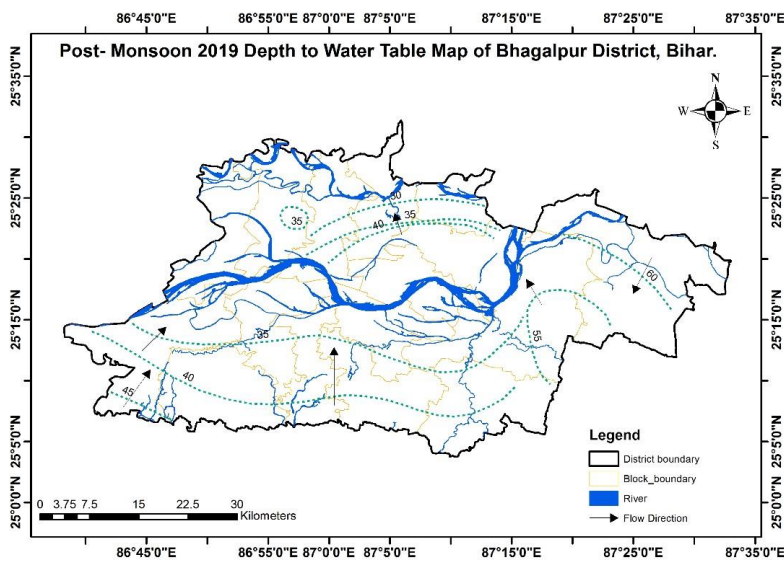


Figure-11(b): Post monsoon water table

Table-7: Depth to water level of pre monsoon and post monsoon of Naugachhia Block

Block	Type of well	Location	Latitude	Longitude	Depth of well (m)	RL(m)	Depth to Water Level (m bgl)		Fluctuation (m)	Water Table (amsl)	
							Pre monsoon	Post monsoon		Pre monsoon	Post monsoon
Naugachhia	DW/ NHS	Naugachhia H. School	25.3862	87.1072	9.00	36.9	6.95	2.50	4.45	29.95	34.40
Naugachhia	Pz	BDO Office	25.3792	87.1080	50.0	49.8	3.41	2.34	1.07	46.39	47.46

4.0 Ground Water Resources

About 3.27 % of the net ground water availability of Bhagalpur district is available in Naugachhia block only. Total ground water resource of the block is 3304 ham and the total ground of draft of the block is 1327.4 ham. The SOD is 44.64 % whereas of the district SOD is 27.87%. The block comes under “Safe” category, says that there are sufficient scope for ground water development.

Table-8: Ground Water Resources estimation -2020

District	Block	Recharge from Rainfall during Monsoon season (ham)	Recharge from Rainfall during Non-Monsoon season (ham)	Recharge from Other Sources during Monsoon season (ham)	Recharge from Other Sources during Non-Monsoon season (ham)	Total Annual Ground Water Recharge (ham)	Total Natural Discharges	Annual Extractable GW Resource (ham)	GW Extraction for Irrigation (ham)	GW Extraction for Industrial (ham)	GW Extraction for Domestic (ham)	Total Extraction (ham)	Net GW Availability for Future Development (ham)	Stage of Ground Water Development(ham)	Category: Safe / Semi-critical/ Critical/ Over-exploited
Bhagalpur	Naugachhia	2631.9	282.12	204.76	185.22	3304	330.4	2973.6	903	81.00	343.40	1327.4	1603.86	44.64	Safe

5.0 Chemical quality of Ground Water

Result of chemical analysis (2019) of ground water (sample collected during May 2019) of shallow aquifer of Naugachhia block is given in the table below. In general water of shallow aquifer is potable. However, Fluoride contamination of groundwater has been reported from the Naugachhia block (as

per GW Resource Assessment of Bihar as on March 2022).

Table-9: Chemical quality of Ground Water of Naugachhia Block

Location	pH	EC	TH	Ca	Mg	Na	K	HCO ₃	Cl	SO ₄	NO ₃	F	TDS
Naugachhia	8.1	1004	450	138	26	24	1.4	372	39	62	50	0.88	602

6.0 Management Plan

6.1. Supply side intervention in Agriculture and Irrigation

From the existing land/agriculture and irrigation practices it is understood that the Block is principally agricultural depending. However, the average cropping intensity is recorded as 123.5 %. It reveals that considerable cropped area is not under assured irrigation coverage. The dynamic ground water resource reports stage of development is 44.64 % which indicates there exists further scope of ground water development in the block both for agriculture and drinking/domestic purposes. 5th MI Census data shows that majority of irrigation tube wells accompanied within the depth of 50 m. Therefore further development may be planned from the deeper part as well.

Considering projected 70% development 1710.21 ham further resource may be developed safely for irrigation development. This balance resource is recommended for development through STW/DTW as per the prevailing terrain condition and hydrogeology of the area. Considering unit draft of 2.4 and 5.2032 ham for STW and DTW respectively following number of irrigation structures have been proposed. Thus in Naugachhia block 534 STW and 82 DTW may be constructed. (Table10). These tube wells will add to the irrigation potential in the block.

Table-10(a): Additional resource for 70% development

Assessment Unit Name	Total Area of Assessment Unit (Ha)	Recharge Worthy Area (Ha)	Annual Extractable Ground Water Resource (Ham)	Total Extraction (Ham)	(Ha Draft for 70% m) development	Additional resource available for 70% development (Ham)
NAUGACHHIA	10670	10670	2973.6	1327.4	2081.52	754.12

Table-10(b): Recommended number of structures for further irrigation development

Additional resource available for 70% development (Ham)	Resource allocated for development by STW (Ham)	Resource allocated for development by DTW (Ham)	Unit draft of STW (Ham)	Unit draft of DTW (Ham)	No. of STW proposed	No. of DTW proposed
754.12	565.59	188.53	2.4	4.8768	236	39

6.2 Supply side intervention through Artificial Recharge and rain water harvesting

Based on post monsoon water level, long term water level trend, local geological and geomorphological settings and availability, non-committed surplus runoff, the feasibility of artificial recharge to augment ground water resources in the Naugachhia block has been worked out (Artificial Recharge Management Plan, 2019). An area of 4.19 Sq. km has been found as suitable for artificial recharge.

Based on the local geology/hydrogeology and underlying lithological disposition injection wells in village tank, de-silting of existing tank/talao/pond may be practiced in Naugachhia block. The tentative number of the above structures is as follows

Table-10: Proposed AR structure and RWH

Naugachhia Block	
Recharge Structure	
Type	Number
De-silting of existing tank /pond /talao	2
Injection Well in Village Tank	2

Source: ARMP, 2019

6.3 Demand side intervention

Considering the area being high potential in terms of ground water resources and limited development status in the block the additional resources may be utilized for more water intensive crops like paddy, cereals etc. along with the other crops. This may create further irrigation potential in the block. Suitable crop rotation may be practiced. Monitoring and surveillance of water quality for F or As contamination in ground water may be given due importance.

AQUIFER MAPS AND MANAGEMENT PLAN OF RANGRACHOWK BLOCK, BHAGALPUR DISTRICT, BIHAR

1. Salient Information

Name of the Block/Area	Rangrachowk/119.94 sq km
District/State	Bhagalpur/Bihar
Population	Total- 108365 Rural- 108365 Urban- 0
Rainfall	Normal Monsoon- 977.3 Non-monsoon rainfall- 231
Agriculture and Irrigation	Principal crops - Rice – Wheat, Rice – Gram, Rice – Pulses, Rice – Rai. Gross cropped area- 9776.35 Net sown area- 7868.1 Irrigation practices- Surface water by canal -Ground water by tube well and DW Cropping intensity- 124.5 %, Number and types of abstraction structures – DW- 11, STW- 226, MDTW-166, DTW-5
Geology	Quaternary alluvium- Diara and Ganga-Kosi Formation
Geomorphology	Major Physiographic units- Alluvial plain Major Drainage- Ganga, Bagmati Sub basin
Ground water resource availability and extraction	Annual Ground Water Resource (Ham)-3532.12 Net Ground Water Availability for future use (Ham)- 2442.88 Ground water extraction (Ham)- 720.6 SOD 23%
Existing and future water demand	720.6 Ham/140.52 Ham (annual GW allocation for domestic as on 2025)
Water level behaviour	Pre-monsoon SWL- 6-7 mbgl Post-monsoon SWL- 4-8 mbgl

2. Aquifer Disposition

Number of Aquifers	03; up to the explored depth of 100 m
---------------------------	---------------------------------------

Aquifer disposition and basic characteristics	1st aquifers within 20 m depth fine sand mostly phreatic 2nd aquifers within 40-60 m depth and 3rd or deeper aquifers within 60-100 m depth medium to coarse sand, semi-confined to confined.
--	--

3. Ground water resource, extraction, contamination and other issues

GWResource/Categorization	Safe
Chemical quality of ground water and contamination	Potable; except few sporadic occurrences of As above 10 ppb

4. Supply Side Interventions

Ground Water Development Strategies-	Number of STW and DTW may be proposed for irrigation uses- STW-470, DTW-77
Aquifer wise space available for recharge and proposed interventions	As per ARMP, 2020, for Bhagalpur district 385.41 sq km is suitable for recharge. Percolation tank-8, Gully plug-471, Contour bunding & Trenching-764, Check dam-22, Nala bunding-37, Recharge shaft-86, Desilting of existing tanks-157 and injection well-210 etc. are some suitable structures in the area

5. Demand side interventions

Advanced Irrigation Practices	Project based drip/sprinkler irrigation, lining of field channels etc.
Change in cropping pattern	Water intensive crop like paddy, wheat may be encouraged; crop rotation
Alternate water sources	Conjunctive uses of groundwater/surface water sources,
Regulation and Control	Capacity building for awareness generation for arsenic contamination in ground water

1.1 General Information

1. Area	in Sq. Km	:	119.94
2. No. of revenue village		:	16
3. Population (2011)	Total	:	1,08,365
	Rural	:	1,08,365
	Urban	:	—
4. Normal annual rainfall (District)	(mm)	:	1158
5. Basin / Sub-basin		:	Bagmati-Kosi Sub-basin
6. Location		:	
	Latitude	:	25°15'40.487 "N to 25°27'31.575"N
Longitude		:	87°7'1.002"E to 87°16'42.710"E

The Rangachowk block of Bhagalpur district is surrounded in the north-east by Katihar district, in the north by Purniya District, in the west by Naugachhia block, in the south by Gopalpur block and in the south-east by Colgong block. (Fig:1). Block headquarter of Rangachowk block is Rangachowk town. It belongs to Bhagalpur division. Naugachhia city, Bhagalpur city, Colgong city, Katihar city are the nearby cities to Rangachowk block. Rangachowk block consist of 16 villages and 10 panchayats. Madsudanpur is the smallest village and Rangra is the biggest village of Rangachowk block. Bhagalpur (Bhagdattpuram), Munger, Sahibganj, Malda (mango city), English-Bazar(Malda) are the nearby important tourist destinations. Maithili is the local language , people also speaks Hindi, Urdu.

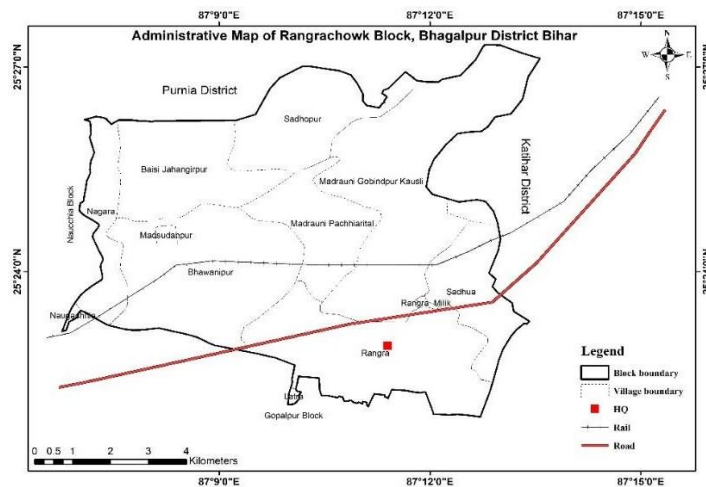


Fig-1, Administrative Map of Rangachowk Block, Bhagalpur District

1.2 Basic Demographic Detail of Rangrachowk Block as per 2011 census data

Total population of Rangachowk block is 108365 among which 48240 is male population, 42044 is female population and 18081 is child population. Number of household is 17416. There are 10 gram panchayats and 16 villages in the Rangachowk block, (Table-2).

Table-1: Demographic distribution of Rangrachowk Block

Block	No. of Household	Males	Females	Child	Total
Rangachowk	17416	48240	42044	18081	108365

Source: Census 2011

Table-2: Panchayat wise village Rangrachowk Block

S.No.	Panchayat	Villages
1	Baisi Jahagirpur	2
2	Sadhua Chapar	2
3	Koskiour Sahora	1
4	Rangra	4
5	Murli	1
6	Bania Baisi	2
7	Bhawanipur	1
8	Madrauni	1
9	Tintanga Diara North	1
10	Tintanga Diara South	1
	Total	16

Source: Census 2011

Distribution of persons engaged in agriculture and other workers/ non workers in the block

In Rangachowk block, 70 % of total population is non-workers. It is evident from diagram given below, that 17 % of the total population in the block is engaged in agriculture, 8% engaged as cultivator, 1% comprises household industrial workers and 4% comprises other worker, (Fig-2).

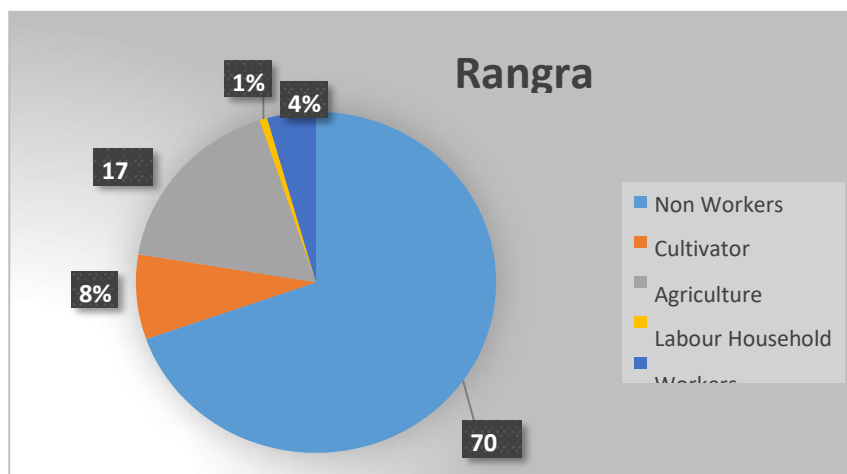


Fig-2, Demographic classification of Rangachowk Block, Bhagalpur District

Source: Census 2011

1.3 Rainfall and Temperature

Normal annual rainfall of Rangachowk block is 1158 mm of which 80% occurs during the monsoon season. The normal rainfall during monsoon season is 977.3 mm and during non-monsoon season is 231 mm. The temperature varies from 45 to 50°C.

1.4 Soil

Rangachowk block contains mainly fine sandy loamy soil.

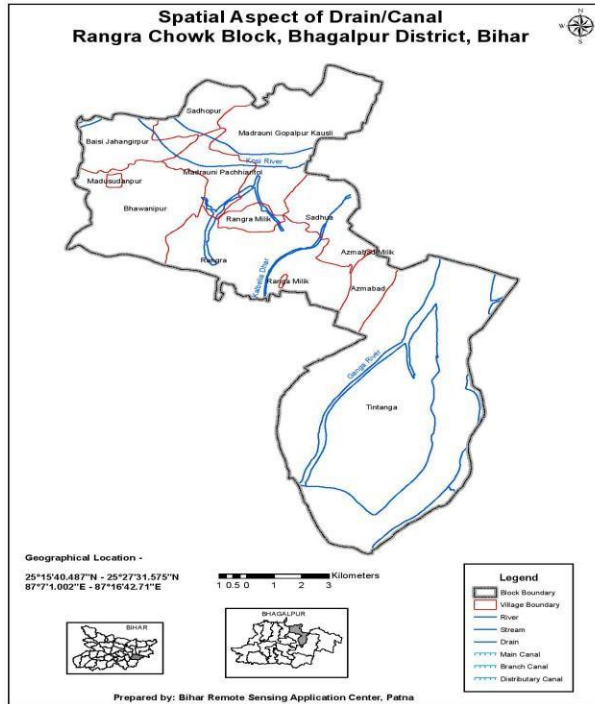
Table-3: Soil type

Block	Soil Type
Rangachowk block	Fine sandy loamy Soils, Clayey Soils

Source: District Irrigation Plan, 2019

1.5 Physiography, Basin/sub-basin, Drainage

The Rangachowk block is situated in northern part of Bhagalpur district. Rangachowk block forms part of Bagmati-Kosi Sub-basin. Dendritic and parallel to sub-parallel drainage patterns are dominating in this region. Rangachowk block has average elevation 45m. Kosi, Kalbelia and Ganga Rivers are flowing in this block.

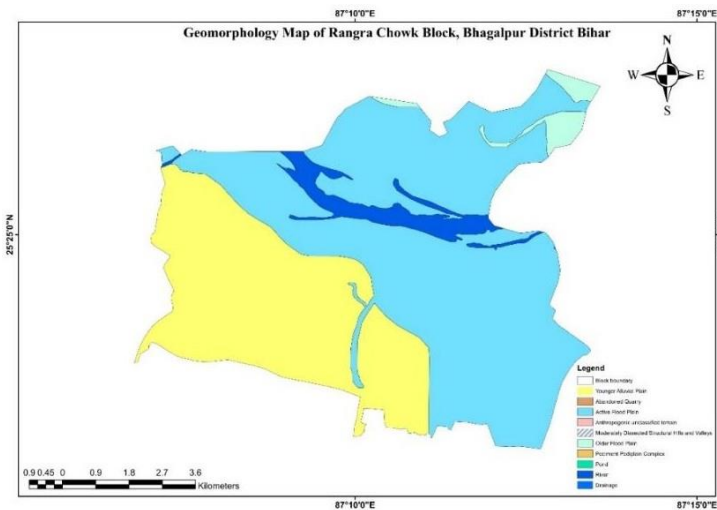


(Fig-3: Drainage and canal network in Rangrachowk Block)

Source: District Irrigation Plan, 2019

1.6 Geomorphology

The Rangachowk block is a part of Indo-Gangetic alluvium plain, having gentle slope. Quaternary alluvium plain of fluvial (deposited by flood during rainy season) origin covers the major part of the block. A small part of the block covered by water bodies.



(Fig-4: Geomorphological map of Rangrachowk block)

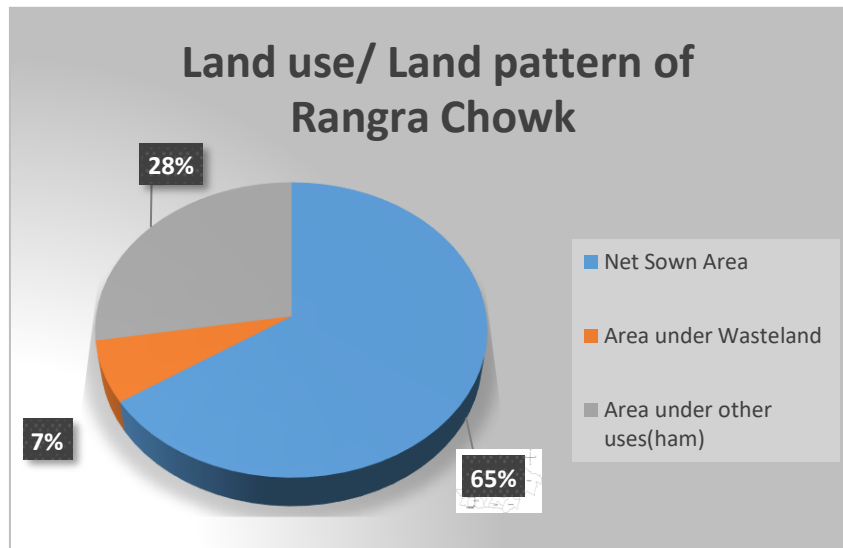
1.7 Land use / Land Cover

Total geographic area of the Rangachowk block is 11994.00 ha. Rangachowk block has net sown area is 7868.1 ha and gross cropped area is 9776.35 ha. Therefore area under multiple cultivation is 1908.25ha area and 812 ha area is under wasteland. It is evident that net sown area is 65.60%, area under multiple cultivation is 15.91 % and wasteland is 6.77 % of total geographical area. The cropping intensity of the block is 124.25 %.

Table-4: Land use/Land Pattern of Rangrachowk block

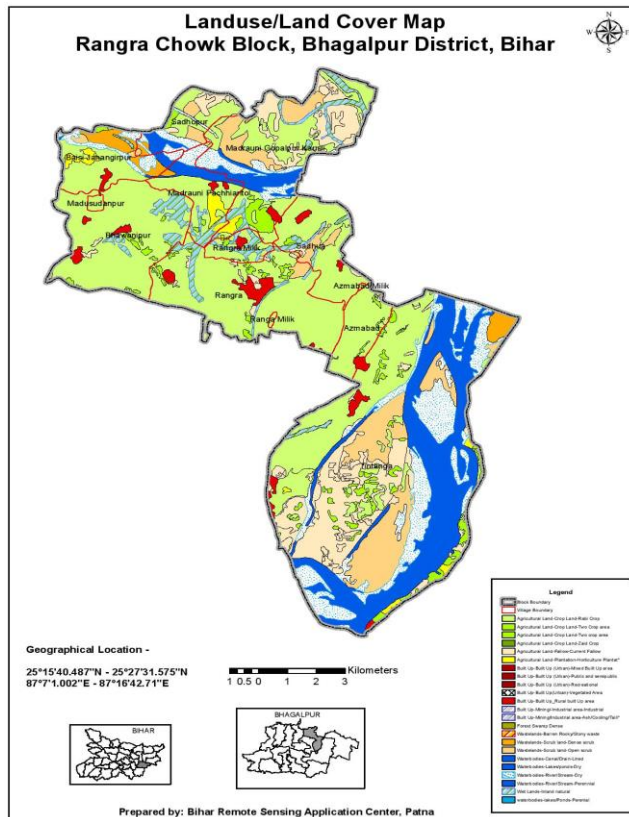
Name of the Block	No. of Gram Panchayat	Total Geographical Area (ham)	Gross cropped Area (ham)	Net Sown Area (ham)	Area Sown more than once (ham)	Area under Forest (ham)	Area under Wasteland (ham)	Cropping Intensity (%)
Rangachowk	10	11994	9776.35	7868.1	1908.25	0	812	124.25

Source: District Irrigation Plan,2019



(Fig-5: Land use and Land cover of in Rangrachowk Block)

Source: District Irrigation Plan,2019



(Fig-6: Land use and Land cover of in Rangrachowk Block)

Source: District Irrigation Plan, 2019

1.8 Agriculture and Irrigation

Agriculture is the main stay of the people living in Rangachowk block, which is evident from census figures of 2011. Rangachowk block falls in the Agro-climatic Zone III A. Rangachowk block is producer of several crops such as paddy, miaze, arhar, mung ands urad during Khaif season. Wheat, maize, barely, pulses and oil seeds during Rabi season and summer season. Cereal are the major crops in the block.

Table-5: Area under different crops in Rangachowk Block

Crops	Cropped Area (ha)	Kharif (ha)	Rabi (ha)	Summer Rabi (ha)
Coarse Cereal	10003.2	4617.6	3825.6	1560
Pulses	1184.4	408	164.4	612
Oil Seeds	256	22	234	0

Source: District Irrigation Plan, 2019

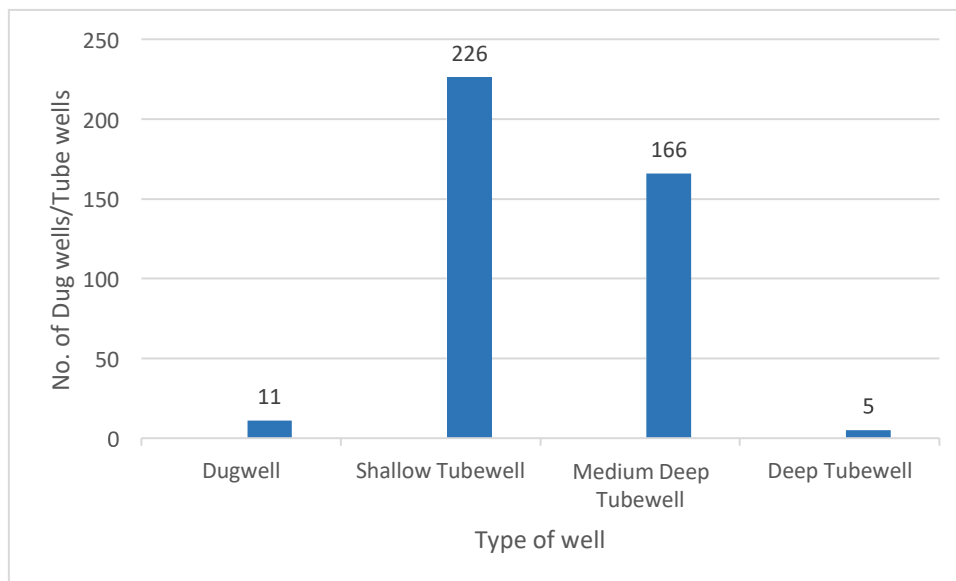
Surface irrigation network comprises canal irrigation, tanks, surface flow and lift irrigation. A considerable area is brought under irrigation by numbers of tanks.

Ground water irrigation is limited and is accomplished mainly through dug wells, shallow tube wells, medium deep tube wells and limited numbers of deep tube wells. Shallow tube wells are limited to the depth of 0-35 m bgl. Ground water extraction for irrigation use is 568.5 ham.

Table-6: Block level statistics of no. of tubewells for irrigation use as per 5th MI Census

Block Name	Dugwell	Shallow Tube well			MediumDeep Tube well	Deep Tube well
	No.	0-20 m depth	20-35 m depth	35-40 m depth	No.	No.
Rangachowk	11	97	129	-	166	5

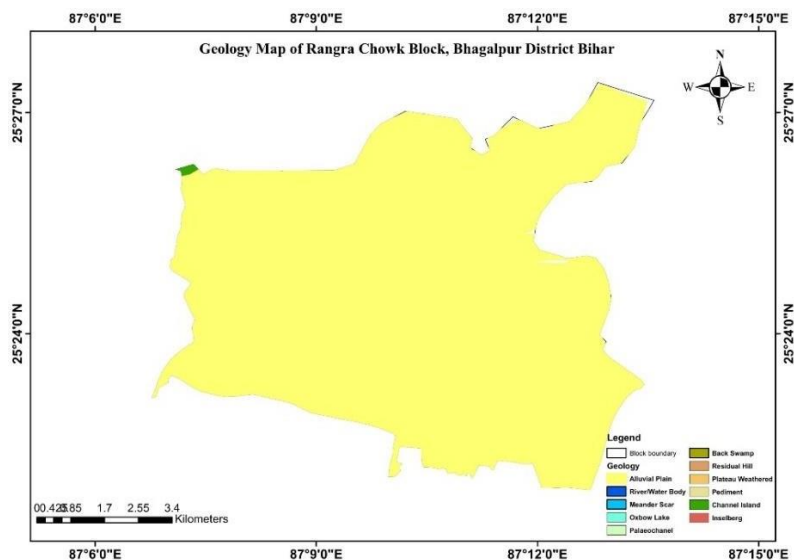
Source: 5th Minor Irrigation Census, 2013-14)



(Fig-7: Number of minor irrigation structures in the Rangachowk Block)

2.0 Geology

Major part of the block is covered by Diara formation, Ganga-kosi formation and Belhar formation of Middle to Late Holocene age. The Diara formation is represented by un-oxidised grey sand, silt and clay of the present day flood plain, channel bares, levees and back swamps, The Ganga-kosi formation is represented by fine to medium sand, silt and clay inundated in rainy season, bank erosion and redeposition and The Belhar formation is represented by silty loam with sand, feebly oxidized.



(Fig-8: Geology of Rangrachowk Block)

3.0 Hydrogeology

Considerably thick sand layers with intermittent clay in the Quaternary Alluvium (mostly younger) of Late Holocene age form the main source of ground water in the block. Based on the strata logs and hydrogeological properties, the aquifer system in the district can be divided into three categories,

- i. The 1st aquifers within 20 m depth.
- ii. The 2nd aquifers within 40-60 m depth.
- iii. The 3rd or deeper aquifers within 60-100 m depth.

In shallow aquifers, the ground water occurs under unconfined condition and in deeper under semi-confined conditions. The shallow aquifers consisting of fine to medium sand with clay. The deeper aquifers mainly consist of sand with alternating layers of clay.

Hydrogeologically the Rangachowk block is underlain by porous, unconsolidated formation. The unconsolidated formation comprises clay, silt and different grades of sand down to depth of 108 m. The thick granular sand zone constitute potential aquifer system. The shallow aquifer is mainly under phreatic condition whereas differ part is under semi-confined to confined condition. The exploratory well data of CGWB, reveals that tube wells of 50 m depth yield at 50.8 m³/hr with drawdown 18.84 m. The transmissivity of the aquifer varies 205.57 m²/day, specific capacity 2.64 m³/hr/m and storativity is 1.0 x 10⁻³.

3.1 Aquifer Disposition and Characteristics

Aquifer disposition of the area has been studied from the existing lithological data. The lithological cross section, across the block represents multiple aquifer system up to depth of 108 m.

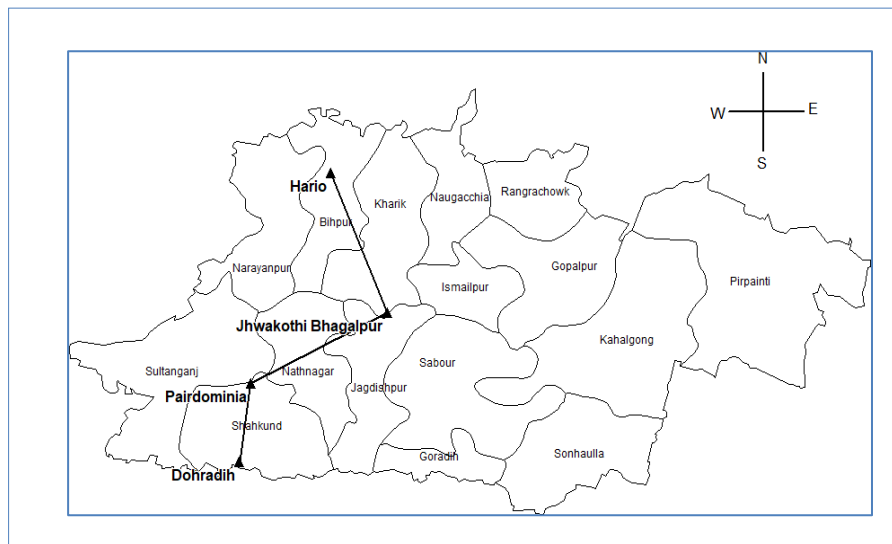


Figure-9(a): Location Map of the bore holes in Bhagalpur District

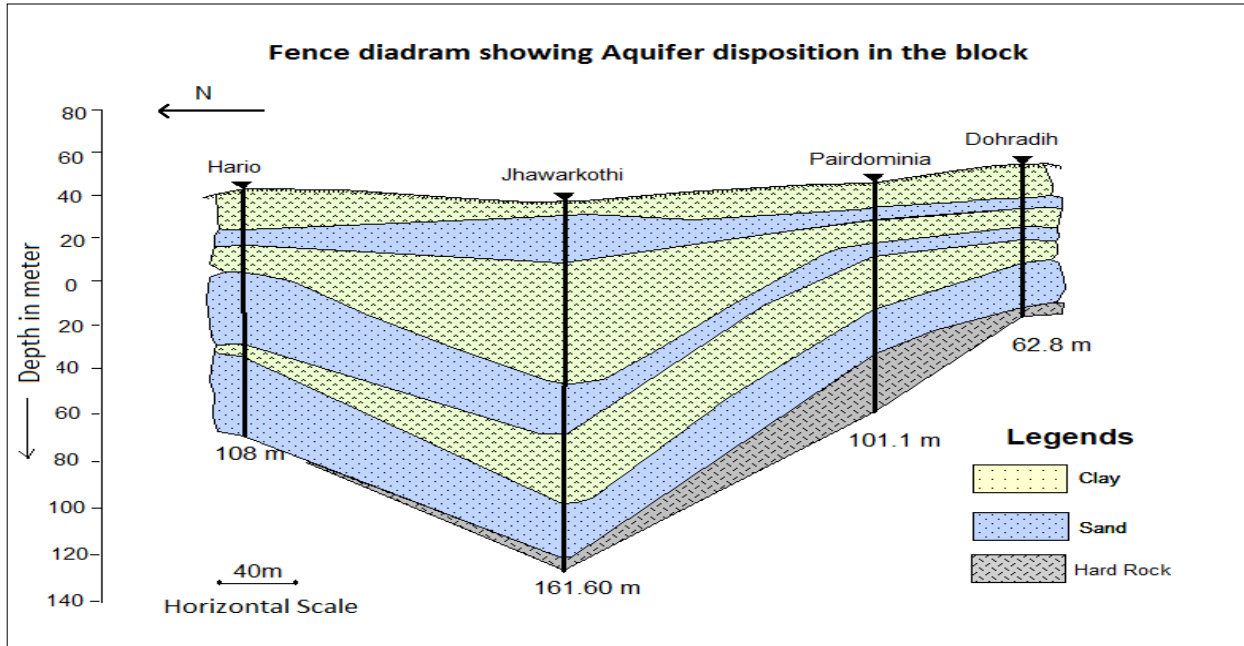


Figure-9(b): Fence diagram showing Aquifer disposition in the Block

3.2 Depth to Water Level

The groundwater regime of the block has been monitored from the existing network monitoring wells and inventoried observation wells. Observation wells are private, dug wells, piezometer of minor irrigation department, Government of Bihar. The average depth of dug wells is 8 m bgl. Piezometers are on an average 50 m bgl depth whereas the PHED deep tubewells are in general, deeper 120 m bgl. The pre monsoon water level in dug well zone 6-7 m bgl and in post monsoon water level varies from 3-4 m bgl. Comparatively deeper water level 4-8 m bgl is reported from the deep tubewells of PHED. Ground water level fluctuation 2-4 m in general reflects more or less uniform and low fluctuation, (Fig- 10a-c).

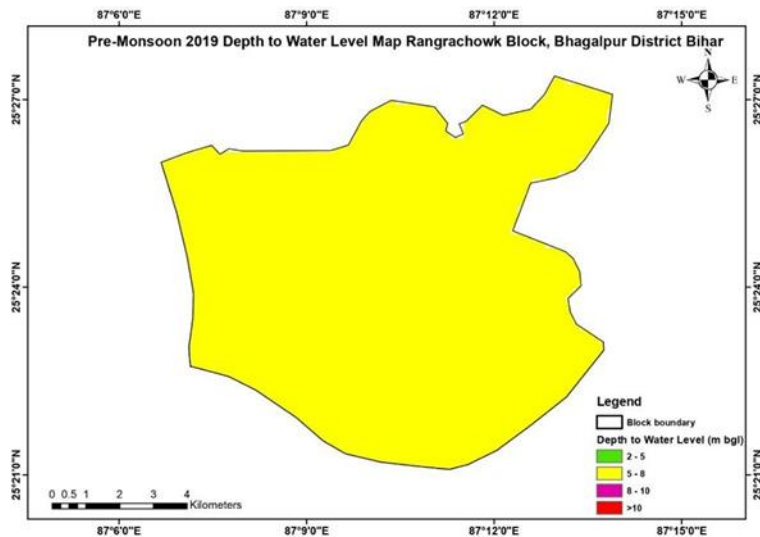


Figure-10(a): Pre monsoon water level

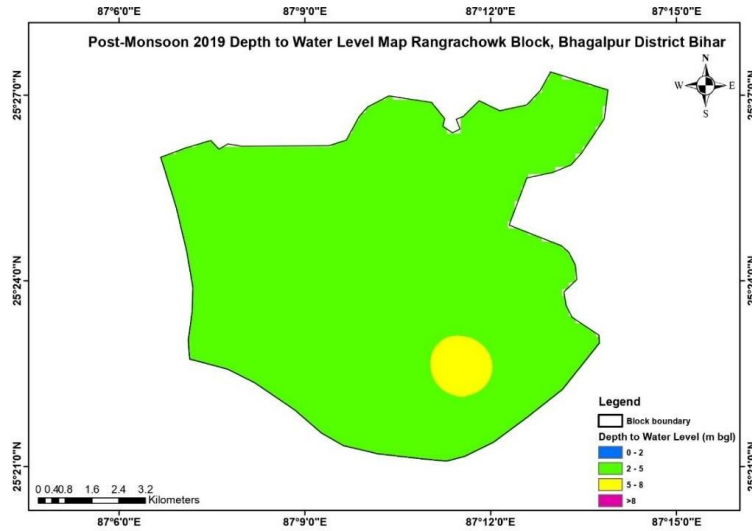


Figure-10(b): Post monsoon water level

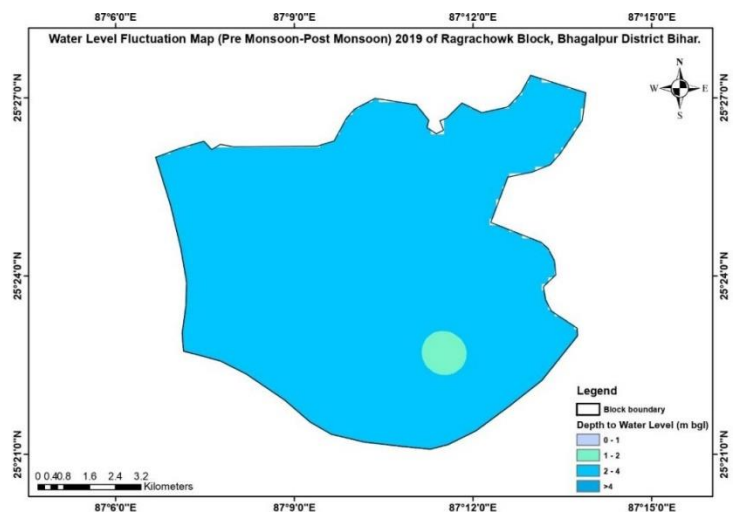


Figure-10(c): Fluctuation of water level

3.3 Ground Water Flow

Water table map has been prepared from the elevation and depth to water level data of the observation wells. In a groundwater regime, equipotential lines, the line joining points of the equal head on the potentiometric surface, were drawn based on the area of variation of the head of an aquifer. Based on the Water table elevation, ground water flow directions (from S-N) are demarcated in *Fig-11*. It has been observed that the ground water flow directions follow the major drainage channels and topography of the area. This indicates the topographic control for the ground water movement.

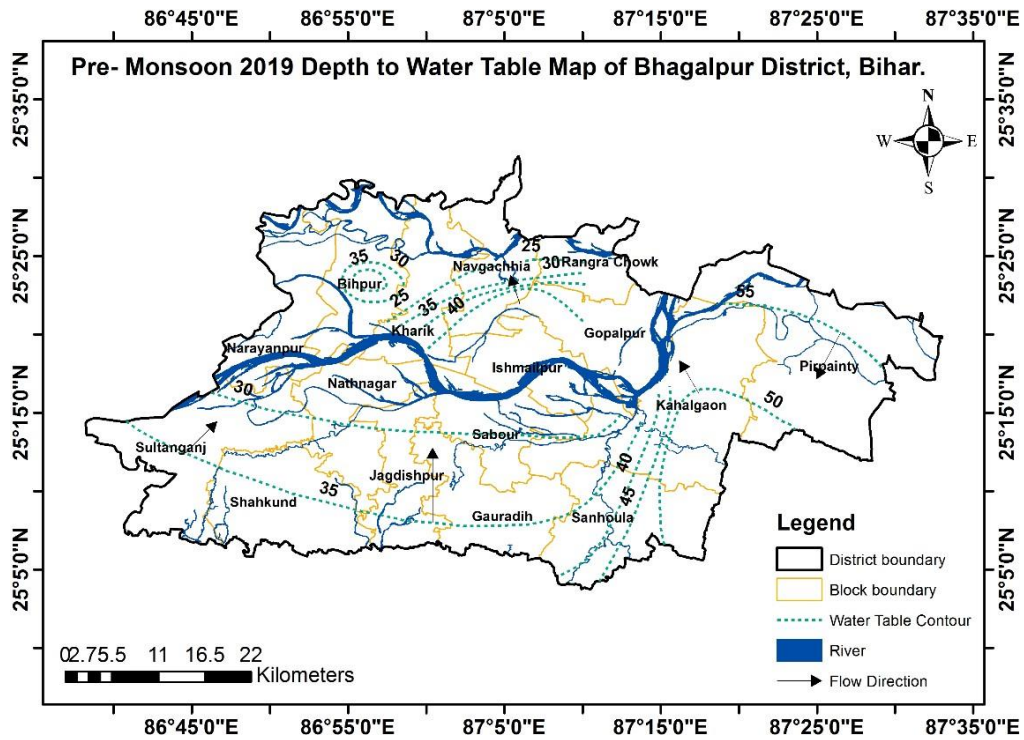


Figure-11(a): Pre monsoon water table

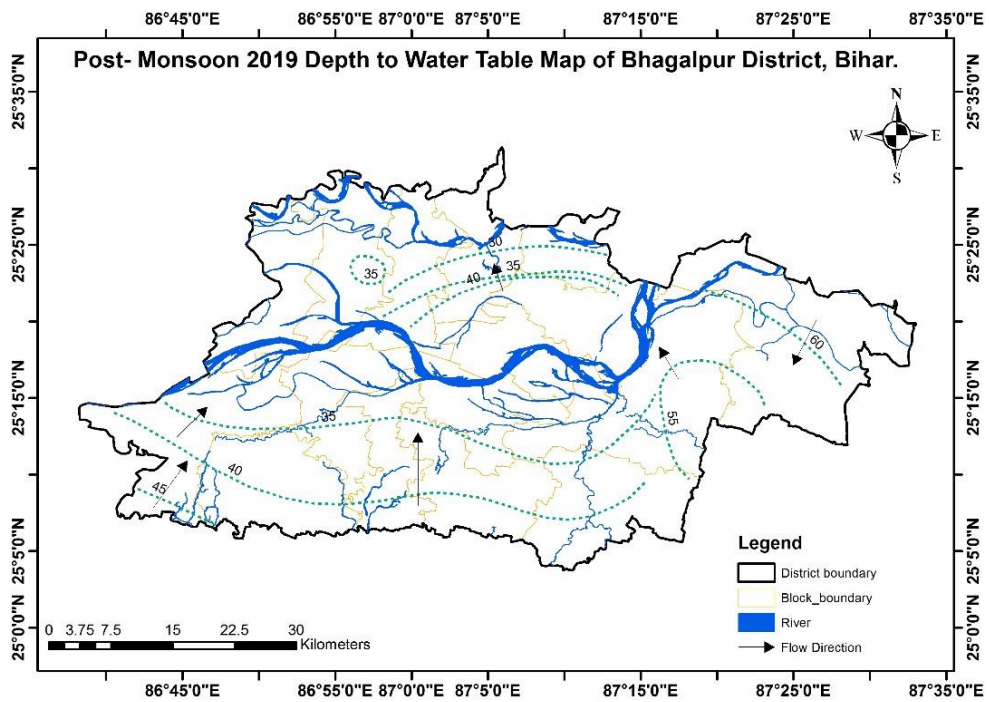


Figure-11(b): Post monsoon water table

Table-7: Depth to water level of pre monsoon and post monsoon of Rangrachowk Block

Block	Type of well	Location	Latitude	Longitude	Depth of well (m)	RL(m)	Depth to Water Level (m bgl)		Fluctuation (m)	Water Table (amsl)	
							Pre monsoon	Post monsoon		Pre monsoon	Post monsoon
Rangrachowk	DW/NHS	Primary School, Kursela	25.3987	86.1719	7.4	33	5.77	2.10	3.67	27.23	30.90
Rangrachowk	PHED_DTW	PHED water supply	25.3941	87.1940	101	34.1	5.86	2.75	3.11	28.24	31.35
Rangrachowk	PZ	BDO office	25.2400	86.9300	50	45	7.28	5.57	1.71	37.72	39.43

4.0 Ground Water Resources

About 4.98 % of the net ground water availability of Bhagalpur district is available in Rangrachowk block only. The SOD is 22.67 % whereas of the district SOD is 27.87%. Total ground water resource of the block is 3532.12 ham and the total ground of draft of the block is 720.6 ham. The block comes under “Safe” category, says that there are sufficient scope for ground water development.

Table-8: Ground Water Resources estimation -2020

District	Block	Recharge from Rainfall during Monsoon season (ham)	Recharge from Rainfall during Non-Monsoon season (ham)	Recharge from Other Sources during Monsoon season (ham)	Recharge from Other Sources during Non-Monsoon season (ham)	Total Annual Ground Water Recharge (ham)	Total Natural Discharges	Annual Extractable GW Resource (ham)	GW Extraction for Irrigation (ham)	GW Extraction for Industrial (ham)	GW Extraction for Domestic (ham)	Total Extraction (ham)	Net GW Availability for Future Development (ham)	Stage of Ground Water Development(ham)	Category: Safe / Semi-critical/ Critical/ Over-exploited
Bhagalpur	Rangrachowk	2958	317	134	122	3532	353	3179	569	27.0	125	720.6	2443	23	Safe

5.0 Chemical quality of Ground Water

Result of chemical analysis (2019) of ground water (sample collected during May 2019) of shallow aquifer of nearby Block of Rangrachowk block is given in the table below. In general water of shallow aquifer is potable. Arsenic contamination in ground water above permissible limit has been reported from Madrauni Chawk village area in the block where 19 ppb arsenic has been recorded.

Table-9: Chemical quality of Ground Water of Rangrachowk Block

Location	pH	EC	TH	Ca	Mg	Na	K	HCO ₃	Cl	SO ₄	NO ₃	F	TDS
Rangrachowk	7.8	668	305	102	12	15.3	1.2	214	43	40	25	0.81	401

6.0 Management Plan

6.1. Supply side intervention in Agriculture and Irrigation

From the existing land/agriculture and irrigation practices it is understood that the block is principally agricultural depending. However, the average cropping intensity is recorded as 124.25%. It reveals that considerable cropped area is not under assured irrigation coverage. The dynamic ground water resource reports stage of development is 22.67 % which indicates there exists further scope of ground water development in the block both for agriculture and drinking/domestic purposes. 5th MI Census data shows that majority of irrigation tube wells accompanied within the depth of 50 m. Therefore, further development may be planed from the deeper part as well.

Considering projected 70% development 1504.637 ham further resources may be developed safely for irrigation development. This balance resource is recommended for development through STW/DTW as per the prevailing terrain condition and hydrogeology of the area. Considering unit draft of 2.4 and 4.8768 ham for STW and DTW respectively following number of irrigation structures have been proposed. Thus in Rangrachowk block 470 STW and 77 DTW may be constructed. (Table10).

Table-10(a): Additional resource for 70% development

Assessment Unit Name	Total Area of Assessment Unit (Ha)	Recharge Worthy Area (Ha)	Annual Extractable Ground Water Resource (Ham)	Total Extraction (Ham)	Draft for 70% development (Ha m)	Additional resource available for 70% development (Ham)
RANGRA CHOWK	11994	11994	3178.91	720.6	2225.237	1504.637

Table-10(b): Recommended number of structures for further irrigation development

Additional resource available for 70% development (Ham)	Resource allocated for development by STW (Ham)	Resource allocated for development by DTW (Ham)	Unit draft of STW (Ham)	Unit draft of DTW (Ham)	No. of STW proposed	No. of DTW proposed
1504.637	1128.478	376.1593	2.4	4.8768	470	77

6.2 Supply side intervention through Artificial Recharge and rain water harvesting

As per the proposed ARMP of Bihar state, considering the post monsoon water level and long term water level trend, no such area has been delineated for implementation of AR structures in the block. However, based on the local hydrological situation and site specific development scenario artificial recharge and water harvesting techniques may be practiced for efficient and sustainable management of ground water resources in the block. In Rangrachowk urban area, roof top rain water harvesting may be practiced for water conservation. The gram panchayat buildings, schools, Govt. buildings etc. may beshortlisted, in phases, for implementation of roof top rain water harvesting.

6.3 Demand side intervention

Considering the area being high potential in terms of ground water resources, water intensive crops like paddy , wheat may be encourage along with the other crops. This may create further irrigation potential in the block. Suitable crop rotation may be practiced. Conjunctive use of surface and ground water may be practiced.

Arsenic contamination in ground water is reported with more than the permissible limit from few area in the block. The Madrauni chawk village has been reported with 19 ppb contamination. Therefore, the water samples of the tube wells may be tested for chemical analysis before utilization in the block. Deeper aquifer may be targeted for arsenic free water with cement sealing techniques. Domestic and community level arsenic removal plant and awareness generation through capacity buildings may be suitable mitigation.

AQUIFER MAPS AND MANAGEMENT PLAN OF SHAHKUND BLOCK, BHAGALPUR DISTRICT, BIHAR

1. Salient Information

Name of the	Shahkund/168.18 sq km
Block/Area	
District/State	Bhagalpur/Bihar
Population	Total- 225325 Rural- 225325 Urban- 0
Rainfall	Normal Monsoon- 977.3 Non-monsoon rainfall- 231
Agriculture and Irrigation	Principal crops - Rice – Wheat, Rice – Gram, Rice – Pulses, Rice – Rai. Gross cropped area- 17021.1 Net sown area- 12998.89 Irrigation practices- Surface water by canal -Ground water by tube well and DW Cropping intensity- 131 %, Number and types of abstraction structures – DW- 26, STW- 821, MDTW-55, DTW-1
Geology	Quaternary alluvium- Diara and Belhar formation
Geomorphology	Major Physiographic units- Alluvial plain Major Drainage- Ganga, Badua-Koa Sub basin
Ground water resource availability and extraction	Annual Ground Water Resource (Ham)-4848.42 Net Ground Water Availability for future use (Ham)- 3123.85 Ground water extraction (Ham)- 1691.84 Sod: 34%; safe
Existing and future	1691.84 Ham/296.38 Ham (annual GW allocation

water demand for domestic as on 2025)

Water level behaviour Pre-monsoon SWL- 4.32-6.65 mbgl

Post-monsoon SWL- 2-3.10 mbgl

2. Aquifer Disposition

Number of Aquifers 02; up to the explored depth of 70 m

Aquifer disposition and basic characteristics 1st aquifers within 30 m depth fine sand mostly phreatic

2nd aquifers within 30-70 m depth medium to coarse sand, semi-confined to confined.

3. Ground water resource, extraction, contamination and other issues

GW Safe

Resource/Categorization

Availability Potable

Chemical quality of ground water and contamination

4. Supply Side Interventions

Ground Water Development Strategies- Number of STW and DTW may be proposed for irrigation uses- STW-532, DTW-44

Aquifer wise space available for recharge and proposed interventions As per ARMP, 2020, for Bhagalpur district 385.41 sq km is suitable for recharge. Percolation tank-8, Gully plug-471, Contour bunding & Trenching-764, Check dam-22, Nala bunding-37, Recharge shaft-86, Desilting of existing tanks-157 and injection well-210 etc. are some suitable structures in the area

5. Demand side interventions

Advanced Irrigation Practices

Project based drip/sprinkler irrigation, lining of field channels etc.

Change in cropping pattern

Water intensive crops like paddy etc. may be practiced. Less water intensive crop like pulses, oilseeds may be encouraged for creation of more irrigation potential.

Alternate water sources

Conjunctive uses of groundwater/surface water sources,

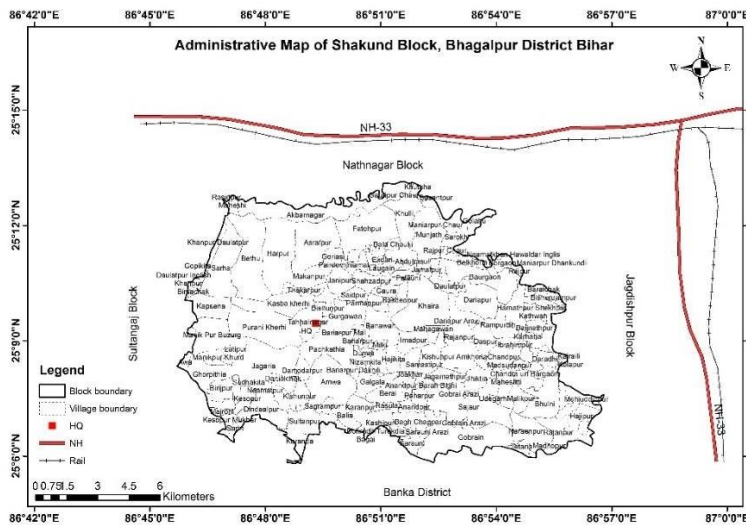
Regulation and Control

Capacity building for awareness generation for fluoride/arsenic contamination.(if needed)

1.1 General Information

1.Area	in Sq. Km	:	168.18
2.No. of revenue village		:	168
3.Population (2011)	Total	:	2,22,325
	Rural	:	2,22,325
	Urban	:	—
4.Normal annual rainfall (District)	(mm)	:	1098
5.Basin / Sub-basin		:	Badua-Koa Sub-basin
6.Location Latitude		:	25°15'40.49" N to 25°27'31.56" N
Longitude		:	87°07'1.00" E to 87°16'42.71" E

The Shakhund block of Bhagalpur district is surrounded in east by Jagdishpur block, in the north-east by Bihpur block, in the north by Narayanpur block, in the north-west by Sultanganj block and in the south by Banka district (Fig:1). Block headquarter of Shakhund is Shakhund town. It belongs to Bhagalpur division. Bhagalpur city, Amarpur city, Kharagpur city are the nearby cities to Shakhund. Sarhi is the smallest village and Gobrain is the biggest village. Bhagalpur (Bhagdattpuram), Sahibganj, Munger , Deoghar (Baba Dham) , Dumka are the nearby important tourist destinations. Maithili is the local language , people also speaks



Hindi, Urdu.

Fig-1, Administrative Map of Shakhund Block, Bhagalpur District

1.2 Basic Demographic Detail of Shahkund block as per 2011 census data

Total population of Shahkund block 222325 among which 100033 is male population, 88046 is female population and 34246 is child population. Number of household is 35689. There are 19 gram panchayats and 168 villages in the Shahkund block, (Table-1 and 2).

Table-1: Demographic distribution of Shahkund Block

<i>Block</i>	<i>No. of Household</i>	<i>Males</i>	<i>Females</i>	<i>Child</i>	<i>Total</i>
Shahkund	35689	100033	88046	34246	222325

Source: Census 2011

Table-2: Panchayat wise village in Shahkund block

<i>S.No.</i>	<i>Panchayat</i>	<i>Villages</i>
1	Belthu	3
2	Kaswakheri	8
3	Amba	11
4	Khaira	6
5	Daspur	11
6	Hajipur	3
7	Gobaray	5
8	Bholni	12
9	Saroni	12
10	Khulni	18
11	Paeldominiyahal	6
12	Saroj	5
13	Makandpur	3
14	Basodeopur	16
15	Harnadh	6
16	Dariyapur	17
17	Dindayalpur	9
18	Jagarlya	10
19	Kishanmkhoriya	7
	Total	168

Source: Census 2011

Distribution of persons engaged in agriculture and other workers/ non workers in the block

In Shahkund block, 63% of total population is non workers. It is evident from diagram given below, that 22% of the total population in the block is engaged in agriculture, 4% engaged as cultivator, 3% comprises household industrial workers and 3% comprises other worker, (Fig-2).

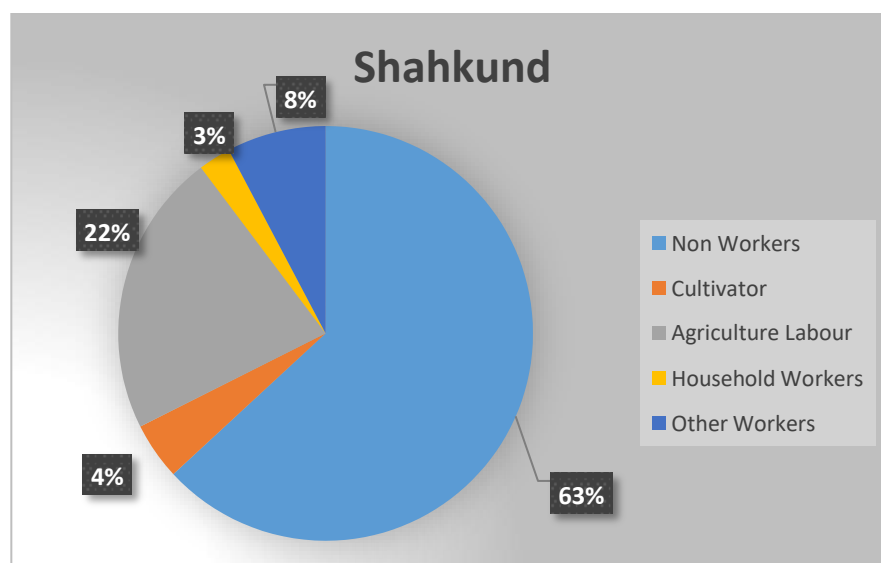


Fig-2, Demographic classification of Shahkund Block, Bhagalpur District

Source: Census 2011

1.3 Rainfall and Temperature

Normal annual rainfall of Shahkund block is 1098 mm of which 80% occurs during the monsoon season. The normal rainfall during monsoon season is 977.3 mm and during non-monsoon season is 231 mm. The temperature varies from 45 to 50°C.

1.4 Soil

Shahkund block contains mainly fine sandy loamy soil.

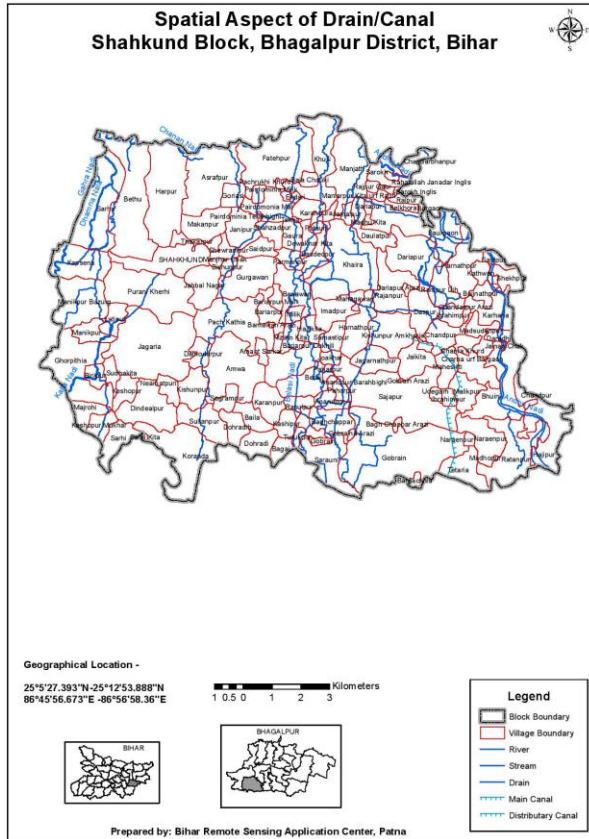
Table-3: Soil type

Block	Soil Type
Shahkund	Fine sandy loamy Soils, Clayey Soils

Source: District Irrigation Plan, 2019

1.5 Physiography, Basin/sub-basin, Drainage

The Shahkund block is situated in south part of Bhagalpur District. Shahkund forms part of Badua-Koa Sub-basin. Dendritic and parallel to sub-parallel drainage patterns are dominating in this region. Shahkund block has average elevation 42m. Chandan, Ghaghra, Kallanadi, Belasi and Andhari Rivers are flowing in this block.

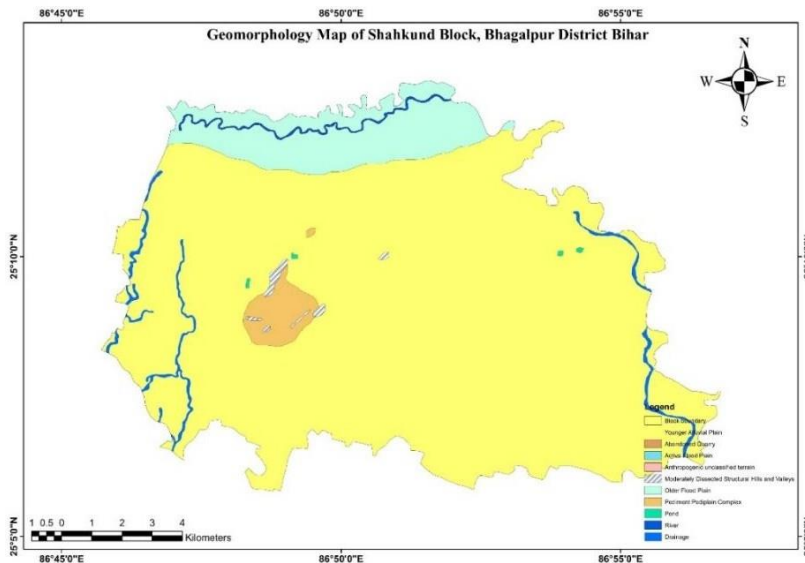


(Fig-3: Drainage and canal network in Shahkund Block)

Source: District Irrigation Plan, 2019

1.6 Geomorphology

The Shahkund block is a part of Indo-Gangetic alluvium plain, having flat or gentle slope. Quaternary alluvium plain of fluvial origin covers the major part of the block.



(Fig-4: Geomorphological map of Shahkund Block)

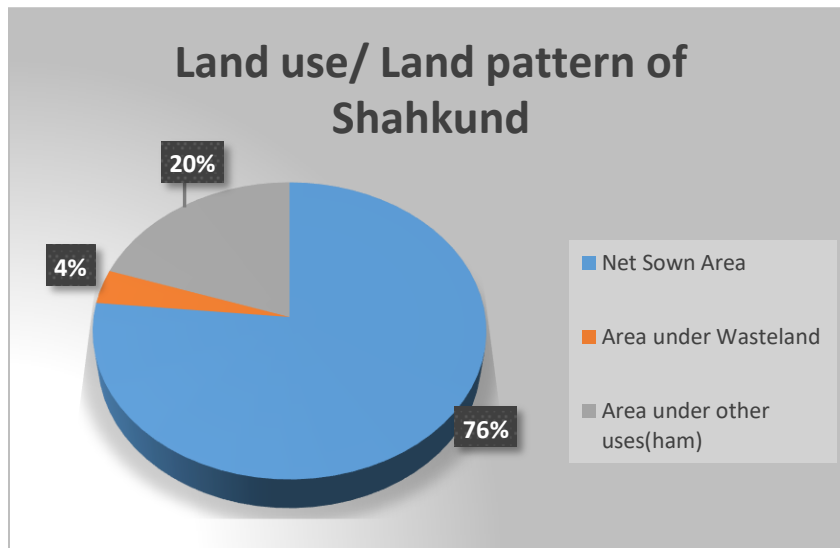
1.7 Land use / Land Cover

Total geographic area of the Shahkund block is 16818.00 ha. Shahkund block has net sown area is 12998.89 ha and gross cropped area is 17021.13 ha. Therefore area under multiple cultivation is 4022.24 ha area and 624.37 ha area is under wasteland. It is evident that net sown area is 77.29 %, area under multiple cultivation is 23.92 % and wasteland is 3.71 % of total geographical area. The cropping intensity of the block is 131 %.

Table-4: Land use/Land Pattern of Shahkundh Block

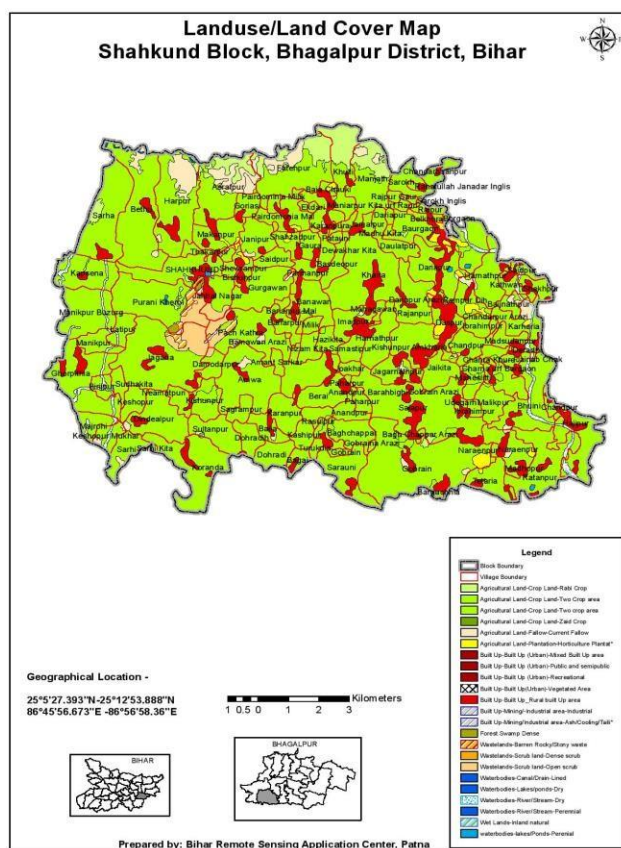
Name of the Block	No. of Gram Panchayat	Total Geographical Area (ham)	Gross cropped Area (ham)	Net Sown Area (ham)	Area Sown more than once (ham)	Area under Forest (ham)	Area under Wasteland (ham)	Cropping Intensity (%)
Shahkund	19	16818	17021.13	12998.89	4022.24	0	624.37	131

Source: District Irrigation Plan,2019



(Fig-5: Land use and Land cover of in Shahkund Block)

Source: District Irrigation Plan,2019



(Fig-6: Land use and Land cover of in Shahkund Block)

Source: District Irrigation Plan, 2019

1.8 Agriculture and Irrigation

Agriculture is the main stay of the people living in Shahkund block, which is evident from census figures of 2011. Shahkund block falls in the Agro-climatic Zone III A. Shahkund block is producer of several crops such as paddy, maize, arhar, mung and urad during Kharif season. Wheat, maize, barely, pulses and oil seeds during Rabi season and Summer Rabi season. Cereals are the major crops in the block.

Table-5: Area under different crops in Shahkund Block

Crops	Cropped Area (ha)	Kharif (ha)	Rabi (ha)	Summer Rabi (ha)
Coarse Cereal	18296	12632.4	5529.2	134.4
Pulses	1455	431.4	330	693.6
Oil Seeds	363	15	348	0

Source: District Irrigation Plan, 2019

Surface irrigation network comprises canal irrigation, tanks, surface flow and lift irrigation. A considerable area is brought under irrigation by numbers of tanks.

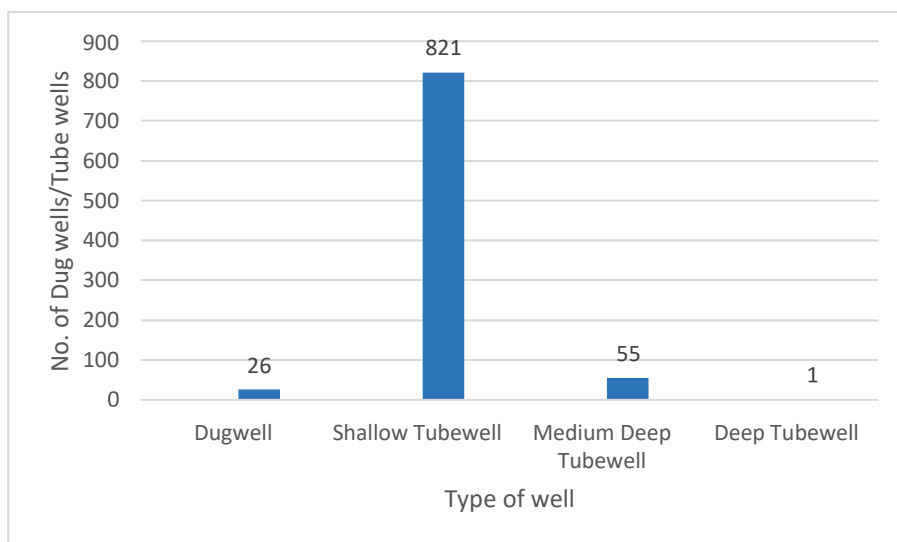
Ground water irrigation is limited and is accomplished mainly through dug wells, shallow tube wells,

medium deep tubewells and limited numbers of deep tube wells. Shallow tube wells are limited to the depth of 0-35 m bgl. Ground water extraction for irrigation use is 1365 ham.

Table-6: Block level statistics of no. of tubewells for irrigation use as per 5th MI Census

Block Name	Dugwell	Shallow Tubewell			Medium Deep Tubewell	Deep Tubewell
	No.	0-20 m depth	20-35 m depth	35-40 m depth	No.	No.
Shahkund	26	264	557	-	55	1

Source: 5th Minor Irrigation Census, 2013-14



(Fig-7: Number of minor irrigation structures in the Shahkund Block)

2.1 Geology

Major part of the block is covered by Diara formation, Belhar formation of Late Pleistocene to Holocene age and Munger Group of Archean to Lower Proterozoic age. The Diara formation is represented by unoxidised grey sand, silt and clay of the present day flood plain, channel bares, levees and back swamps, the Belhar formation is represented by silty loam with fine sand, feebly oxidized and Munger Group is represented by quartzite, quartz-sericite gneiss, slate and phyllite.

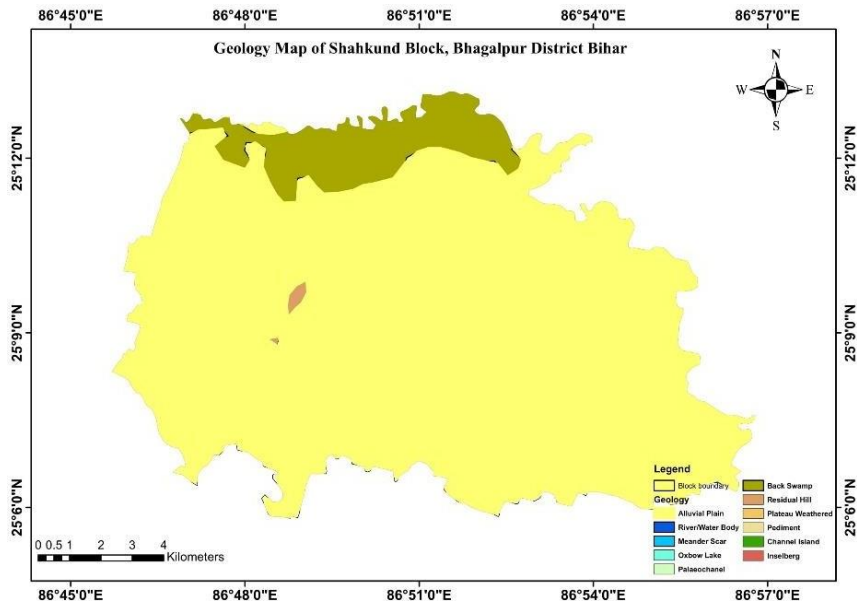


Fig-8: Geology of Shahkund Block

3.0 Hydrogeology

Considerably thick sand layers with intermittent clay in the Quaternary Alluvium (mostly younger) of Late Holocene age form the main source of ground water in the block. Based on the strata logs and hydrogeological properties, the aquifer system in the district can be divided into two categories,

- i. The shallow aquifers within 30 m depth.
- ii. The deep aquifers within 40-70 m depth.

In shallow aquifers, the ground water occurs under unconfined condition and in deeper under semi-confined conditions. The shallow aquifers consisting of fine to medium sand with clay. The deeper aquifers mainly consist of sand with alternating layers of clay.

Hydrogeologically the Shahkund block is underlain by porous, unconsolidated formation. The unconsolidated formation comprises clay, silt and different grades of sand down to depth of 108.11 m. The thick granular sand zone constitute potential aquifer system. The shallow aquifer is mainly under phreatic condition whereas differ part is under semi-confined to confined condition. The exploratory well data of CGWB, reveals that tube wells of 61.28 m depth yield at 41.5 m³/hr with drawdown 21.87 m. The specific capacity 1.90 m³/hr/m and storativity is 2.24 x 10⁻³.

3.1 Aquifer Disposition and Characteristics

Aquifer disposition of the area has been studied from the existing lithological data. The lithological cross section, across the block represents multiple aquifer system up to depth of 108.11 m.

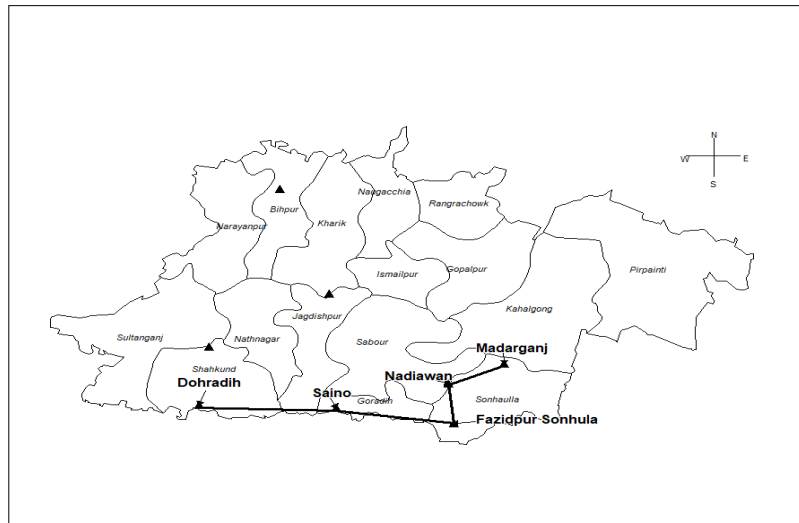


Figure-9(a): Location Map of the boreholes in Bhagalpur District

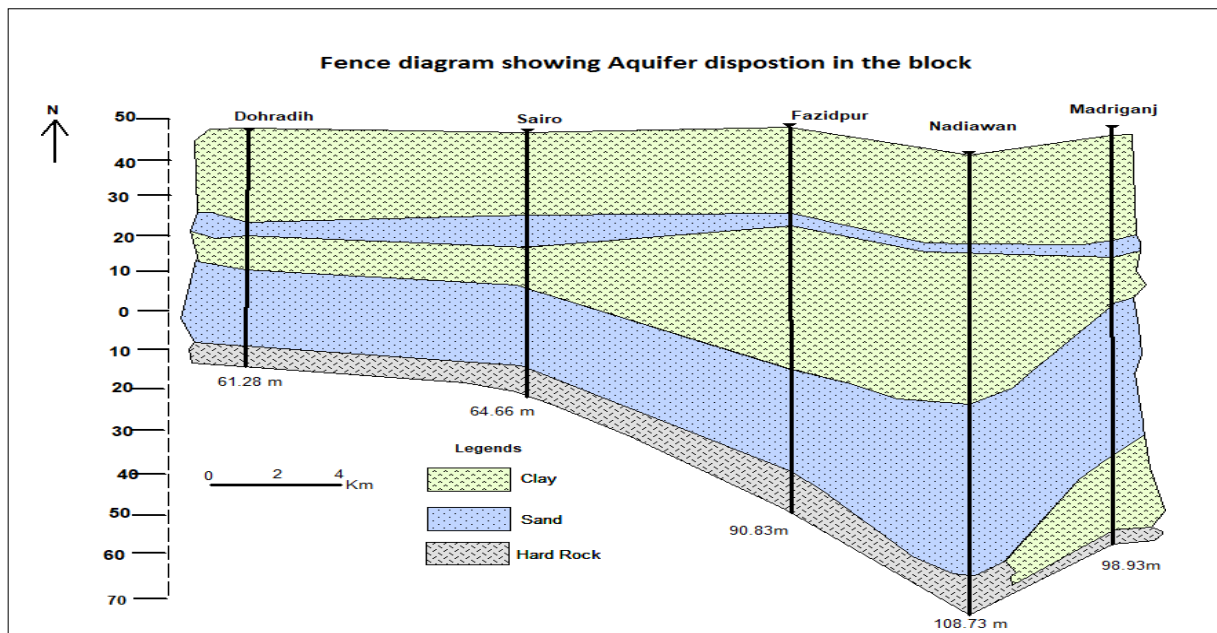


Figure-9(b): Fence diagram showing Aquifer disposition in the Block

3.2 Depth to Water Level

The groundwater regime of nearby area of the Shakkund block has been monitored from the existing network monitoring wells and inventoried observation wells. Observation wells are private, dug wells, piezometer of minor irrigation department, Government of Bihar. The average depth of dug wells is 9 to 10 m bgl. Piezometers are on an average 50 m bgl depth whereas the PHED deep tube wells are in general, deeper (155 m bgl). The pre monsoon water level in dug well zone 4.32-6.65 m bgl and in post monsoon water level varies from 2.00-3.10 m bgl. Comparatively deeper water level 4-8 m bgl is reported from the deep tube wells of PHED. Ground water level fluctuation 2-4 in general reflects more or less uniform and low fluctuation, (Fig-10a-c).

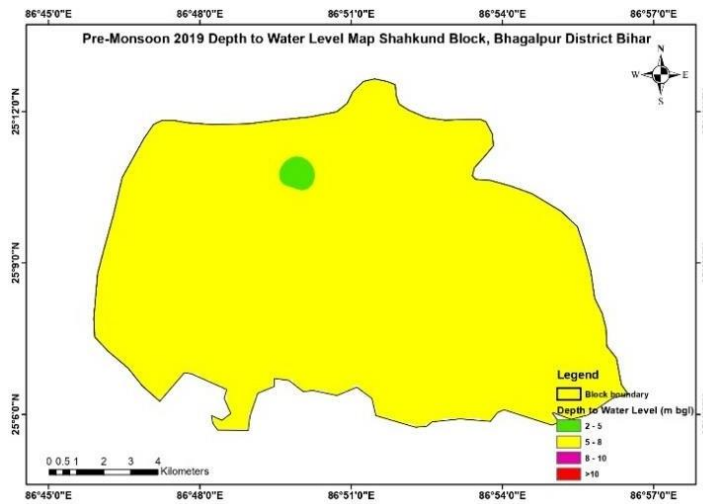


Figure-10(a): Pre monsoon water level

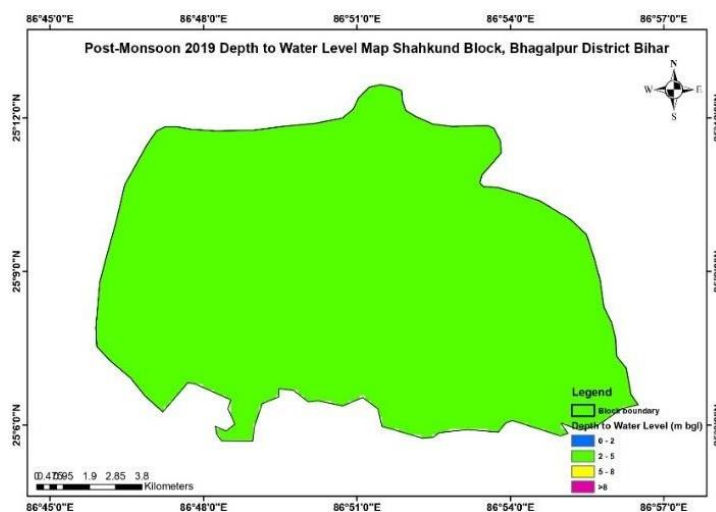


Figure-10(b): Post monsoon water level

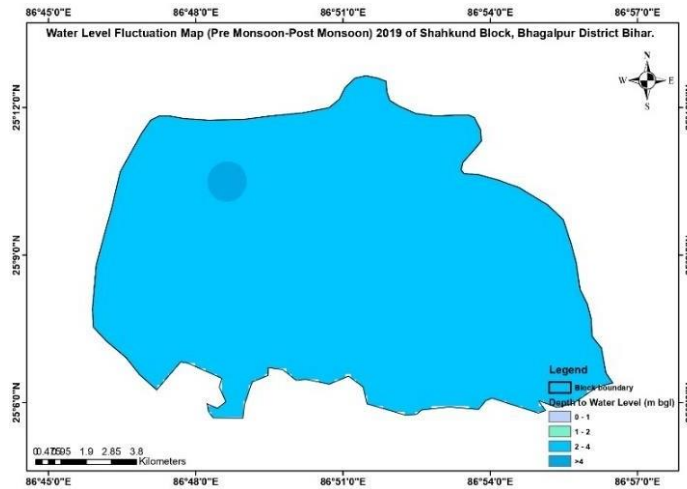


Figure-10(c): Fluctuation of water level

3.3 Ground Water Flow

Water table map has been prepared from the elevation and depth to water level data of the observation wells. In a groundwater regime, equipotential lines, the line joining points of the equal head on the potentiometric surface, were drawn based on the area of variation of the head of an aquifer. Water table elevation in Sakhund block is 30-40 m amsl. Based on the water table elevation, ground water flow directions are demarcated in Fig-11. It has been observed that the ground water flow directions follow the major drainage channels and topography of the area. This indicates the topographic control for the ground water movement.

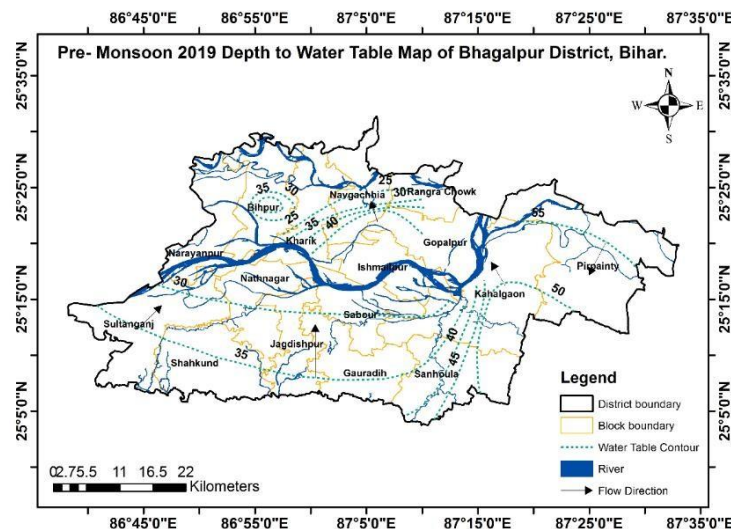


Figure-11(a): Pre monsoon water table

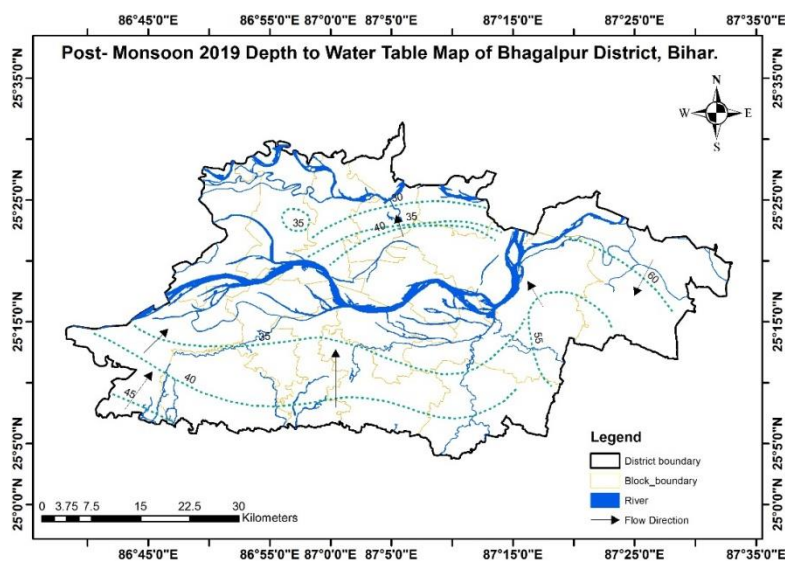


Figure-11(b): Post monsoon water table

Table-7: Depth to water level of pre monsoon and post monsoon of Shahkund Block

Block	Type of well	Location	Latitude	Longitude	Depth of well (m)	RL(m)	Depth to Water Level (m bgl)		Fluctuation (m)	Water Table (amsl)	
							Pre monsoon	Post monsoon		Pre monsoon	Post monsoon
Shahkund	DW/NHS	Within Compound of DB IB	25.1750	86.8125	9.0	38	6.65	2.40	4.25	31.35	35.60
Shahkund	DW	Middle School	25.1730	86.8294	7.25	40	5.53	3.10	2.43	34.87	37.30
Shahkund	PHED_MDTW	Muslim Tola	25.1769	86.8309	95.0	39.3	4.32	2.00	2.32	34.98	37.30
Shahkund	PZ	BDO office	25.1553	86.8491	50	43.9	7.28	4.52	2.76	36.62	39.38

4.0 Ground Water Resources

About 6.38 % of the net ground water availability of Bhagalpur district is available in Shahkund block only. The SOD of the block is 34.00 % whereas of the district SOD is 27.87%. Total ground water resource of the block is 5386.91 ham and the total ground of draft of the block is 1691.84 ham. The block comes under “Safe” category, says that there are sufficient scope for ground water development.

Table-8: Ground Water Resources estimation

District	Block	Recharge from Rainfall during Monsoon season (ham)	Recharge from Rainfall during Non-Monsoon season (ham)	Recharge from Other Sources during Monsoon season (ham)	Recharge from Other Sources during Non-Monsoon season (ham)	Total Annual Ground Water Recharge (ham)	Total Natural Discharges	Annual Extractable GW Resource (ham)	GW Extraction for Irrigation (ham)	GW Extraction for Industrial (ham)	GW Extraction for Domestic (ham)	Total Extraction (ham)	Net GW Availability for Future Development (ham)	Stage of Ground Water Development(ham)	Category: Safe / Semi-critical/ Critical/ Over-exploited
Bhagalpur	Shahk und	4148	445	395.45	398	5387	539	4848	1365	63.00	264	1692	3124	34	Safe

5.0 Chemical quality of Ground Water

Result of chemical analysis (2019) of ground water (sample collected during May 2019) of shallow aquifer of nearby blocks of Shahkund block is given in the table below. In general water of shallow aquifer is potable.

Table-9: Chemical quality of Ground Water of nearby blocks of Shahkund Block

Block	Location	pH	EC	TH	Ca	Mg	Na	K	HCO ₃	Cl	SO ₄	NO ₃	F	TDS
Sultanganj	Akbarnagar	7.0	458	149	9	26	39	1.4	211	19	49.0	7.0	0.49	298
Sultanganj	Sultanganj	7.4	522	172	22	30	49	1.5	244	29	42.0	6.0	0.88	339

6.0 Management Plan

6.1. Supply side intervention in Agriculture and Irrigation

From the existing land/agriculture and irrigation practices it is understood that the Block is principally agricultural depending. However, the average cropping intensity is recorded as 131.00 %. It reveals that considerable cropped area is not under assured irrigation coverage. The dynamic ground water resource reports stage of development is 34% which indicates there exists further scope of ground water development in the block both for agriculture and drinking/domestic purposes. 5th MI Census data shows that majority of irrigation tubewells accompanied within the depth of 50 m. Therefore further development may be planed from the deeper part as well.

Considering projected 70% development 1701.914 ham further resources may be developed safely for irrigation development. This balance resource is recommended for development through STW/DTW as per the prevailing terrain condition and hydrogeology of the area. Considering unit draft of 2.4 and 6.969 ham for STW and DTW respectively following number of irrigation structures have been proposed. Thus in Shahkund block 532 STW and 44 DTW may be constructed. (Table10).

Table-10(a): Additional resource for 70% development

Assessment Unit Name	Total Area of Assessment Unit (Ha)	Recharge Worthy Area (Ha)	Annual Extractable Ground Water Resource (Ham)	Total Extraction (Ham)	Draft for 70% development (Ha m)	Additional resource available for 70% development (Ham)
SHAHKUND	16818	16818	4848.22	1691.84	3393.754	1701.914

Table-10(b): Recommended number of structures for further irrigation development

Additional resource available for 70% development (Ham)	Resource allocated for development by STW (Ham)	Resource allocated for development by DTW (Ham)	Unit draft of STW (Ham)	Unit draft of DTW (Ham)	No. of STW proposed	No. of DTW proposed
1701.914	1276.436	425.4785	2.4	9.696	532	44

6.2 Supply side intervention through Artificial Recharge and rain water harvesting

As per the proposed ARMP of Bihar state, considering the post monsoon water level and long term water level trend, no such area has been delineated for implementation of AR structures in the block. However, based on the local hydrological situation and site specific development scenario artificial recharge and water harvesting techniques may be practiced for efficient and sustainable management of ground water resources in the block. In Shahkund urban area, roof top rain water harvesting may be practiced for water conservation. The gram panchayat buildings, schools, Govt. buildings etc. may be shortlisted, in phases, for implementation of roof top rain water harvesting.

6.3 Demand side intervention

Considering the area being high potential in terms of ground water resources, the additional resources may be utilized for more water intensive crops like paddy, cereals etc. along with the other crops. This may create further irrigation potential in the block. Suitable crop rotation may be practiced. Conjunctive use of surface and ground water may be practiced. Number of blocks in Bhagalpur district has been reported with As or F contamination in ground water, therefore, awareness generations and capacity building for mitigation of the problem due to arsenic and fluoride contamination in ground water may be adopted in community level.

AQUIFER MAPS AND MANAGEMENT PLAN OF SONHAULA BLOCK, BHAGALPUR DISTRICT, BIHAR

1.0 Salient Information

Name of the Block/Area	Sonhaula/174.20 sq km
District/State	Bhagalpur/Bihar
Population	Total- 220189 Rural- 220189 Urban- 0
Rainfall	Normal Monsoon- 977.3 Non-monsoon rainfall- 231
Agriculture and Irrigation	Principal crops - Rice – Wheat, Rice – Gram, Rice – Pulses, Rice – Rai. Gross cropped area- 17156.45 Net sown area- 13135.33 Irrigation practices- Surface water by canal -Ground water by tube well and DW Cropping intensity- 131 %, Number and types of abstraction structures – DW- 26, STW- 467, MDTW-308, DTW-5
Geology	Quaternary alluvium- Belhar, Diara and Sautadih formation
Geomorphology	Major Physiographic units- Alluvial plain Major Drainage- Ganga, Badua-Koa Sub basin
Ground water resource availability and extraction	Annual Ground Water Resource (Ham)-4509.04 Net Ground Water Availability for future use (Ham)- 2985.66 Ground water extraction (Ham)- 1486.4 SOD : 33%; Safe
Existing and future	1486.4 Ham/291.38 Ham (annual GW allocation

water demand for domestic as on 2025)

Water level behaviour Pre-monsoon SWL- 4.42-5.73 mbgl

Post-monsoon SWL- 2-3 mbgl

2. Aquifer Disposition

Number of Aquifers 02; up to the explored depth of 70 m

Aquifer disposition and basic characteristics 1st aquifers within 30 m depth fine sand mostly phreatic

2nd aquifers within 30-70 m depth medium to coarse sand, semi-confined to confined.

3. Ground water resource, extraction, contamination and other issues

GW Resource/Categorization Safe

Availability

Chemical quality of ground water and contamination Potable

4. Supply Side Interventions

Ground Water Development Strategies- Number of STW and DTW may be proposed for irrigation uses-

STW-521, DTW-105

Aquifer wise space available As per ARMP, 2020, for Bhagalpur district 385.41 sq km is suitable for recharge.

for recharge and proposed interventions Percolation tank-8, Gully plug-471, Contour bunding & Trenching-764, Check dam-22, Nala bunding-37, Recharge shaft-86, Desilting of existing tanks-157 and injection well-210 etc. are some suitable structures in the area

5. Demand side interventions

Advanced Irrigation Practices Project based drip/sprinkler irrigation, lining of field channels etc.

Change in cropping pattern Water intensive crops like paddy, wheat may be encouraged along with pulses , oil seeds etc.

Alternate water sources Conjunctive uses of groundwater/surface water sources,

Regulation and Control Capacity building for awareness generation for fluoride/arsenic contamination.(if needed)

General Information

1. Area	in Sq. Km	:	174.20
2. No. of revenue village		:	131
3. Population (2011)	Total	:	2,20,189
	Rural	:	2,20,189
	Urban	:	—
4. Normal annual rainfall (District)	(mm)	:	1180
5. Basin / Sub-basin		:	Badua-Koa Sub-basin
6. Location		:	
Latitude		:	25°03'15.46 "N to 25°11'49.89"N
Longitude		:	87°07'28.57" E to 87°18'59.59" E

Sonhaura block of Bhagalpur district is surrounded in south-east by state boundary of Jharkhand, in the north by Sabour Block, in the west by Goradih block and in the south by Banka district. (Fig:1). Block headquarter of Sonhaura is Sonhaura town. It belongs to Bhagalpur division. Bhagalpur city, Amarpur city, Colgong city, Naugachhia city are the nearby cities to Sonhaura. Mahila is the smallest village and Tarar is the biggest village. Bhagalpur (Bhagdattpuram) , Sahibganj , Munger , Deoghar (Baba Dham) , Pakur (Pakaur) are the nearby important tourist destinations. Maithili is the local language, people also speaks Hindi, Urdu.

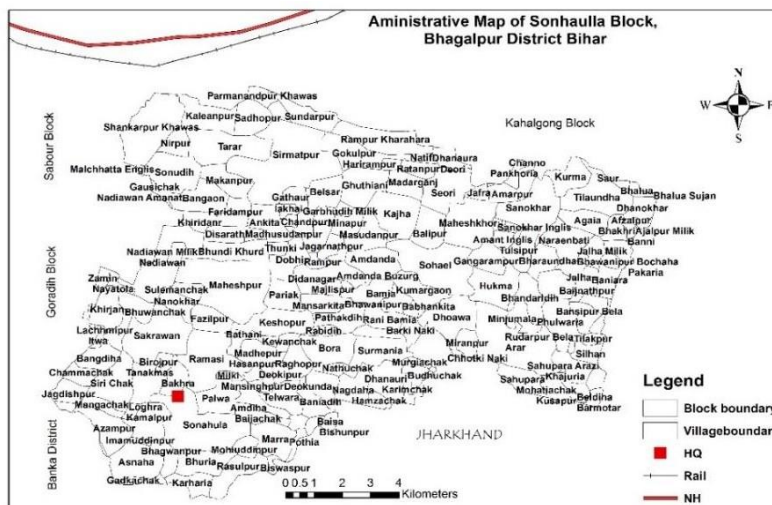


Fig-1, Administrative Map of Sonhaura Block, Bhagalpur District

1.2 Basic Demographic Detail of Sonhaua Block as per 2011 census data

Total population of Sonhaua block 220189 among which 101262 is male population, 81135 is female population and 37792 is child population. Number of household is 35972. There are 18 gram panchayats and 177 villages in the Sonhaua block, (Table-1 and 2).

Table-1: Demographic distribution of Sonhaua Block

Block	No. of Household	Males	Females	Child	Total
Sonhaua	35972	101262	81135	37792	220189

Source: Census 2011

Table-2: Panchayat wise village in Sonhaua Block

S.No.	Panchayat	Villages
1	Tadar	4
2	Maheshpur Ghanshayamchak	7
3	Amdanda	15
4	Fazilpur Sakrama	7
5	Madhopur Bathani	13
6	Kamalpur Srichak	9
7	Sanhaua	8
8	Bhuriya Mahiyama	7
9	Pothia	7
10	Amdiha	7
11	Barinaki	13
12	Borapathakdih	14
13	Madargang	9
14	Dhowabe	9
15	Sanokar	13
16	Telondha	15
17	Arar	6
18	Silhan Khajuria	14
	Total	177

Source: Census 2011

Distribution of persons engaged in agriculture and other workers/ non workers in the Block

In Sonhaua block, 59% of total population is non workers. It is evident from diagram given below, that 27% of the total population in the block is engaged in agriculture, 6% engaged as cultivator, 2% comprises household industrial workers and 6% comprises other worker, (Fig-2).

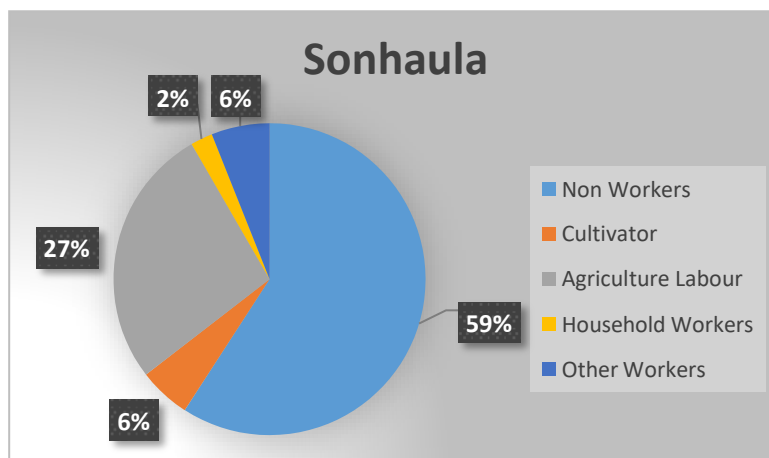


Fig-2, Demographic classification of Sonhaura Block, Bhagalpur District

Source: Census 2011

1.3 Rainfall and Temperature

Normal annual rainfall of Sonhaura block is 1180 mm of which 80% occurs during the monsoon season. The normal rainfall during monsoon season is 977.3 mm and during non-monsoon season is 231 mm. The temperature varies from 45 to 50°C.

1.4 Soil

Sonhaura block contains mainly fine sandy loamy soil

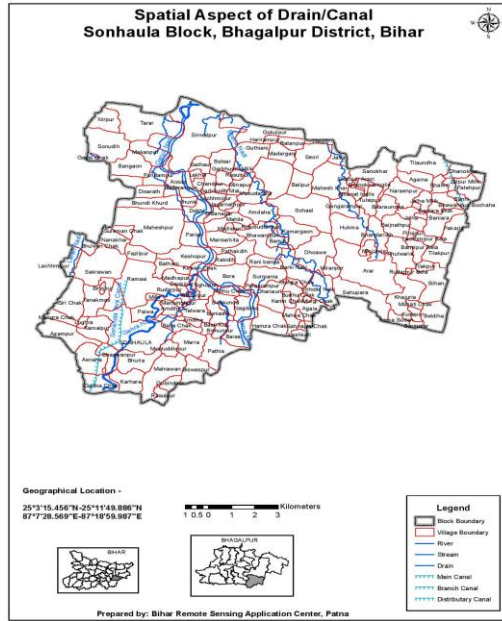
Table-3: Soil type

Block	Soil Type
Sonhaura	Fine sandy loamy Soils, Clayey Soils

Source: District Irrigation Plan, 2019

1.5 Physiography, Basin/sub-basin, Drainage

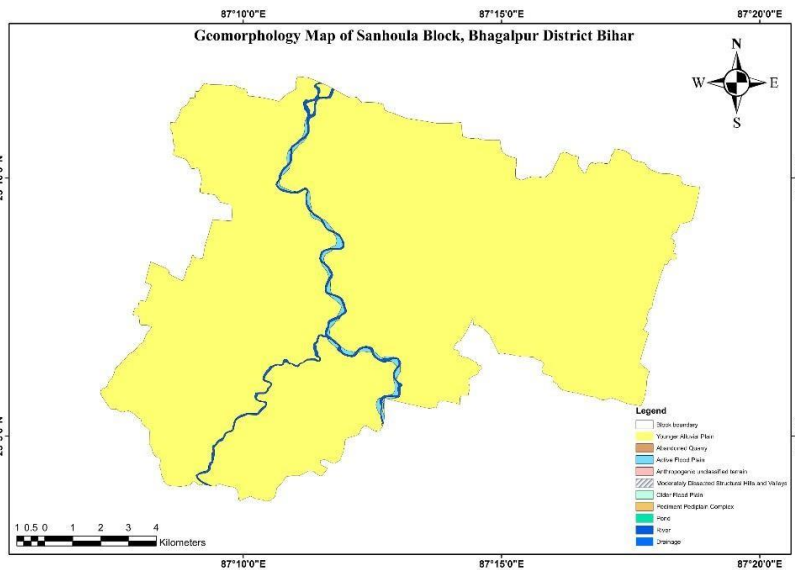
The Sonhaura block is situated in south part of Bhagalpur District. Sonhaura forms part of Badua-Koa Sub-basin. Dendritic and parallel to sub-parallel drainage patterns are dominating in this region. Sonhaura block has average elevation 42m. Gerua, Bhenra, Gohra and Laran Rivers are flowing in this block.



(Fig-3: Drainage and canal network in Sonhaua Block)
 Source: District Irrigation Plan, 2019

1.6 Geomorphology

The Sonhaua block is a part of Indo-Gangetic alluvium plain, having flat or gentle slope. Quaternary alluvium plain of fluvial origin covers the major part of the block. A small part of the block is covered under water bodies.



(Fig-4: Geomorphological map of Sonhaua Block)

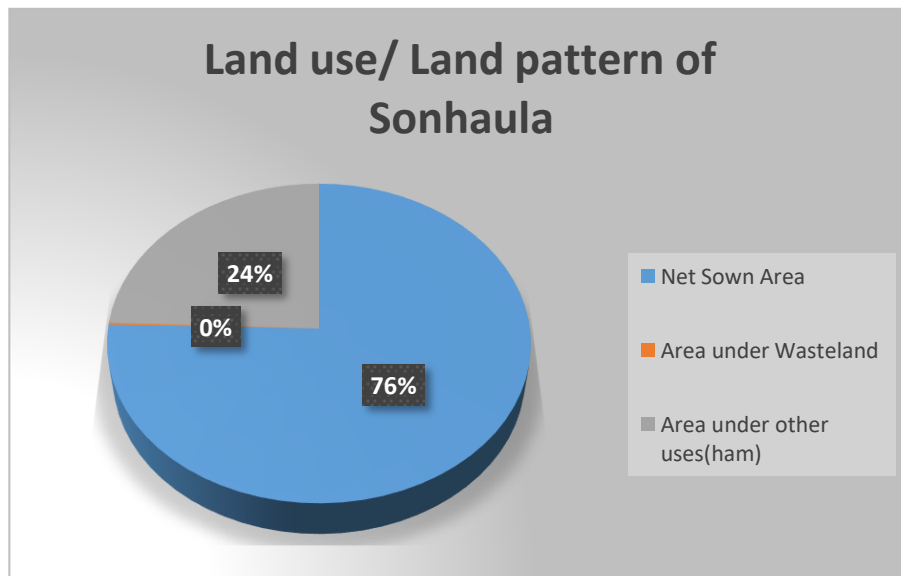
1.7 Land use / Land Cover

Total geographic area of the Sonhaura block is 17420.00 ha. Sonhaura block has net sown area is 13135.33 ha and gross cropped area is 17156.46 ha. Therefore area under multiple cultivation is 4021.12 ha area and 595 ha area is under wasteland. It is evident that net sown area is 76.00 %, area under multiple cultivation is 23.08 % and wasteland is 0.19 % of total geographical area. The cropping intensity of the block is 131.00 %.

Table-4: Land use/Land Pattern of Sonhaura Block

Name of the Block	No. of Gram Panchayat	Total Geographical Area (ham)	Gross cropped Area (ham)	Net Sown Area (ham)	Area Sown more than once (ham)	Area under Forest (ham)	Area under Wasteland (ham)	Cropping Intensity (%)
Sonhaura	18	17420	17156.45	13135.33	4021.12	0	33.69	131

Source: District Irrigation Plan, 2019



(Fig-5: Land use and Land cover of in Sonhaura Block)

Source: District Irrigation Plan, 2019

Source: District Irrigation Plan, 2019

1.8 Agriculture and Irrigation

Agriculture is the main stay of the people living in Sonhaura block, which is evident from census figures of 2011. Sonhaura block falls in the Agro-climatic Zone III A. Sonhaura block is producer of several crops such as paddy, maize, arhar, mung and urad during Kharif season. Wheat, maize, barely, pulses and oil seeds during Rabi season and summer season. Cereals are the major crops in the block.

Table-5: Area under different crops in Sonhaura Block

Crops	Cropped Area (ha)	Kharif (ha)	Rabi (ha)	Summer Rabi (ha)
Coarse Cereal	17684.4	11992.8	5421.6	270
Pulses	1549.2	505.2	330	714
Oil Seeds	447	15	432	0

Source: District Irrigation Plan, 2019

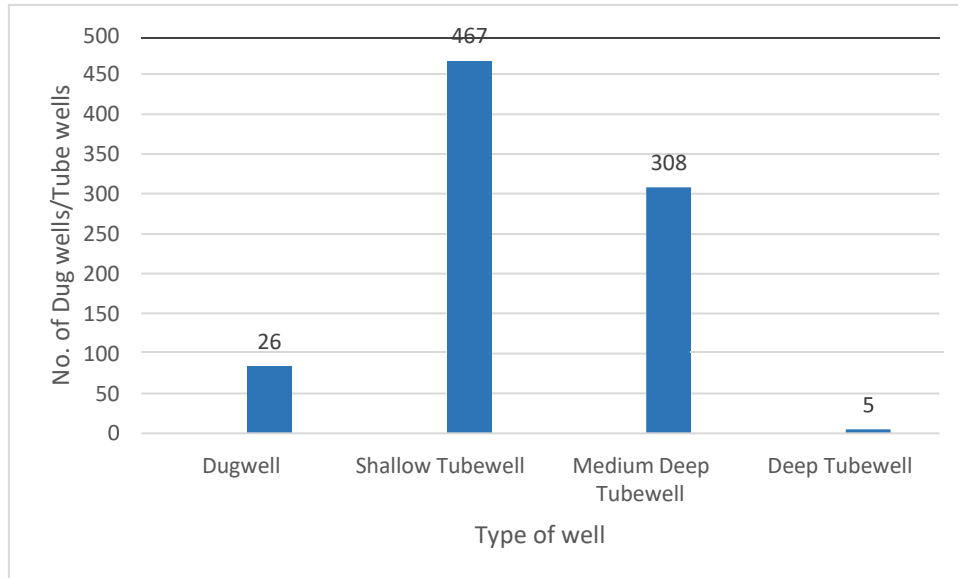
Surface irrigation network comprises canal irrigation, tanks, surface flow and lift irrigation. A considerable area is brought under irrigation by numbers of tanks.

Ground water irrigation is limited and is accomplished mainly through dug wells, shallow tube wells, medium deep tube wells and limited numbers of deep tube wells. Shallow tube wells are limited to the depth of 0-35 m bgl. Ground water extraction for irrigation use is 1155 ham.

Table-6: Block level statistics of no. of tubewells for irrigation use as per 5th MI Census

Block Name	Dugwell	Shallow Tube well			Medium Deep Tube well	Deep Tubewell
	No.	0-20 m depth	20-35 m depth	35-40 m depth	No.	No.
Sonhaura	26	246	221	-	308	5

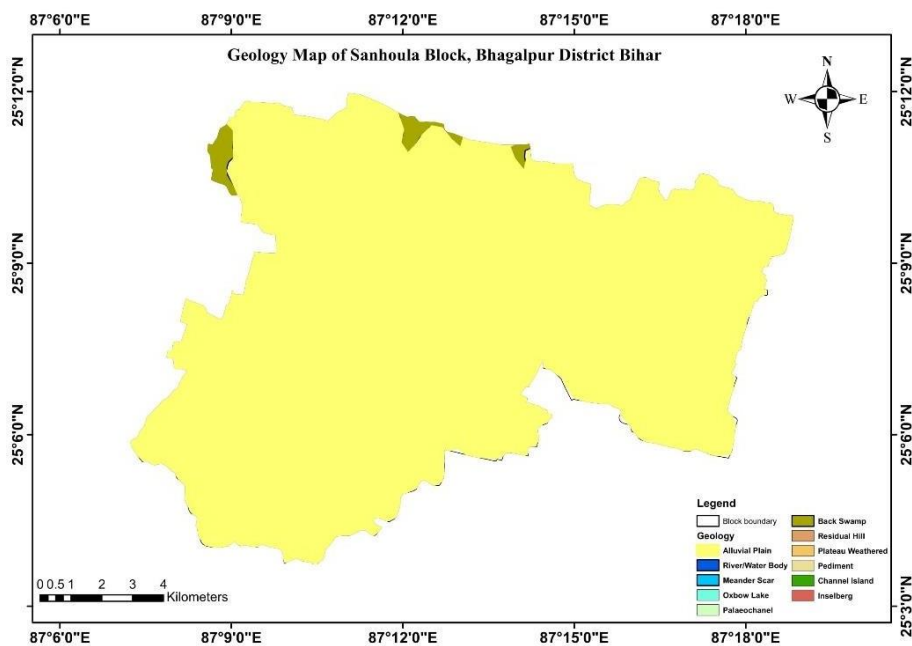
Source: 5th Minor Irrigation Census, 2013-14)



(Fig-7: Numer of minor irrigation structures in the Sonhaura Block)

2.0 Geology

Major part of the block is covered by Belhar, Diara and Sautadih formation of Late Pleistocene to Holocene age. The Belhar formation is represented by silty loam with sand, feebly oxidized, The Diara formation is represented by unoxidised grey sand, silt and clay of the present day flood plain, channel bares, levees and back swamps and the Sautadih formation is represented by Khaki green clay with brown silt and sand, highly oxidized, impregnated with caliche nodules.



(Fig-8: Geology of Sonhaura Block)

3.0 Hydrogeology

The sand layers in the Quaternary Alluvium (mostly younger) of Late Holocene age form the main source of ground water in the district. Based on the strata logs and hydrogeological properties, the aquifer system in the district can be divided into two categories,

- i. The shallow aquifers within 30 m depth.
- ii. The deep aquifers within 40-70 m depth.iii.

In shallow aquifers, the ground water occurs under unconfined condition and in deeper under semi-confined conditions. The shallow aquifers consisting of fine to medium sand with clay. The deeper aquifers mainly consist of sand with alternating layers of clay.

Hydrogeologically, Sonhuala block is underlain by porous, unconsolidated formation. The unconsolidated formation comprises clay, silt and different grades of sand down to depth of 99 m. The thick granular sand zone constitute potential aquifer system. The shallow aquifer is mainly under phreatic condition whereas differ part is under semi-confined to confined condition. The exploratory well data of CGWB, reveals that tube wells of 98.93 m depth yield at 202.7 m³/hr with drawdown 15.51m. The specific capacity 13.06 m³/hr/m and storativity is 0.7 x 10⁻³.

3.10 Aquifer Disposition and Characteristics

Aquifer disposition of the area has been studied from the existing lithological data. The lithological cross section, across the block represents multiple aquifer system up to depth of 99 m.

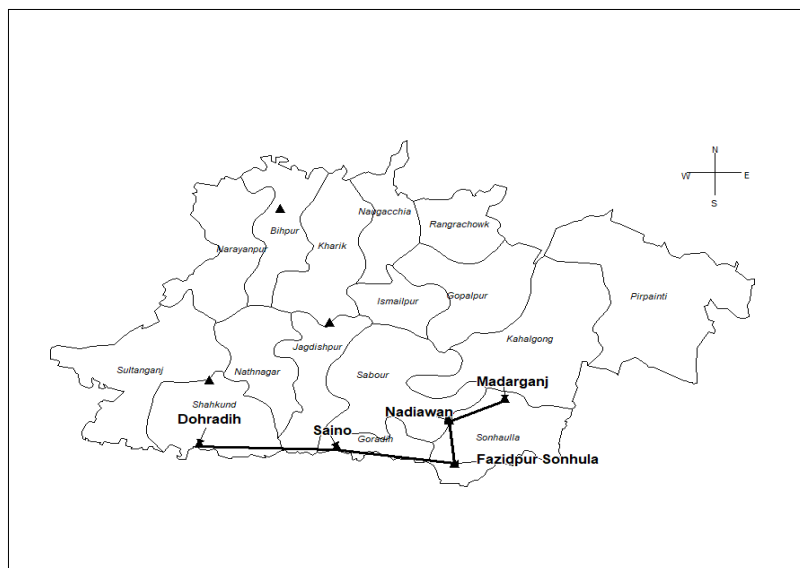


Figure-9(a): Location Map of the boreholes, Bhagalpur District

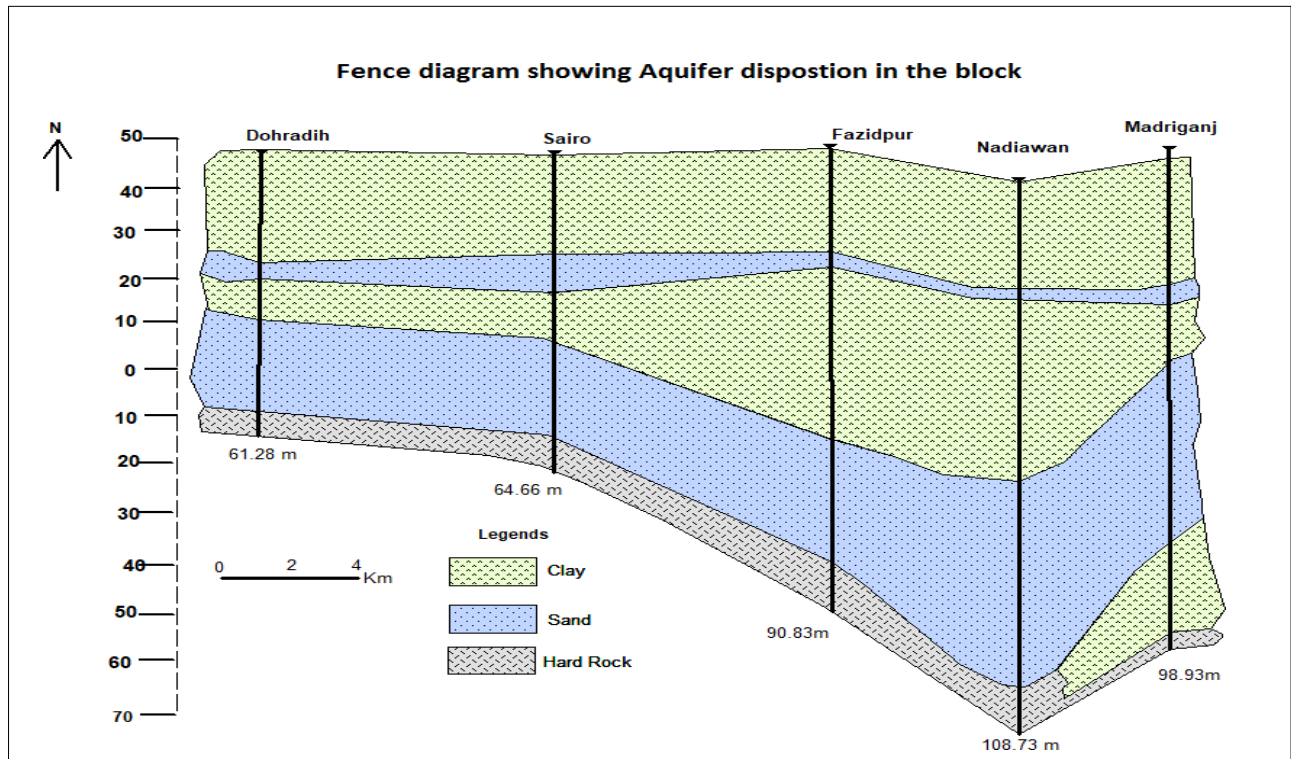


Figure-9(b): Fence diagram showing Aquifer disposition in the Block

3.20 Depth to Water Level

The groundwater regime of nearby area of the Sonhaura block has been monitored from the existing network monitoring wells and inventoried observation wells. Observation wells are private, dug wells, piezometer of minor irrigation department, Government of Bihar. The average depth of dug wells is 9 to 10 m bgl. Piezometers are on an average 50 mbgl depth. The pre monsoon water level in dug well zone 4.42-5.73 m bgl and in post monsoon water level varies from 2.00-2.30 m bgl. Comparatively deeper water level 4-5 m bgl is reported from the deep tube wells. Ground water level fluctuation 1-3m in general reflects more or less uniform and low fluctuation, (Fig-10a -c).

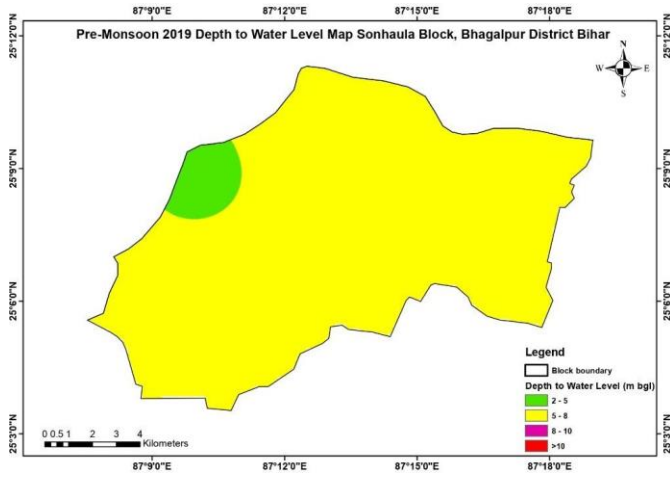


Figure-10(a): Pre monsoon water level

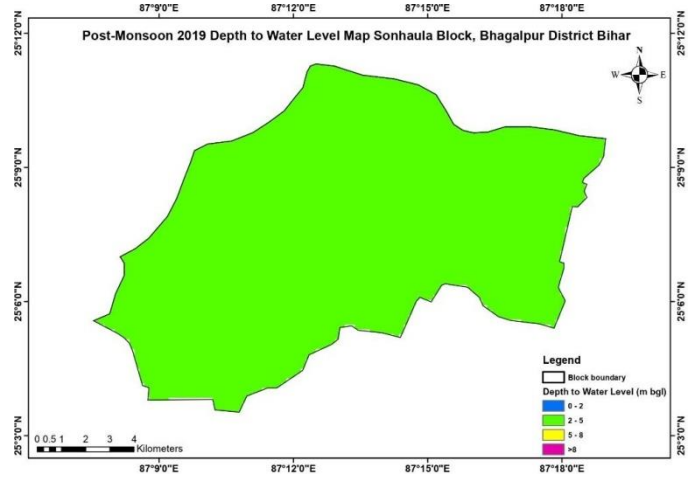


Figure-10(b): Post monsoon water level

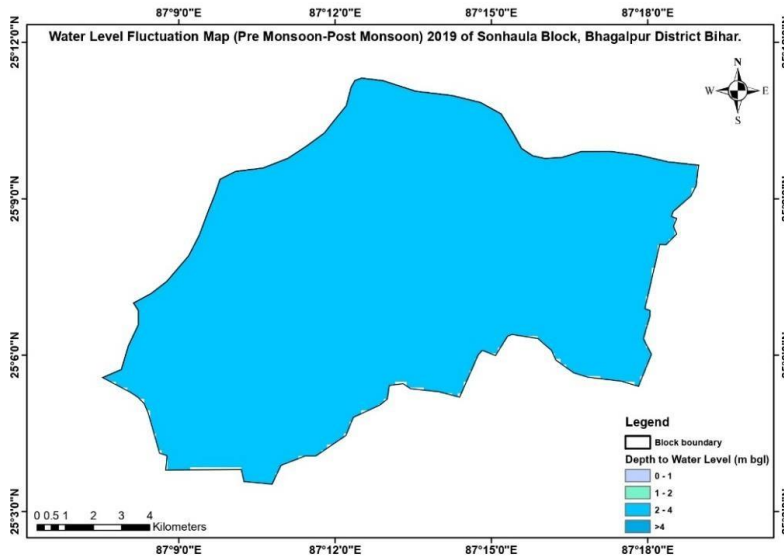


Figure-10(c): Fluctuation of water level

3.3 Ground Water Flow

Water table map has been prepared from the elevation and depth to water level data of the observation wells. In a groundwater regime, equipotential lines, the line joining points of the equal head on the potentiometric surface, were drawn based on the area of variation of the head of an aquifer. Based on the water table elevation, ground water flow directions (from S-N) are demarcated in Fig-11. Water table elevation in Sonhulla block is 40-50 mamsl. It has been observed that the ground water flow directions follow the major drainage channels and topography of the area. This indicates the topographic control for the ground water movement.

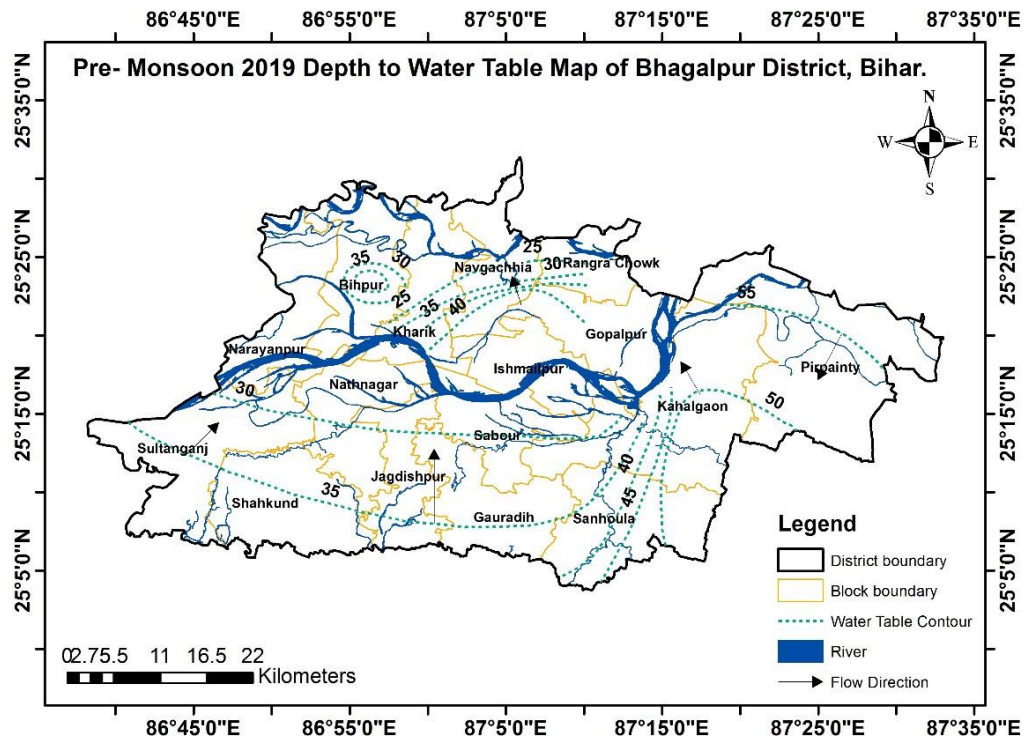


Figure-11(a): Pre monsoon water table

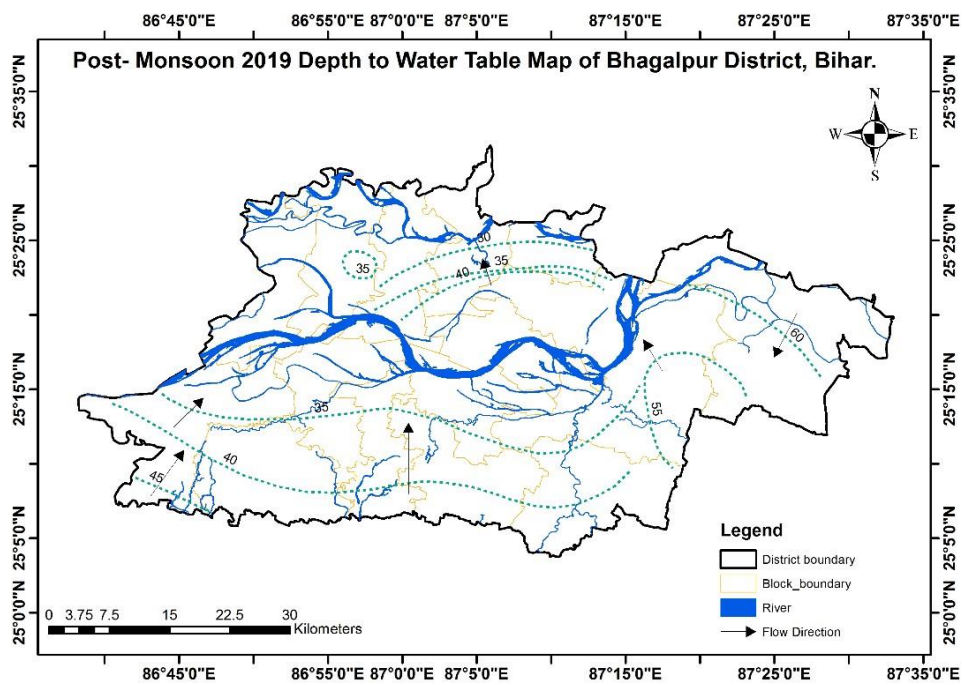


Figure-11(b): Post monsoon water table

Table-7: Depth to water level of pre monsoon and post monsoon of nearby Blocks of Sonhaua Block

Block	Type of well	Location	Latitude	Longitude	Depth of well (m)	RL(m)	Depth to Water Level (m bgl)		Fluctuation(m)	Water Table (amsl)	
							Pre monsoon	Post monsoon		Pre monsoon	Post monsoon
Sonhaua	DW	LHS of Ghoga road from Dhauriya	25.1442	87.1652	9	39.2	4.42	2.3	2.12	35	36.9
Sonhaua	CGW B_O W	School Ground, NHS well	25.1822	87.1649	115	39.8	5.27	4.2	1.07	34.5	35.6
Sonhaua	Pz	BDO office	25.0964	87.1614	50	46.7	7.72	4.53	3.19	38.9	42.1

4.0 Ground Water Resources

About 6.10 % of the net ground water availability of Bhagalpur district is available in Sonhaua block only. The SOD is 33.00 % whereas of the district SOD is 27.87%. Total ground water resource of the block is 4741.09 ham and the total ground of draft of the block is 1486.4 ham. The block come under “Safe” category, says that there are sufficient scope for ground water development.

Table-8: Ground Water Resources estimation -2020

District	Block	Recharge from Rainfall during Monsoon season (ham)	Recharge from Rainfall during Non-Monsoon season (ham)	Recharge from Other Sources during Monsoon season (ham)	Recharge from Other Sources during Non-Monsoon season (ham)	Total Annual Ground Water Recharge (ham)	Total Natural Discharges	Annual Extractable GW Resource (ham)	GW Extraction for Irrigation (ham)	GW Extraction for Industrial (ham)	GW Extraction for Domestic (ham)	Total Extraction (ham)	Net GW Availability for Future Development(ham)	Stage of Ground Water Development(ham)	Category: Safe / Semi-critical/ Over-exploited
Bhagalpur	Sonhaua	3685	460.6	295.95	299.66	4741.09	237.05	4504.04	115.5	72.00	259.40	1486.4	2859.66	33.00	Safe

5.0 Chemical quality of Ground Water

Result of chemical analysis (2019) of ground water (sample collected during May 2019) of shallow aquifer is given in the table below. In general water of shallow aquifer is potable. However, Fluoride contamination of groundwater has been reported from the Sonhaura block (as per GW Resource Assessment of Bihar as on March 2022).

Table-9: Chemical quality of Ground Water of nearby Blocks of Sonhaura Block

Block	pH	EC	TH	Ca	Mg	Na	K	HCO ₃	Cl	SO ₄	NO ₃	F	TDS
Kahalgaon	7.6	764	274	49	37	53	0.1	122	94.0	79.0	29.0	0.33	497
Sabour	7.5	555	122	36	8	75	2.2	132	58.0	92.0	27.0	0.49	361

6.0 Management Plan

6.1. Supply side intervention in Agriculture and Irrigation

From the existing land/agriculture and irrigation practices it is understood that the block is principally agricultural depending. However, the average cropping intensity is recorded as 131.00 %. It reveals that considerable cropped area is not under assured irrigation coverage. The dynamic ground water resource reports stage of development is 33.00 % which indicates there exists further scope of ground water development in the block both for agriculture and drinking/domestic purposes. 5th MI Census data shows that majority of irrigation tubewells accompanied within the depth of 50 m. Therefore further development may be planed from the deeper part too.

Considering projected 70% development 1666.428 ham further resources may be developed safely for irrigation development. This balance resource is recommended for development through STW/DTW as per the prevailing terrain condition and hydrogeology of the area. Considering unit draft of 2.4 and 3.984 ham for STW and DTW respectively following number of irrigation structures have been proposed. Thus in Sonhaura block 521 STW and 105 DTW may be constructed. (Table10).

Table-10(a): Additional resource for 70% development

Assessment Unit Name	Total Area of Assessment Unit (Ha)	Recharge Worthy Area (Ha)	Annual Extractable Ground Water Resource (Ham)	Total Extraction (Ham)	(Ha Draft for 70% m) development	Additional resource available for 70% development (Ham)
SANHAULA	17420	17420	4504.04	1486.4	3152.828	1666.428

Table-10(b): Recommended number of structures for further irrigation development

Additional resource available for 70% development (Ham)	Resource allocated for development by STW (Ham)	Resource allocated for development by DTW (Ham)	Unit draft of STW (Ham)	Unit draft of DTW (Ham)	No. of STW proposed	No. of DTW proposed
1666.428	1249.821	416.607	2.4	3.984	521	105

6.2 Supply side intervention through Artificial Recharge and rain water harvesting

As per the proposed ARMP of Bihar state, considering the post monsoon water level and long term water level trend, no such area has been delineated for implementation of AR structures in the block. However, based on the local hydrological situation and site specific development scenario artificial recharge and water harvesting techniques may be practiced for efficient and sustainable management of ground water resources in the block. In Shahkund urban area, roof top rain water harvesting may be practiced for water conservation. The gram panchayat buildings, schools. Govt buildings etc. may be shortlisted, in phases, for implementation of roof top rain water harvesting.

6.3 Demand side intervention

Considering the area being high potential in terms of ground water resources, additional resources may be utilized for more water intensive crops like paddy, cereals etc. along with the other crops. This may create further irrigation potential in the block. Suitable crop rotation may be practiced. Conjunctive use of surface and ground water may be practiced. A few area in the block is suspected to report with F contamination in ground water. Therefore, regular surveillance, testing, capacity building, awareness generations among stakeholders are to be followed.

