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भारत सरकार

Central Ground Water Board

Department of Water Resources, River
Development and Ganga Rejuvenation,
Ministry of Jal Shakti
Government of India

AQUIFER MAPPING AND MANAGEMENT OF GROUND WATER RESOURCES

Khagaria District
Bihar

मध्य पूर्वी क्षेत्र, पटना
Mid Eastern Region, Patna

जल शक्ति मंत्रालय

Ministry of Jal Shakti

नदीविकासऔरगंगासंरक्षणविभाग

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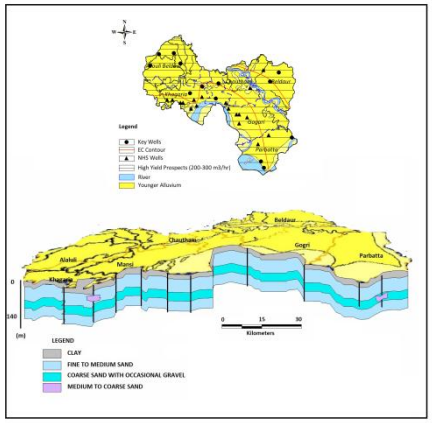
Aquifer Maps and Ground Water Management Plan of Khagaria district, Bihar

जलभृतनक्शेतथाभूजलप्रबंधनयोजना खगरिया जिला, बिहार



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CHAPTER - I

INTRODUCTION

1. Introduction

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

During XII five year plan (2012-17) National Aquifer Mapping (NAQUIM) study was initiated by CGWB to carry out detailed hydrogeological investigation. The Aquifer Mapping programme has been continued till 2023 to cover whole country. During 2020-2021 under National Aquifer Mapping programme, 4 blocks of Khagaria district covering an area of 732 Sq. km and during NAQUIM Phase-III, 3 blocks covering an area 754 Sqkm of have been taken up for detailed hydrogeological survey and preparation of Aquifer maps and Management plan. The aquifer maps and management plans will be shared with the administration of Khagaria district and other user agencies for its effective implementation.

1.1 Objective and Scope

The major objectives of aquifer mapping are

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

The groundwater management plan includes Ground Water recharge, conservation, harvesting, development options and other protocols of managing groundwater. These protocols will be the real derivatives of the aquifer mapping exercise and will find a place in the output i.e, the aquifer map and management plan. The main activities under NAQUIM are as follows:

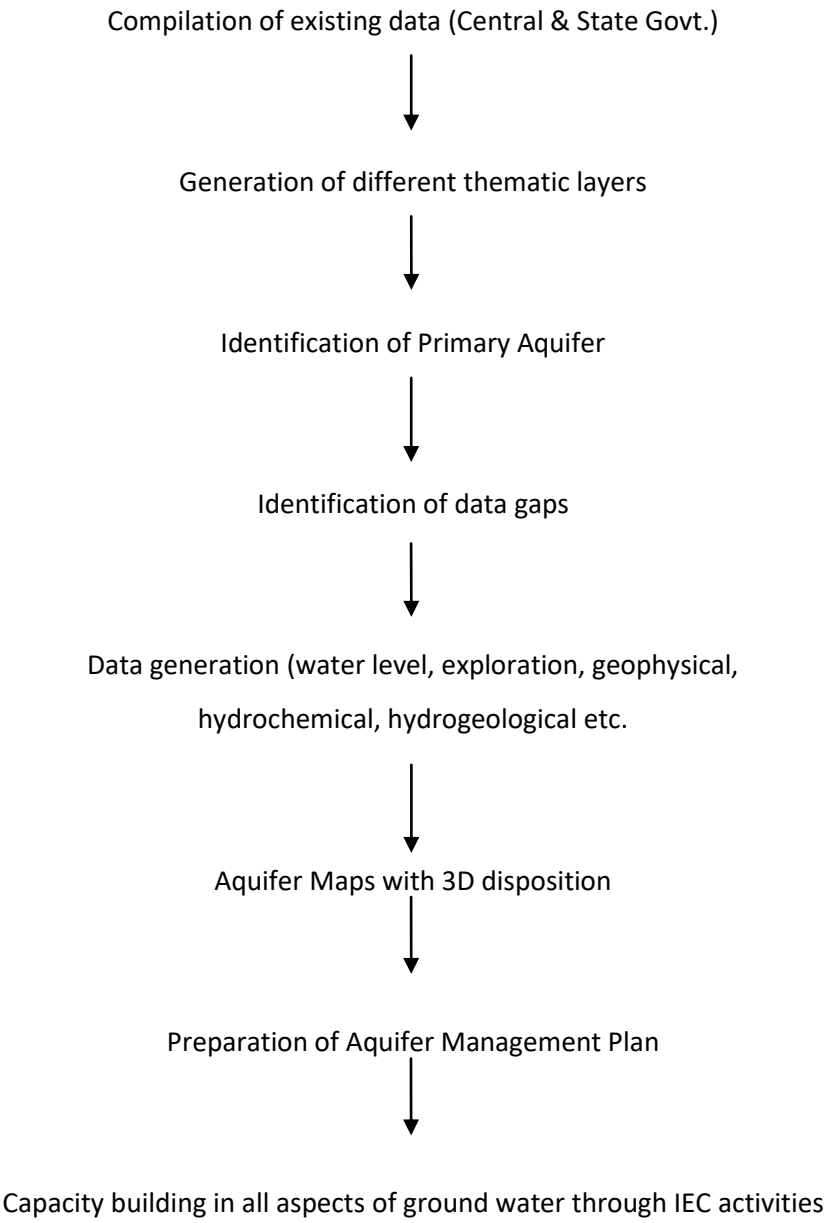
- Identifying the aquifer geometry
- Aquifer characteristics and their yield potential
- Quality of water occurring at various depths
- Aquifer wise assessment of ground water resources
- Preparation of aquifer maps and
- Formulate ground water management plan.

The demarcation of aquifers and their potential will help the agencies involved in water supply in ascertaining, how much volume of water is under their control. The robust and implementable ground water management plan will provide a "Road Map" to systematically manage the ground water resources for equitable distribution across the spectrum. With this background the following aspects are identified as most significant in the context of present study area:

- To understand the aquifer disposition of the area.
- The entire district, which is part of Kosi megafan with huge groundwater potential. Therefore, extensive groundwater development exists.
- The district is reported with seasonal flooding and rapid shifting of river course In order to address the quality issues, suitable remedial measures are to be recommended.
- By considering groundwater quantity and sustainability aspects suitable groundwater management strategies to be adopted

1.2 Approach and Methodology

The ongoing activities of NAQUIM include hydrogeological data acquisition supported by geophysical and hydro-chemical investigations supplemented with ground water exploration down to the depths of 200 meters in hard rocks and 300m in soft rock. Considering the objectives of the NAQUIM, the data on various components was segregated, collected and brought on GIS platform by geo-referencing the available information for its utilization for preparation of various thematic maps. The approach and methodology followed for aquifer mapping is as given below:



In order to achieve above mentioned objectives, present study incorporated collection and compilation of available information on aquifer systems. The work has been approached through demarcation of aquifer extents, characterization and finally compilation of this information in form of aquifer maps at 1:50000 scale along with block-wise groundwater management plan. Artificial recharge measures are proposed based on the feasibility in the area based upon earlier prepared Guideline for Artificial Recharge of Groundwater. For the purpose, groundwater flow system has been conceptualized based on collected data, keeping in view of sustainable groundwater development. Aquifer-wise groundwater resource, groundwater flow-pattern has been assessed. Groundwater quality data has been analyzed. Methodologies adopted include preparation of various thematic maps like land use and land cover map, geomorphology map, geology & hydrogeology map by using various GIS tools. Hydrogeological sections, panel diagrams, hydro-chemical diagrams were

prepared. Data from concerned agencies/departments were also collected for preparation of status of data gap. Groundwater resource data has been taken from 'Report on Dynamic Groundwater Resources of Bihar State' by CGWB. Groundwater level has been monitored from existing NHS wells as well as from newly established key wells. Groundwater quality data is based on water samples collected from existing NHS wells. Finally based on outcome of various analyses, block-wise groundwater management plan has been prepared.

1.3 Area Details

Khagaria district consists of 7 administrative blocks with geographic area of 1486 sq.km. The district is bounded in north by Saharsha and Darbhanga districts, in east by Madhepura and Bhagalpur districts, in south by Munger district, in west by Begusarai and Samastipur districts. Administrative map of the study area is given in Fig. 1.3. As per Govt. of India Population Census (2011), total population of the district is 16,66,886 with decadal growth rate of 30.19%. Projected population as on 30th June 2021 is 21,84644 (Bihar Statistical Handbook, 2016). Demographic details of the administrative blocks are given in Table 1.1.

Table 1.1 Demographic details of the administrative blocks of Khagaria district

District	Block	Total Area (Sq. km.)	Rural Population	Urban Population	Total Population
Khagaria	Allauli	274	2,82,127	0	2,82,127
	Khagaria	262	3,31,952	49,406	3,81,358
	Mansi	68	88,511	0	88,511
	Chautham	166	1,53,831	0	1,53,831
	Beldaur	224	2,00,223	0	2,00,223
	Gogri	251	2,79,017	37,753	3,16,770
	Parbatta	241	2,44,066	0	2,44,066
District Total		1486	15,79,727	87159	**16,66,886**

(as per 2011 population census)

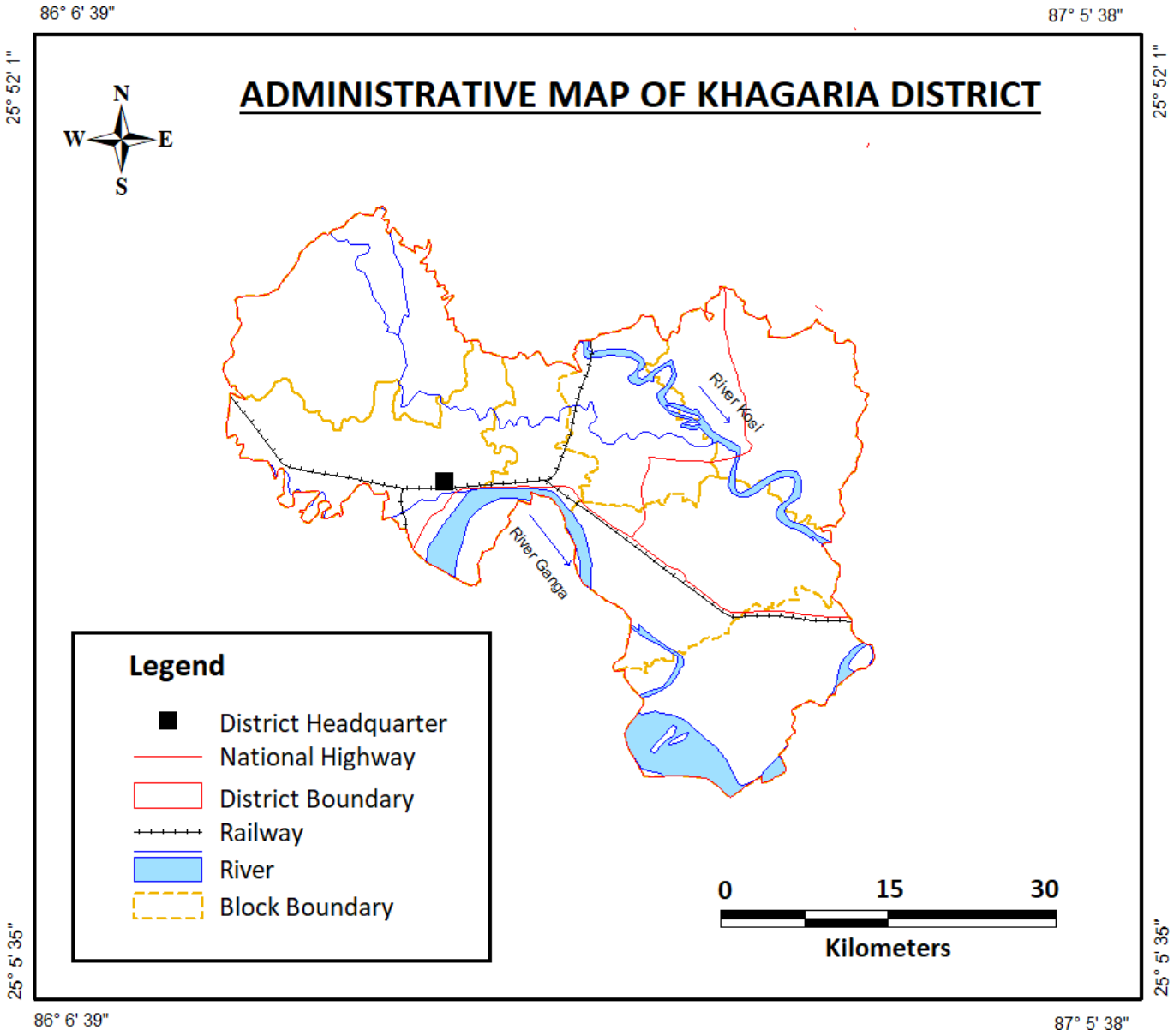


Fig. 1.1 Administrative Map of Khagaria District

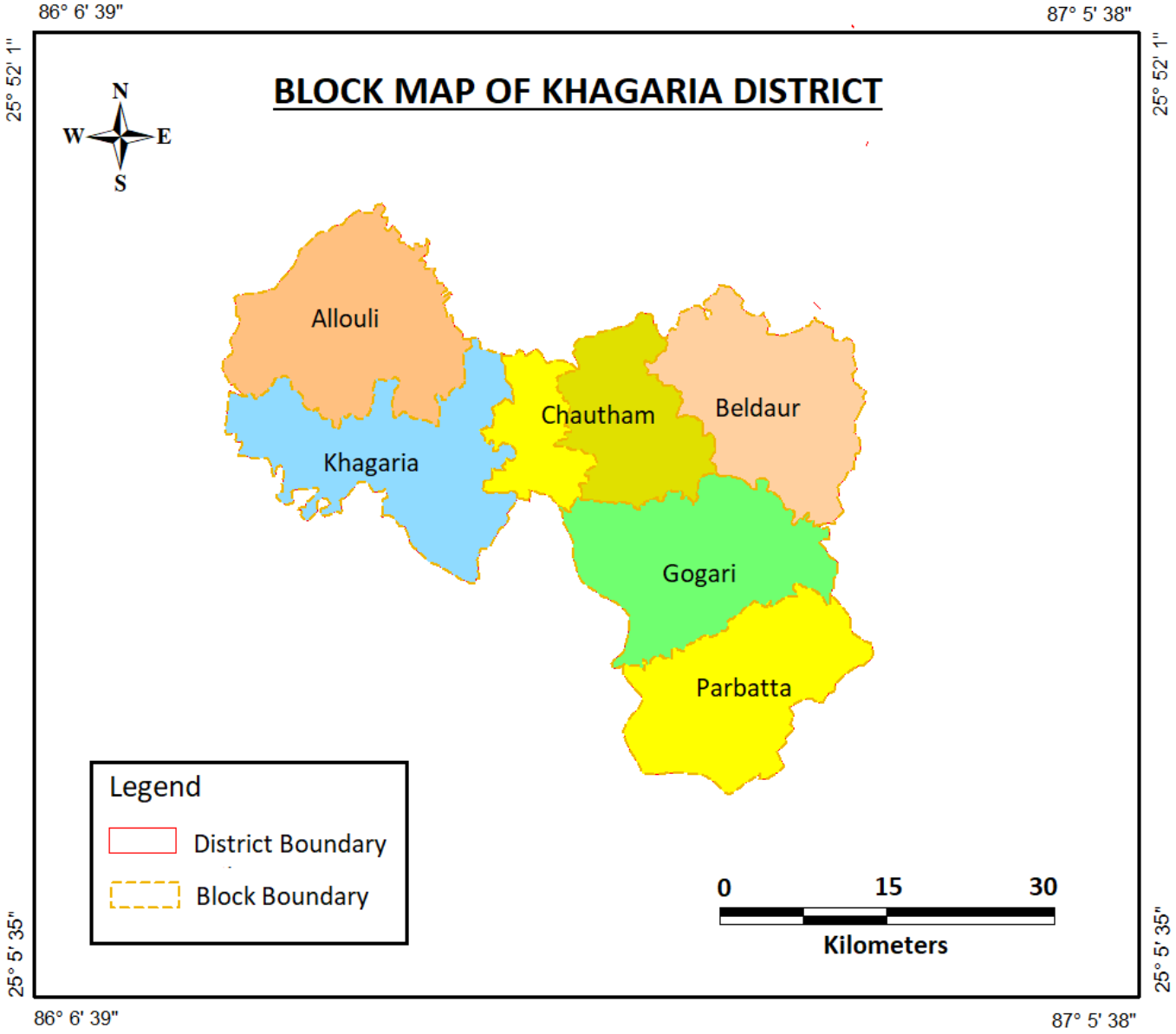


Fig. 1.2 Block Map of Khagaria district

1.4 Brief Description

Khagaria district comes under the Munger Division of north Bihar, with district headquarter at Khagaria town. The district is drained by Kosi and its tributaries, and river Ganga. The river Kosi has its catchment area near India-Nepal province. The river brings enormous sediments during rainy season not only to spread the new sheets of fertile sediments but also alter their beds and their channel courses. This river has severe shifting tendencies resulting in large tract of Diara land.

1.5 Data Availability

Central Ground Water Board carried out hydrogeological surveys, reappraisal surveys and groundwater exploration in different parts of the district. Ground water regime monitoring is carried out on a regular frequency during January, May, August and November every year. The data available from the earlier surveys have been compiled and data gap analysis has been carried out for working out the need for additional data generation in the study area.

1.6 Rainfall and Climate

The district experiences hot and dry climate. The westerly wind along with dust storms during the month of March marks initiation of hot weather. May is the hottest month of the district with temperature raises more than 45 degrees. Summer starts at the middle of March and continues upto tile end of June. The months of April and May have high humidity and intermittent rainfall. The rainy season starts from June and continues up to October. The winter initiates from mid of October and continues up to February. January is the coldest month of the district with night temperature fall below 4 degrees.

The district received annual rainfall of 1367.1 mm during year 2020. The maximum amount of rain occurs from June to September, from the south west monsoon. Most quantum of ground water recharge and replenishment of the resource occur during monsoon season. Normal rainfall (from 1961 to 2010) of the district is 1174.2 mm. Month-wise rainfall pattern for previous nine years from 2012 to 2020 is given in table 1.2.

Table 1.2: Month-wise rainfall from 2012 to 2020 (Source: IMD Website)

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total	M	NM
2012	8.8	0	5.9	4.1	6.8	40.5	233.3	197.1	263.5	74.6	6.1	0	840.7	734.4	106.3
2013	0	5.5	0.1	26	36.4	113.5	200.3	181.7	215.6	146.7	1.6	0	927.4	711.1	216.3
2014	6.8	10.5	5.3	0	129	99.3	499.4	210.7	132.1	17.9	0	0	1111	941.5	169.5
2015	18.9	16.4	20.5	77.9	26.9	141	185	521.2	226.6	0	0	0	1234.4	1073.8	160.6
2016	5.4	3.2	0	17.5	69.4	40.4	227.1	100	241.4	26.1	0	0	730.5	608.9	121.6
2017	0	0	4.3	29.1	51.7	132.4	331.7	179.4	103.9	100.7	0	0	933.2	747.4	185.8
2018	0	0	12.4	15.4	30.4	51.5	216.2	237.5	91.4	95.9	0	8.6	759.3	596.6	162.7
2019	5.5	28.8	0	14.4	19	57.8	395.6	98.2	423.9	49.7	0	9.9	1102.8	975.5	127.3
2020	7	27.6	33.5	70.8	85.2	305.9	305.4	205.5	273	53.2	0	0	1367.1	1089.8	277.3

(Note: All values in mm. M-Monsoon, NM-Non Monsoon)

Trend and distribution of rainfall in the district (Figure 1.3, 1.4 & 1.5) show that maximum rainfall occurs in the monsoon season. Monsoonal rainfall shows sort of cyclicity during the taken period. From the monthly distribution of rainfall of the year 2020, it can be observed that actual

monthly rainfall is far more than normal rainfall in the district except during the months of July, August and October. The district has received highest rainfall during the year 2020 as compared to rest of the years. However, non-monsoon rainfall in the district does not show any peculiar trend.

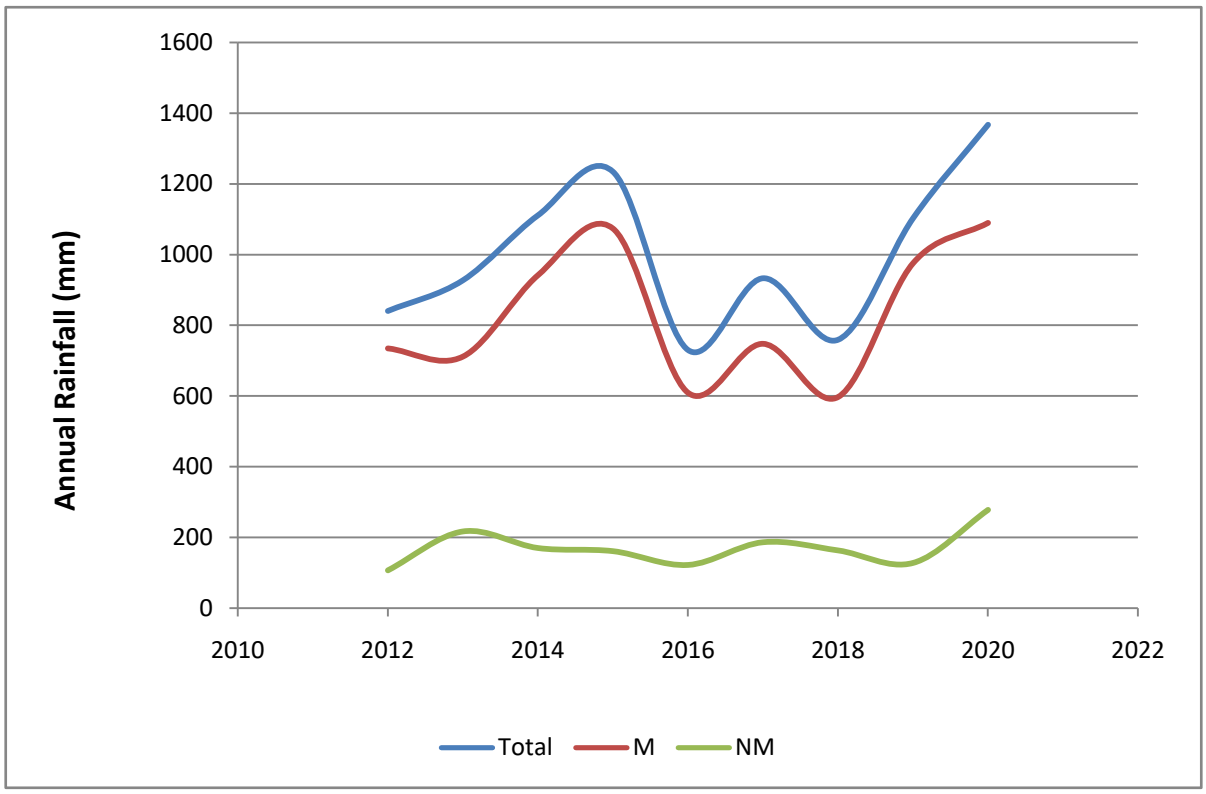


Fig. 1.3: Rainfall trend in Khagaria district from 2012 to 2020

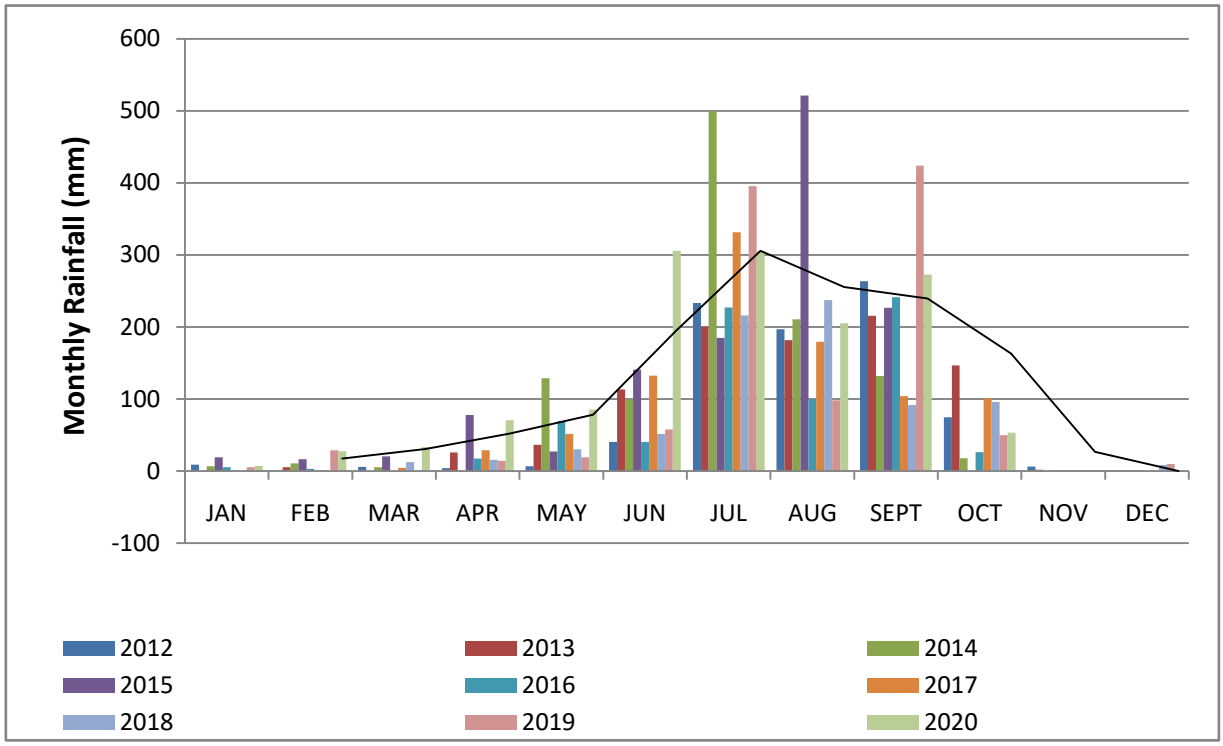


Fig. 1.4 Monthly rainfall pattern of Khagaria district during 2012 to 2020

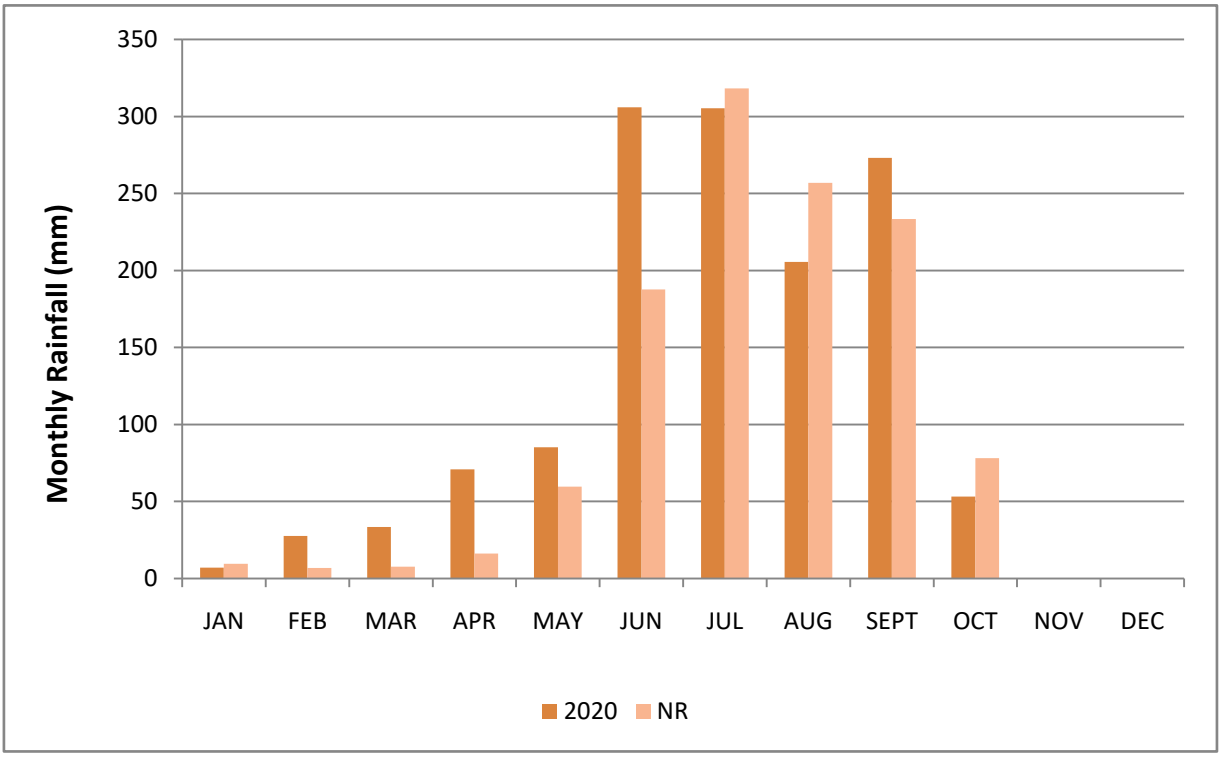


Fig. 1.5 Figure showing Normal rainfall & monthly rainfall during 2020

1.7 Physiographic Setup

The Kosi river emerging from the Siwalik ranges from a megafan while it enters in north Bihar plain. Consequently the emergent physiographic setup is the vast alluvial plain with gentle slope towards south. In Khagaria district 63% of its total geographic area is covered by Kosi megafan. It is to be noted that the river Ganges form the southern boundary of the district, where Kosi outfalls.

1.8 Geomorphology

The district is characterised by monotonous flat topography with elevation ranging from 30 to 60 m above mean sea level. The district is mainly drained by river Kosi and its tributaries. While river Ganga forms the southern boundary of the district. Geomorphologically, the area is covered by Younger alluvial plain (nearly 59% of area of the district) followed by active flood plain (33.47%). The river Kosi left behind a number of palaeochannels and Ox-Bow lakes along its old river courses (fig. 1.6). The district forms part of the lower end of Kosi megafan and is characterized by fertile flat area which is highly prone to flood during the monsoon season. The dimensions of the fan are 154 km by 147 km with fan slope of 0.89 to 0.06 m/km (0.1 to 0.25 m/km cross-fan) (Wells and Dorr, 1987).

Table 1.3: Showing area coverage of various landform units in Khagaria district

Landform Unit	Area (Sq. Km)	Percentage Area (%)
Younger Alluvial plain	875.08	58.89
River	57.10	3.84
Palaeochannel	21.06	1.42
Channel Bar	16.34	1.10
Ponds/Tanks	3.90	0.26
Back Swamp/Ox-bow Lake	15.18	1.02
Active Flood plain	497.34	33.47
Total	**1486**	**100**

1.9 Land-use Land-cover Pattern

Most of the geographical area of the district comprises of agricultural crop land (80.96 %) followed by wetlands/water bodies (8.91%). As per records of Agriculture Department, Govt. of Bihar, the gross cropped area of the district is 167114 ha and net sown area is 1,04,000 ha. The

cropping intensity of the district is 161%. A map showing land use pattern in the district is given in figure -1.7.

Table. 1.4: Land use land cover data of Khagaria district (source: Bhuvan)

Landuse type	Area (Sq. Km)	Percentage area (%)
Agriculture, Crop land	1199.08	80.69
Agriculture, Fallow	12.15	0.82
Built-up, Rural	82.85	5.58
Wetlands/Water Bodies, River/Stream/canals	132.37	8.91
Barren/Wastelands/Gullied/Ravenous Land	5.20	0.35
Agriculture, Plantation	47.75	3.21
Built-up, Urban	5.56	0.37
Mining	1.03	0.07
Total	**1486**	**100**

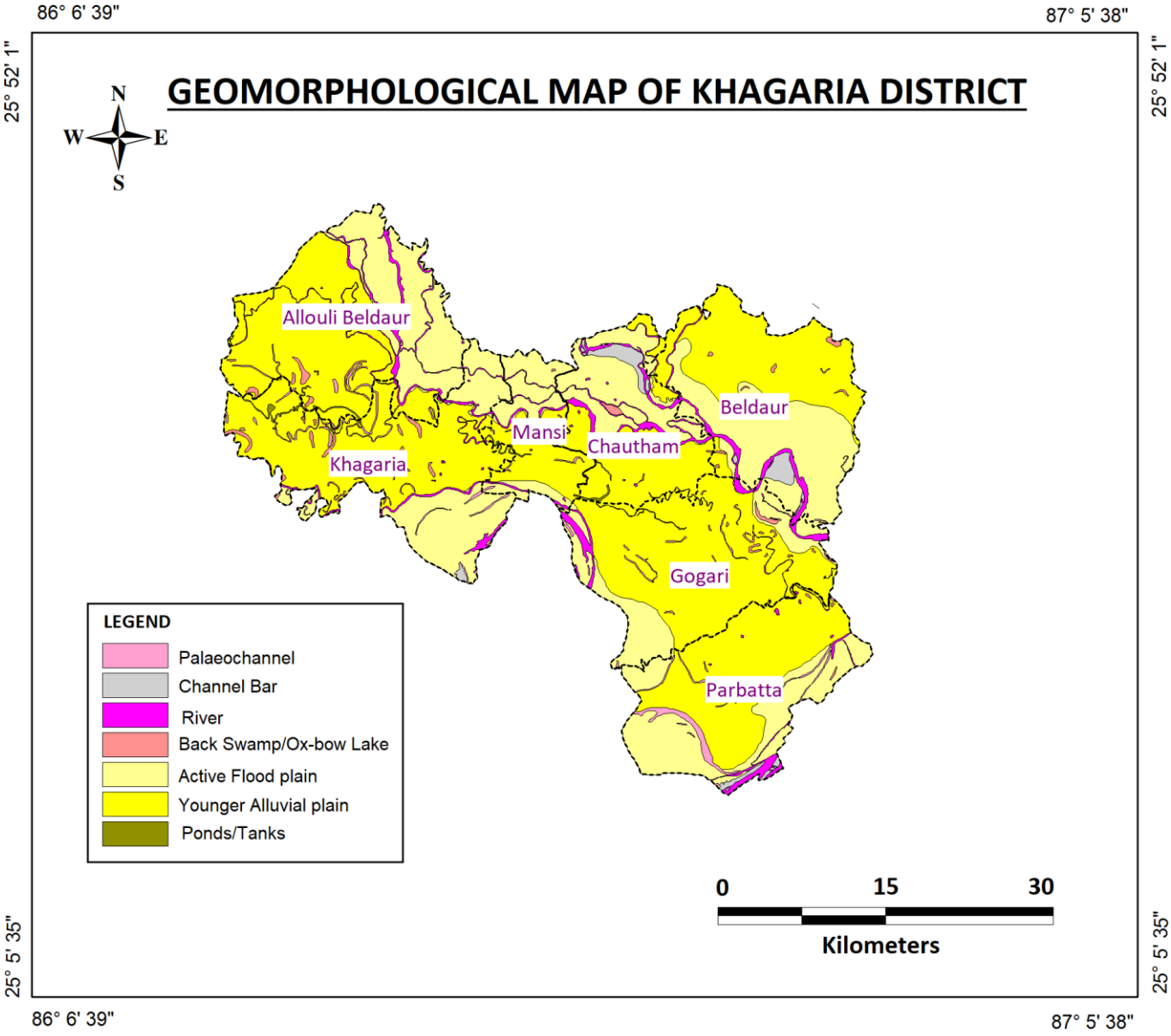


Fig. 1.6: Simplified geomorphological map of Khagaria District (Source: Geological Survey of India-Published maps)

1.10 Soil

Major soil class in the district is fine loamy (37.20%) with area coverage of 636 sq.km. Based on texture, the loam in the district can be categorised into seven soil classes. They are sandy to coarse loamy, fine loamy, loamy to fine loamy, coarse loamy to fine loamy, fine loamy to fine silt, clayey, sandy to loamy types. Soils of the district are highly suitable for cultivation of food crops and horticulture crops such as rice, wheat, maize, pulses, oilseeds, sugarcane, potato, jute, banana, etc.

Soil of Khagaria district comes under two slope classes. 147112 ha area of the district comes under nearly level to very gentle slope (0-3%) followed by nearly level slope (3-8 %). Major soil erosion class of the district is none to slight erosion (80.31%) followed by slight to moderate erosion (8.66%).

Table 1.5: Area covered under various soil types (Source: Agriculture Contingency Plan, Khagaria)

Sl. No.	Soil Type	Area in Sq. Km	Percentage of area covered
1	Sandy to Coarse Loamy	52	3.50%
2	Fine Loamy	636	37.20%
3	Loamy to Fine Loamy	302	20.40%
4	Coarse Loamy to Fine Loamy	23	1.60%
5	Fine Loamy to Fine Silt	323	21.80%
6	Clayey	71	4.80%
7	Sandy to Loamy	14	1%

Table 1.6: Area under different soil erosion classes in Khagaria district

Sl. No.	Erosion class	Area in Sq. Km	Percentage of area covered
1	None to Slight Erosion	1193.38	80.31%
2	Slight to Moderate Erosion	128.69	8.66%
3	Moderate Erosion	2.09	0.14%
4	Miscellaneous class	161.84	10.89%
Total		1486	100%

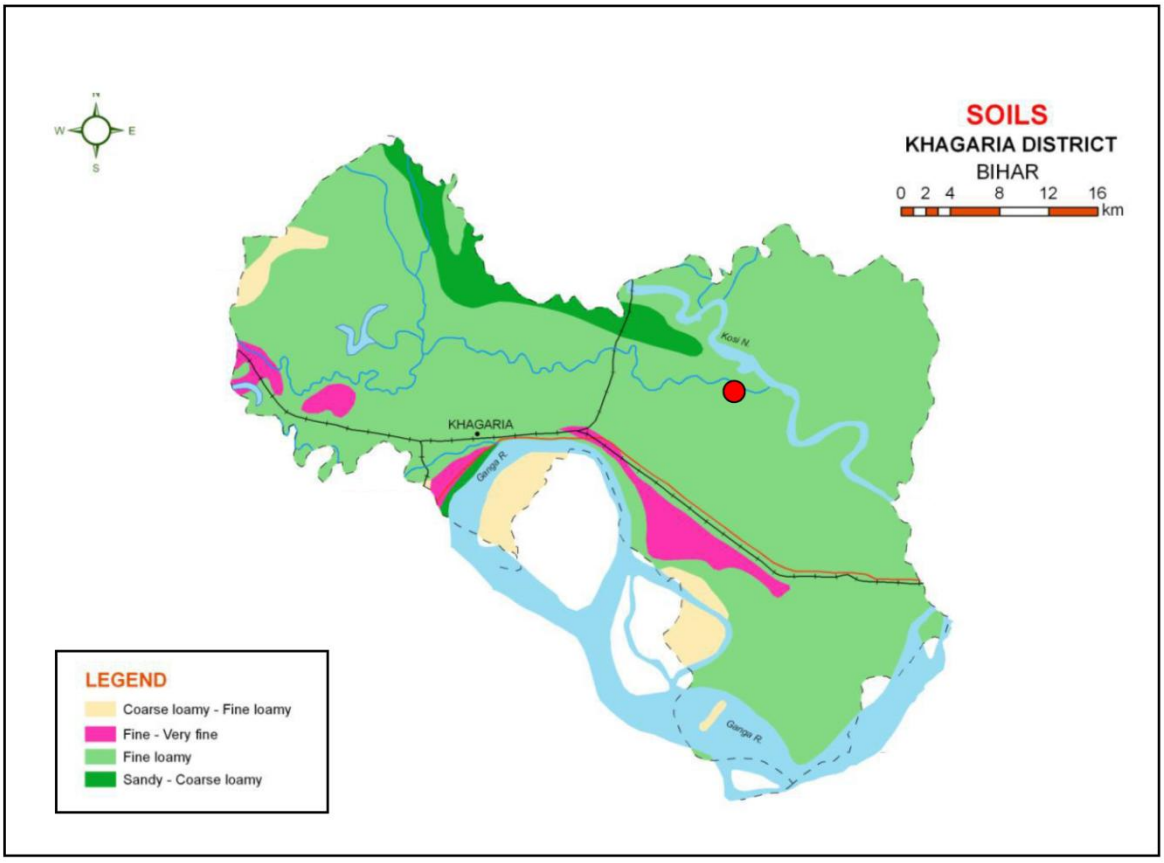


Fig1.7: Soil map of Khagaria district (source: Agriculture contingency plan-Khagaria)

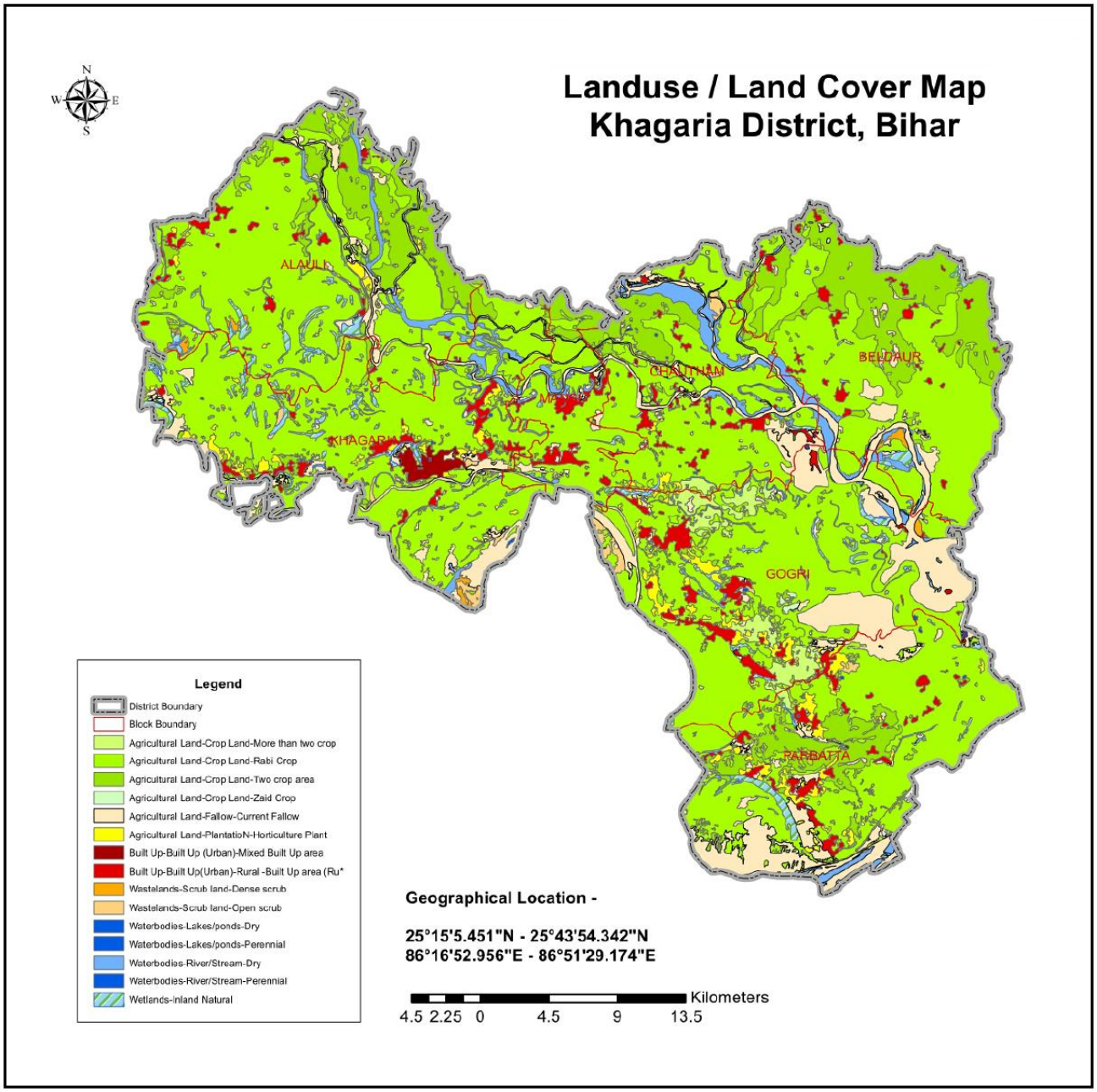


Fig. 1.8: Landuse map of Khagaria district (Source: District Irrigation Plan-Khagaria district)

1.11 Hydrology and Drainage

The district is by and large drained by Kosi and its tributaries, while it outfalls to river Ganga in the southern part of the district. The main rivers of the district are the Ganga, the Burhi Gandak, the Bagmati, the Kamla and the Ghugri (mainstream of Koshi), the Kachna, the Malti etc. These rivers have their catchment basins in The Siwalik ranges. Kosi bring enormous sediment load during the monsoon season and deposit along the megafan area. The river Ganga forms the southern boundary of the district in its entire length. The river Ganga has severe shifting tendencies resulting in formation of island areas locally called “Diara land”. Due to presence of vast area of Diara land, during rainy season, at some places, the breadth of the river runs into miles.

The Burhi Gandak, runs a zigzag course through the district of Begusarai and enters by the side of the Khagaria town, and discharges into river Ganga. It forms the western boundary of the Khagaria town. An embankment built along the eastern side of this river protects Khagaria town from flood of Burhi Gandak during monsoon. River Bagmati enters the district from the western side through the district of Begusarai. It flows easterly direction, till it joins into river Kamla near Chautham. River Kamla enters the district from Darbhnga, near Mohraghat. It then flows south east to Chautham and joins into river Bagmati and further flows into Bhagalpur where it is known as Ghugri. The common drainage pattern observed in the district is dendritic and rectangular to parallel. The drainage and canal map of the district is shown in fig. 1.8.

It is to be noted that the river Kosi has migrated from its channel to about 113 km westward in last 228 years at the rate of 19 km/year (Fig.1.9). There are multiple causes for shifting of the river channel which include deposition and avulsion during major flood cycles, regional tilting, deflection of flow by fanhead tilting, derangement of drainages by earthquakes, neo-tectonic activities etc.

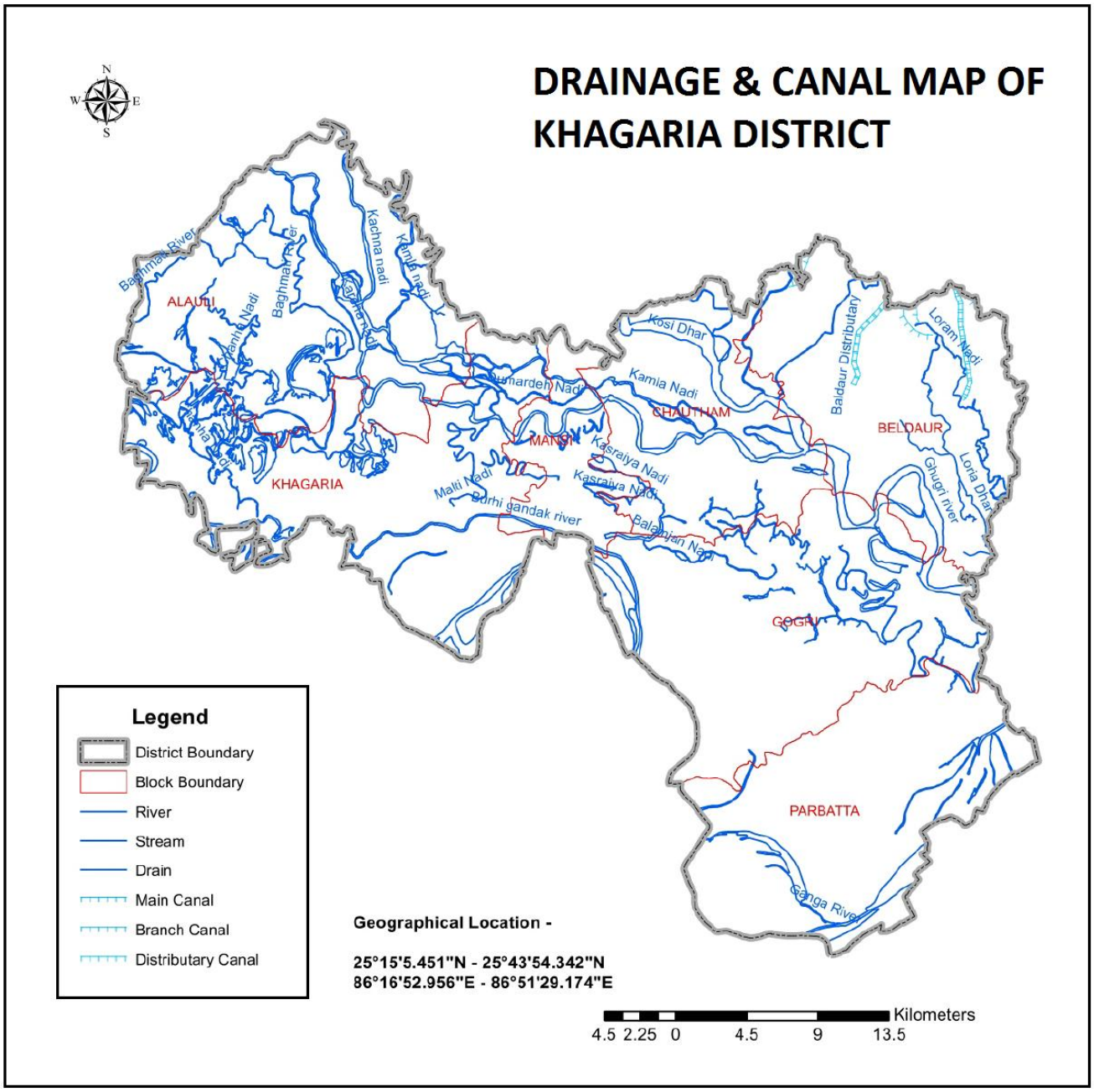


Fig. 1.9: Drainage and Canal map of Khagaria district (Source: District Irrigation Plan-Khagaria district)

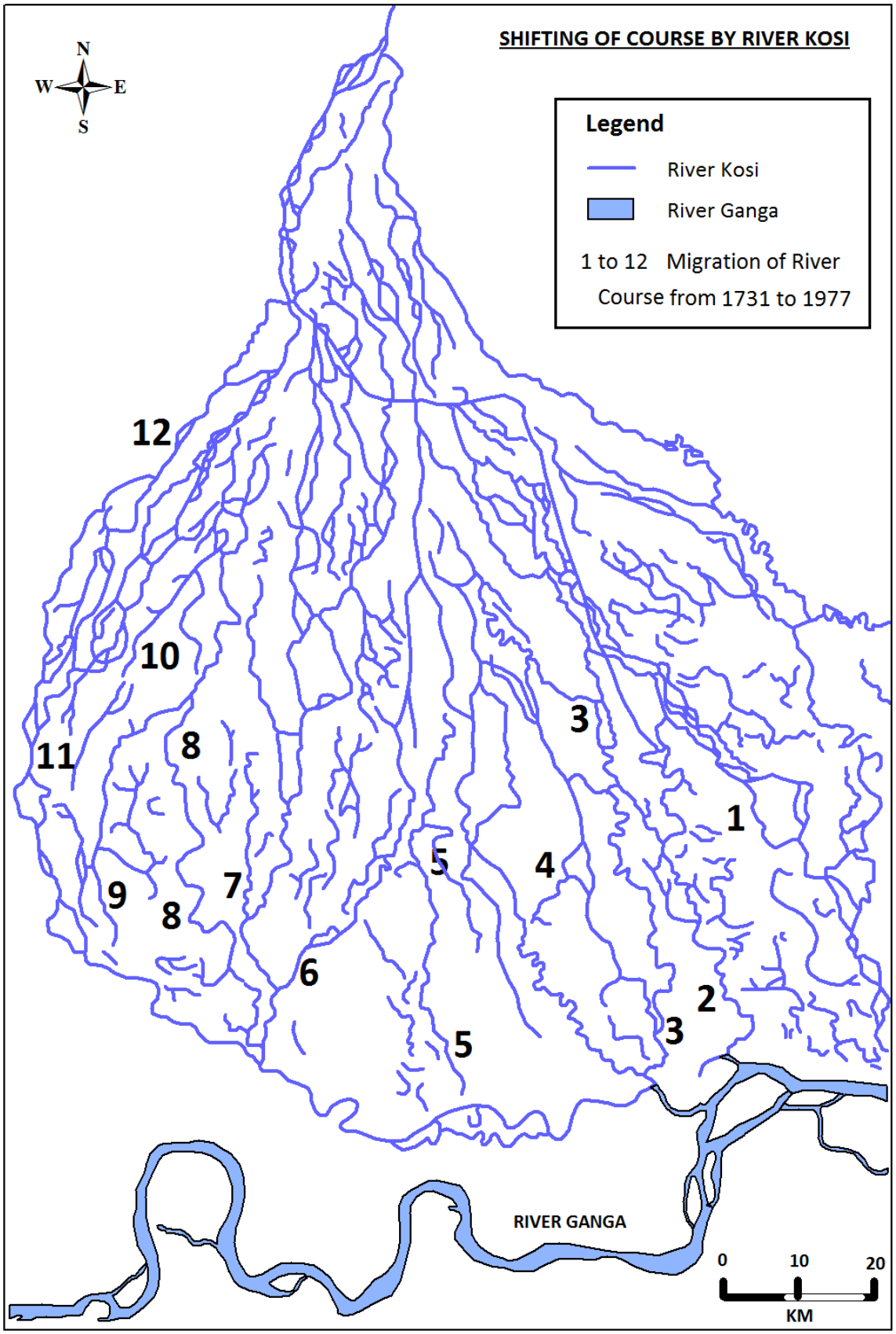


Fig.1.10 Shifting of course by river Kosi from 1731 to 1977 (after Well N A & Dorr J A, 1987) Detes of occupation of channels: 1. 1731, 2. 1770-75, 3. 1807-39, 4. 1840-73, 5. 1873-93, 6. 1893-1921, 7. 1921-26, 8. 1926-30, 9. 1930-36, 10. 1936-42, 11. 1942-48, 12. 1977

1.12 Agriculture

The district comes under agro-climatic zone II. As per NARP classification, the district comes under North East Alluvial Plain Zone (BI-2). Agriculture is the main livelihood of the population in the district. The net sown area of the district is 1,04,000 ha and cropping intensity of the district is 161% (Source: District Irrigation Plan-Khagaria). The major crop cultivated in the district is cereals and coarse cereals (82.05%) followed by pulses (15.21%) and oil seeds (2.74%).

1.13 Irrigation

Irrigation in the district is mainly catered through tube wells (76.6%). A number of minor and medium irrigation schemes, Open borings, irrigation wells and tube wells have been introduced in the district during the different plan periods. There are around 150 state tube wells and 20 lift irrigation schemes but 75 percent of the tube wells and 80 percent of the lift irrigation schemes are non functional because of its poor maintenance. Although the district is rich with abundant river courses, there does not have any canal irrigation system. Details of area-wise, crop-wise irrigation status of the district are shown in table 1.7.

Table 1.7: Area-wise, crop-wise irrigation status of Khagaria district (Source: DIP-Khagaria)

Crop Type	Kharif Area (ha)		Rabi Area (ha)		Summer area	
	Irrigated	Rainfed	Irrigated	Rainfed	Irrigated	Rainfed
Cereals	6000	14000	29400	12600	0	0
Coarse cereals	8100	18900	37100	15900	3750	0
Pulses	855	1995	3150	1350	3500	0
Oil Seeds	105	245	2526	1082	280	0
Horticrop/Plantation	0	0	0	0	5025	0
Total	**15060**	**35140**	**72176**	**30932**	**12555**	**0**

Table 1.8: Block-wise irrigation status Khagaria district (Source: DIP-Khagaria)

Sl. No.	Name of Block	Irrigated area (ha)		Rainfed Area (ha)		
		Gross Irrigated Area	Net Irrigated Area	Partially Irrigated /Protective Irrigation	Un-Irrigated or Totally Rainfed	Total
1	Alauli	17676	14385	579	9110	9689
2	Beldaur	13787	10851	608	8032	8640
3	Chautham	12058	8474	522	3865	4387
4	Gogri	19676	13539	674	6018	6692
5	Khagaria	15702	12263	752	9741	10493
6	Mansi	5972	4008	393	583	976
7	Parbatta	14922	8656	662	8299	8961
Total		**99793**	**72176**			**49838**

Table 1.9: Block level statistics of minor irrigation structures in Khagaria district (as per 5th MI census)

Sl. No.	Block	DW	STW (0 to 35 m)	MDTW (35 to 70 m)	DTW (70 to 150 m)	SW Flow	SW Lift	Small Tank	Large Tank
1	Alauli	8	851	192	1276	13	182	11	1
2	Beldaur	5	2388	1	0	0	0	0	0
3	Chautham	9	724	248	1	0	0	0	0
4	Gogri	10	2139	59	1	0	0	0	0
5	Khagaria	2	600	7	0	0	0	0	0
6	Mansi	10	434	110	0	2	0	0	0
7	Parbatta	2	731	1174	1	0	0	0	0
Khagaria		**46**	**7867**	**1791**	**1279**	**15**	**182**	**11**	**1**

DW: Dug Well, STW: Shallow Tube Well, MDTW: Medium Depth Tube Well, DTW: Deep Tube Well, SW: Surface Water

In Khagaria district, irrigation is mainly done through shallow tube wells and medium depth tube wells. However, in Allauli block, irrigation is also done through surface water flow and lift irrigation methods. Allauli block is also having the largest number of deep irrigation tube wells in the district.

1.14 Cropping Pattern

The cropping calendar starts from the month of July and continue to the month of June of the succeeding year before the onset of monsoon. Thus a calendar year is divided into four crop season viz., Kharif, Rabi and Garma. During Kharif season, irrigation in the district is mainly dependent on monsoon rainfall. However, both rabi and garma crops are mainly depended groundwater. The season-wise major crops under irrigation in the district is given in table 1.7.

1.15 Prevailing Water Conservation/Recharge Practices

In Khagaria district, the existing village pond/Tanks are the traditional water conservation structures. Major water conservation measures are not necessary in the district by considering the resource availability except in some blocks.

1.16 Geology

Geologically, the entire Khagaria district is covered by Quaternary alluvium deposits comprising of various grades of sand, silt and clay. As per the surface geological map, the oldest group of lithounits exposed in the district is Newer Alluvium, comprising three formations viz the Kosi-Ganga Formation overlain by Purnea Formation, and Fatwa Formation on the top. All these formations are of Holocene age. The youngest age group of lithounits are the present day deposits which are confined to the river channels. A generalised statigraphic chart of the district is given below. A simplified geological map is given under fig. 1.11.

Age	Group	Formation	Lithology
Meghalayan	Newer Alluvium	Present Day Deposits	Sand, Silt and Clay
Holocene	Newer Alluvium	Fatwa Formation	Sand, Silt and Clay
Holocene	Newer Alluvium	Purnea Formation	Sand, Silt and Clay
Holocene	Newer Alluvium	Kosi-Ganga Formation	Sand, Silt and Clay

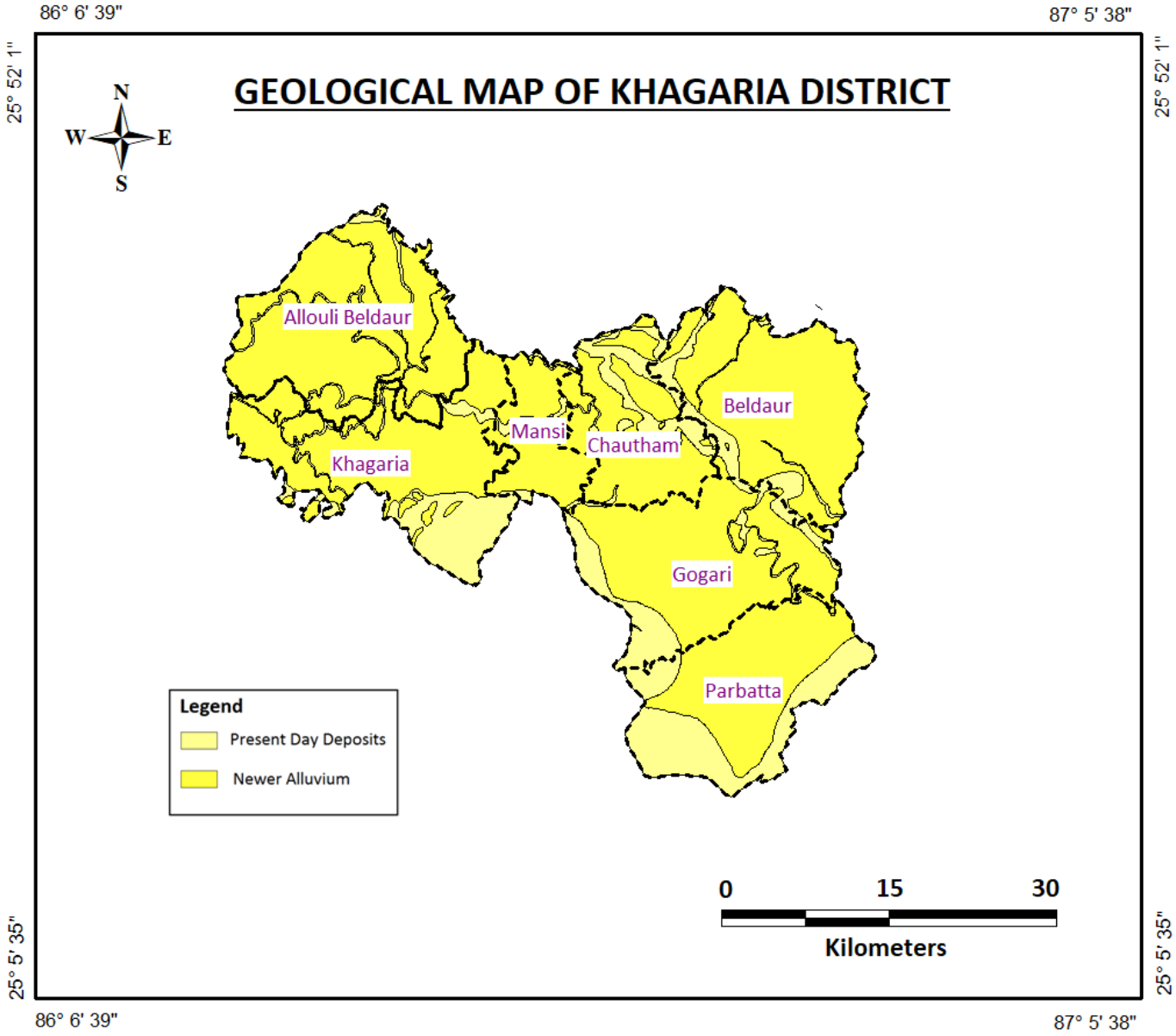


Fig. 1.11: Simplified Geological Map of Khagaria District (Source: Geological Survey of India-Published Maps)

CHAPTER-II

DATA COLLECTION AND GENERATION

The primary Data such as water level, quality, geophysical data and exploration details available with CGWB has been collected and utilized as baseline data. The Central Ground Water Board has established a network of observation wells under National Hydrograph Network programme to study the behavior of ground water level and quality of ground water in the district. To understand the sub–surface geology, identify the various water bearing horizons including their depth, thickness and compute the hydraulic characteristics such as transmissivity and storativity of the aquifers, exploratory drilling programme was carried out by Central Ground Water Board. For other inputs such as hydrometeorological, Landuse, cropping pattern etc. were collected from concerned State and Central Govt. departments and compiled.

2.1 Hydrogeology

Geologically, Khagaria district is characterised by the Younger alluvium to present day sediments transported and deposited by river Kosi. Since the Himalayan river brings huge quantum of sediments during monsoon season, it gets deposited along the flat north Bihar Plain forming a megafan. This alluvial fan forms the proliferous aquifer system in the district. Based on the available data, it is inferred that the district is covered by thick pile of alluvium sediments of Quaternary age comprising various grades of clay, silt and sand. The top most layer comprises of clay mixed with kankar and silt and, in many places with fine sand. The top layer is semi pervious, which is followed by fairly thick sands of various grades forming potential aquifer system. Available data indicates presence of prolific mono-aquifer system up to the explored depth of 310 mbgl.

2.2 Water Level

2.2.1 Depth to Water Level and Water Table

Ground water monitoring had been carried out at in the district during the course of study (2019-20, and 2020-21) (**Annexure – 2**). A map showing location of the established NHS monitoring stations and key wells in Khagaria district is prepared and given under Fig. 2.1. The depth to water level map representing the shallow aquifer has been prepared for pre and post monsoon seasons (Fig. 2.2 & 2.3). Depth to water level map of the district shows that majority of the area has water level between 5 to 10 m bgl during pre-monsoon and between 2 to 5 m bgl during post monsoon. In some patches of Parbatta and Gogari blocks, it varies from 2 to 5 m bgl during pre-monsoon and between 0 to 2 m bgl during post-monsoon. A water level fluctuation map has also been prepared and given in fig. 2.4, It can be seen that depth to water level fluctuates between 3 to 4 m in most of the part

of the district.

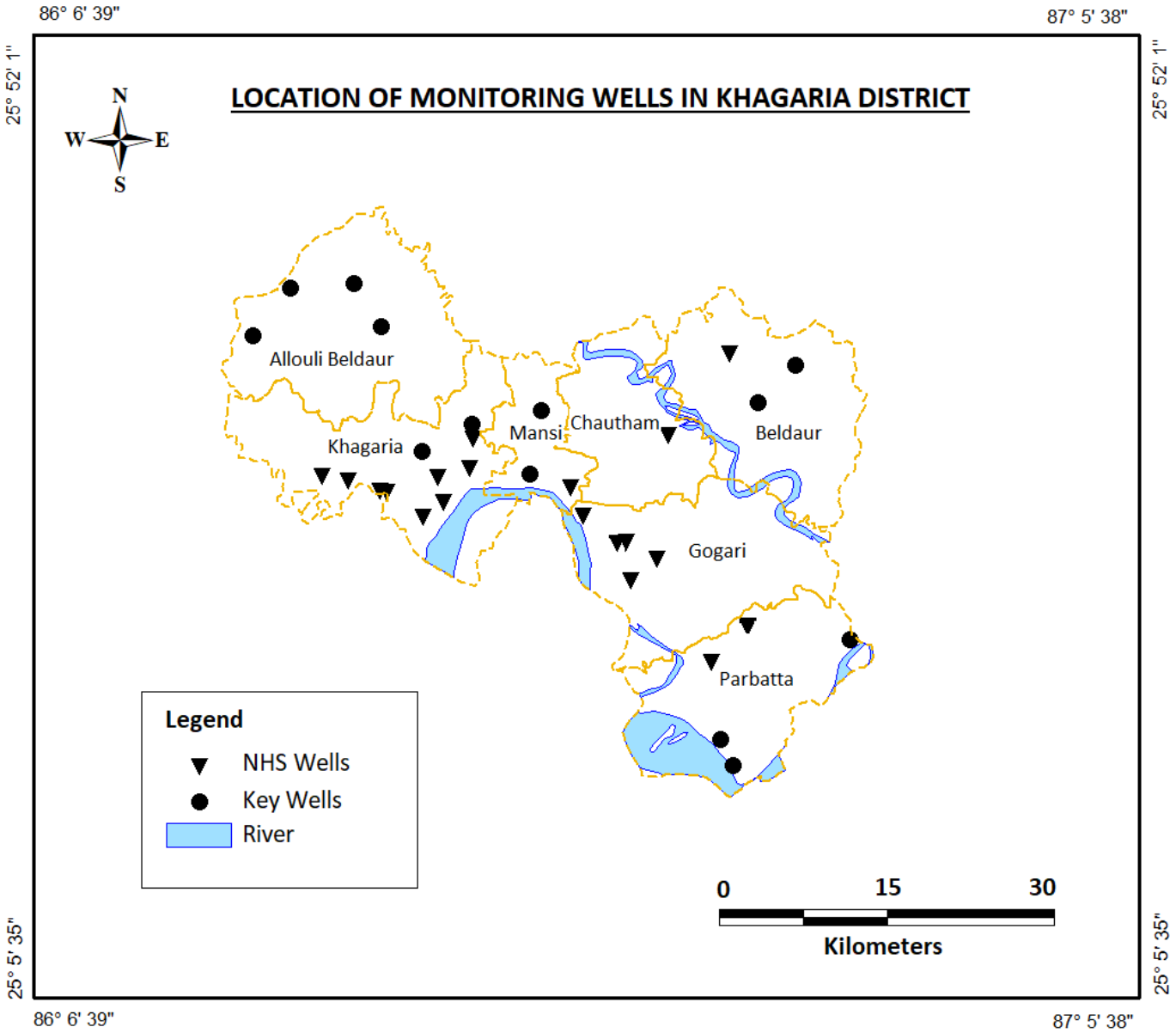


Fig.2.1: Location of monitoring Wells in Khagaria District

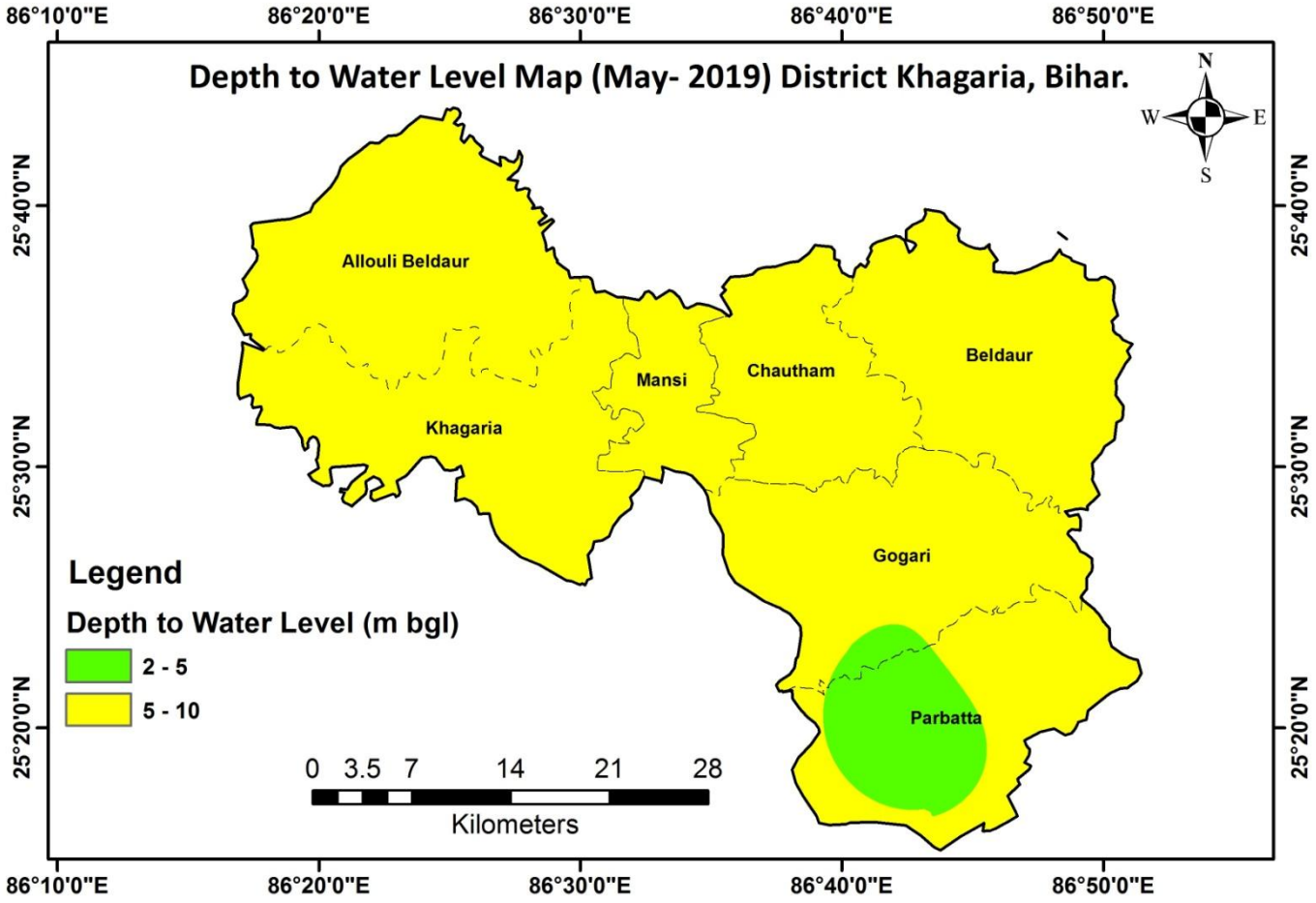


Fig. 2.2: Pre-Monsoon (May 2019) depth to water level map of Khagaria district

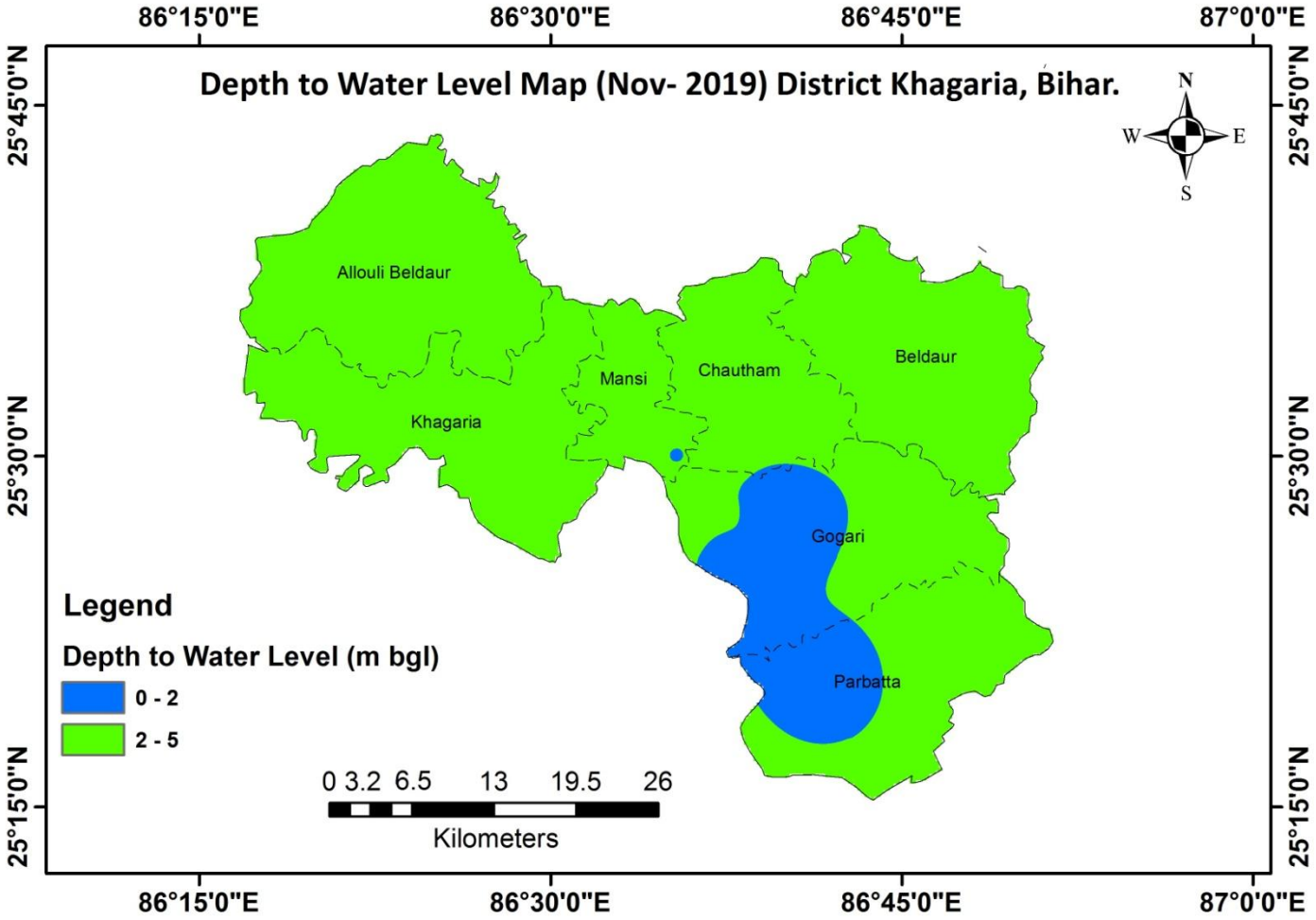


Fig 2.3: Post-monsoon (November 2019) Depth to water level Map of Khagaria district

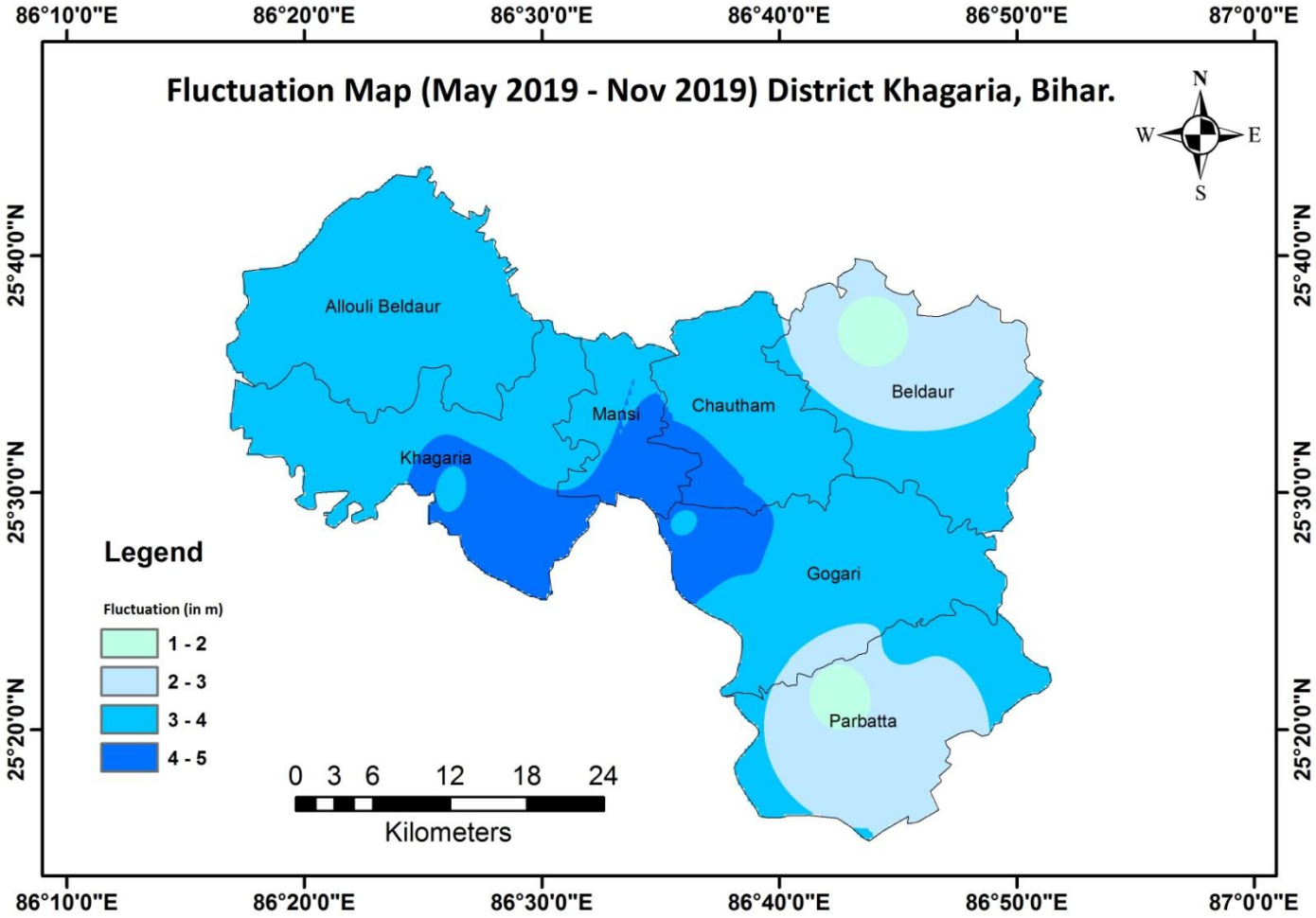


Fig 2.4: Water level fluctuation map of Khagaria district

2.2.2 Long Term Groundwater Level

Long term groundwater level trend over ten years (from 2010 to 2019) has been analysed by using data from 21 network monitoring stations in Khagaria district. Depth to water level during January, May, August and November months has been enumerated over this period and hydrographs were prepared (Fig.2.5 to 2.8). From the hydrographs, it can be seen that no significant variation in groundwater level is observed over long term in the district.

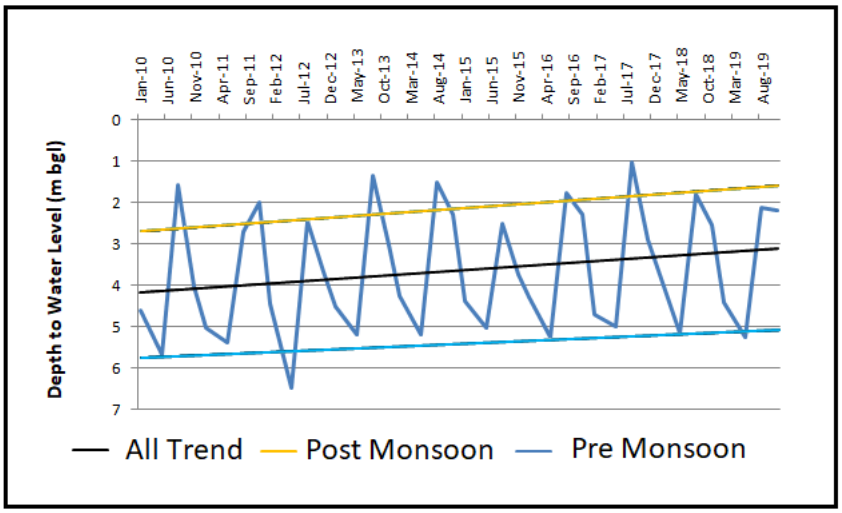


Fig. 2.5: Hydrograph of NHS monitoring Well at Chautam

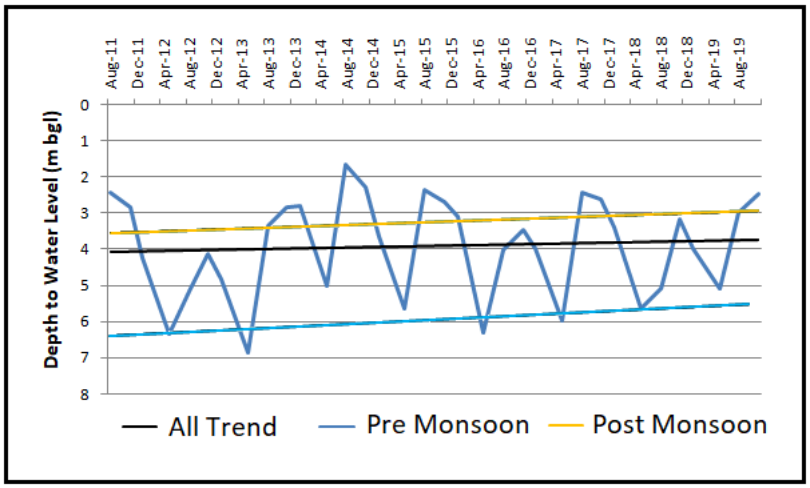


Fig. 2.6: Hydrograph of NHS monitoring Well at Jamalpur

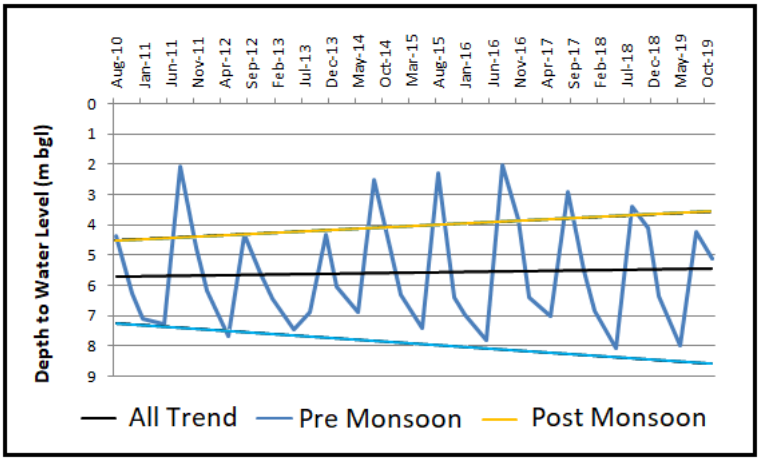


Fig. 2.7: Hydrograph of NHS monitoring Well at Khagaria

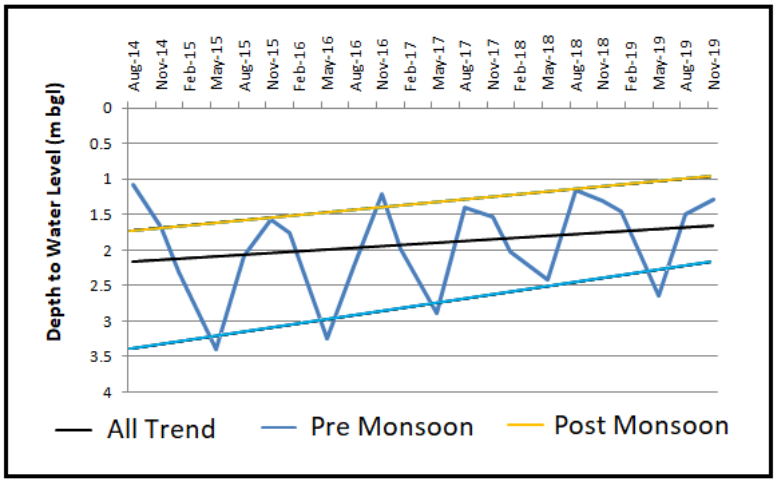


Fig. 2.8: Hydrograph of NHS monitoring Well at Dewri

Table 2.1: Showing long term groundwater level trend of some NHS wells in Khagaria district

Sl. No.	NHS Well	Pre-monsoon Trend (cm/year)	Post Monsoon Trend (cm/year)	Pre/Post Trend
1	Chautam	0.02	0.02	Flat/Flat
2	Jamalpur	0.03	0.01	Flat/Flat
3	Khagaria	-0.01	0.0007	Flat/Flat
4	Dewri	0.06	0.02	Flat/Flat

2.3 Hydrogeochemical Investigation

Water Quality Sampling, Number of Samples and Analysis Mechanism

Groundwater quality of an area is a function of physical and chemical parameters that are greatly influenced by geochemical characteristics of the formations and anthropogenic activities. The concentration of the major ions and other dissolved ions in ground water are function of the availability of the constituents in the aquifer matrices and their solubility. Quality of ground water is as much demanding as its quantity. Suitability of ground water for drinking and irrigational purpose is important for its safe and effective use. In Khagaria district, both irrigation and domestic requirement are mostly depended on groundwater.

Groundwater quality studies have been done based on the samples collected from the study area during May-2019 and February 2021. A total number of 19 samples were collected for analysis. Water samples were collected and stored in 01 litre capacity clean high-density polyethylene bottles

with poly-seal caps. Before collection of samples, bottles were properly washed and were rinsed by the water to be sampled. The hand-pumps were pumped for sufficient duration before collecting ground water sample so that the stagnant water, if any, is completely removed.

These water samples were analysed in chemical laboratory of CGWB MER-Patna. Besides these, available previous year data of chemical analysis of ground water were also studied to have an understanding of ground water chemistry of the area. From the chemical data it can be observed that pH of the analysed samples vary from 8.10 to 9.4 indicating that waters are slightly alkaline. Concentration of major parameters has been plotted in Box and Whisker diagram and given in fig. 2.9. The prominent hydro chemical facies has been identified from Hill-Piper diagram and Durov plot (fig. 2.10 & 2.11). From the diagram, it can be observed that majority of the analysed samples comes under 'Magnesium/Sodium Bicarbonate Type' facies. Analytical results of ground water samples are given in **Annexure III**.

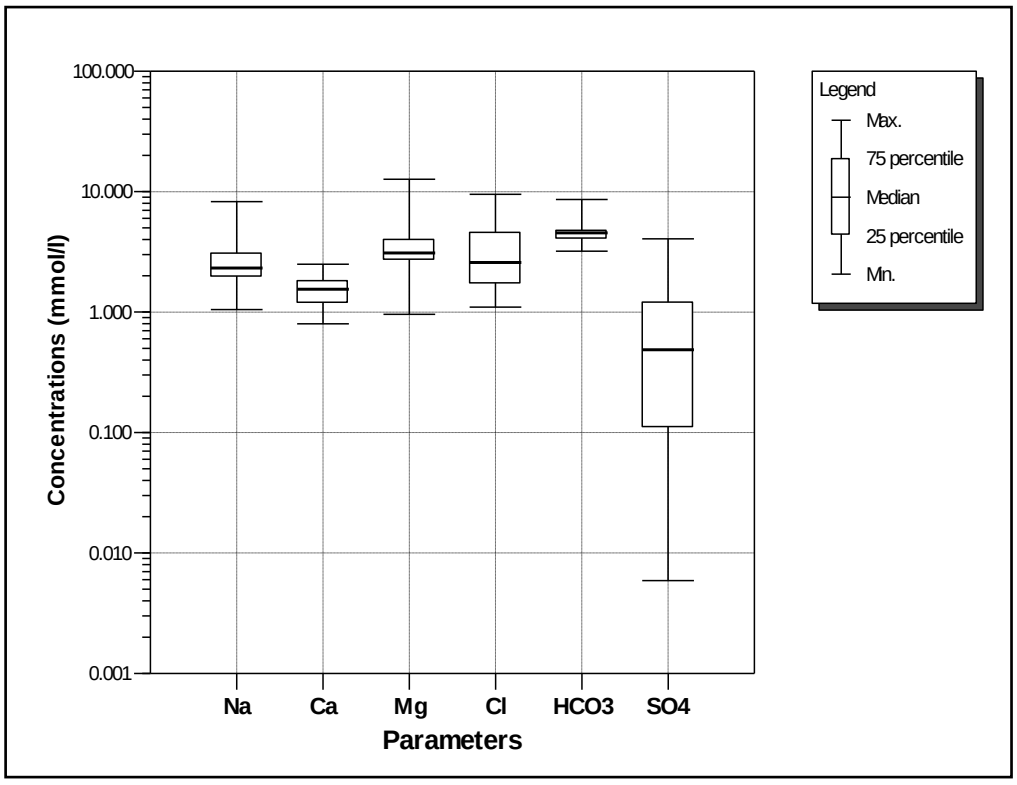


Fig. 2.9: Box-Whisker plot showing concentration of major parameters in the analyzed samples

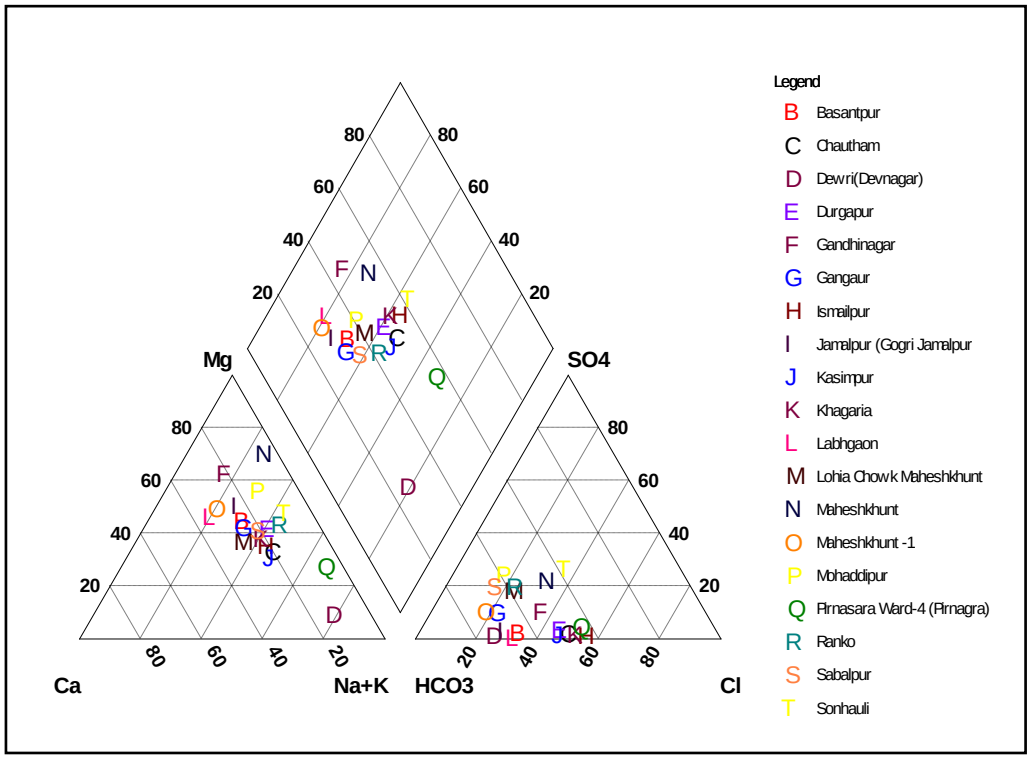


Fig. 2.10: Hill-Piper Trilinear Diagram showing hydro-chemical facies of the analyzed samples

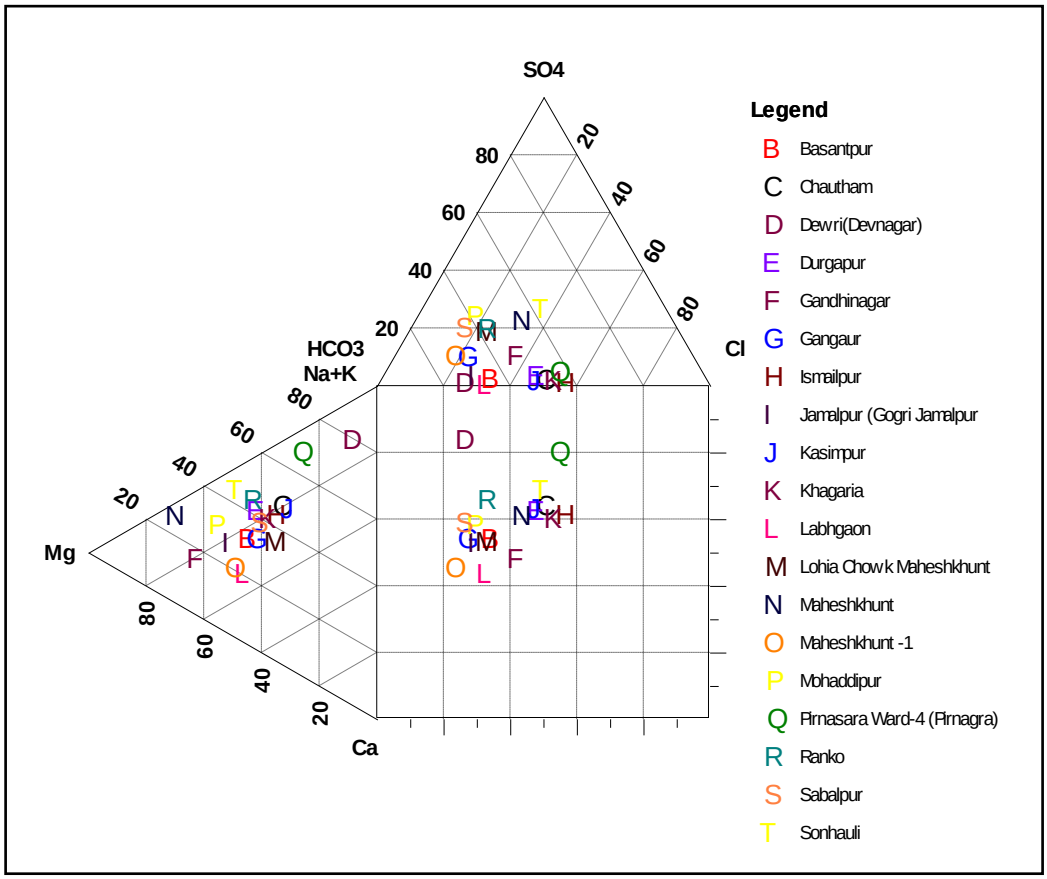


Fig. 2.11: Durov plot showing hydro-chemical facies of the analyzed samples

Quality of irrigation water varies significantly based on its dissolved salts. The salts may originate from dissolution or weathering of rocks and soil. From the analysis of data, it can be seen that TDS values ranges from 227.37 mg/L (Kasimpur) to 1307.8 mg/L (Pirnagra), which is within the permissible limit as per Bureau of Indian Standards (BIS) for drinking purpose. Correspondingly, EC values of analyzed samples ranges from 349.80 (Kasimpur) to 2012 (Pirnagra) µS/cm @ 25°. The results obtained from chemical analysis were plotted in USSL diagram as shown in figure 2.12. From the figure, it can be observed that all samples have low SAR value and come under moderate-high salinity hazard zone.

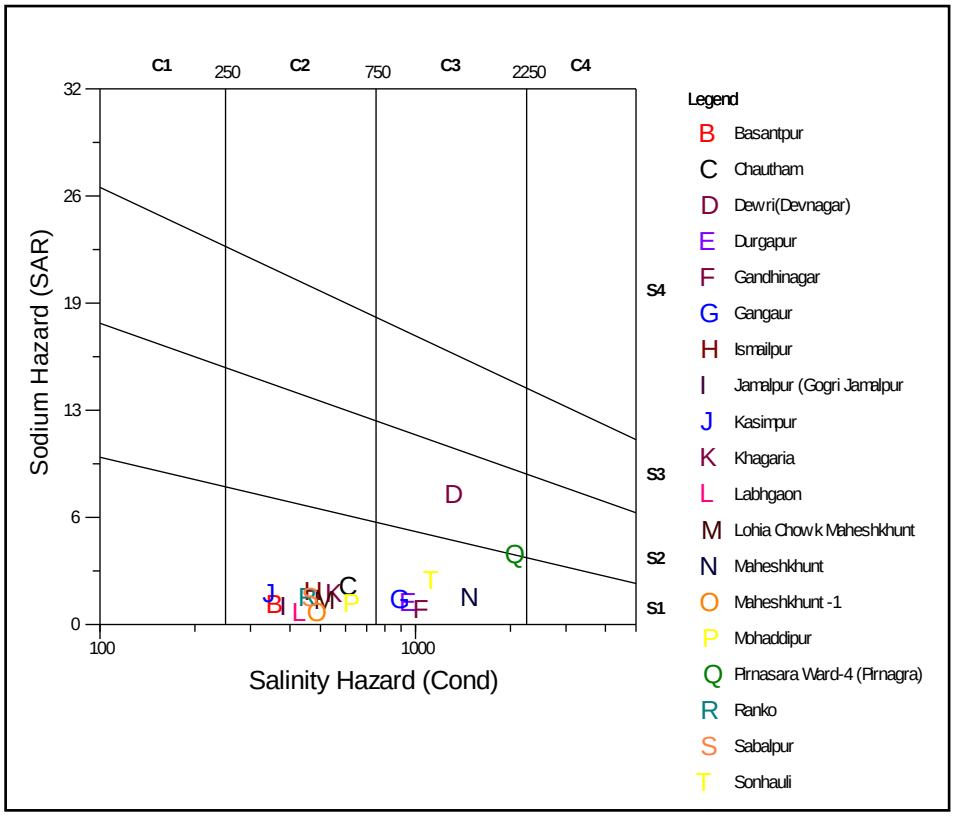


Fig. 2.12: US Salinity Diagram showing suitability of groundwater for irrigation

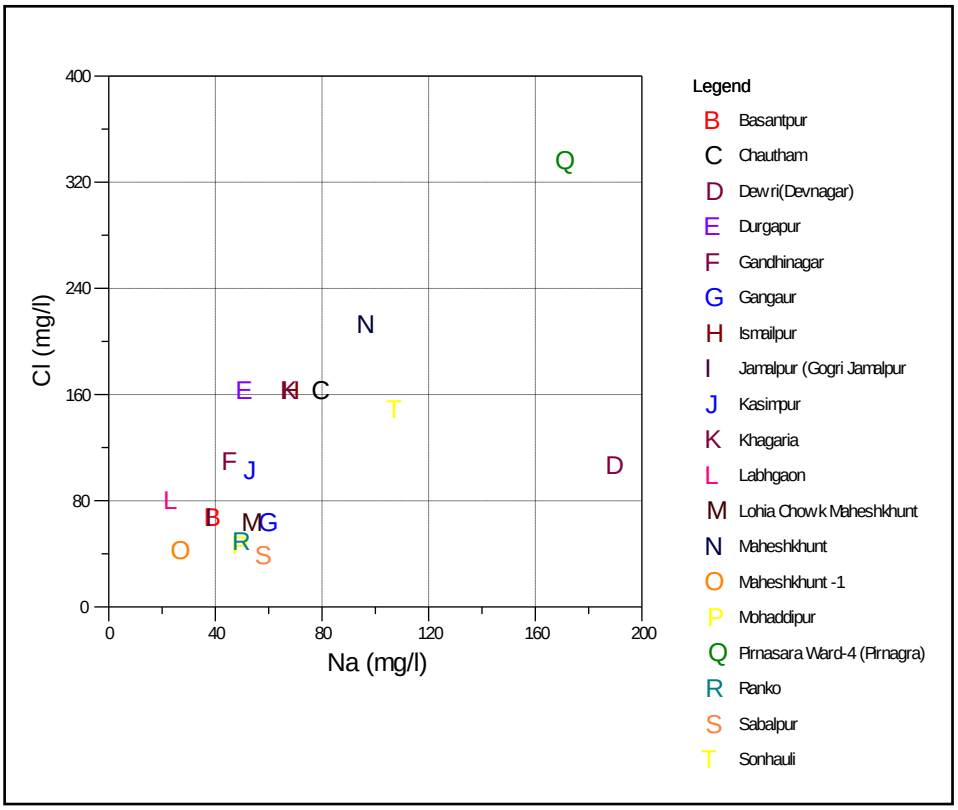


Fig. 2.13: Bivariate plot showing concentration of Sodium V/s Chloride

2.4 Exploratory Drilling - CGWB and Outsourcing

Sub-surface lithological information (down to 190 mbgl) from the available drilling records of exploratory well of CGWB and wells constructed by other agencies have been tabulated in Table 2.3A & 2.3B. A map showing locations of exploratory wells constructed in the district has been given in Fig. 2.17. Corresponding lithologs are given in **Annexure-IV**.

Table 2.2A: Location Details of Exploratory Wells Drilled by CGWB

Sl. No.	Location	Block	Longitude	Latitude	Depth Drilled (m bgl)	Year of Construction
1	Rahimpur	Khagaria	86.4675	25.49167	310	2020
2	Samaspur	Gogri	86.6188	25.4683	291.62	2020
3	Baisa	Parbatta	86.7283	25.3513	257.56	2020
4	Srisarnia	Gogri	86.645	25.4277	309.4	2020

Table 2.2 B: Location Details of Exploratory Wells Drilled by other agencies

Sl. No.	Location	Block	Latitude	Longitude	Elevation (m amsl)	Depth Drilled (m bgl)
1	Babhan gawan	Khagaria	25.5457	86.3930	40.2	85.4
2	Bachhauta	Khagaria	25.5426	86.4561	37.1	103.7
3	Bhadas	Khagaria	25.5515	86.4297	38.8	135.4
4	Darhi	Khagaria	25.5117	86.4174	38.2	85.4
5	Dumaria	Parbatta	25.3020	86.6938	37.3	69.81
6	Fatehpur	Gogri	25.3996	86.6789	40	79.57
7	Goriyami	Allauli	25.6160	86.3834	39.7	92.99
8	Harinmar	Gogri	25.3849	86.6128	39.7	94.51
9	Haripur	Allauli	25.6561	86.3358	37.4	94.51
10	Jahangira	Khagaria	25.5207	86.3687	39.3	128.35
11	Jhajhra	Parbatta	25.3947	86.7707	35.7	91.46
12	Jogia	Allauli	25.6450	86.3454	39.7	71.46
13	Kaithi	Chautham	25.5317	86.6859	43	96.03
14	Khutia	Mansi	25.5121	86.5503	40.8	91.46
15	Malia	Gogri	25.4213	86.6787	39.1	79.3
16	Marar	Khagaria	25.5909	86.5052	41	97.6
17	Mehsauri	Khagaria	25.5303	86.5088	38.3	95
18	Mujona	Allauli	25.6378	86.3135	38.1	88.41
19	Nayagaon	Parbatta	25.3282	86.6949	38	83
20	Nista	Allauli	25.6459	86.3324	40.9	88.41
21	Rahimpur	Parbatta	25.3150	86.6916	32.1	80
22	Rasonk	Khagaria	25.5591	86.5014	39.4	141
23	Ratan	Gogri	25.4450	86.6424	39.9	91.8
24	Raun	Allauli	25.6397	86.3840	38	91.46
25	Samaspur	Gogri	25.4790	86.6253	39.5	69.82
26	Saraiya	Chautham	25.5305	86.6692	38.6	79.29
27	Saurh	Parbatta	25.3192	86.8148	37	85.36
28	Sauthihi Bishnupur	Allauli	25.6295	86.5277	41	91.46
29	Sher Chakla	Gogri	25.3878	86.7070	39.1	91.5
30	Sondiha	Gogri	25.4015	86.7303	40.3	91.46
31	Sanihar	Allauli	25.5911	86.2937	38.6	91.46
32	Tetarabad	Khagaria	25.4958	86.3620	42	103.7
33	Thatha-I	Chautham	25.5413	86.6568	40.2	73.47
34	Timarpur	Parbatta	25.3581	86.6739	38.7	97.56

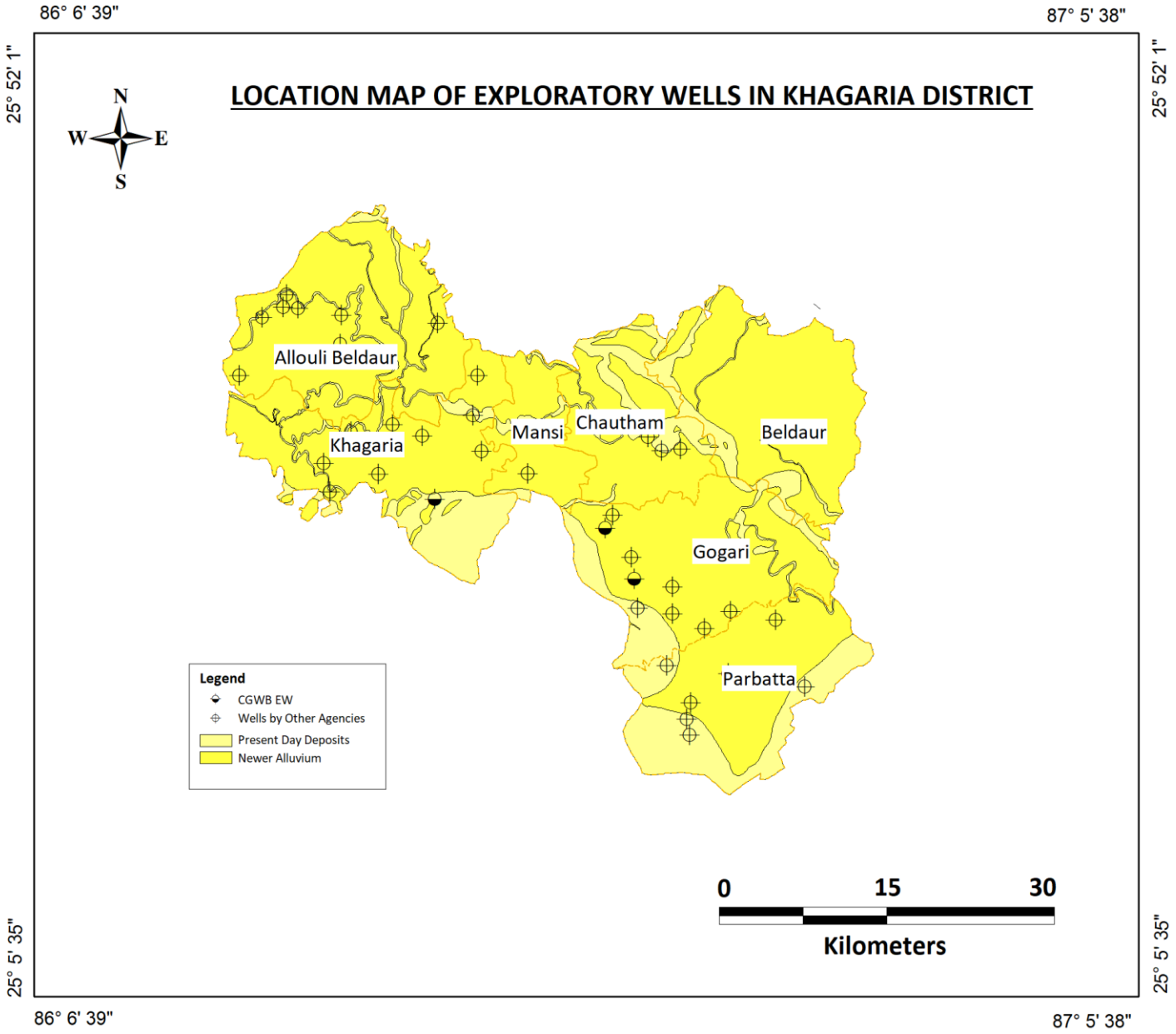


Fig. 2.14: Location map of exploratory wells constructed by CGWB and other agencies in Khagaria district

2.5 Hydrogeological Map

Hydrogeological map of the study area has been generated by integrating hydrogeological, chemical data obtained through the study. The map generated has been given under fig. 2.15.

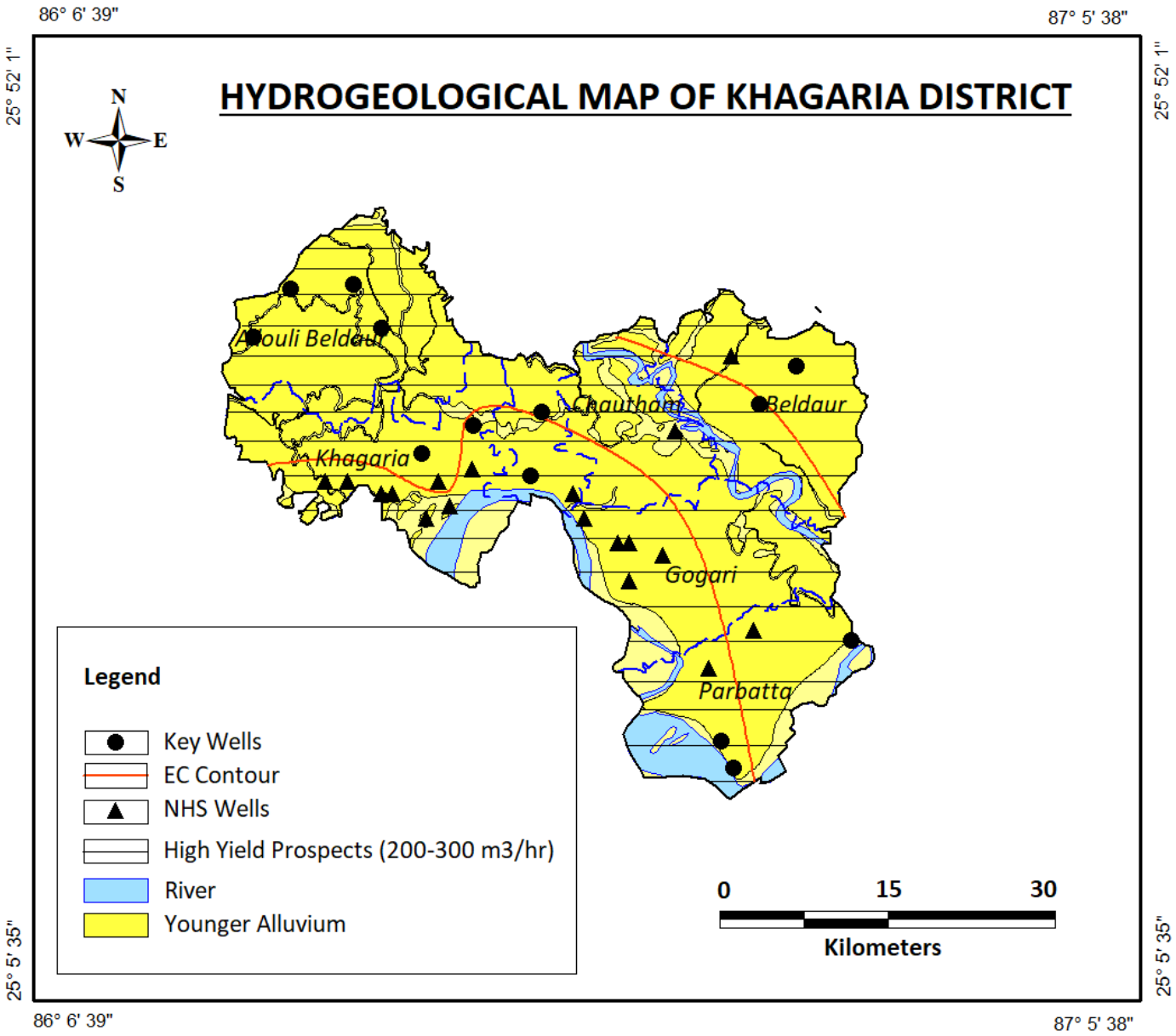


Fig. 2.15: Hydrogeological map of Khagaria district

CHAPTER-III

DATA INTERPRETATION, INTEGRATION AND AQUIFER MAPPING

3.1 Hydrogeology

The north to central part of the district forms part of lower end of Kosi mega fan, while the southern part forms flood plain of river Ganga. The entire district is covered by thick Quaternary alluvium deposits of various grades of sands with lenses of clay layers with limited extend. The thickly bedded sand layer forms groundwater reservoir of the area. The top most layer comprises of clay mixed with kankar and silt and, in many places with fine sand and is semi pervious in nature. The top layer is followed by a prolific mono-aquifer system down to the explored depth of 310 mbgl.

3.2 Aquifer Disposition

Aquifer disposition of the district has been studied through prepared sections based on the lithologs obtained through exploratory drilling done by CGWB and other agencies. Based on this, detailed aquifer geometry on regional scale has been established in the study area. Principal aquifer in the area has been delineated by grouping the fine to medium sand, coarse sand as aquifers. The granular zones encountered at different depths are grouped into an aquifer system based on its lateral continuity.

As per surface geological map, more than 90% of area of the district is occupied by Younger alluvium deposits. While present day deposits are limited to the river channels. Based on the available borehole data, major sand horizons are delineated and geological sections are prepared. As per drilling data, the sand horizon extends upto explored depth of 310 m. A correlation of the lithologs of other wells clearly shows that there is no any intervening, regionally continuous aquitard layer encountered in the basin. Therefore, the various sands down to depth of 310 m bgl can be considered as mono-aquifer system. There is a surface clay layer of thickness 5 to 10 m which caps the mono-aquifer system in the area. It is to be noted that the water level observed are within 5m, and the area also does not have many deep wells. The common depth of boring is restricted within 80-100 m. Disposition of aquifer through the study of different lithological sections, fence diagrams based on borehole data are given in Fig 3.1.

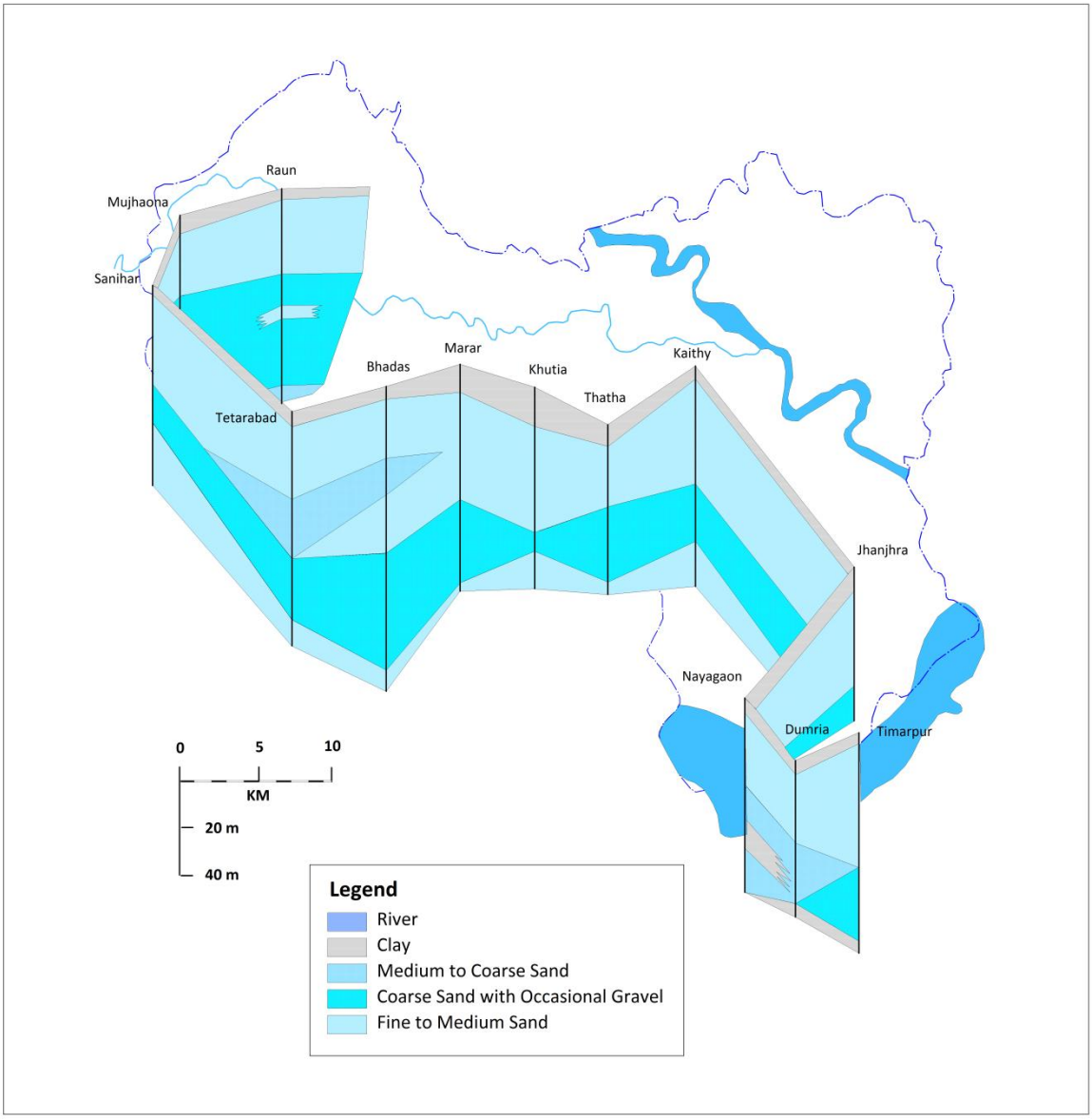


Fig. 3.1: Panel diagram showing aquifer disposition from Timarpur to Raun area.

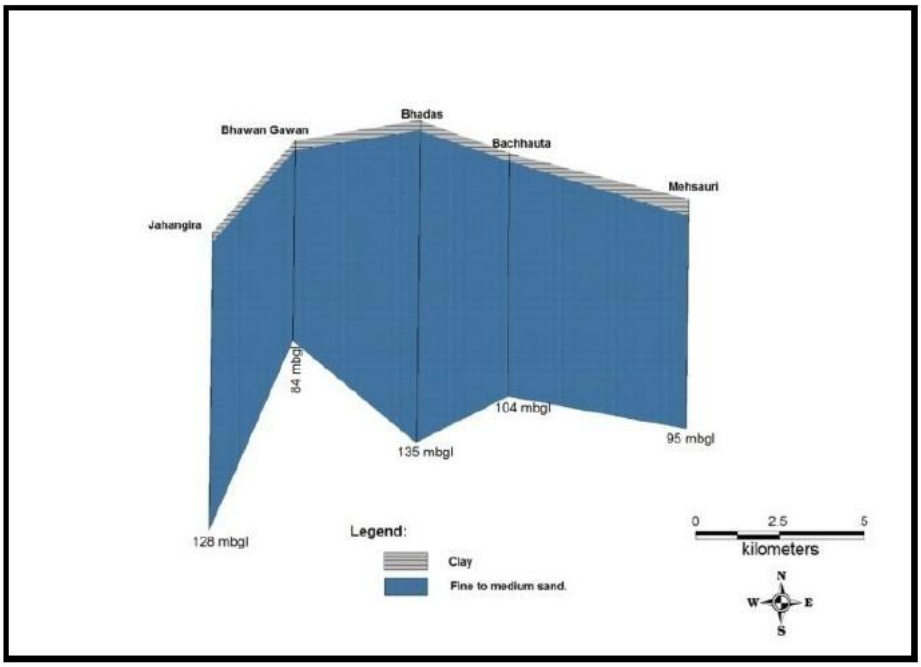


Fig. 3.2: Aquifer disposition in Khagaria block

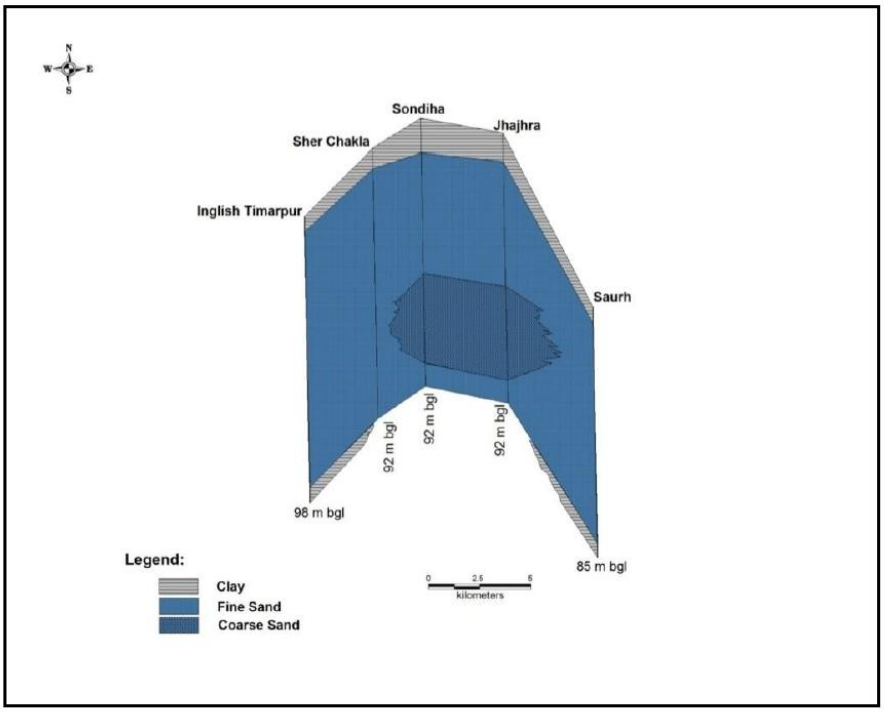


Fig. 3.3: Aquifer disposition in Parbatta block

3.2.1 Panel Diagram

Aquifer disposition of the study area has been deciphered through the panel diagram plotted by connecting exploratory wells drilled from Raun to Timarpur area. The top capping semi-pervious clay layer has been encountered in all bore holes, which is followed by extensively thick sand layers of various grades. The aquifer is regionally extensive and highly potential upto the explored depth of 310 m bgl. Thus it can be inferred that mono-aquifer system exists in the district with localised patches of black clay indicating change in facies during sedimentation. The fine to medium grained sand constitute major part of the aquifer system, as the entire district forms part of the lower part of fan area.

3.2.2 3-D Aquifer Disposition

Aquifer disposition of Khagaria district in 3-D has been generated based on the available borehole data and other subsurface information and is given in fig. 3.4. From the 3-D disposition, single-aquifer system in the district can be well demarcated. The aquifer system is characterised by predominance of fine to medium-grained sand. The basin slopes towards the south and forms part of the Himalayan foreland. The aquifer system forms the southern part of lower fan area of the Kosi mega-fan.

3.2.3 Ground Water Dynamics

CGWB has drilled very few wells in the area and therefore there is a general paucity of data. Pumping test data of CGWB wells have been analyzed to arrive at the hydraulic characteristics of the aquifers. Data of wells constructed by State Government indicate that shallow tube wells tapping aquifer (within 110 m bgl) can yield 200 to 300 m3/hr for a drawdown of 2- 4 m. Groundwater occurs under water table to unconfined condition in the district. However, in some boreholes, patches of clay are encountered below the granular zone indicating semi-confined condition of the aquifer. A perusal of the pumping test data shows potentiality of the aquifer of the area with high transmissivity rates. The disposition and hydraulic properties shows that aquifer in the district is heterogeneous both vertically and laterally.

3.3 Ground Water Exploration

As mentioned earlier, there is a general paucity of data as exploratory wells drilled by CGWB in the district is limited (04 no.s). However, wells drilled by State Govt. and other agencies are used for preparation of aquifer disposition and in order to decipher the hydraulic properties of the aquifers. Exploratory drilling has been conducted down to the depth of 310 m bgl in order to decipher the subsurface aquifer configuration. Aquifer parameters have been determined by

conducting pumping tests. Lithologs of CGWB and State Govt. agencies were compiled, correlated and hydrogeological sections, and 3 D aquifer disposition of the district has been prepared.

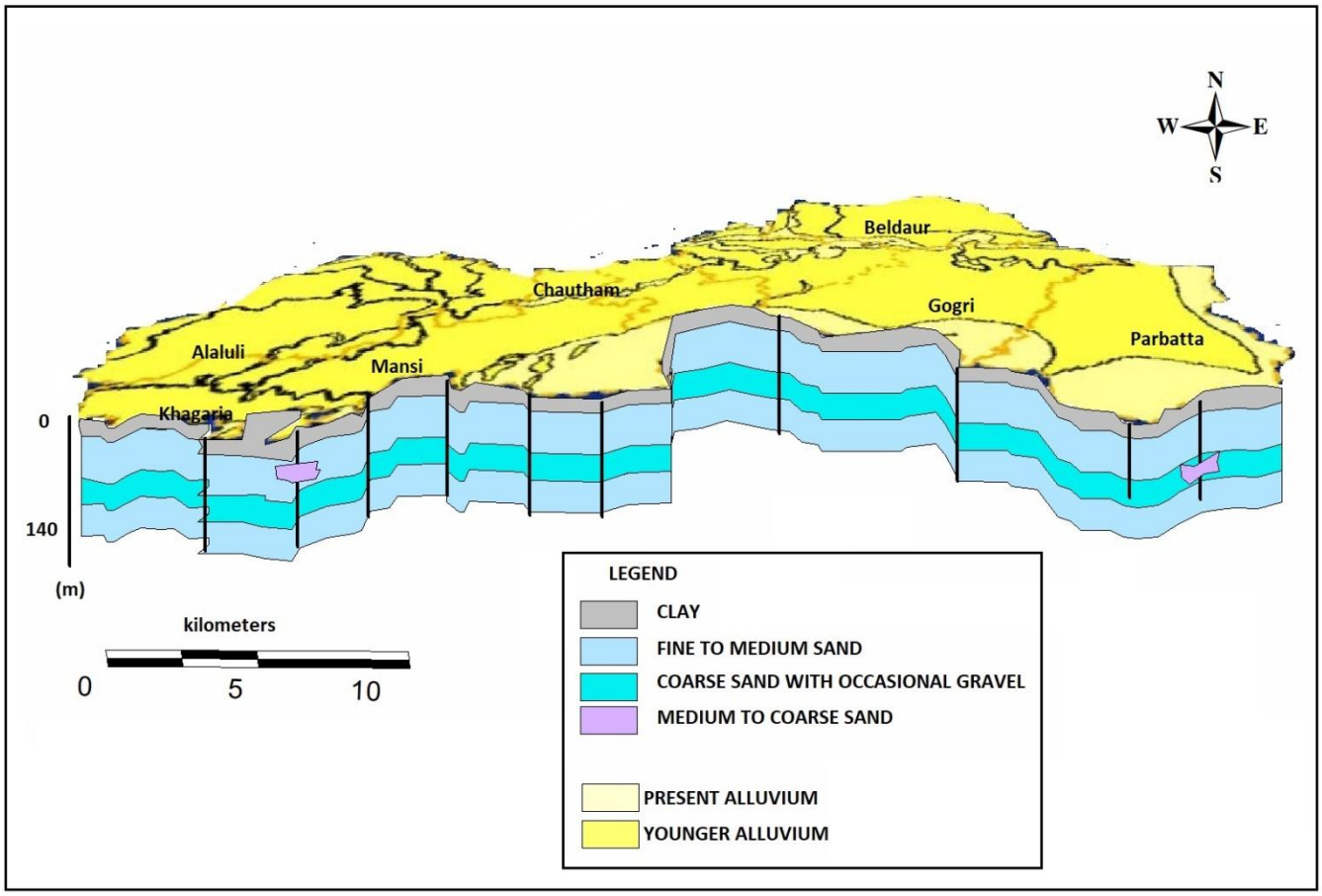


Fig. 3.4: 3-D aquifer disposition of Khagaria district

3.4 Ground Water Quality

A perusal of the groundwater quality data shows that pH of the analysed samples vary from 8.10 to 9.4 indicating that waters are slightly alkaline. Majority of the analysed samples comes under 'Magnesium/Sodium Bicarbonate Type' facies. Quality of irrigation water varies significantly based on its dissolved salts. The salts may originate from dissolution or weathering of rocks and soil. From the chemical data, it can be seen that TDS values ranges from 227.37 mg/L (Kasimpur) to 1307.8 mg/L (Pirnagra), which is within the permissible limit as per Bureau of Indian Standards (BIS) for drinking purpose. Correspondingly, EC values of analyzed samples ranges from 349.80 (Kasimpur) to 2012 (Pirnagra) µS/cm @ 25°. Data plotted in USSL diagram shows that all samples have low SAR value and come under moderate-high salinity hazard zone.

3.5 Aquifer Map

Aquifer map of the district is generated by integrating the hydrogeological sections, hydrogeological map and 3-D aquifer disposition of the area and is given in fig. 3.7. The map provides a holistic view of the aquifer systems of the district in a single view.

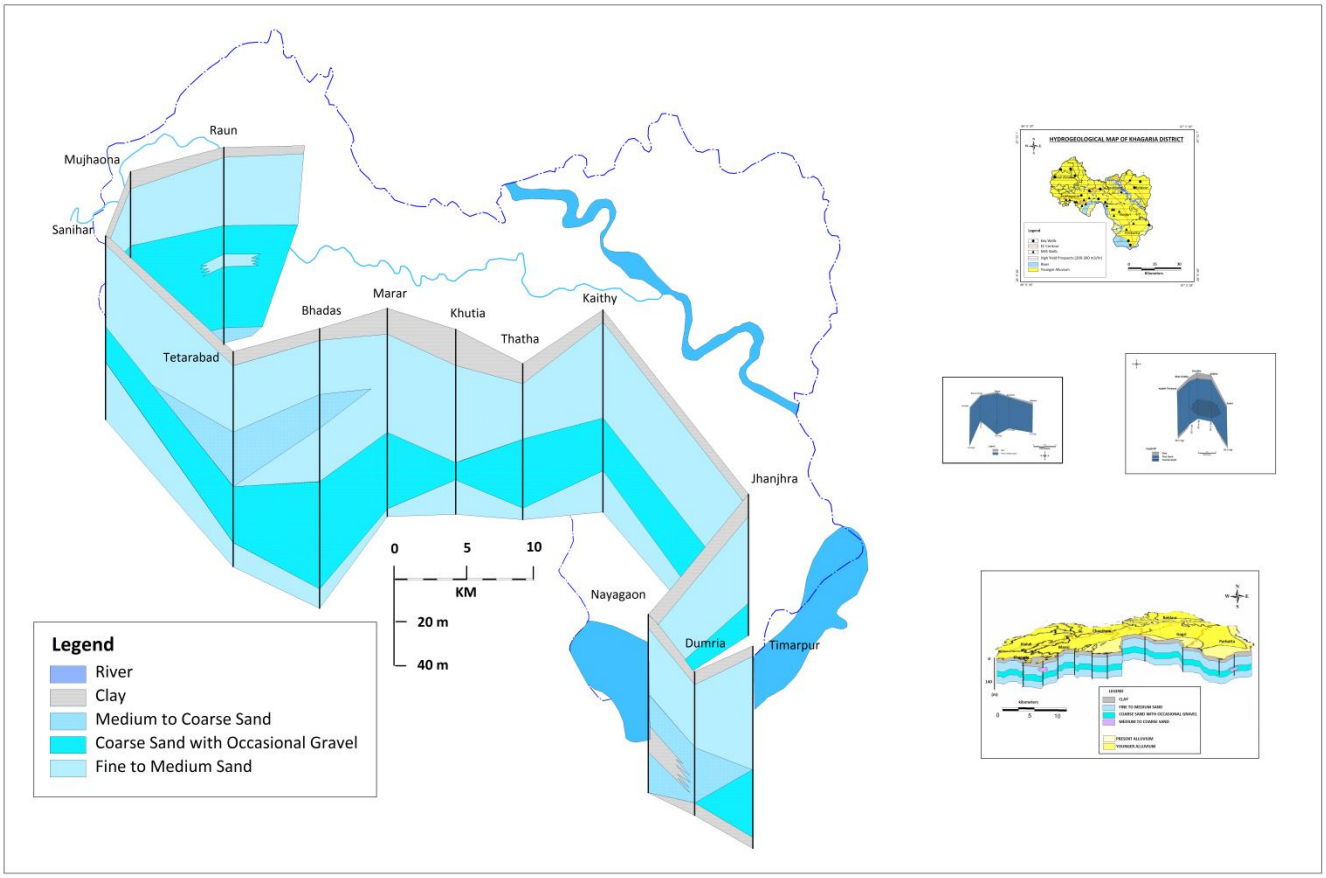


Fig. 3.5: Aquifer map of Khagaria district

CHAPTER-IV

GROUND WATER RESOURCES

4.1 Dynamic Ground Water Resources

Dynamic ground water resources of 7 blocks of Khagaria district has been assessed, as on March 2020. A summary of same is given in Table 4.1. Dynamic groundwater resource assessment of Bihar State has been jointly carried out by Minor Water Resource Department, Govt. of Bihar and Central Ground Water Board, Ministry of Jal Shakti, Govt. of India, as on March 2020. Dynamic resource of the study area has been estimated by using the norms prescribed under GEC-15. As on March 2020, estimated net groundwater resource of Khagaria district is 0.53 BCM and gross extraction is 0.26 BCM with stage of extraction of 50.26%.

Table 4.1: Summary of Dynamic Groundwater Resource Assessment in Khagaria district (as on 31st March, 2020)

	Dynamic GW Resource
	(in BCM)
Total Ground Water Recharge	**0.58**
Provision for Natural Ground Water Discharge	**0.05**
Net Ground Water Availability	**0.53**
Gross Ground Water Draft for All Uses	**0.26**
Current Annual GW Draft for Irrigation	**0.22**
Current Annual GW Draft for Domestic and Industrial uses	***0.04***
Stage of G.W. Extraction (%)	**50.26%**
Future allocation of GW for Domestic and Industrial use	**0.03**
Net GW Availability for 'Future Use'	**0.26**

Overall stage of groundwater extraction (SOE) in the district is 50.26 %. In the district, all the 07 blocks comes under safe category on the basis of the status of ground water utilisation. However, spatial variation in SOE exists. The SOE in the district varies between 27.57 % (Khagaria Block) and 66.18% (Gogri Block). Based on groundwater resource availability in the high yielding aquifer system, the district can be extensively developed.

As per GWRE-2020, irrigation consumes about 84.34% (district total) of total groundwater requirement in the district which varies from 63.88 % in Khagaria block to 88.96% in Parbatta block. Domestic and industrial use accounts for the rest 15.66% (district total) requirement. The block-wise groundwater requirement in Khagaria district is shown in figure 4.1.

In the supply side, on the other hand, 78.04 % of the total dynamic resource is constituted by monsoon rainfall recharge, whereas non-monsoon rainfall recharge contributes to about 7.39 %. Recharge from other sources constitutes the rest 14.57% (monsoon and non-monsoon combined).

It is to be noted that the entire district covered under thick Quaternary alluvium. The district is bestoed with mono-aquifer system with high groundwater yield potential. From the graph, it can be observed that blocks with lower usage for irrigation such as Allauli, Chautham, Khagaria, Mansi can be extensively developed by groundwater resource rather than canals.

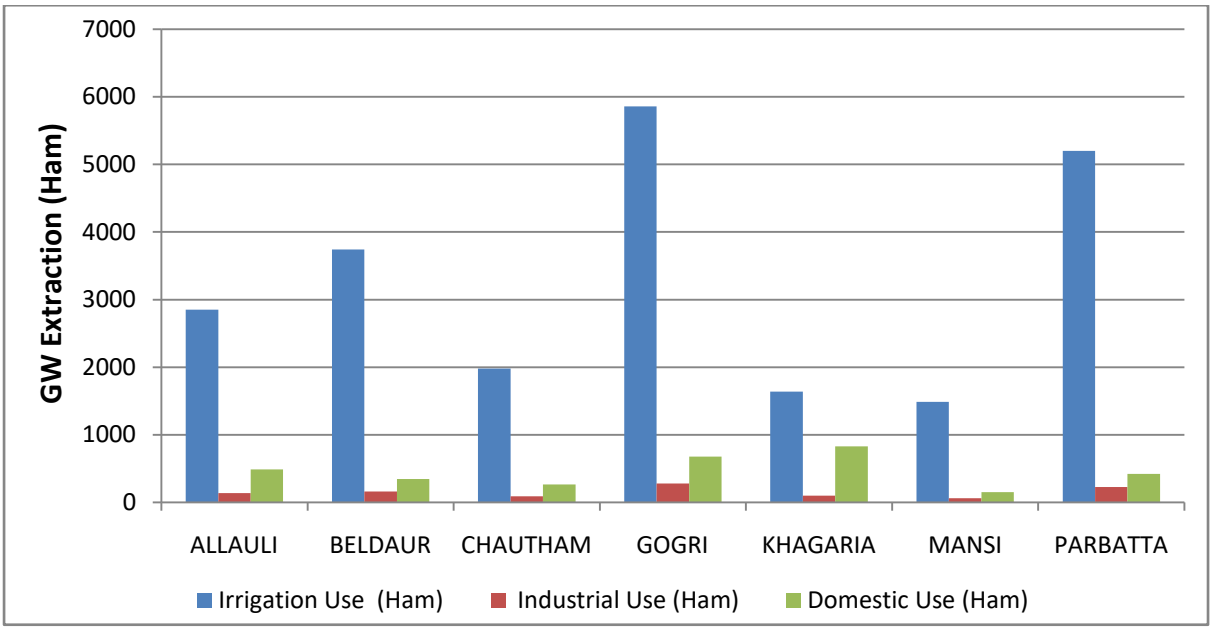


Fig. 4.1: Graph showing sector-wise groundwater draft, as per GWRE-2020

Table 4.2: Dynamic groundwater resource of Khagaria district as per GWRE-2020

Sl. No.	Blocks	Recharge from Rainfall during Monsoon (ham)	Recharge from Rainfall during Non Monsoon (ham)	Recharge from Other Sources- Monsoon (ham)	Recharge from Other Sources- Non Monsoon (ham)	Total Annual Ground Water Recharge (ham)	Provision for Natural Discharges (ham)	Net Annual Ground Water Availability (ham)
1	Alauli	6923.92	802.33	504.14	640.81	8871.2	443.56	8427.64
2	Beldaur	5260.75	653.51	607.71	782.14	7304.11	365.2	6938.91
3	Chautham	5590.3	479.32	324.98	417.83	6812.43	681.25	6131.18
4	Gogri	8533.93	731.71	950.76	1223.74	11440.14	1144.02	10296.12
5	Khagaria	8944.75	766.93	272.93	350.37	10334.98	1033.5	9301.48
6	Mansi	2386.88	204.65	251.97	320.38	3163.88	316.38	2847.5
7	Parbatta	8217.88	704.61	835.39	1076.36	10834.24	1083.43	9750.81

Blocks	Existing Gross Ground Water extraction for irrigation (ham)	Existing Gross Ground water extraction for Domestic and Industrial use (ham)	Existing Gross Ground Water D extraction for All Uses (ham)	Annual GW Allocation for Domestic Use as on 2025 (ham)	Net Ground Water Availability for future use (ham)	Stage of Ground Water Development (ham)	Category: Safe / Semi-critical/ Critical/ Over-exploited
Alauli	2852.64	621.05	3473.69	545.98	4894.02	41.22	safe
Beldaur	3742.2	506.94	4249.15	387.48	2647.22	61.24	safe
Chautham	1980.72	355.02	2335.74	297.7	3762.76	38.10	safe
Gogri	5859	954.82	6813.82	759.15	3398.97	66.18	safe
Khagaria	1638	926.24	2564.24	929.24	6635.24	27.57	safe
Mansi	1489.32	215.49	1704.8	171.29	1123.9	59.87	safe
Parbatta	5201.28	645.48	5846.76	472.33	3852.2	59.96	safe

4.2 Static Ground Water Resources

In-storage groundwater resource of unconfined aquifer has been estimated and given in table 4.3. The exercise has been carried out block-wise based on available data. Specific yield has been taken as per the prescribed norms in GWRE-2020. Static resource of Khagaria district is estimated to be 4.46 BCM. Highest static resource is estimated in Alauli, Parbatta, Beldaur blocks and lowest static resource is estimated in Mansi block due to its less area coverage.

Table 4.3: Estimated In-storage resource of unconfined aquifer in Khagaria district

Sl. No.	Block	Lithology	GW Worthy Area (ha)	Bottom of Unconfined Aquifer (m bgl)	Pre-Monsoon Water Level (m bgl)	Specific Yield	In-Storage Resource (ham)	In-Storage Resource (BCM)
1	Alauli	Alluvium	27447	40	6.07	0.1	93127.67	0.93
2	Beldaur	Alluvium	22356	40	5.32	0.1	77530.61	0.78
3	Chautham	Alluvium	16397	25	5.6	0.1	31810.18	0.32
4	Gogri	Alluvium	25031	35	5.51	0.1	73816.42	0.74
5	Khagaria	Alluvium	26236	30	7.69	0.1	58532.52	0.59
6	Mansi	Alluvium	7001	45	6.8	0.1	26743.82	0.27
7	Parbatta	Alluvium	24104	40	5.07	0.1	84195.27	0.84
Total							**445756.5**	**4.46**

CHAPTER - V

GROUND WATER RELATED ISSUES

5.1 Identification of issues

Issues related to groundwater in the study area are basically focused on the aspect of quality, quantity and sustainability. The major quality issue of the district is the reported arsenic contamination in shallow depth tube wells. As per earlier records of CGWB, it is already established that deep tube wells are free from arsenic contamination. In the case of quantity, all the blocks of the district comes under safe category as per GWRE-2020. Major groundwater issues in the district are detailed below:

5.1.1 Arsenic contamination

In Khagaria district, the four blocks namely Khagaria, Gogri, Parbatta, Mansi have already been reported with geogenic arsenic contamination. Thus a cumulative population of 1.03 million peoples is under threat of arsenic contamination, since groundwater is the major source of drinking and domestic use.

5.1.2 Seasonal flooding and water logging

The district forms part of the Kosi mega fan and experiences seasonal flooding and water logging in many parts of the district. The river enters into plains of north Bihar, the velocity of flow is dropped leading to reduction of sediment carrying capacity. Thus sediments deposited into river beds, resulting into rise of river bed and bank erosion. The mouth of the channels also gets choked causing shift in river courses. This further contributed to the rise in the river water level, which ultimately leads to overtopping and breaches of banks and flooding in the basin area.

Flooding and water logging potentially arrest agriculture activities and crop productivity. Water logging in vast flood plains of Kosi persists till October and this delays agriculture activities during Rabi season. Flooding and water logging coupled with demographic pressure put farmers to go for subsistence crops rather than value crops in many parts of the district.

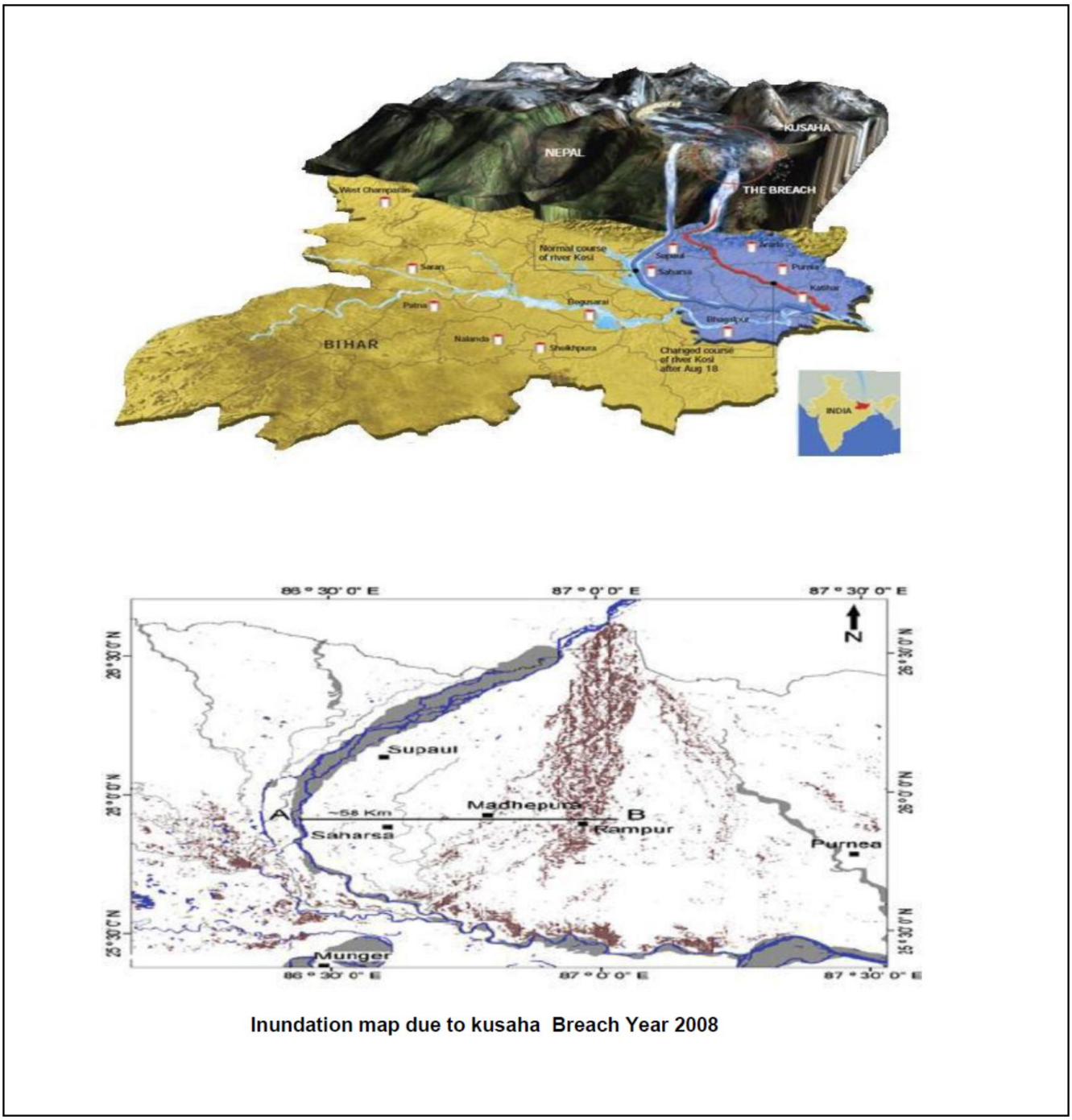


Fig. 5.1: Inudation map of river Kosi due to breach at Kusaha, Sunsari district, Nepal during 2008 flood (Source: Report on flood and sediment management in Kosi river, FMISC, Patna)

5.1.3 Irrigation demand for groundwater

Irrigation in the district is mainly dependent on groundwater. From agriculture statistics, and minor irrigation census data it can be observed that about 76.6% of the district's irrigation needs are catered by groundwater. A comparison of groundwater resource position of the district as on 2017 and 2020 has been given in the following table. It is to be noted that, in non-monsoon recharge from

other sources, there has been a major drop by 83.3% from assessment year 2017 to 2020. On the demand side, the irrigation draft has been increased by 24.67% from 2017 to 2020. Therefore, the stage of extraction has been increased by about 18% in assessment year 2020 as compared with GWRE-2017.

Table 5.1: Resource position of the district as per GWRE-2017 & GWRE-2020

Assessment Year	Annual Ground Water Recharge (ham)					Total Natural Discharges (ham)	Annual Extractable Ground Water Resource (ham)
	Monsoon Season		Non-monsoon Season		Total Annual Ground Water Recharge		
	Recharge from rainfall	Recharge from other sources	Recharge from rainfall	Recharge from other sources			
2017	38532.68	5090.31	3974.6	28655.65	76253.24	7625.32	68627.91
2020	45858.41	3747.88	4343.06	4811.63	58760.98	5067.34	53693.64

Assessment Year	Annual Ground Water Extraction (ham)				Annual GW Allocation for Domestic Use as on 2025 (ham)	Net Ground Water Availability for future use (ham)	Stage of Ground Water Extraction (%)
	Irrigation	Industrial	Domestic	Total			
2017	18258.48	1075.07	2860.09	22193.65	2860.13	46434.22	32.34
2020	22763.16	1053.00	3172.03	26988.20	3563.17	26314.31	50.26

Table 5.2: Block-wise comparison of Extraction as per GWRE-2017 & GWRE-2020

Block	Annual Extractable GW Resource		Gross Extraction irrigation		Percentage Increase Irrigation Extraction (%)	Gross Extraction Domestic		Percentage Increase Domestic Extraction (%)	SOE (%)		Difference (%)
	2017	2020	2017	2020		2017	2020		2017	2020	
Alauli	19287.87	8427.64	2288	2852.64	24.68	464.42	486.04	4.66	14.98	41.21	26.23
Beldaur	15906.14	6938.91	3000.68	3742.2	24.71	329.60	344.94	4.65	21.98	61.23	39.25
Chautham	7052.958	6131.18	1589.68	1980.72	24.60	253.23	265.02	4.66	27.44	38.09	10.65
Gogari	8834.481	10296.12	4699.06	5859	24.68	645.74	675.81	4.66	63.68	66.17	2.49
Khagaria	7352.694	9301.48	1314.2	1638	24.64	619.64	827.23	33.50	27.69	27.56	-0.13
Mansi	2289.96	2847.5	1196.38	1489.32	24.49	145.70	152.48	4.65	61.54	59.87	-1.67
Parbatta	7903.809	9750.81	4170.48	5201.28	24.72	401.77	420.47	4.65	60.74	59.96	-0.78
Khagaria	68627.91	53693.64	18258.48	22763.16	**24.67**	2860.09	3172.03	**10.91**	32.34	50.26	**17.92**

From table 5.2, it can be seen that change in stage of extraction is conspecus in Allauli, Beldaur and Chautham blocks only. However, irrigation draft has uniformly increased in all blocks. In case of domestic draft, there is a sharp increase in Khagaria block by 33.50%. In rest of the block, domestic draft shows uniform growth (5.1). From graph 5.1, it is clear that availability of net resource reduced by half in Allauli and Beldaur blocks.

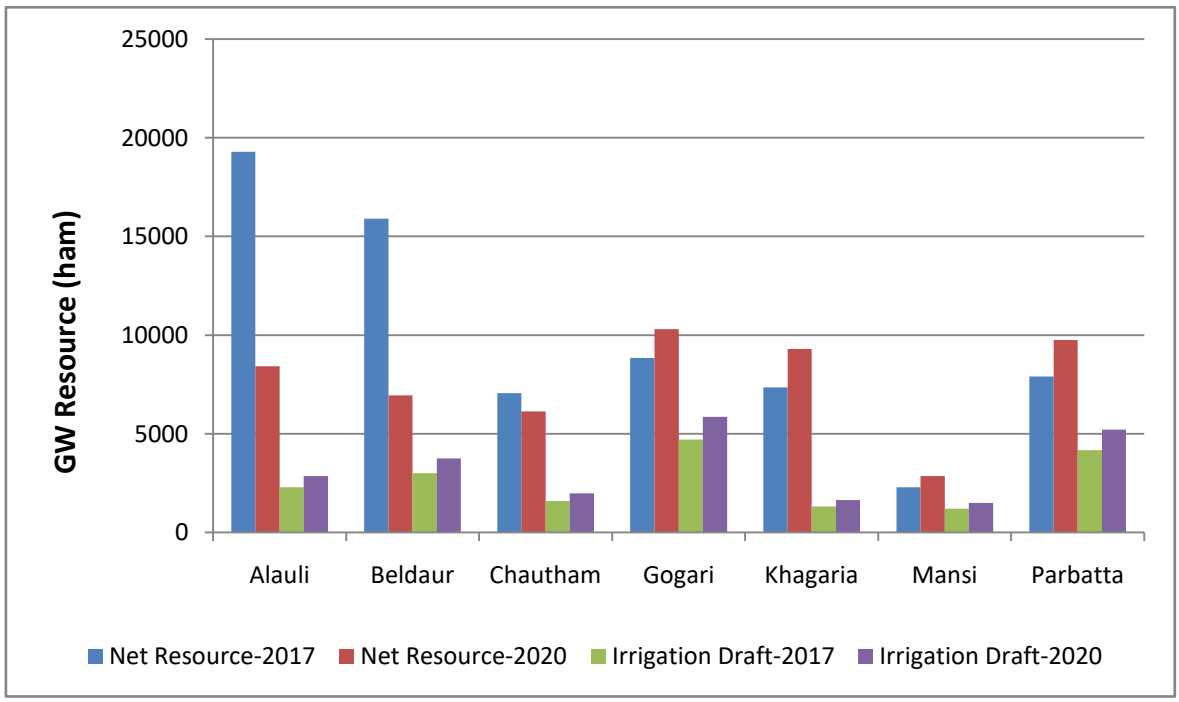


Fig. 5.2: Graph showing variation of net resource and Irrigation draft in Khagaria district

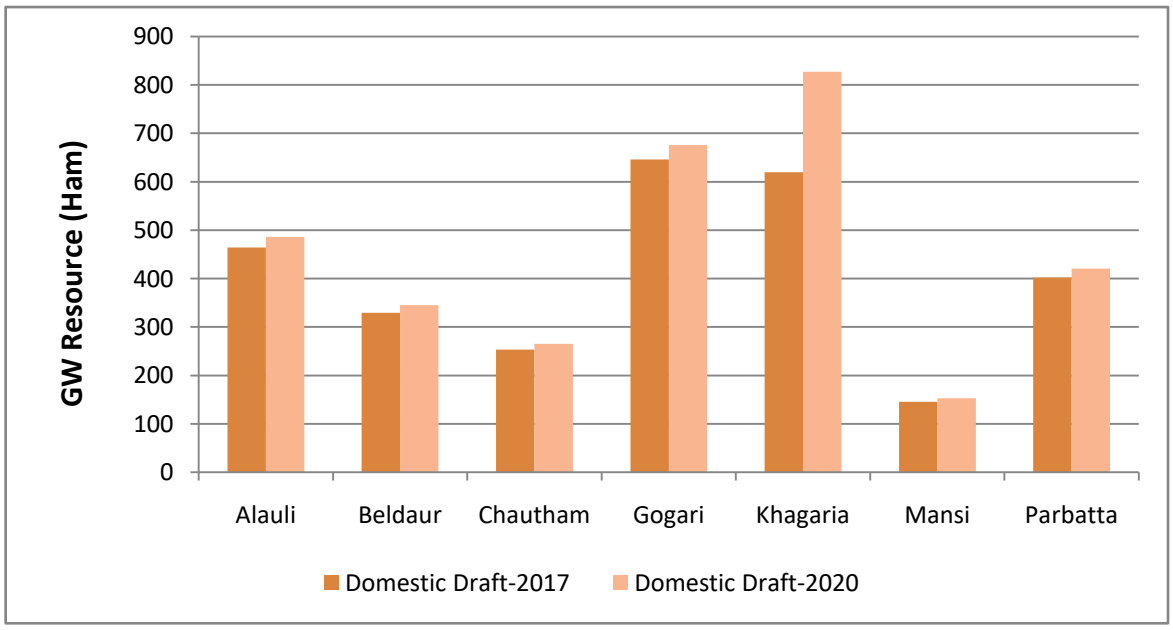


Fig. 5.3: Graph showing variation of Domestic draft in Khagaria district

CHAPTER - VI

MANAGEMENT STRATEGIES

Management plan for groundwater resource of the district is made in order to address the issues detailed in Chapter-V. The plan has been prepared in such a way that groundwater resource shall be optimally utilised ensuring quality, equitability and sustainability. It is observed from the field survey that irrigation practices in the district are mainly dependent on groundwater, and major canal systems are not developed in the district (DIP-Khagaria). Thick alluvium sedimentation by Kosi and its tributaries in the district resulted in formation of potential mono-aquifer system. The alluvium aquifer is characterised by various grades of sand and lenses of clay and groundwater is at unconfined condition. With this background, management strategies are proposed considering quality and quantity aspects.

6.1 Arsenic contamination

In khagaria district, arsenic contamination has been reported in four out of seven blocks (source: PHED, Govt. of Bihar). They are Khagaria, Gogri, Mansi and Parbatta with cumulative population of more than one million. As mentioned earlier, the aquifer system in the district is composed of various grades of sands and extends down to explored depth of 310 m bgl. The mono-aquifer system is capped with a thin surface clay layer on the top. Some lenses of clay are observed in exploratory bore holes but are not regionally extensive.

This aquifer geometry causes a unique problem in terms of arsenic contamination. The blocks do not have any alternate groundwater source which is arsenic free. At present the contamination problem is restricted within only top-part of the aquifer (detected in some shallow depth tube wells). This is due to the prolific nature of the aquifer with water level commonly within 5m and not having many deep wells. Commonly depth of tube well is restricted within 30-40 m with maximum depth of 80-100 m. This indicates that only the top part of the aquifer has been developed so far. However, there is a fair possibility that with gradual increase in development of resource of deeper part of the aquifer, arsenic shall be reported from the deeper parts also, as the entire sequence is under single hydrodynamic regime.

Therefore, construction of arsenic free tube well is not possible. Hence, restriction on depth of construction of tube wells is the only viable solution at present with only exception for drinking water supply tube wells. The restriction may be continued till the deeper (>300m) parts of the

aquifer are explored and alternative arsenic free groundwater source is found out. In addition, all drinking water supply tube wells should be planned to be fitted with arsenic removal plant with frequent check on water quality.

6.2 Management Plan for Irrigation Sector

Major crops cultivated in Khagaria district are Paddy, Wheat, Jute, Maize. Pulses, and Potato. Cereals and coarse cereals constitute 87 percentage of the total cropped area of the district. While pulses and oil seeds together constitute only 9% of the total cropped area. The cultivation of value crops and horti-crops are scanty in the district. The gross cropped area of the district is 167114 ha and net sown area is 104000 ha with cropping intensity of the district is 161% and 76.6% of the area under irrigation is catered by groundwater resources. From table 6.3, it can be seen that 69.40% of total cultivable land in the district is under assured irrigation. A total of 31824 ha cultivable land is to be brought under irrigation within the safe limit of exploitation of the resource.

Table 6.1: Irrigated area and area to be brought under irrigation

Block	Cultivable area/Net Sown area (ha)	Net Irrigated Area (ha)	Area to be brought under Irrigation (ha)	% of cultivable area under assured irrigation
Alauli	20572	14385	6187	69.93
Beldaur	15592	10851	4741	69.59
Chautham	12195	8474	3721	69.49
Gogari	19500	13539	5961	69.43
Khagaria	17759	12263	5496	69.05
Mansi	5775	4008	1767	69.40
Parbatta	12607	8656	3951	68.66
Khagaria	**104000**	**72176**	**31824**	**69.40**

The additional area available for cultivation is proposed for pulses and oil seeds based on its lower water requirement. Water requirement for pulses and oilseeds are taken as 50 cm, which is less as compared to requirement for cereals crops. Thus volume of additional water required to extend irrigation to the remaining area has been calculated from crop water requirement taking delta factor 0.5 m. To bring the entire cropped area under assured irrigation through ground water, an additional 15912 ham (Table 6.2). It is assumed that allocation for drinking/domestic purpose as per GWRE-2020 meets full coverage for the current projected population of the district.

Table 6.2: Total groundwater requirement in drinking/domestic and irrigation sectors

Block	Net cultivable area (ha)	Additional area to be brought under Irrigation (ha)	Additional irrigation Water Requirement (Delta factor:50 cm) for Pulses/oilseeds (ham)
Alauli	20572	6187	3093.5
Beldaur	15592	4741	2370.5
Chautham	12195	3721	1860.5
Gogari	19500	5961	2980.5
Khagaria	17759	5496	2748
Mansi	5775	1767	883.5
Parbatta	12607	3951	1975.5
Khagaria	**104000**	**31824**	**15912**

As per the Dynamic Ground Water Resource Assessment, 2020, total annual extractable ground water resource in Khagaria district is 53693.64 ham with SOD of 50.26%. Considering the safe limit of development, at 70% of SOD, the additional resource available is estimated to be 10597.35 ham, (Table 6.3). The additional resource therefore can be utilized for creation of additional irrigation potential for less water intense crops like pulses, oilseeds etc. As per the block wise availability of ground water, 18605.93 ha irrigation potential may further be created which on an average constitute 66.60% of uncovered area under irrigation. Effective management in surface irrigation network is required to bring the remaining 13218.07 ha area under assured irrigation. The available ground water resource may be effectively utilized to create significant irrigation potential in Chautham, Khagaria. Allauli blocks (Table 6.5). Surface irrigation network may be practiced in the recource deficit blocks such as Beldaur, Gogri blocks for further enhancement of irrigation potential. It is to be noted that the additional resource allocated for irrigation is 9302.97 ham (Table 6.4).

Table 6.3: Additional area brought under Irrigation with available groundwater resources

Block	Area to be brought under Irrigation (ha)	Additional resource required (ham) for pulses/oil seeds	Total Annual Extractable Ground Water (ham)	Present Gross Draft for all uses (ham)	Annual resource availability considering 70% development	Water available for further development (ham)	Area to bring under irrigation for pulses/oilseeds with additional resources (ha)	Remaining Area (ha)	% area to be brought under irrigation by additional resource
Alauli	6187	3093.5	8427.64	3473.69	5899.35	2425.66	4851.32	1335.68	78.41
Beldaur	4741	2370.5	6938.91	4249.15	4857.24	608.09	1216.17	3524.83	25.65
Chautham	3721	1860.5	6131.18	2335.74	4291.83	1956.09	3912.17	0	100
Gogari	5961	2980.5	10296.12	6813.82	7207.28	393.46	786.93	5174.07	13.20
Khagaria	5496	2748	9301.48	2564.24	6511.04	3946.80	7893.59	0	100
Mansi	1767	883.5	2847.5	1704.8	1993.25	288.45	576.90	1190.10	32.65
Parbatta	3951	1975.5	9750.81	5846.76	6825.57	978.81	1957.61	1993.39	49.55
Khagaria	**31824**	**15912**	**53693.64**	**26988.2**	**37585.55**	**10597.35**	**21194.7**	**13218.07**	**66.60**

The additional irrigation potential may be created through construction of shallow/medium depth tube wells. The unit draft of STW/MDTW is considered 2.52 ham/year based on the norms taken for GWRE-2020. The block wise requirement of additional STW/MDTW has been estimated. 3692 STW/MDTW may be required for the purpose (Table 6.4). However, installation of proposed structures should always be implemented in phases as per the actual site specific feasibility. Proposed structures can bring additional 9302.97 ha irrigation potential in the district which accounts for about 66.60% additional irrigation potential to the uncovered cultivable area.

Table 6.4: Number of tube wells proposed in order to achieve additional irrigation potential

Block	Volume of water available for future Irrigation development (ham) within 'safe' limit	Additional resource required for future irrigation (ham) within safe limit	Actual additional resource available 3 = (Lowest of 1 and 2)	Unit draft of STW/MDTW (ham)	Required no of STW/MDTW
Alauli	2425.66	3093.50	2425.66	2.52	963
Beldaur	608.09	2370.50	608.09	2.52	241
Chautham	1956.09	1860.50	1860.50	2.52	738
Gogari	393.46	2980.50	393.46	2.52	156
Khagaria	3946.80	2748.00	2748.00	2.52	1090
Mansi	288.45	883.50	288.45	2.52	114
Parbatta	978.81	1975.50	978.81	2.52	388
Khagaria	**10597.35**	**15912.00**	**9302.97**	**2.52**	**3692**

6.3 Artificial Recharge to groundwater

Artificial recharge is recommended in various blocks of the district by considering the variation in yield potential of aquifer systems in the district. Basic requirements for recharging the aquifer are availability of surplus rainwater and availability of storage space in the aquifer system. Central Ground Water Board, MER, Patna has prepared "Master Plan for Artificial Recharge to Ground Water in Bihar State" on 2019. The Master Plan broadly identified areas which needs urgent attention. Based on this, recharge plan has been proposed considering variations in groundwater resource in Khagaria district. Based on terrain type of identified areas, various artificial recharge structures have been proposed and a tentative number of each structure has been estimated.

Identification of the area suitable for artificial recharge has been done based on depth of post-monsoon water level and ground water level trend. Using GIS tools, post-monsoon (November, 2019) depth-to-water level map and long-term (2007-2017) trend of ground water level map has been superimposed over administrative boundary in order to identify feasible areas for recharge. Using the prepared map, feasible areas are identified, subject to fulfilling the below mentioned conditions

a) Areas showing water levels between 3 and 6 m bgl and declining trend of > 10 cm/yr;

b) Areas with depth to water level between 6 and 9 m bgl and declining trend;

c) Areas with depth to water level > 9 m bgl with or without declining trend.

Since the district comes under groundwater rich aquifer system of the Kosi belt, artificial recharge feasible area was assessed to be about 13.99 sq km only. The available storage column/space (post-monsoon) for has been calculated for respective blocks by computation of average depth of unsaturated zone below 3 m water level in post monsoon time. Total volume of available storage space is calculated by multiplying storage area by specific yield. Considering the efficiency of the structure as 75%, the total water required to fill the storage space has been assessed. Total volume of unsaturated zone is 77.60 mcm. A volume of 9.57 mcm water is required to fill the unsaturated space. The proposed number and capacity of recharge structures in the district is given in table 6.8.

Table 6.5: Type, capacity and no. of proposed recharge structures in suitable area types

Area Type	Type of Structure	Dimensions	Storage Capacity (MCM)	No. of Fillings
Alluvium	De-silting of existing	100 m x 80 m x 6 m	0.20	2

Area Type	Type of Structure	Dimensions	Storage Capacity (MCM)	No. of Fillings
	tank /pond /talab			
	De-silting of Mauns (Ox-bow lake)	10 – 500 ha /100 ha	6	1
	Injection Well in Village Tank	100 m x 100 m x 3 m Tank with 40 m Boring	0.03	2
	Renovation of traditional Ahar-Pyne System	As per Existing Structure / Km	0.1	1
Urban Areas	Roof-top Rain Water Harvesting Structures	100 m2 (Roof) with 40 m Boring	0.00009	1
	De-silting and revival of existing ponds	50 m x 20 m x 6 m	0.006	2

The block wise number and type of artificial recharge structures proposed as per "Master Plan for Artificial Recharge to Ground Water in Bihar State-2019" is given below.

Table 6.6: Type, and no. of proposed recharge structures in Khagaria district

Block	Lateral Recharge Shaft	Recharge Shaft	Percolation Tank	De-silting of existing tank /pond	Injection Well in Village Tank
Alauli	0	0	0	0	0
Beldaur	0	0	0	0	0
Chautham	0	0	0	0	0
Gogari	0	0	0	0	0
Khagaria	1	3	0	5	7
Mansi	0	0	0	0	0
Parbatta	0	0	0	0	0
Khagaria	**1**	**3**	**0**	**5**	**7**

6.4 Demand-side Management

In demand side management, micro/precision irrigation is proposed in the district. Micro irrigation intended to effectively utilize water by various techniques such as drips, sprinklers, pivots, rain-guns etc. in the farm. Under Pradhan Mantri Krishi Sinchayee Yojana (PMKSY), popularization of micro irrigation plans is one of the focus areas in order to ensure 'Per drop-More crop'. Under the scheme additional irrigation potential will be created by installing drips, sprinklers, pivots, rain-guns and other application devices. It is proposed that 10% of the command area should be brought under micro/precision irrigation for efficient water management (District Irrigation Plan-Khagaria). The scheme will be implemented in phase-wise.

CHAPTER-VII

SUMMARY

Khagaria district with geographic area cover of 732 Sq. km have been taken up during AAP 2020-21 as a part of NAQUIM studies (the remaining are covering 754 sq. km has already covered under NAQUIM Phase-III). The district has agrarian economy and comes under agro-climatic zone II (North East Alluvial Plain Zone, BI-2). The district is characterized by monotonous flat topography with elevation ranging from 30 to 60 m above mean sea level. The district forms part of the lower fan area of Kosi mega fan. The district is mainly drained by river Kosi and its tributaries. While river Ganga forms the southern boundary of the district. Most of the geographical area of the district comprises of agricultural crop land (80.96 %) followed by wetlands/water bodies (8.91%).

With this background, NAQUIM studies have been done in the district in order to decipher the aquifer characterization, resource scenario, identification of major groundwater related issues and preparation of suitable management plans. Data collected and generated involves hydrogeological data, and hydro-chemical data. Meteorological and hydrological data has been collected from concerned Central and State Govt. Departments. Depth to water level (DTWL) map and water level fluctuation maps has been prepared based on Key wells and NHS data. Depth to water level map of the district shows that majority of the area has water level between 5 to 10 m bgl during pre-monsoon and between 2 to 5 m bgl during post monsoon. In some patches of Parbatta and Gogari blocks, it varies from 2 to 5 m bgl during pre-monsoon and between 0 to 2 m bgl during post-monsoon. Water level fluctuation map shows that depth to water level fluctuates between 3 to 4 m in most of the part of the district. Long term groundwater level trend over ten years (from 2010 to 2019) has been analyzed by using data from 21 network monitoring stations in Khagaria district. It is observed that there is no significant variation in groundwater level in the district over long term.

The north to central part of the district forms part of lower end of Kosi mega fan, while the southern part forms flood plain of river Ganga. The entire district is covered by thick Quaternary alluvium deposits of various grades of sands with lenses of clay layers with limited extend. The thickly bedded sand layer forms groundwater reservoir of the district. The top most layer comprises of clay mixed with kankar and silt and, in many places with fine sand and is semi pervious in nature. The top layer is followed by a prolific mono-aquifer system down to the explored depth of 310 mbgl.

As per surface geological map, more than 90% of area of the district is occupied by Younger alluvium deposits. While present day deposits are limited to the river channels. Based on the available borehole data, major sand horizons are delineated and geological sections are prepared. As

per drilling data, the sand horizon extends upto explored depth of 310 m. A correlation of the lithologs of other wells clearly shows that there is no any intervening, regionally continuous aquitard layer encountered in the basin. Therefore, the various sands down to depth of 310 m bgl can be considered as mono-aquifer system. There is a surface clay layer of thickness 5 to 10 m which caps the mono-aquifer system in the area. It is to be noted that the water level observed are within 5m, and the area also does not have many deep wells. The common depth of boring is restricted within 80-100 m.

CGWB has drilled very few wells in the area and therefore there is a general paucity of data. Data of wells constructed by State Government indicate that shallow tube wells tapping aquifer (within 110 m bgl) can yield 200 to 300 m3/hr for a drawdown of 2- 4 m. Groundwater occurs under water table to unconfined condition in the district. However, in some boreholes, patches of clay are encountered below the granular zone indicating semi-confined condition of the aquifer. A perusal of the pumping test data shows potentiality of the aquifer of the area with high transmissivity rates. The disposition and hydraulic properties shows that aquifer in the district is heterogeneous both vertically and laterally.

A perusal of the groundwater quality data shows that pH of the analysed samples vary from 8.10 to 9.4 indicating that waters are slightly alkaline. Majority of the analysed samples comes under 'Magnesium/Sodium Bicarbonate Type' facies. Quality of irrigation water varies significantly based on its dissolved salts. The salts may originate from dissolution or weathering of rocks and soil. From the chemical data, it can be seen that TDS values ranges from 227.37 mg/L (Kasimpur) to 1307.8 mg/L (Pirnagra), which is within the permissible limit as per Bureau of Indian Standards (BIS) for drinking purpose. Correspondingly, EC values of analyzed samples ranges from 349.80 (Kasimpur) to 2012 (Pirnagra) µS/cm @ 25°. Data plotted in USSL diagram shows that all samples have low SAR value and come under moderate-high salinity hazard zone.

Dynamic ground water resources of 7 blocks of Khagaria district has been assessed, as on March 2020. Dynamic groundwater resource assessment of Bihar State has been jointly carried out by Minor Water Resource Department, Govt. of Bihar and Central Ground Water Board, Ministry of Jal Shakti, Govt. of India, as on March 2020. Dynamic resource of the study area has been estimated by using the norms prescribed under GEC-15. As on March 2020, estimated annual extractable groundwater resource of Khagaria district is 0.53 BCM and gross extraction is 0.26 BCM with stage of extraction of 50.26%.

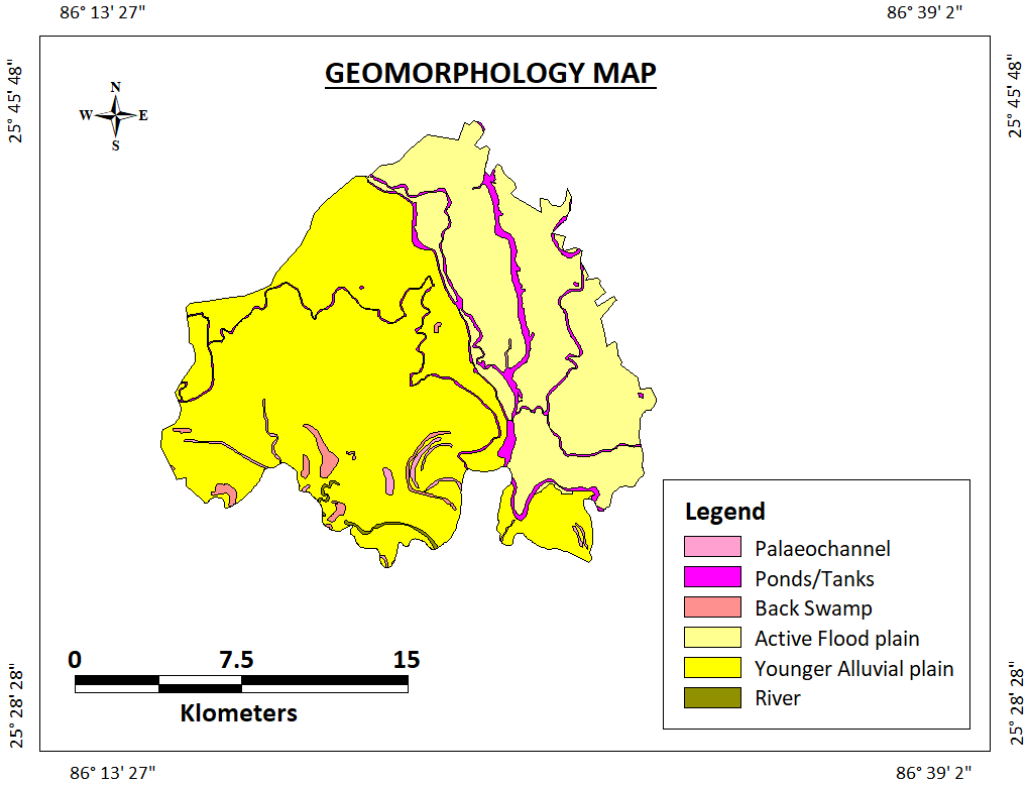
The major groundwater issues in the study area are arsenic contamination, seasonal flooding and water logging and increased demand of groundwater for irrigation sector. Management plans

prepared involves management plan for arsenic affected areas, management plan for irrigation sector, artificial recharge to groundwater. Apart from these, demand side interventions are also discussed such as installation of drip/sprinkler irrigation system etc. in order to improve the groundwater resource of the district. Crop diversification can also be practiced by projecting the SOE to 60% in the district as per the plan detailed in Chapter-VI.

CHAPTER-VIII
BLOCK WISE AQUIFER MAPS AND MANAGEMENT PLANS

1. Salient Information

Name of the Block of Aquifer (in Km^2)	**Allauli** (274.47 Sq. Km.)
District/State	Khagaria/Bihar
Population	Rural: 2,82,127 Urban: 0
Rainfall	Normal Monsoon: 985.4mm/ Non-monsoon rainfall: 188.8 mm
Agriculture and Irrigation	The block falls in the Argo-climatic Zone II. The cropping sequence followed in this zone is Rice – Wheat – Moong. The soils in this zone are sandy loam, clayey loam with pH in the range of 6.5 – 7.8. The gross irrigated area 17676 ha and net irrigated area is 14385 ha.
Geology & Geomorphology	Geomorphologically, most of the area is covered by younger alluvial plain and active flood plain. Back swamps and palaeochannels can also be observed in the vicinity of older river course of Kosi River. Geologically the entire district is covered by alluvium deposits of Quaternary age.
Ground water resource availability and extraction	The dynamic ground water resource of Allauli block has been assessed as 84.27 MCM. The gross ground water draft for all uses stands at 34.73 MCM. The stage of Development is 41.22%.
Existing and future water demand	Irrigation: 2852.64 ham Domestic & Industrial: 621.05 ham
Water level behaviour	The depth to water level varies from 5 to 10 m bgl during pre-monsoon season. In post monsoon season, the depth to water level varies from2 to 5 m bgl and in northern parts it is less than 2 m bgl.


86° 13' 27"
86° 39' 2"
GEOMORPHOLOGY MAP
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25° 45' 48"
25° 28' 28"
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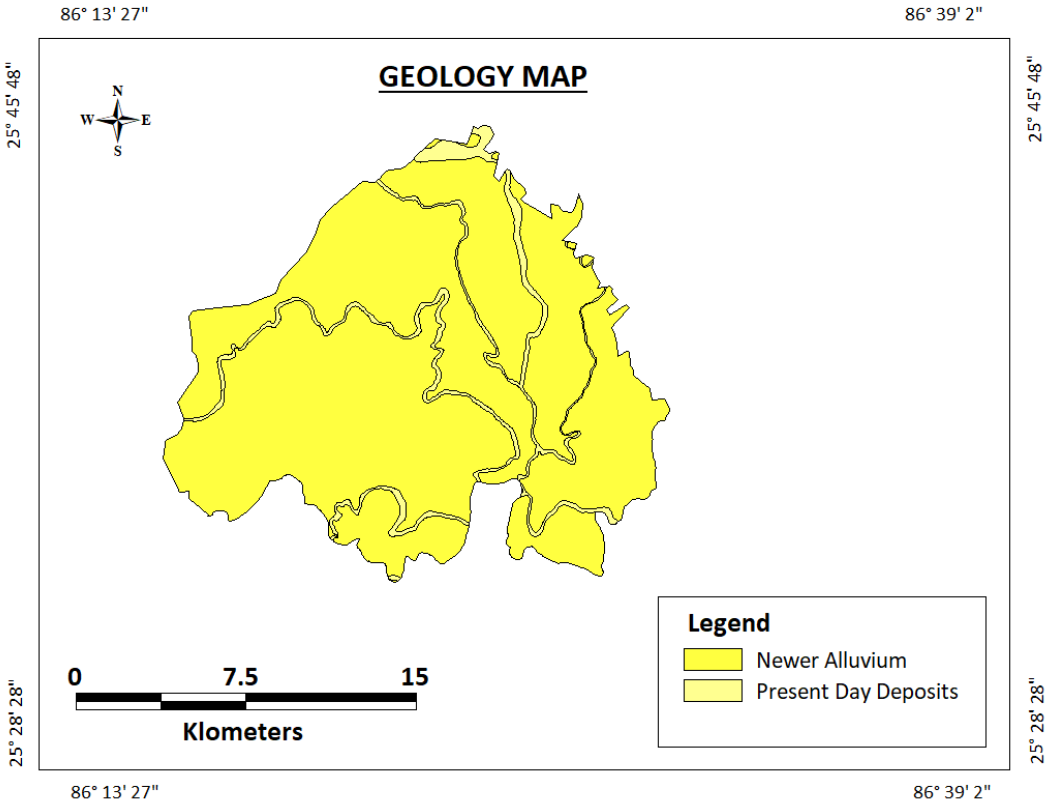
Klometers
Legend
Palaeochannel
Ponds/Tanks
Back Swamp
Active Flood plain
Younger Alluvial plain
River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GEOLOGY MAP
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25° 45' 48"
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Klometers
Legend
Newer Alluvium
Present Day Deposits

2. Aquifer Disposition

The area is bestowed with mono- aquifer system. The section depicting the aquifer disposition is shown in district report. The mono-aquifer system extends upto the investigated depth of 310 m. There is no alternate groundwater source. Hence, groundwater development in the area should be done with caution, as arsenic contamination has been reported in nearby blocks.

3. Chemical Quality of Ground Water and Contamination

On the basis of Piper diagram and Durov plot, groundwater of the block is potable and based on USSL plot, groundwater is suitable for irrigational purposes.

4. Ground Water Resource Enhancement

As the stage of groundwater development is within the safe limits and there is no long-term water level decline in the area, the need for artificial recharge is not felt.

5. Supply Side Interventions

In view of the issue of arsenic contamination in nearby blocks, it is recommended to use deeper part of the aquifer solely for meeting the drinking water supply requirement. Development for irrigation and other uses may be restricted within 60 m. The additional resource available may be utilized for creation of additional irrigation potential for less water intense crops like pulses, oilseeds etc by projecting SOD to 70%. The additional irrigation potential created and required number of TW's are estimated and given below.

Block	Area to be brought under Irrigation (ha)	Additional resource required (ham) for pulses/oil seeds	Total Annual Extractable Ground Water (ham)	Present Gross Draft for all uses (ham)	Annual resource availability considering 70% development	Water available for further development (ham)	Area to bring under irrigation for pulses/oilseeds with additional resources (ha)	Remaining Area (ha)	% area to be brought under irrigation by additional resource
Alauli	6187	3093.5	8427.64	3473.69	5899.35	2425.66	4851.32	1335.68	78.41

Block	Volume of water available for future Irrigation development (ham) within 'safe' limit	Additional resource required for future irrigation (ham) within safe limit	Actual additional resource available 3 = (Lowest of 1 and 2)	Unit draft of STW/MDTW (ham)	Required no of STW/MDTW
Alauli	2425.66	3093.5	2425.66	2.52	963

6. Demand Side Interventions

In demand side management, micro/precision irrigation is proposed in the block. Micro irrigation intended to effectively utilize water by various techniques such as drips, sprinklers, pivots, rain-guns etc. in the farm. Under Pradhan Mantri Krishi Sinchayee Yojana (PMKSY), popularization of micro irrigation plans is one of the focus areas in order to ensure 'Per drop-More crop'. Under the scheme additional irrigation potential can be created by installing drips, sprinklers, pivots, rain-guns and other application devices. It is proposed that 10% of the command area should be brought under micro/precision irrigation for efficient water management (District Irrigation Plan-Khagaria). The scheme shall be implemented in phase-wise.

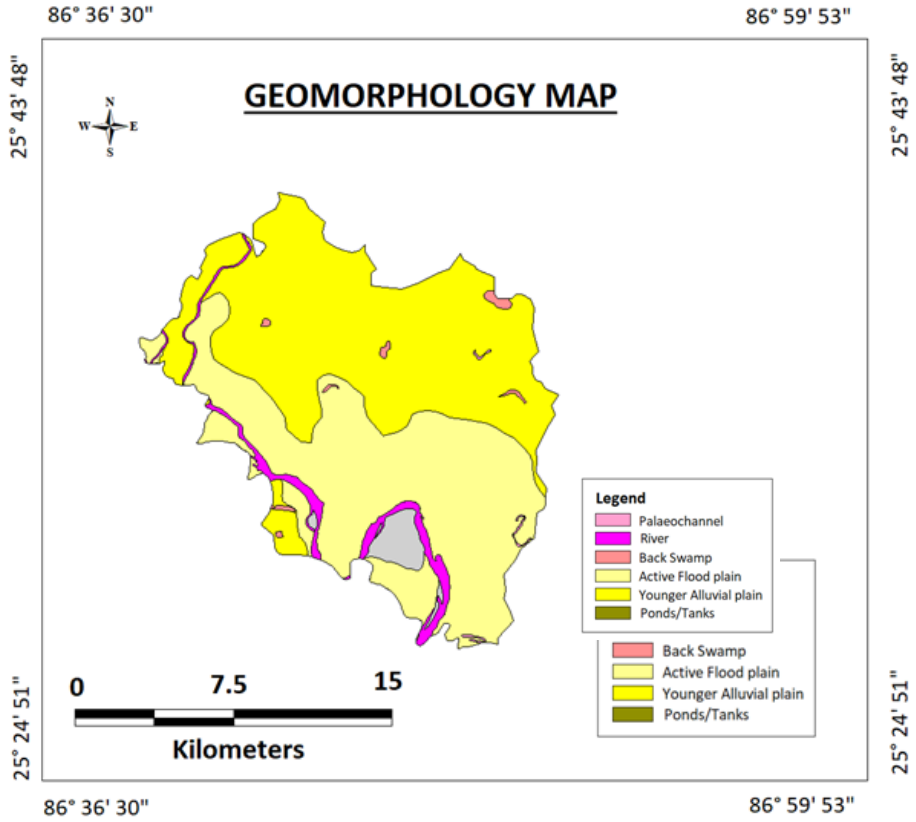
Table 1: Dynamic Ground Water Resource (as on 31st March, 2020)

District	Block	Recharge from Rainfall during Monsoon season	Recharge from Rainfall during Non Monsoon season	Recharge from Other Sources during Monsoon season	Recharge from Other Sources during Non Monsoon season	Total Annual Ground Water Recharge	Provision for Natural Discharges	Net Annual Ground Water Availability	Existing Gross Ground Water Draft for irrigation	Existing Gross Ground water Draft for Domestic and Industrial Water Supply	Existing Gross Ground Water Draft for All Uses	Provision for Domestic and Industrial Requirement for Next 25 years	Net GW Availability for Future Irrigation Development	Stage of Ground Water Development	Category: Safe / Semi-critical/ Critical/ Over-exploited
		(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	
Khagaria	Aluti	6923.92	802.33	504.14	640.81	8871.2	443.56	8427.64	2852.64	621.05	3473.69	545.98	4894.02	41.22	**Safe**

BLOCK WISE
AQUIFER MAPS AND MANAGEMENT PLANS

1. Salient Information

Name of the Block of Aquifer (in Km²)	**BELDAUR**(223.56 Sq. Km.)
District/State	Khagaria/Bihar
Population	Rural: 2,00,223 Urban: 0
Rainfall	Normal Monsoon: 985.4mm/ Non-monsoon rainfall: 188.8 mm
Agriculture and Irrigation	The block falls in the Argo-climatic Zone II. The cropping sequence followed in this zone is Rice – Wheat – Moong. The soils in this zone are sandy loam, clayey loam with pH in the range of 6.5 – 7.8. The gross irrigated area 13787 ha and net irrigated area is 10851 ha.
Geology & Geomorphology	Geomorphologically, most of the area is covered by younger alluvial plain and active flood plain. Back swamps and palaeochannels can also be observed in the vicinity of older river course of Kosi River. Geologically the entire district is covered by alluvium deposits of Quaternary age.
Ground water resource availability and extraction	The dynamic ground water resource of Beldaur block has been assessed as 69.38 MCM. The gross ground water draft for all uses stands at 42.49 MCM. The stage of Development is 61.24%.
Existing and future water demand	Irrigation: 3742.2 ham Domestic & Industrial: 506.94 ham
Water level behaviour	The depth to water level varies from 5 to 10 mbgl during pre-monsoon season. In post monsoon season, the depth to water level varies from2 to 5 mbgl and in northern parts it is less than 2 mbgl.


86° 36' 30"
86° 59' 53"
25° 43' 48"
25° 24' 51"
GEOMORPHOLOGY MAP
N
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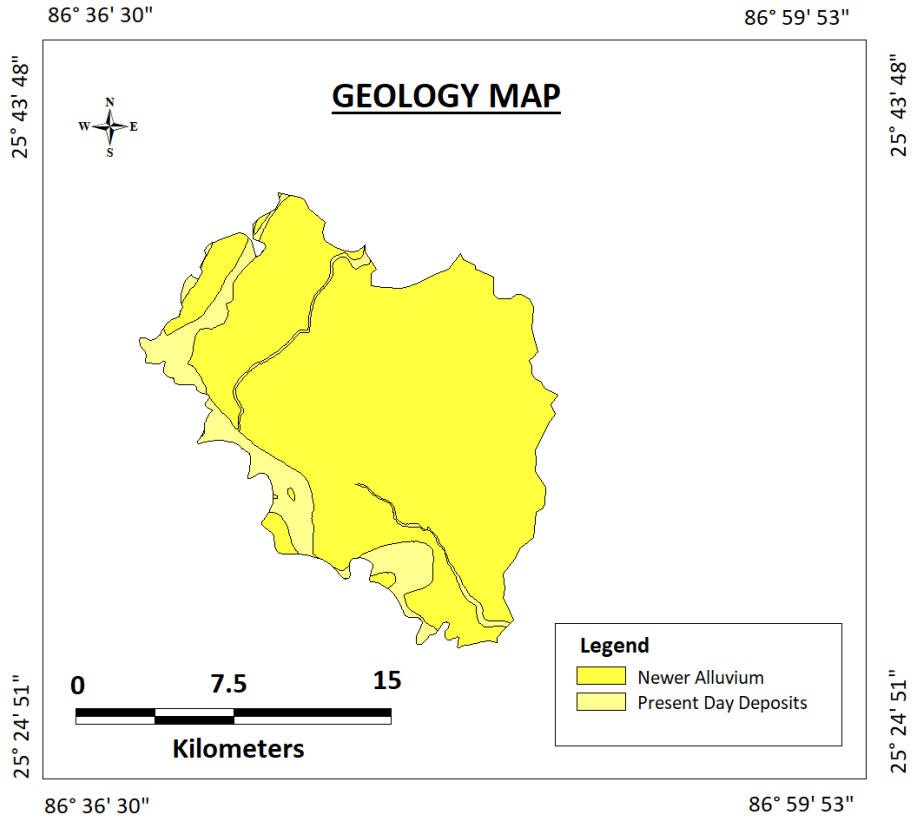
Legend
Palaeochannel
River
Back Swamp
Active Flood plain
Younger Alluvial plain
Ponds/Tanks
Back Swamp
Active Flood plain
Younger Alluvial plain
Ponds/Tanks
0
7.5
15
Kilometers


86° 36' 30"
86° 59' 53"
25° 43' 48"
25° 24' 51"
GEOLOGY MAP
N
W
E
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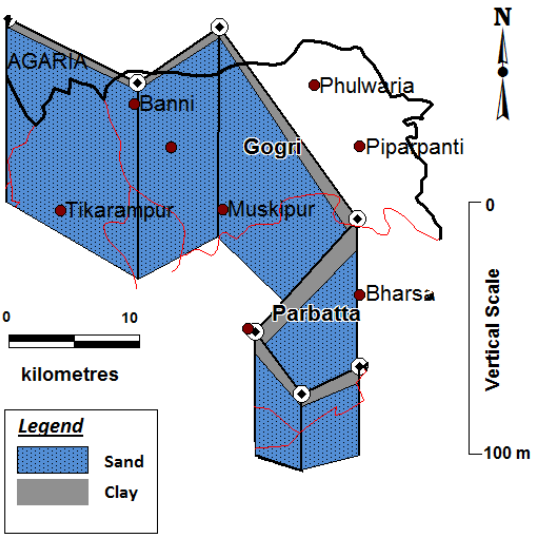
Legend
Newer Alluvium
Present Day Deposits
0
7.5
15
Kilometers

2. Aquifer Disposition

The area is bestowed with mono- aquifer system and there is no alternate groundwater source. The area is represented by mono-aquifer system down to investigated depth of 310m. Hence, groundwater development in the area should be done with caution, as arsenic contamination has been reported in nearby blocks. The section depicting the aquifer disposition is shown below.



3. Chemical Quality of Ground Water and Contamination

On the basis of Piper diagram and Durov plot, groundwater of the block is potable and based on USSL plot, groundwater is suitable for irrigational purposes.

4. Ground Water Resource Enhancement

As the stage of groundwater development is within the safe limits and there is no long-term water level decline in the area, the need for artificial recharge is not felt.

5. Supply Side Interventions

In view of the issue of arsenic contamination in nearby blocks, it is recommended to use deeper part of the aquifer solely for meeting the drinking water supply requirement. Development for irrigation and other uses may be restricted within 60 m. The additional resource available may be utilized for creation of additional irrigation potential for less water intense crops like pulses, oilseeds etc by projecting SOD to 70%. The additional irrigation potential created and required number of TW's are estimated and given below.

Block	Area to be brought under Irrigation (ha)	Additional resource required (ham) for pulses/oil seeds	Total Annual Extractable Ground Water (ham)	Present Gross Draft for all uses (ham)	Annual resource availability considering 70% development	Water available for further development (ham)	Area to bring under irrigation for pulses/oilseeds with additional resources (ha)	Remaining Area (ha)	% area to be brought under irrigation by additional resource
Beldaur	4741	2370.5	6938.91	4249.15	4857.24	608.09	1216.17	3524.83	25.65

Block	Volume of water available for future Irrigation development (ham) within 'safe' limit	Additional resource required for future irrigation (ham) within safe limit	Actual additional resource available 3 = (Lowest of 1 and 2)	Unit draft of STW/MDTW (ham)	Required no of STW/MDTW
Beldaur	608.09	2370.5	608.09	2.52	241

6. Demand Side Interventions

In demand side management, micro/precision irrigation is proposed in the block. Micro irrigation intended to effectively utilize water by various techniques such as drips, sprinklers, pivots, rain-guns etc. in the farm. Under Pradhan Mantri Krishi Sinchayee Yojana (PMKSY), popularization of micro irrigation plans is one of the focus areas in order to ensure 'Per drop-More crop'. Under the scheme additional irrigation potential can be created by installing drips, sprinklers, pivots, rain-guns and other application devices. It is proposed that 10% of the command area should be brought under micro/precision irrigation for efficient water management (District Irrigation Plan-Khagaria). The scheme shall be implemented in phase-wise.

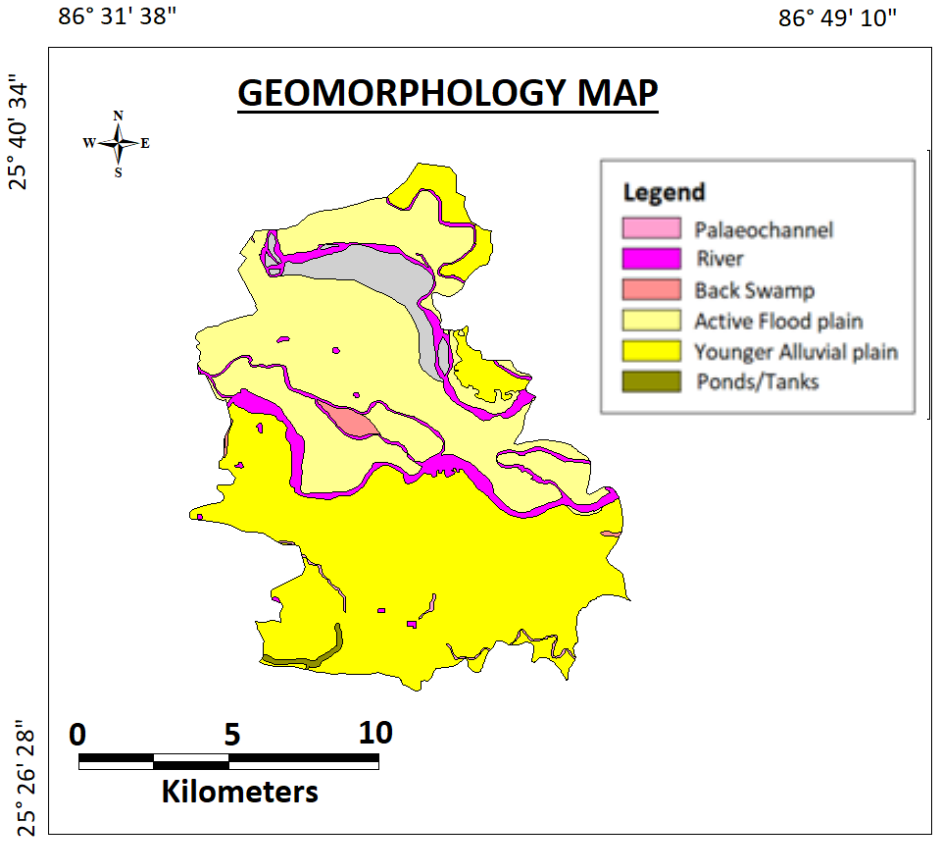
Table 1: Dynamic Ground Water Resource (as on 31st March, 2020)

District	Block	Recharge from Rainfall during Monsoon season	Recharge from Rainfall during Non Monsoon season	Recharge from Other Sources during Monsoon season	Recharge from Other Sources during Non Monsoon season	Total Annual Ground Water Recharge	Provision for Natural Discharges	Net Annual Ground Water Availability	Existing Gross Ground Water Draft for irrigation	Existing Gross Ground water Draft for Domestic and Industrial Water Supply	Existing Gross Ground Water Draft for All Uses	Provision for Domestic and Industrial Requirement for Next 25 years	Net GW Availability for Future Irrigation Development	Stage of Ground Water Development	Category: Safe / Semi-critical/ Critical/ Over-exploited
		(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	
Khagaria	Beldaur	5260.75	653.51	607.71	782.14	7304.11	365.20	6938.91	3742.20	506.94	4249.15	387.48	2647.22	61.24	Safe

BLOCK WISE
AQUIFER MAPS AND MANAGEMENT PLANS

1. Salient Information

Name of the Block of Aquifer (in Km²)	**CHAUTHAM** (163.57 Sq. Km.)
District/State	Khagaria/Bihar
Population	Rural: 1,53,831 Urban: 0
Rainfall	Normal Monsoon: 985.4mm/ Non-monsoon rainfall: 188.8 mm
Agriculture and Irrigation	The block falls in the Argo-climatic Zone II. The cropping sequence followed in this zone is Rice – Wheat – Moong. The soils in this zone are sandy loam, clayey loam with pH in the range of 6.5 – 7.8. The gross irrigated area 12058 ha and net irrigated area is 8474 ha.
Geology & Geomorphology	Geomorphologically, most of the area is covered by younger alluvial plain and active flood plain. Back swamps and palaeochannels can also be observed in the vicinity of older river course of Kosi River. Geologically the entire district is covered by alluvium deposits of Quaternary age.
Ground water resource availability and extraction	The dynamic ground water resource of Chautham block has been assessed as 61.31 MCM. The gross ground water draft for all uses stands at 23.35 MCM. The stage of Development is 38.10%.
Existing and future water demand	Irrigation: 1980.72 ham Domestic & Industrial: 355.02 ham
Water level behaviour	The depth to water level varies from 5 to 10 mbgl during pre-monsoon season. In post monsoon season, the depth to water level varies from2 to 5 mbgl and in northern parts it is less than 2 mbgl.


86° 31' 38"
86° 49' 10"
25° 40' 34"
25° 40' 34"
GEOMORPHOLOGY MAP
N
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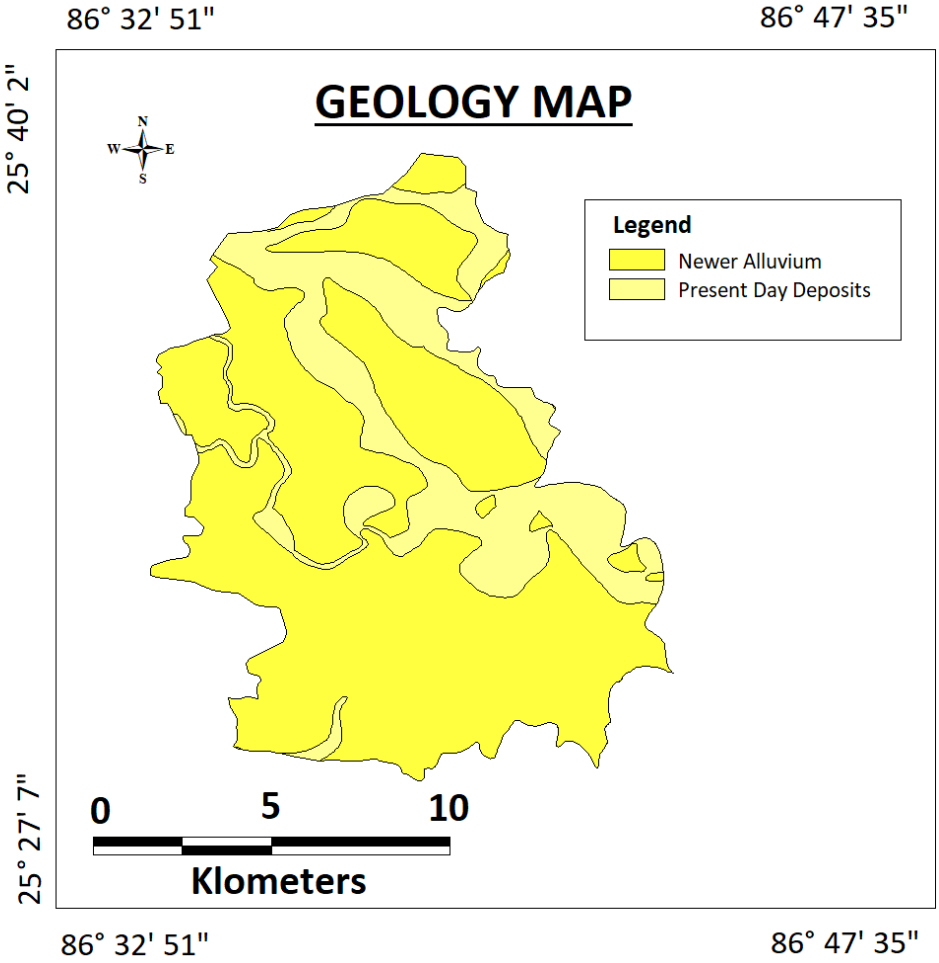
Legend
Palaeochannel
River
Back Swamp
Active Flood plain
Younger Alluvial plain
Ponds/Tanks
0
5
10
Kilometers
25° 26' 28"
25° 26' 28"


86° 32' 51"
86° 47' 35"
25° 40' 2"
25° 40' 2"
GEOLOGY MAP
N
W
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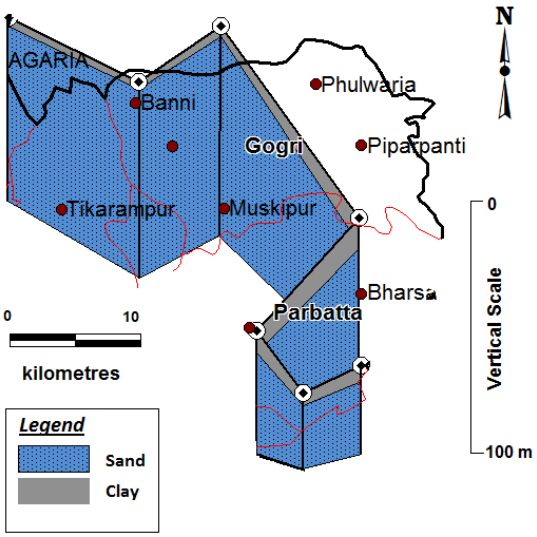
Legend
Newer Alluvium
Present Day Deposits
0
5
10
Klometers
25° 27' 7"
25° 27' 7"
86° 32' 51"
86° 47' 35"

2. Aquifer Disposition

The area is represented by mono-aquifer system down to investigated depth of 310m and there is no alternate groundwater source. Hence, groundwater development in the area should be done with caution, as arsenic contamination has been reported in nearby blocks. The section depicting the aquifer disposition is shown below.



3. Chemical Quality of Ground Water and Contamination

On the basis of Piper diagram and Durov plot, groundwater of the block is potable and based on USSL plot, groundwater is suitable for irrigational purposes.

4. Ground Water Resource Enhancement

As the stage of groundwater development is within the safe limits and there is no long-term water level decline in the area, the need for artificial recharge is not felt.

5. Supply Side Interventions

In view of the issue of arsenic contamination in nearby blocks, it is recommended to use deeper part of the aquifer solely for meeting the drinking water supply requirement. Development for irrigation and other uses may be restricted within 60 m. The additional resource available may be utilized for creation of additional irrigation potential for less water intense crops like pulses, oilseeds etc by projecting SOD to 70%. The additional irrigation potential created and required number of TW's are estimated and given below.

Block	Area to be brought under Irrigation (ha)	Additional resource required (ham) for pulses/oil seeds	Total Annual Extractable Ground Water (ham)	Present Gross Draft for all uses (ham)	Annual resource availability considering 70% development	Water available for further development (ham)	Area to bring under irrigation for pulses/oilseeds with additional resources (ha)	Remaining Area (ha)	% area to be brought under irrigation by additional resource
Chautham	3721	1860.5	6131.18	2335.74	4291.83	1956.09	3912.17	0	100

Block	Volume of water available for future Irrigation development (ham) within 'safe' limit	Additional resource required for future irrigation (ham) within safe limit	Actual additional resource available 3 = (Lowest of 1 and 2)	Unit draft of STW/MDTW (ham)	Required no of STW/MDTW
Chautham	1956.09	1860.5	1860.5	2.52	738

6. Demand Side Interventions

In demand side management, micro/precision irrigation is proposed in the block. Micro irrigation intended to effectively utilize water by various techniques such as drips, sprinklers, pivots, rain-guns etc. in the farm. Under Pradhan Mantri Krishi Sinchayee Yojana (PMKSY), popularization of micro irrigation plans is one of the focus areas in order to ensure 'Per drop-More crop'. Under the scheme additional irrigation potential can be created by installing drips, sprinklers, pivots, rain-guns and other application devices. It is proposed that 10% of the command area should be brought under micro/precision irrigation for efficient water management (District Irrigation Plan-Khagaria). The scheme shall be implemented in phase-wise.

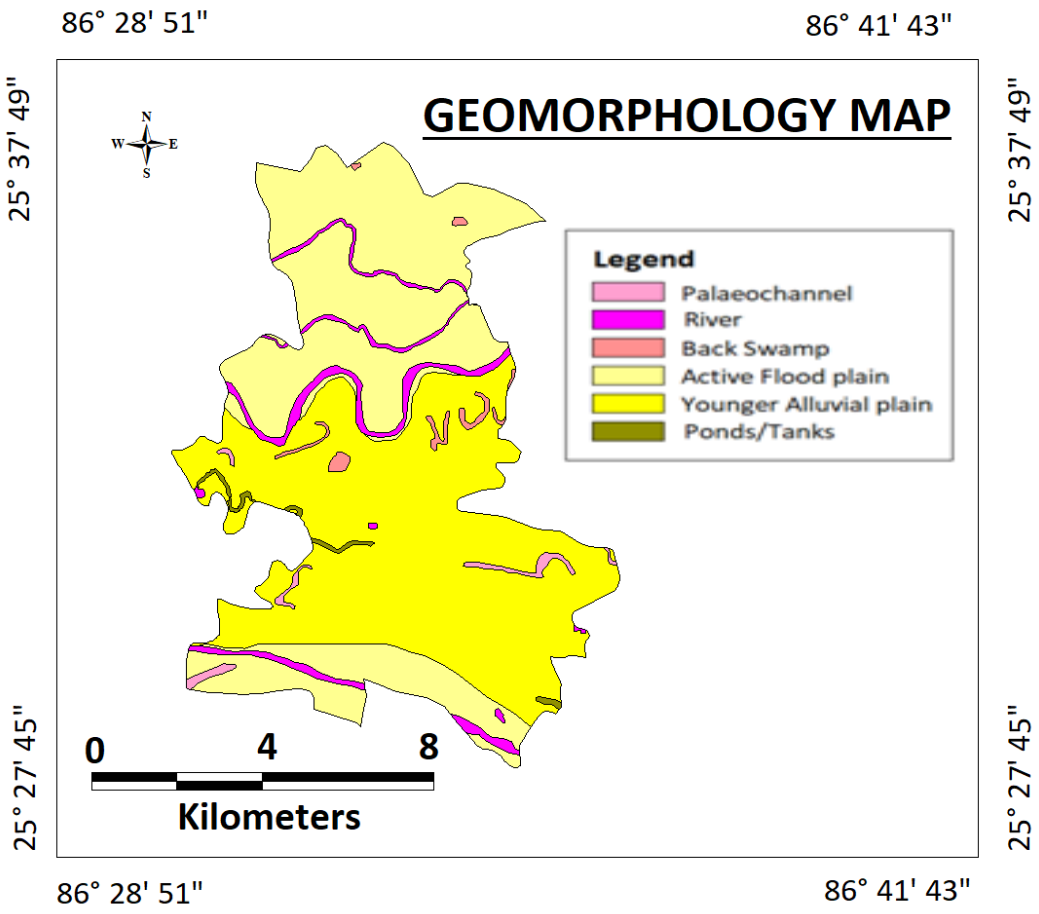
Table 1: Dynamic Ground Water Resource (as on 31st March, 2020)

District	Block	Recharge from Rainfall during Monsoon season	Recharge from Rainfall during Non Monsoon season	Recharge from Other Sources during Monsoon season	Recharge from Other Sources during Non Monsoon season	Total Annual Ground Water Recharge	Provision for Natural Discharges	Net Annual Ground Water Availability	Existing Gross Ground Water Draft for irrigation	Existing Gross Ground water Draft for Domestic and Industrial Water Supply	Existing Gross Ground Water Draft for All Uses	Provision for Domestic and Industrial Requirement for Next 25 years	Net GW Availability for Future Irrigation Development	Stage of Ground Water Development	Category: Safe / Semi-critical/ Critical/ Over-exploited
		(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	
Khagaria	Chautham	5590.30	479.32	324.98	417.83	6812.43	681.25	6131.18	1980.72	355.02	2335.74	297.70	3762.76	38.10	Safe

BLOCK WISE
AQUIFER MAPS AND MANAGEMENT PLANS

1. Salient Information

Name of the Block of Aquifer (in Km²)	**MANSI** (70.01 Sq. Km.)
District/State	Khagaria/Bihar
Population	Rural: 88,511 Urban: 0
Rainfall	Normal Monsoon: 985.4mm/ Non-monsoon rainfall: 188.8 mm
Agriculture and Irrigation	The block falls in the Argo-climatic Zone II. The cropping sequence followed in this zone is Rice – Wheat – Moong. The soils in this zone are sandy loam, clayey loam with pH in the range of 6.5 – 7.8. The gross irrigated area 5972 ha and net irrigated area is 4008 ha.
Geology & Geomorphology	Geomorphologically, most of the area is covered by younger alluvial plain and active flood plain. Back swamps and palaeochannels can also be observed in the vicinity of older river course of Kosi River. Geologically the entire district is covered by alluvium deposits of Quaternary age.
Ground water resource availability and extraction	The dynamic ground water resource of Mansi block has been assessed as 28.47 MCM. The gross ground water draft for all uses stands at 17.04 MCM. The stage of Development is 59.87%.
Existing water demand	Irrigation: 1489.32 ham Domestic & Industrial: 215.49 ham
Water level behaviour	The depth to water level varies from 5 to 10 mbgl during pre-monsoon season. In post monsoon season, the depth to water level varies from2 to 5 mbgl and in northern parts it is less than 2 mbgl.


86° 28' 51"
86° 41' 43"
25° 37' 49"
25° 27' 45"
GEOMORPHOLOGY MAP
N
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Legend
Palaeochannel
River
Back Swamp
Active Flood plain
Younger Alluvial plain
Ponds/Tanks
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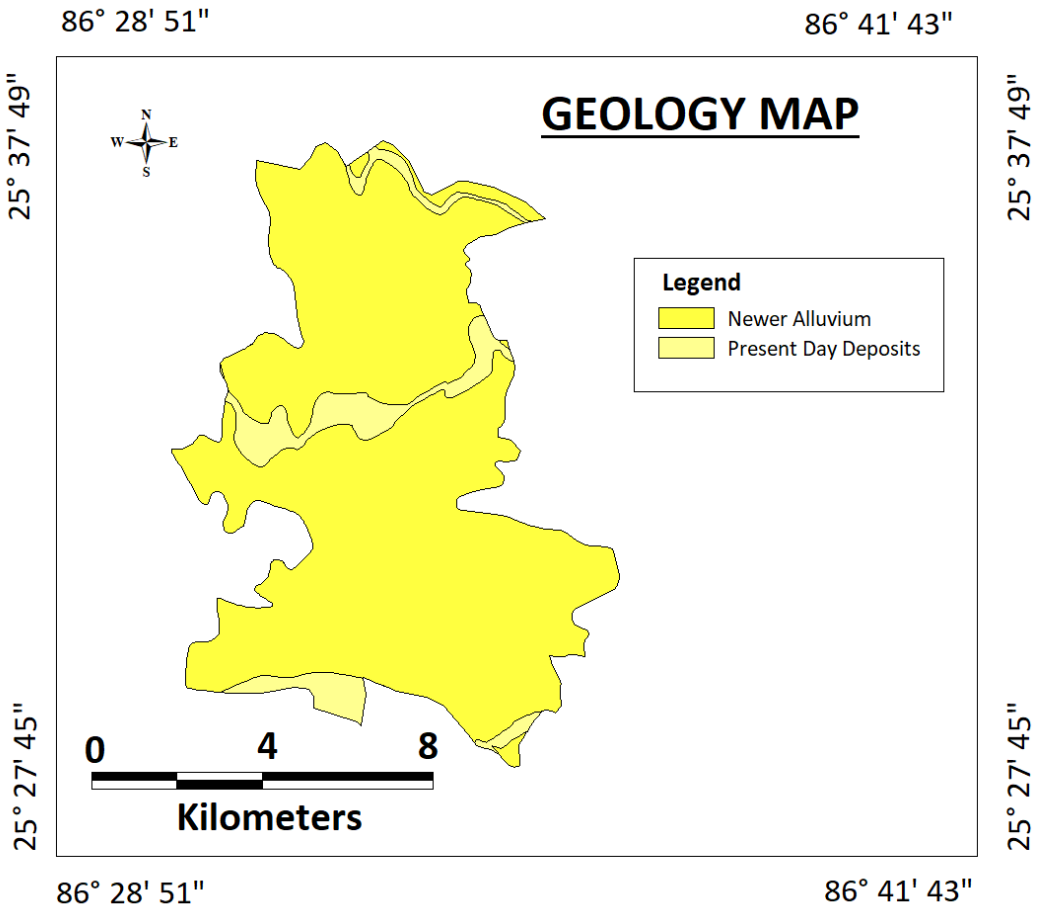
4
8
Kilometers


86° 28' 51"
86° 41' 43"
25° 37' 49"
25° 27' 45"
GEOLOGY MAP
N
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Legend
Newer Alluvium
Present Day Deposits
0
4
8
Kilometers

2. Aquifer Disposition

The area is bestowed with mono- aquifer system. Arsenic contamination of groundwater has been reported from the area. As the area is represented by mono-aquifer system down to investigated depth of 310m, there is no alternate groundwater source. Hence, groundwater development in the area should be done with caution. Though, deeper part of the aquifer is relatively arsenic free, with continued development sufficient chance exists for its getting contaminated. Hence, only the top part of the aquifer should be developed along with measures of conjunctive uses. Arsenic treatment plant may be installed for drinking water sources. The section depicting the aquifer disposition is shown in district report.

3. Chemical Quality of Ground Water and Contamination

On the basis of Piper diagram and Durov plot, groundwater of the block is potable and based on USSL plot, groundwater is suitable for irrigational purposes.

4. Ground Water Resource Enhancement

As the stage of groundwater development is within the safe limits and there is no long-term water level decline in the area, the need for artificial recharge is not felt.

5. Supply Side Interventions

In view of the issue of arsenic contamination in nearby blocks, it is recommended to use deeper part of the aquifer solely for meeting the drinking water supply requirement. Development for irrigation and other uses may be restricted within 60 m. The additional resource available may be utilized for creation of additional irrigation potential for less water intense crops like pulses, oilseeds etc by projecting SOD to 70%. The additional irrigation potential created and required number of TW's are estimated and given below.

Block	Area to be brought under Irrigation (ha)	Additional resource required (ham) for pulses/oil seeds	Total Annual Extractable Ground Water (ham)	Present Gross Draft for all uses (ham)	Annual resource availability considering 70% development	Water available for further development (ham)	Area to bring under irrigation for pulses/oilseeds with additional resources (ha)	Remaining Area (ha)	% area to be brought under irrigation by additional resource
Mansi	1767	883.5	2847.5	1704.8	1993.25	288.45	576.9	1190.1	32.65

Block	Volume of water available for future Irrigation development (ham) within 'safe' limit	Additional resource required for future irrigation (ham) within safe limit	Actual additional resource available 3 = (Lowest of 1 and 2)	Unit draft of STW/MDTW (ham)	Required no of STW/MDTW
Mansi	288.45	883.5	288.45	2.52	114

6. Demand Side Interventions

In demand side management, micro/precision irrigation is proposed in the block. Micro irrigation intended to effectively utilize water by various techniques such as drips, sprinklers, pivots, rain-guns etc. in the farm. Under Pradhan Mantri Krishi Sinchayee Yojana (PMKSY), popularization of micro irrigation plans is one of the focus areas in order to ensure 'Per drop-More crop'. Under the scheme additional irrigation potential can be created by installing drips, sprinklers, pivots, rain-guns and other application devices. It is proposed that 10% of the command area should be brought under micro/precision irrigation for efficient water management (District Irrigation Plan-Khagaria). The scheme shall be implemented in phase-wise.

Table 1: Dynamic Ground Water Resource (as on 31st March, 2020)

District	Block	Recharge from Rainfall during Monsoon season	Recharge from Rainfall during Non Monsoon season	Recharge from Other Sources during Monsoon season	Recharge from Other Sources during Non Monsoon season	Total Annual Ground Water Recharge	Provision for Natural Discharges	Net Annual Ground Water Availability	Existing Gross Ground Water Draft for irrigation	Existing Gross Ground water Draft for Domestic and Industrial Water Supply	Existing Gross Ground Water Draft for All Uses	Provision for Domestic and Industrial Requirement for Next 25 years	Net GW Availability for Future Irrigation Development	Stage of Ground Water Development	Category: Safe / Semi-critical/ Critical/ Over-exploited
		(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	(ham)	
Khagaria	Mansi	2386.88	204.65	251.97	320.38	3163.88	316.38	2847.5	1489.32	215.49	1704.8	171.29	1123.9	38.10	Safe

Annexure - I

Block-wise Land-use Land-cover Details (in ha)

Sl No.	Name of Block	Geographical area (Sq km)	Forest	Area under waste land	Land under other uses	Gross cropped area	Net sown area	Area sown more than one time	Cropping intensity (%)
	1	2	3	4	5	6	7	8	9
1	Allauli	274	2500	3415	3711	29595	20572	9023	144
2	Beldaur	224	2000	1700	2828	24167	15592	8575	155
3	Chautham	166	0	1375	2298	20747	12195	8552	170
4	Gogri	251	1500	2510	4242	31652	19500	12152	162
5	Khagaria	262	0	2690	4596	25837	17759	8078	145
6	Mansi	68	0	610	1237	11470	5775	5695	199
7	Parbatta	241	2000	2530	3889	23646	12607	11039	188
Khagaria		**1486**	**8000**	**14830**	**22800**	**167114**	**104000**	**63114**	**161**

Annexure - II

Details of Key wells Established in Khagaria District with Water Level

District	Location	Latitude	Longitude	Depth to Water Level May-2019 (m bgl)	Depth to Water Level Nov-2019 (m bgl)	Fluctuation (m)
Khagaria	Pirnasara	25.61	86.73	5.45	3.81	1.64
Khagaria	Basantpur	25.5	86.59	6.53	1.95	4.58
Khagaria	Chautham	25.55	86.68	5.27	2.21	3.06
Khagaria	Maheshkhunt 1	25.46	86.64	5.9	1.4	4.5
Khagaria	Gandhinagar	25.45	86.67	4.98	1.47	3.51
Khagaria	Jamalpur	25.43	86.64	5.1	1.47	3.63
Khagaria	Maheshkhunt _Lohiya Chowk	25.48	86.6	6.75	2.89	3.86
Khagaria	Maheshkunt	25.46	86.63	7.36	2.47	4.89
Khagaria	Durgapur	25.48	86.46	8.36	4.12	4.24
Khagaria	Gangaut	25.51	86.37	7.97	4.07	3.9
Khagaria	Ismailpur	25.51	86.39	7.45	4.02	3.43
Khagaria	Kasimpur	25.5	86.42	7.6	2.7	4.9
Khagaria	Khagaria	25.49	86.48	7.95	3.1	4.85
Khagaria	Labhgaon	25.5	86.43	8.02	4.56	3.46
Khagaria	Ranko	25.52	86.5	6.88	3.12	3.76
Khagaria	Sabalpur	25.54	86.5	7.25	3.92	3.33
Khagaria	Sonhauli	25.51	86.47	8.56	4.53	4.03
Khagaria	Dewri	25.36	86.71	2.65	1.28	1.37
Khagaria	Mohaddipur	25.39	86.75	6.8	3.72	3.08

Annexure - III

Results of Chemical Analysis Groundwater Samples of Khagaria District

Block	Location	pH	EC	TDS	F-	Cl-	HCO3-	CO3 2-	SO4 2-	NO3 -	TH	Ca2+	Mg2+	Na+	K+
Chautham	Basantpur	8.53	363.40	236.21	0.46	67.35	225.88	12	5.65	0.22	200	28.02	31.54	39.71	5.21
Chautham	Chautham	8.10	615.40	400.01	0.54	163.07	274.72	0	7.65	0.18	225	34.03	33.96	79.72	23.16
Parbatta	Dewri(Devnagar)	8.44	1321.00	858.65	0.36	106.35	525.02	33	4.61	2.34	545	26.02	11.64	189.8	10.56
Khagaria	Durgapur	8.17	962.70	625.755	0.23	163.07	305.24	0	14.93	4.93	275	32.03	47.31	51.59	63.99
Gogri	Gandhinagar	8.54	1055.00	685.75	0.97	109.89	274.72	27	40.75	19.26	500	50.04	91.00	46.01	0.287
Khagaria	Gangaur	8.34	893.20	580.58	0.99	63.81	335.77	15	36.71	0.33	305	46.04	46.09	59.87	15.93
Khagaria	Ismailpur	8.32	473.20	307.58	0.58	163.07	219.78	15	2.83	0.52	225	34.03	33.96	68.19	19.99
Gogri	Jamalpur (Gogri Jamalpur	8.83	399.40	259.61	0.5	67.35	280.82	21	9.34	1.12	245	30.02	41.25	39.87	4.72
Khagaria	Kasimpur	8.51	349.80	227.37	0.4	102.81	195.36	9	3.95	0.33	155	26.02	21.83	53.97	18.41
Khagaria	Khagaria	8.30	556.20	361.53	0.35	163.07	250.30	15	5.43	0.33	250	36.03	38.82	68.06	20.63
Khagaria	Labhgaon	8.17	436.00	283.4	0.43	80.47	286.93	0	0.28	0.26	225	38.03	31.53	24.13	4.17
Gogri	Lohia Chowk Maheshkhunt	8.38	506.20	329.03	0.59	63.81	286.93	15	68.93	0.41	250	44.04	33.96	52.92	14.72
Chautham	Maheshkhunt -1	8.39	486.70	316.355	0.42	42.54	286.93	6	31.82	0.40	250	38.03	37.60	26.97	4.87
Chautham	Maheshkhunt	8.77	1490.00	968.5	0.55	212.70	518.91	39	194.99	11.26	675	16.01	154.12	96.67	18.97
Parbatta	Mohaddipur	8.61	622.00	404.3	0.46	46.09	280.82	21	89.00	5.79	275	22.02	53.39	48.79	9.75
Beldore	Pirnasara Ward-4 (Pirnagra)	9.40	2012	1307.8	0.66	336.78	500.60	54	39.69	3.69	310	24.02	60.67	169.84	192.44
Khagaria	Ranko	8.71	454.60	295.49	0.45	49.63	213.67	21	56.47	0.72	175	16.01	32.76	49.67	23.4

Khagaria	Sabalpur	8.53	465.00	302.25	0.57	39.00	262.51	42	63.12	0.99	235	32.03	37.61	58.23	15.55
Khagaria	Sonhauli	9.18	1167.00	758.55	0.51	148.89	250.30	33	142.38	11.72	330	18.01	69.17	109.2	24.44

(All in mg/L except pH, EC, TH)

Annexure – IV

Litholog of Exploratory Wells Constructed in Khagaria District

Unique ID	**1**
Location	**Awadh Bihari Sanskrit College**
Taluka/Block	**Khagaria**
District	**Khagaria**
Lat	**25.4916**
Long	**86.4675**
RL (m amsl)	
Drilled Depth	**300**
Casing	
SWL (m bgl)	
Discharge (lps)	
Date/Year	

Depth Range (m)		**Thickness (m)**	**Composite Lithology**
From	**To**		
0	4	4	Top soil, yellowish brown in colour mixed with few mica
4	6	2	Top soil, yellowish brown in colour mixed with few mica
6	8.2	2.2	Clay: mixed with sand, fine grained, yellowish grey in colour mixed with few mica
8.2	10.4	2.2	Fine sand, greyish in colour mixed with mica
10.4	14	3.6	Sand: very fine sand, greyish in colour mixed with few mica
14	32	18	Sand: very fine sand, greyish in colour mixed with few mica
32	56	24	Sand: very fine sand, greyish in colour mixed with few mica
56	100	44	Gravel mixed with few sand
100	106	6	Sand: Fine sand, greyish in colour mixed with few mica

106	114	8	Clay: mixed with sand, medium to fine grained, yellowish grey in colour and gravel
114	172.8	58.8	Sand: very fine sand, yellowish in colour mixed with few gravel
172.8	177	4.2	Clay: mixed with sand, medium to fine grained, yellowish grey in colour
177	188	11	Sand: Fine sand, greyish yellow in colour mixed with few gravel
188	194	6	Sand: Very fine sand, greyish yellow in colour mixed with few gravel
194	208	14	Sand:Fine sand, yellowish in colour
208	212.4	4.4	Sand:Very fine sand, yellowish in colour
212.4	220.4	8	Sand:Fine sand, yellowish grey in colour
220.4	231.2	10.8	Sand:Very fine sand, yellowish grey in colour
231.2	234	2.8	Fine sand, yellowish grey in colour
234	240	6	Clay: yellowish brown in colour mixed with medium grained sand
240	242.8	2.8	Sand:Fine sand, greyish in colour
242.8	244	1.2	Sand: Very fine sand, greyish in colour
244	247.2	3.2	Sand:Fine sand, greyish in colour
247.2	269.2	22	Sand:Very fine sand, yellowish grey in colour
269.2	276	6.8	Clay: yellowish brown in colour mixed with medium grained sand
276	282.4	6.4	Sand: Fine sand, yellowish grey in colour mixed with few mica
282.4	287.2	4.8	Clay, yellowish brown mixed with silt
287.2	290	2.8	Sand: Fine sand, yellowish grey in colour mixed with few mica
290	300	10	Clay, yellowish brown in colour mixed with silt

Unique ID	2
Location	High School Baisa
Taluka/Block	Parbatta
District	Khagaria
Lat	25.3513
Long	86.7283
RL (m amsl)	
Drilled Depth	257
Casing	
SWL (m bgl)	
Discharge (lps)	
Date/Year	

Depth Range (m)		Thickness (m)	Composite Lithology
From	To		
0	7.58	7.58	Top soil brownish
7.58	10.66	3.08	Sand Fine grained yellowish gray mixed with few mica
10.66	22.98	12.32	Sand fine grained greyish mixed with mica
22.98	32.22	9.24	Sand medium to fine grained yellowish gray with mica
32.22	38.38	6.16	Sand Coarse to medium grained yellowish gray
38.38	41.46	3.08	Sand coarse to medium grained yellow mixed with gravel
41.46	44.54	3.08	Sand coarse to medium greyish yellow mixed few gravel
44.54	53.78	9.24	Sand coarse to medium greyish yellow mixed with gravel
53.78	56.86	3.08	Sand coarse grained greyish mixed with gravel and kankar
56.86	57.9	1.04	Sand coarse grained greyish yellow mixed with gravel
57.9	62.2	4.3	Sand coarse grained greyish yellow mixed with gravel
62.2	70.26	8.06	Sandy clay yellowish grey
70.26	75.34	5.08	Sand medium to fine grained greyish mixed with mica
75.34	78.42	3.08	Sand coarse to medium yellowish mixed with few gravel and kankar
78.42	81.5	3.08	Sand coarse to medium grained greyish

81.5	84.58	3.08	Sand coarse grained mixed with gravel and kankar
84.58	87.66	3.08	Sand coarse grained yellowish
87.66	93.82	6.16	Sand medium to fine grained greyish mixed with mica
93.82	103.06	9.24	Sand fine grained greyish mixed with few mica
103.06	115.38	12.32	Sand medium to coarse grained yellowish gray mixed with
115.38	118.46	3.08	Sand coarse grained yellowish in colour with gravel & kankar
118.46	121.54	3.08	Sand medium to coarse grained yellowish gray
121.54	124.62	3.08	Sand coarse grained greyish mixed with gravel
124.62	133.86	9.24	Sandy clay mixed gravel yellowish
133.86	136.94	3.08	Sand fine grained greyish mixed with mica
136.94	145.1	8.16	Sand medium to coarse grained greyish mixed with gravel
145.1	158.5	13.4	Silt mixed with clay yellowish
158.5	161.58	3.08	Sand medium to coarse grained greyish mixed with mica
161.58	163.8	2.22	Sand medium to fine grained yellowish gray
163.8	170.5	6.7	Sandy clay yellowish grey
170.5	180.06	9.56	Sand coarse grained greyish yellow mixed with gravel
180.06	183.84	3.78	Sand medium grained greyish
183.84	186.22	2.38	Sand medium to fine grained greyish

186.22	192.38	6.16	Sand medium to coarse grained yellowish gray mixed with gravel
192.38	198.54	6.16	Sand medium to fine grained greyish mixed with mica
198.54	204.7	6.16	Sand medium to coarse grained greyish
204.7	207.78	3.08	Sand coarse grained yellowish gray
207.78	210.86	3.08	Sand medium to fine grained yellowish gray
210.86	213.94	3.08	Sand medium grained yellowish gray mixed with kankar
213.94	220.1	6.16	Sand medium grained yellowish gray
220.1	226.26	6.16	Sand coarse grained greyish yellow mixed with gravel
226.26	229.34	3.08	Sand medium to fine grained greyish mixed with mica
229.34	232.42	3.08	Sand coarse grained yellowish gray
232.42	235	2.58	Sand medium to fine grained greyish mixed with mica
235	239	4	Clay greyish
239	242.5	3.5	Sandy clay greyish
242.5	257	14.5	Clay yellowish

Unique ID	3
Location	Jawahar Inter Vidyalaya, Samaspur
Taluka/Block	Gogri
District	Khagaria
Lat	25.4683
Long	86.6188
RL (m amsl)	
Drilled Depth	300
Casing	
SWL (m bgl)	
Discharge (lps)	
Date/Year	

Depth Range (m)		Thickness (m)	Composite Lithology
From	To		
0	3.08	3.08	Top soil brownish yellow
3.08	12.32	9.24	Sand: Fine grained Sand brownish with mica
12.32	27.72	15.4	Sand: Fine grained Sand grayish with few mica
27.72	36.96	9.24	Sand: medium to fine grained sand grayish with mica
36.96	40.04	3.08	Sand: Coarse to medium grained sand yellowish gray with few mica
40.04	43.12	3.08	Sand: Coarse to medium grained sand yellowish gray with few gravel
43.12	46.2	3.08	Sand: Medium to fi8ne sand grayish with few gravel and mica
46.2	49.28	3.08	Sand: Coarse to medium grained sand grayish yellow with gravel, mica and kankar
49.28	55.44	6.16	Sand: Medium to fine grained sand grayish yellow with few gravel and mica
55.44	58.22	2.78	Sand: Medium to fine grained sand grayish with mica and gravel
58.22	61.6	3.38	Sand: Fine silt yellowish grey with few mica and gravel
61.6	73.92	12.32	Sand: Coarse to medium grained sand yellowish with mica and gravel
73.92	83.16	9.24	Sand: Fine Grained sand greyish with few mica

83.16	89.32	6.16	Silt: yellowish grey with few mica and gravel
89.32	95.48	6.16	Sand: Coarse sand yellowish with few gravel
95.48	98.56	3.08	Sand: Med. to fine grained sand yellowish grey
98.56	101.64	3.08	Sand: Coarse sand yellowish with gravel
101.64	107.8	6.16	Sand: Fine sand yellowish grey with few mica
107.8	1 10.88	3.08	Sand: Med. to fine sand yellowish grey with few gravel
1 10.88	l 13.96	3.08	Sand: Coarse to medium sand yellowish with few gravel
l 13.96	120.12	6.16	Sand: Coarse sand yellowish with few gravel
120.12	129.36	9.24	Clay: yellowish with silt
129.36	1 35.52	6.16	Sand: Med.to fine sand yellowish grey with kankar and gravel
1 35.32	138.6	3.08	Sand: Fine grained sand with mica
138.6	146	7.4	Sand: Coarse grained sand grayish yellow with gravel
146	154	8	Clay :Yel1owish Grey
154	161.24	7.24	Sand: Coarse sand yellowish with few gravel
161.24	165.5	4.26	Sand: Fine grained sand grayish with mica
165.5	169	3.5	Clay: yellowish grey with Silt
169	181.72	12.72	Sand: Med to fine sand greyish with few mica

181.72	184.8	3.08	Sand: Med grained sand yellowish with few mica
184.8	194.04	9.24	Sand: Fine sand yellowish grey,
194.04	197.12	3.08	Clay: yellowish with Silt
197.12	203.28	6.16	Sand: Coarse grained sand yellowish with gravel
203.28	206.36	3.08	Sand: Fine grained sand grayish
206.36	209.44	3.08	Sand: Med to fine grained sand grayish with few gravel
209.44	218.68	9.24	Sand: Coarse sand yellowish grey
218.68	221.76	3.08	Clay: yellowish with Silt
221.76	224.84	3.08	Sand: Coarse to med sand yellowish with few gravel
224.84	227.92	3.08	Sand: Coarse sand yellowish
227.92	231	3.08	Sand: Fine sand greyish with mica
231	240.24	9.24	Sand: Coarse sand yellowish with few gravel
240.24	243.32	3.08	Clay: Yellowish with Silt
243.32	246.4	3.08	Sand: Coarse sand yellowish
246.4	252.56	6.16	Sand: Medium to fine grained sand yellowish grey
252.56	255.64	3.08	Sand: fine sand grayish
255.64	261.8	6.16	Sand: Coarse sand of yellowish with gravel
261.8	267.96	6.16	Sand: Coarse to medium sand grayish
267.96	271.04	3.08	Sand: Coarse sand yellowish grey with gravel
271.04	274.12	3.08	Sand: Coarse to medium sand grayish with gravel

274.12	283.36	9.24	Sand: Coarse grained sand grayish yellow
283.36	300	16.64	Clay yellowish with silt

Unique ID	4
Location	Madhya Vidyalaya, Srisarnia
Taluka/Block	Gogri
District	Khagaria
Lat	25.4277
Long	86.645
RL (m amsl)	
Drilled Depth	310
Casing	
SWL (m bgl)	
Discharge (lps)	
Date/Year	

Depth Range (m)		Thickness (m)	Composite Lithology
From	To		
0	2	2	Sand: Fine grained sand,greyish in colour mixed with mica & soil
2	6	4	Sand: Fine to medium grained sand, greyish in colour mixed with mica & soil
6	10	4	Sand: Fine to medium grained sand, brownish grey in colour mixed with mica
10	15.2	5.2	Sand: Coarse grained sand, brownish grey in colour mixed with mica
15.2	20	4.8	Sand: Very fined grained sand, brownish grey in colour mixed with mica
20	24	4	Sand: Fine to medium grained sand, brownish grey in colour mixed with mica
24	30	6	Sand: Fine to medium grained sand, brownish grey in colour mixed with mica
30	36	6	Sand: Coarse grained sand, brownish grey in colour mixed with mica
36	60	24	Sand: Fine to medium grained sand, yellowish mixed with Kanakar
60	72	12	Sand: Fine to medium grained sand, greyish yellow mixed with few kankar
72	96	24	Kankar mixed with few medium grained yellowish sand & gravel

96	112	16	Sand: Medium to fine sand, greyish yellow in colour mixed with mica
112	116	4	Sand: Medium to fine grained sand mixed with kankar
116	152	36	Sand: Medium to fine grained greyish yellow mixed with kankar
152	156	4	Clay mixed with sand, medium grained, yellowish grey in colour and few kankar
156	160	4	Sand: Medium to fine grained sand, yellowish grey in colour mixed with few kankar
160	174	14	Sand: Very fine grained sand, yellowish grey in colour mixed with few kankar
174	178	4	Sand: Coarse grained sand, yellowish grey in colour mixed with kankar
178	195	17	Sand: Fine to medium grained sand, yellowish grey m colour mixed with few kankar
195	202	7	Sand: Fine to medium grained sand, yellowish grey m colour mixed with kankar
202	212	10	Sand: Coarse grained sand, yellowish in colour mixed with few kankar
212	216	4	Sand: Medium to fine grained sand ,greyish yellow in colour mixed with mica
216	220	4	Sand: Medium to fine grained sand,greyish yellow in colour mixed with mica

220	225	5	Sand: Very fine grained sand,greyish yellow in colour mixed with mica
225	230	5	Sand: Medium to fine grained sand,greyish yellow in colour mixed with mica
230	233	3	Silt, greyish yellow in colour mixed with mica
233	248	15	Sand: Fine to medium grained sand,greyish in colour mixed with kankar
248	256	8	Sand: Very fine grained sand,greyish in colour mixed with mica
256	260	4	Sand: Fine to medium grained sand,greyish yellow in colour mixed with kankar
260	264	4	Sand: Fine to medium grained sand,greyish yellow in colour mixed with kankar
264	266	2	Silt, greyish yellow in colour mixed with kankar
266	274	8	Sand: Fine to medium grained sand,greyish yellow in colour mixed with kankar
274	282	8	Sand: Fine to medium grained sand, yellowish grey in colour mixed with kankar
282	286	4	Silt yellowish grey in colour mixed with kankar
286	296	10	Sand: Very fine grained sand, yellowish grey in colour mixed with kankar

296	300	4	Sand: Fine to medium grained sand, yellowish grey in colour mixed with kankar
300	302	2	Sand : Coarse grained sand ,yellowish grey in colour mixed with mica
302	306	4	Sand: Fine to medium grained sand,greyish in colour mixed with mica

Unique ID		5
Location		Saurh
Taluka/Block		Parbatta
District		Khagaria
Lat		25.3192
Long		86.8148
RL (m amsl)		37
Drilled Depth		85.36
Depth range (m)		Lithology
0	6.1	Black Clay
6.1	17.4	Coarse Sand
17.4	18.3	Yellow Clay
18.3	24.4	Fine Sand
24.4	27.44	Medium Sand
27.44	76.21	Coarse Sand
76.21	82.3	Fine Sand

Unique ID		6
Location		Sondiha
Taluka/Block		Gogri
District		Khagaria
Lat		25.4015
Long		86.7303
RL (m amsl)		40.3
Drilled Depth		91.46
Depth range (m)		Lithology
0	3.04	Surface Clay
3.04	12.2	Clay
12.2	30.5	Fine Sand
30.5	51.5	Medium Sand
51.5	83.84	Coarse Sand
83.84	91.46	Clay

Unique ID		7
Location		Jhajhra
Taluka/Block		Parbatta
District		Khagaria
Lat		25.3947
Long		86.7707
RL (m amsl)		35.7
Drilled Depth		91.46
Depth range (m)		Lithology
0	9.15	Clay
9.15	27.43	Fine Sand
27.43	51.8	Medium Sand
51.8	83.84	Coarse Sand and Gravel
83.84	91.46	Fine to medium Sand

Unique ID		8
Location		Harinmar
Taluka/Block		Parbatta
District		Khagaria
Lat		25.3849
Long		86.6128
RL (m amsl)		39.7
Drilled Depth		94.51
Depth range (m)		Lithology
0	4.6	Surface Clay
4.6	32.06	Fine sand
32.06	56.4	Fine to medium sand
56.4	86.4	Coarse sand with gravel
86.4	86.9	Coarse sand
86.9	94.51	Fine Sand

Unique ID		9
Location		Nayagaon
Taluka/Block		Parbatta
District		Khagaria
Lat		25.3282
Long		86.6949
RL (m amsl)		38
Drilled Depth		83.23
Depth range (m)		Lithology
0	3.96	Gray Brownish silty clay of medium plasticity
3.96	16.15	Very fined sand-grey
16.15	25.3	Medium sand, grey
25.3	28.35	Grey medium to coarse sand with clay.
28.35	35.06	Grey medium sand
35.06	46.03	Grey fine to medium sand with mica
46.03	50.6	Grey coarse sand
50.6	71.64	Grey coarse to very coarse sand with fine gravel carbonate nodules.
71.64	77.44	Grey coarse sand
77.44	83.23	Grey medium to coarse sand.

Unique ID		10
Location		Rahimpur
Taluka/Block		Parbatta
District		Khagaria
Lat		25.3150
Long		86.6916
RL (m amsl)		32.1
Drilled Depth		80
Depth range (m)		Lithology
0	13.12	Gray fine sand with mica
13.12	20.73	Gray fine sand
20.73	23.78	Gray fine to medium sand with fine gravel.
23.78	25.3	Gray clayey fine sand
25.3	28.35	Light grey medium to coarse sand with fine gravel.
28.35	37.5	Light grey medium sand.
37.5	43.6	Light grey well graded coarse sand with fine gravel & carbonate nodules.
43.6	46.64	Grey fine sand with mica & little clay.
46.64	54.3	Light grey well graded coarse sand with fine sand.
54.3	55.8	Grey fine to medium sand & cobbles of clay
55.8	58.84	Grey medium to fine sand
58.84	71.04	Grey coarse to medium sand with fine gravel
71.04	74.08	Grey medium sand
74.08	80.2	Grey well graded

Unique ID		11
Location		Timarpur
Taluka/Block		Parbatta
District		Khagaria
Lat		25.3581
Long		86.6739
RL (m amsl)		38.7
Drilled Depth		97.56
Depth range (m)		Lithology
0	4.6	Surface clay
4.6	16.8	Fine sand
16.8	57.8	Fine to medium sand
57.8	91.46	Coarse sand with kankar
91.46	97.56	Black clay

Unique ID		12
Location		Dumaria
Taluka/Block		Parbatta
District		Khagaria
Lat		25.3020
Long		86.6938
RL (m amsl)		37.3
Drilled Depth		69.81
Depth range (m)		Lithology
0	3.96	Grey fine sand and clay
3.96	11.58	Gray very fine sand with mica
11.58	25.3	Gray fine sand
25.3	29.9	Gray fine sand with coarse mica
29.9	31.4	Gray medium to fine sand and carbonate nodules
31.4	36.6	Gray medium uniform sand
36.6	40.55	Gray sand carbonate nodules mixed with well gravel
40.55	50.61	Gray medium to coarse sand, Carbonate nodules, sand nodules fine gravel.
50.61	64.02	Gray well graded coarse sand to medium sand gravel and sandy nodules.
64.02	65.85	Gray fine sand & nodules of clay
65.85	68	Dark gray silty clay of medium plasticity
68	69.81	Dark grey silty clay of medium plasticity sand, sand stone.

Unique ID		13
Location		Fatehpur
Taluka/Block		Gogri
District		Khagaria
Lat		25.3996
Long		86.6789
RL (m amsl)		40
Drilled Depth		79.57
Depth range (m)		Lithology
0	11	Dark grey silty clay of Medium plasticity
11	13.12	Dark grey fine sand with silt.
13.12	16.16	Gray fine sand
16.16	19.2	Gray medium sand
19.2	22.26	Gray medium to fine sand with mica
22.26	31.4	Gray medium sand
31.4	34.45	Gray medium sand
34.45	42.07	Gray medium to fine sand
42.07	55.3	Gray coarse to medium sand with fine gravel
55.3	58.84	Gray well graded coarse sand & fine gravel & C-nodules.
58.84	64.94	Gray coarse to medium sand with fine gravel carbonate nodules.
64.94	68.3	Gray yellowish very coarse sand with fine gravel sandy nodules
68.3	71.03	Gray medium uniform sand to little coarse sand.
71.03	77.13	Gray coarse to medium sand and fine gravel, C-nodules
77.13	79.57	Gray fine to medium sand.

Unique ID		14
Location		Malia
Taluka/Block		Gogri
District		Khagaria
Lat		25.4213
Long		86.6787
RL (m amsl)		39.1
Drilled Depth		79.3
Depth range (m)		Lithology
0	6.4	Yellowish grey fine sand & silt
6.4	9.45	Gray fine sand
9.45	12.5	Gray very fine sand & silt
12.5	30.8	Gray fine uniform sand
30.8	55.18	Gray medium uniform sand
55.18	79.6	Gray well graded coarse sand & fine gravel
79.6	86.3	Gray medium to coarse sand and fine gravel
86.3	91.8	Gray fine sand.

Unique ID		15
Location		Sher Chakla
Taluka/Block		Gogri
District		Khagaria
Lat		25.3878
Long		86.7070
RL (m amsl)		39.1
Drilled Depth		91.5
Depth range (m)		Lithology
0	6.1	Clay
6.1	42.7	Fine sand
42.7	57.9	Fine medium sand
57.9	88.41	Coarse sand with gravel
88.41	91.5	Fine medium sand

Unique ID		16
Location		Tetarabad
Taluka/Block		Khagaria
District		Khagaria
Lat		25.4958
Long		86.3620
RL (m amsl)		42
Drilled Depth		103.7
Depth range (m)		Lithology
0	9.15	Clay
9.15	36.6	Fine sand
36.6	67.07	Medium sand
67.07	97.6	Coarse sand
97.6	103.7	Fine sand

Unique ID		17
Location		Babhan gawan
Taluka/Block		Khagaria
District		Khagaria
Lat		25.5457
Long		86.3930
RL (m amsl)		40.2
Drilled Depth		85.4
Depth range (m)		Lithology
0	3.64	Surface clay
3.64	24.4	fine sand
24.4	33.53	Medium sand
33.53	42.7	Fine sand
42.7	77.74	Medium sand with kankar
77.74	85.4	fine sand

Unique ID		18
Location		Marar
Taluka/Block		Khagaria
District		Khagaria
Lat		25.5909
Long		86.5052
RL (m amsl)		41
Drilled Depth		97.6
Depth range (m)		Lithology
0	3.04	Surface clay
3.04	12.2	Clay
12.2	24.4	Very fine sand
24.4	59.5	Fine sand
59.5	93	Medium sand with kankar
93	97.6	Fine sand

Unique ID		19
Location		Jahangira
Taluka/Block		Khagaria
District		Khagaria
Lat		25.5207
Long		86.3687
RL (m amsl)		39.3
Drilled Depth		128.35
Depth range (m)		Lithology
0	3.35	Gray sand & little clay
3.35	6.7	Gray sand clyayey silt & sand boulders
6.7	9.5	Gray very fine sand & silt mixed
9.5	27.7	Gray fine sand with mica
27.7	33.84	Gray medium sand & carbonate nodules
33.84	39.9	Gray medium to coarse sand & little fine gravel
39.9	46.04	Gray fine uniform sand
46.04	49.1	Gray medium sand
49.1	55.2	Gray medium sand & carbonate nodules
55.2	70.43	Gray fine uniform sand
70.43	73.5	Gray coarse sand & gravel
73.5	76.22	Gray medium sand
76.22	82.62	Gray coarse sand & gravel
82.62	91.8	Gray medium sand
91.8	94.8	Gray very fine sand & silt mixed
94.8	125.3	Gray well graded very coarse sand gravel and pebbles
125.3	128.35	Gray medium sand

Unique ID		20
Location		Bhadas
Taluka/Block		Khagaria
District		Khagaria
Lat		25.5515
Long		86.4297
RL (m amsl)		38.8
Drilled Depth		135.4
Depth range (m)		Lithology
0	4	Silt, with gray yellowish and clay
4	7.01	Sand, fine gray
7.01	13.12	Sand, Gray fine with mica
13.12	22.3	Sand, gray fine
22.3	31.4	Sand, gray, fine with mica
31.4	37.5	Sand, gray medium to coarse & fine gravel
37.5	45.1	Sand, gray well graded coarse and fine gravel
45.1	48.2	Sand, gray, coarse
48.2	61.9	Sand, gray, fine with mica
61.9	64.9	Sand, gray, medium to fine
64.9	77.13	Sand, gray fine, uniform
77.13	80.8	Sand, gray medium to coarse
80.8	102.4	Sand gray, fine with mica
102.4	104.6	Sand, gray fine to coarse with fine gravel sand
104.6	114.3	Sand, Gray fine with mica
114.3	119.2	Sand, light gray, medium to coarse, well graded & fine gravel.
119.2	123.8	Sand, gray, very fine with mica
123.8	129	Sand, gray coarse, well graded & fine gravel with carbonate nodules.
129	135.4	Sand, gray, fine uniform with mica

Unique ID		21
Location		Darhi
Taluka/Block		Khagaria
District		Khagaria
Lat		25.5117
Long		86.4174
RL (m amsl)		38.2
Drilled Depth		85.4
Depth range (m)		Lithology
0	12.2	Clay
12.2	24.4	Fine sand
24.4	30.5	Sand fine to medium
30.5	33.53	Sand, fine
33.53	39.6	Sand, Medium
39.6	47	Sand, Coarse with gravel
47	54.5	Sand, Medium
54.5	80.8	Sand, Coarse with gravel
80.8	85.4	Sand, Fine

Unique ID		22
Location		Bachhauta
Taluka/Block		Khagaria
District		Khagaria
Lat		25.5426
Long		86.4561
RL (m amsl)		37.1
Drilled Depth		103.7
Depth range (m)		Lithology
0	3.04	Clay
3.04	24.4	Sand fine to medium
24.4	64.02	Sand, medium
64.02	79.3	Sand, Coarse
79.3	98.2	Sand, Coarse with gravel
98.2	103.7	Sand, fine to medium

Unique ID		23
Location		Kaithy
Taluka/Block		Choutham
District		Khagaria
Lat		25.5317
Long		86.6859
RL (m amsl)		43
Drilled Depth		96.03
Depth range (m)		Lithology
0	3.04	Surface clay
3.04	6.29	Clay
6.29	24.39	Sand, fine
24.39	57.87	Sand, Medium
57.87	79.26	Sand, Coarse with kankar
79.26	88.41	Sand, med. With kankar
88.41	96.03	Sand, fine

Unique ID		24
Location		Saraiya
Taluka/Block		Choutham
District		Khagaria
Lat		25.5305
Long		86.6692
RL (m amsl)		38.6
Drilled Depth		79.24
Depth range (m)		Lithology
0	3.05	Surface Clay
3.05	7.62	Clay
7.62	27.44	Sand, fine
27.44	30.49	Clay, Blank
30.49	54.88	Sand, fine to medium
54.88	71.65	Sand, medium
71.65	74.7	Sand, medium with kankar
74.7	79.24	Sand, very fine.

Unique ID		25
Location		Mehsauri
Taluka/Block		Khagaria
District		Khagaria
Lat		25.5303
Long		86.5088
RL (m amsl)		38.3
Drilled Depth		95
Depth range (m)		Lithology
0	4	Silty clay, brownish gray, medium to high plasticity.
4	7.62	Silty clay, yellow of Med. Plasticity
7.62	11	Sand, gray, fine
11	13.12	Clay, dark gray of medium Plasticity
13.12	16.16	Sand, gray, fine to medium With mica
16.16	19.2	Sand, gray, very fine with mica
19.2	37.2	Sand, gray, medium to fine
37.2	55.2	Sand gray well graded, coarse to medium and fine gravel carbonate nodules
55.2	62	Sand gravel fine with mica
62	69.2	Sand, gray, medium to fine
69.2	71.04	Sand, gray, med. To fine, carbonate nodules & clay
71.04	78.05	Sand, gray fine to med. With mica
78.05	89.3	Sand, gray, coarse, with fine gravel
89.3	95.12	Sand, gray, fine to med. With mica

Unique ID		26
Location		Rasonk
Taluka/Block		Khagaria
District		Khagaria
Lat		25.5591
Long		86.5014
RL (m amsl)		39.4
Drilled Depth		141
Depth range (m)		Lithology
0	5.5	Silty clay brownish, med. Plasticity
5.5	17.1	Sand, gray, fine with mica
17.1	19.2	Clay, dark grey with sand, med. To fine with mica.
19.2	40.5	Sand, gray, med. to fine with mica
40.5	48.2	Sand, light gray fine with mica
48.2	49.7	Silty clay, dark grey with sand & Kankar (carb. Nodules)
49.7	52.7	Sand, sand stone, grey fine with carbonate nodules
52.7	62	Sand gray fine with mica
62	64.9	Sand gray fine to medium with micaceous sand stone
64.9	71.04	Sand gray, fine to med. With mica
71.04	74.1	Sand, gray, very fine with mica
74.1	80	Sand, gray uniform med. & little coarse sand.
80	81.7	Sand gray fine & cobbles of clay
81.7	104.6	Sand gray uniform fine
104.6	117	Sand grey coarse to med. with fine gravel
117	120	Sand gray well graded with fine gravel & sand
120	129	Sand gray, fine with mica
129	135	Sand gray, med. To coarse
135	141	Sand, gray, fine to med. With mica.

Unique ID		27
Location		Thatha-I
Taluka/Block		Choutham
District		Khagaria
Lat		25.5413
Long		86.6568
RL (m amsl)		40.2
Drilled Depth		73.47
Depth range (m)		Lithology
0	3.28	Kanakr, yellowish gray, carbonate nodules.
3.28	8.53	Kankar, yellowish gray with silty clay.
8.53	12.5	Sand gray, very fine with mica
12.5	21.6	Sand, gray, fine
21.6	24.6	Sand, gray, med. with cobbles.
24.6	27.74	Sand with little clay.
27.74	33.84	Sand, gray, fine with mica.
33.84	36.58	Sand, gray, fine with mica
36.58	37.8	Sand, gray, medium with gravel
37.8	42.98	Sand, gray, medium to coarse.
42.98	55.18	Sand, gray coarse to medium
55.18	58.23	Sand, gray, med. with coarse sand.
58.23	61.28	Sandy, gray, medium
61.28	64.32	Sand, gray well graded with fine gravel & Carb. Nodules
64.32	67.37	Sand, coarse, grays well graded with gravel.
67.37	73.47	Sand, gray, medium

Unique ID		28
Location		Khutia
Taluka/Block		Choutham
District		Khagaria
Lat		25.5121
Long		86.5503
RL (m amsl)		40.8
Drilled Depth		91.46
Depth range (m)		Lithology
0	3.05	Surface clay
3.05	18.29	Clay sandy
18.29	27.43	Sand fine
27.43	34.45	Sand, med. To coarse
34.45	39.63	Sand, fine
39.63	46.34	Sand, medium
46.34	48.78	Sand, fine
48.78	55.79	Sand, coarse
55.79	64.02	Sand, fine
64.02	73.78	Sand, med. To coarse
73.78	85.36	Sand, medium with kankar
85.36	91.46	Sand, fine.

Unique ID		30
Location		Goriyami
Taluka/Block		Allauli
District		Khagaria
Lat		25.6160
Long		86.3834
RL (m amsl)		39.7
Drilled Depth		92.99
Depth range (m)		Lithology
0	24.39	Sand, fine
24.39	52.74	Sand, fine to medium.
52.74	84.15	Sand, medium & Kankar
84.15	92.99	Sand, fine to medium.

Unique ID		29
Location		Sauthihi Bishnupur
Taluka/Block		Allauli
District		Khagaria
Lat		25.6295
Long		86.5277
RL (m amsl)		41
Drilled Depth		91.46
Depth range (m)		Lithology
0	6.1	Clay
6.1	27.44	Sand, fine
27.44	52.44	Sand, Coarse
52.44	73.78	Sand, fine
73.78	84.45	Sand, medium
84.45	91.46	Sand, fine

Unique ID		31
Location		Samaspur
Taluka/Block		Choutham
District		Khagaria
Lat		25.4790
Long		86.6253
RL (m amsl)		39.5
Drilled Depth		69.82
Depth range (m)		Lithology
0	3.69	Clay, silty, yellowish with kankar
3.69	11.89	Caly, silty, gray of med. Plasticity
11.89	13.11	Sand, gray fine with mica
13.11	19.21	Sand, gray, very fine
19.21	22.26	Sand, gray fine uniform
22.26	25.3	Sand, gray, med. To fine, cobbles of clay and sand stone.
25.3	32.93	Sand, gray, fine
32.93	37.5	Sand, gray, med. with coarse sand.
37.5	40.55	Sand, gray, coarse to med. & fine grained
40.55	46.65	Sand, gray coarse.
46.65	49.7	Sand, gray, medium To coarse & Cobble
49.7	55.79	Sand, gray, medium to coarse sand

55.79	64.94	Sand, gray, coarse with fine gravel
64.94	67.99	Sand, gray, well graded, fine gravel, carb. Nodules.
67.99	69.82	Sand, gray, well graded with fine gravel and Sandy nodules.

Unique ID		32
Location		Nista
Taluka/Block		Allauli
District		Khagaria
Lat		25.6459
Long		86.3324
RL (m amsl)		40.9
Drilled Depth		88.41
Depth range (m)		**Lithology**
0	3.05	Sandy clay
3.05	15.24	Sand, fine
15.24	35.37	Sand, medium
35.37	46.95	Sand, coarse
46.95	54.88	Sand, fine
54.88	80.79	Sand, coarse
80.79	82.32	Sand, fine
82.32	85.37	Clay, black.
85.37	88.41	Sand, fine.

Unique ID		33
Location		Sanihar
Taluka/Block		Allauli
District		Khagaria
Lat		25.5911
Long		86.2937
RL (m amsl)		38.6
Drilled Depth		91.46
Depth range (m)		**Lithology**
0	3.04	Surface clay
3.04	15.24	Sand, very fine
15.24	45.73	Sand, medium
45.73	60.97	Sand, coarse, with pebbles
60.97	70.12	sand, fine
70.12	85.36	Sand, medium with kankar
85.36	91.46	Sand, fine.

Unique ID		34
Location		Jogia
Taluka/Block		Allauli
District		Khagaria
Lat		25.6450
Long		86.3454
RL (m amsl)		39.7
Drilled Depth		71.46
Depth range (m)		**Lithology**
0	3.05	Sandy, clay
3.05	10.67	Clay, sticky
10.67	42.68	Sand, fine
42.68	79.27	Sand, coarse
79.27	85.37	Sand, fine
85.37	88.41	Clay, sticky
88.41	71.46	Sand, fine.

Unique ID		35
Location		Haripur
Taluka/Block		Allauli
District		Khagaria
Lat		25.6561
Long		86.3358
RL (m amsl)		37.4
Drilled Depth		94.51
Depth range (m)		Lithology
0	3.05	Sandy clay
3.05	33.54	Sand, fine
33.54	39.63	Sand, coarse
39.63	42.68	Clay, black
42.68	51.83	Sand, fine
51.83	82.32	Sand, coarse
82.32	88.41	Sand, medium
88.41	91.46	Sand, fine
91.46	94.51	Clay, black

Unique ID		36
Location		Mujona
Taluka/Block		Allauli
District		Khagaria
Lat		25.6378
Long		86.3135
RL (m amsl)		38.1
Drilled Depth		88.41
Depth range (m)		Lithology
0	3.04	Sandy, clay
3.04	27.43	Sand, fine
27.43	33.53	Sand, medium
33.53	82.3	Sand, coarse
82.3	85.36	Sand, fine
85.36	88.41	Clay, black

Unique ID		37
Location		Raun
Taluka/Block		Allauli
District		Khagaria
Lat		25.6397
Long		86.3840
RL (m amsl)		38
Drilled Depth		91.46
Depth range (m)		Lithology
0	3.04	Clay, sandy
3.04	35.06	Sand, medium
35.06	48.78	Sand, coarse
48.78	54.87	Sand , fine
54.87	82.31	Sand, coarse
82.31	88.41	Sand , fine
88.41	91.46	Clay, black.