केंद्रीय भूमि जल बोर्ड
जल संसाधन, नदी विकास और गंगा संरक्षण
विभाग, जल शक्ति मंत्रालय
भारत सरकार

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

AQUIFER MAPPING AND MANAGEMENT OF GROUND WATER RESOURCES PASCHIM CHAMPARAN DISTRICT, BIHAR STATE

Mid Eastern Region, Patna
2022

AQUIFER MAP AND MANAGEMENT PLAN PASCHIM CHAMPARAN DISTRICT BIHAR STATE

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ACKNOWLEDGEMENT

I would like to take an opportunity to thank Shri G Krishnamurthy, Regional Director, Central Ground Water Board, West Central Region, Ahmedabad, Gujarat, Shri Thakur Bramhanand Singh, Regional Director, Central Ground Water Board, Mid Eastern Region, Patna, Bihar, and Shri Rajiv Ranjan Shukla, Head of Office Mid Eastern Region, Patna, Bihar, for offering such opportunity of detailed study of the district. I am very much delighted to express my deep sense of gratitude and regards to my respected senior colleagues of MER Patna Region Shri Sanjib Chakraborty (Sc-D),MER, Shri Singaren Sandeep Purty (Sc-C) , Shri A K Sinha (Sc-D), Shri Pankaj Kumar, (Sc-D), Shri Satyendra Kumar, (Sc-C), and seniors/colleagues of WCR Ahmedabad Shri Ramesh Jena, (Sc-C), Shri Kamar Ujjam Khan, (Sc-B), for their valuable and meticulous guidance and support during the study.

I am deeply thankful to Smt. Mansi Bhattacharya (Sc-B), OIC Chemical Lab, Dr Suresh Kumar (ACH), Shri Anurag Shukla (STA Chem) and all other scientists of chemical team for timely analysis of the water samples of the district.

I would like to extend my gratitude to establishment and store section of MER, Patna region for providing all the requisites to carry out field activities in the district. The help and co-operation of all Scientists, staffs, MTS of CGWB, MER, Patna is greatly recognizable.

Finally, I would like to acknowledge my family members for their unselfish sacrifices, constant blessing and moral support at every stage in my life.

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AQUIFER MAP AND MANAGEMENT PLAN
PASCHIM CHAMPARAN DISTRICT

Introduction

Aquifer mapping is a process wherein a combination of geologic, geophysical, hydrologic and chemical field and laboratory analyses are applied to characterize the quantity, quality and sustainability of ground water in aquifers. There has been a paradigm shift from "groundwater development" to "groundwater management". An accurate and comprehensive micro-level picture of groundwater in India through aquifer mapping indifferent hydrogeological settings will enable robust groundwater management plans at the appropriate scale to be devised and implemented for this common-pool resource. This will help achieving drinking water security, improved irrigation facility and sustainability in water resources development in large parts of rural India, and many parts of urban India as well. The aquifer mapping program is important for planning suitable adaptation strategies to meet climate change also. Thus, the crux of NAQUIM is not merely mapping, but reaching the goal – that of ground water management through community participation.

Objective

The primary objective of the Aquifer Mapping Exercise can be summed up as "Know your Aquifer, Manage your Aquifer". Demystification of Science and thereby involvement of stake holders is the essence of the entire project. The involvement and participation of the community will infuse a sense of ownership amongst the stakeholders. This is an activity where the Government and the Community work in tandem. Greater the harmony between the two, greater will be the chances of successful implementation and achievement of the goals of the Project. As per the Report of the Working Group on Sustainable Ground Water Management, "It is imperative to design an aquifer mapping programme with a clear-cut groundwater management purpose. This will ensure that aquifer mapping does not remain an academic exercise and that it will seamlessly flow into a participatory groundwater management programme. The aquifer mapping approach can help integrate ground water availability with ground water accessibility and quality aspects.

Methodology

Methodology involves creation of database for each of the principal aquifer. Delineation of aquifer extent (vertical and lateral). Standard output for effective presentation of scientific integration of Hydrogeological, geophysical, geological, hydro chemical data facts and on GIS platform, identification of issues, manifestation of issues and formulation of strategies to address the issues by possible interventions at local and regional level.

The activities of the Aquifer Mapping can be grouped as follows.

Data Compilation & Data Gap Analysis

One of the important aspects of the aquifer mapping programme was the synthesis of the large volume of data already collected during specific studies carried out by Central Ground Water Board and various Government organizations with a new data set generated that broadly describe an aquifer system. The data were assembled from the available sources, analyzed, examined, synthesized, and interpreted. These sources were predominantly non-computerized data, which was converted into computer-based GIS data sets and based on available data, data gaps were identified.

Data Generation

There a strong need for generating additional data to fill the data gaps to achieve the task of aquifer mapping. This was achieved by multiple activities such as exploratory drilling, geophysical techniques, hydro-geochemical analysis, remote sensing, and hydrogeological surveys to delineate multi aquifer system to bring out the efficacy of various geophysical techniques and a protocol for use of geophysical techniques for aquifer mapping in different hydrogeological environs.

Aquifer Map Preparation

On the basis of integration of data generated from various studies of hydrogeology & geophysics, aquifers have been delineated and characterized in terms of quality and potential. Various maps have been prepared bringing out details of Aquifers, these are termed as Aquifer maps providing spatial variation (lateral & vertical) in reference to aquifer extremities (i.e. quality & quantity).

Aquifer Management Plan Formulation

Aquifer response Model has been utilized to identify a suitable strategy for sustainable development of the aquifer in the area.

All the above activities under the ground National Aquifer Mapping programme are depicted/elaborated in Annexures and presented in figure I.

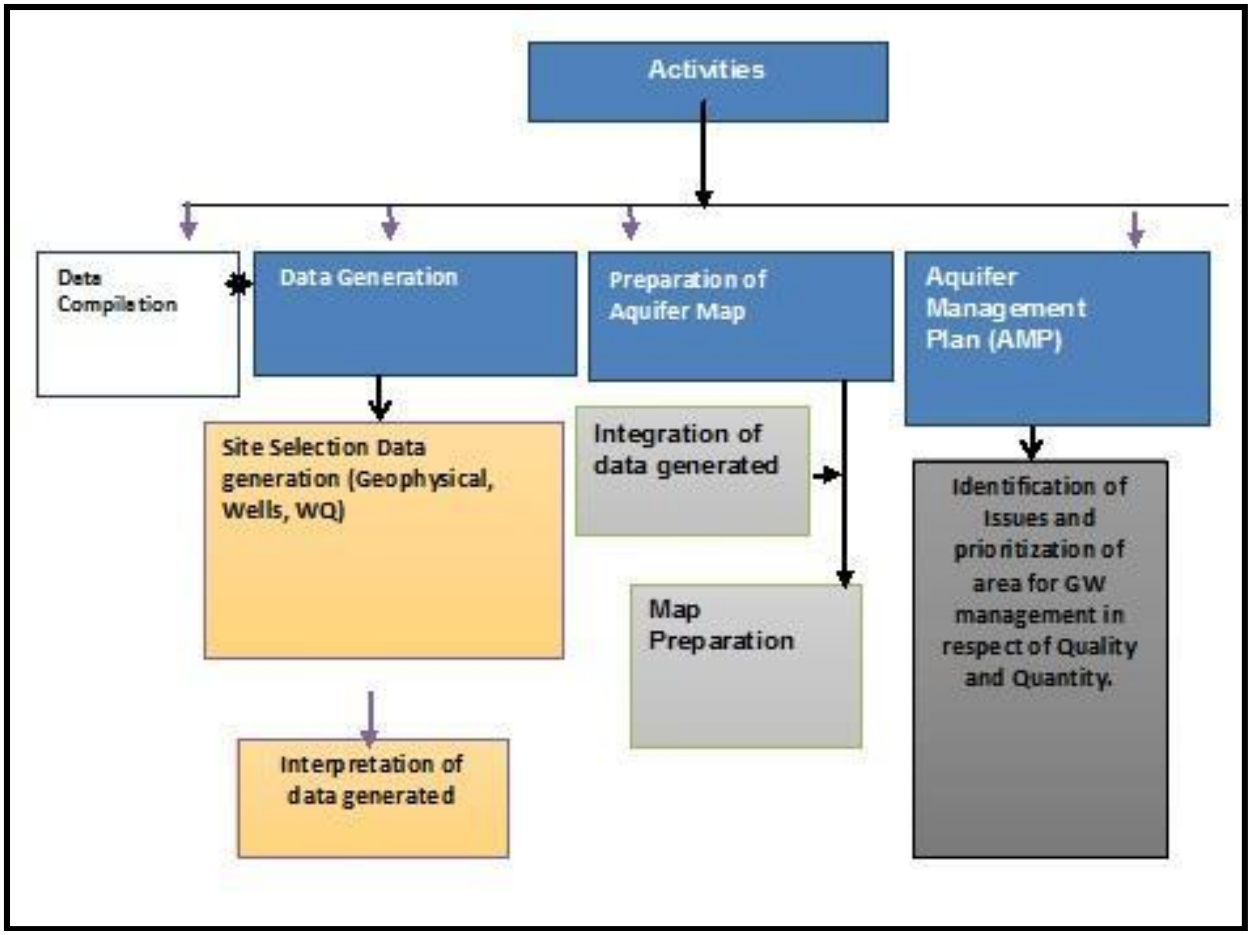

Figure I : Activities under the National Aquifer Mapping programme

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PASCHIM CHAMPARAN District

1. INTRODUCTION

The district of Paschim Champaran was carved out of the old Champaran district in the year 1972 as a result of reorganization of the district in the State. It was formerly a subdivision of Saran District and then Champaran District as a sub-division known as Bettiah sub-division. It is said that Bettiah got its name from Baint (Cane) plants commonly found in this district. The name Champaran is a degenerate form of Champaka aranya, a name which dates to the time when the district was a tract of the forest of Champa (Magnolia) trees & was the abode of solitary aesthetics.

Paschim Champaran ranks 9th in terms of population (39,35,042) and 1st in terms of area (5,228 sq.km.) in the state of Bihar. It is the 35th densely populated district in the state with 753 persons per sq.km as against the state's 1,106. The district ranks 24th in terms of sex-ratio (909) against the state's 918 and, ranks 8th in terms of child sex-ratio (953) against the state's 935. There are 118 uninhabited villages (out of 1,483 total villages) in the district of Paschim Champaran. Literacy rate of the district is 55.70 %.

It consists of 18 Development blocks. The district is basically agrarian with 76 % arable area. Farmers of the region are involved in cultivation of paddy, sugarcane, and cane reeds. One of the popular agro-based industries of the district is sugar mills established at Majhaulia, Bagaha, Ramnagar, Narkatiaganj, Chanpatia and Lauria.. The irrigation facility is developed in 46% of the total culturable land. The groundwater is largely remained unexploited due to the presence of canal network in the district. Intensive surveys by the Central Ground Water Board and, erstwhile ground water wing of Geological survey of India, besides the State Ground Water Investigation department, Govt. of Bihar, revealed large scale ground water potential of Paschim Champaran district. The irrigation potential by groundwater and, the total ground water potential has been calculated block wise with the norms of the "Ground Water Estimation Committee 2015". Utilization of groundwater can bring more area under assured irrigation, and thereby change the socio-economic conditions of rural populace by increased production and profitability. The economic development of the district depends largely on the growth of agriculture and agro-based industries as it is lacking in mineral resources.

Figure 1: Administrative map of Paschim Champaran district.

1.1 Location And Extent

The district lies in the extreme north western part of the State and has the geographical area of 5228 sq.km. out of which 5133.60 sq.km. is rural and 94.40 sq.km. is urban area. It lies between 26°34'59.4"N to 27°31'17.4"N latitudes and 83°49'58.4"E to 84°45'39.9"E longitudes and covers Survey of India toposheet nos. 63 M/15, 16; 72 A/3, 4, 7, 8,11, 12; 72 B/1, 5, 6, 9, 10. The district is bounded on the north by the hilly region of Nepal, on the South by Gopalganj and part of Purb Champaran districts, on the West by Padrauna & Deoria District of Uttar Pradesh and on the east by Purb Champaran district. The international border is open with five blocks of the district, namely, Bagaha-II, Ramnagar, Gaunaha, Mainatand & Sikta.

1.2 Communication

The district of Paschim Champaran is well served by a network of fair and all-weather roads along with rail communication. The district still lags in having sufficient communication linkage by metalled roads within its territory. National Highway 28 B cris-crosses this district. While it is well connected with the State capital by road. The district headquarter Bettiah is located on the State high way and connected with railhead. The most important roads are those which lead from the Nepal border to the banks of the Gandak, important among the State high ways and district roads are –

(1) Motihari-Madhubani ghat road
(11) Sugauli-Bettiah road
(111) Bettiah-Bagaha Road
(iv) Bagaha-Bhaisalot an (Valmikinagar) Road.

The railways were introduced in the year 1888 when Bettiah was linked with Muzaffarpur. The line was extended subsequently to Bhikhna Thori on the Indo-Nepal border, A line also runs from Narkatiaganj to Bairgania vai Raxaul. The construction of Chhitauni Rail Bridge has resulted in a direct link of the district with Gorakhpur, Lucknow, Delhi, and Mumbai by train. The district has a landing ground for planes but there is no regular air service. Bettiah and Valmikinagar have small airports with facility for landing of small planes. The airport at Valmiki Nagar is metaled.

1.3 Administrative Divisions

The district is divided into 18 blocks and 3 subdivisions 1. Bettiah 2. Narkatiyaganj 3. Bagaha. There are 315 Panchayats in the district with 1483 numbers of villages, 5 towns and 3 Census Towns.
The names and geographical area with population (as per 2011 Census of the blocks are given below:

Table 1: Development Blocks in Paschim Champaram District and population (Census 2011)

Sl No	Blocks	Area (km²)	Population (2011)
1	Bagaha	379	3,98,000
2	Bairia	237	2,06,098
3	Bettiah	68	2,24,200
4	Bhitaha	137	66,203
5	Chanpatia	261	2,97,748

Sl No	Blocks	Area (km²)	Population (2011)
6	Gaunaha	469	2,08,169
7	Jogapatti	213	2,43,516
8	Lauriya	205	2,30,162
9	Madhubani	150	89,608
10	Mainatanr	241	1,90,744
11	Majhaulia	291	3,29,347
12	Narkatiaganj	354	3,77,842
13	Nautan	190	2,33,575
14	Piprasi	153	38,592
15	Ramnagar	667	2,49,102
16	Sidhaw	875	3,09,874
17	Sikta	195	1,89,496
18	Thakrahan	142	52,766

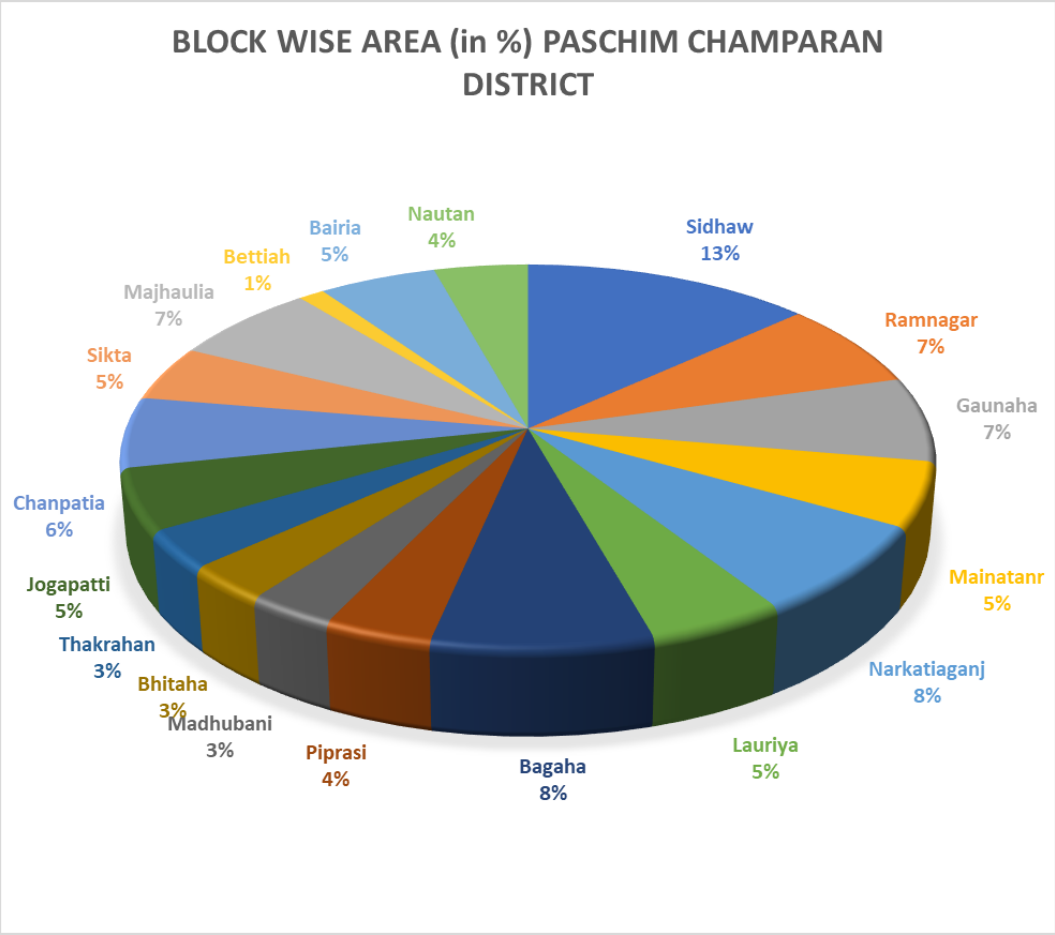


Figure 2: Block wise area (in %) Paschim Champaran district

1.4 Demography

The population in the district is 3935042 souls. Out of which, 3541877 (90.01%) consists of rural population and Urban population is 393165 (9.99%) which is below the state average of 11.29 %. The density of population is 753 which is below the State density of 1106. The literacy rate in the district is 55.70 and the decennial population

growth rate (2001-2011) is 29.29 %. Percentage of scheduled case population to total population is 14.08% and the Scheduled tribe is 6.35 %.

As per the economic activity in the district cultivators (14.71%) and agricultural laborer's (67.54%) together constitute 82.25 percent of the total workers of the district. The proportion of cultivators varies between 25.28 percent for Bhitaha Sub-district and 6.06 percent for Bettiah Sub-district. Proportion of agricultural laborer's varies between 76.22 percent in Madhubani Sub-district and 24.63 percent in Bettiah Subdistrict.

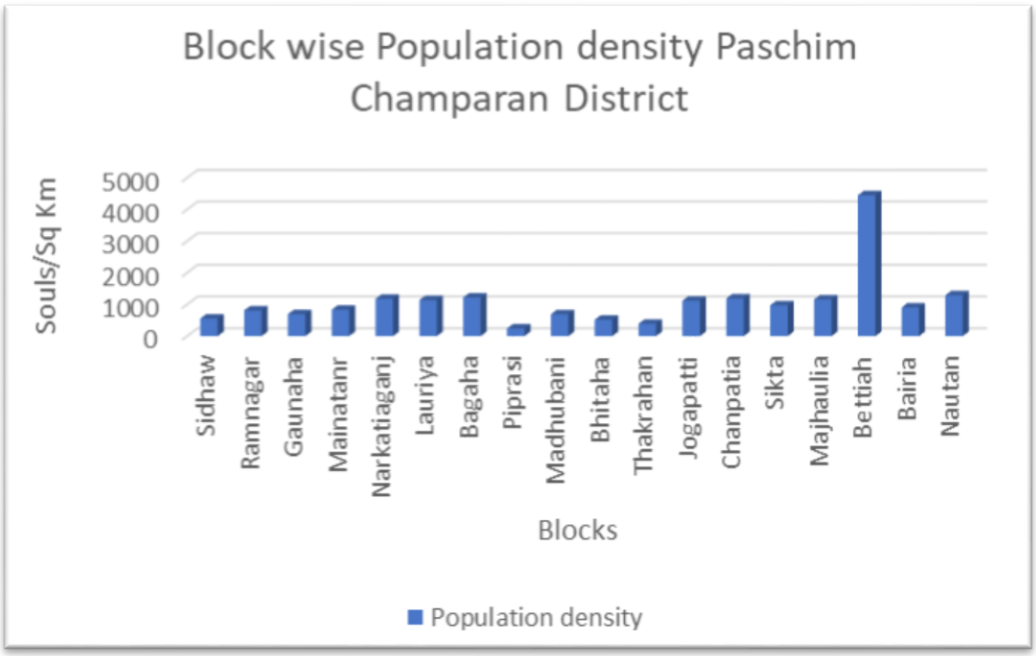


Figure 3: Block wise population density Paschim Champaran District (Census 2011)

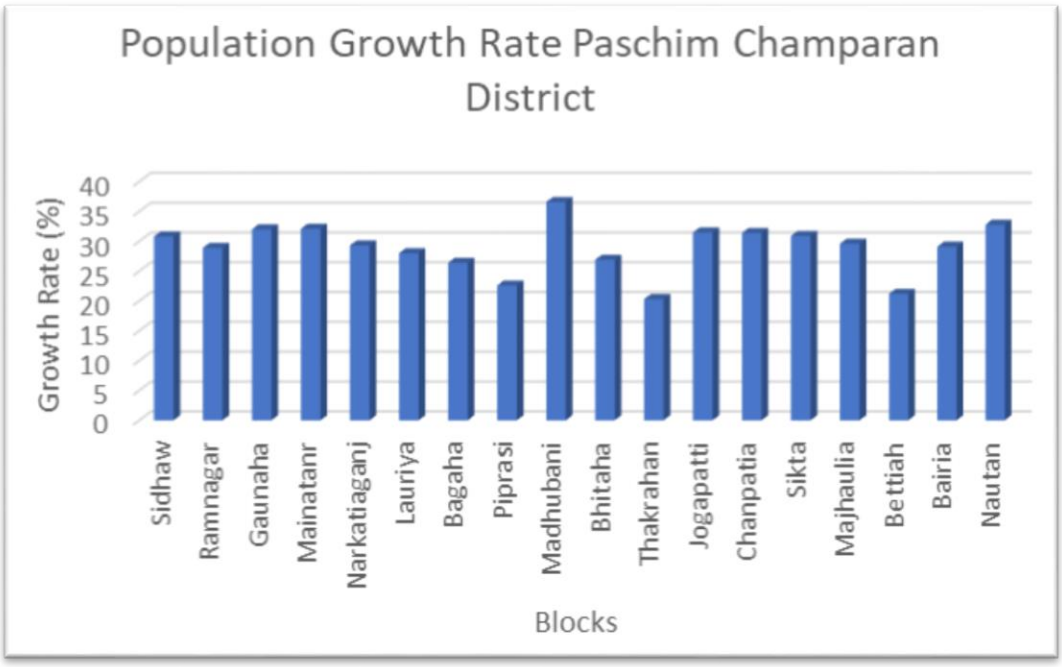


Figure 4: Population Growth rate block wise in Paschim Champaran District (census 2011)

1.5 Previous Work

Exploration program was taken up by erstwhile Tubewell Corporation, Govt. of Bihar during 1964-68 to appraise the technical and economic feasibility of ground water development in the district. Systematic hydrogeological Surveys in the district has been done by C.G.M.B. Monitoring of National Hydrograph Network Stations in the district is being carried out since 1975 by Central Ground Water Board. This has generated a valuable data on Chemical quality, water level fluctuation, depth to water level etc. Besides this, the Ground Water Investigation Department, Govt. of Bihar, has also been carried out hydrogeological Survey and Monitoring of hydrograph stations is being done.

1.1 Land Use

The district is basically agrarian in nature. The cultivated area of 2,71,000 hectares in the district forms about 56 % of the geographical area and about 76.68 % of the cultivated area is irrigated by different sources. Barren and uncultivable land is almost nil and the land put to non- agricultural use is 7.44 % of the total geographical area of the district. The forest cover is modest which around 19.01 %.

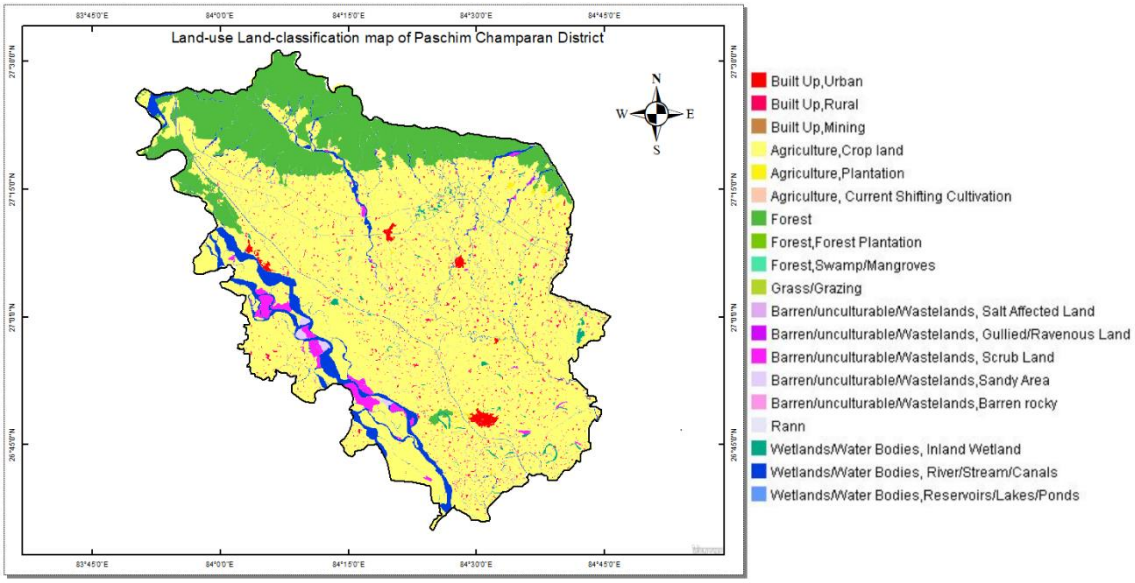
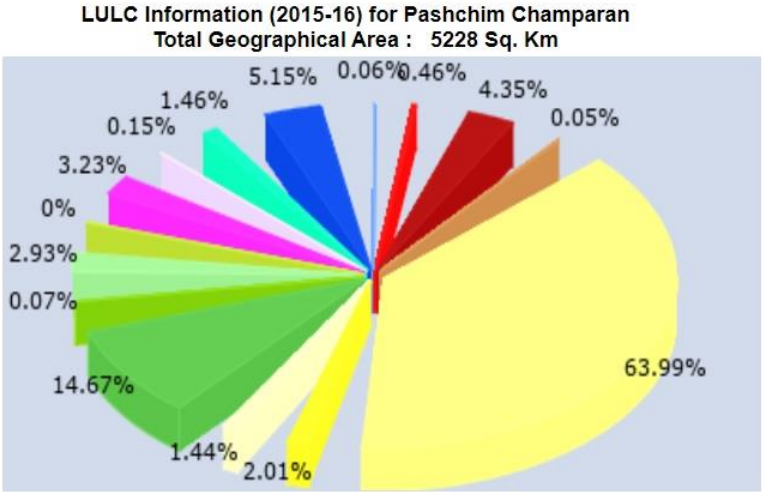


Figure 5: LULC map of Paschim Champaran District (BHUVAN)



LULC Class	Area (Sq.Km)	LULC Class	Area (Sq.Km)
Builtup,Urban	23.79	Builtup,Rural	227.52
Builtup,Mining	2.43	Agriculture,Crop land	3345.4
Agriculture,Plantation	105.05	Agriculture,Fallow	75.22
Forest,Deciduous	767.19	Forest,Forest Plantation	3.55
Forest,Scrub Forest	152.96	Grass/Grazing	0.11
Barren/unculturable/ Wastelands, Scrub land	168.67	Barren/unculturable/ Wastelands, Sandy area	7.59
Wetlands/Water Bodies, CoastalWetland	76.09	Wetlands/Water Bodies, River/Stream/canals	269.44
Wetlands/Water Bodies, Reservoir/Lakes/Ponds	2.97		

Figure 6: LULC distribution in Paschim Champaram District (BHUVAN)

1.2 Agriculture and Irrigation

The crops in the district are grouped in three divisions, viz. Aghani, Bhadai, and Rabi. The principal Aghani crops are the winter Rice crop and Sugarcane. The principal Bhadai crops are early rice, maize, various millets where as the Rabi crops are wheat, barley and Rahar. Taking the district the most important crops are rice, maize, sugarcane, wheat and barley. In the Terai tract of the district towards the north, rice is almost the only crop grown in all seasons. The intensity of cropping is 145 % which can be improved appreciably by exploiting ground water. Canal is the principal source of irrigation in the northern parts of the district. Canals operate particularly in the summer months and are designed mainly to protect the summer rice crops. The major canals operating in the district is Triveni canals which is most prominent. The Tribeni canal traverses the entire northern part of the district from Tribenighat to Mainatanr. This canal obtains its water-supply from the river Gandak at the point where it enters the district, and has its head sluice at Bhaisalotan (Balmiki Nagar) near the village of Tribeni, from which it derives its name. The Tribeni Canal extension scheme has been of great benefit to the area concerned.

There are two other canals, Tirhut and Done which are operating in the district. They get their water supply from the Gandak river at Balmikinager, the northern most part of the district bordering Nepal.

The canal irrigation contributes about 37.2 % of the total irrigation in the district. Irrigation by ground water contributes 60.05 %. The irrigation facility is generated in 50.56 % of the total cultivable area of the district. The rest 49.44% of cultivable area is rain feed area.

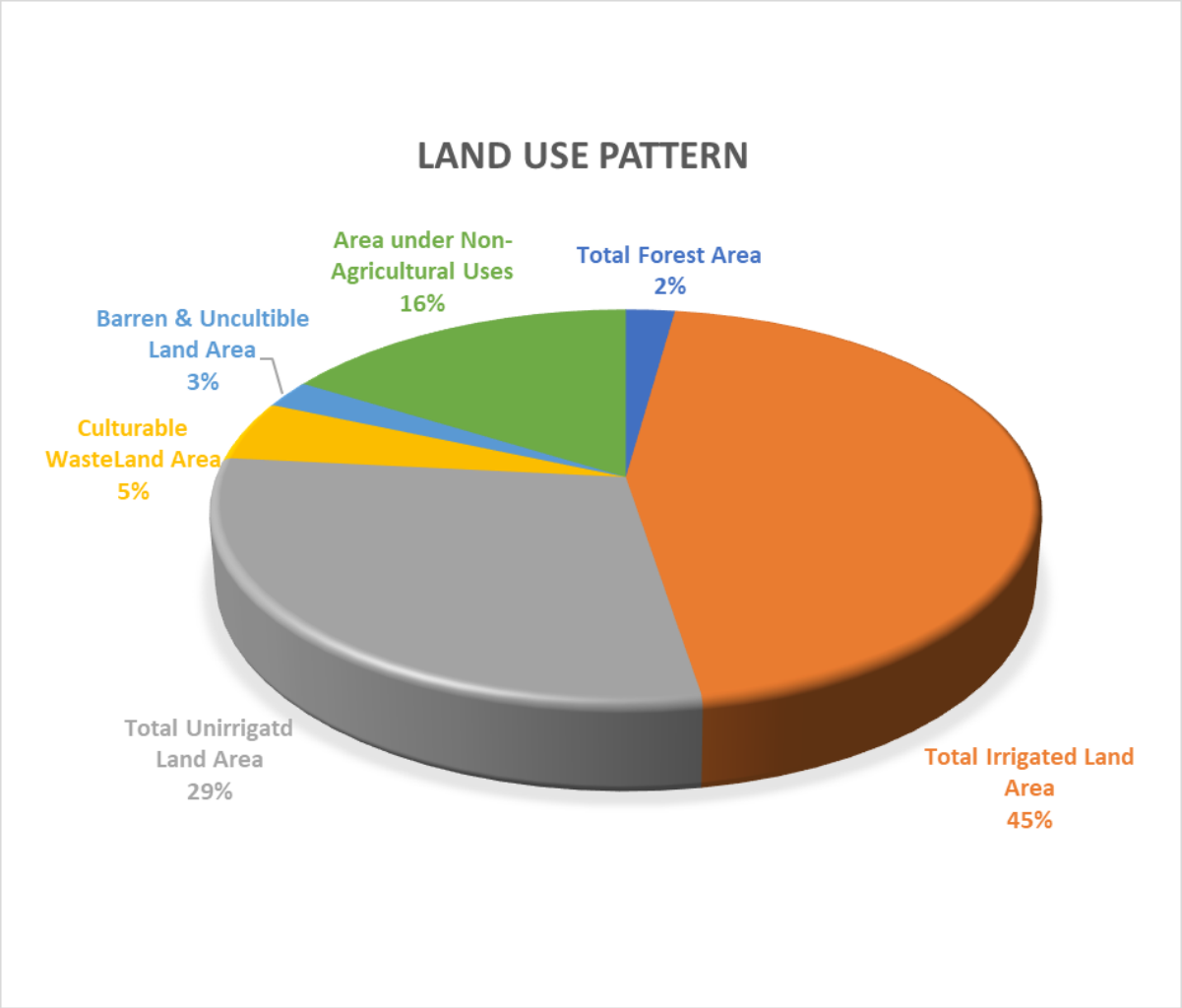


Figure 7: Land use pattern in Paschim Champaran District

Table 2:Block wise numbers of abstraction structures as per MI Census 5

Sl No	District	Block/Tehsil	Number of Shallow Tubewells by depth in metres		Number of Medium Tubewells by depth in metres			Number of Deep Tubewells by depth in metres				
			0-20	20-35	35-40	40-60	60-70	70-90	90-110	110-130	130-150	>150
1	WEST CHAMPARAN	BAGAHA	199	143	26	1094	57	0	7	140	16	3
2	WEST CHAMPARAN	BAIRIA	116	10	3	572	0	0	0	1	0	0
3	WEST CHAMPARAN	BETTIAH	32	0	0	116	0	0	6	6	0	2
4	WEST CHAMPARAN	BHITAHA	185	20	0	3	0	0	0	0	0	0
5	WEST CHAMPARAN	CHANPATIA	150	65	0	656	5	0	1	11	1	0
6	WEST CHAMPARAN	GAUNAHA	30	7	2	1082	5	3	20	23	0	0
7	WEST CHAMPARAN	JOGAPATTI	522	107	14	218	6	0	0	2	4	3
8	WEST CHAMPARAN	LAURIA	517	971	1	65	3	0	2	2	0	0
9	WEST CHAMPARAN	MADHUBANI	44	0	0	95	1	0	0	0	0	0
10	WEST CHAMPARAN	MAINATAND	174	182	7	506	8	0	0	6	1	2
11	WEST CHAMPARAN	MAJHAULIA	1	1	1	1039	132	2	0	4	0	1
12	WEST CHAMPARAN	NARKATIAGANJ	510	422	14	685	268	5	1	16	1	6
13	WEST CHAMPARAN	NAUTAN	31	11	6	454	5	0	33	76	15	13
14	WEST CHAMPARAN	PIPRASI	0	1	0	265	0	0	0	3	0	0
15	WEST CHAMPARAN	RAMNAGAR	891	476	56	541	3	2	1	12	0	1
16	WEST CHAMPARAN	SIDHAW	150	105	4	663	0	0	0	1	0	0
17	WEST CHAMPARAN	SIKTA	18	1	52	439	29	5	11	122	0	13
18	WEST CHAMPARAN	THAKRAHA	0	0	0	215	0	0	0	0	0	0
19	TOTAL		3570	2522	186	8708	522	17	82	425	38	44

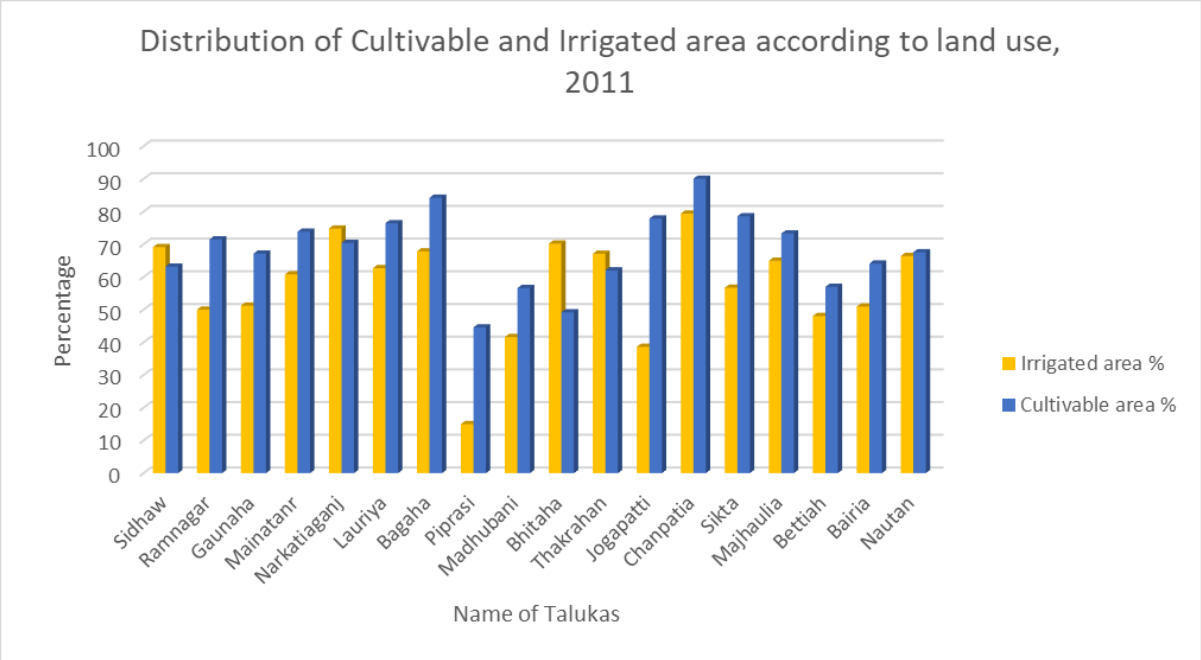


Figure 8: Distribution of Cultivated and Irrigated land area block wise in Paschim Champaran District

1.1 Climate and Rainfall

The overall climatic condition of the district is Cold and Humid in nature. The foot hill zone or the terai region comprising block areas of Ramnagar, Bagaha and Narkatiyaganj is considered unhealthy for living. In summers, westerly winds with dust and hot wave flow through the area from mid of March. The temperature increases to a maximum of 43-44° C in the month of May which is the hottest month in the district.

The district falls in agro-climatic Sub-Zone I. The average annual rainfall reported from the district of West Champaran is 1472 mm with Terai region receiving very heavy rainfall. This is just sufficient for the type of agriculture practiced traditionally in this district. Due to changing climate situation, the district faces erratic monsoon behaviors. Frequent drought due to low rainfall (700-900 mm) is witnessed every alternate year. More than 90% of the total precipitation occurs during Monsoon season (June-September). Approximately 60-70 per cent of the total precipitation received during the monsoon goes to main streams as runoff due to poor runoff management practices. During the rest period the rainfall is sporadic or scanty. Winter rains along have also been reported from the district. Number of Rainy days in the district is around 68 days, with average monthly rainfall of 94.84mm. A plot showing month wise rainfall (in mm) of West Champaran district is given below in Fig. 9.

The winter's starts just after the monsoon with pleasant climate. During winters the temperature going down upto 4-5° C. Lowest temperature is reported from the end of December to January.

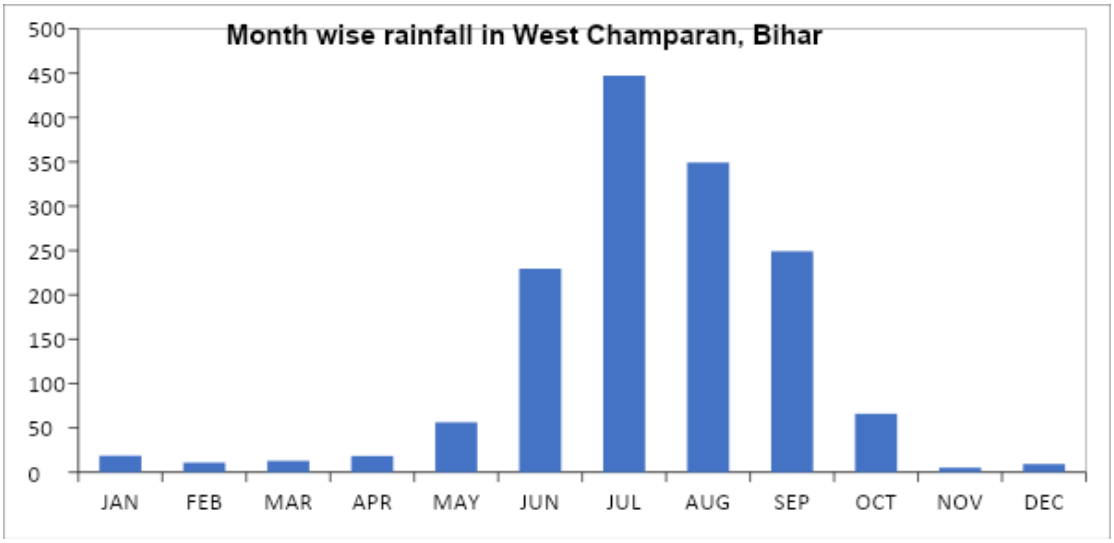


Figure 9: Month wise rainfall plot for the district

2. Geomorphology & Physiography

2.2 Physiography

The district area consisting of piedmont belt (Bhabar/Terai), which is a part of Gandak Sub-Basin of Ganga Basin. It is devoid of any relief feature in Central and Southern parts but towards the north-west the surface is more undulating and rises gradually near the Nepal frontier. A range of low hills extends in south easterly direction for some 30 Kms, from the north western corner, between this range and the Someshwar range which extends along the whole of the northern frontier lies the Dun valley. The area is gently sloping towards the south and the maximum elevation in the north being 111 meter above mal at Valmikinagar. The minimum elevation in the extreme southern part is 70 m. Levees along the stream bank, back swamps, or flood basins/Chaurs land of various sizes are the only significant features over the area. Drainage The district consists of a vast low lying plain intersected by numerous streams originating in the Himalayas. The Gandak is the most important river of the district. It rises in the Central Mountain basin of Nepal known as Sapt-Gandaki from the seven streams which unite to form this river. After flowing for about 50 Kms beyond the Indian borders, the river descends to the plains at Tribeni, at its confluence with the Sonaha and the Panchnad. Being the snow fed the Gandak is a torrential stream until it leaves the hills, after which it becomes wider and less turbulent. It is navigable upto Tribeni. The Sikrahna is the second largest river in the district. It originates in Chawtarwa Chawr; and flows in south easterly direction through the central portion of the district till it turns south at Lakhaura, north of Motihari. The southern portion of the river is known as Burhi Gandak. Environmental Aspect Water logging, soil erosion, floods and occasional mild to normal droughts are the main environmental problems in the district. Ox-bow lakes, back swamp/flood basins and Chawr land forms the sak wet land area and occur specially in the southern parts of the district.

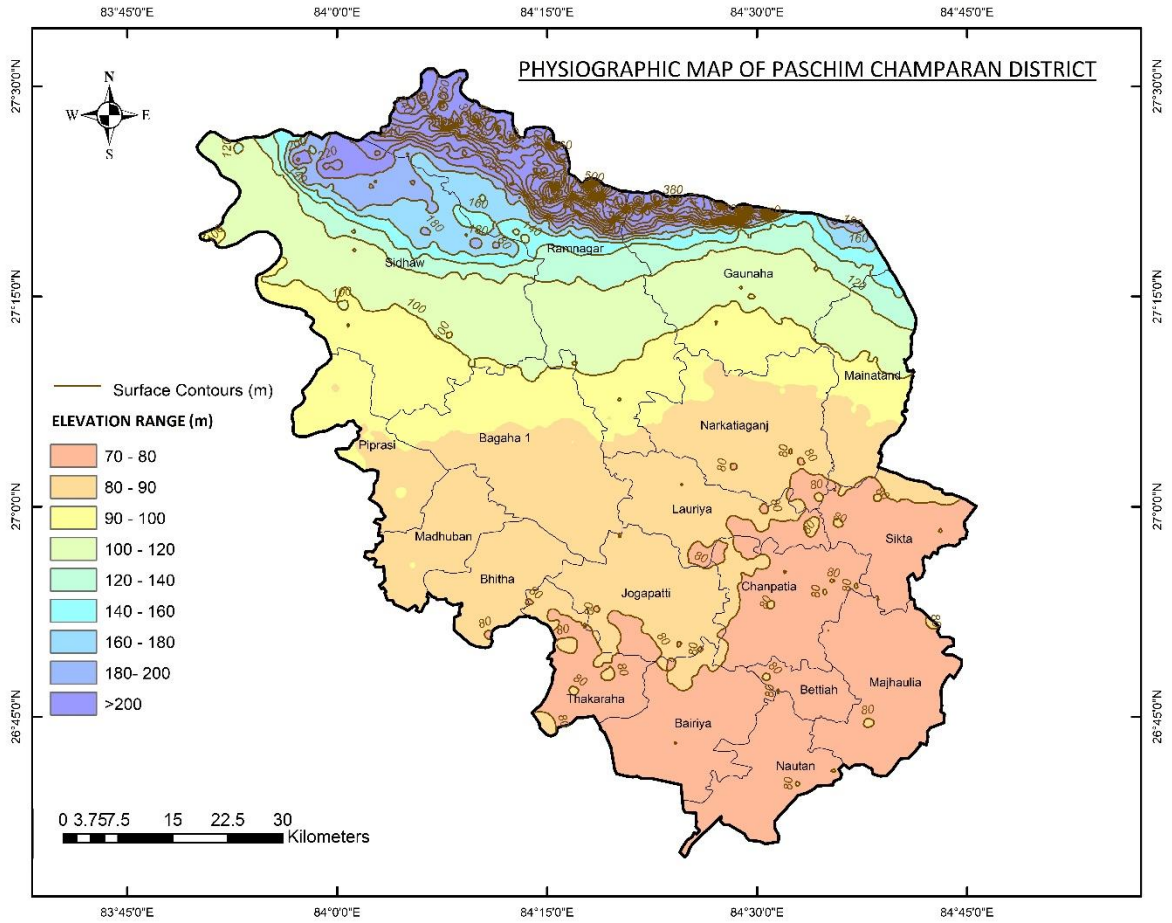


Figure 10: Physiographic map of Paschim Champaran district

2.1 Geomorphology

The areas of the district are dominated by vast low lying denudational plains intersected by numerous streams originating from Himalayan ranges. The area is exposed to soil erosion, occasional floods and mild to moderate occasional droughts. Some parts of the district remain water logged. Common landscape features in the area include ox-bow lakes, back swamps or flood plains and chaur land which forms the wet area occurring mostly in Southern part of the district. The District of West Champaran can be divided into few distinct tracts, such as, the hilly tract of Someswar and secondly, Dun range in the north at the foot hills of Himalayas. It has been noticed that the soil even at the foothills has no rocky formations. The hilly streams, brings down huge quantities of sand & destroys lot of cultivable lands. The hills contain large stretches of forests also.

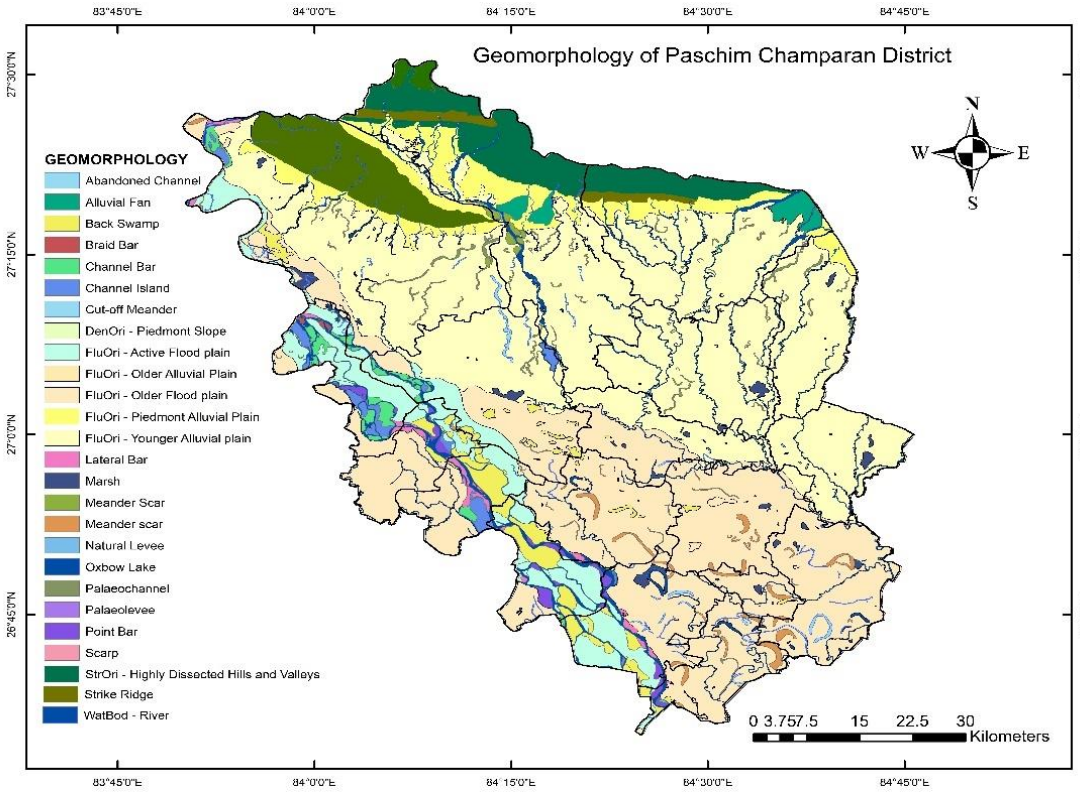


Figure 11: Geomorphological map of Paschim Champaran district

2.2 DRAINAGE

2.2.1 Surface Water Resources

The perennial rivers, such as Gandak and Six Sikrana, Masan, Dhanauti and some old courses constitute the principal sources of surface water. The surface water bodies as flood basins, ox-bow lakes over a major part of the area, do not hold much water during the lean period, but most of them are full to brink and inundate large areas during the monsoon.

The Gandak : The Gandak is the most important river of the district It rises in the Central mountain basin of the Nepal known as Sapt- Gandaki from the seven streams which unite to form this river. The total catchment area of this river is 98,124 Sq.Km. of which 9125 Sq.Km. is being covered in Bihar. The average discharge of 300 m^3/ Second was observed during the month of March and the average discharge during the July 90's was observed to be 5363 m^3/Second at Valmikinagar.

The Sikrahna: This is the second largest river in the district. It originates in the Chautarwa Chawr, and flows in South-Easterly direction through the central part of the district till it turns south at Lakhaura, north of Motihari. Canals: The 739.14-meter-long barrage on the Gandak river at Valmikinagar divert the river water through the Tirhut and Triveni canals. Tirhut, Triveni and Dun branch canals are the very important canal system in the district. It covers about a lac's hectare irrigated area in the sidhaw, Ramnagar, Lauria, Bagaha, Majhawlia, Sikta, Mainatanr, Gaunaha, Narkat iaganj, Chanpatia, Jogapatti, Baria, Nautan and Bettiah blocks. Canal irrigation covers over 73 % of the irrigated area.

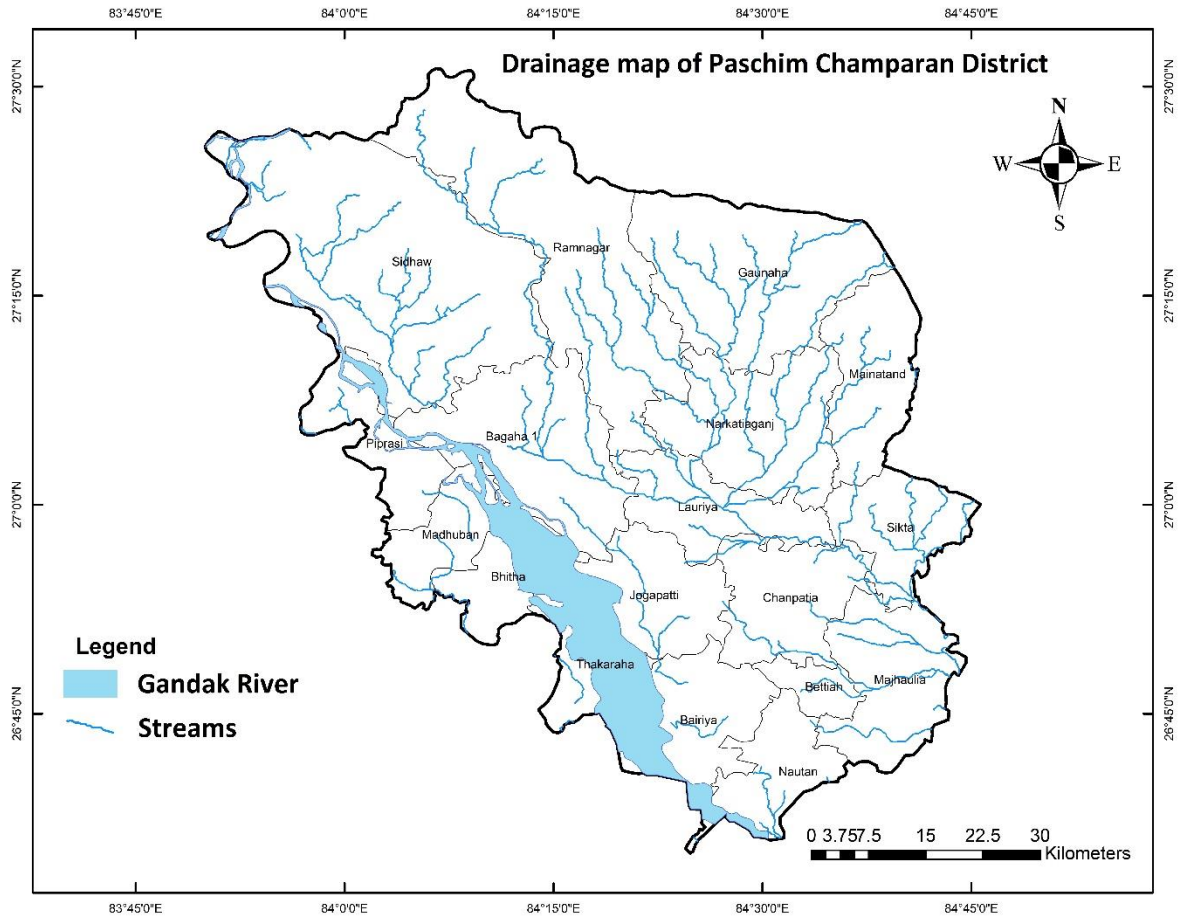


Figure 12: Drainage Map of Paschim Champaran District

2.3 Soil and Land Use Soils:

The soils of the district are highly calcareous. It is a mixture of clay, sand and silt in varying proportions. "Bhangar" soil is found in the low lying central and southern parts of the district. A classification based on "7th approximation system" (as per the soil Survey Staff, 1975) and considering the field criteria such as colour, thickness and soil profile character, the soils of the district have been classified as follows: -

2.3.1 1. Entisols :

The weakly developed mineral soils are classified as entisols which are again sub-divided into younger alluvial soils (Udifluvent) and Bhabar soils (Ustodirepto) (a) The younger alluvial soils are restricted between Gandak and Burhi Gandak rivers barring the patches around Bettiah and to south of it. This soil is difficient in x nitrogen, Phosphoric acid Texturally this is and humus but generally not in Potash and lime, sandy to loamy sand and the PH values are not on alkaline side. The soil profiles are not yet developed sufficiently. The younger alluvial soils are laden with moisture and these area are often flood prone. These are most fertile soils and eminently suitable for extensive cultivation of high water-demand ing crops like rice, Jute and Sugarcanes. The wastes arising out of industrial and domestic sources and also the use of chemical fertilizers and pesticides may create hazardous conditions and wide spread polution because of the water logging and flooding of the area. (b) Bhabar : This soil comprises loose detrital permeable matter and coarser sediments deposited in the upper Siwaliks foot hills occuring in the extreme north in the district. These soils are deficient in lime, phosphoric acid

and humus. The top soils are z usually deficient in calcium and phosphate with variable contents of nitrogen.

2.3.2 2. Mollisols –

These are base rich soils with a mollic apipedon, called Terai soils. These are found in the northern parts of the district along the Tertiaries. These soils are particularly deficient is phosphate due to its inherent richness in nitrogen and organic matter. The soils are acidic (the pH ranges from 4.7 to 5.8). The se soils are often deficient in certain salts, especially the iodides. Continued intake of such water and food crops in the Terai soils may induced maladies arising out of iodine deficiency. A combination of nitrogen and phosphatic fertilizers has been found to increase rich yields in these soils.

2.3.3 3. Inceptisols –

These are moderately developed soils of humid regions normally with a cambric horizon and no spodic, argillic or Oxic horizone. This inceptisols can further be sub-divided into calcareous alluvial soils and shallow black soils. Calcareous Alluvial soils occur in a small patches in the extreme southern part of the district. This contains more highly calcareous soil. The pH values of the soils are on alkaline side and contents available phosphoric acid and potash are generally low. .J The ground water and surface water in the calcareous soil belt is ather hard, calling for suitable treatment for effective industrial and domestic use.

2.3.4 4. Alfisols –

These are the soils with an argillic horizon and moderate to high base status. Older Alluvium soils- a subdivision of alfisols occur in the north of the Burhi Gandak in the district. These are fairly mature soils with well developed profiles which are subject to continuous leaching operation, often leading to formation of calcareous nodules, ferrugenous concretions and ferruginous clay pans. The se soils usually comprise well drained reddish yellow silty, sandy and clayey loams. Careful management of this highly permeable soil mantle is important to preserve fertility and salinity status, and also to keep it free from pollution hazard owing to the wide spread use of chemical fertilizers and pesticides.

2.3.5 5. Ultisols :-

These soils also contain argillic horizon and have low base status. The Brown, red and yellow soils- a sub division of ultisols occurs in the extreme north in the areas constituted of Siwalik hills.

3. HYDROGEOLOGICAL CONDITIONS

3.1 Geological Framework

The district forms a part of the vast alluvial terrain of lower Ganga plains in the Gandak and Burhi Gandak Sub-basins, consisting of a thick pile of unconsolidated Quaternary sediments. It is multicyclic and the sediments gradually becomes coarser with depth. Sediments form boulder coble-pebble-gravel sequence commonly known as Bhabar belt in the northern part of the district at the fat foot-hill. The The exact thickness of the unlithified quarternary sediments is not known but estimated to be several hundred metres in southern parts. It is underlain by Siwaliks in the north where it is also exposed and Mesozoic/Precambrian in the areas farther south. The Tertiaries are exposed in Masan area, north of the Gaunaha and Sidhaw, as a series of low hillocks. They represents upper Siwalike of the Sub-imalayas and consist of Sandstone, siltstone and shales. The Siwaliks are disturbed by folding and thrust faulting. The entire sequence here occurs as a inlier in alluvial terrain. The alluvial sediments of the area have been classified primarily on the principles of soil stratigraphy and oxidation characteristics of the cover sediments and lithology, into four geological units. Magoraha-I and II in piedmont area,

Mainatanr and Bettiah in flood plain area (After G.S.I.) However the Mogoraha-I terrace is equivalent to Mainatanr terrace and the Magoraha-II terrace is to the Bettiah terrace.

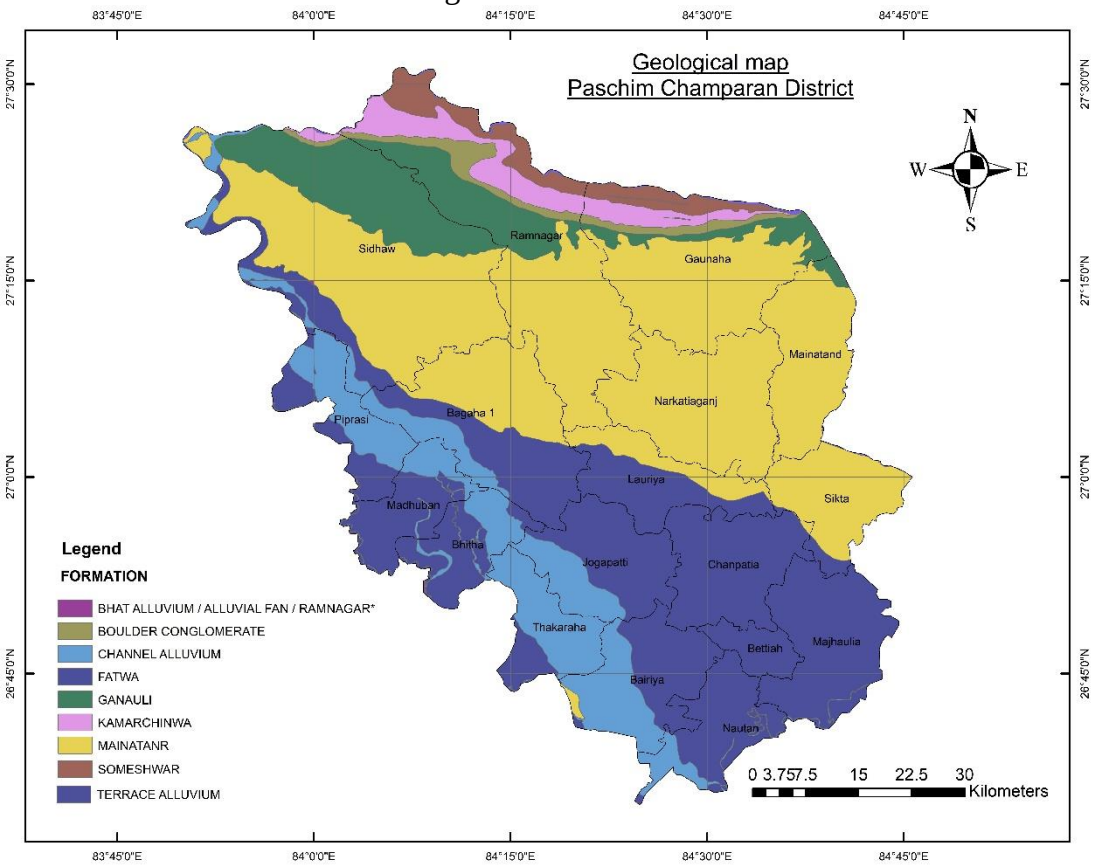


Figure 13: Geological Map of Paschim Champaran District

The tentative stratigraphic succession of the Quaternary geological units in the district is as :

Magoraha-I Terrace: It occurs along the foot hills in the form of patches and constitute the highest geomorphic unit in the piedmont plain. The terrace is highly dissected and predominantly sandy. The soil cover is highly oxidised. The terrace is southerly sloping and forms table land. This table land is covered by Terrai forest.

Magoraha-II Terrace: The immediate lower terrace in the piedmont plain with gentler southerly slope and lesser degree of dissection is Magoraha-II terrace. The southern margin of this terrace is Characterised by a spring zone which feeds a number of small streamlets. This terrace is consist of sandy to silty soil which is feebly oxidised and sustained good forest. The present day alluvial fan, talus cone and river channels are characterised by poorly dissected barren surfaces and heterogenous surficial sediments. These areas are normally devoid of vegetation.

Mainatanr Terrace: It is the highest terrace in the flood plain area and well developed around Mainatanr. It extends from the boundary of the Magoraha-II terrace to southwards almost upto the Sikrana river. This is the oldest flood plain terrace, dissected by Sub- parrallel, well incised, moderately meandering streams which has a gentle southward slopes. Small aggraded meander cut offs of the channels are seen in the southern parts of the terrace. It is immune to flood and the soil profile is feebly oxidized. This terrace has an abundant ground water resources and sustained human settlement and cultivation.

Bettiah Terrace: The nearly flat with numerous meander scrolls, flood basin swamps, ox-bow lakes, aggraded and moribund channels of flood plains which extends from the Sikrana river to southward upto the present flood plain of the Gandak, constitute the Bettiah terrace named after the Bettiah town. This surface is formed by the alluviation of meandering and oscillating channels of the Sikrana, Gandak and the tributaries. The soil profile is unoxidised. The flood basins, and partially aggraded channels become water logged during the monsoon. This terrace is separated from the present flood plain of the Gandak and Sikrana by a well defined 1 to 1.50 metre high valley wall. The narrow, linear and discontinuous patches of low ground on either side of the major streams and rivers constitute the present flood plain. The land forms observed in this areas are impersistent levee and flood basin, meander scrolls, ox-bow lakes, and point bars, lateral bars etc.

3.2 Nature, Extent and Geometry of Aquifers:

Thick Quaternary alluvial sediments and Siwalik rocks comprising fresh water deposits occur in the area. The thickness of the alluvial sediments is several hundreds meter in the southern parts and less in the North as the semi-consolidated Siwalik rocks are exposed in the North. The sequence of sediments is presented by sand, grave and pebbles of various grades along with clay and silt deposits. The deposition of sediments are cyclic in nature. Changes in depositional environment have resulted vertical and lateral variation in texture and composition of the alluvial deposit. Lithological information is available to a maximum depth of 155 metres but not in much details about the actual depth range of aquifers encountered.

The sub-Himalayan Hills occuped by Upper Siwaliks comprises sandstones, claystones, and boulder beds have a varying dips towards the south. The bedding planes, joints, fractures and other weaker planes are the main repository of ground water. Springs occur where the ground water table cuts the surface.

The dry and porous tract lying south of the Siwaliks, extending NNE SSN near Valmikinagar and E-W at Sidhaw and Gaunaha, constitute the hydrogeologic unit commonly known as the Bhabar. This tract is wider around 12 Km. at sidhaw and gradually becomes narrow at Gaunaha to about 3 Km. This bouldery sloping Bhabar belt gradually merges with the adjoining unit of Terai in the South. The contact of the two units is marked by change in slopes and a chain of ground water affluents which form the spring line. The Bhabar is widespread fluvial piedmont apron consisting of numerous coalescent fans. These fans have been formed by accumulation of debris brought by heavily loaded streames on their emergence from the hills and dumped on to a relatively flat area. The lateral linking and gradually merger of these innumerable fans have given rise to fluvial coalescent fans which in term eventuated the Bhabar. The Bhabar comprises a sequence of unconsolidated, heterogenous and unasserted mixture of boulders, cobbles and pebbles in a matrix of redish bown, coarse to medium sand and little silt. The coarser clastic bed is overlain by silt and silty clay beds.

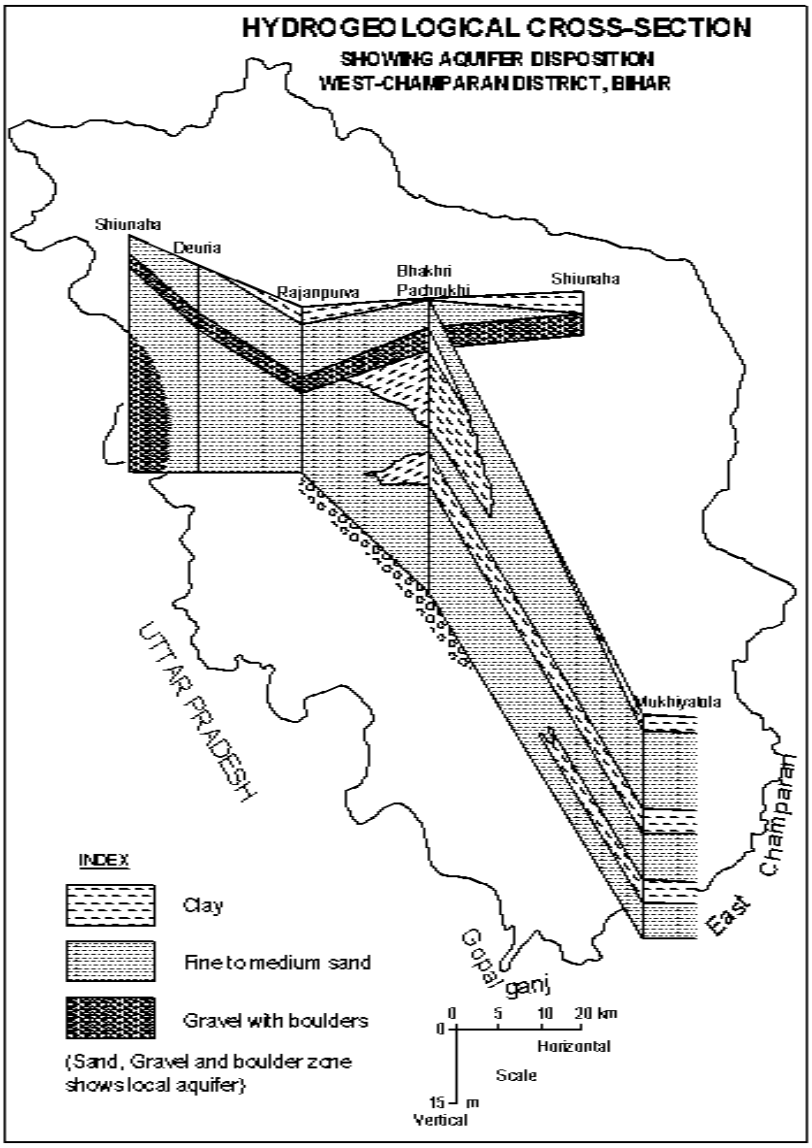


Figure 14: Hydrogeological Cross section showing Aquifer Disposition of Paschim Champaran District

The area between the Bhabar and Gandak flood plain forms a E-W running belt of varying width, in the north of Bagaha, Lauria and Chanpatia. constitute the hydrogeologic unit known as Terai. The northern boundary of the Terai is defined by spring line and marked changes in slopes. However, the southern boundary with the Gandak flood plain is not so sharp. The separation of the two hydrogeological units is inferred from the variations in terrain, drainage, vegetation pattern, sediments and depth to water levels. The Terai is characterized by a moist, water logged gently undulating and southerly sloping terrain traversed by numerous perennial, sluggish channels which emanate from the spring line and amalgamate downstream to form rivers and render the area swampy. The Terai deposits are dominantly fine sediments consisting of clay and silt with well sorted granular material comprising boulder, cobble, pebble, gravel and sands. The Ratio of the fine versus coarse sediments average 70 : 30. The area lying to the south of the Terai is a flood plain of Gandak which is a nearly flat area with numerous meander scrolls, flood basin swamp, ox-bow lakes, aggraded and moribund channels which extend southward upto the present flood plain of the Gandak. The flood plain deposits of Gandak are dominantly fine sediments consisting of clay and silt with well sorted granular material comprising sands and some gravels.

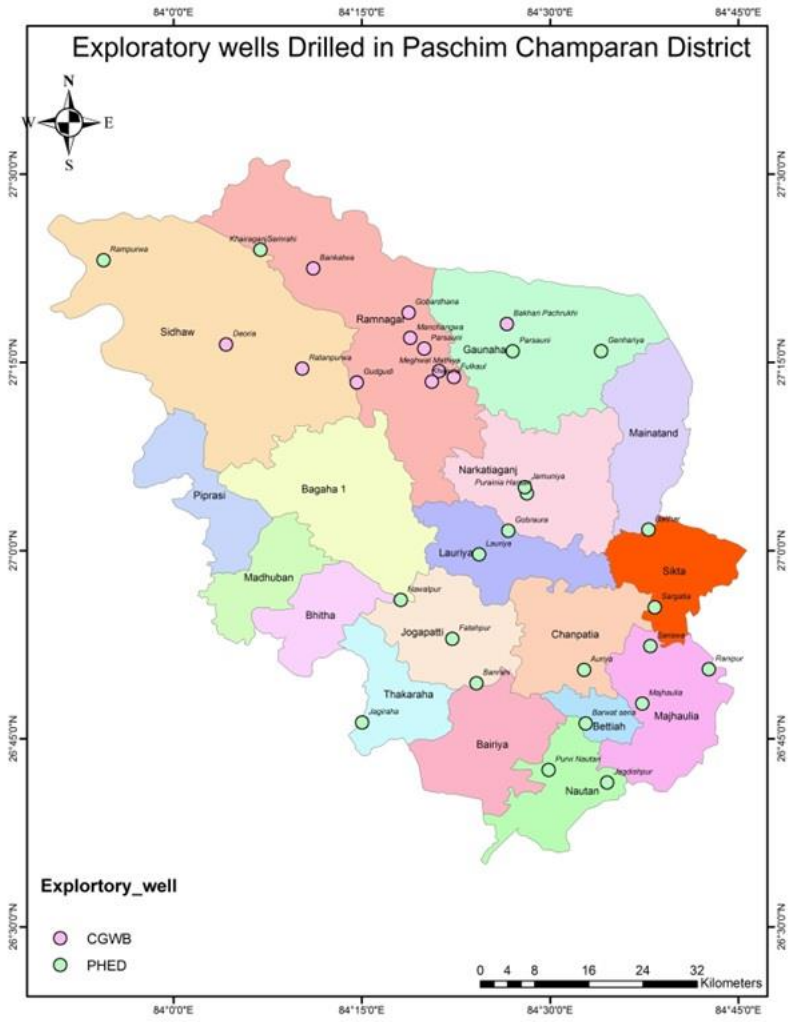


Figure 15: Location of wells drilled in Paschim Champaran District

3.3 Disposition of Aquifers systems in Paschim Champaran District

Based on drilling data and the lithological information two aquifer systems can be established in the district. The Aquifer system 1 occurring from 1mbgl to 85mbgl with thickness ranging from 2m to 85m , it comprises mostly sandy formations occasionally with gravels, kankers and clay lenses. This is underlain by Aquitard formation occurring from 1.5 mbgl to 85mbgl with thickness ranging from 1m to 30m , and comprising Clay formations with clayey sand sady clay and occasionally kankers. This roughly separates Aquifer system 1 from aquifer system 2, which is occurring from 1.5 mbgl to 111mbgl with thickness ranging from 11m to 95m , it comprises mostly sandy formations occasionally with gravels, boulders, and clay lenses. These are underlain by tertiary sandstones of Shiwaliks, which is occurring from 50 mbgl to 155mbgl with thickness ranging from 2m to 43m , encountered in the drilling activities in the district upto 200m.

Table 3: Aquifer system in Paschim Champaran District

Stratigraphy	Aquifer Nomenclature	Lithology	Depth of Occurance (m)		Thickness Range(m)	
			From	To	Min	Max
Quaternary	Aquifer Group 1	Comprises sandy formation occasionally gravels, Kankers and clay lenses	1	85	2	85
	Aquitard	Comprises Clay, sandy Clay, Clayey sand and Kankers	1.5	85	1	30
	Aquifer Group 2	Comprises sandy formation ocassionally with gravels , boulders and clay lenses	1.5	111	11	95
Tertairy	Sandstone	Sandstone and gravels and boulder	50	155	2	43

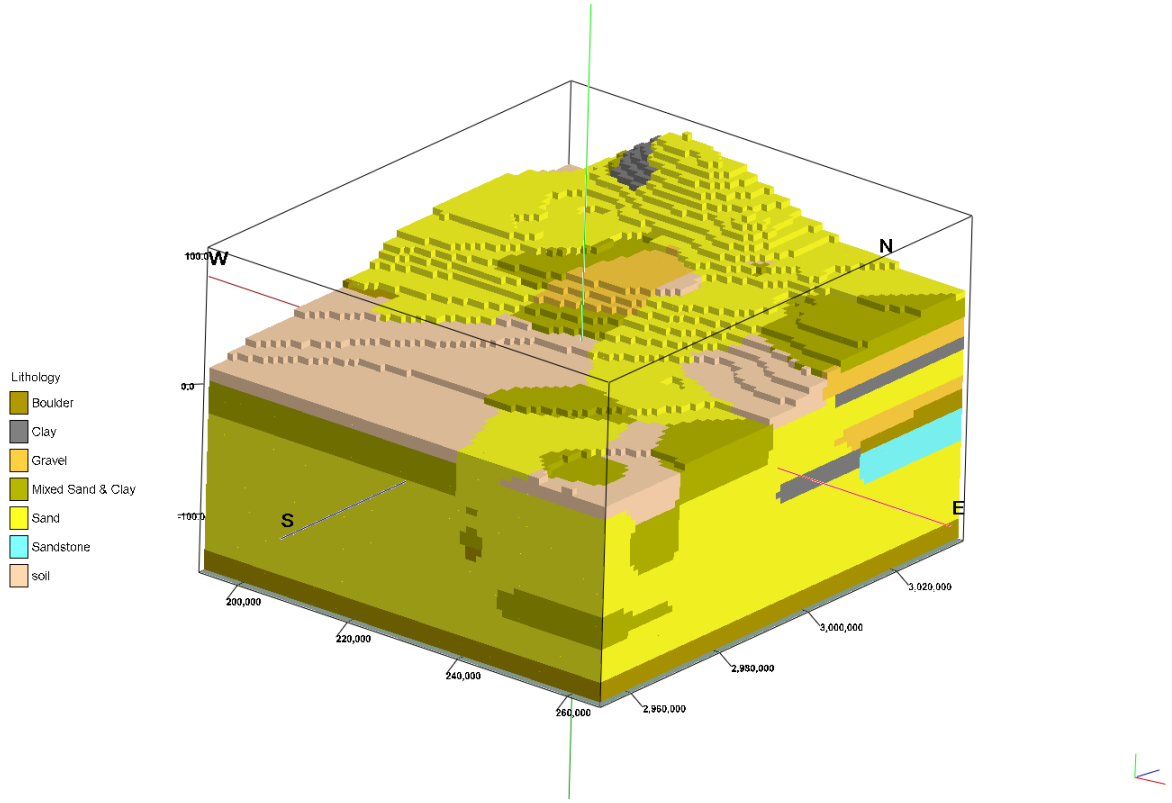


Figure 16: 3D lithological Disposition of Aquifers systems in Paschim Champaran District

3.4 Conceptualization of Aquifer system in 2D

A total of 28 drilled wells and piezometers of CGWB and State government PHED were analysed for lithologs are utilized to decipher the subsurface geometry of the aquifer by using Rockworks 16 software prepared hydro geological cross sections, Fence diagram and 3D Model up to the depth of 200 mbgl. And four hydrogeological cross sections (2D) are drawn in different direction to cover entire area as per the availability of data point in the district and represented in figure 20 (A-A') to figure 23 (D-D').
Figure 16 Shows 3D Lithological disposition of Aquifer system in Paschim Champaran district. It can be seen broadly five type of lithological units are encountered in the subsurface.

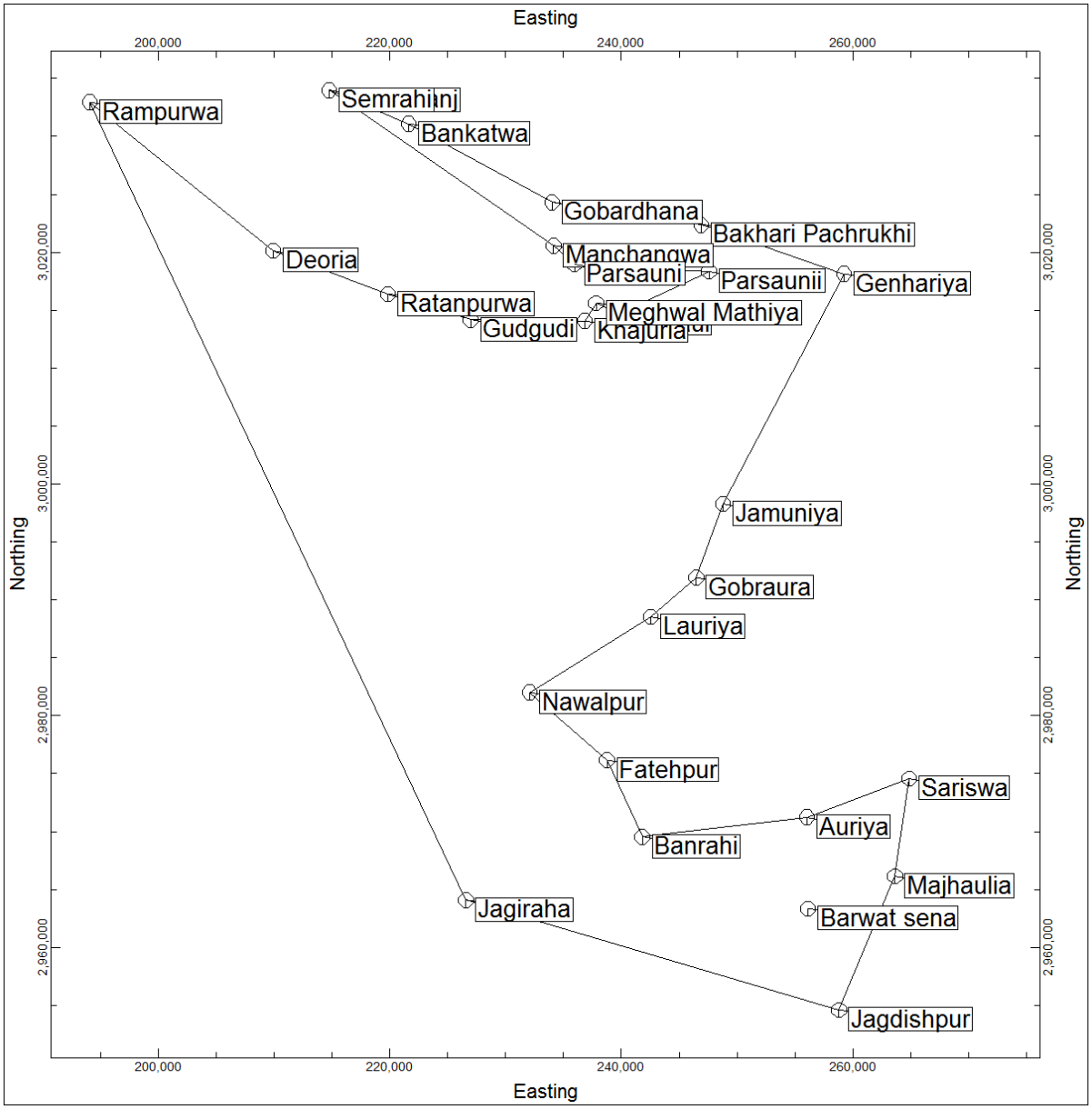


Figure 17: Location Map for fence diagram of Lithological disposition

In Figure-18 it can be seen in 3D Fence Diagram the lateral and vertical disposition Lithological units of Aquifer system in Paschim Champaran district.

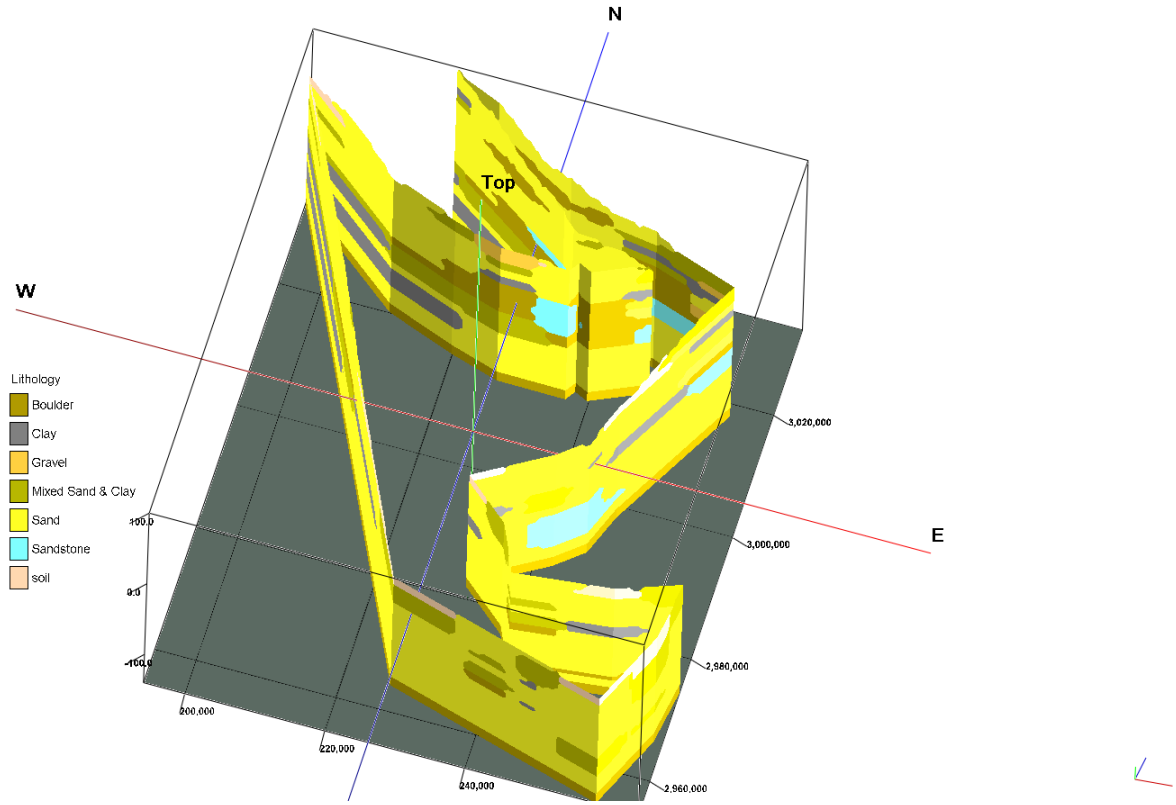


Figure 18: Fence Diagram of Lithological Disposition

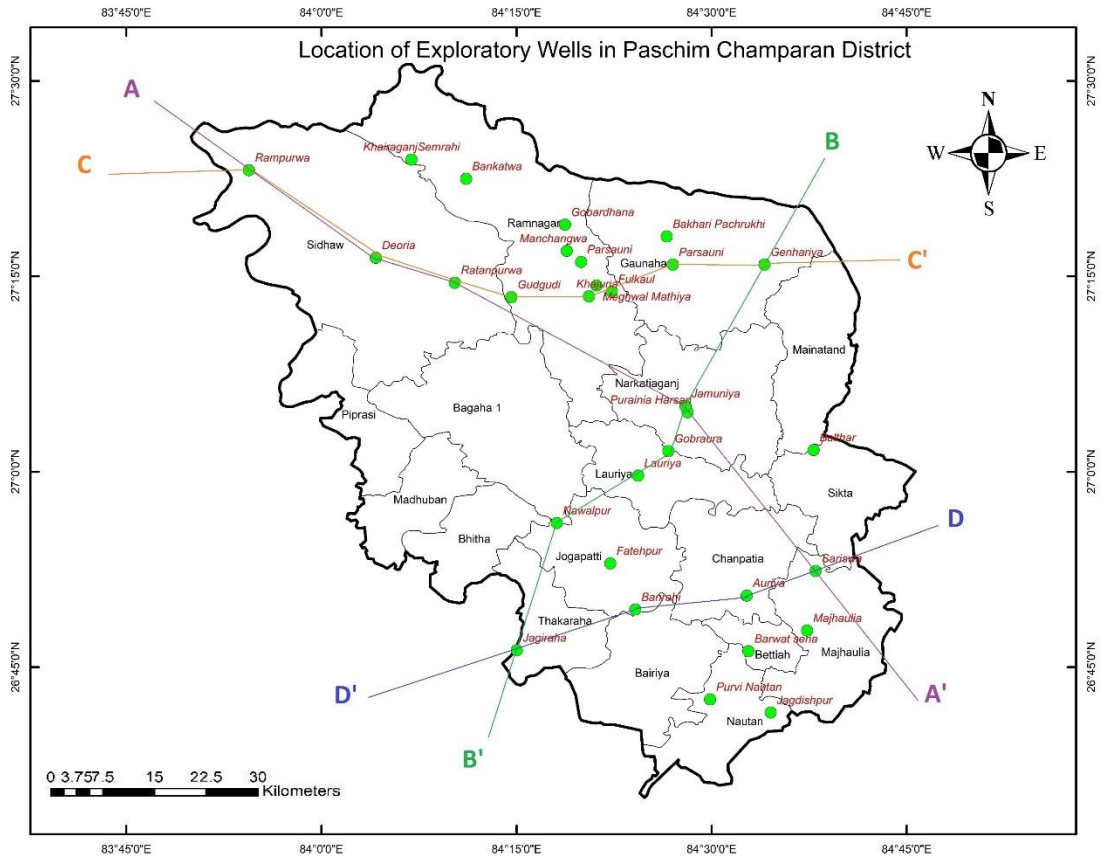


Figure 19: Location map showing section lines AA' to DD'

1. Section A-A' (Fig. 12)- Section is drawn NW-SE direction of the district through Bagaha 2, Ramnagar, Narkatiyaganj Lauriya, Chanpatia and Majhaulia blocks, passing through villages Rampurwa, Deoria, Ratanpurwa, Jamunia and Sariswa. Section is represented lithologically. The north western part of the section line near Rampurwa shows limited thickness of second aquifer system with repetitive clayey formations, the central part also shows appreciable thickness of mixed sand and clayey formation along with boulder formations and tertiary sandstones.

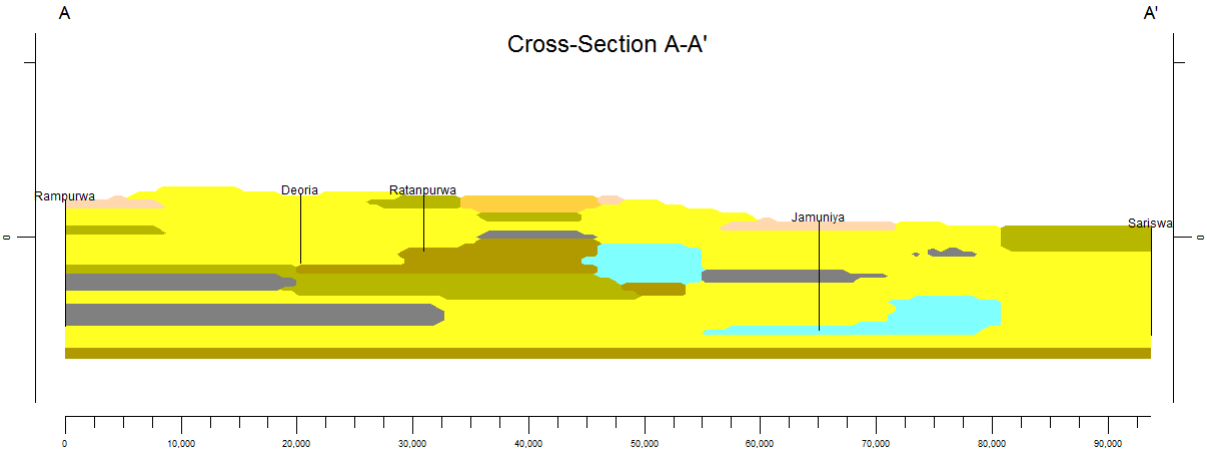


Figure 20: Section AA' from Rampurwa to Sariswa through Deoria, Ratanpurwa and Jamuniya

2. Section B-B' (Fig. 13)- Section is drawn NE-SW direction of the district through Gaunaha, Narkatiyaganj, Lauriya, Jogapatti and Thakraha blocks, passing through villages Genhariya, Jamunia, Gobraura, Lauriya, Nawalpur and Jagiraha. Section is represented lithologically. Near Genhariya in the north east part of the section line the thickness of sandy formation is very less and boulder formations are encountered along with tertiary sandstones of Shivalik's around 70 metres. Whereas near Jagiraha below the mixed sand and clay unit thick continuous sand units are encountered. Near Jamunia and Gobraura sandstone units are again encounted around 70 to 80 metres.

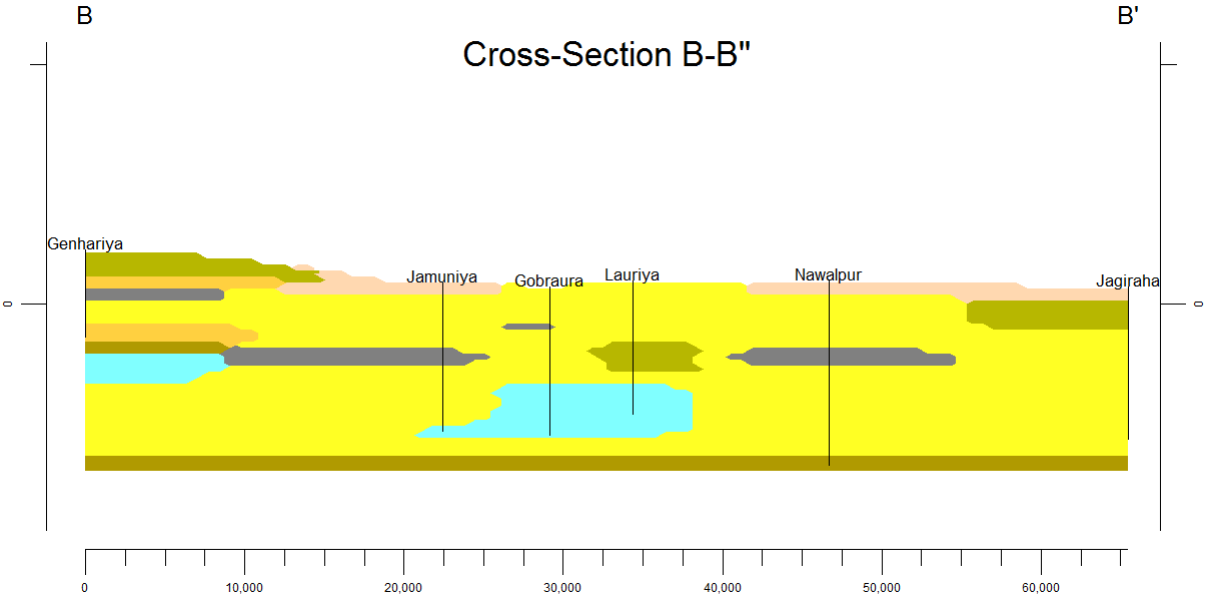


Figure 21: Section BB' from Genhariya to Jagiraha through Jamuniya, Gobraura, Lauriya and Nawalpur

3. Section C-C’ (Fig. 14)- Section is drawn roughly W-E direction through northern part of the district through Bagaha 2, Ramnagar and Gaunaha blocks, passing through villagesRampurwa, Deoria, Ratanpurwa, Gudgudi, Khajuria, Fulkaul. Parsauni, and Genhariya Section is represented lithologically. In the eastern part of the section near Genhariya it can be seen that the second aquifer system is better developed in comparision to the first which comprises of gravely and bouldery formation at the shallower depths.

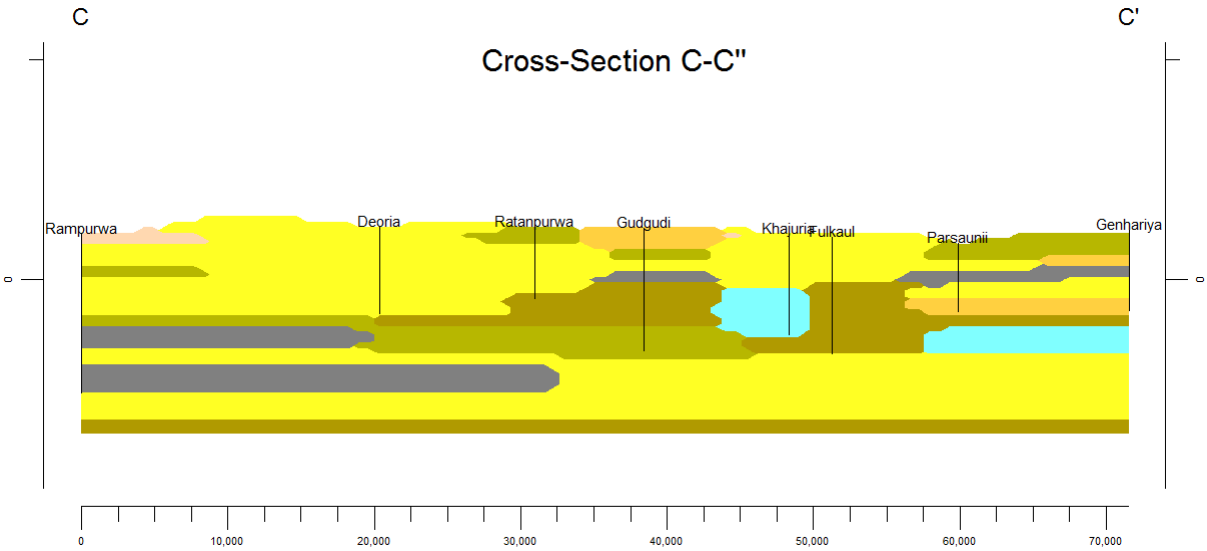


Figure 22: Section CC' Rampurwa to Genhariya through Deoria, Ratanpurwa, Gudgudi, K

hajuria, Fulkaul and Parsauni

4. Section D-D’ (Fig. 15)- Section is drawn roughly E-W direction in the southern part of the district through Majhaulia, Chanpatiya, Jogapatti and Thakraha blocks, passing through villages Sariswa, Auriya, Banrahi and Jagiraha. Section is represented lithologically. It can be seen that both near Sariswa and Jagiraha the mixed lithology is encountered from surface which are being brought by Gandak and Budi Gandak rivers in both end of section. In the central part of the section like it can be seen that the upper and lower aquifer system are separated by mixed sand and clay formation and grading to Clay at some places and further by bouldery formation.

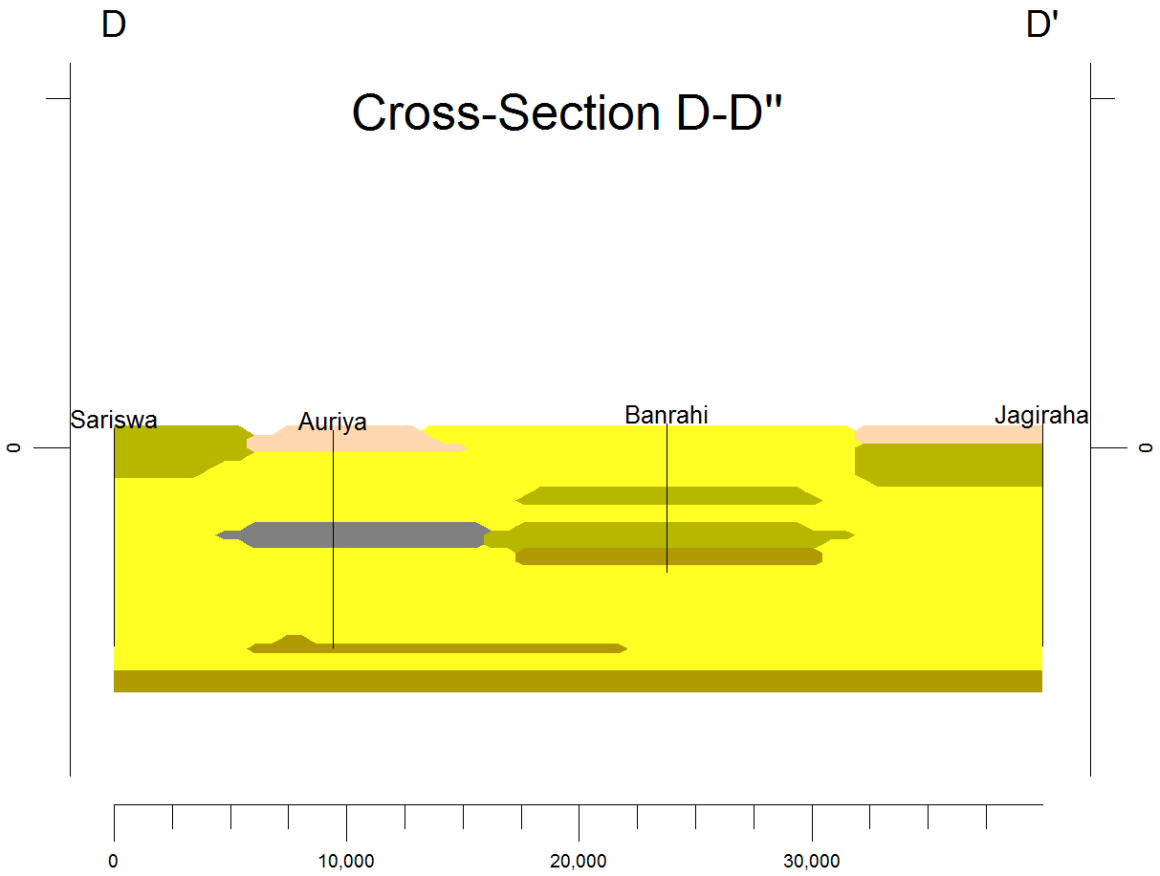


Figure 23: Section DD' Sariswa to Jagiraha through Auriya and Banrahi

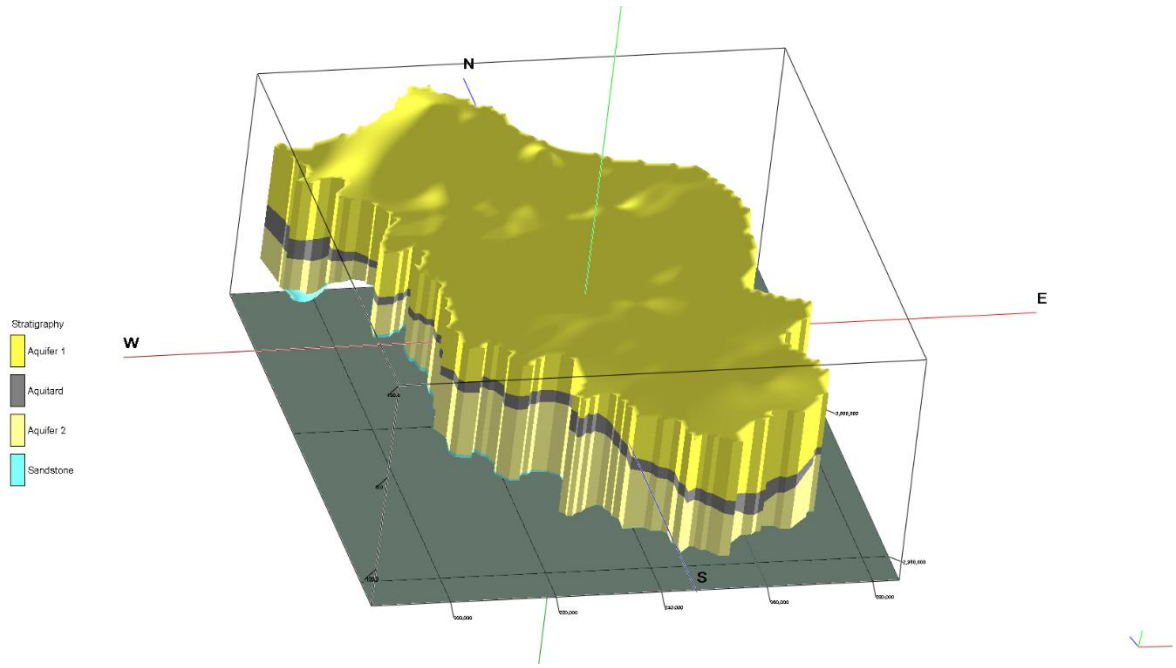


Figure 24: 3D disposition of Aquifer Systems in Paschim Champaran District

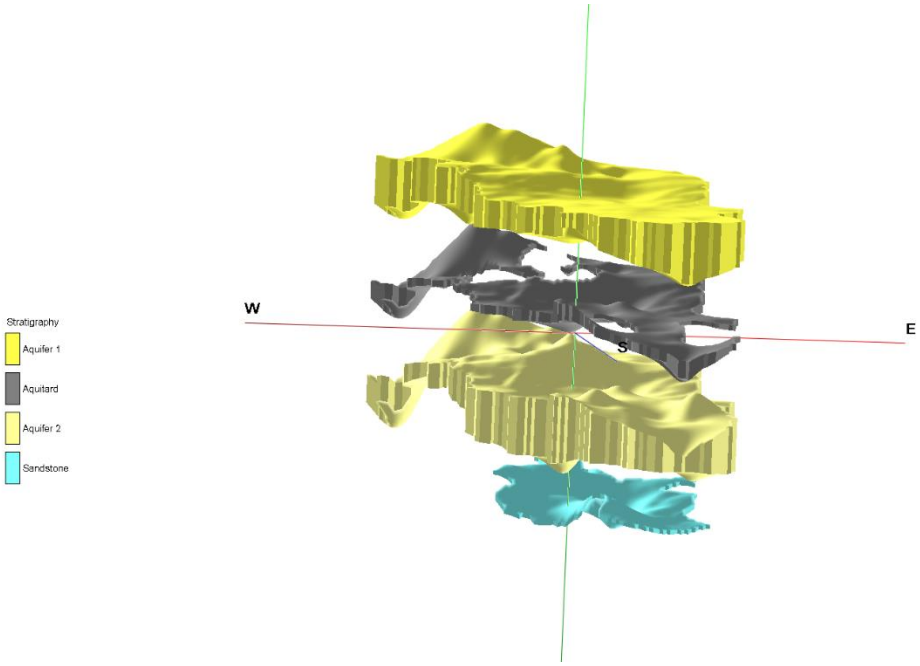


Figure 25: 3D disposition of Aquifer systems in Paschim Champaran District with three different aquifers.

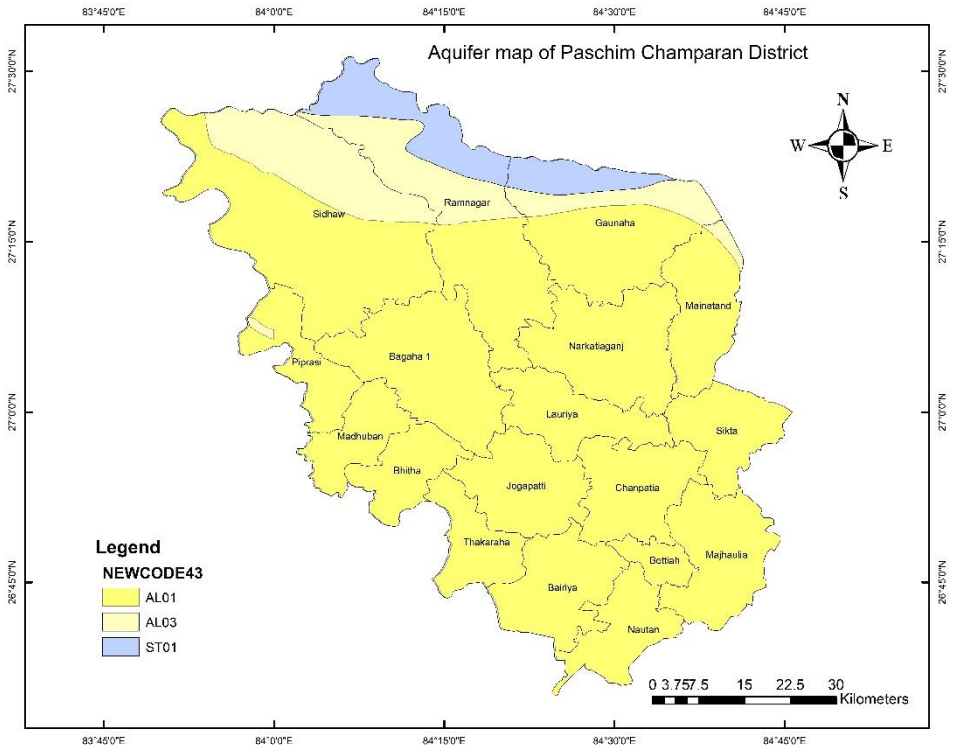


Figure 26: Aquifer map of Paschim Champaran District

3.3 Mode of Occurrence of Ground Water:

Quaternary alluvium forms the main repository of ground water in the district. Ground water occurs under unconfined and semiconfined to confined conditions depending upon the nature of aquifer. The near surface sand, silt and clayey silt mainly support open wells where ground water occurs, under water table condition. Depth thx of the open wells are shallow in western parts where it varies from 3-4 m below ground level and little more in the rest of the area where

it varies from 6-7 m bgl. The ground water may occure in the semiconfined to confined conditions where the aquifers at depths are overlain by the clay beds.

3.3.1 Depth to Water level :

Depth to water level maps for the pre and post monsoon seasons were prepared on the basis of water level data of the national Hydrograph network stations for the year 2022 and key wells established in data gap areas (Fig. 27 & 28). In the pre-monsoon season, areas where ground water level is within 2-3 mbgl occurs in a small elongated patch covering Bettiah and extending towards the south in narrow patch. Areas with water level between 3-4 mbgl occurs in the central and Southern parts of the district comprising Bagaha, Markatiyaganj, Lauria, Jogapatti, Baria, Nautan and the western parts of the Gandak river. Areas with water level between 4-5 m bgl occurs in the northern and eastern parts in a narrow belt. In the northern part it comprises the area around Ramnagar, Caunaha and south of Sidhaw. This water level depth occurs in the eastern part in a semi circle around a Sikta area. Areas with water level between 5-6 mbgl occurs in the Bhabar belt comprising Sidhaw, Valmikinagar and Harnatanr in the north, and around the Sikta in the east. In the post monsoon season, water level rises with recharge from rainwater and occurs within 2 meter bgl in the southern parts of the district. The water level in the northern part is some deeper where it varies from 2-4 mbgl. Exceptionally shallow water level which is less than a meter occurs around Bettiah town. Water level fluctuation Fluctuation in water level is mainly influence by seasonal changes which is conspicuous by rise and fall of water level during monsoon and non-monsoon periods. The changes in water level reflects the changes in storage of ground water. In order to study the behaviour of water level fluctuation in Paschim Champaran district, the Central Ground Water Board have established observation wells under the All India Net Work programme.

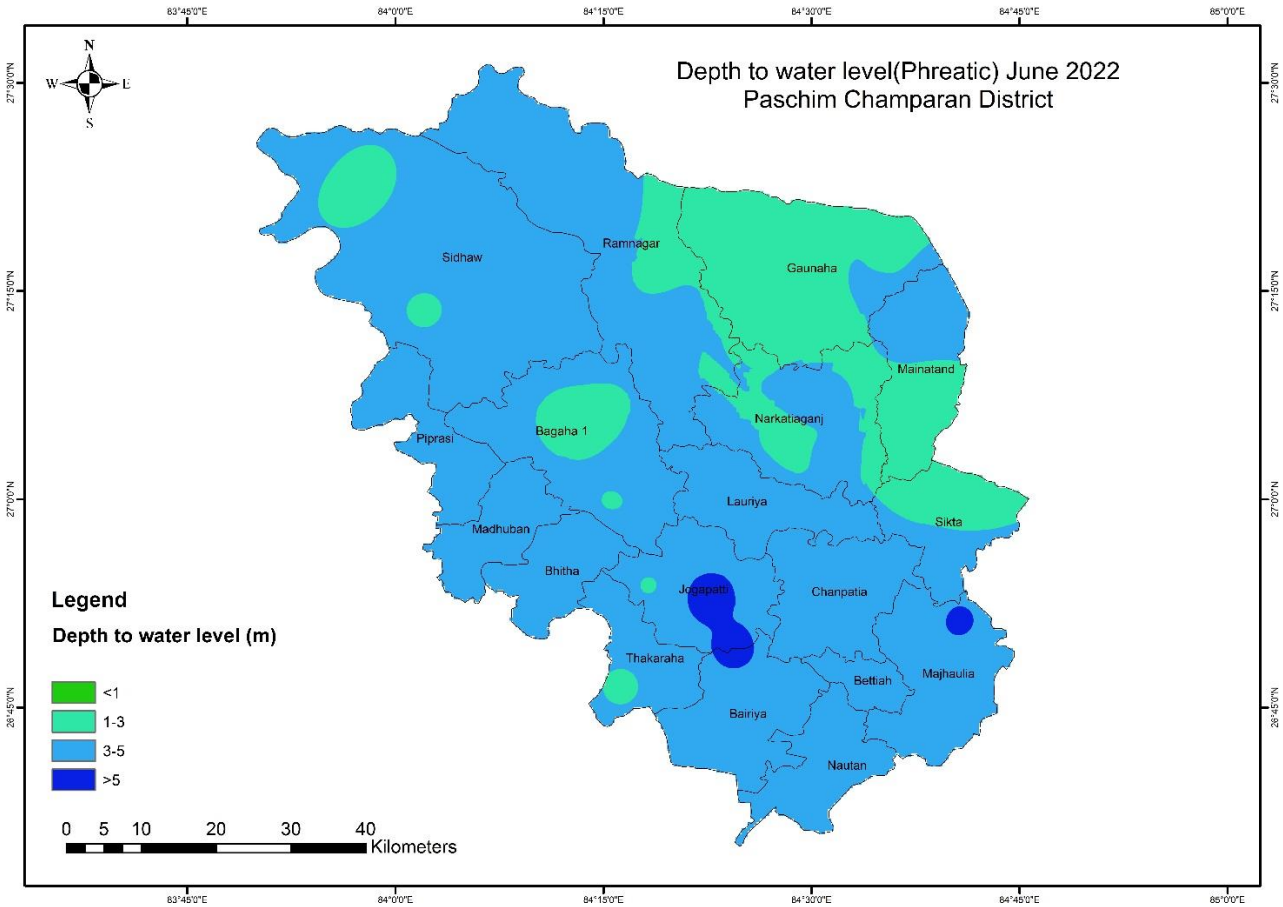


Figure 27: Depth to Water Level of Phreatic Aquifers for Pre-monsoon 2022.

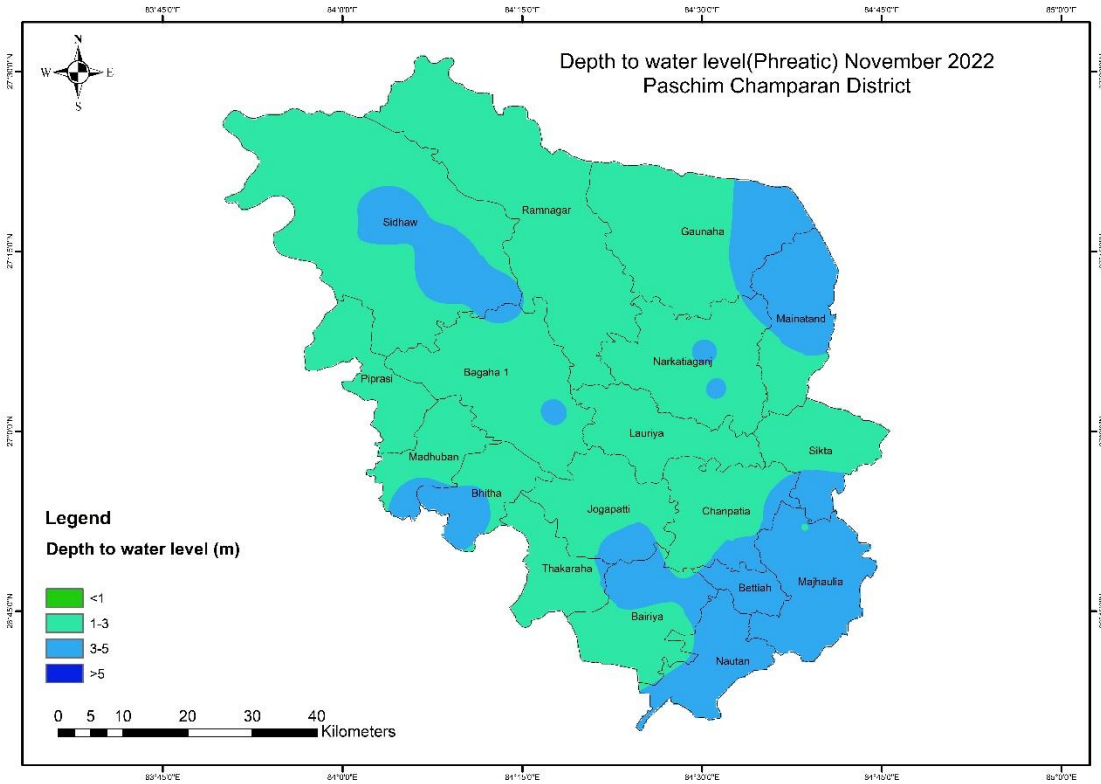


Figure 28: Depth to Water Level of Phreatic Aquifers for Post-monsoon 2022.

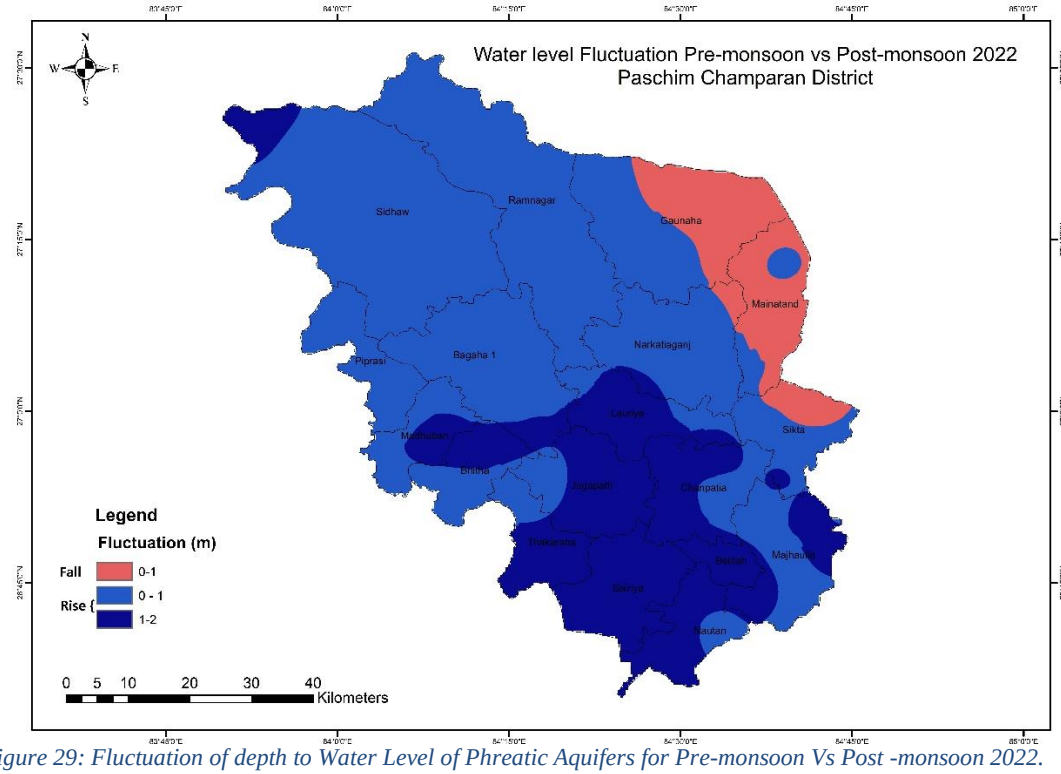


Figure 29: Fluctuation of depth to Water Level of Phreatic Aquifers for Pre-monsoon Vs Post -monsoon 2022.

A perusal of hydrograph (Fig.- 30) indicate that maximum seasonal fluctuation occurs in post monsoon period. The rise in water lable ranges from 0.7 to 2.14 m. Water level rise is directly influenced by quantity of rainfall received over the area. A water level fluctuation map has been prepared (Fig.- 29) using the average fluctuation for the year 2022 between pre-monsoon and post-monsoon data. The map shows that maximum fluctuation between 0-2 m occurred in

the northern part of the district covering the area. Fluctuation between 2 - 4.00 m occurs in the southern part of the district and the fluctuation more than 4 m is observed in Sikta area.

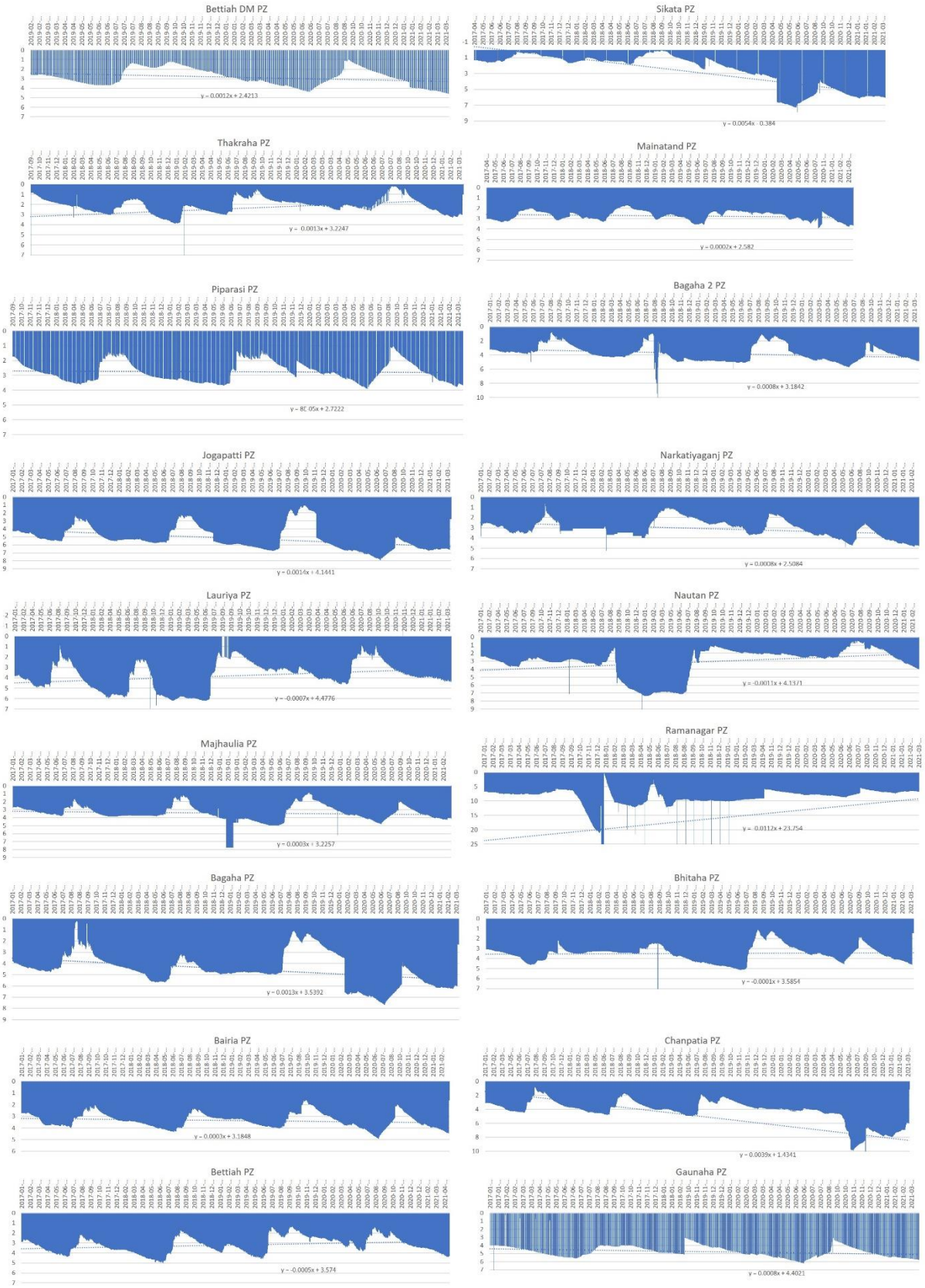


Figure 30:Ground water hydrographs from DWLRs since 2017

Table 4:Block wise Ground water level trend from DWLRs since 2017

Sl no	Block	Ground water Trend in (mm) Falling	Ground water Trend in (mm) Rising
1	BAGAHA 1	1.3	-
2	BAGAHA 2	0.8	-
3	BAIRIYA	0.3	-
4	BETTIAH Mcorp	1.2	-
5	BETTIAH	-	0.5
6	BHITAHA	-	0.1
7	CHANPATIA	3.9	-
8	GAUNAHA	0.8	-
9	LAURIYA	-	0.7
10	MAINATAND	0.2	-
11	MAJHAULIA	0.3	-
12	NARKATIAGANJ	0.8	-
13	NAUTAN	-	1.1
14	PIPRASI	0.8	-
15	RAMNAGAR	-	0.8
16	SIKTA	5.4	-
17	THAKARAHA	-	1.3
18	YOGAPATTI	1.4	-

3.4 Direction and Movement of Ground Water

The direction and movement of ground water is determined from the water level contours(Fig-30). The water level elevation ranges from 110 in the north western part at Valmikinagar, to 65 m above mean sea levels in the extreme southern part of the district. The water table contours trends generally north-west to south-east with the hydraulic gradient towards the south east. The hydraulic gradient varies from 0.26 m/Km to 1.3 m/Km per Kilometer. The gradientés rather higher in the Central part of the district between Ramnagar and Lauria because of relatively low transmissivity of the aquifer. It is gentler (0.50 m/Km) in the northern part of the district as the transmissivity is high in the area. The hydraulic gradient become still more gentler (i.e. 0.15 m m/km) in the Southern parts covering the area south of the Lauria. Enlongated mound of ground water around the Bettiah town is due to recharge from the moribund rivers, burried channels and natural or artificial depression. Majority of the rivers in the district are effluent in nature and generally drains the ground water (as base flow) during the post-monsoon period. In general, the northern part of the district is act as a ground water recharge area and the southern parts as discharge area. Hydraulic Characteristics of Aquifer Exploration in the district has not yet been carried out. As such transmissivity and storativity of the aquifers is not known. However, discharge and drawdown data are available from the tubewells constructed by State Government.

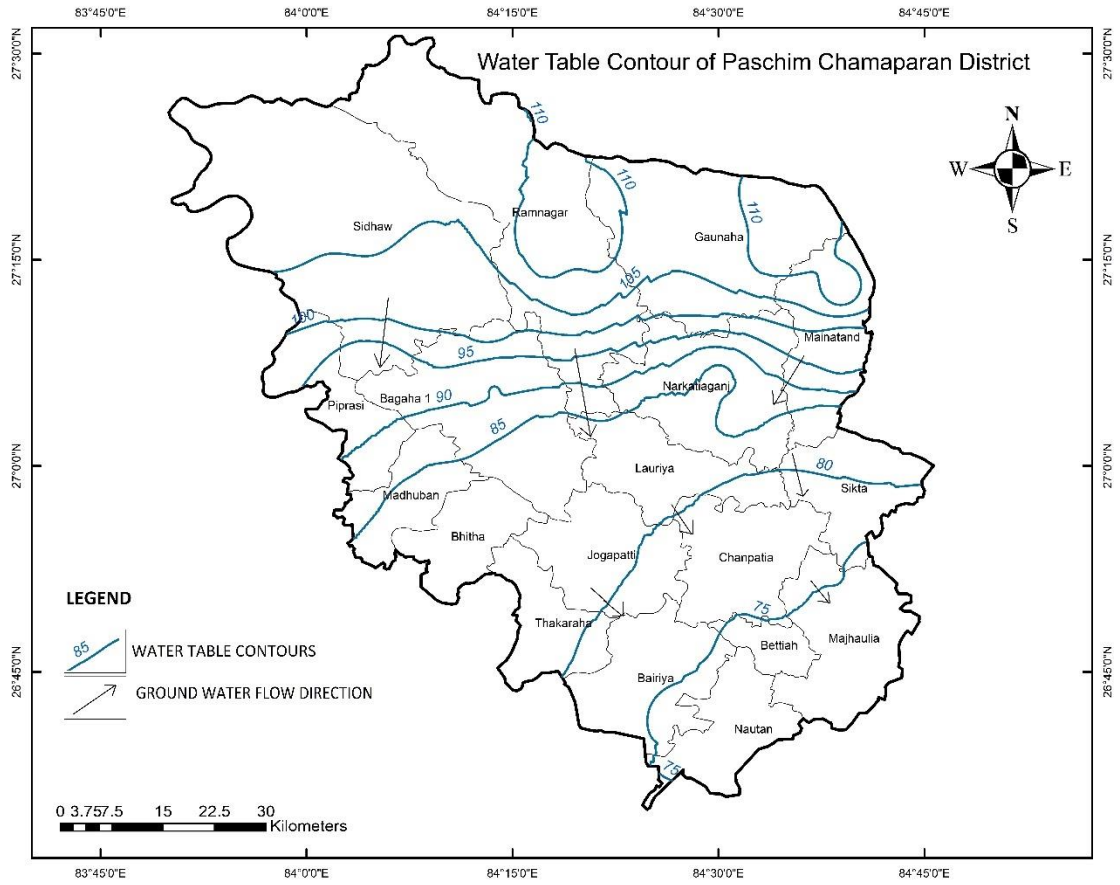


Figure 31: Water Table Contour map with ground water flow directions

4. HYDROCHEMISTRY

Chemical analysis data of water samples collected from the observation wells in the district, appended in Annexures II & III, were used to study the Chemical quality of ground water. As per lithology and stratigraphic disposition 2 aquifer systems have been established in the district. One shallow and other deeper. Study of the chemical analysis data of ground water in these aquifers revealed that the deeper Aquifer has lower minerals dissolved and is relatively better than the shallow aquifer system.

4.1 Shallow Aquifer

In general the shallow Aquifer has electrical conductivity and chloride value being mostly less than 625 µS/cm at 25°c and 44 mg/litre, respectively. The total dissolved solid in the ground water varies from 148 to 1253 mg/l. In general, quality of ground water in the district is good and suitable for drinking, industrial and agricultural purposes. The range of various cations and anions are given in Table -5.

Hydrogen Ion Concentration

The ground water of the shallow aquifer is slightly alkaline in reaction as the pH values ranges between 7.29 to 8.2. The electrical conductivity of the area revealed that water of the area is fresh in general.

Bicarbonate ions ranges between 115.9 -597.8 mg/litre in most part of the district. The high content of Bicarbonate in the water may be due to the reason that water of river having catchment areas in Himalayan terrain comprising calcareous rocks. This is the common

constituent of ground water. Leaching of salt from alluvial deposit, return flow of irrigation water to ground water are among the factors contributing chloride content in ground water.
Chloride content is below 43 mg/litre in most parts of the district, where as in Majhaulia it shows value higher that 200mg/l. The chloride content is well below the permissible limit in all the water samples of the district except at Senuaria Mauji, Majhaulia .
Total Hardness It is expressed as the equivalent of calcium carbonate water. Total hardness varies from 100-575 ppm in most of the water samples of the district

4.2 Deeper Aquifer

Whereas the ground water in deeper aquifer revealed that water of the deeper aquifer in the district is of very good quality and the electrical conductivity and chloride value being mostly less than 538µS/cm and 30mg/litre, respectively. The range of various cations and anions are given in Table -6.

Hydrogen Ion Concentration
The ground water of the shallow aquifer is slightly alkaline in reaction as the pH values ranges between 7.2 to 8.5. The electrical conductivity of the area revealed that water of the area is fresh in general.

Chloride content is below 30 mg/litre in most parts of the district
Total Hardness It is expressed as the equivalent of calcium carbonate water. Total hardness varies from 110-260ppm in most of the water samples of the district

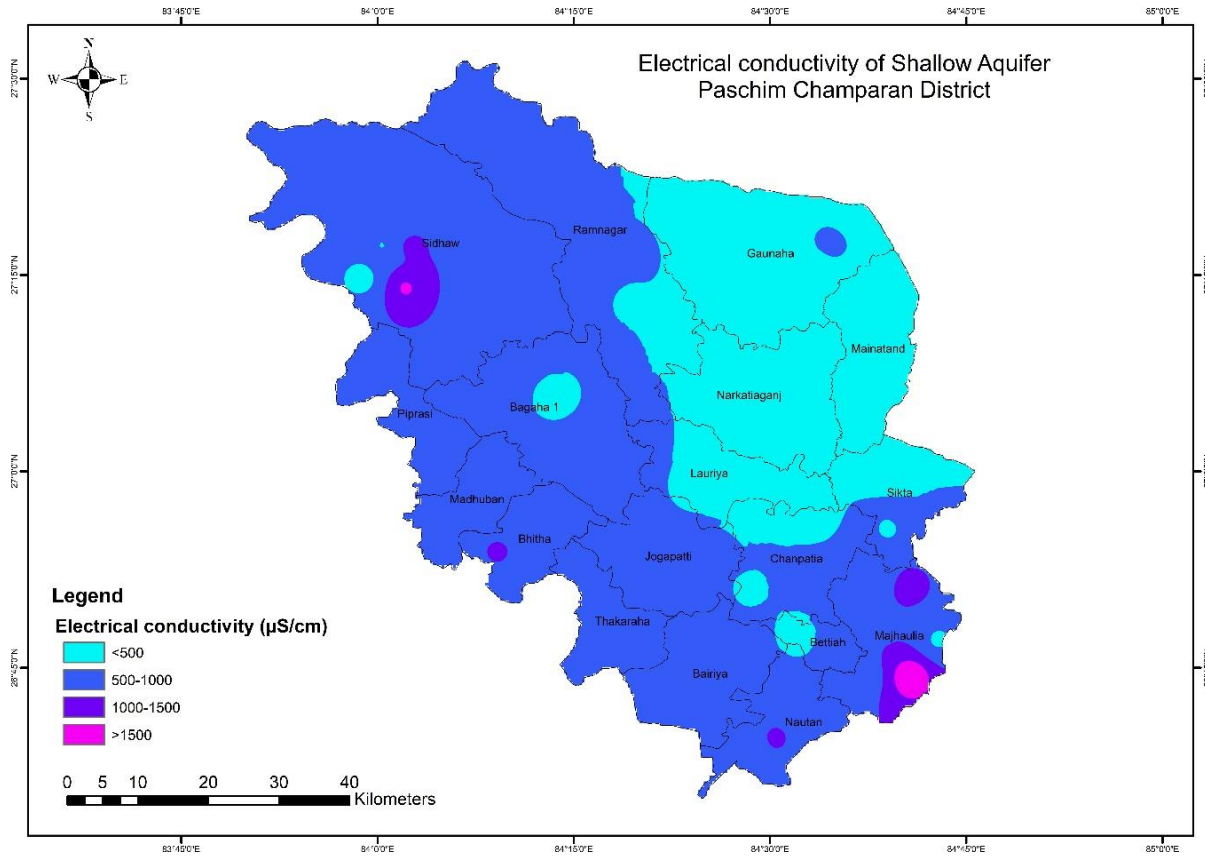


Figure 32: Electrical Conductivity of Shallow Aquifer in Paschim Chmaparan District

Table 5: Chemical Constituents in Shallow Aquifer in Paschim Champaran District

Sl No	Parameters	Minimum (in mg/l)	Maximum (in mg/l)	Average (in mg/l)
1	pH	7.29	8.2	7.82
2	EC	228	1928	624.91
3	TDS	148.2	1253.2	406.19
4	TH	100	575	249.91
5	Ca2+	16	136	61.52
6	Mg2+	2.43	68.04	23.36
7	Na+	0	162	22.49
8	K+	0	26.31	6.01
9	CO32-	0	0	0.00
10	HCO3-	115.9	597.8	260.83
11	Cl-	7.1	252.05	43.91
12	SO42-	0	100.23	23.76
13	NO3-	0	30.32	5.70
14	PO43-	0	0	0.00
15	F-	0.06	0.85	0.39
16	SiO2	9.4	19.87	13.76

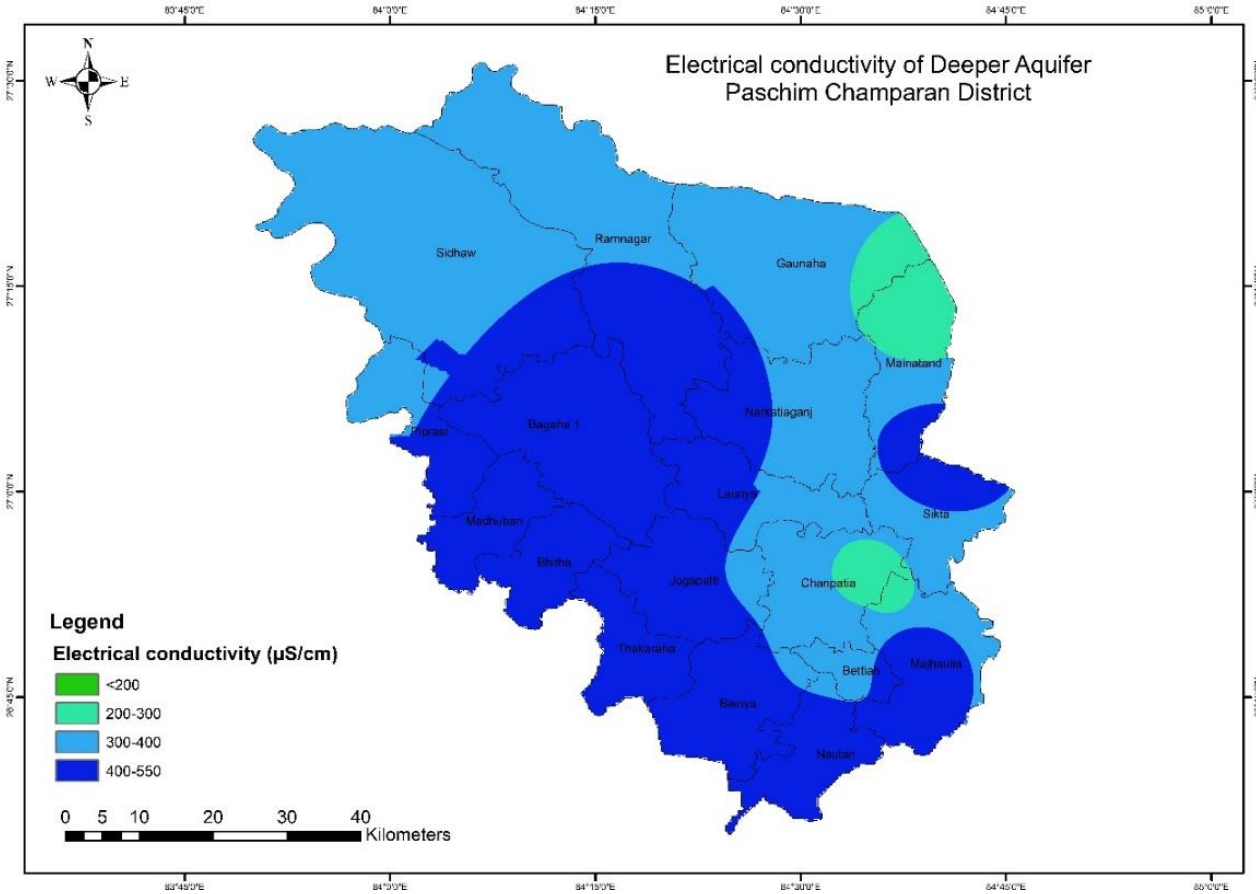


Figure 33: Electrical Conductivity of Deeper Aquifer in Paschim Chmaparan District

Table 6: Chemical Constituents in Deep Aquifer in Paschim Champaran District

Sl No	Parameter	Minimum (in mg/l)	Maximum (in mg/l)	Average (in mg/l)
1	pH	7.2	8.5	7.44
2	Turb.	1	2	1.43
3	EC	215	538	386.64
4	TDS	140	350	251.5
5	TH	110	260	158.57
6	Ca	32	64	45.43
7	Mg	4.8	24	12.56
8	Cl	20	30	21.43
9	Alkalinity	120	240	166.43

5. GROUND WATER RESOURCES POTENTIAL

5.1 Ground Water Resources as on 2022

The ground water resources of the district were calculated as on March 2022 in collaboration with the Government of Bihar using the methodology suggested by Ground Water Resource Estimation Committee (GEC-15). These resources were computed after reorganization of the districts.

Table 7:Dynamic Ground water Resources of Paschim Chamaparan District 2022

Name of District	Ground water Recharge (in Ham)					Total Natural Discharge	Annual Extractable Ground Water Resource	Current Annual Ground water Extraction (in Ham)				Annual Ground water allocation for Domestic use as on 2025	Net ground water availability for future use	Stage of Ground water extraction (%)
West Champaran	Monsoon Season		Non-Monsoon Season		Total Annual Groun water Recharge			Irrigation	Industrial	Domestic	Total			
	Recharge from rainfall	Recharge from other Sources	Recharge from rainfall	Recharge from other Sources										
	90685.45	43474.75	4241.96	29432.25	167834.73	15594.73	152239.67	26003.18	2440.40	12694.33	41137.89	13792.10	110113.00	27.02

5.2 Annual Ground Water Extractable Resource

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The Annual Ground Extractable Ground Water Resource varies from 1954.2 ham (Bhitaha block) to 17671.54 ham (Bagha block). The Gross Annual Ground Water Recharge in the district is 152239.7 ham.

5.3 Ground Water Draft

The ground water draft for irrigation, Domestic and Industrial uses is presented in Table: 6. The Existing Gross Ground Water Draft for all uses varies from 639.37 (Thakrahan block) to 5269.25 ham (Majhaulia block). The Gross Ground Water Draft for all uses in the district is 41137.89 ham.

5.4 Projected demand for Domestic and Industrial use upto 2025

Projected demand for domestic and industrial uses varies from 130.7 ham (Ramnagar block) to 1399.38 ham, (Nautan block). The total Projected demand for domestic and industrial uses in the district is 13792.1 ham.

5.5 Ground water Availability for future irrigation

Ground water availibilty for future irrigation is varies from 974.46 ham (Bettiah block) to 14801.24 Ham (Bagha block) and total 110113 ham ground water is available for future irrigation.

5.6 Stage of Ground Water Development

As per the Ground Water Resource Estimation (GWRE-2020), the stage of Ground Water Development varies from 7.03 % (Bagha 2 block) to 51.37 % (Bhitaha block). The overall ground water development in the district is 27.02 %. All the 18 blocks of the district are categorized as SAFE.

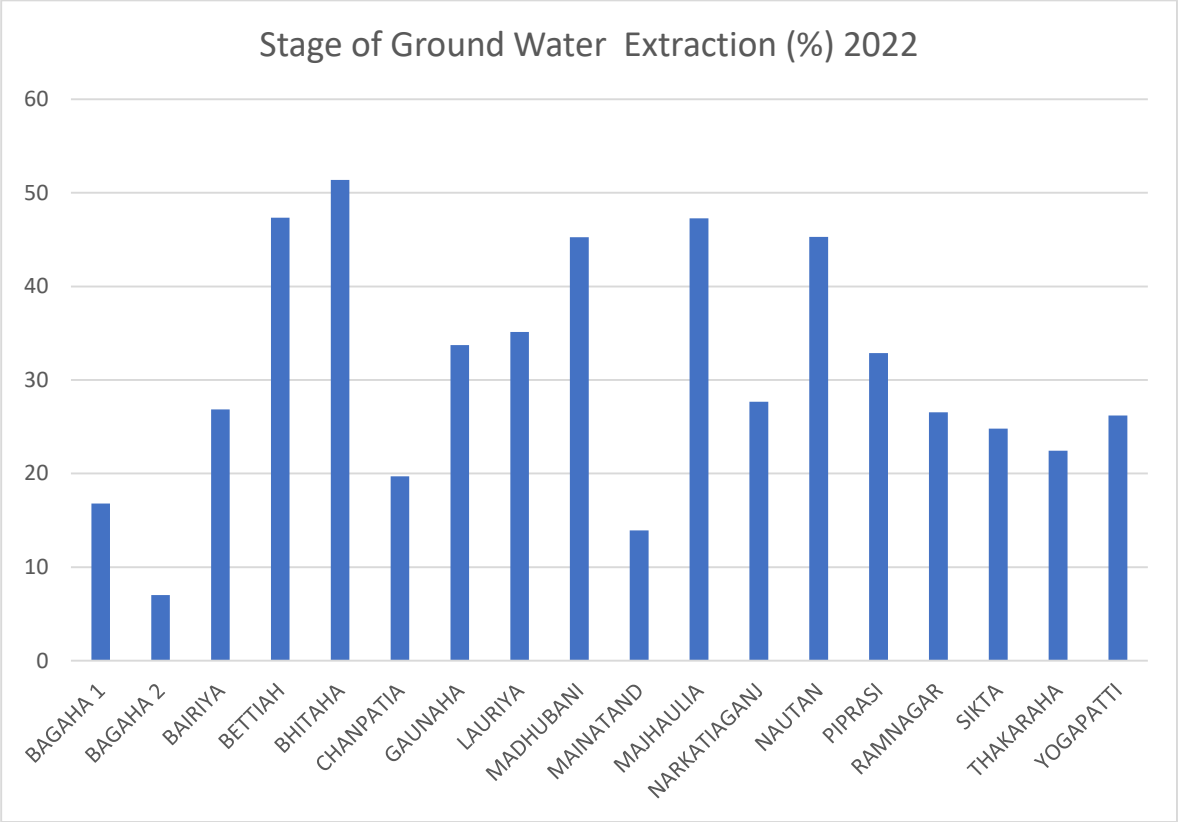

Figure 34: Stage of Ground water Extraction block wise in Paschim Champaran District 2022

The study of ground water resources extraction of the entire district (blockwise) reveals that the extraction of ground water in the district is very low. The district of Paschim Champaran has a large network of canal system which has restricted the extraction of ground water though the district has enormous ground water resources. Ground water extraction is good to moderate in the southern parts of the district which falls in the tail end of the canal command area. The block wise data of ground water extraction (Table 6) reveals that the utilization of ground water is the highest in the Bhitaha block where it is 51.37 % of the resources and closely followed by Bettaih, Majhaulia, Nautan and Madhubani blocks where percentage of ground water development is 47.34%, 47.27%, 45.3% and 45.25 % respectively. The development of

groundwater in the blocks Bagaha1, Bagaha 2, Chanpatia and Mainatand block is <20 %. The irrigation potential available with balance ground water resources has been computed on the basis of crop water requirement in the alluvial terrain for various crops in prevailing agro climatic zone. It is estimated by Pusa agriculture University that the average water application comes to be 0.65 meter in the district of Paschim Champaran. Thus the block wise irrigation potential with the balance ground water resources in the district has been computed as per the crop water requirement. This has indicated that further irrigation potential of 16515.52 Hectares is available in the district which can be developed to boost the irrigation facility even in canal command areas where the water scarcity is being felt in peak water demand time and in general. This conjunctive use of ground and surface waters will lead to maintain the natural environment and prevent the area being water logged due to man-made structures.

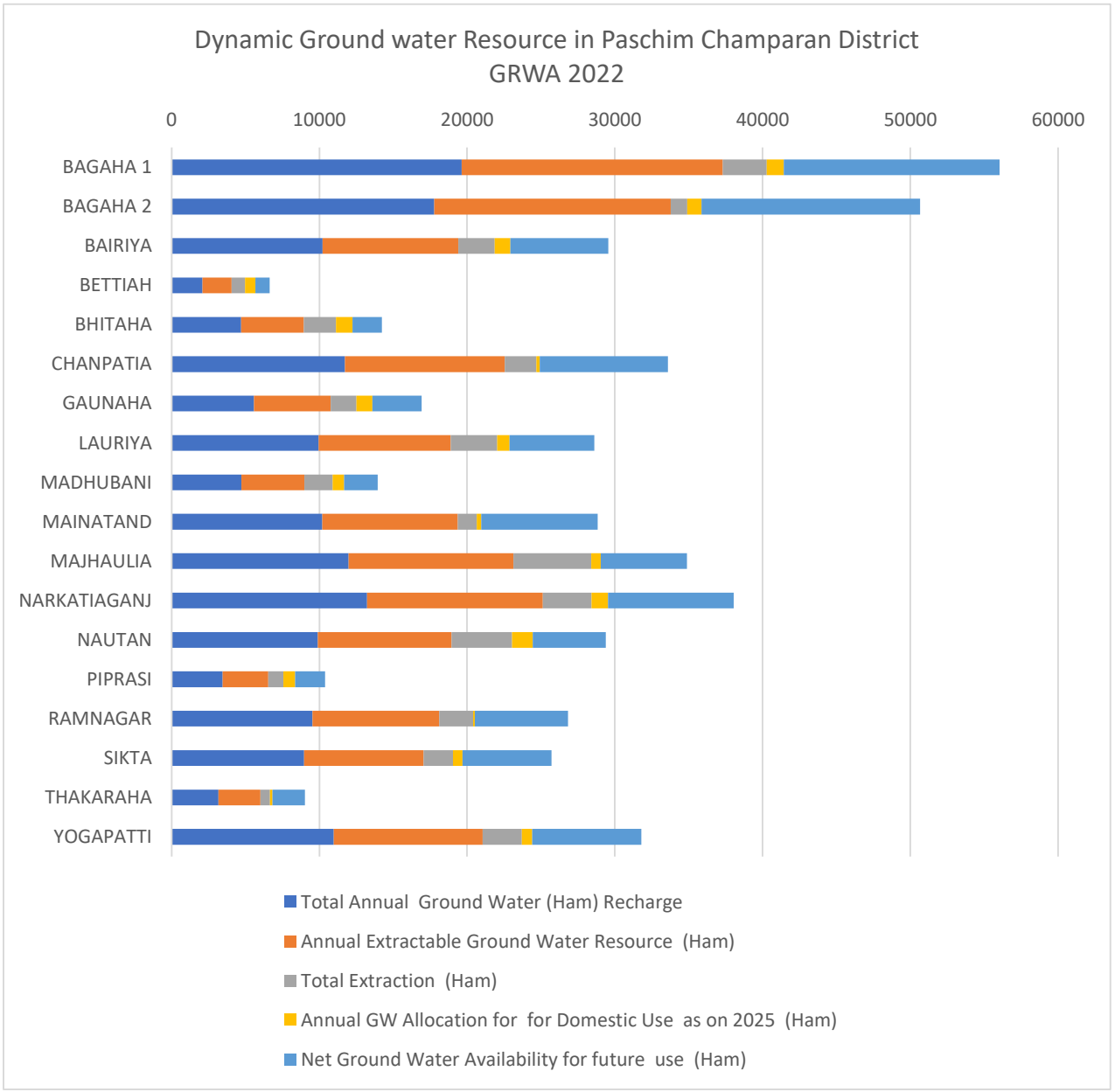

Figure 35:Dynamic Ground water Resources Block wise Paschim Champaran district

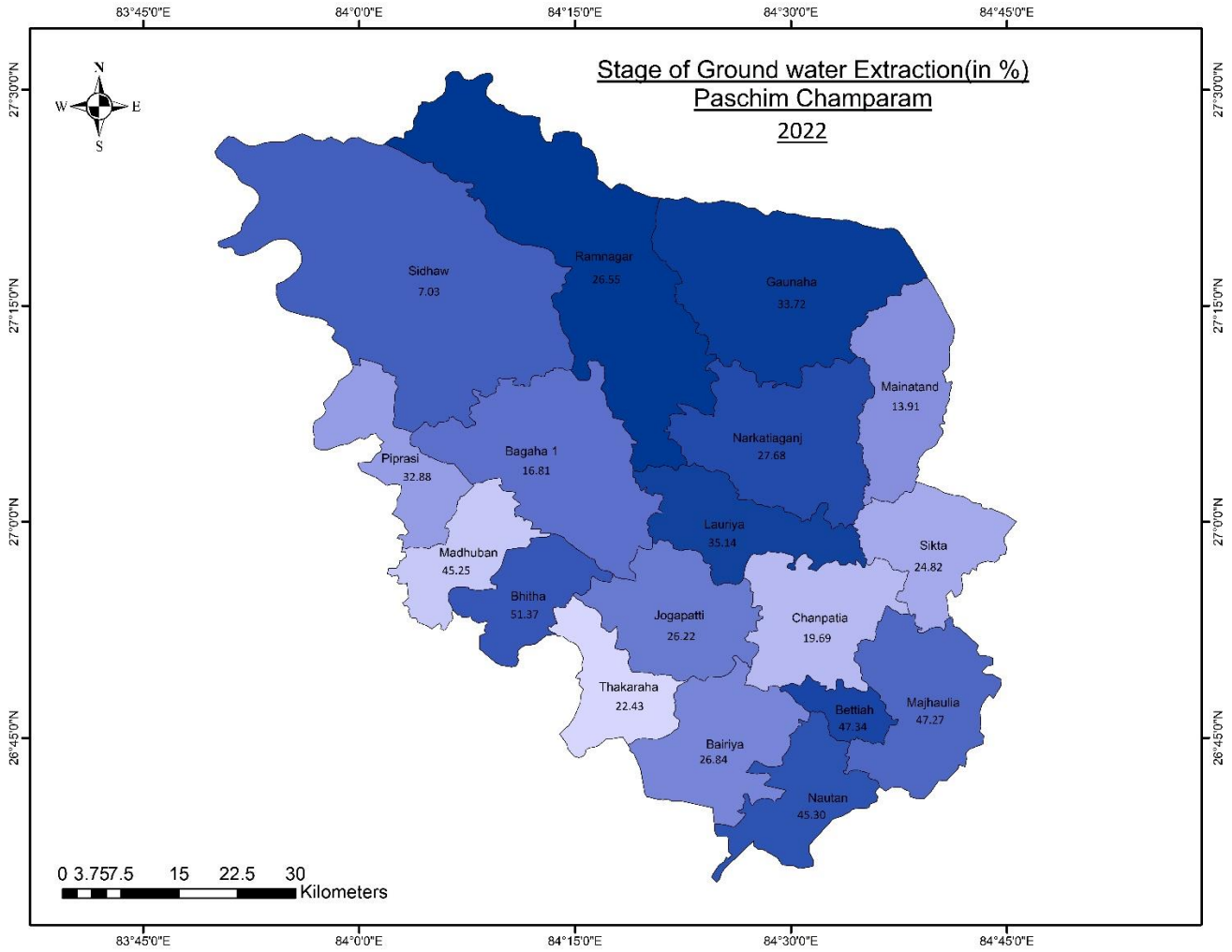

Figure 36: Stage of Ground water Extraction map of Paschim Champaran District 2020

Table 8: Taluka Wise Ground Water Resources, Availability, Utilization and Stage of Ground Water Development (2022)

Sl. No	Assessment Unit Name	Recharge from Rainfall-Monsoon Season	Recharge from Other Sources-Monsoon Season	Recharge from Rainfall-Non Monsoon Season	Recharge from Other Sources-Non Monsoon Season	Total Annual Ground Water (Ham) Recharge	Total Natural Discharges (Ham)	Annual Extractable Ground Water Resource (Ham)	Ground Water Extraction for Irrigation Use (Ham)	Ground Water Extraction for Industrial Use (Ham)	Ground Water Extraction for Domestic Use (Ham)	Total Extraction (Ham)	Annual GW Allocation for for Domestic Use as on 2025 (Ham)	Net Ground Water Availability for future use (Ham)	Stage of Ground Water Extraction (%)	Categorization (Over-Exploited/Critical/Semicritical/Safe/Saline)
1	2	3	4	5	6	7	8	10	11	12	13	14	15	16	17	18
1	BAGAHA 1	9793.14	5842.99	433.93	3564.98	19635.04	1963.5	17671.54	1555.56	345	1070.08	2970.64	1162.61	14608.37	16.81	safe
2	BAGAHA 2	6544.5	6027.65	324.22	4883.61	17779.98	1778	16001.98	0	240	884.26	1124.27	960.73	14801.24	7.03	safe
3	BAIRIYA	6257.38	2248.46	255.81	1453.15	10214.8	1021.48	9193.32	1418.59	83	965.91	2467.51	1049.44	6642.28	26.84	safe
4	BETTIAH	1280.27	399.33	67.53	351.67	2098.8	144.6	1954.2	281.66	11.4	632.04	925.09	686.69	974.46	47.34	safe
5	BHITAHA	4194.25	190.78	154.34	173.64	4713.01	471.3	4241.71	1109.05	40	1029.83	2178.89	1118.89	1973.76	51.37	safe
6	CHANPATIA	6158.95	3145.94	282.51	2148.27	11735.67	913.59	10822.08	1819.23	105	206.36	2130.6	224.21	8673.63	19.69	safe
7	GAUNAHA	3107.81	1186.59	160.54	1127.05	5581.99	401.25	5180.74	675.36	83	988.44	1746.8	1073.91	3348.47	33.72	safe
8	LAURIYA	4609	3251.6	223	1862.34	9945.94	994.6	8951.34	2326.43	60	759.06	3145.5	824.71	5740.19	35.14	safe
9	MADHUBANI	4184.72	202.83	153.99	184.21	4725.75	472.58	4253.17	1169.2	38	717.44	1924.64	779.48	2266.49	45.25	safe
10	MAINATAND	4653.86	3649.11	256.88	1638.19	10198.04	1019.81	9178.23	926.22	71	279.32	1276.54	303.47	7877.54	13.91	safe
11	MAJHAULIA	6685.43	2831.14	313.51	2155.64	11985.72	838.97	11146.75	4461.69	213	594.57	5269.25	645.99	5826.08	47.27	safe
12	NARKATIAGANJ	7211.34	3178.87	377.86	2454.7	13222.77	1322.28	11900.49	2026.93	240	1026.61	3293.52	1115.39	8518.19	27.68	safe
13	NAUTAN	4174.72	3514.57	206.53	2008.67	9904.49	860.45	9044.04	2738.89	70	1288	4096.88	1399.38	4944.77	45.3	safe
14	PIPRASI	3180.25	47.51	175.54	44.12	3447.42	344.75	3102.67	264.06	28	728.08	1020.14	791.04	2019.57	32.88	safe
15	RAMNAGAR	5518.35	1963.16	243.67	1812.59	9537.77	953.78	8583.99	1507.46	651	120.29	2278.75	130.7	6294.83	26.55	safe
16	SIKTA	4859.6	2535.75	214.51	1362.99	8972.85	897.29	8075.56	1339.91	74	590.68	2004.58	641.76	6019.9	24.82	safe
17	THAKARAHA	2857.5	79.09	157.72	72.78	3167.09	316.71	2850.38	448.9	26	164.48	639.37	178.7	2196.79	22.43	safe
18	YOGAPATTI	5414.38	3179.38	239.87	2133.65	10967.28	879.79	10087.48	1934.05	62	648.88	2644.92	705	7386.44	26.22	safe
19	**TOTAL**	**90685.5**	**43474.8**	**4241.96**	**29432.3**	**167834**	**15594.7**	**152240**	**26003.2**	**2440.4**	**12694.3**	**41137.9**	**13792.1**	**110113**	**27.02**	**Safe**

6. Management plan

The stage of ground water extraction in the district is very low i.e. 27.02% and falls under safe category, and moreover the depth to water level in the district is below 9 mbgl.

Thus no supply side interventions are recommended in the district nor Demand side interventions are recommended. However there is a surplus run off of 3974 mcm available in the district which may be used for conjunctive use of Water resources.

Owing to low ground water development in the District, development plan to extract more ground water is recommended in the district, to elevation stage of ground water extraction by 5% in all blocks. Which can be used to reduce Culturable waste land, Barren & uncultivable land and unirrigated land of around 555 sq km area.

This will result in the stage of ground water extraction increase by 27.02% to 32.02 %. and increase the area under irrigation thereby increasing profit to farmers by allowing additional crops.
For elevating stage of ground water extraction additional 846 abstraction structures of depth around 150 meters and unit drat of 9ham (10hr/day) to elevate the economic growth of District as per the below distribution.

Table 9: Abstraction Structure recommended for to elevate ground water extraction in the district

Block	Annual Extractable Ground Water in ham	Total Extraction in Ham	Present stage of extraction	ElevateD SOD by 5% in all blocks	Proposed extraction after elevated development	Additional water in ham	Drinking/ Domestic water allocation for 2025	NGW Avail for future irrigation in ham	No of DTW (unit draft 9 ham 10 hr/day)	Irrigation Potential Created
BAGAHA 1	17671.54	2970.64	16.81031	21.81031	3854.217	883.577	1162.61	12654.71	98	1963.504
BAGAHA 2	16001.98	1124.27	7.025818	12.02582	1924.369	800.099	960.73	13116.88	89	1777.998
BAIRIYA	9193.32	2467.51	26.84025	31.84025	2927.176	459.666	1049.44	5216.704	51	1021.48
BETTIAH	1954.2	925.09	47.33855	52.33855	1022.8	97.71	686.69	244.71	11	217.1333
BHITAHA	4241.71	2178.89	51.3682	56.3682	2390.976	212.0855	1118.89	731.8445	24	471.3011
CHANPATIA	10822.08	2130.6	19.68753	24.68753	2671.704	541.104	224.21	7926.166	60	1202.453
GAUNAHA	5180.74	1746.8	33.71719	38.71719	2005.837	259.037	1073.91	2100.993	29	575.6378
LAURIYA	8951.34	3145.5	35.13999	40.13999	3593.067	447.567	824.71	4533.563	50	994.5933
MADHUBANI	4253.17	1924.64	45.25189	50.25189	2137.299	212.6585	779.48	1336.392	24	472.5744
MAINATAND	9178.23	1276.54	13.90835	18.90835	1735.452	458.9115	303.47	7139.309	51	1019.803
MAJHAULIA	11146.75	5269.25	47.27163	52.27163	5826.588	557.3375	645.99	4674.173	62	1238.528
NARKATIAGANJ	11900.49	3293.52	27.6755	32.6755	3888.545	595.0245	1115.39	6896.556	66	1322.277
NAUTAN	9044.04	4096.88	45.29922	50.29922	4549.082	452.202	1399.38	3095.578	50	1004.893
PIPRASI	3102.67	1020.14	32.87942	37.87942	1175.274	155.1335	791.04	1136.357	17	344.7411
RAMNAGAR	8583.99	2278.75	26.54651	31.54651	2707.95	429.1995	130.7	5745.341	48	953.7767
SIKTA	8075.56	2004.58	24.8228	29.8228	2408.358	403.778	641.76	5025.442	45	897.2844
THAKARAHA	2850.38	639.37	22.43104	27.43104	781.889	142.519	178.7	1889.791	16	316.7089
YOGAPATTI	10087.48	2644.92	26.21983	31.21983	3149.294	504.374	705	6233.186	56	1120.831
TOTAL	152239.7	41137.89	27.02179	32.02179	48749.87	7611.984	13792.1	89697.7	846	16915.52

6.1 Proposal for Well Construction

Development of ground water resources in the entire district is very poor, basically due to presence of high network of canal system. Although, hydrogeological conditions are extremely favourable for constructing tube wells having potential discharge of 200 m^3/hr and above. The most suitable wells would be 30-40 meter deep in shallow aquifer sand 100-150 meter in case of heavy duty tubewells, equipped with pumps having discharge 50 to 200 m^3/hr capacity depending upon the requirements. It has been calculated that a tubewell having 50 m^3/hr discharge and moderate to deep tubewells having 100 m^3/hr to 200 m^3/hr discharge if operated for 1800 hours annually would produce an annual unit draft of 0.09, 0.18 and 0.36 MCM respectively.

(a) Shallow Tubewells: Shallow tubewells in the range of 30-40meter deep are feasible in all parts of the district. It is recommended that about 10 meter thickness of aquifers should be tapped which would provide sufficient discharge of 40-50 m^3/hr for a drawdown of 2-3 meter. In the Bhabar zone where gravel bed occurs at shallow depth slotted pipe should be placed directly against this aquifer. Gravel packing shall be provided where the aquifer materials are fine to medium grained.

(b) Deep Tubewells : The Central and Southern parts of the district ake highly favourable for constructing heavy duty tubewell having discharge of 200 m^3/hr and above. The permeability of the aquifer is very high. The well should be constructed without the gravel packing where the aquifer materials are very coarse sand and gravels. The gravel packing shall be used where the aquifer material is medium to fine grained. Seeing the proposed design of tube well in Paschim Champaran district, it has been observed that due to lack of knowledge, the farmers generally construct tubewells very closely which adversely affects each other's. This results in the term of lowering of discharge due to mutual interference. Therefore, it is important that a farmer or user should know about the spacing of the wells. From the experience of the similar hydrogeological conditions, the following spacing for different types and size of tubewells have been calculated. Distance between two wells 400.

7. EXECUTIVE SUMMARY

1. The Paschim Champaran district comprises eighteen administrative blocks in three sub-divisions - Bettiah Sadar, Narkatiyaganj and Bagaha, with district head quarter as Bettiah. The district is basically agrarian with 77% arable land. The area experiences Sub-Tropical climate with 1472 mm rainfall as district normal. Though the quantity of rainfall is appreciable but delay or failure of rainfall very adversely effects agricultural production. All the rivers except the Gandak in the district carry little waters during lean period but become turbulent during the monsoon, causing inundation in low lying areas. Mild to normal draughts occur occasionally.

2.Paschim Champaran district grows stapple crops like paddy, wheat Sugarcane, Maize and Barley, among which paddy is grown widely. In the northern part of the district paddy is grown almost in all season and the vegetables are grown during the entire year. The internisty of agriculture is 145 % but can be improved appreciably. About 51 % of the area is having assured irrigation facility by different sources. Out of which ground water contribution is 60 % and has been increasing every year..

3. Geologically the district is covered by Quaternary alluvial sediments and Siwaliks. The alluvial sediments in southern parts are expected to be several hundred meters in thickness. Its constituent are clay,silt and sands of different grades in varying proportions with gravel,pebble and boulders. Fluviatile nature of deposit is marked by multi-cyclic character, interingering of lithofacies and sediments being finer in upward sequences.

4. The dry and porous tract lying south of the Siwaliks, extending in E - W direction, constitute the hydrogeological unit commonly known as the Bhabar. This southerly sloping Bhabar belt gradually merges with the adjoining unit of Terai in the south. The contact of the two units is marked by change in slopes and a chain of ground water affluent which form the spring line. The Gandak flood plain laying south of the Terai in inferred from the variation in terrain, drainage, vegetation pattern, Sediments and depth to water levels. Ground Water occurs under water lable and semi-confined conditions in the Bhabar and Gandak flood plain where as confined conditions may occurs in deeper aquifers in Terai area. In most parts of the district potential aquifers occur at shallow depth. The top aquifer is generally composed of fine to medium grained sand and followed by coarser sediments at depth which is some times mixed with gravel sand pebbles. Gravel and boulders occur at shallow depth in Bhabar area.

5. In the district water table in generally found to occur between 2-5mbgl but varies locally depending upon the prevailing hydrogeological conditions. In the Bhabar area ground water is generally deep and rest between 4-5 m bgl. Following the Bhabar area is Terai where ground water is moderately deep which rest between 3-4 m bgl and in Gandak flood plain ground water found to occur between 2-3 m bgl. Exceptionally shallow water level about less than a meter found to occurs around the Bettiah town.

6. The water table fluctuation varies from less than a meter to over 2 meter in general. The maximum fluctuation in water level found to occur in and around Sikta. The direction of ground water movement is from North to Southward, with average hydraulic gradient of 0.58 m per Kilometer. Hydrogeological conditions in the district are extremely favourable for the construction of tubewells. High capacity tubewells having discharge of 200 m^3/hr and above can be constructed by tapping deeper aquifers. However, the shallow tubewells can be constructed which will yield 50 m^3/hr and above. This would be sufficient to irrigate four hectares of land which will be very useful and economical for marginal and average farmers. However, a very shallow irrigation well having yield potential of 15 m^3/hr can also be very useful when designed suitably.

7. The quantitative assessment of ground water in the district has revealed that gross annual ground water recharge is 1678.35 MCM with Annual extractable ground water resources as 1522.40 MCM and the net annual draft is in the order of 411.38 MCM only. Hence a total of 1101.13 MCM (including domestic and industrial uses) is available for future development through suitable ground structures for irrigation, industries and domestic requirements of the district. This huge quantity of ground water could be usefully developed either by 846 Nos. deep tubewells having discharge of 9ham (10hr/day) which will create an irrigation potential of 16915.52 Hectares for the entire district. In a select areas small diameter shallow irrigation wells fitted with centrifugal pumps which is capable of yielding 15-20 m^3/hr discharge can also be constructed.

8. Ground water occurs at very shallow depth in and around Bettiah town which causes water logging in the area and thereby affecting the agricultural fields. As the direction of ground water flow is from North to Southward, it is recommended that the heavy duty tubewells should extensively be constructed in the areas to the North of Bettiah. It would not only be a perennial

source of water supply but will also eliminate the water logging to some extent in the affected areas.

9. The Terai belt occurs in the Central parts of the district. The Terai areas are generally potential for artesian conditions where free flow of water took place. Therefore, deep exploratory wells can be constructed to tap the aquifers which are under artesian conditions. It would be a measure towards energy conservation in the power hungry district as Paschim Champaran.

10. The spacing between the two wells should be kept about 400 meter in case of heavy duty tubewells.

11. The huge ground water resources can be utilised judiciously in con-junction with surface water to fulfil the water requirement of the district. This will reduce the water logging in the area caused by canal system and bring the natural eco-system.

12. The district is completely lacking in mineral resources, as such the development of agriculture and agro-based industries can only bring the prosperity in the district.

ANNEXURE I :List of Key wells established in West Champaran District for NAQUIM study 2022-23

Sample_No	Village	BLOCK	DISTRICT	STATE	Latitude	Longitude	Pre-monsoon depth to Water level	Post-monsoon depth to Water level	Water level Fluctuation	Surface RL (m)	Pre-monsoon Water table RL(m)
1	Fattuchhapar	Bairiya	West Champaran	Bihar	26.6999	84.4519	3.8	2.34	1.46	78	74
2	Mangalpur Godariya	Nautan	West Champaran	Bihar	26.65182	84.47618	4.7	3.2	1.5	82	77
3	Bhartitola	Nautan	West Champaran	Bihar	26.6608	84.5062	4.3	3.2	1.1	73	69
4	Gamhariya Jagdishpur	Nautan	West Champaran	Bihar	26.6721	84.5514	5	4.25	0.75	79	74
5	Jaukatiya Gachali tola	Majhaulia	West Champaran	Bihar	26.737	84.6222	4.8	3.5	1.3	78	73
6	Senuaria Mauji	Majhaulia	West Champaran	Bihar	26.7384	84.67844	4.1	3.1	0	76	72
7	Naukatola	Majhaulia	West Champaran	Bihar	26.78562	84.71451	4.62	3.3	1.32	74	69
8	Biruna Tola	Majhaulia	West Champaran	Bihar	26.8558	84.6734	5.5	4.32	1.18	78	73
9	Dhankutwa	Majhaulia	West Champaran	Bihar	26.8665	84.6436	3.7	2.95	0.75	79	75
10	Lohiyariya	Chanpatia	West Champaran	Bihar	26.87351	84.56176	3.3	2.92	0.38	82	79
11	Bagahi Baghambarpur	Jogapatti	West Champaran	Bihar	26.8243	84.4089	5.4	3.83	1.57	85	80
12	Fatehpur	Jogapatti	West Champaran	Bihar	26.88334	84.37491	5.75	2.93	2.82	86	80
13	Kaulapur	Jogapatti	West Champaran	Bihar	26.89675	84.30487	2.9	2.9	0	88	85
14	Baswaria	Bagaha 1	West Champaran	Bihar	26.9702	84.2666	4.2	2.8	1.4	86	82
15	Bibi Bankatwa	Bagaha 1	West Champaran	Bihar	26.99662	84.26205	2.64	1.87	0.77	86	83

Sample_No	Village	BLOCK	DISTRICT	STATE	Latitude	Longitude	Pre-monsoon depth to Water level	Post-monsoon depth to Water level	Water level Fluctuation	Surface RL (m)	Pre-monsoon Water table RL(m)
16	Hamira Majhauwa	Bagaha 1	West Champaran	Bihar	27.0234	84.29	4.24	3.3	0.94	86	82
17	Balthar	Sikta	West Champaran	Bihar	27.0268	84.6332	1.8	1.87	-0.07	82	80
18	Haripur Dharampur	Sikta	West Champaran	Bihar	27.02176	84.68682	1.2	1.9	-0.7	83	82
19	Mehasada	Sikta	West Champaran	Bihar	26.89702	84.64106	4.6	3.5	1.1	80	75
20	Maghia Khargaulia	Chanpatia	West Champaran	Bihar	26.93659	84.55324	4.1	2.62	1.48	79	75
21	Koirgawan	Narkatiaganj	West Champaran	Bihar	27.07144	84.48496	2.1	1.65	0.45	86	84
22	Gubraura	Lauriya	West Champaran	Bihar	27.02137	84.44167	3.2	1.53	1.67	85	82
23	Rajgurawlia	Chanpatia	West Champaran	Bihar	26.84652	84.47282	3.9	2.3	1.6	79	75
24	Garahia	Bagaha 1	West Champaran	Bihar	27.09135	84.22776	2.05	1.82	0.23	92	90
25	Bhakhari Bazar	Ramnagar	West Champaran	Bihar	27.26436	84.31601	2.9	2.58	0.32	125	122
26	Birkenhi	Ramnagar	West Champaran	Bihar	27.225	84.32526	3.2	2.53	0.67	111	108
27	Laxmipur	Sidhaw	West Champaran	Bihar	27.17648	84.21967	3.4	3.29	0.11	106	103
28	Semara	Sidhaw	West Champaran	Bihar	27.22275	84.13946	3.4	3.29	0.11	108	105
29	Kailashpur	Sidhaw	West Champaran	Bihar	27.41966	83.89285	4.28	2.35	1.93	109	105
30	Santpur	Sidhaw	West Champaran	Bihar	27.379	83.94636	2.2	1.91	0.29	112	110

Sample_No	Village	BLOCK	DISTRICT	STATE	Latitude	Longitude	Pre-monsoon depth to Water level	Post-monsoon depth to Water level	Water level Fluctuation	Surface RL (m)	Pre-monsoon Water table RL(m)
31	Mohana	Sidhaw	West Champaran	Bihar	27.2876	84.00592	3.1	2.7	0.4	112	109
32	Khajuria	Sidhaw	West Champaran	Bihar	27.28515	84.04262	4.75	3.75	0	115	110
33	Karmaha	Sidhaw	West Champaran	Bihar	27.23326	84.03581	2.74	2.2	0.54	103	100
34	Bagha 1 Shashtrinagar	Bagaha 1	West Champaran	Bihar	27.10809	84.0752	3.3	2.7	0.6	93	90
35	Thakraha Baghi Tola	Thakaraha	West Champaran	Bihar	26.77628	84.2719	2.81	1.8	1.01	84	81
36	Hatuahwa	Bhitha	West Champaran	Bihar	26.8997	84.1533	4.3	3.74	0.56	89	85
37	Dhanaha Laxmipur	Madhuban	West Champaran	Bihar	26.9404	84.1575	4.2	2.7	1.5	86	82
38	Jamunia Premnagar	Gaunaha	West Champaran	Bihar	27.2718	84.5643	4.05	4.62	-0.57	118	114
39	Dewar	Gaunaha	West Champaran	Bihar	27.28399	84.57261	2.38	3.32	-0.94	124	122
40	Sakraul	Mainatand	West Champaran	Bihar	27.13889	84.65254	2.72	3.24	-0.52	99	96
41	Behari	Mainatand	West Champaran	Bihar	27.214	84.64838	4.12	4	0.12	117	113
42	Parsa	Gaunaha	West Champaran	Bihar	27.2785	84.5157	1.07	1.3	-0.23	107	106
43	Bhitiharwa	Gaunaha	West Champaran	Bihar	27.23839	84.48957	3	2.5	0.5	108	105
44	Tarharwa	Narkatiaganj	West Champaran	Bihar	27.1051	84.5003	3.55	3.24	0.31	87	83
45	Baitapur	Narkatiaganj	West Champaran	Bihar	27.0599	84.5153	3.4	3.25	0.15	90	87

Sample_No	Village	BLOCK	DISTRICT	STATE	Latitude	Longitude	Pre-monsoon depth to Water level	Post-monsoon depth to Water level	Water level Fluctuation	Surface RL (m)	Pre-monsoon Water table RL(m)
46	Khargahia Purb	Bettiah	West Champaran	Bihar	26.78912	84.53341	4.75	3.35	1.4	79	74

ANNEXURE II: Chemical Quality of deeper Aquifer

Sl. No.	Block	Panchyat	Village	Name of Habitation	Location of Source	Latitude	Longitude	pH	Turb.	EC	TDS	TH	Ca	Mg	Cl	Alka.
2	LAURIYA	TELPUR	TELPUR	TELPUR	TELPUR RWS EXTENSION	27.0516	84.3353	7.2	1	520	338	200	64	23	30	220
3	NAUTAN	BLOCK CAMPUS	BLOCK CAMPUS	BLOCK CAMPUS	NAUTAN PWS (EXTENSION)	26.7089	84.4744	7.5	2	485	315	200	56	14.4	20	210
4	BAIRIYA	BAIRIYA	BAIRIYA	BAIRIYA	BAIRIYA RWS (EXTENSION)	26.764	84.4397	7.4	2	538	350	260	64	24	30	180

5	MAJHAULIYA	BAITHANIYA BHANCHAK	GURCHURWA	WARD-10 PART-2	HAR GHAR NAL KA JAL KA PRD NEAR MUNNA KUMAR	26.8044	84.6343	7.8	2	480	310	140	48	4.8	20	240
8	BAGAHA-2	VALMIKINAGAR	VALMIKINAGAR	WARD-17PART-1	HAR GHAR NAL KA JAL PHED SBD-53-19/20	27.4202	83.9121	7.4	2	330	215	120	40	4.8	20	130
12	BAGAHA-1	BASWARIYA	PURBI LAGUNAHA	WARD-10	HAR GHAR NAL KA JAL KA BORING PRD	27.0193	84.25	8.5	1	412	268	150	44	16	20	160
13	MAINATANR	RAMPUR	RAMPUR MISSION	WARD-08	HAR GHAR NAL KA JAL KA BORING PRD	27.225	84.6455	7.2	1	215	140	110	32	12	20	120
15	CHANPATIYA	SOUTH GHOGHA	GHOGHA GHAT	GHOGHA GHAT	M V S GHOGHA GHAT UGR	26.9006	84.5872	7.3	1	274	178	110	32	7.2	20	120
17	MAJHAULIYA	RATANMALA	RATANMALA	RATANMALA	M V S GHOGHA GHAT ZONAL	26.8739	84.6098	7.3	1	267	174	110	32	7.2	20	120
18	CHANPATIYA	GIDHA	GIDHA	GIDHA	M V S GIDHA	26.8967	84.5707	7.3	1	269	175	110	32	7.2	20	120
19	RAMNAGAR	TAULAHA	TAULAHA	WARD-9,10,11,12,13,14,15	TAULAHA PANI	27.1502	84.3777	7.3	2	410	270	180	48	14.4	20	170

					TANKI PWS(EXT)											
20	BETTIAH	BARWATSENA	BARWATSENA	BARWAT	S V S BARWATSENA BATCH-1	26.80119	84.4976909	7.4	2	363	236	170	48	12	20	180
21	SIKTA	BALTHAR	BHAURA	WARD-8	S V S BALTHAR BATCH-2	27.0365	84.6644	7.3	1	490	318	200	56	14.4	20	210
22	YOGAPATTI	NAWALPUR	NAWALPUR	NAWALPUR	S.V.S. NAWALPUR BATCH 1	26.79638	84.5055458	7.3	1	360	234	160	40	14.4	20	150

ANNEXURE III: Chemical Quality of shallow Aquifers

LOCATION	LATITUDE	LONGITUDE	TYPE OF WELL	pH	EC	TDS	TH	Ca2+	Mg2+	Na+	K+	CO32-	HCO3-	Cl-	SO42-	NO3-	PO43-	F-	SiO2
Bagahi Ratanpur	26.7716	84.4743	Handpump	7.5	69	454.35	330	60	43.74	0.8	8.41	0	384.3	14.2	2.31	0.26	0	0.06	11.8
Fattuchhapar	26.6999	84.4519	Handpump	7.31	57	371.15	190	20	34.02	30.13	16.21	0	207.4	42.6	31.21	21.92	0	0.79	9.4
Mangalpur Godariya	26.6518	84.4761	Dugwell	7.29	75	491.4	305	70	31.59	23.26	14.45	0	274.5	67.45	43.51	3.1	0	0.28	12.41
Bhartitola	26.6608	84.5062	Handpump	7.81	10 74	698.1	390	8	29.16	56.3	15.5	0	427	88.75	43.51	4.71	0	0.45	13.36
Gamhariya Jagdishpur	26.6721	84.5514	Handpump	7.96	87 7	570.05	370	94	32.805	27.92	2.57	0	396.5	67.45	5.86	11.56	0	0.41	16.12
Jaukatiya Gachali tola	26.737	84.6222	Handpump	7.73	71 7	466.05	330	64	41.31	9.02	5.56	0	353.8	28.4	18.9	0.25	0	0.08	12.12

Senuaria Mauji	26.7384	84.67844	Dugwell	8.02	19 28	1253.2	57 5	11 8	68.04	162	22.56	0	597.8	252.05	77.35	27.83	0	0.81	17.98
Naukatola	26.78562	84.71451	Handpump	8.05	43 5	282.75	13 0	30	13.365	37.15	2.6	0	201.3	21.3	13.56	0.29	0	0.46	11.35
Biruna Tola	26.8558	84.6734	Handpump	7.93	13 59	883.35	45 5	13 6	27.945	87.78	21.21	0	445.3	177.5	59.36	0.34	0	0.49	12.31
Dhankutwa	26.8665	84.6436	Handpump	8.12	51 5	334.75	19 0	46	18.225	28.65	0	0	274.5	14.2	0.46	0	0	0.73	14.98
Lohiyariya	26.87351	84.56176	Handpump	7.35	68 0	442	32 5	78	31.59	3.92	0.81	0	298.9	31.95	41.83	0.03	0	0.49	10.23
Bagahi Baghambarpur	26.8243	84.4089	Handpump	7.91	66 9	434.85	27 0	64	26.73	22.28	8.13	0	250.1	53.25	41.38	1.3	0	0.24	11.78
Fatehpur	26.88334	84.37491	Handpump	7.85	73 5	477.75	29 5	78	24.385	23.85	12.83	0	341.6	35.5	25.31	3.41	0	0.6	11.84
Kaulapur	26.89675	84.30487	Handpump	7.65	57 5	373.75	26 5	60	27.945	5.02	4.37	0	280.6	17.75	28.31	0.08	0	0.18	10.92
Baswaria	26.9702	84.2666	Handpump	7.62	71 2	462.8	30 0	72	29.16	22.46	2.63	0	274.5	53.25	45.25	0.24	0	0.26	13.65
Bibi Bankatwa	26.99662	84.26205	Handpump	7.93	84 0	546	33 0	10 0	19.44	36.11	4.07	0	280.6	92.35	45.25	0.63	0	0.33	15.48
Hamira Majhauwa	27.0234	84.29	Handpump	8.03	87 3	567.45	41 0	10 6	35.235	9.39	3.28	0	420.9	39.05	25.5	4.5	0	0.22	14
Balthar	27.0268	84.6332	Handpump	7.84	33 9	220.35	15 0	40	12.15	6.08	1.8	0	170.8	14.2	1.6	1.2	0	0.34	17.98
Haripur Dharampur	27.02176	84.68682	Handpump	7.98	32 4	210.6	14 5	38	12.15	5.47	0.56	0	164.7	7.1	4.9	1.5	0	0.19	14.23
Jagannathpur	26.92292	84.64939	Handpump	8.2	43 3	281.45	17 5	40	18.225	16.8	0.63	0	225.7	10.65	5.1	0.9	0	0.3	15.23
Mehasada	26.89702	84.64106	Handpump	7.31	88 2	573.3	28 5	84	18.225	69.81	2.07	0	292.8	74.55	82.21	5.6	0	0.36	16.241
Maghia Khargaulia	26.93659	84.55324	Handpump	7.51	31 8	206.7	11 0	36	4.86	19.38	0.68	0	158.6	10.65	2.39	2.6	0	0.53	11.13

Koirgawan	27.07144	84.48496	Handpump	7.67	325	211.25	140	52	2.43	5.3	1.2	0	158.6	17.75	2.54	0.32	0	0.52	12.1
Gubraura	27.02137	84.44167	Handpump	7.89	328	213.2	130	36	9.72	10.23	0.87	0	170.8	10.65	2.36	0.41	0	0.5	13.2
Marhiya	26.97915	84.3971	Handpump	7.91	438	284.7	200	68	7.29	5.06	2.52	0	219.6	14.2	11	5.3	0	0.13	14.26
Rajgurawlia	26.84652	84.47282	Handpump	8.03	454	295.1	175	56	8.505	19.52	2.23	0	231.8	10.65	11	1.2	0	0.28	12.02
Garahia	27.09135	84.22776	Handpump	8.11	368	239.2	155	46	9.72	10.86	0.45	0	176.9	17.75	1.2	0.98	0	0.37	10.36
Bhakhari Bazar	27.26436	84.31601	Handpump	7.35	585	380.25	245	64	20.655	16.79	1.96	0	244	49.7	14.01	1.05	0	0.66	11.36
Birkenhi	27.225	84.32526	Handpump	7.46	479	311.35	195	58	12.15	13.12	6.94	0	231.8	17.75	14.1	4.65	0	0.6	17.6
Laxmipur	27.17648	84.21967	Handpump	7.51	550	357.50	240	60	21.87	12.94	0.46	0	292.8	21.30	0	0.48	0	0.63	14.23
Semara	27.22275	84.13946	Handpump	7.99	541	351.65	210	36	29.16	22.23	1.98	0	305	10.65	0	0	0	0.6	11.03
Pachrukha	27.24498	83.98083	Handpump	7.83	339	220.35	160	46	10.935	1.06	1.65	0	170.8	17.75	0	0.44	0	0.43	18.69
Kailashpur	27.41966	83.89285	Dugwell	8.11	773	502.45	365	72	44.955	0	11.63	0	402.6	17.75	19.39	0.56	0	0.24	17.54
Santpur	27.379	83.94636	Dugwell	7.91	865	562.25	320	64	38.88	40.12	15	0	341.6	71	31.94	10.77	0	0.81	16.35
Mohana	27.2876	84.00592	Handpump	7.83	491	319.15	220	46	25.515	10.56	0.6	0	189.1	39.05	23.48	2.23	0	0.44	15.12
Khajuria	27.28515	84.04262	Dugwell	7.79	1075	698.75	400	72	53.46	48.03	20.13	0	341.6	113.6	67.51	27.69	0	0.54	14.98
Karmaha	27.23326	84.03581	Dugwell	7.81	1559	1013.35	575	122	65.61	72.2	26.31	0	524.6	152.65	100.23	27.69	0	0.63	13.36
Bari Asthan	27.11193	83.95965	Handpump	7.61	942	612.35	365	98	29.16	35.63	15.02	0	359.9	67.45	52.31	27.69	0	0.17	11.6

Bagha 1 Shashtrinagar	27.10809	84.0752	Handpump	7.56	915	594.75	410	110	32.805	19.88	1.19	0	256.2	102.95	74.36	20.86	0	0.23	12.25
Thakraha Baghi Tola	26.77628	84.2719	Handpump	7.91	712	462.85	275	60	30.375	26.48	12.93	0	244	56.8	59.11	11.23	0	0.18	11.63
Hatuahwa	26.8997	84.1533	Handpump	7.97	1034	672.15	415	98	41.31	34.6	12.02	0	353.8	81.65	80.48	30.32	0	0.21	15.21
Dhanaha Laxmipur	26.9404	84.1575	Handpump	8.11	788	512.25	310	120	3.645	27.18	10.23	0	280.6	95.85	14.51	3	0	0.28	13.6
Jamunia Premnagar	27.2718	84.5643	Tubewell	8.13	228	148.20	100	24	9.72	1.23	0.64	0	115.9	7.1	2.1	0.9	0	0.24	14.3
Shivnagar	27.26631	84.56416	Tubewell	8.01	234	152.10	110	26	10.935	0	0.61	0	115.9	10.65	1.87	1.02	0	0.24	15.68
Bhikhana Thori 1	27.33385	84.6159	Tubewell	7.92	251	163.15	120	26	13.365	0	1.45	0	122	10.65	1.2	0.52	0	0.22	14.61
Bhikhana Thori 2	27.33385	84.6159	Tubewell	8.11	263	170.95	125	28	13.365	1.26	0.91	0	134.2	7.1	1.06	0.41	0	0.22	11.1
Dewar	27.28399	84.57261	Dugwell	7.85	867	563.55	330	60	43.74	37.94	12.36	0	317.2	67.45	41.83	28.25	0	0.85	12.61
Sakraul	27.13889	84.65254	Handpump	7.79	310	201.50	140	40	9.72	2.62	1.36	0	170.8	7.1	1.2	0.59	0	0.25	19.87
Behari	27.214	84.64838	Handpump	7.91	243	157.95	110	26	10.935	2.11	0.51	0	122	10.65	1.4	1.42	0	0.25	18.36
Parsa	27.2785	84.5157	Handpump	7.88	256	166.40	100	26	8.505	10.97	1.23	0	128.1	7.1	2.23	1.98	0	0.55	14.15
Bhitiharwa	27.23839	84.48957	Handpump	7.65	263	170.95	120	16	19.44	2.07	1.15	0	134.2	10.65	2.02	1.74	0	0.23	11.23
Tarharwa	27.1051	84.5003	Handpump	8.11	328	213.25	145	40	10.935	4.18	2.32	0	176.9	10.65	1.55	0.45	0	0.24	10.98
Baitapur	27.0599	84.5153	Handpump	7.93	307	199.55	140	42	8.505	2.78	1.02	0	164.7	10.65	0.71	0.74	0	0.3	12.36
Khargahia Purb	26.78912	84.53341	Handpump	7.99	323	209.95	120	42	3.645	13.96	4.81	0	164.7	10.65	1.2	0.65	0	0.49	16.98

ANNEXURE IV: Locations of Wells drilled in Paschim Champaran District

District	Block	Site	Latitude	Longitude	Agency	Elevation	Depth drilled
Paschim Champaran	Bettiah	Barwat sena	26.77027	84.54719	PHED	9	130
Paschim Champaran	Nautan	Jagdishpur	26.69182	84.57578	PHED	10.27163	125
Paschim Champaran	Bairiya	Banrahi	26.82368	84.40219	PHED	14.30308	85.4
Paschim Champaran	Majhaulia	Majhaulia	26.79675	84.62234	PHED	5.594726	140
Paschim Champaran	Majhaulia	Sariswa	26.87301	84.63315	PHED	10.94056	125
Paschim Champaran	Lauriya	Lauriya	26.99494	84.40578	PHED	18.994	112
Paschim Champaran	Lauriya	Gobraura	27.02634	84.4445	PHED	14.1904	125
Paschim Champaran	Chanpatia	Auriya	26.84147	84.54505	PHED	9.757425	125
Paschim Champaran	Yogapatti	Fatehpur	26.88266	84.37022	PHED	15.7812	125
Paschim Champaran	Yogapatti	Nawalpur	26.93428	84.30169	PHED	19.3667	155
Paschim Champaran	Gaunaha	Parsauni	27.26477	84.45027	PHED	33.09179	63
Paschim Champaran	Gaunaha	Genhariya	27.26495	84.56779	PHED	44.78143	74

Paschim Champaran	Gaunaha	Jamuniya	27.08406	84.46636	PHED	17.13874	125
Paschim Champaran	Ramnagar	Semrahi	27.39943	84.11542	PHED	98.9952	52
Paschim Champaran	Ramnagar	Khairaganj	27.39943	84.11542	PHED	98.9952	55.5
Paschim Champaran	Ramnagar	Bankatwa	27.37473	84.18542	CGWB	91.53444	51.51
Paschim Champaran	Ramnagar	Gobardhana	27.31604	84.31211	CGWB	78.83867	56.48
Paschim Champaran	Ramnagar	Parsauni	27.26833	84.33282	CGWB	55.62087	79.25
Paschim Champaran	Ramnagar	Meghwal Mathiya	27.23826	84.35247	CGWB	44.04376	87.78
Paschim Champaran	Ramnagar	Manchangwa	27.2824	84.31426	CGWB	63.54265	60.95
Paschim Champaran	Ramnagar	Fulkaul	27.23028	84.37222	CGWB	39.00547	107.2
Paschim Champaran	Ramnagar	Gudgudi	27.22328	84.24334	CGWB	46.78955	112.78
Paschim Champaran	Ramnagar	Bakhari Pachrukhi	27.30089	84.44249	CGWB	52.1932	118.87
Paschim Champaran	Bagaha 2	Rampurwa	27.38567	83.90706	PHED	40.70165	145
Paschim Champaran	Bagaha 2	Deoria	27.27366	84.06981	CGWB	48.47085	79.25
Paschim Champaran	Bagaha 2	Khajuria	27.22427	84.34284	CGWB	40.7652	92.24
Paschim Champaran	Bagaha 2	Ratanpurwa	27.24171	84.17092	CGWB	47.5536	65.53
Paschim Champaran	Thakraha	Jagiraha	26.77153	84.25034	PHED	14.38102	128

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