केन्द्रीय भूमि जल बोर्ड

जल संसाधन, नदी विकास और गंगा संरक्षण

विभाग, जल शक्ति मंत्रालय

भारत सरकार

Central Ground Water Board

Department of Water Resources, River Development and Ganga Rejuvenation,

Ministry of Jal Shakti

Government of India

AQUIFER MAPPING AND MANAGEMENT OF GROUND WATER RESOURCES

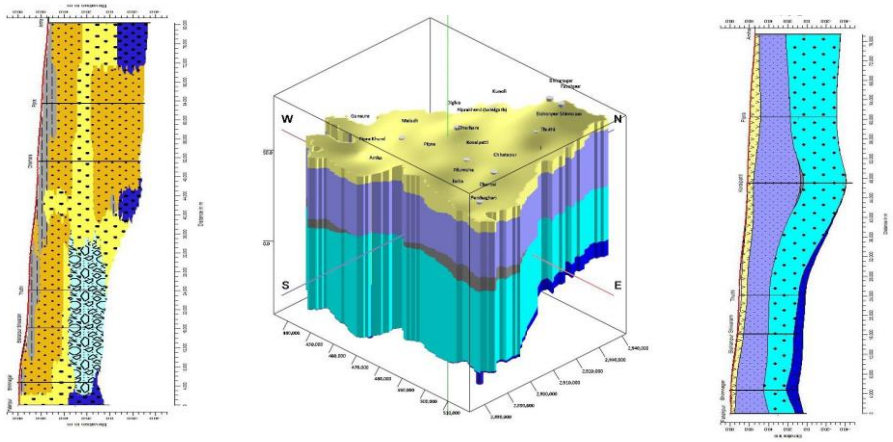
Supaul District
Bihar

मध्य पूर्वी क्षेत्र, पटना

Mid Eastern Region, Patna

राष्ट्रीय जलभृत मानचित्रण और प्रबंधन योजना
सुपौल जिला, बिहार

NATIONAL AQUIFER MAPPING AND MANAGEMENT PLAN IN SUPAUL DISTRICT, BIHAR



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Ministry of Jal Shakti Government of India

Principal Author

Sanjib Chakraborty, Scientist C

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Mid-Eastern Region, Patna-Bihar

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Contributors Page

Principal Author	***Sanjib Chakraborty, Scientist C***
Field Studies, Data collection and Analysis Preparation of thematic maps and 2D and 3D Maps ; Report compilation and preparation	Sanjib Chakraborty, Scientist C
Chemical Analysis and plot	*Manasi Bhattacharya, Sc B and Shelja Tiwari, ACH*
Other Contributions	*Vishal Srivastava, Sc- B* *Shipra Kumari , Young Professional*

CONTENTS

List of Figures

CHAPTER-1

Introduction

Bihar is one of the poorest states in India. Besides, it's long suffered dire poverty, stagnant economic growth frequent and recurrent floods for ages had been a customary phenomenon. The geographical extent of the State in the Eastern Himalayan foothills bordering Nepal, particularly the northern parts of River Ganges, popularly termed as "North Bihar" becomes the foci of the devastation of the relentless flooding. Bihar accounts for about 17% of the flood-prone area and 22% of the flood-prone population in India. As much as three-fourths of Bihar's area is flood-prone and three- fourths of north Bihar's population is under the threat of recurrent floods. Bihar's vulnerability to floods is due to its very flat topography just downstream of the steep Himalayas, intense Monsoon rains (more than 2,500mm/yr. in the upstream areas and about 1,200 mm/yr in the State, 80% during the months of June-September), high sediment loads, high population density (880 per sq.km), low-socio-economic development. The Kosi River is one of the biggest tributary of River Ganga originating from Tibet and joins the Ganges in Bihar state (India) via Nepal. Total drainage area of the Kosi River is 95156 km^2. Majority of the area comes from Tibet and Nepal (80%), and only 20% drainage area is in Indian Territory. The upper catchment (80% drainage) area is responsible for the morphological activities in the downstream reaches as it receives an average rainfall of 1,456 mm. It carries huge amount of sediment with its flow every year causing change in morphological behaviour of the river. The Kosi River is annoyingly known as the "Sorrow of Bihar. It was named "River of Sorrow" because it had caused widespread human sufferings in the past. The Kosi river from its source has built up a large fan shaped complex alluvial depositional systems, popularly known as Kosi Megafan or Inland Delta (Golle and Chittale ,1966) which has an immense impact on the alluvial sedimentation in the north Bihar plain. The present study area, Supaul District lies in the apex or in the upper and middle fan area and geomorphological, drainage, sedimentation, potentiality of ground water resources etc. by and large is influenced by the dynamics of the Kosi Megafan.

The District of Supaul had been a part of Mithilanchal since the Vedic period. The area has been referred as the fishery area (Matasya Kshetra) in the Hindu mythology. The two oldest democracies namely Angutaran and Apadnigam are known for their existence in the Buddhist era, which comprises of today's area of district Supaul. The district was carved out from the erstwhile Saharsa district on 14 March 1991.

Geo-morphologically and hydrogeologically the district is characterised by flat terrain bordering the Eastern Himalayan foothill regions. The area, although, witnesses very shallow ground water level and accounts for huge ground water potential in thick alluvial sediments , however, profusions of ground water has become a liability for the district in terms of water resource management. Consistent and periodic shift in river courses, river avulsions, abundances of paleo channels causes widespread inundations and water logging. Access to the safe, clean, good quality drinking water sources even becomes a concern to the population in the area. Therefore, effective ground water management to ascertain access to the good quality ground water for both drinking domestic as well as irrigation uses necessitate needful intervention in Ground Water Sectors.

The National Aquifer Mapping and Management Programme (NAQUIM) of Central Ground Water Board (CGWB) has been envisaged to focus on the geology , hydrogeology, aquifer disposition, occurrences , availability of ground water resources, ground water quality and to formulate effective management plan for judicious utilisation and sustainable development of water resources in the District.

Under the Annual Action Plan of 2020-21 of CGWB, MER, Patna, aquifer mapping programme and subsequent formulation of management plan were undertaken in Supaul district, Bihar. The present study includes the entire district comprising an area of 2410 sq km.

1.1 Objective

The broad objective of the study is to establish the nature and disposition of the underlying aquifer systems in horizontal and vertical domain, assessment of resource potential in respect of quantity and quality, aquifer characterization, scope for development potential and prepare management plan for drinking and domestic sectors and for agriculture activities. Therefore the objective of aquifer mapping is aimed at

- Understating the terrain conditions, geomorphology, drainage and geology of the area.
- Study of impacts of anthropological influences e.g. land use and cropping pattern agriculture and irrigation practices on ground water systems.
- Identifying the Aquifer Geometry and delineation of aquifer systems
- Study of ground water regime in long term
- Assessment of aquifer yield and potentiality
- Ground water resource assessment
- Study of ground water quality

- Preparation of aquifer maps in 2D and 3 D
- Formulation of Management Plan

The delineation of aquifers and appraisal of potentiality in long term development may facilities the administrators and the agencies to prepare the Road Map for effective intervention for sustainable development of ground water resources.

1.2 Scope of Study

The scope of the present study is broadly within the framework of National Aquifer Mapping & Management Programme (NAQUIM) being implemented by CGWB. There are four major activity components viz.: (i) Data collection / compilation (ii) Data gap analysis (iii) Data generation and (VI) Preparation of aquifer maps and management plan. Data compilation includes collection of maps, reports and information from CGWB archive and concerned agencies, such as the Survey of India, Geological Survey of India, State Government Departments etc. Identification of Data Gap includes ascertaining requirement for further data generation (hydro-geological, geophysical, chemical, hydrological, hydro-meteorological etc.) in addition to the existing data in respect of prevailing hydrogeological subsurface geological condition in the area. Data generation includes pre and post monsoon monitoring of aquifer wise water level and water quality from the existing network monitoring wells and other available feasible wells, incorporation of observation based on field studies, data collection through ground water exploration work in the study area, collection of water samples etc. Finally the subsurface dispositions of lithology and aquifer maps have been prepared and management plan has been framed.

1.3 Approach and Methodology

An approach and methodology adopted to achieve the major objective have been shown below step-wise.

i) Compilation of existing data and reports of CGWB and State Govt. Departments, Research organisations, agencies etc.
ii) Identification of data gaps
iii) Preparation and compilation of thematic maps under GIS platform (Mapinfo 9.5 and Arc Gis 10.3) referring the source data from USGS earth explorer, bhukosh@gsi.gov.in etc.
iv) Data generation through monitoring of pre and post monsoon water level from the NHNS stations and key observation wells in different aquifers, compilation of water level data from

telemetry based piezometers of Minor Water Resource Dept. , Govt. of Bihar, monitoring of water quality, preparation/ compilation of lithological logs, yield and aquifer parameter data of the boreholes of CGWB exploratory wells and the drinking water wells of PHED, Govt. of Bihar

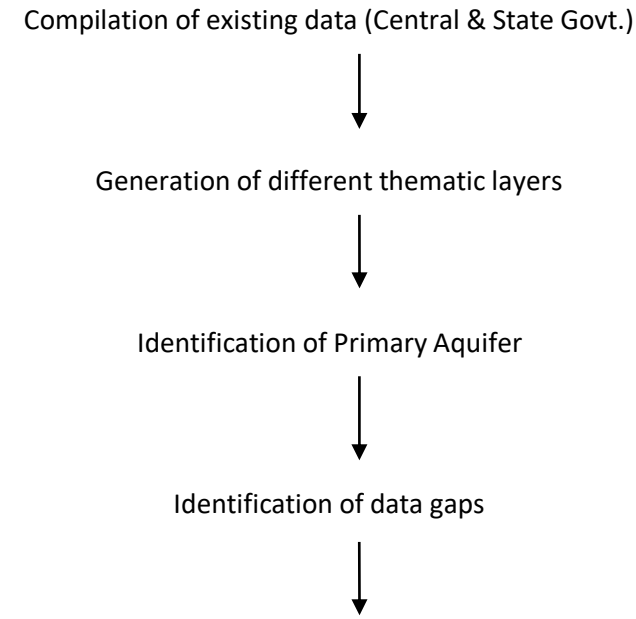
v) Identification/demarcation of individual aquifer systems in the area from the available lithologs, previous literature and observation from field studies etc.

vi) Preparation of aquifer maps, e.g. 3D and 2D disposition of lithology and aquifers under RockWorks 17 platform.

vii) Analysis of 5th Minor Irrigtaion Census Data for block wise compilation of number of STW, MDTW, DTW for assessment of existing draft for irrigation uses. Based on the available cultivable area and irrigation potential created so far (DIP Supaul, Dept. of Agriculture, Govt. of Bihar under PMKSY of Govt . of India), the further area to be brought under irrigation in the district from the available resources has been estimated and accordingly the management plan has been proposed.

viii) Assessment of water quality and feasible proposals for remedial measures.

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



Hydrochemical, hydrogeological etc.

↓

Aquifer Maps with 3D disposition

↓

Preparation of Aquifer Management Plan

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Capacity building in all aspects of ground water through IEC Activties

1.4 Area Detail/Location, Extent and Accessibility of the study area

Supaul is situated at $25^0$37'-$26^0$25' N latitude and $86^0$22' – $87^0$10' E Longitude. The district is a part of the Kosi division and covers an area of 2,410 sq km. Supaul town is the administrative headquarters of the district and is located at $86^0$36'44'' and $26^0$07'15". The district is bounded by Nepal in the north, Saharsa in the south, by Araria district in the East and on the west by Madhubani district (Fig.1). The district head quarter is at Supaul and is well connected through road and rail network with the State capital Patna. The distance between the district HQ and State Capital is 250 km.

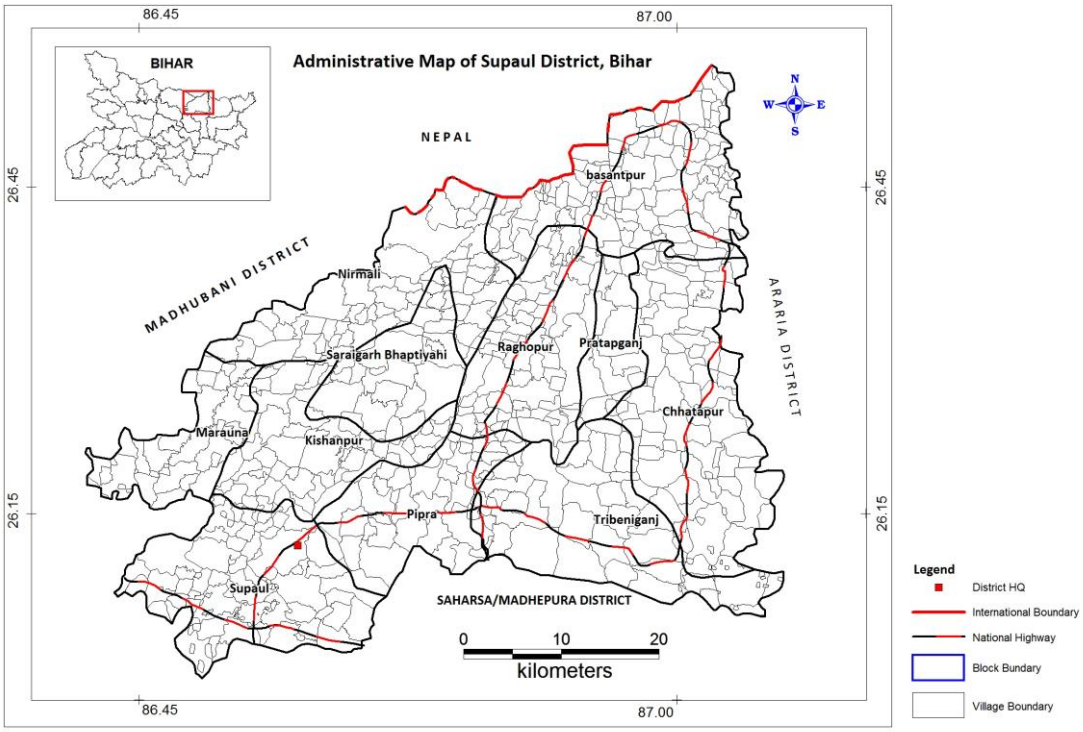


Fig. 1 Administrative Map of the Study Area

1.5 Administrative Divisions and Demographic Details:

The district comprises 4 sub-divisions: Supaul Sadar, Birpur, Triveniganj and Nirmali. Supaul sub-division consists 4 blocks: Supaul, Kishanpur, Saraigadh-Bhaptiyahi and Pipra. Birpur sub-division is further divided into 3 blocks: Basantpur, Raghopur and Pratapganj. Triveniganj sub-division has 2 blocks, namely, Triveniganj and Chhatapur, and Nirmali sub- division comprises 2 blocks, namely, Nirmali and Marauna. There are 11 administrative blocks, 177 gram panchayets, 540 villages and 418973 households in Supaul district. (Table 1.1)

Table 1.1: Major Administrative Division and Geographical Area

Block	No. of panchayats	No of villages	Geographical Area (sq. km)	Rural Area (sq km.)	Urban Area (sq. Km.)
Supaul	26	75	309.59	287.22	22.37
Kisanpur	16	44	196.69	196.69	
Saraigarh	12	39	206.41	206.41	
Nirmali	6	22	129.35	124.05	5.3
Marona	13	38	166.57	166.57	
Pipra	16	39	197.51	197.51	
Triveniganj	24	63	320.97	320.97	
Chhatapur	23	66	312.75	312.75	
Pratapganj	9	16	110.8	110.80	
Raghopur	18	58	208.09	208.09	
Basantpur	14	80	251.53	242.86	8.67
Total	**177**	**540**	**2410.26**	**2373.92**	**36.34**

Table 1.2 Population detail in the district

Block	Household	Total Population (Census 2011)	Rural	Urban
Supaul	60194	360198	294761	65437
Kisanpur	34945	167669	167669	0

Saraigarh	22626	122772	122772	0
Nirmali	16030	98435	78246	20189
Marona	29560	145136	145136	0
Pipra	39878	201399	201399	0
Triveniganj	59000	322477	322477	0
Chhatapur	57430	286456	286456	0
Pratapganj	21697	106884	106884	0
Raghopur	41516	215643	215643	0
Basantpur	36097	202007	182075	19932
Total	**418973**	**2229076**	**2123518**	**105558**

According to the census 2011, Supaul district had a population of 2, 22, 90076. The district was reported with population density of 919 inhabitants per square kilometres. Its population growth rate over the decades 2001-2011 was 28.62%. Maithali is the principal language spoken in the district, more than 75% population. The area in the district mostly as rural with more than 98% of total geographical area is classified as rural area, less than 2% comprises urban area. Supaul town, Nirmali and Basantpur comprises urban clusters in the district. 95.26% population, 2123518 persons live in rural villages on the other hand only 4.74 % live in urban area in the district which comprises 105558 people (Table 1.2)

Classification of the population on the basis of workers and non-workers shows that only 39% of the total population is the working mass for the area and rest 61% are non-workers (Table 1.3, Fig2.). Among the workers cultivators and agriculture labors together constitutes the agriculture workers which is 86 % of the total worker class. 3% constitute the households and industrial workers and 11% other workers. Therefore, workers in the district are principally dependent on agriculture

Table 1.3 Classification of workers

Block	Total workers (main + marginal workers	Cultivators	Agricultural labourers	Household industry workers	Other workers
Supaul	129202	30121	68889	3689	26503
Kisanpur	73093	17907	47067	2418	5701
Saraigarh	49824	14030	29570	1509	4715
Nirmali	37074	8510	19609	1893	7062
Marona	57994	15753	38059	1682	2500
Pipra	86923	21331	57833	1435	6324
Triveniganj	139287	34469	88829	3420	12569
Chhatapur	112993	20000	84036	2330	6627
Pratapganj	41375	9353	24879	1249	5894
Raghopur	84284	16903	55551	1933	9897
Basantpur	65633	13505	39949	997	11182
Total	**877682**	**201882**	**554271**	**22555**	**98974**

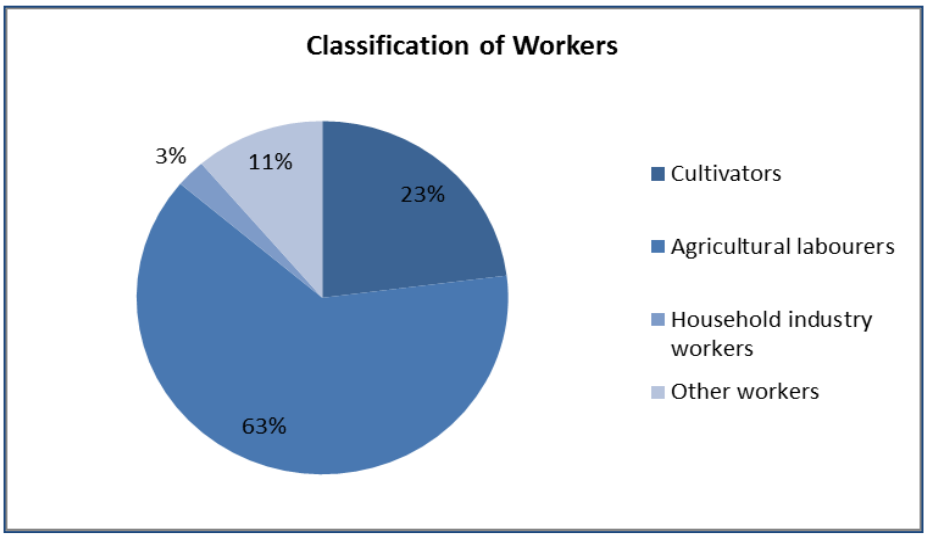


Fig.2 Classification of workers

1.6 Land use, Agriculture, Iirrigation and cropping pattern

According to R.H. Best, the term land use deals with the spatial aspects of human activities on the land and with the way in which the land surface is adapted or could be adapted,

to serve human needs. The geographical, topographical, hydro-geomorphological, socio-economic and cultural features of the district determine the suitability of its land for utilisation. Similarly factors influencing land use pattern are variable as well. The nature of the underlying soils, rainfall pattern, human factors, classes of worker etc to some extent influence the land use pattern in the area. No parts of Supaul district lies under forest area. Major area in the district is under cultivation. Net sown or the net cropped area in the district comprises 144581 ha which is 60% of the total geographical area in the district. Area under double cropped in the district is 105878 ha with average cropping intensity in the district is 175% (Table1.4, fig.3,4).

Therefore, the scope of agriculture activities in the district is favourable.

Table 1.4-: Land-use pattern in the district

(Area in ha)

S.no	Name of the Block	Gross cropped Area	Net Sown Area	Area Sown more than once	Area under Forest	Area under Wasteland	Area under other uses
1	Supaul	34475	20769	13706	0	2855	7717
2	Kisanpur	19938	12781	7157	0	1966	7163
3	Saraigarh	15049	9585	5463	0	1626	6639
4	Nirmali	9617	5592	4026	0	1238	6761
5	Marona	16926	10384	6542	0	1536	4940
6	Pipra	22877	12781	10097	0	1827	5442
7	Triveniganj	47017	21567	25449	0	2942	7781
8	Chhatapur	26823	18372	8451	0	2850	10068
9	Pratapganj	17973	7189	10784	0	983	2258
10	Raghopur	21424	14378	7045	0	1825	3837
11	Basantpur	18340	11183	7157	0	2252	11295

Source: District Irrigation Plan, Supaul

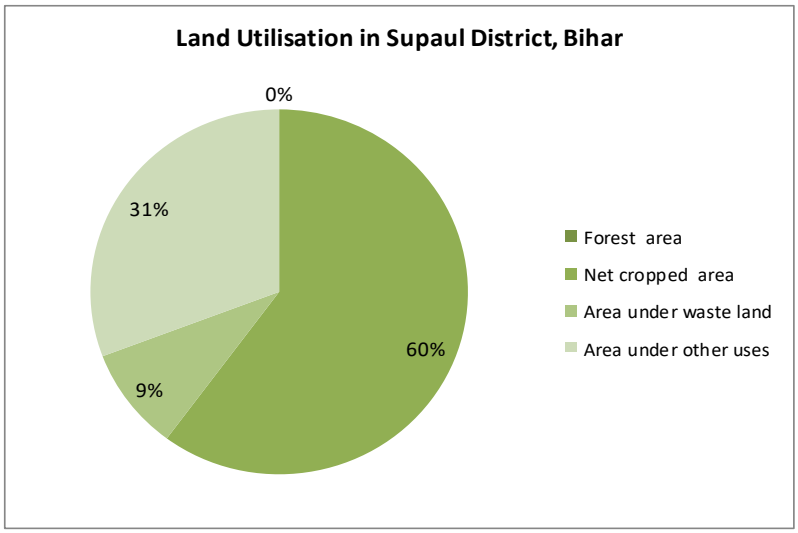
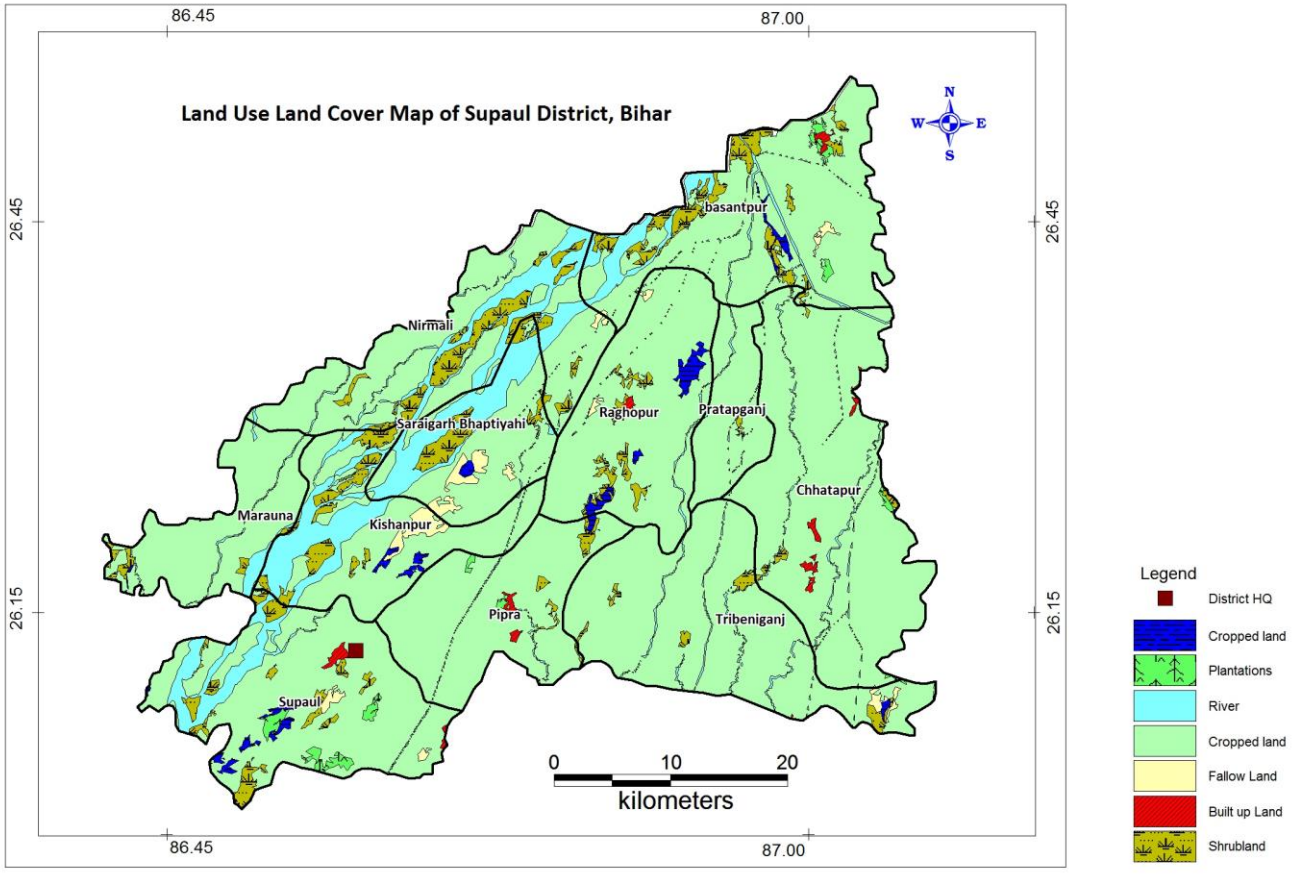


Fig.3 Land Utilizations in Supaul District



Source: earth explorer.com

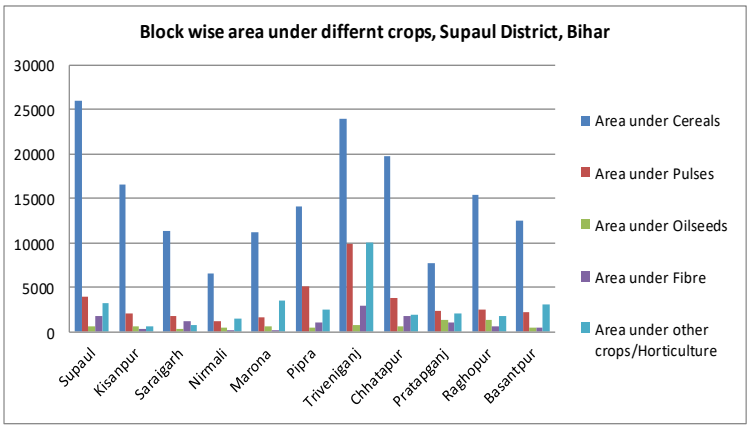
Fig.4 Land Use and Land Cover Map in Supaul District

Agriculture and Irrigation

In general, there are four agricultural seasons in one year; (i) Bhadai (ii) Aghani (iii) Rabi & (iv) Garma. During Rabi the important crops, which are grown in the district include wheat, rice, corn, mustard, jawar etc. Paddy is mainly grown during June to November. The climate allows round the year vegetable cultivation of cabbage, cauliflower, carrot, radish, chili, capsicum, beans and long beans, gourd, potato, onion, coriander, turmeric, ginger, Garlic etc. The staple cereal of this district is rice. Cereals constitutes 66% of the total cropped area followed by pulses and oilseeds of 14% and 12 % respectively (Table 1.5, fig 5). Less production of pulses, oilseeds and other crops is a concern for future in the district. Therefore, diversification of cropping pattern may increase the cropping potential in the district.

Table 1.5 Area under different crops in the district

Block	Gross Area under Cereals	Gross Area under Pulses	Gross Area under Oil seeds	Gross Area under Fibre	Gross area under other crops/ Horticulture etc.
Supaul	25942	3938	644	1786	3185
Kisanpur	16519	1985	635	338	657
Saraigarh	11331	1784	303	1144	672
Nirmali	6497	1134	454	226	1467
Marona	11224	1566	584	186	3477
Pipra	14089	5091	387	1024	2487
Triveniganj	23955	9943	710	2933	9987
Chhatapur	19698	3779	607	1700	1878
Pratapganj	7767	2291	1248	1016	2068
Raghopur	15414	2552	1317	633	1764
Basantpur	12454	2170	412	473	2998
Total	**164890**	**36233**	**7301**	**11459**	**30640**



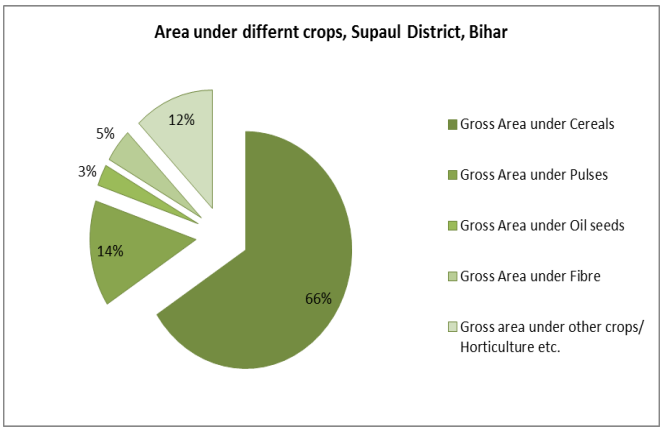


Fig.5 Area under different crops

Even though, the economy of the district is agrarian in nature, the agricultural activities to a large extent depend on rain water and kharif cultivation contributes considerable share of agriculture activities than rabi and summer crops. Total rain fed cultivation in the district is 110702 ha whereas the gross area under irrigation for different crops 139821 ha. A block wise picture of rain fed vs irrigated area in Supaul is represented in Table 1.6, Fig.6.

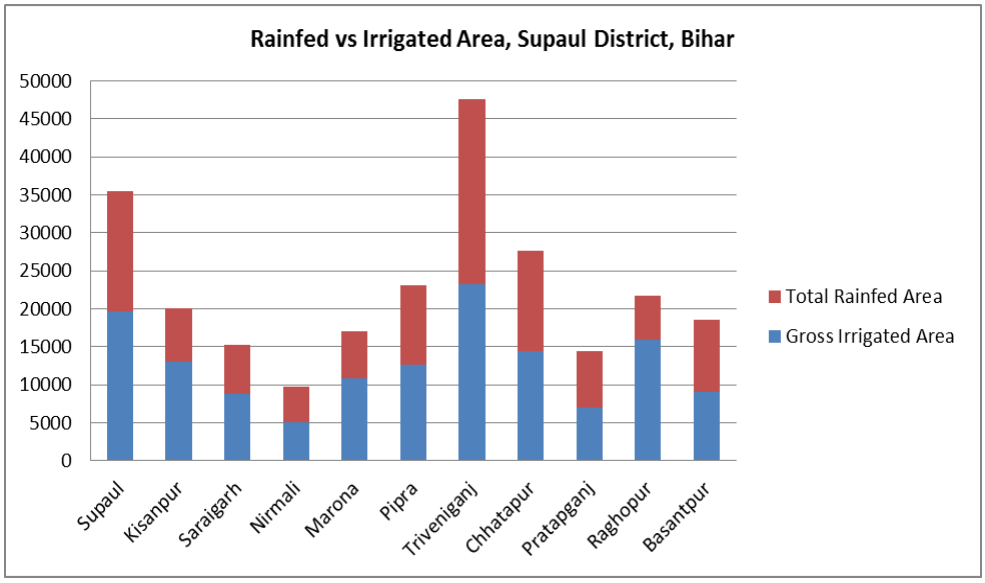


Fig.6 Rainfed vs Irrigation; A block wise representation

However, irrigation plays a vital role in the agriculture development in this district. The district being located in the eastern Kosi command area and hence, a considerable part of the irrigation in the

district is met from canal water. All the blocks except Nirmali and Marauna are well traversed with numbers of canal networks of Kosi Command area. Total developed canal command in the district is 38581.7 ha through Govt. canals. However during summer, canal system remains dry. Heavy siltation in canals has reduced the flowing capacity (Fig.7,8).

Fig7. Kosi Main Canal and Irrigation from Canal

Fig.8 Loss of flow in canals due to heavy sand deposits, a common feature in canal networks in the district.

Besides, irrigation through canal command area development, a considerable area is under irrigation coverage through minor surface irrigation networks of community tanks/ponds, Ahar-Pyne systems and by Govt. reservoirs and dams which create a command area of 1500 ha. Traditional water harvesting systems also contributes an irrigation command of 6875 ha.

In minor irrigation schemes, ground water irrigation occupies a major share, where ground water irrigation is achieved through shallow, medium and deep tube wells of either Govt. department or pvt. Shallow tube wells are commonly run by the pvt. ownerships. Since water level remains shallow and cost of making a shallow tube well is low, people try to have their own bore well in

their agriculture fields. In general, a local design of well assembly is lowered in the boreholes and in many cases bamboo with slot openings fills up the purpose in a rather shallower borehole. Most of the tube wells are within a depth of 5-20 m with their tops directly fitted with 3-5 HP diesel operated pumps (fig 9).

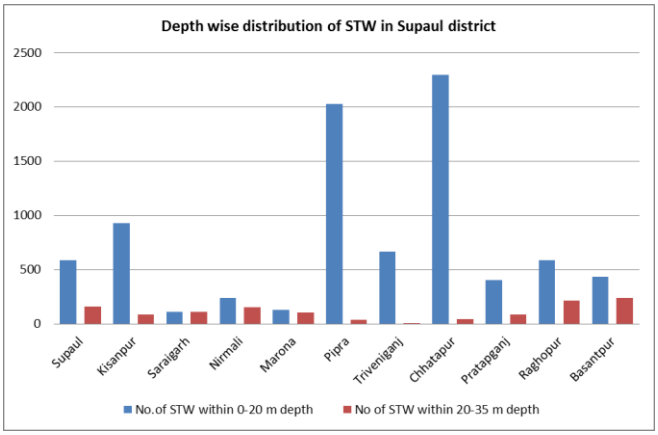

Fig.9 Irrigation from uncased shallow boreholes

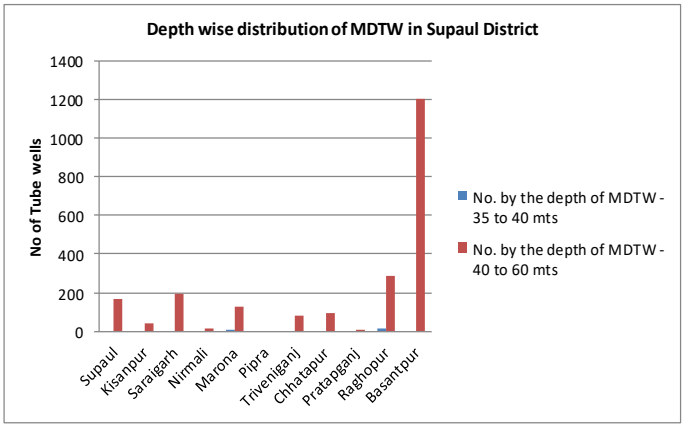
Depth class of shallow, medium and deep tube wells have been worked out from 5th MI census data. Total numbers of irrigation tube wells, shallow, medium and deep as per the census data is 11897. Among which more than 70% lies within the depth of 0-20 m bgl. The remaining are within the depth of 60 mbgl. Deep tube wells of more than 100 m depth are rare for irrigation uses. Chhatapur and Pipra block are reported with more than 2000 STW within 20 m depth, whereas Basantpur block is reported with maximum number of MDTW (1208) within the depth of 40-60 mbgl (Table 1.6, fig.10).

Table 1.6 Block wise distribution of Irrigation Tube Wells as per 5th MI census Data

District	Block	No. by the depth of Shallow Tubewells - 0 to 20 mts	No. by the depth of Shallow Tubewells - 20 to 35 mts	Total no of STW	No. by the depth of MDTW - 35 to 40 mts	No. by the depth of MDTW - 40 to 60 mts	No. by the depth of MDTW - 60 to 70 mts	Total no of MDTW	No. by the depth of DTW - 110-150 mts
Supaul	Supaul	588	156	744		165		165	
	Kisanpur	929	86	1015		41		41	
	Saraigarh	113	113	226		196	1	197	
	Nirmali	237	152	389		16		16	
	Marona	128	103	231	1	130		131	
	Pipra	2024	35	2059				0	
	Triveniganj	666	5	671		80		80	

	Chhatapur	2295	40	2335		95		95	13
	Pratapganj	404	88	492		10		10	
	Raghopur	585	213	798	11	288		299	
	Basantpur	436	240	676		1208		1208	6
Total		**8405**	**1231**	**9636**	**12**	**2229**	**1**	**2242**	**19**





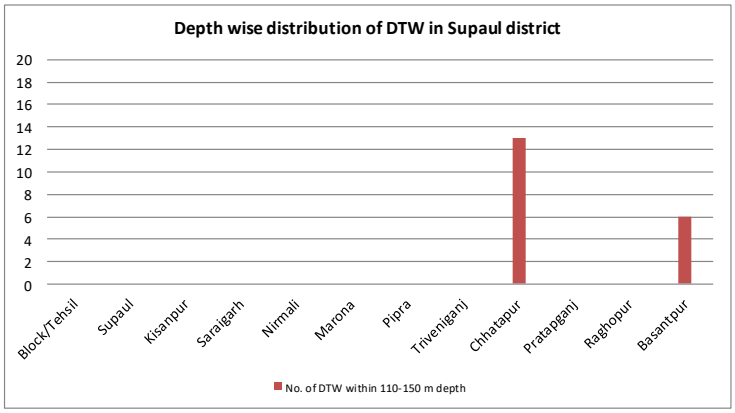


Fig.10 Depth wise Distribution of Irrigation Tube wells in Supaul district, Bihar

Net sown area stands at 60 % of the total geographical area of the district. However, 44 % of total geographical area, that is, 73% of net sown area is put under double cropped area. Tribeniganj, Pratapganj, Pipra and Nirmali blocks is reported with high agriculture intensity with 218%, 250%, 179% and 172 % respectively. The average cropping intensity in the district is 175%. The state average cropping intensity is around 140%. As far as the irrigation intensity is concerned, the district possesses a better status in comparison to the state. Raghopur, Kishanpur, Marauna and Kishanganj blocks show irrigation intensity of 75 to 65%, the average is around 56%. Irrigation intensity is a measure to compare gross irrigated area wrt to the gross cropped area (Table 1.7, fig 11).

Table1.7. Status of Cropping and Irrigation development in Supaul district

Block	Geographical Area	Net Cropped Area	Area sown more than once	Gross cropped Area	Gross Irrigated Area	Cropping Intensity	Irrigation Intensity
Supaul	31340	20768.5	13706.39	34474.89	19669	166	57
Kisanpur	21910	12780.64	7157.15	19937.79	13001	156	65
Saraigarh	17850	9585.48	5462.97	15048.45	8798	157	58
Nirmali	13590	5591.53	4025.9	9617.43	5106	172	53
Marona	16860	10384.27	6542.09	16926.36	10874	163	64
Pipra	20050	12780.64	10096.7	22877.34	12695	179	55
Triveniganj	32290	21567.33	25449.44	47016.77	23199	218	49
Chhatapur	31290	18372.17	8451.19	26823.36	14425	146	54
Pratapganj	10430	7189.11	10783.66	17972.77	6959	250	39
Raghopur	20040	14378.28	7045.26	21423.54	15973	149	75
Basantpur	24730	11183.06	7157.15	18340.21	9122	164	50
Total	**240380**	**144581.01**	**105877.9**	**250458.91**	**139821**	**175**	**56**

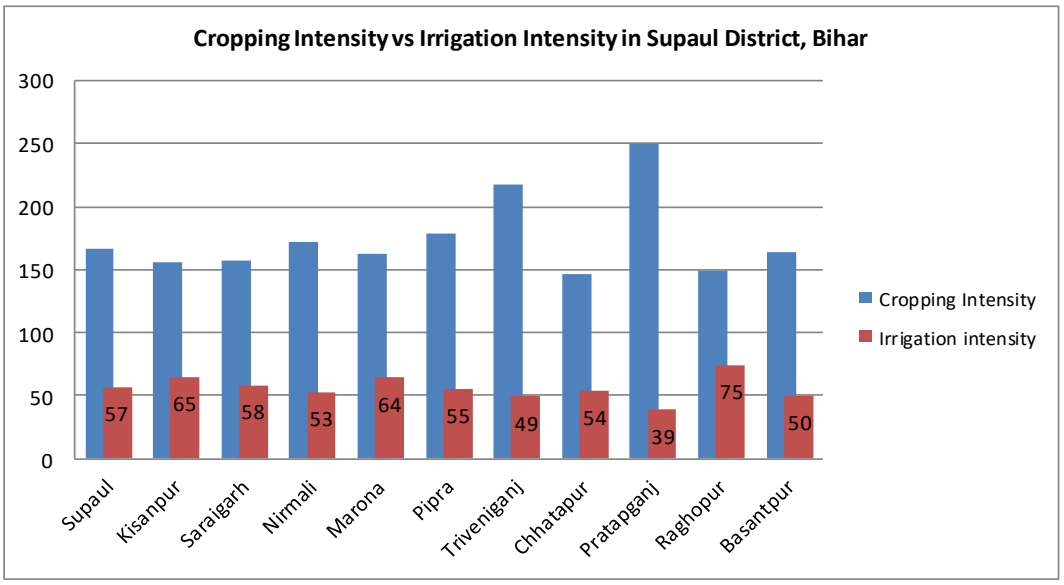


Fig.11 Cropping and Irrigation Intensity in Supaul district, Bihar

Table 1.8 Rainfed and Irrigated area for different crops in the district.

Area in ha

Block	Cereals		Gross Area under Cereals	Pulses		Gross Area under Pulses	Oil Seeds		Gross Area under Oil seeds	Fibre		Gross Area under Fibre	Any other crops/ Horticulture etc.		Gross area under other crops/ Horticulture etc.
	Irrigated	Rainfed		Irrigated	Rainfed		Irrigated	Rainfed		Irrigated	Rainfed		Irrigated	Rainfed	
Supaul	14527	11415	25942	2205	1733	3938	360	284	644	1000	786	1786	1577	1608	3185
Kisanpur	10735	5784	16519	1290	695	1985	412	223	635	219	119	338	345	312	657
Saraigarh	6580	4751	11331	1034	750	1784	176	127	303	663	481	1144	345	327	672
Nirmali	3434	3063	6497	599	535	1134	240	214	454	119	107	226	714	753	1467
Marona	7183	4041	11224	1001	565	1566	374	210	584	119	67	186	2197	1280	3477
Pipra	7747	6342	14089	2816	2275	5091	213	174	387	563	461	1024	1356	1131	2487
Triveniganj	13421	10534	23955	3655	6288	9943	374	336	710	996	1937	2933	4753	5234	9987
Chhatapur	10044	9654	19698	1926	1853	3779	310	297	607	867	833	1700	1278	600	1878
Pratapganj	4181	3586	7767	762	1529	2291	358	890	1248	364	652	1016	1294	774	2068
Raghopur	11405	4009	15414	1888	664	2552	976	341	1317	496	137	633	1208	556	1764
Basantpur	6123	6331	12454	1062	1108	2170	201	211	412	231	242	473	**1505**	1493	2998

Table 1.9 Status of Irrigation Development in Supaul District

Sl no	Name of Block	Source of Irrigation	Surface Irrigation (1)					Ground Water (2)						Other sources including traditional WHS
			Canal Based		Tanks I Ponds I Reservoirs/Ahars Pynes			Tube well		Open wells		Bore well		
			Govt. Canal	Comm unity /Pvt. Canal	Community ponds including small	Individual /Pvt.Po nds	Govt. reserv oir / Dams	Govt.	Pvt.	Communi ty / Govt.	Pvt.	Govt.	Pvt.	
1	Supaul	Number	2	0	0	157	27	3	0	5	25	0	1339	2
		Command Area (ha)	6230.7	0	0	24	12.66	10	0	0	0	0	5359	1292
2	Kisanpur	Number	3	0	0	105	34	4	0	6	34	0	916	2
		Command Area (ha)	3834.3	0	0	44	20.4	10	0	0	0	0	3664	383
3	Saraigarh	Number	2	0	0	130	20	6	0	45	50	0	605	3
		Command Area (ha)	2875.7	0	0	50	21	10	0	0	0	0	2414	596
4	Nirmali	Number	0	0	0	67	37	0	0	5	12	0	766	3
		Command Area (ha)	0	0	0	24	42.9	0	0	0	0	0	3066	348
5	Marona	Number	0	0	0	52	21	0	0	15	8	0	1448	3
		Command Area (ha)	0	0	0	18	7.9	0	0	0	0	0	5793	645
6	Pipra	Number	6	0	0	161	51	6	0	32	48	0	818	4
		Command Area (ha)	3834.3	0	0	61	18.1	10	0	0	0	0	3246	796

Sl no	Name of Block	Source of Irrigation	Surface Irrigation (1)					Ground Water (2)						Other sources including traditional WHS
			Canal Based		Tanks I Ponds I Reservoirs/Ahars Pynes			Tube well		Open wells		Bore well		
			Govt. Canal	Comm unity /Pvt. Canal	Community ponds including small	Individual /Pvt.Po nds	Govt. reserv oir / Dams	Govt.	Pvt.	Communi ty / Govt.	Pvt.	Govt.	Pvt.	
7	Triveniganj	Number	6	0	0	157	46	6	0	22	56	0	1414	4
		Command Area (ha)	6470.1	0	0	52	115.22	0	0	0	0	0	6140	647
8	Chhatapur	Number	4	0	0	96	33	4	0	8	54	0	1378	2
		Command Area (ha)	5511.6	0	0	38	223	20	0	0	0	0	5514	130
9	Pratpganj	Number	3	0	0	27	2	0	0	6	22	0	465	5
		Command Area (ha)	2156.7	0	0	9	1.96	0	0	0	0	0	1861	447
10	Raghop ur	Number	3	0	0	181	94	4	0	20	96	0	900	4
		Command Area (ha)	4313.4	0	0	72.4	64.08	0	0	0	0	0	3606	895
11	Basantpur	Number	5	0	0	77	8	22	0	13	84	0	576	2
		Command Area (ha)	3354.9	0	0	31	523	50	0	0	0	0	2307	696
	Total		38581.7	0	0	423.4	1050.22	110	0	0	0	0	42970	6875

1.7 Climate and Rainfall

The area has warm and humid climate with high temperature and medium to high rainfall. The temperatures are lowest during December-January with an average minimum of 8^0C to 10^0C and maximum of 24^0C to 25^0C. The temperatures in the hottest months of April to June are minima 23^0C to 25^0C and maxima 35^0C to 38^0C. The normal annual rainfall for the district stands at 1404 mm. Most of the rainfall (80% to 90%) is received during July to September (Fig.12).The late September-October rains (locally known as 'Hathia') are very crucial to agriculture in the region and their timing and distribution make all the difference between plenty andscarcity.

The long term rainfall analysis in the area reveals that after 2000 there was a decline of total annual rainfall.

Table 1.10: Rainfall distribution in the district in last six years

Year/Month	2014	2015	2016	2017	2018	2019
January	0			0		2.46
February				0		23.4
March		50.9	24.8	3.65		5.73
April		3.8	29.4		10.7	80.7
May	61	39.7	109.9	1.36	22.1	40.4
June	81	104.2	229.2	145	132	168
July	226	138.6	317.6	452	337	464
August	299.2	191.8	138.2	461	225	118
September	168.1	131.4	437	137	149	490
October	55.4	13.9	80.8	27.6	19	5.39
November						
December					4.33	3.31
Total	**890.7**	**674.3**	**1366.9**	**1227.61**	**899.13**	**1401.39**

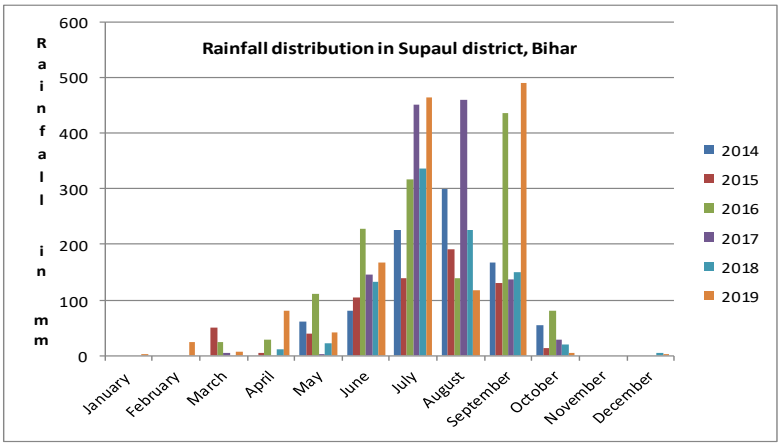


Fig.12 Rainfall distribution in last six years in Supaul district, Bihar

1.8 Geomorphology

Geo-morphologically the district is represented by two distinct geomorphic surfaces i.e, Purnea surface represented by older flood plain and Diara surfaces represented by younger alluvial plain and present day deposits. Besides, paleo-channels, active flood pain, channel bar deposits, point bar sedimentation, meander scars, oxbow lakes etc constitute other geomorphic landforms (Fig13). The geomorphic features typical of river shifting, migration and flood plain area are predominant in the district. However, the geomorphic landforms in the district to a large extent are influenced by the mighty Kosi River hydrology and basin movements/neo tectonic activities which are discussed subsequently.

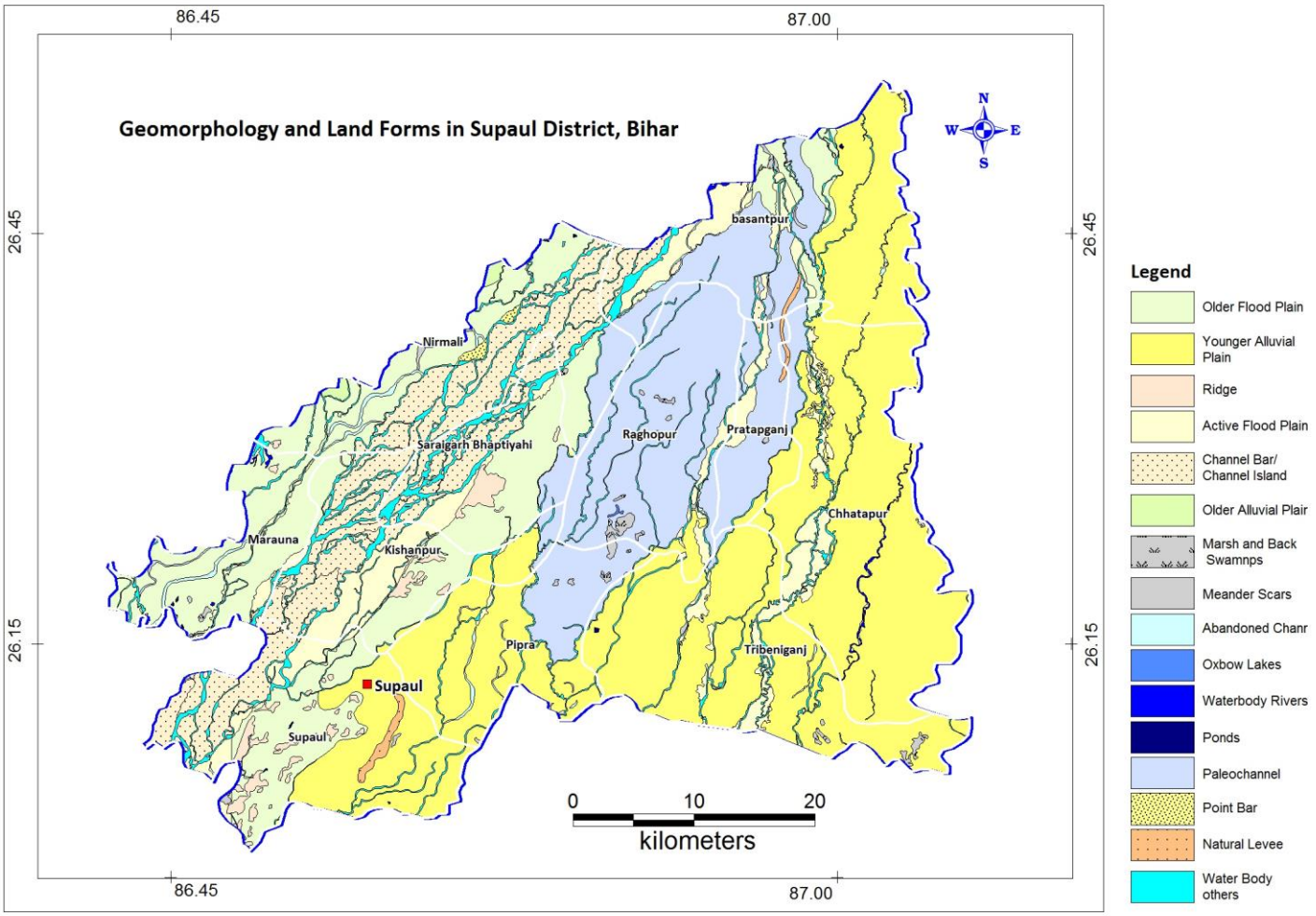


Fig.13 Geomorphic Landform in Supaul District, Bihar

The area represents more or less flat topography with land slope from north east towards south west parts of the district. The maximum elevation is around 98 mamsl in the northern parts

and minimum is around 40 mamsl (fig.14). The slope map of the district has been generated from DEM data, under ArcGis platform using spatial analyst tool revels that the entire district represents land slope of 1-2% to 2-3% (fig15).

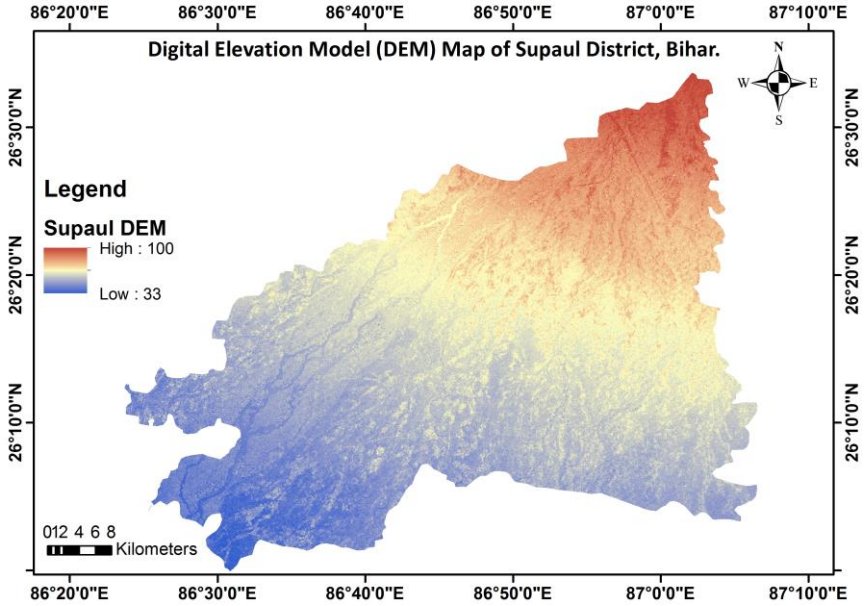


Fig.14 Elevation Map in Supaul District, Bihar

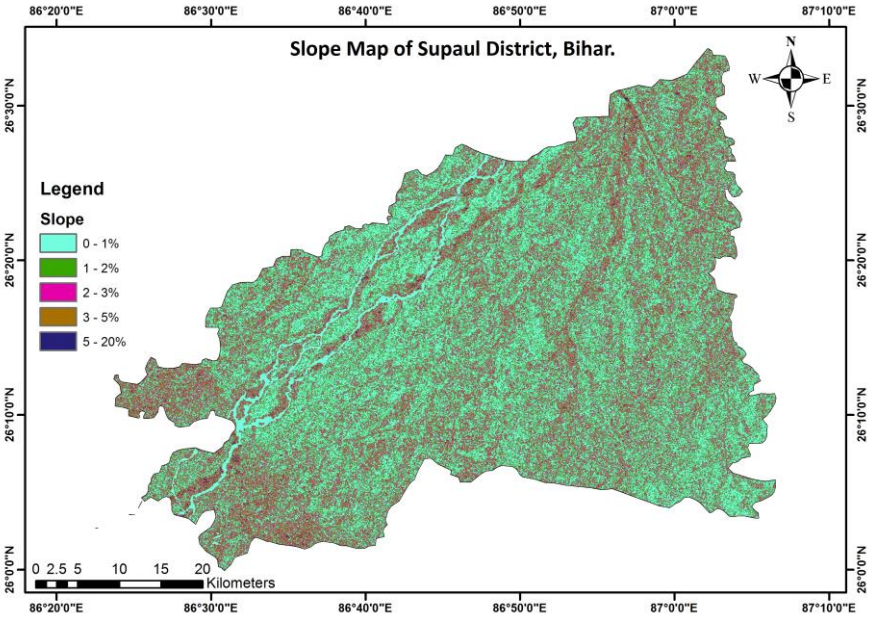


Fig.15. Slope Map of Supaul District, Bihar

1.9 Drainage

The district forms a part of the Kosi basin. The North Bihar Plains are mainly characterized by fan (megafan) and interfan areas. In the west of the Supaul district lies the Gandak Megafan, whereas in the east lies the Kosi megafan. The entire area of the Supaul district forms a part of the Kosi megafan. The Kosi river originates from upper and middle Himalayan ranges with large

catchments in Tibet and Nepal, carries huge sediment load and on its merge with the flat lands the debouching of sediments tend to create a huge cone or fan shaped alluvial deposits of considerable areal extent popularly known as Kosi Mega fan. This are also termed as inland delta. The active Kosi River flows in the extreme western parts of the district. Siwaliks in the foothills of the Himalayas form the northern boundary of the megafan. The reach segment of the Kosi River within the district Supaul is wide (6 to 8 km) and highly braided in nature. Huge sedimentation load in the river along with neo-tectonic activities in the region causes frequent shifting of the river course from east towards west to the present day location of the river Kosi. A number of old channel beds of the river are traceable in Supaul district. The district Supaul is subjected to frequent flooding related to either shifting of the river Kosi or bank over-topping/breaching by floodwater. Thus, over-bank sedimentation is a common phenomenon in the district, though; it has been decreased after the construction of the eastern embankment.

Kosi river has an exceptionally high sediment yield of 0.43 million tonnes/year/km^2 which is accommodated in a very narrow alluvial plains almost one-fifth of the upland area. This has resulted in predominantly aggrading channels of the Kosi and building up of a very large positive topography called Mega fan. Most analysts agree that the confinement of the Kosi within the embankment further worsened the situation and has caused significant aggradation within the channel belt. Kosi River shows a large braided network of streams of various orders of magnitudes. Its (i) large dimension, (ii) multi-threads morphology, (iii) sandy bed, and (iv) avulsive behaviour make it very important to understand the sediment dynamics and propose a management strategy. Kosi River shifts laterally over the Himalaya foreland plain by continual minor cut-offs, bank cutting and by episodic major shifts across watersheds. Migration is unidirectional because after a channel is filled to instability, floodwater will drain preferentially into a new adjacent low area rather than across it to the next watershed or back to the last abandoned channel. Records show that between year 1736 and 1953 the river moved through a distance of about 112 Km. westward till its course was confined through jacketing by constructing embankments on both the banks. The historic shift is shown in fig 16.

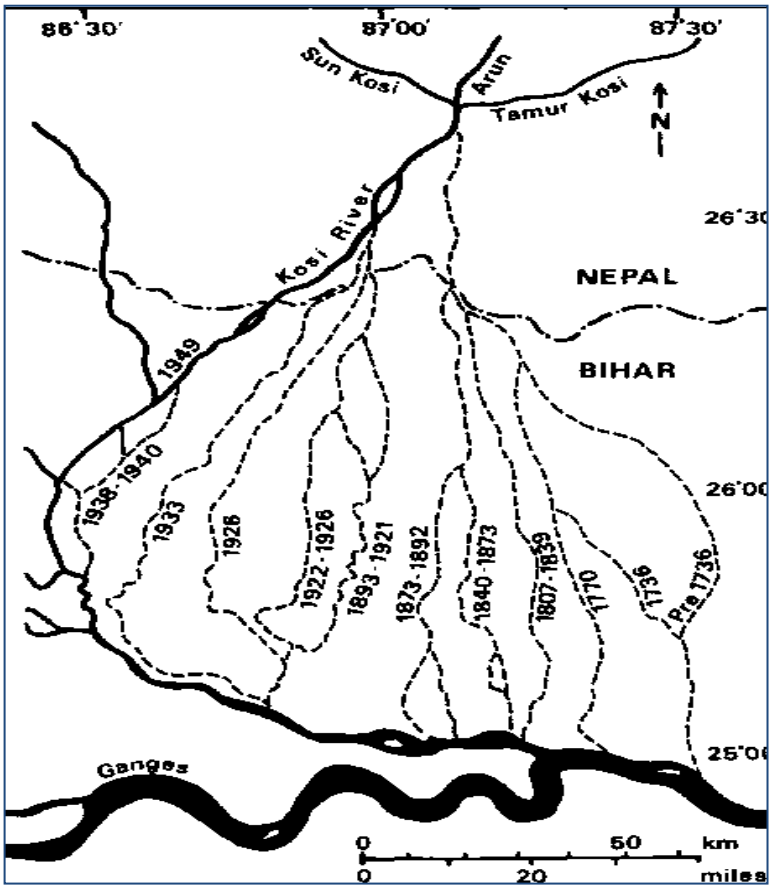


Fig.16 The record since 1731 showing the westward shifting of the Kosi River by channel avulsion. The river has maintained the course of the river through the western parts of Supaul district since 1950. The figure also shows the course along which the river was flowing due to bank breach at Kusaha, Nepal and causing large scale devastation in the downstream parts.

The Kosi River, an important northern tributary of the Ganga River and Tilyuga Chhaimra, Kali, Tilawe, Bhenga, Mirchaiya, Sursar are the tributaries to it. The river has remained dynamic from historic parts and as such few paleo-channels of the river are traced in the district. Mis-fit channels with significant drainage during monsoon flow across the district towards south. Besides, major rivers, the drainage map has been prepared from DEM data using spatial analyst tools in Arcgis platform and ultimately numeric ordering of streams has been depicted (fig.17). In Supaul district, stream order from 1st to 3rd is identified. The higher order stream coincides with the major rivers in the district.

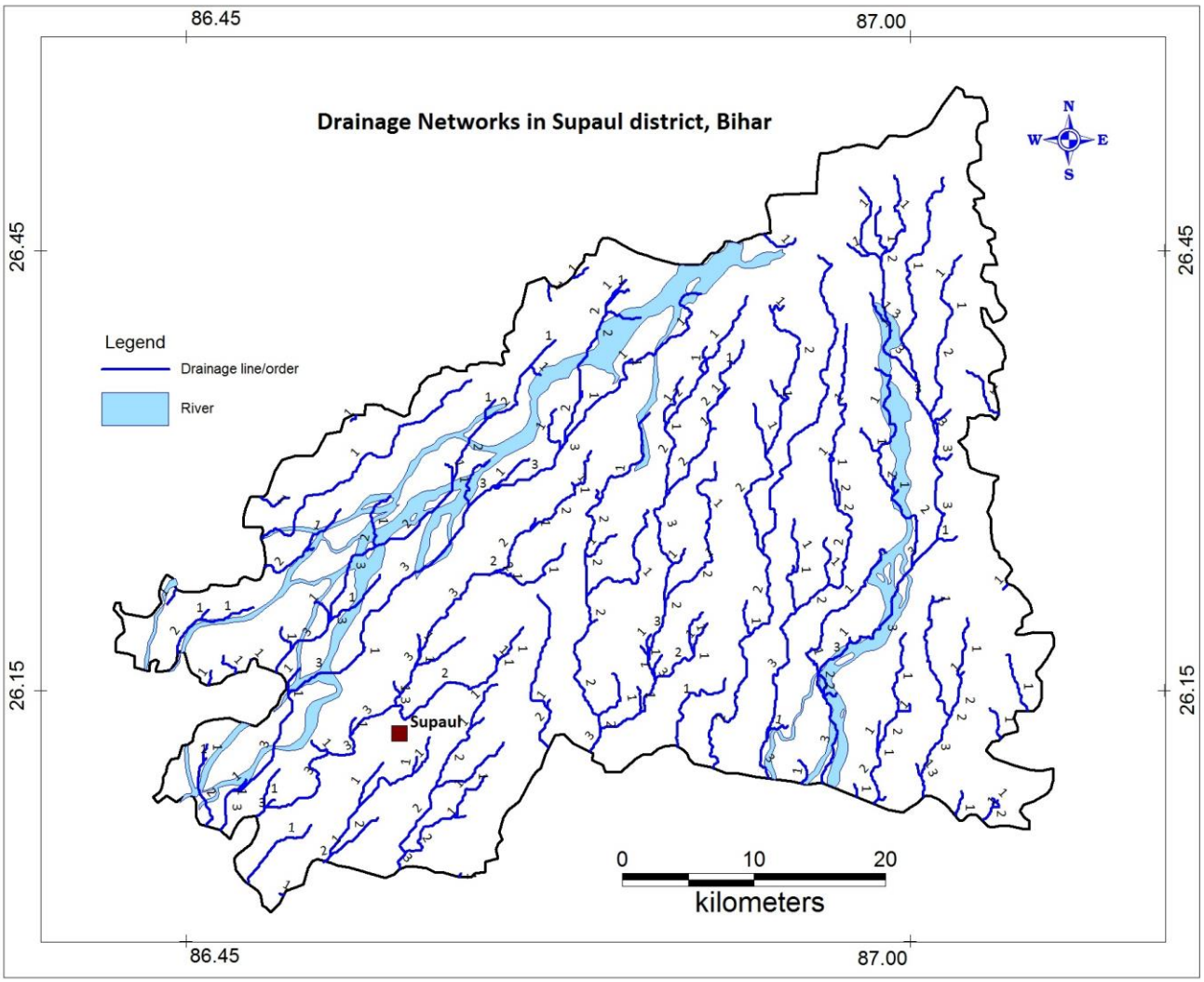


Fig.17 Drainage map in Supaul District, Bihar

1.10 Soil Characteristics

The district in general possesses alluvial soil. The soils are of poorly drained type. The areas close to the Kosi channels possess soil types of sandy loam, loamy sand and sand character, whereas, the areas away from the river channels consist of silty sand to sandy silt in nature. The soils in general are fine textured away from the river course and rivulets and coarse textured along their courses. Nature of the soil is the function to support the growth of agricultural and horticultural crops. Soil is the mainstay of agriculture and horticulture, forming as it does the medium in which growth and ultimately the yield of food producing crops occurs. Farmers and gardeners have worked with their soils over many centuries to produce increasing amounts of food to keep pace with the needs of a burgeoning world population. The soil's natural cycles go a long way in ensuring that the

soil can provide an adequate physical, chemical and biological medium for crop growth. The farmer and horticulturalist have also become skilled in managing soils so that these natural cycles can be added to as necessary to facilitate adequate soil support and increasing yield to enhance production.

Table 1.11 Nature and types of Soil

Sl. No.	Name of Block	Soil Type	
		Major Soil Classes	Area (ha)
1	Supaul	sandy loam	31340
2	Kisanpur	sandy loam	21910
3	Saraigarh	sandy soil	17850
4	Nirmali	sandy soil/sandy loam	13590
5	Marona	sandy loam/loam	16860
6	Pipra	sandy loam	20050
7	Triveniganj	sandy loam/loam	32290
8	Chhatapur	sandy soil	31290
9	Pratapganj	sandy soil/sandy loam	10430
10	Raghopur	sandy soil	20040
11	Basantpur	sandy soil	24730
		Total-	240380

Source: DIP, Supaul

1.11 General and Local Geology

The entire Ganga plain covering the northern part of the distrct is mostly underlain by considerably thick fluvial sediments of variable thickness, belonging to Quaternary age bordered by Siwalik group of rocks (Eocene period) in the north. The southern boundary of this vast plain is with plateau comprising formations belonging to Proterozoic period. Isolated patches of formations of Gondwana system are seen at places. The Siwalik succession constituting the southern slopes of Himalayan foothills provide a vital link of the reconstruction of geological history of Ganga basin.

In the vicinity of foothill, the Quaternary sequence lies un-comfortably over the Siwalik formations. It slopes southerly and is texturally dominated by pebble, cobble and boulders in sandy/silty matrix along with inter-bedded sand, silt and clay of variable thickness. Such gravel pebble zone commonly known as Bhabar belt and falls outside the project area.

The grain size considerably reduces in down slope direction. The bulk of Ganga alluvium present in the project area consists of thick pile of unconsolidated sediment comprising multi- cyclic sequence of finer clastic, gradually fining upwards. The exact thickness of alluvial sediments is still

unknown, but may be few hundred meters. The recent studies of Oil and Natural Gas Commission, both geophysical and exploratory drilling has indicated the thickness of Quaternary alluvial sediments around 300 to 400 m, underlain by Siwalik sediments.

The Geological Survey of India have identified 5 broad geological domain with different geological character over north Bihar plain viz. (1) Kosi – Mahananda belt (2) Kosi –Gandak interfluve belt (3) Gandak – Ghaghra doab (4) Ganga meander and (5) South Ganga Plain. The study area forms a part of Kosi – Mahananda belt. The older Quaternary units are exposed along narrow belt in the vicinity of Himalayan belt exhibiting distinct angular unconformity with underlying Neogene sediments. These sediments are limited to the extreme north– western corner of North Bihar.Local stratigraphic sequence /geological successions of Supaul district is given in Table 1.12.

The entire district is covered under Quaternary sediments of Pliestocene to late Holocene age and as per the nature of sediments and depositional age the sediments are classified in four Formations named as per their type area, these are Hazipur formation of pliestocene age, followed by Purnea , Kosi and Diara Formation. The Diara formation is the youngest, present day deposits. Hazipur formation is exposed in the north western parts of the district for limited areal extent constitutes older alluvium deposits (Fig.18)

Table 1.12 Geological Succession in Supaul district, Bihar

Stratigraphic Units	Lithology	Geomorphic landforms	Age
Diara Formation	Loose sand, silt loam and their admixtures	Flat or gentle slope, unconsolidated sediments, mostly inundated in rainy seasons	Late Holocene to Recent
Kosi Formation	Un-oxidized, gray, clayey silts and sandy silts or silty clay	Flat or gentle slope, unconsolidated sediments, prone to flooding in rainy seasons	Holocene
Purnia Formation	Feebly oxidized, brownish ,silty sands and sandy silts or clayey sands	Isolated undulated land-form in the vicinity of paleochannel, mainly barren land	Holocene
Hazipur Formation	Oxidized brownish yellow silty clay with caliche	Unconsolidated compact sediments	Pliestocene to early Holocene

Source DRM Map, GSI

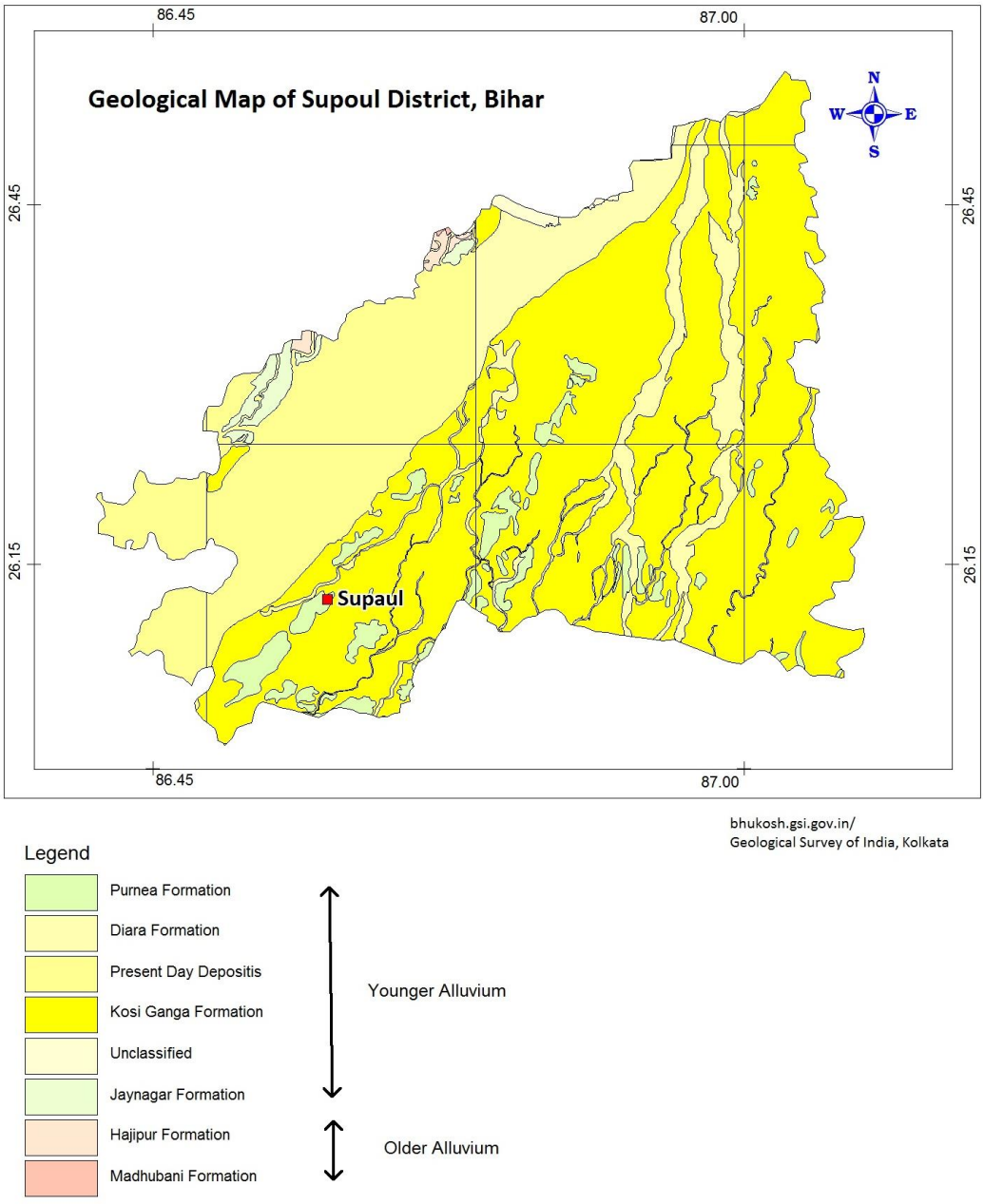


Fig.18 Geological Map of the Study Area

1.12 Sub-Surface Geology

The subsurface geology of the area has been unearthed from the lithological data of the bore holes of PHED, Govt. of Bihar. Under the rural drinking water supply schemes of Govt. of Bihar number of tube wells have been constructed by PHED in each block. However, depth of these wells is restricted within 100 mbgl. Few lithologs of the bore holes across the district has been studied, compiled and utilized for preparation subsurface lithological disposition in the district.

The area is underlain by thick unconsolidated sediments of Quaternary age consisting of sands of various grades, gravels, cobbles, pebbles etc. up to the explored depth of 100 mbgl. The

clay capping is thin (< 1 m to 5 m) and even absent at many places. Though in general clay/mud capping is present at places in Supaul district, sands in many instances are lying exposed. This makes the aquifer unconfined. From the distribution pattern of formations, the whole area can be considered to be a single aquifer system to the depth of 50-100 m.

The detail subsurface geology has been discussed in chapter 3 in this report.

CHAPTER-2

Data Collection and Generation

2.1 Hydrogeology

In general, the Kosi megafan shows two major formations (Singh et al., 1993); the upper formation is of 8-10 m thickness (less commonly from 16 to 40 m) and is composed typically of fine sand and mud, whereas the lower formation is thicker (> 60 m within the explored depth of 100 m). The lower formation is in general composed of medium to coarse sand to gravel. The lower formation is thought to have been deposited by a highly braided Kosi River during the Late Quaternary. The upper formation represents the sequence of strata deposited by the Kosi during the latest sweep across the megafan from east to west. The upper formation forms the younger alluvium, while the lower one is thought to belong to an older sequence.

Though, in general, thin clay/mud capping is present over the upper formation in Supaul district, however the clay is not persistent and is mainly found as surface soil in major parts of the district. Therefore, the shallower aquifers, which are often developed by dug wells and shallow wells, are in phreatic condition. The underlying granular materials, by and large, is connected to the upper aquifers in absence of significant thick separating clay layers. Broadly, the aquifers in the district within the depth range of 100 m is dominantly constitutes a single aquifer system.

2.2 Ground Water Regime, Water Table, Ground Water Movement

Depth to Water Level

Ground water development in the district is accomplished by dug wells, shallow bore/ tube wells within the depth of 10-15 mbgl. Below 15 m depth shallow tube wells and medium tube wells are major ground water abstraction structures for irrigation uses. These are restricted within 60-70 m depth. Besides that, private hand pumps for domestic uses and drinking water tube wells of PHED, Gram Panchayets etc. are commonly used in the district. The maximum depth of the drinking water tube wells of PHED are reported as 80-100 mbgl.

To study the ground water regime of prevailing aquifer system in the study area, under the data generation activity of the NAQUIM , about 63 observation wells representing shallow parts and deeper parts of the alluvial aquifer have been monitored during the pre and post monsoon period (fig.19). The shallow wells are the private dug wells (NHNS wells) and the inventoried key observation wells under NAQUIM study. The deeper observation wells drinking water tube wells of PHED, Govt. of Bihar and piezometers of Minor Irrigation Departments, Govt. of Bihar. The maximum depth of the dug wells are within 10 m bgl. The piezometers of

Minor Irrigation department, Govt. of Bihar, lie at the depth of about 50 mbgl. The drinking water tube wells of PHED, Govt. of Bihar generally lies at 80-90 m depth. These two are grouped together to represent the depth of ground water level from the deeper parts of the alluvial sedimentation. Pre and post monsoon depth to water level maps of dug well zones and deeper parts of the aquifer (for PZ and DTW) wells have been prepared to portray water level behavior of the aquifer zones within 100 m depth.

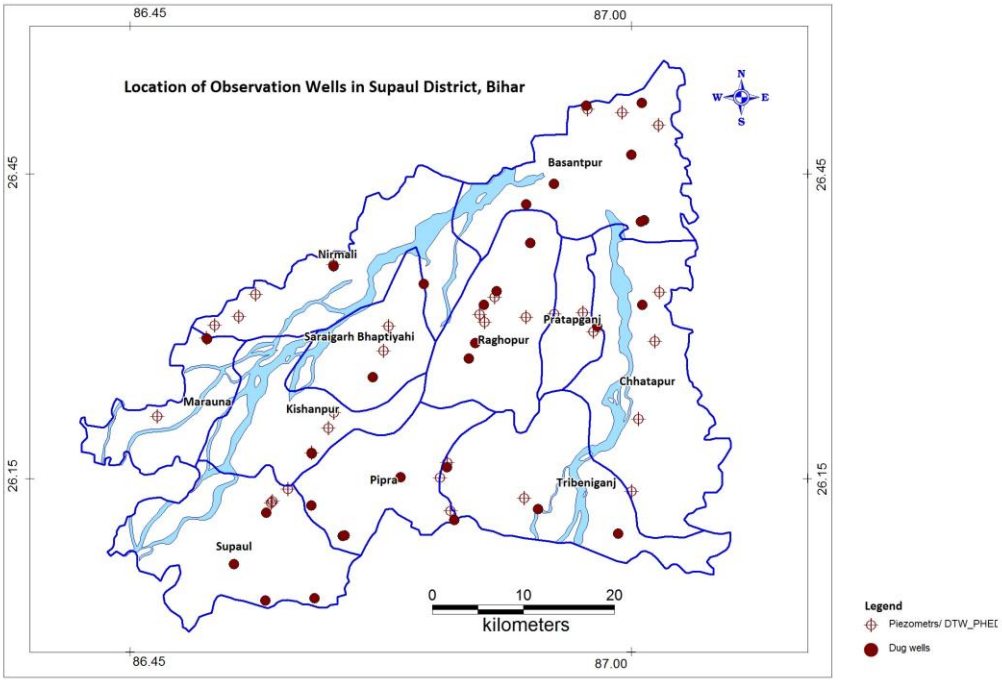


Fig.19 Distribution of Observation wells

Premonsoon depth to water level map of the dug well zone reveals average water level of 3.01 mbgl and post monsoon average water level at 2.12 mbgl. The water level is comparatively shallower in the northern and in north western part of the district. Whereas, the premonsoon water level as measured from the piezometers and the tube wells of PHED show average water level at 3.00 mbgl and post monsoon average water level at 1.59 mbgl. Therefore, the dug wells zone and the drinking water tube wells/pz zones in Supaul district represent similar ground water regime in terms of depth to water level. During the pre-monsoon time majority of the area is under water level within 3-5 mbgl. Comparatively deeper water level in Pipra, Raghopur, Tribeniganj, Chhatapur etc. may be reflection of more development through irrigation tube wells in the area. Similarly, the post monsoon water level in major parts of the district is shallower and lies within 0-2 mbgl (Fig.20-23)

Ground water level fluctuation, (pre-post, fig.24) of the aquifer system (both dug well and pz/ Tw zones) reflects more or less uniform and moderate fluctuation of 0-1 m and 1-2 m in the

major parts of the area. However, fluctuation of more than 2 m has been reported in small isolated area.

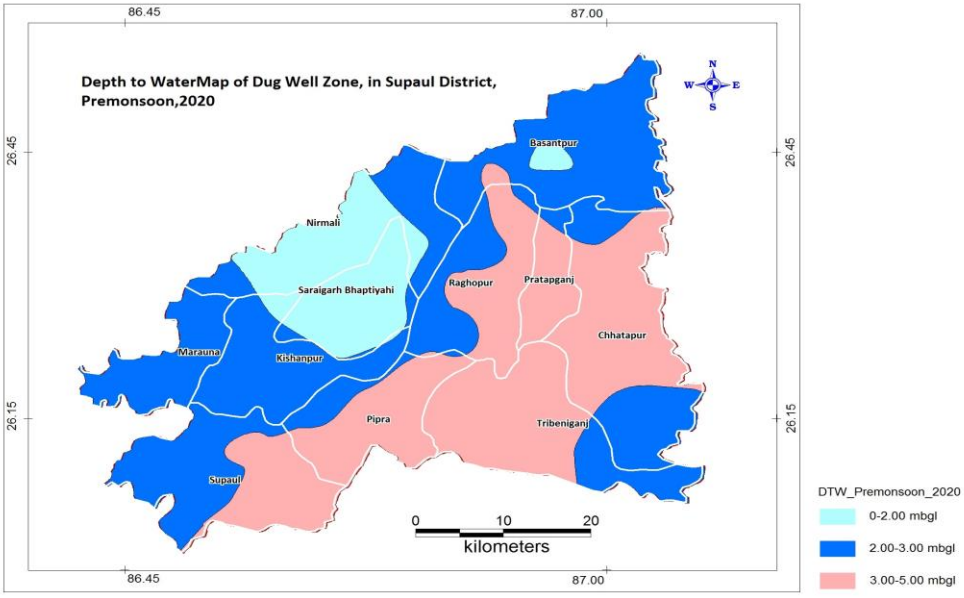


Fig.20. DTW water level Map of Dug well Zone in Supaul District, Premonsoon 2020

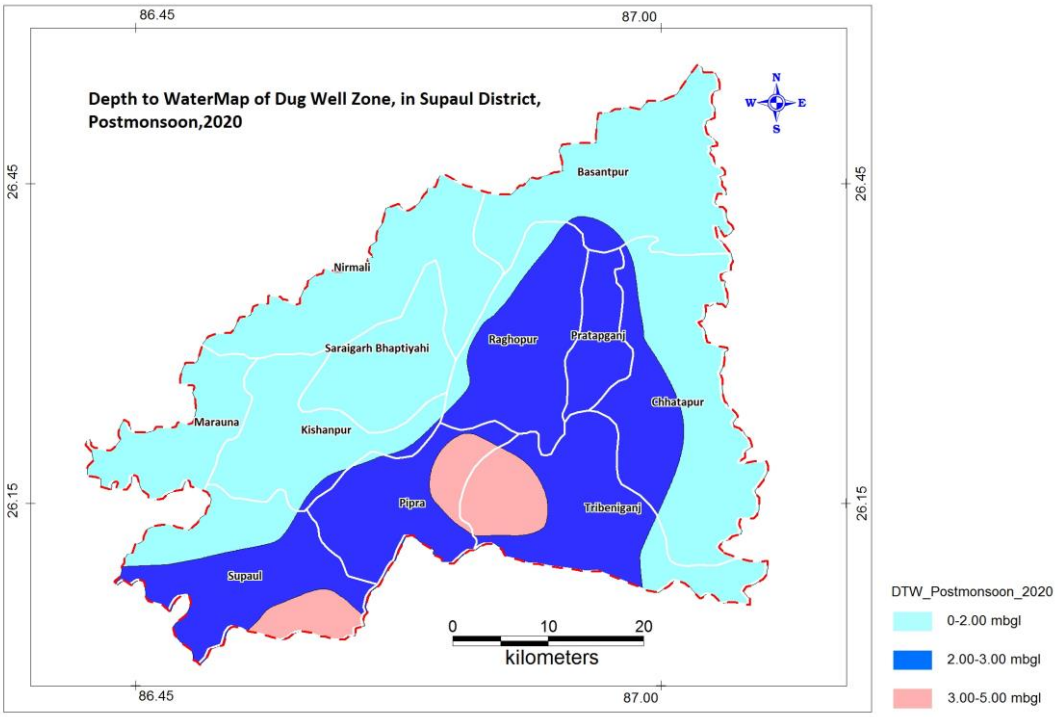


Fig.21 DTW water level Map of Dug well Zone in Supaul District, Post-monsoon 2020

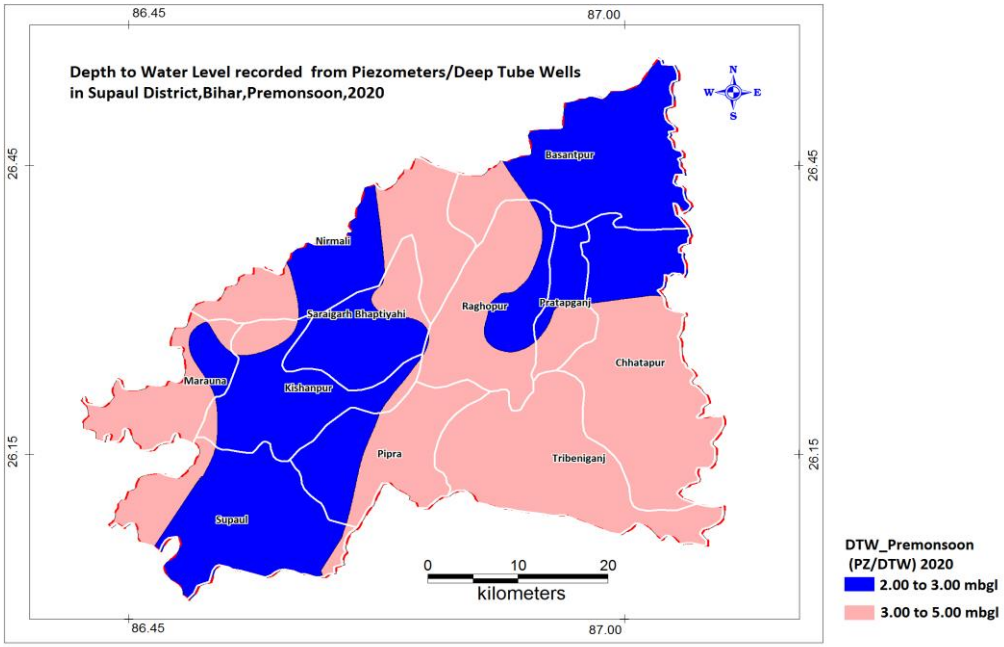


Fig.22 DTW water level Map of piezometers/deep tube wells in Supaul District, Pre-monsoon 2020

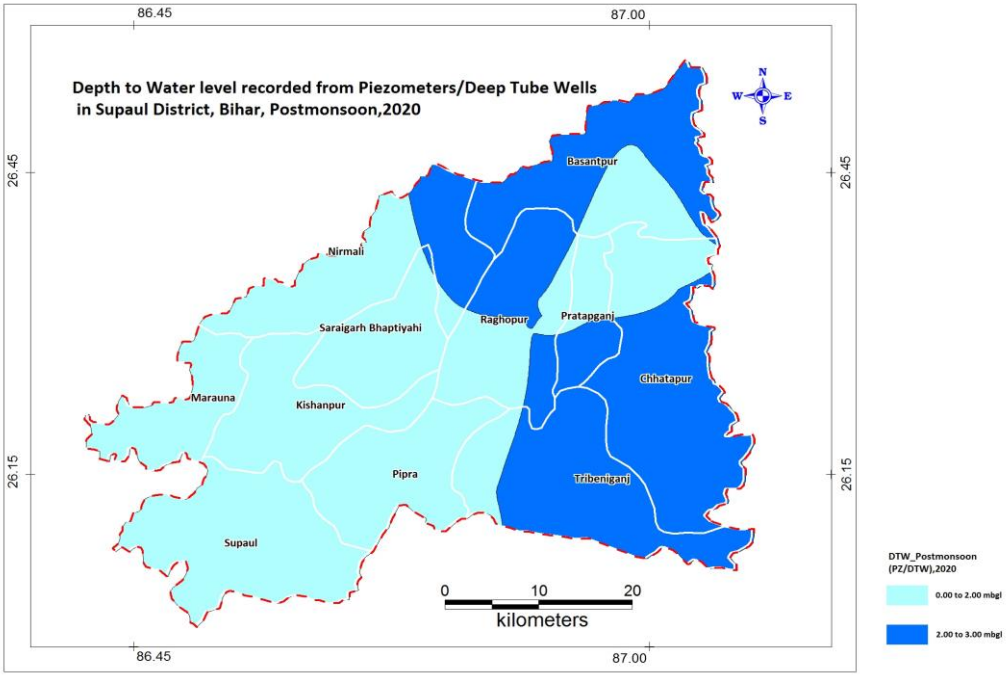


Fig.23 DTW water level Map of piezometers/deep tube wells in Supaul District, Post-monsoon 2020

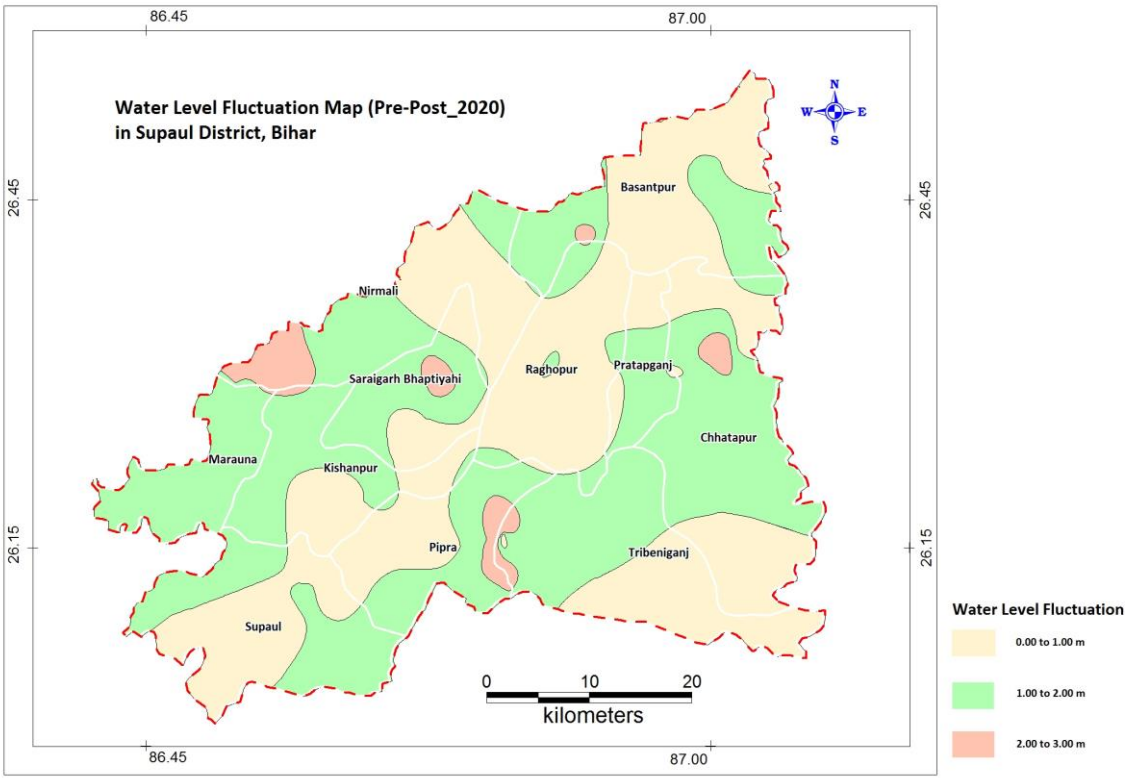


Fig.24 Water level Fluctuation Map in Supaul District, Bihar

Table: 2.1 Detail of Well Inventory Key Observation Stations in Supaul District, Bihar

Sl No	Village	Block_Name	Type_of_Well	Depth (mbgl)	Premonsoon/SWL mbgl	Postmonsoon SWL/bgl (2019)	fluctuation (pre-post)	RL of GL	Water Table (Premonsoon)	Water Table (Postmonsoon)
1	Chainsingpatti	Supaul	PHED/ DTW	90.00	2.50	1.75	0.75	53.6	51.1	51.85
2	Sohagpur	Kishanpur	PHED/ DTW	90.00	2.75	1.50	1.25	57.9	55.15	56.4
3	Chadpipar	Saraigarh Bhaptiyahi	PHED/ DTW	90.00	2.70	0.86	1.84	62	59.3	61.14
4	Piprahi-Dharampatti	Raghopur	PHED/ DTW	90.00	0.00	0.00	0.00	66.3	66.3	66.3
5	Belhi	Pratapganj	PHED/ DTW	90.00	2.50	1.00	1.50	66	63.5	65
6	Bishanpur Daulat	Raghopur	PHED/ DTW	90.00	2.35	2.00	0.35	65.4	63.05	63.4
7	Bhawanipur	Pratapganj	PHED/ DTW	90.00	2.30	1.15	1.15	65.2	62.9	64.05
8	Jibachpur	Chhatapur	PHED/ DTW	90.00	2.60	2.00	0.60	67.2	64.6	65.2
9	Mohaddinpur	Chhatapur	PHED/ DTW	90.00	4.00	2.20	1.80	63.5	59.5	61.3
10	Bishunia	Chhatapur	PHED/ DTW	90.00	3.10	2.40	0.70	57.4	54.3	55
11	Pipra	Pipra	PHED/ DTW	140.00	3.50	1.25	2.25	59.4	55.9	58.15
12	Amha	Pipra	PHED/ DTW	90.00	4.50	1.50	3.00	57.6	53.1	56.1
13	Khantaha	Basantpur	PHED/ DTW	80.00	2.70	2.00	0.70	78.8	76.1	76.8
14	Bhimnagar	Basantpur	PHED/ DTW	80.00	2.50	2.10	0.40	80.6	78.1	78.5
15	Dighia Bazar	Nirmali	PHED/ DTW	90.00	2.75	1.50	1.25	63.4	60.65	61.9
16	Jarauli	Nirmali	PHED/ DTW	90.00	3.30	1.16	2.14	62.4	59.1	61.24
17	Gamharia	Maruna	PHED/ DTW	90.00	3.00	0.98	2.02	58.2	55.2	57.22
18	Banskhora	Maruna	PHED/ DTW	90.00	3.30	1.00	2.30	53.6	50.3	52.6
19	Basantpur	Basantpur	PZ	50.00	2.62	2.11	0.51	80.7	78.08	78.59
20	Chhatapur	Chhatapur	PZ	50.00	3.59	2.41	1.18	65	61.41	62.59
21	Kishanpur	Kishanpur	PZ	50.00	2.68	1.45	1.23	55.9	53.22	54.45
22	Pratapganj	Pratapganj	PZ	50.00	3.98	2.70	1.28	66.1	62.12	63.4
23	Supaul	Supaul	PZ	50.00	3.01	1.84	1.17	52.1	49.09	50.26
24	Saraigarh Bhaptiyahi	Saraigarh Bhaptiyahi	PZ	50.00	3.07	0.86	2.21	62	58.93	61.14
25	Supaul DM	Supaul	PZ	50.00	2.45	2.08	0.37	54.3	51.85	52.22

Sl No	Village	Block_Name	Type_of_Well	Depth (mbgl)	Premonsoon/SWL mbgl	Postmonsoon SWL/bgl (2019)	fluctuation (pre-post)	RL of GL	Water Table (Premonsoon)	Water Table (Postmonsoon)
	House									
26	Triveniganj	Triveniganj	PZ	50.00	3.89	2.54	1.35	59	55.11	56.46
27	Marauna	Marauna	PZ	50.00	3.87	0.98	2.89	58.5	54.63	57.52
28	Pipra	Pipra	PZ	50.00	3.60	1.25	2.35	59	55.4	57.75
29	Nirmaili	Nirmaili	PZ	50.00	3.68	1.16	2.52	61	57.32	59.84
30	Raghopur	Raghopur	PZ	50.00	3.10	1.95	1.15	65.1	62	63.15
31	Rajapur STW	Kishanpur	STW	20.00	2.30	1.90	0.40	56.7	54.4	54.8
32	Norha		STW	15.00	3.50	2.60	0.90	65.7	62.2	63.1
33	Bhawanipur 1	Basantpur	DW		2.12	0.90	1.22	78	75.88	77.1
34	Bhimnagar NHS	Basantpur	DW		2.20	1.18	1.02	81.4	79.2	80.22
35	Birpur	Supaul	DW		2.30	1.85	0.45	82.3	80	80.45
36	Ratanpura1	Basantpur	DW		1.95	1.85	0.10	74.2	72.25	72.35
37	Balua 1	Basantpur	DW		2.88	1.39	1.49	74.2	71.32	72.81
38	Balua Bazar	Chhatapur	DW		2.14	1.83	0.31	72.8	70.66	70.97
39	Bhasanpatti	Chhatapur	DW		3.06	1.00	2.06	73.1	70.04	72.1
40	Andauli	Supaul	DW		1.85	1.30	0.55	60.2	58.35	58.9
41	Hardi	Supaul	DW		3.90	2.50	1.40	52	48.1	49.5
42	Kario	Pipra	DW		3.78	2.60	1.18	52.4	48.62	49.8
43	Malhani	Supaul	DW		2.81	2.50	0.31	50.5	47.69	48
44	Supaul	Supaul	DW		3.06	2.00	1.06	54	50.94	52
45	Thumba	Supaul	DW		3.62	2.72	0.90	59.4	55.78	56.68
46	Pipra chowk	Pipra	DW		5.00	4.30	0.70	58.1	53.1	53.51
47	Shyam Nagar	Pipra	DW		3.95	2.85	1.10	56.9	52.95	54.05
48	Ganpatganj1	Raghopur	DW		2.55	2.14	0.41	66	63.45	63.86
49	Kaithtola	Raghopur	DW		3.65	3.00	0.65	63.4	59.75	60.33
50	Karjain	Raghopur	DW		3.15	2.60	0.55	74.6	71.45	72
51	Norha	Raghopur	DW		2.80	2.08	0.72	66.5	63.7	64.42
52	Parsarma	Raghopur	DW		2.93	2.13	0.80	66.1	63.17	63.97
53	Pratapganj	Pratapganj	DW		3.30	2.49	0.81	66.7	63.4	64.21
54	Jadia	Tribeniganj	DW		2.89	1.95	0.94	56.4	53.51	54.45
55	Tribeniganj	Tribeniganj	DW		3.68	2.95	0.73	57.6	53.92	54.65
56	Rajapur	Kishanpur	DW	6.00	2.40	2.00	0.40	56.7	54.3	54.7
57	Kario	Pipra	DW		3.20	2.45	0.75	54	50.8	51.55
58	Laukha	Supaul	DW	8.00	4.35	3.30	1.05	52.9	48.55	49.6
59	Baruari	Supaul	DW	7.50	4.50	3.25	1.25	52.3	47.8	49.05
60	Saraswatipur	Chhatapur	DW	6.00	3.50	1.00	2.50	69.1	65.6	68.1
61	Dighia Bazar DW	Nirmali	DW	5.00	1.90	1.10	0.80	63.7	61.8	62.6

Sl No	Village	Block_Name	Type_ of_Well	Depth (mbgl)	Premonsoon/SWL mbgl	Postmonsoon SWL/bgl (2019)	fluctuation (pre-post)	RL of GL	Water Table (Premonsoon)	Water Table (Postmonsoon)
62	Gamharia DW	Maruna	DW	6.00	2.10	1.00	1.10	58.2	56.1	57.2
63	Kalayanpur	Saraigarh Bhaptiyahi	DW	7.00	1.90	1.40	0.50	66.1	64.2	64.7

Water table and Ground Water Movements

The movement of water in the aquifer and the gradient of movement are of utmost significance for better understanding the nature of aquifer system in the area. The pre and post monsoon water level data from the shallow aquifer has been utilised to estimate the water table or the head with respect to the reduced level (fig.25-26). The pre and post monsoon water table elevation ranges between 48 mamsl to 80 mamsl. The average water table elevation in the district is 60 m amsl. The higher water table contour lies in the northern and north eastern parts of the district, more than 75 m amsl and whereas the lower elevation is around 50 m amsl in southern parts around Supaul blocks etc. The pre-and post-monsoon water table maps prepared for the Supaul district indicate a few crucial aspects of groundwater recharge and movement in the districts. In both the seasons, despite shallow water levels, distinct patterns of groundwater flow are evident. In general groundwater flows in a NW-SE to north south trend. The water table seems marginally gentler during post monsoon time. At few locations, there may be a signature of comparatively more development of ground water for irrigation purpose i.e around Raghopur, Chhatapur and few areas around Basantpur. Otherwise, ground water occurrences, flow and recharge in the district are significantly influenced by local geomorphology and hydrostratigraphy. The shallow aquifer in the district exists under unconfined condition. However, from the interpretation of water table maps it is evident that, other than the direct contributions from the rainfall through vertical recharge, lateral flows (recharge) from specifically the Kosi River and other active channels is very significant for the district. It is interesting note that the active channel of Kosi acts as a recharge source for groundwater in different parts of the district in both the seasons. Superimposition of pre and post monsoon water table map on the geomorphology of the district (fig.27) reveals steady recharge components to the ground water in different parts of the district. Earlier studies in the district, however, also depicts that the small streams flowing in the abandoned channels of Kosi are gaining in nature i.e. those are fed from groundwater.

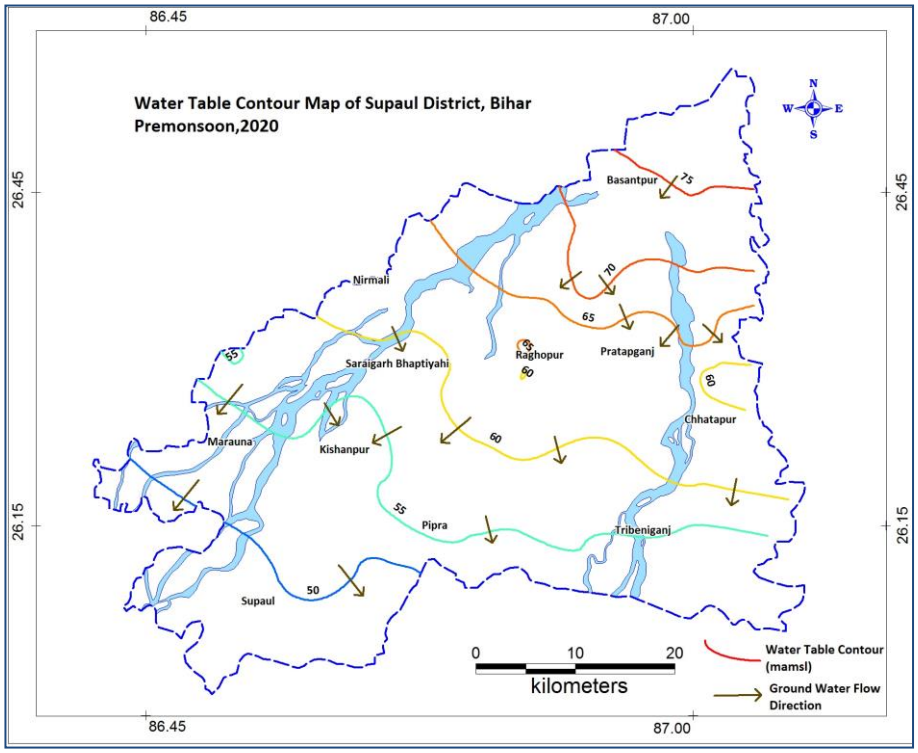


Fig.25 Water Table Contour Map and Ground Water Flow in Supaul District, Bihar (Premonsoon -2020)

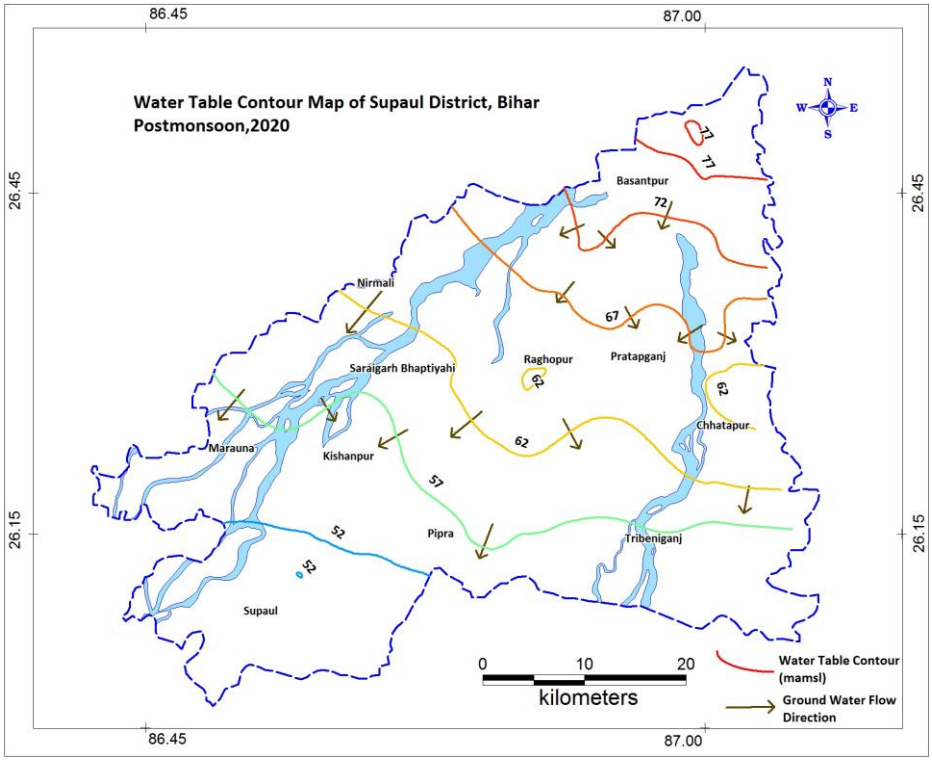


Fig.26 Water Table Contour Map and Ground Water Flow in Supaul District, Bihar (Postmonsoon -2020)

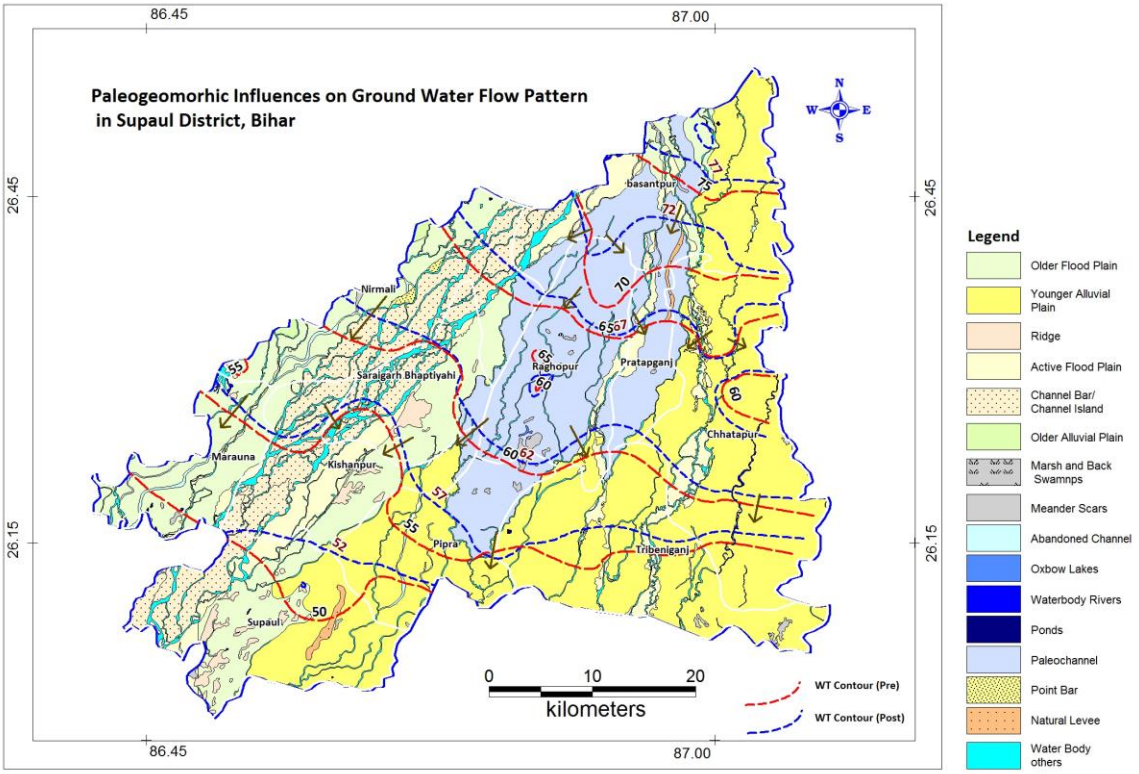


Fig.27 Geomorphologic influence on ground water flow in Supaul district, Bihar

Long Term Water Level Trend Analysis

Total annual rainfall in the district in last 6 yrs (2014-2019 varies from less than 800 mm to more than 1400 mm. There may be one or two spell of rainfall deficient year which witnesses rain fall less than 1000 mm/year. The area, being under phreatic condition direct rainfall recharge is dominant one. Variation of water level with rainfall in few observation wells in the district for few previous years (2014-2019) is depicted in fig.28. Direct correlation of water level to the rainfall is obvious, deeper water level is witnessed during May and water level is shallower in November.

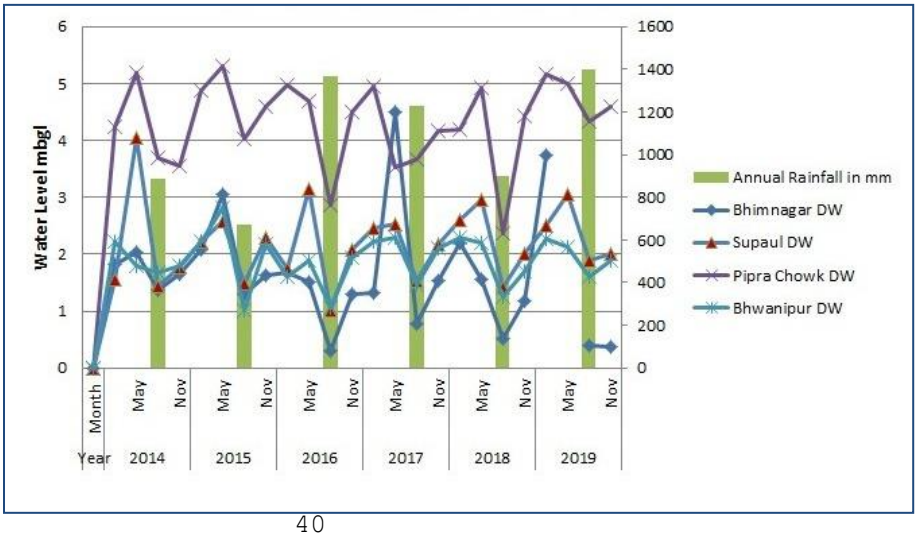


Fig.28 Rainfall vs. water level in few observation wells in Supaul district, Bihar;

The historical data of water level of few observation wells/NHNS wells of CGWB in Supaul district has been analyzed for last 6 yrs. The hydrograph of the observation wells are represented for 2014-2019. The hydrograph reveals that recession of water level starts after November through January and become deepest in May. The shallower water level is witnessed in August to November. In fig.29 hydrograph of pipra chowk represents deeper water level of 5 mbgl and shallower water level is reported in Bhimnagar, Balua Bazar.

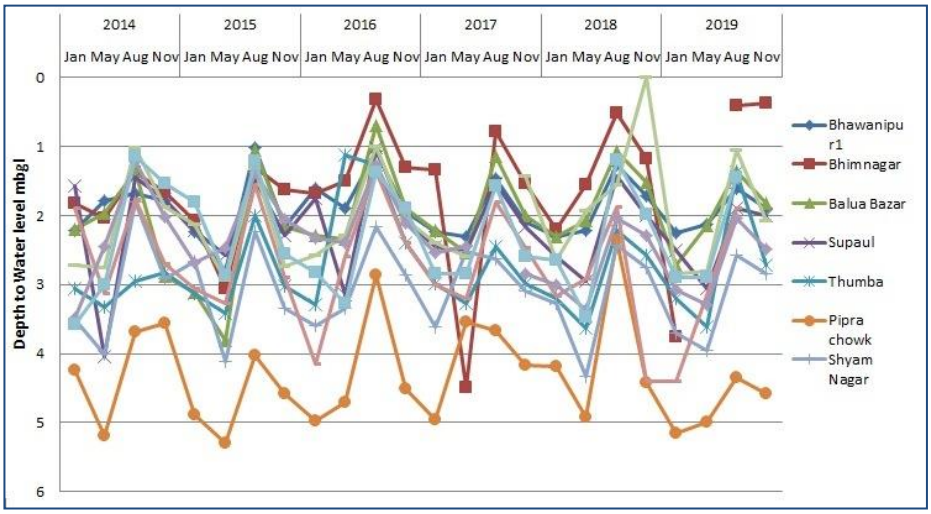


Fig.29 Hydrographs of Observation wells in Supaul district, Bihar;

Seasonal variation of water level over last six years (2014-2019) of 11 observation wells in the district has been plotted and represented in fig.30. Thus the variation of water level in last 6 years for each observation wells is represented in a series. Although there are some variation of water level of individual observation wells based on their location and other hydrogeological factors, however overall trend of water level in last six years considering time (2014-2019) and space (spatial distribution of observation wells across the district), an overall trend of 0.25 cm /year fall has been noticed which may be treated as insignificant. Therefore, the district seems to sustain a steady ground water regime over the years; in time and in space.

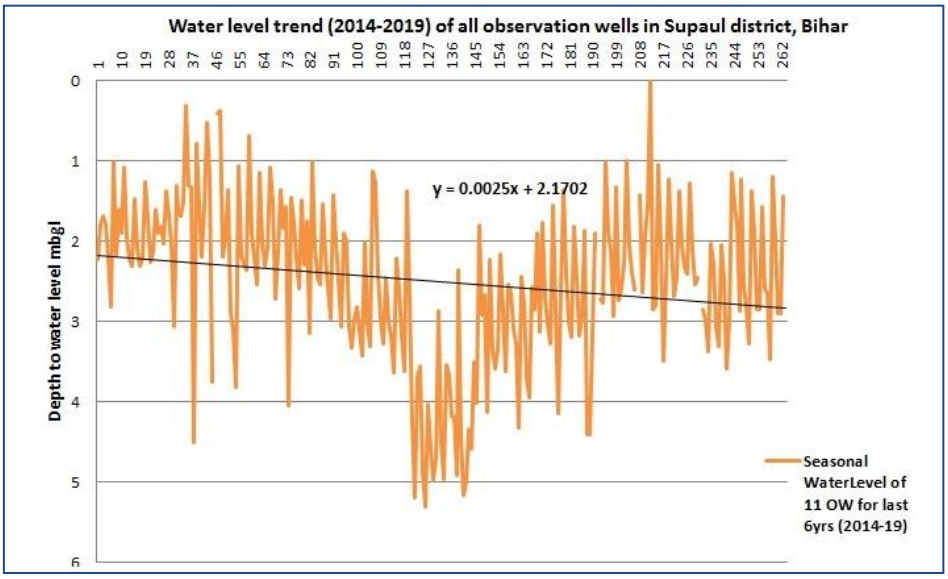
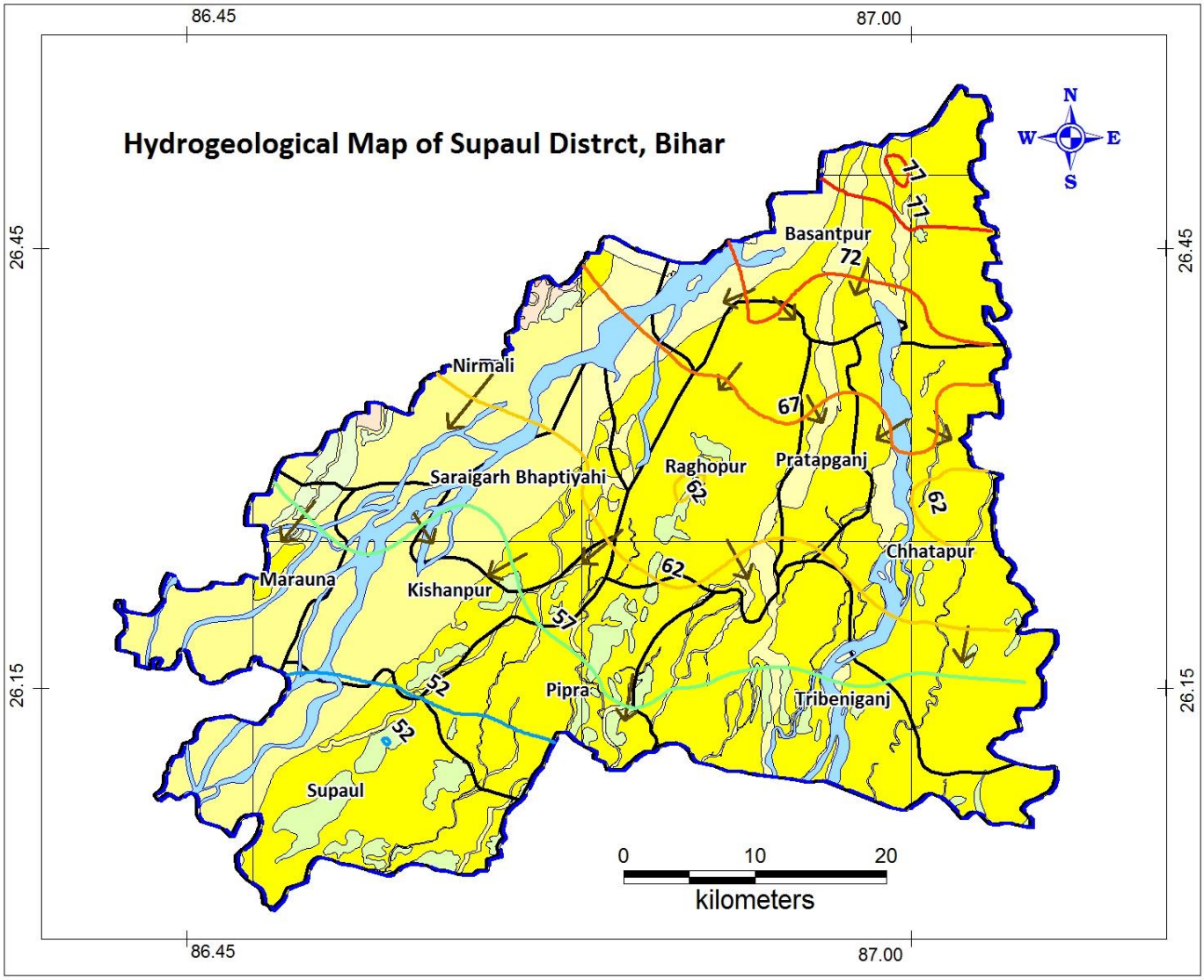


Fig.30 Long term water level trend in time and space in Supaul district

2.3 Aquifer Potentiality

The potentiality of the aquifer largely depends on the nature of the underlying formation, extent of the aquifers, scope of recharge and recharge potential and on the aquifer parameters. The district is blessed with copious ground water potential. The shallow tube wells for irrigation uses within the depth of 5-20 m yield at 20 m^3/hr when fitted with 5 HP pumps. However shallow and medium deep tube wells are capable to yield at 50 to 75 m^3/hr. Deep tube wells within the depth of 100 m of 150x100 mm diameter are in use for drinking and domestic sectors under PHED, Govt. of Bihar. As per the detail report of PHED , these tube wells are reported to yield at 8.5 " with 90^0 V notch, thus 100m^3/hr yield with moderate drawdown is expected. Only a few well has been installed in the district, so far, under ground water exploration activities of CGWB. However, the nature, thickness and extent of the underlying formations and the existing yield of the wells reveal very high transmissivity of the aquifer system in the district.

Based on occurrence of newer and older alluvium, subsequent discharge in each formation and water table contour, the Hydrogeological Map of Supaul district has been prepared (fig.31).



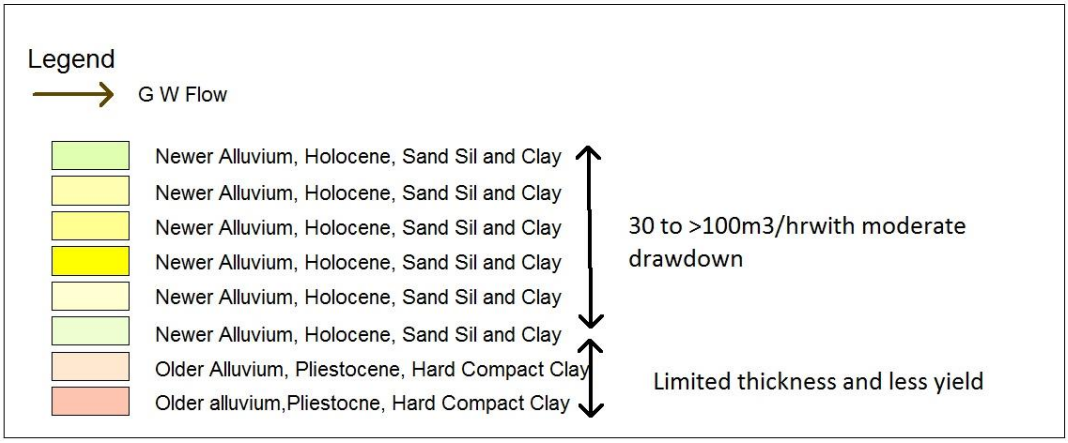


Fig.31 Hydrogeological Map

2.4 Hydro-**geochemistry**

Chemical analysis of ground water samples from dug wells and DTW of PHED has been carried out which reveals no significant variation of water quality parameters in shallow and deeper ground water. pH varies between 7.7 to 8.00 and EC varies from 199 to 655 micro Seimens/cm. Ground water in the district is potable in terms of water quality parameters, however in a few cases for e.g shallow ground water in Pipra block has been reported with Nitrate concentration about 60 mg/l, which is high in comparison to the drinking water standard. In Kishanpur block higher concentration of HCO_3 has been reported from shallow ground water.

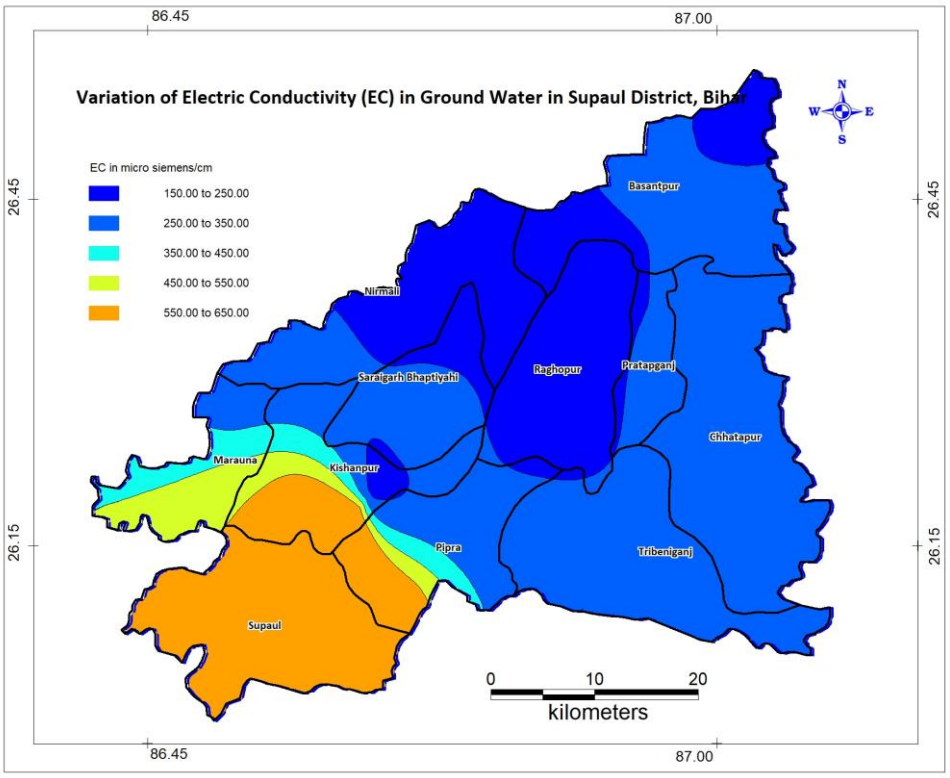


Fig. 32 EC Map of Ground Water Samples in Supaul District, Bihar

Table2.2: Water Quality Parameters of Ground Water in Supaul District, Bihar

S.no	Block	Type of well	Latitude	Longitude	pH	EC	TDS	TH	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	CO_3^{2-}	HCO_3^{-}	Cl^{-}	SO_4^{2-}	NO_3^{-}
						µS/cm											
1	Kishanpur	DW	26.1747	86.649354	7.79	655	425.75	205	62	12.15	37.27	26.54	0	237.9	53.3	25.56	5.97
2	Pipra	DW	26.09344	86.6833	7.89	642	417.3	230	74	10.935	23.92	19.43	0	176.9	42.6	32.47	60.53
3	Kishanpur	DTW/PHED	26.1989	86.6678	8.07	232	150.8	85	24	6.075	8.89	7.65	0	115.9	7.1	0	5.69
4	Saraigarh Bhaptiahi	DTW/PHED	26.27504	86.728395	7.83	280	182	110	40	2.43	10.34	8.65	0	134.2	10.7	5.54	0.69
5	Raghopur	DTW/PHED	26.31068	86.833515	7.9	194	126.1	75	26	2.43	2.84	6.54	0	97.6	7.1	0	4.57
6	Chatapur	DTW/PHED	26.332822	87.03122	7.78	327	212.55	125	40	6.075	5.08	9.32	0	146.4	10.7	0.23	0.63
7	Pipra	DTW/PHED	26.117349	86.80158	7.89	295	191.75	125	38	7.29	2.29	8.76	0	152.5	3.55	2.9	0.96
8	Raghopur	DW	26.327949	86.850301	7.89	195	126.75	65	22	2.43	3.86	13.23	0	67.1	14.2	18.31	0.71
9	Basantpur	DTW/PHED	26.509845	86.989958	7.95	241	156.65	95	22	9.72	4.5	11.23	0	122	10.7	0	2.09
10	Basantpur	DTW/PHED	26.512893	86.95196	7.9	272	176.8	110	34	6.075	5.2	9.33	0	140.3	7.1	0	1.04
11	Nirmali	DTW/PHED	26.359403	86.673263	7.88	199	129.35	60	20	2.43	10.32	6.19	0	85.4	10.7	3.07	7.01
12	Nirmali	DTW/PHED	26.330488	86.587679	7.73	337	219.05	120	36	7.29	18.21	5.69	0	183	7.1	0	2.8
13	Marauna	DTW/PHED	26.287274	86.534051	7.72	300	195	110	32	7.29	11.23	7.18	0	152.5	7.1	0	0.73
14	Marauna	DTW/PHED	26.210271	86.479783	7.63	445	289.25	125	38	7.29	34.32	11.79	0	237.9	7.1	0	2.37

Modified Piper Diagram

The Chadah's Diagram or Modified Piper diagram are used to explain the different hydrogeochemical processes, such as cat ion exchange reaction, saline water, sulphate reduction and related chemical processes. The results of the analysis are plotted in the diagram to test its applicability for geochemical classifications. The majority of the samples are Ca-Mg-HCO_3 type.

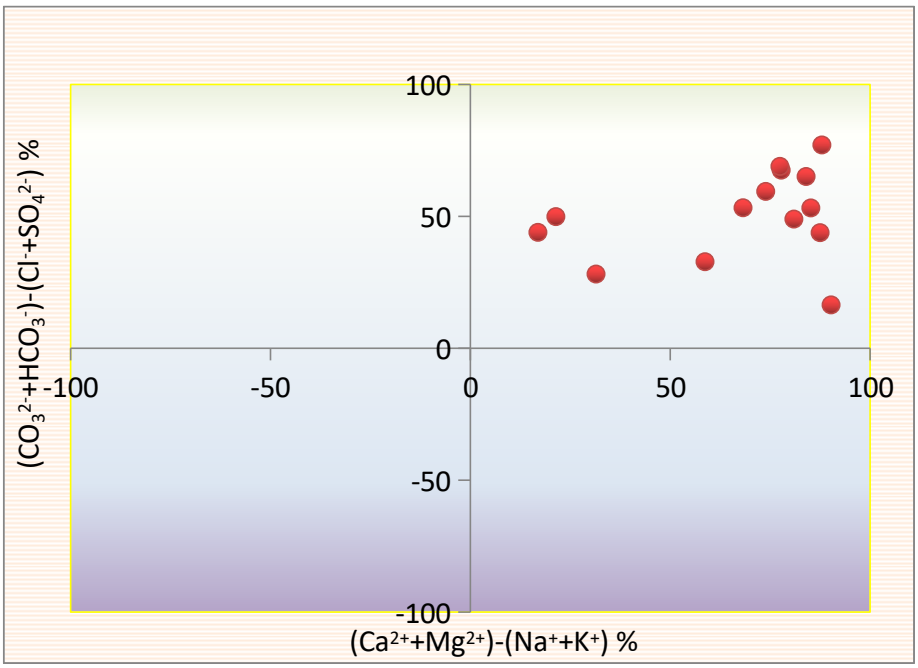


Fig. 33 Modified Piper Diagram

	pH	EC	TH	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	HCO_3^{-}	Cl^{-}	SO_4^{2-}	NO_3^{-}
pH	1										
EC	-0.37	1									
TH	-0.25	0.96	1								
Ca^{2+}	-0.27	0.94	0.98	1							
Mg^{2+}	-0.15	0.78	0.80	0.66	1						
Na^{+}	-0.55	0.84	0.68	0.65	0.58	1					
K^{+}	-0.08	0.83	0.77	0.74	0.67	0.66	1				
HCO_3^{-}	-0.64	0.82	0.75	0.69	0.73	0.85	0.53	1			
Cl^{-}	-0.03	0.85	0.80	0.80	0.62	0.65	0.94	0.45	1		
SO_4^{2-}	0.06	0.71	0.70	0.73	0.42	0.48	0.85	0.23	0.90	1	
NO_3^{-}	0.15	0.61	0.67	0.70	0.41	0.32	0.45	0.17	0.60	0.71	1

Fig.34 Correlation Matrix of Water Quality Parameters in Supaul District.

The relationship between two parameters is explained by correlation matrix of water quality parameters of ground water samples. The pH shows negative correlation almost with the each chemical

parameter. High correlation has been observed among EC and Hardness, Ec and Ca, Ca and Total Hardness. Moderate to high correlation is observed among Mg and bicarbonate and Na and bicarbonate. The water chemistry in the district is influenced by parent sediments, water sediments interactions and to some extents with anthropogenic influences.

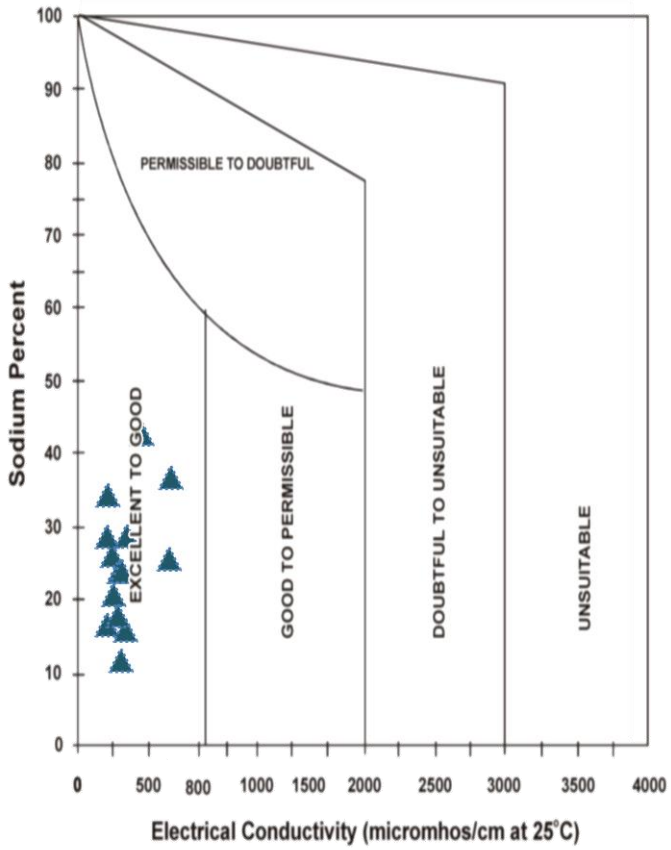


Fig. 35 Wilcox Diagram explaining the suitability of Ground Water in Banka District for irrigation

Wilcox (1955) used sodium % and specific conductance in evaluating the suitability of groundwater to irrigation. Sodium percentage determines the ratio of sodium to total cations viz., sodium, potassium, calcium and magnesium. All the concentration values are expressed in equivalents per million (epm). Based on the plot) the water samples in the district are excellent to good wrt the suitability of ground water irrigation.

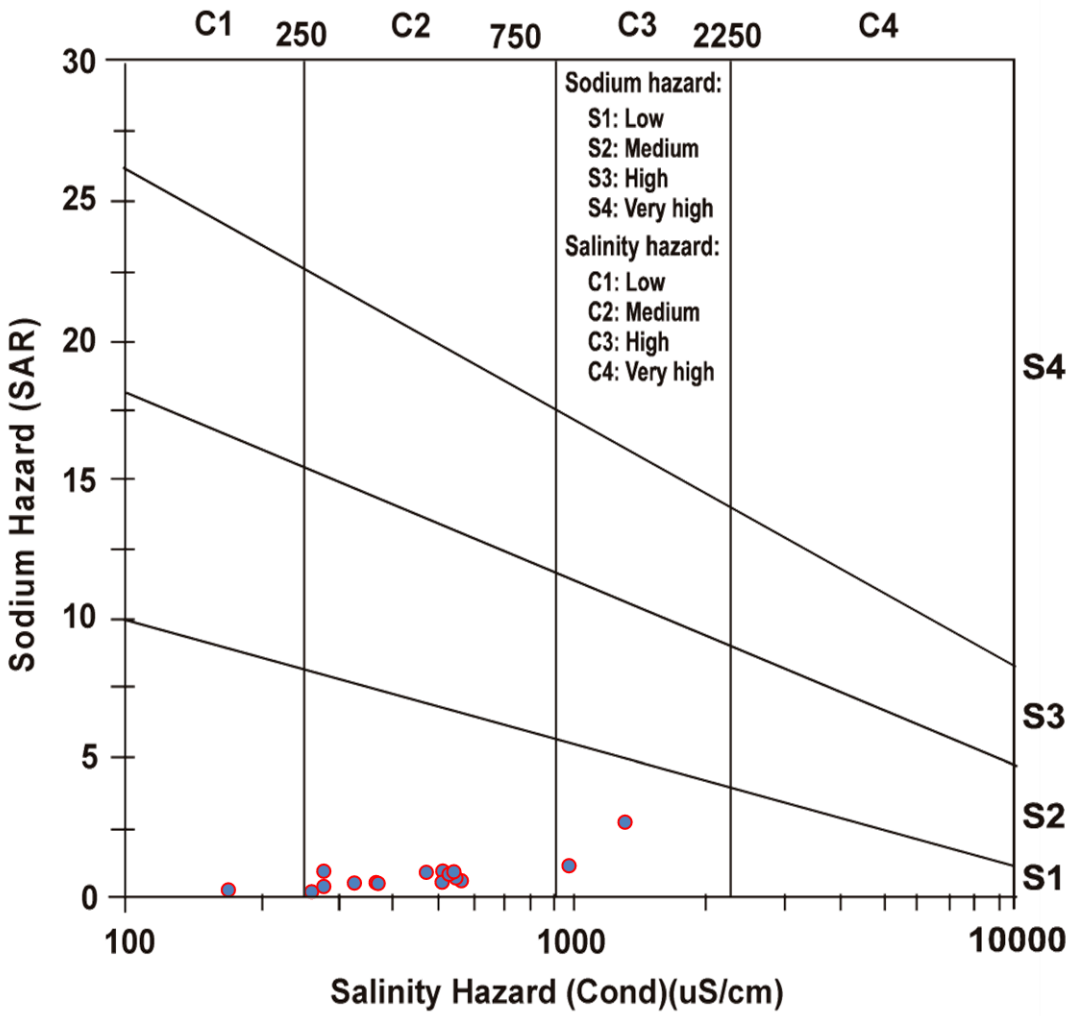


Fig.36 US Salinity Diagram explains the salinity and Sodium Hazards

The USSL diagram best explains the combined effects of salinity hazard and sodium hazards in classification of irrigation water. It is a plot between sodium hazard (SAR) on y axis and salinity hazard (EC) along X axis which allows water to be grouped into 16 classes. In the present sample set the water is C_2S_1 to C_3S_1 type, therefore with low sodium hazard to medium salinity hazard.

In Kosi megafan area, concentration of Iron (Fe) more than the permissible limit has been reported as the major groundwater quality problem. A detail groundwater sampling was carried out during the period of ''Groundwater Management Study'' of Supaul district, Bihar(2011). A total of 49 water samples were got tested for groundwater iron concentration from Indian School of Mining University, Dhanbad. Results show 53 % of the total number of samples exceeding the permissible limit of 1 ppm. Out of these, 45.9 % shows iron concentration between 1ppm and 5 ppm and 8.16% of samples show concentration of more than 5ppm, Maximum concentration of 16.94 has been reported from Bhawanipur area.

Out of total 49 water samples, only two tube wells (7-10 m depth range) at the eastern side of the district,one at Chhattapur and the other Sukhnagar around Pratapganj, yield ground water arsenic of more than maximum permissible limit (10 ppb).

Only a few tube wells recorded ground water arsenic 5-10 ppb and most of the samples recorded arsenic concentration in ground water as negligible. Higher concentration of Fe in ground water in Kosi Megafan and in Supaul district is an indication of high arsenic in ground water as most of the cases high arsenic is associated with higher concentration of Fe in ground water. The previous studies revealed that high arsenic in ground water was identified in the central and eastern parts of Supaul district around the abandoned channel and cut off channel of Kosi river.

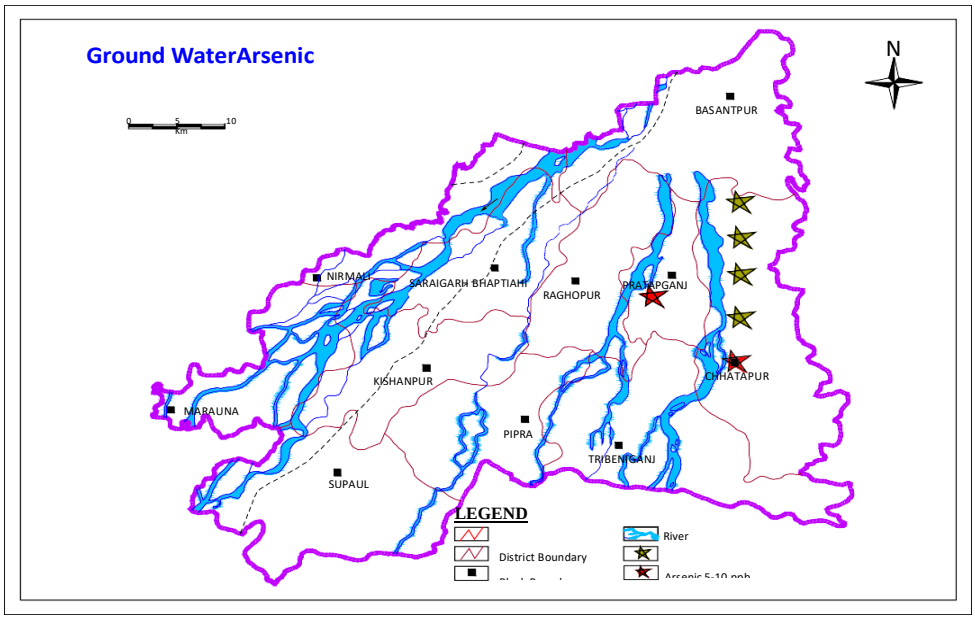


Fig. 37 Ground water arsenic distribution in Supaul district. Few patches at the central portions of abandoned channels of Kosi River seem to be little vulnerable to the contamination. (Source: GWMS in Supaul District;

CHAPTER 3

Data Interpretations, integrations and Aquifer Maps

In order to frame the aquifer map of the area the detail lithological disposition in the area has been worked out from the available lithological data collected from PHED, Govt. of Bihar. The individual lithology, unconsolidated sediments etc. has been demarcated and accordingly lithological model, fence, sections are prepared. The lithology model/ sections are interpreted and grouped to generate aquifer map of the area.

3.1. Lithological disposition and Generation of Aquifer Maps

The subsurface geology of the area has been unearthed by correlation of subsurface lithological units. The lithologs of the tube wells data in Supaul district has been compiled for preparation subsurface correlation diagram. The location map of the bore holes has been plotted in **fig.38.**

The entire Supaul distrct under Kosi Megafan is characterised by huge thickness of Quaternary alluvial deposits. The area is underlain by thick unconsolidated sediments of Quaternary age consisting of sands of various grades, gravels, cobbles, pebbles etc. up to the explored depth of 80 -100 m. The clay capping is thin (< 1 m to 5 m) and even absent at many places. In general, the Kosi megafan shows two major formations (Singh et al., 1993); the upper formation is of 8-10 m thickness (less commonly from 16 to 40 m) and is composed typically of fine sand and mud, whereas the lower formation is thicker (> 60 m) and composed up of in general medium to coarse sand to gravel .The lower formation is thought to have been deposited by a highly braided Kosi River during the Late Quaternary. The upper formation represents the sequence of strata deposited by the Kosi during the latest sweep across the megafan from east to west. The upper formation forms the younger Alluvium, while the lower one is thought to belong to an older sequence. Though in general clay/mud capping is present over the upper formation in the Supaul district, sands in the upper formation in many instances are lying exposed. This makes the aquifer in the upper formation unconfined. From the distribution pattern of formations, the whole area can be considered to be a single aquifer system to the depth of 50-100 m.

In areas such as Supaul, Chattapur, Bhaptiahi, Bhimnagar and Birpur the lower formation is encountered at a depth of 5-9 m.

Fig.40 shows that plan view of lithology disposition, the entire district except the north western parts of the district has limited clay capping or clayey soils. Fig.41 depicts 3D lithology model which revels continuous sequence of fine, medium and coarse sands. Fig. 42-44 shows lithologic disposition

along Ganura_Charnai (EW) section, Dighia_Parshaghari (NW-SE) section and Fatehpur_Amha (NE_SW) section. It is observed that dominance of fine to medium sands throughout the district down to the depth of 80-90 m. The coarse sands are limited and are found in few patches. Occurrences of coarse sands with gravels and boulders are observed at adepth of 30 m in Bhimnagar, Bishanpur area of Basantpur and in northern parts of Chhatapur block.

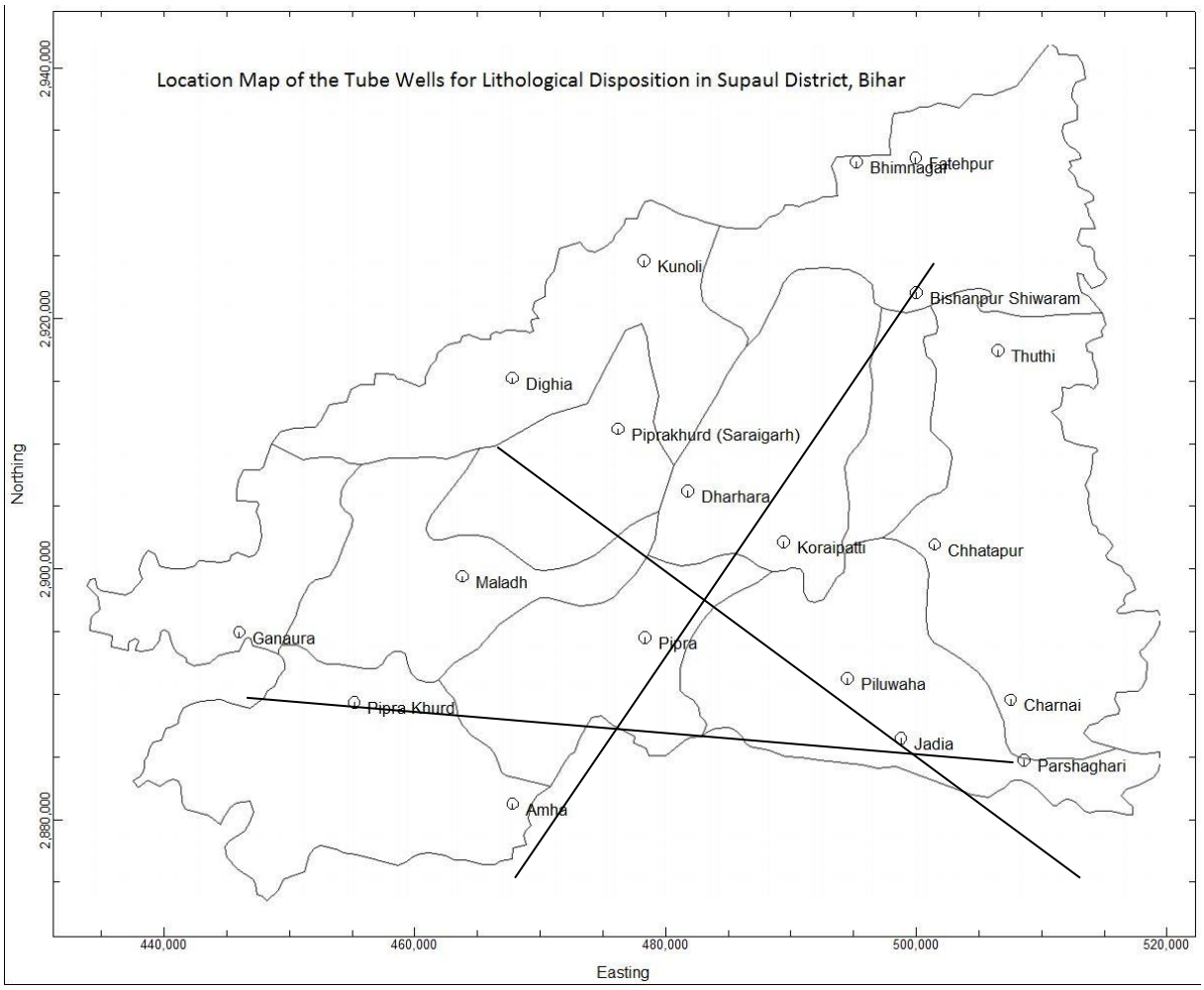


Fig.38 Location of the bore holes (PHED, Govt of Bihar), considered for lithological and Aquifer disposition

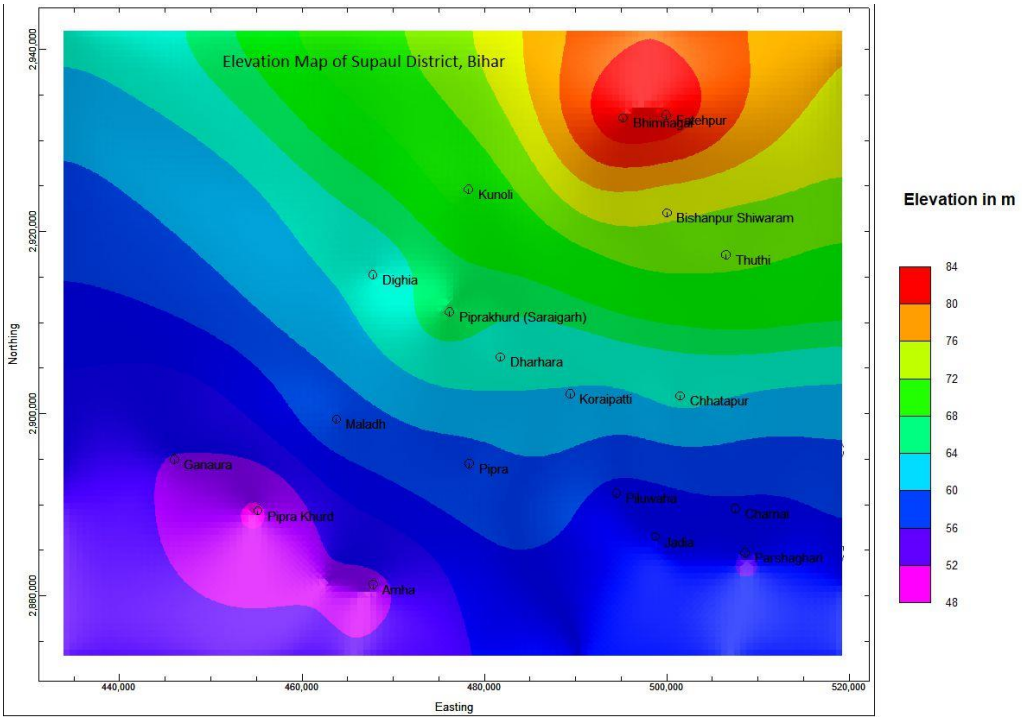


Fig.39 Elevation of the bore holes

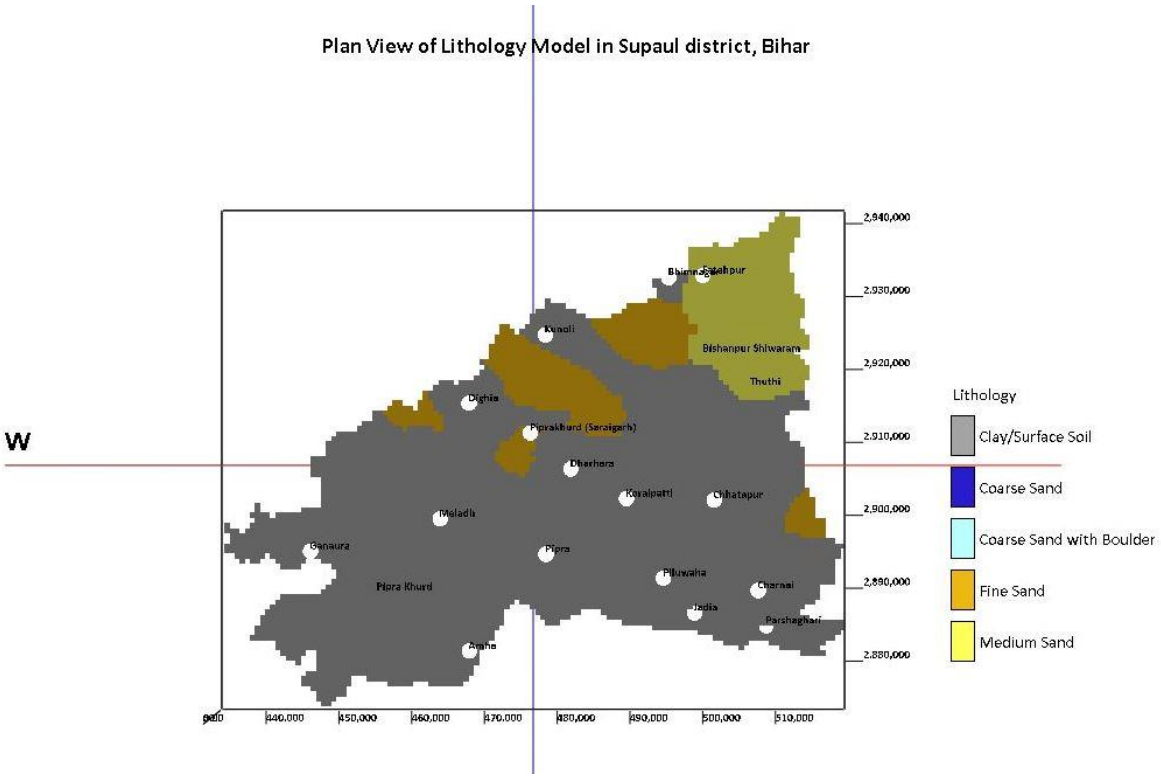


Fig.40 Plan View of Lithology Disposition in Supaul District

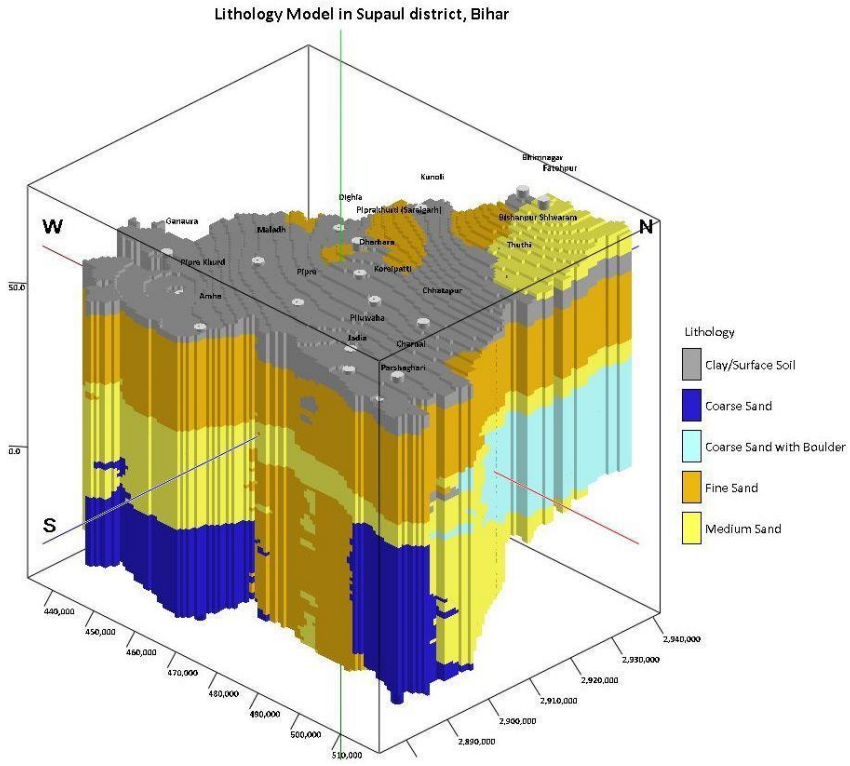


Fig41. Lithology Model in Supaul District

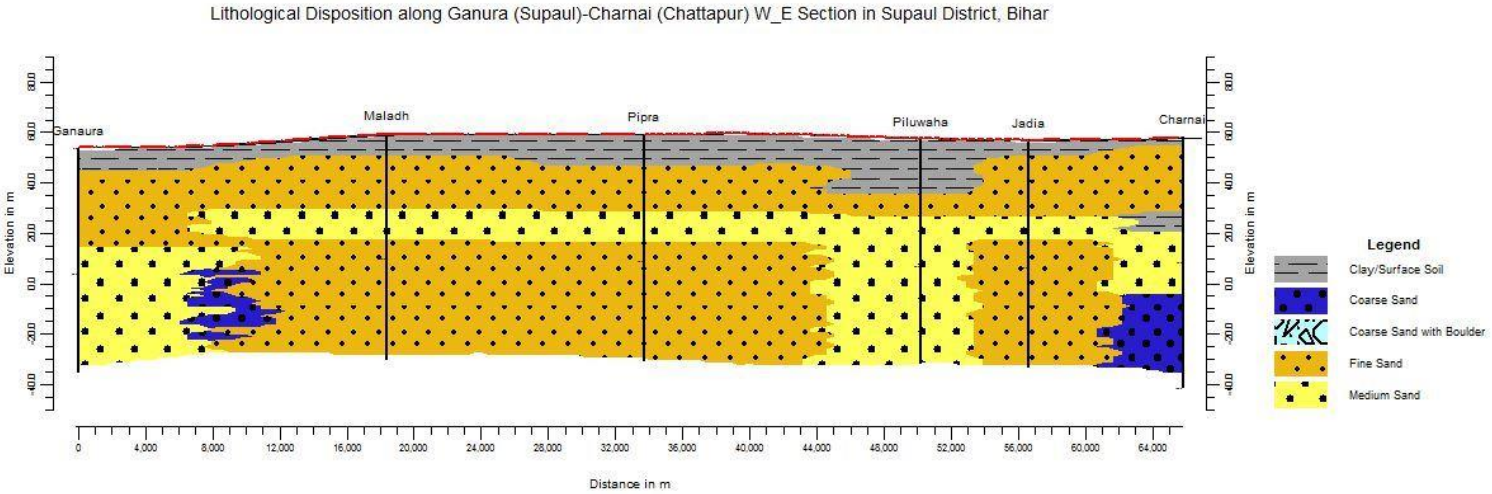


Fig.42 Lithology Disposition in E_W Section

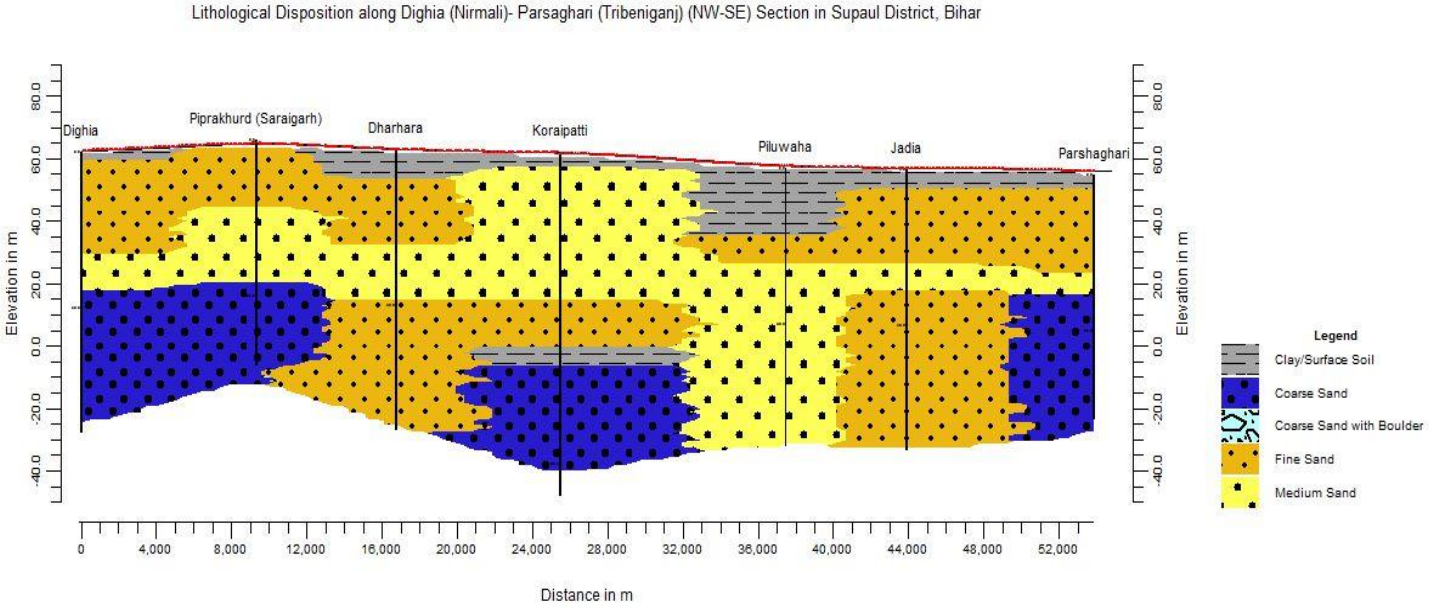


Fig.43 Lithology Disposition in NW_SE Section

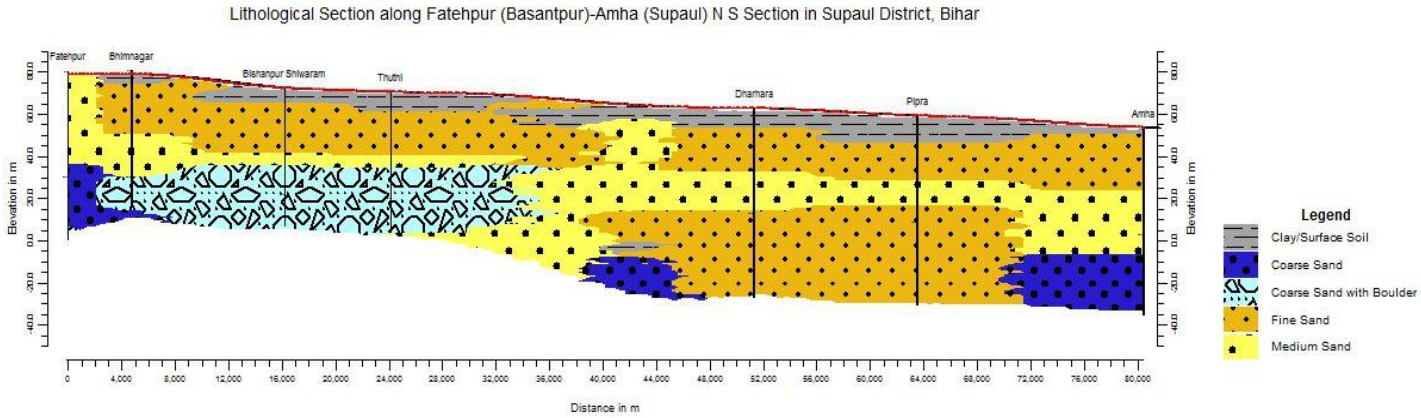


Fig.44 Lithology Disposition in NNE_SSW Section

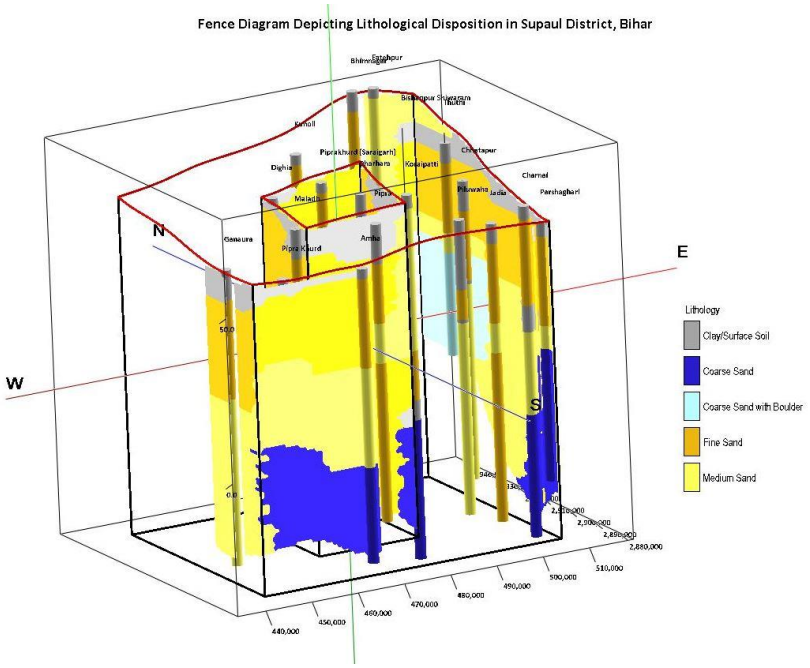


Fig.45 Lithology Fence in Concentric Section in and around Supaul Distrct

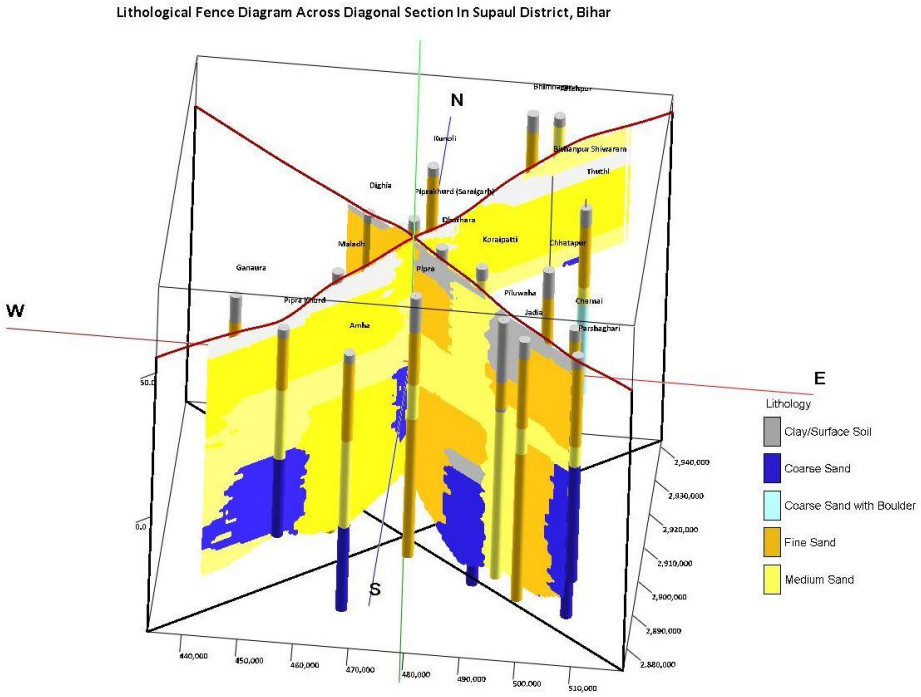


Fig.46 Lithology Fence across Diagonal Section in Supaul District

3.2 Aquifer Disposition

The correlations, interpretation, generalization and subsequent grouping of the granular horizons and disposition of clay facies revel the existence of single aquifer system down to the explored depth of 100 m. However, the detail hydro-stratigraphic characteristics of sediments constitute two minor aquifers, locally, within the entire vertical sequence. Two perceptible clay facies which comprises Aquitard-1 and Aquitard-2 respectively are found, however, these are not significant as compared to the thickness and persistence of granular materials down to the explored depth of 100m bgl. The upper clay, however, are persistent but only 5-7 m thick throughout the district. The lower clay facies are local and mainly found around the southern parts of the district and 3-10 m thick at places. Therefore, within the single aquifer system, two minor aquifers are broadly identified based on stratigraphic connotations.

The aquifer 1, is of fine to medium sands are very recent deposits and represents the depositional history of shifting of the river Kosi. This is either continues with aquifer 1a or at places are separated by local aquitard-2. The aquifer 1a comprises medium to coarse sands of late Holocene deposits. In few area, particularly in the northern parts of the Supaul district around Bhimnagar, Fatehpur in Basanpur etc. coarse sands, gravels and boulders of Bhabar formation are found. The aquifer 1 and 1a locally constituted prolific aquifer in the district. The detail 3 D aquifer model, aquitard disposition and aquifer disposition along NS and EW section are given in **fig 47-50.** Thickness of aquifer 1 and aquifer 1a is depicted in Isopach maps; fig.51 &52. The average thickness of aquifer1 is 20 m, maximum around 30 m. The aquifer 1a is comparatively thicker and maximum thickness is around 50 m.

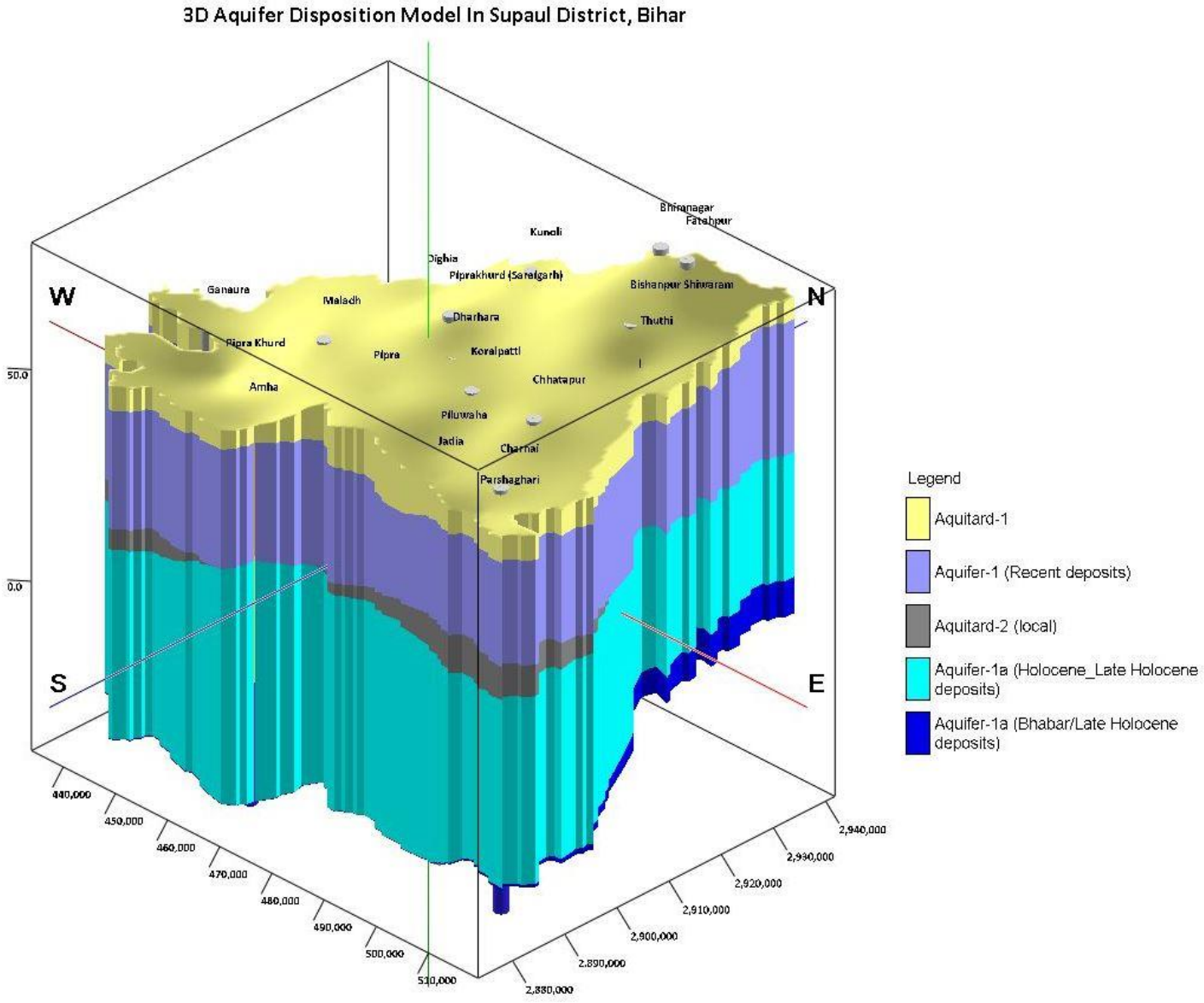


Fig.47 3D Aquifer Model in Supaul District

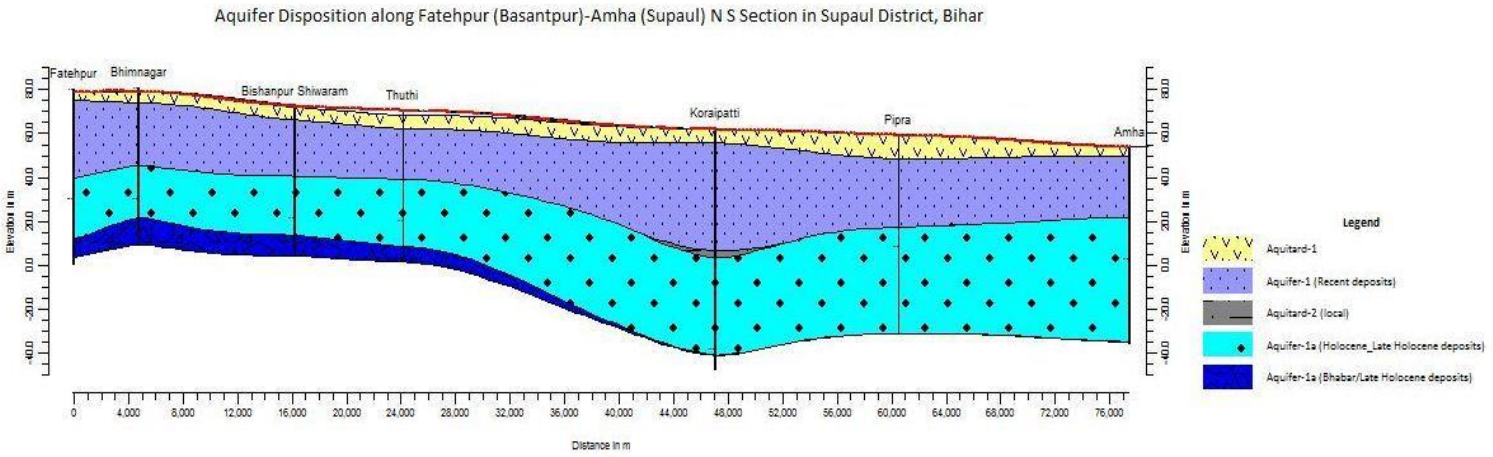


Fig.48 Aquifer disposition in N -S section in Supaul District

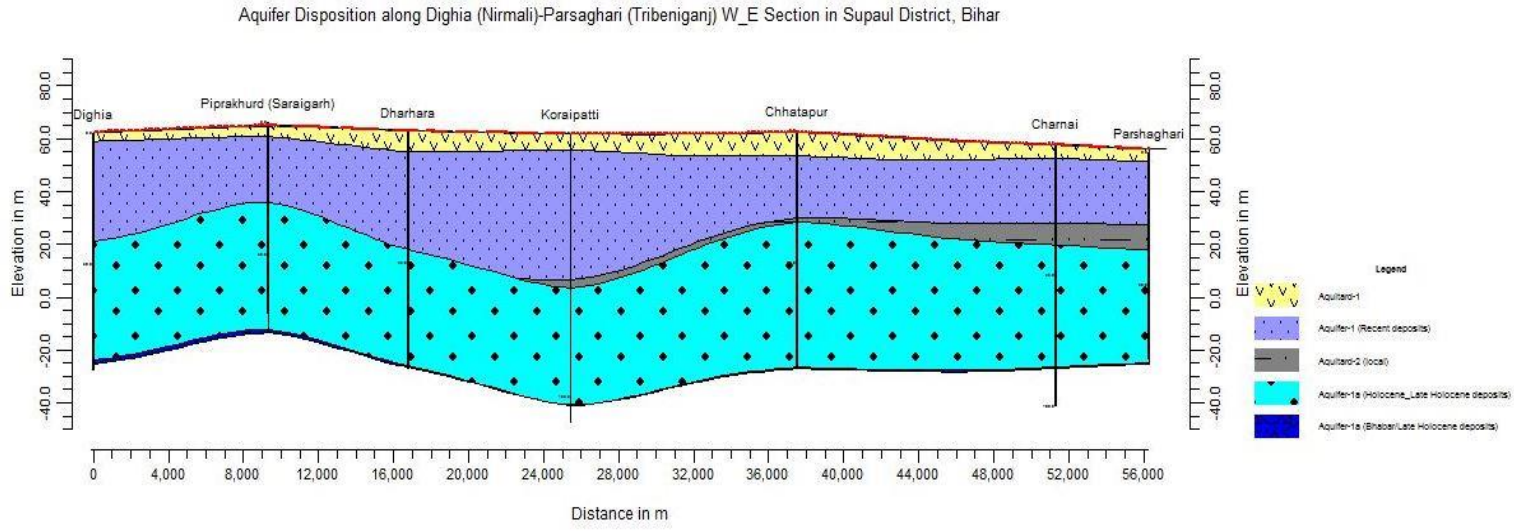


Fig.49 Aquifer disposition in E-W section in Supaul District

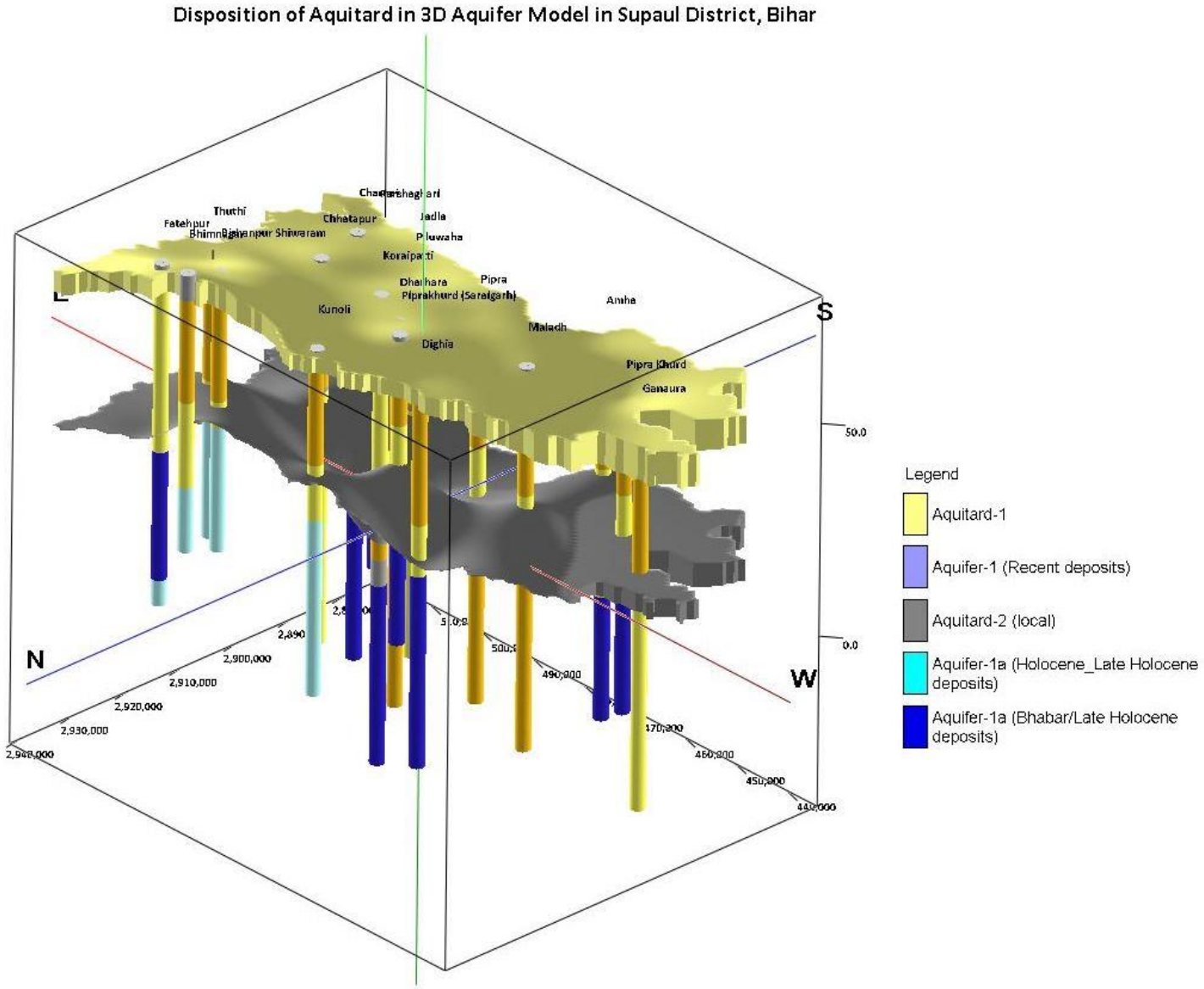


Fig.50 Aquitard in Supaul district

3.3 Aquifer Characterization

The district is blessed with potential mono-aquifer down to the explored depth of 100 m. The STWs in the depth range of 30 – 50 m bgl can yield up to 50 to 75 m3/hr. A well assembly of about 76 to 102 mm diameter with about 10 to 20 m slotted pipe can be used for construction of such wells. Shallow tube wells with very high yield of 25 m^3/hr are found to operate in the district within 5-15 m depth. Deep tube wells at a depth of 100 m depth can yield at 100m^3/hr. for moderate drawdown. The very thick granular horizons with fine to coarse sands constituted prolific aquifer system. Although exploratory tube wells data are not available in the district, but the nature of the aquifer system indicates very high transmissivity of the aquifer.

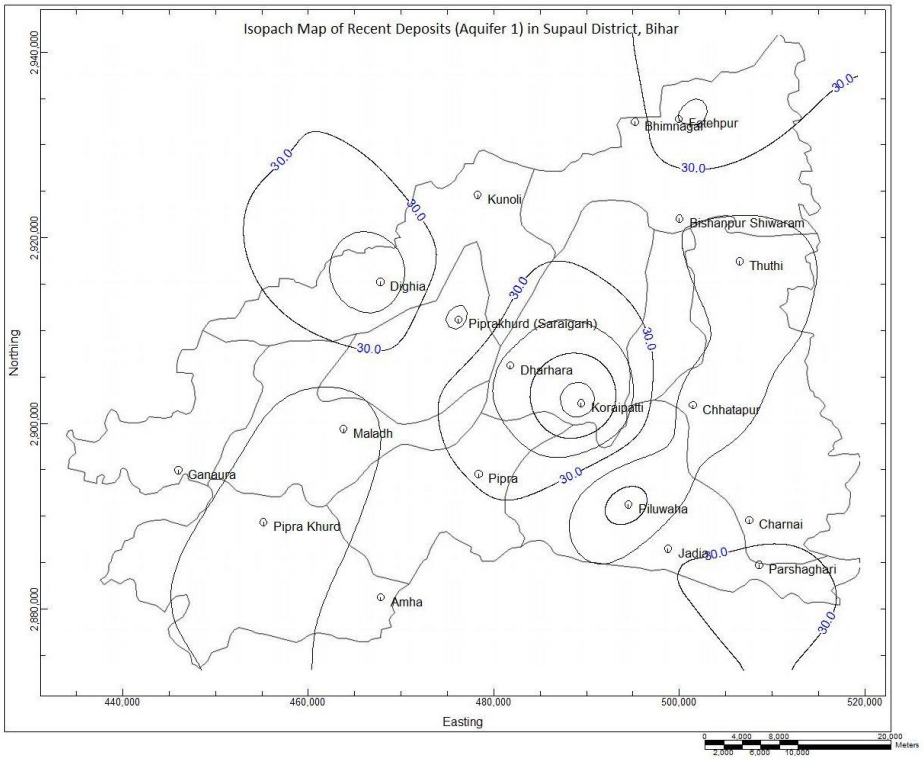


Fig. 51 Isopach Map of Aquifer 1

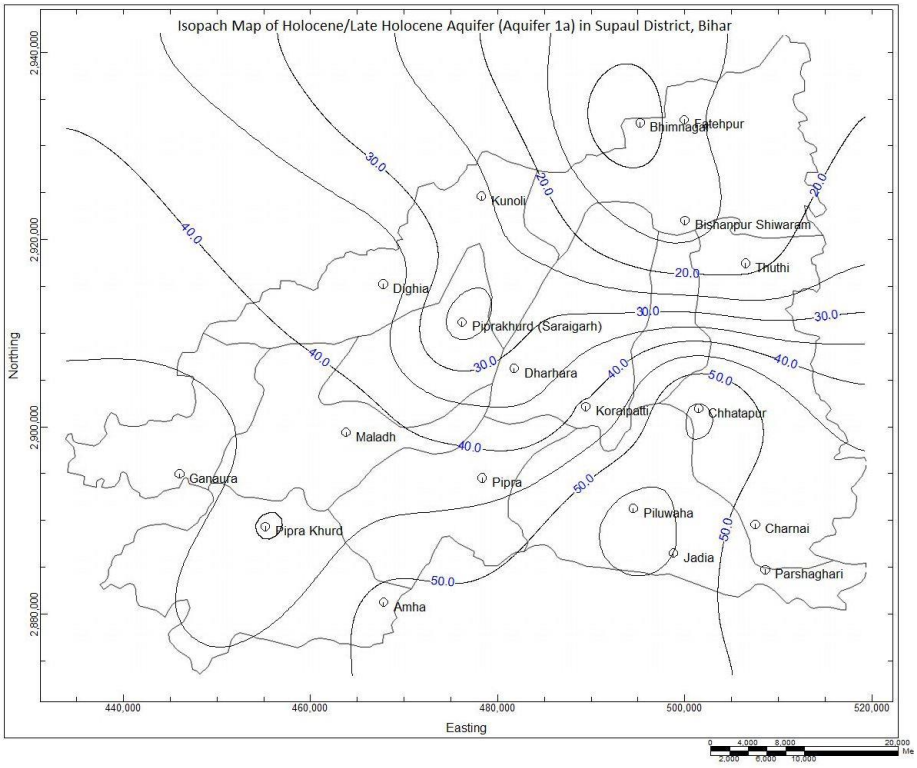


Fig. 52 Isopach Map of Aquifer 1a

CHAPTER-4

Ground Water Resources

4.1 Dynamic Ground Water Resource

Dynamic ground water resources for phreatic aquifer in the district have been assessed following the methodology of GEC-2015. All administrative blocks have been taken as the unit of the assessment. The total annual recharge has been estimated based on the recharge due to rainfall in monsoon and non monsoon seasons and recharge due to other sources like return seepage from surface irrigation networks, return seepage from ground water irrigation or percolation from tanks, ponds etc. As per the norms recommended by GEC-2015, the annual extractable ground water recharge has been estimated after subtracting unaccounted natural discharge, which goes out of the aquifer as base flow etc. The total annual ground water recharges for Supaul district is 82421 ha m or 824 MCM and total annual extractable ground water resource in the district is 74179 ha m or 742 MCM. The total annual extraction of ground water in the district is 306 MCM under irrigation, industrial and domestic draft. Irrigation draft contributes almost 81% of total annual draft in the district. The irrigation draft has been assessed on the basis of 5th MI census data of the shallow, medium and deep tube wells and their unit draft. Overall ground water development in the district is less, Basantpur, Chattapur, Pipra, Raghopur witness moderate development, however in other blocks development is further low. Net ground water availability for future uses in the district is 430 MCM. Therefore, a major share of net ground water availability in the district is still available for future development. The stage of ground water extraction on an average in the district is 40%, lowest being 22% in Saraigarh Bhaptiyahi block and maximum of 70% in Pipra block. Overall development status in the district is below from State average development. All the blocks are categorised as safe in terms of level of ground water development. Table 4.10 and fig.53 describes the assessment unit wise comparative attributes of ground water resources and block wise development status in the district.

Table: 4.1 Annual Extractable Ground Water Resource (based on GEC-2015)

S. No.	District	Ground Water Recharge (Ham)				Total Annual Ground Water Recharge (Ham)	Total Natural Discharges (Ham)	Annual Extractable Ground Water Resource (Ham)
		Monsoon		Non-monsoon				
		Recharge from Rainfall	Recharge from Other Sources	Recharge from Rainfall	Recharge from Other Sources			
1	BASANTPUR	5717.02	1370.47	735.27	1124.78	8947.54	894.75	8052.79
2	CHHATAPUR	7108.48	2456.98	914.23	1319.07	11798.76	1179.88	10618.88
3	KISHANPUR	4470.56	1034.06	574.96	752.85	6832.43	683.24	6149.19
4	MARAUNA	3785.96	179.53	486.92	127.11	4579.52	457.95	4121.57
5	NIRMALI	2939.99	992.33	378.12	641.71	4952.15	495.21	4456.94
6	PIPRA	4489.2	1803.59	577.36	1012.93	7883.08	788.31	7094.77
7	PRATAPGANJ	2518.37	722.97	323.89	174.54	3739.77	373.97	3365.8
8	RAGHOPUR	4729.67	1291.8	608.29	815.52	7445.28	744.53	6700.75
9	SARAIGARH BHAPTIYAHI	4691.48	209.23	603.38	148.15	5652.24	565.22	5087.02
10	SUPAUL	7036.66	1128.86	904.99	680.66	9751.17	975.12	8776.05
11	TRIBENIGANJ	7295.31	1876.93	938.26	728.38	10838.88	1083.88	9755
Total								

Table: 4.2 Draft and Categorization in Supaul District

Assessment units (block)	Annual Extractable Ground Water Resource (Ham)	ANNUAL GROUND WATER DRAFT (Ham)				Annual GW Allocation for Domestic Use as on 2025 (Ham)	Net Ground Water Availability for future use (Ham)	Stage of Ground Water Extraction (%)	Categorization (Over-Exploited/ Critical/ Saline)
		Irrigation	Industrial	Domestic	Total Extraction				
BASANTPUR	8052.79	3909.75	225	416.7	4551.45	468.08	3449.96	56.52	safe
CHHATAPUR	10618.88	5101.2	279	493.51	5873.71	554.36	4684.32	55.31	safe

KISHANPUR	6149.19	2230.8	126	288.86	2645.66	324.48	3467.91	43.02	safe
MARAUNA	4121.57	764.4	45	250.04	1059.43	280.87	3031.31	25.7	safe
NIRMALI	4456.94	856.05	63	239.15	1158.19	268.64	3269.26	25.99	safe
PIPRA	7094.77	4350.45	234	346.97	4931.42	389.75	2120.57	69.51	safe
PRATAPGANJ	3365.8	1060.8	63	184.14	1307.94	206.85	2035.15	38.86	safe
RAGHOPUR	6700.75	2318.55	135	371.51	2825.06	417.32	3829.88	42.16	safe
SARAIGARH BHAPTIYAHI	5087.02	893.1	54	211.51	1158.61	237.59	3902.33	22.78	safe
SUPAUL	8776.05	1920.75	135	846.02	2901.77	950.34	5769.96	33.06	safe
TRIBENIGANJ	9755	1587.3	108	555.56	2250.86	624.07	7435.63	23.07	safe

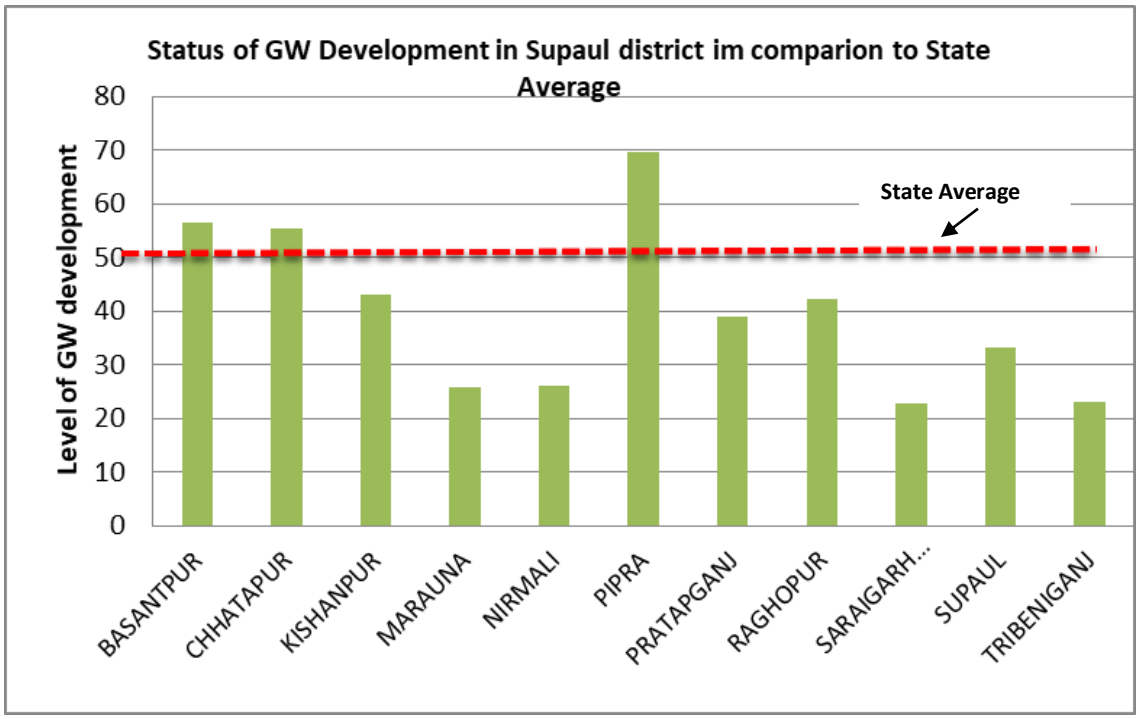


Fig.53 Status of Ground Water development in Supaul District

4.2 Additional potential recharge due to shallow water table

In shallow water table areas, particularly in discharge areas, rejected recharge would be considerable and water level fluctuation is subdued resulting in under-estimation of recharge component. In the area where the groundwater level is within 5 m below ground level (bgl) , additional potential resource are assessed based on the following equation.

Potential groundwater recharge = (5-D) X A X Sp. Yield

Where,

D = depth to water table below ground surface in pre-monsoon season in shallow aquifers;

A=area of shallow water table zone

The shallow water table area in the district has been delineated based on the pre monsoon water level area, area under shallow water level has been added to arrive at the total shallow water table area in the district, it has been identified that almost entire district experiences shallow water table area even in premonsoon time. The shallow water table imparts additional potential resource in the district; Total additional potential resource is estimated as 478 MCM. This additional resource along with the resource in the dynamic zone in the district constitutes huge ground water reserve (Table.4.3)

Table: 4.3 Additional Potential Resources

Sl no	Block	Annual Extractable Ground Water Resource (Ham)	Area where average Pre monsoon WL within 1.5 m in (sq km)	Additional potential resource in MCM	Area where average Pre monsoon WL within 2.5 m (sq km)	Additional potential resource in MCM	Area where average Pre monsoon WL within 4 m (sq km)	Additional potential resource in MCM	Total Additional potential Resource	Total Additional potential Resource in Ham
1	BASANTPUR	8052.79	14.16	4.96	264.94	66.24	8.12	0.81	72.00	7200.32
2	CHHATAPUR	10618.88		0.00	89.79	22.45	232.69	23.27	45.72	4571.71
3	KISHANPUR	6149.19	12.05	4.22	173.88	43.47		0.00	47.69	4768.80
4	MARAUNA	4121.57		0.00	124.77	31.19	0.00	0.00	31.19	3119.25
5	NIRMALI	4456.94	141.20	49.42	100.12	25.03		0.00	74.45	7445.03
6	PIPRA	7094.77		0.00	36.04	9.01	149.89	14.99	24.00	2400.04
7	PRATAPGANJ	3365.80		0.00	7.76	1.94	69.32	6.93	8.87	887.09
8	RAGHOPUR	6700.75		0.00	97.75	24.44	124.63	12.46	36.90	3690.13
9	SARAIGARH BHAPTIYAHI	5087.02	134.40	47.04	10.98	2.75		0.00	49.79	4978.60
10	SUPAUL	8776.05		0.00	153.99	38.50	120.70	12.07	50.57	5056.80
11	TRIBENIGANJ	9755.00		0.00	61.05	15.26	221.41	22.14	37.40	3740.28
	Total	**74178.76**	**301.81**		**1121.08**		**926.76**			**47858.04**

CHAPTER-5

5.1 Major Ground Water Related Issues in the Area

- Very limited ground water development in the district, water logging and frequent flooding. Among 11 blocks, 8 blocks namely Nirmali, Marauna, Raghopur, Supaul, Pratapganj, Saraigarh etc. register less ground water development than the state average of around 50%.
- The hydrogeomorphic and hydrogeological scenario of the district is accountable for huge ground water resources, the huge reserve and on the other hand limited development contribute to the additional resources in the district which in turn results in flooding and water logging throughout the district.
- Frequent shifting of the river Kosi in the recent past has left behind enormous deposits of granular material spatially and vertically, the huge sands constitutes prolific aquifer system.
- Immense ground water pressure and predominance of fine sands with insignificant clay in vertical sequence often results in collapsing of bore holes, therefore, deep drilling of tube well often poses difficulties.
- Some stretches in the district are reported with As contamination in ground water above permissible limit. High arsenic in ground water was identified in the central and eastern parts of Supaul district around the deep abandoned channel and cut off channel of Kosi river. Although the hydro-geomorphic environment in Kosi-Megafan area in Supaul district are not very much favourable for release of arsenic in ground water as other parts of arsenic rich Ganga Flood plain area of Bihar, however, loss of sand load and subsequent increase of clay facies at some abandoned channel may increase the possibility of release of arsenic in groundwater. However, rapid release of arsenic in the area may not be expected.
- Considering excess reserve of ground water in the district, further recharge or rain water harvesting for artificial recharge may not be encouraged in the district. However, roof top rain water harvesting for conservation may be practiced in the urban parts of the district.
- High Fe in ground water in Supaul district and Kosi Megafan area, as well, has been reported as major ground water quality problem. The previous study of CGWB reveals that 50% of the analyzed samples were reported with Fe more than 1 ppm .

CHAPTER-6

Management Strategies

Aquifer Management Plan

On the basis of interpretation and analysis of Aquifer disposition/Aquifer Maps of Supaul district an effective Aquifer Management Plan is proposed to address the above said issues. Attempt has been made to accommodate the issues considering the disposition and potentiality of the underlying aquifers, available resource, existing development, future scope for further development, present irrigation potential from ground water and surface water resources in the district, existing cropping pattern , cropping intensity and moreover the quality. The management plan encompasses both demand and supply side approaches for effective management in drinking, domestic and irrigation sectors.

6.1 Ground Water Management Plan for Drinking and Domestic Sectors/ an Approach of Supply Side Management

Public Health Engineering Department (PHED), Govt. of Bihar is entrusted with the water supply to the population in rural and urban area in the State. The source of drinking water supply is hand pumps and pipe water supply schemes. The dependence on ponds, river and streams has declined during the last 10 years (2001-2011) from 10.7% to 3.06%. Hand pumps remain the major source of drinking water in rural areas supplying water to 91.4% households (Census 2011). One hand pump is designed for 200-250 population whereas the pipe water supply covers 1000-1500 population. Bihar, however, witnesses very high volume of hand pumps of more than 6, 00,000 in the state. However, the tap water supply based on pipe water supply schemes was not adequate till date. It is to be noted that the tube wells within the premises of the individual households are mostly shallow therefore; these are mostly affected by contamination from surface leaching and microbial contamination. In recent times, under the active initiation of Govt. of Bihar mass scale installation of drinking water tube wells and pipe water based water supply has been taken up in the State. These are principally mini water supply scheme for 1000-1500 population. Each water supply scheme in Supaul district has been designed to cater 155 households and 900 population @ 70 lpcd. Based on the proposed capacity of the pump motor of 3 HP, the designed discharge has been assumed as 3 lps or 10.8 m^3/hr.

The table 6.1 shows that for the population as per 2011 census, demand in the drinking and domestic sector is 68.13 MCM. The above demand can be met from 2880 TW as per the proposed

design discharge for 150 mm diameter well for 6 hr/day running. However, considering the huge potentiality of the underground aquifer in the district, the above demand can be met safely from 311 TW, for heavy duty deep tube well with design discharge of 100m^3/hr. As per the information received from district PHED about 2900 schemes has been taken up in the district.

The demand for 2025 has also been assessed considering the decadal growth rate of population. It is assumed that , additional 27.28 MCM water supply may be required to meet the increased demand and for which 1150 TW with present designed discharge may be required further (Table 6.2).

The present depth of installation of the tube wells for drinking domestic sector in the district are 80- 100 m depth.

Table : 6.1 Demand in Drinking and Domestic Water Supply based on 2011 census population

Block	Population as per census 2011	Demand @70 lpcd in MCM	Unit Draft in MCM @ 10.8m^3 /hr for 6hr running/day	Number of TW may be required	Unit Draft in MCM for100 m^3 /hr 6hr running/day	Number of TW may be required
Supaul	428187	10.94017785	0.023652	463	0.219	50
Kisanpur	200571	5.12458905	0.023652	217	0.219	23
Saraigarh	146587	3.74529785	0.023652	158	0.219	17
Nirmali	117254	2.9958397	0.023652	127	0.219	14
Marona	174645	4.46217975	0.023652	189	0.219	20
Pipra	239495	6.11909725	0.023652	259	0.219	28
Triveniganj	383929	9.80938595	0.023652	415	0.219	45
Chhatapur	344844	8.8107642	0.023652	373	0.219	40
Pratapganj	128088	3.2726484	0.023652	138	0.219	15
Raghopur	259489	6.62994395	0.023652	280	0.219	30
Basantpur	243343	6.21741365	0.023652	263	0.219	28
Total	**2666432**	**68.1273376**		**2880**		**311**

Table : 6.2 Demand in Drinking and Domestic Water Supply based on projected population in 2025

Block	Population as per census 2011	Population in 2025 considering the decadal Growth Rate	Demand in 2025 in MCM @70lpcd	Increase in demand in MCM as compared to 2011	Unit Draft MCM for 10.8m^3 /hr for 6hr/day running	No of additional TW may be required in future
Supaul	428187	599633	15.3206	4.3804	0.0237	185
Kisanpur	200571	280880	7.1765	2.0519	0.0237	87
Saraigarh	146587	205280	5.2449	1.4996	0.0237	63
Nirmali	117254	164203	4.1954	1.1995	0.0237	51
Marona	174645	244573	6.2488	1.7867	0.0237	76
Pipra	239495	335389	8.5692	2.4501	0.0237	104
Triveniganj	383929	537654	13.7371	3.9277	0.0237	166
Chhatapur	344844	482920	12.3386	3.5278	0.0237	149
Pratapganj	128088	179374	4.5830	1.3104	0.0237	55
Raghopur	259489	363388	9.2846	2.6546	0.0237	112
Basantpur	243343	340778	8.7069	2.4895	0.0237	105
Total	**2666432**	**3734071**	**95.4055**	**27.2782**		**1153**

6.2 Ground Water Management Plan for Irrigation Sectors; Demand and Supply Side Interventions

Agriculture is one of the principal sources of livelihoods of the people in the area. The major crops in the area are cereals which include paddy, wheat, maize etc. Other major crops are pulses, oilseeds, other horticulture crops, plantations etc. Three crop seasons are predominant in the district kharif, rabi and summer. Major share of kharif cultivation is rainfed although irrigation is provided as per need. The table 6.3 shows that among the total cultivable area of 187500 ha in the district, about 90000 ha is net irrigated area; 50% of cultivable area. Further 97500 ha area may be brought under assured irrigation.

It is observed that pulses, oilseed cultivation in the district falls much below than cereals crop. Therefore, crop diversification and modification of cropping pattern; (keeping the fundamental crops unchanged) may increase the cropping intensity in a particular block. The tentative water column required for different crops is given in Table 6.4.

However, the surface irrigation network in the district is largely depends on canal irrigation of Kosi canal command area. Considering the huge potential and shallow ground water level in the district further irrigation may be attempted from ground water development.

Table 6.3 Area to be brought under Irrigation

Block	Net Cropped Area	Cultivable area	Net irrigated area	Gross Irrigated area	Area to be brought under Assured Irrigation
Supaul	20768.5	26933.65	12927.98	19669	14005.67
Kisanpur	12780.64	16574.58	7955.68	13001	8618.90
Saraigarh	9585.48	12430.94	5966.76	8798	6464.18
Nirmali	5591.53	7251.38	3480.61	5106	3770.77
Marona	10384.27	13466.85	6463.99	10874	7002.86
Pipra	12780.64	16574.58	7965.68	12695	8608.90
Triveniganj	21567.33	27969.61	13425.21	23199	14544.40
Chhatapur	18372.17	23825.96	11436.29	14425	12389.67
Pratapganj	7189.11	9323.20	4475.07	6959	4848.13
Raghopur	14378.28	18646.48	8950.14	15973	9696.34
Basantpur	11183.06	14502.76	6961.22	9122	7541.54
Total	**144581.01**	**187500.00**	**90008.63**	**139821**	**97491.37**

Table 6.4 Crop Water Requirements

Crop	Water Requirement (mm)	Crop	Water Requirement (mm)
Rice	1000-2000	Chilies	500
Wheat	450-650	Sunflower	350-500
Sorghum	450-650	Castor	500
Maize	500-800	Bean	300-500

Sugarcane	1500-2500	Cabbage	380-500
Groundnut	500-700	Pea	350-500
Cotton	700-1300	Banana	1200-2200
Soybean	450-700	Citrus	900-1200
Tobacco	400-600	Pineapple	700-1000
Tomato	600-800	Gingerly	350-400
Potato	500-700	Ragi	400-450
Onion	350-550	Grape	500-1200

6.5 Dynamic Ground Water Resource Position in Supaul District.

District	Annual Extractable Ground Water Resource (Ham)	ANNUAL GROUND WATER DRAFT (Ham)				Annual GW Allocation for Domestic Use as on 2025 (Ham)	Stage of Ground Water Extraction (%)	Categorization (Over-Exploited/ Critical/ Semi critical/ Safe/ Saline)
		Irrigation	Industrial	Domestic	Total Extraction			
BASANTPUR	8052.79	3909.75	225	416.7	4551.45	468.08	56.52	Safe
CHHATAPUR	10618.88	5101.2	279	493.51	5873.71	554.36	55.31	Safe
KISHANPUR	6149.19	2230.8	126	288.86	2645.66	324.48	43.02	Safe
MARAUNA	4121.57	764.4	45	250.04	1059.43	280.87	25.7	Safe
NIRMALI	4456.94	856.05	63	239.15	1158.19	268.64	25.99	Safe
PIPRA	7094.77	4350.45	234	346.97	4931.42	389.75	69.51	Safe
PRATAPGANJ	3365.8	1060.8	63	184.14	1307.94	206.85	38.86	Safe
RAGHOPUR	6700.75	2318.55	135	371.51	2825.06	417.32	42.16	Safe
SARAIGARH BHAPTIYAHI	5087.02	893.1	54	211.51	1158.61	237.59	22.78	Safe
SUPAUL	8776.05	1920.75	135	846.02	2901.77	950.34	33.06	Safe
TRIBENIGANJ	9755	1587.3	108	555.56	2250.86	624.07	23.07	Safe
Total	**74178.76**	**24993.15**	**1467**	**4203.97**	**30664.1**	**4722.35**	**39.63**	

As per the Dynamic Resource of Ground Water Resource Assessment, 2020, in Supaul district, total annual extractable ground water resource in the district is 74178.76 ham and total extraction in all uses is 30664 ham. Average stage of ground water extraction in the district is 40% with minimum around 23% in Saraigrarh and maximum around 70% around Pipra block.

It is proposed to increase the ground water development beyond 70% to utilize the huge ground water resource which in turn may lower the ground water level in the district. 90% of the extractable ground water resource is proposed to be developed which provide scope for utilization of 36096.78 ham additional resource. 518 .38 ham is put under reserve for allocation in drinking domestic sector in 2025, rest 35578.40 ham may be planned for further irrigation development through construction of additional shallow and deep tube well for irrigation uses.

Table 6.6 NGWA for future Irrigation for 90% development

Block	Annual Extractable Ground Water in ham	Total Extraction in Ham	Proposed extraction in ham for 90% development	Additional water in ham	Drinking/Domestic water allocation for 2025	NGW Avail for future irrigation in ham
Supaul	8776.05	2901.77	7898.445	4996.675	104.32	4892.355
Kisanpur	6149.19	2645.66	5534.271	2888.611	35.62	2852.991
Saraigarh	5087.02	1158.61	4578.318	3419.708	26.08	3393.628
Nirmali	4456.94	1158.19	4011.246	2853.056	29.49	2823.566
Marona	4121.57	1059.43	3709.413	2649.983	30.83	2619.153
Pipra	7094.77	4931.42	6385.293	1453.873	42.78	1411.093
Triveniganj	9755	2250.86	8779.5	6528.64	68.51	6460.13
Chhatapur	10618.88	5873.71	9556.992	3683.282	60.85	3622.432
Pratapganj	3365.8	1307.94	3029.22	1721.28	22.71	1698.57
Raghopur	6700.75	2825.06	6030.675	3205.615	45.81	3159.805
Basantpur	8052.79	4551.45	7247.511	2696.061	51.38	2644.681
	74178.76	**30664.1**	**66760.884**	**36096.784**	**518.38**	**35578.404**

The volume of water available for future irrigation development may be utilized through construction of irrigation tube wells. Based on the prevailing practices 75% of available resource may be allocated for STW and 25% for DTW. The unit draft for STW may be considered as 3 ham for 25 m^3/hr yield for 10 hr/day run in 120 irrigation days. The unit draft for one DTW may be considered as 9 ham for 75 m^3/hr yield for 10 hr/day run in 120 irrigation days. The block wise requirement of STW and DTW has been estimated. 8895 STW and 988 DTW may be constructed in the district to accomplish 90% development (Table 6.7).

However, installation of proposed structures should always be implemented in phases as per the actual site specific feasibility. The regular monitoring of ground water regime may be continued to identify any significant reflection in water level, if any.

Table 6.7 Proposed numbers of structures

Block	NGWAvail for future irrigation in ham	Allocation 75% for STW	Allocation 25% for DTW	No of STW (unit draft 3 ham for 10 hr/day)	No of DTW (unit drfat 9 ham 10 hr/day)
Supaul	4892.355	3669.26625	1223.08875	1223	136
Kisanpur	2852.991	2139.74325	713.24775	713	79
Saraigarh	3393.628	2545.221	848.407	848	94
Nirmali	2823.566	2117.6745	705.8915	706	78
Marona	2619.153	1964.36475	654.78825	655	73
Pipra	1411.093	1058.31975	352.77325	353	39
Triveniganj	6460.13	4845.0975	1615.0325	1615	179
Chhatapur	3622.432	2716.824	905.608	906	101
Pratapganj	1698.57	1273.9275	424.6425	425	47
Raghopur	3159.805	2369.85375	789.95125	790	88
Basantpur	2644.681	1983.51075	661.17025	661	73
Total				**8895**	**988**

The Supaul district is characterized by very shallow water level, usual water logging and flooding. The shallow water level enhances the probability of water logging which in turn adversely affects the agriculture yield by developing soil salinity etc. Therefore, based on the pre monsoon depth to water level in the district the shallow water level area (<5 mbgl) has been identified and additional potential resource in each block has been assessed. These additional resources are added to the AEGWR. Hence the actual resource available for further development is increased and the projected SOD for increased development is given in table 6.8. The average stage of ground water extraction in the district may increase to 56%. Therefore, the scope for development further exists.

Table 6.8 Projected SOD for increased development

Block	Annual Extractable Ground Water Resource (Ham)	Additional Resource for shallow water level area (< 5 mbgl) ham	Total Available Resource in ham	Proposed extraction for 90% development in ham	Projected SOD for increased development
Supaul	8776.05	5056.80	13832.85	7898.445	57.10
Kisanpur	6149.19	4768.80	10917.99	5534.271	50.69
Saraigarh	5087.02	4978.60	10065.62	4578.318	45.48
Nirmali	4456.94	7445.03	11901.97	4011.246	33.70
Marona	4121.57	3119.25	7240.82	3709.413	51.23
Pipra	7094.77	2400.04	9494.81	6385.293	67.25
Triveniganj	9755	3740.28	13495.28	8779.5	65.06
Chhatapur	10618.88	4571.71	15190.59	9556.992	62.91
Pratapganj	3365.8	887.09	4252.89	3029.22	71.23
Raghopur	6700.75	3690.13	10390.88	6030.675	58.04
Basantpur	8052.79	7200.32	15253.11	7247.511	47.51
Total	**74178.76**	**47858.04**	**122036.80**	**66760.884**	**55.47**

The available resource may be utilized for generation of further irrigation potential in the district. Considering the delta factor of 0.5 m for pulses , oilseeds etc. 62748 ha additional irrigation potential may be created. 83% of cultivable area may be brought under assured irrigation in the district. Scope for further development also prevails.

Table 6.9 Area under Assured Irrigation

Block	NGW Avail for future irrigation in ham	Area can be brought under irrigation with delta factor 0.5 m (ham)	Area under assured irrigation in ham (ref table no 6.3)	% of cultivable area under assured irrigation
Supaul	4046.335	8092.67	21020.65	78
Kisanpur	2564.131	5128.262	13083.942	79
Saraigarh	3182.118	6364.236	12330.996	99
Nirmali	2584.416	5168.832	8649.442	119
Marona	2369.113	4738.226	11202.216	83
Pipra	1064.123	2128.246	10093.926	61
Triveniganj	5904.57	11809.14	25234.35	90
Chhatapur	3128.922	6257.844	17694.134	74
Pratapganj	1514.43	3028.86	7503.93	80
Raghopur	2788.295	5576.59	14526.73	78
Basantpur	2227.981	4455.962	11417.182	79

6.3 Management Interventions for Mitigation of Arsenic in ground water: a Demand and Supply side interventions

Few tube wells within the depth range of 10 mbgl are reported with arsenic contamination of more than 10 ppb in the eastern parts of Supaul district in Chattapur and in Pratapganj block. Although the hydrogeomorphic environment in Kosi Mega fan area are not much favourable for arsenic release in ground water in absence of prominent and persistent clay facies, however, considering the threat each shallow tube wells in the vicinity of the area may be tested for arsenic before use wither for drinking-domestic or for irrigation uses. It has been observed from various arsenic affected flood and deltas plains in the world that high groundwater arsenic, very often, is associated with high groundwater iron. Therefore , high Fe content in ground water may be viewed as an alarm for arsenic infestation, and suitable action plan may be observed. In absence of conspicuous clay facies cement sealing of the upper aquifer may not be very effective, but deep drilling and relocation of sites in arsenic infested area may serve as short term measures for drinking water tube wells.

Domestic and community level arsenic removal techniques and filter may be introduced in absence of alternate source. Mass scale awareness generations among the stakeholder may be familiarised.

CHAPTER-7

7.0 Conclusion and Recommendation:

- Supaul district falls within Kosi Megafan area and lies at the apex and in the eastern parts of the Megafan. Kosi river flowing along the western of the district and largely controls the tectonic and geo-mophologic set up of the district. The geomorphic features typical of river shifting, migration and flood plain area are predominant in the district.
- The Kosi-megafan and the Supaul district is bordered in the north by Siwalik group of rocks in the foothill of Himalayas. Huge sediments are flown by the mighty Kosi and are deposited in the downstream.
- The district is underlain by huge thickness of Quaternary alluvial deposits. In the area bordering the foothill area gravels and pebbles of Bhabar area are found to occur whereas the entire district is underlain by sands of various grain sizes from fine to coarse sands. Occurrences of clay facies are occasional. The grain size considerably reduces in the down slope.
- The huge Quaternary alluvial sediments dominated by sands constitute the prolific aquifer system in the district.
- The economy of the district is agrarian in nature; agriculture is rain fed and irrigation based. Average cropping intensity is 175%. Paddy is the principal crops.
- Surface irrigation is from Kosi canal command and ground water irrigation from STW/MDTW/DTW. The major parts of irrigation tube wells are restricted within 5-20 m depth.
- The huge thickness of Quaternary sediments constitutes more or less single aquifer system down to the explored/studies depth of 100 m bgl. Few local aquitard of limited thickness occasionally form minor 2^{nd} aquifer.
- Though, in general, thin clay/mud capping is present over the upper formation in Supaul district, however the clay is not persistent and is mainly found as surface soil in major parts of the district. Therefore, the shallower aquifers, which are often developed by dug wells and shallow wells, are in phreatic condition.
- Premonsoon depth to water level map of the dug well zone reveals average water level of 3.01 mbgl and post monsoon average water level at 2.12 mbgl.
- The average water table elevation in the district is 60 m amsl. In general groundwater flows in a NW-SE to north south trend. The interpretation of water table maps reveals that, other than

the direct contributions from the rainfall through vertical recharge, lateral flows (recharge) from specifically the Kosi River and other active channels is very significant for the district.

- The long term water level behaviour in the district reveals a steady ground water regime over the years; in time and in space.
- The shallow tube wells for irrigation uses within the depth of 5-20 m yield at 20 m^3/hr when fitted with 5 HP pumps. However shallow and medium deep tube wells are capable to yield at 50 to 75 m^3/hr. Deep tube wells within the depth of 100 m of 150x100 mm diameter are in use for drinking and domestic sectors under PHED, Govt. of Bihar. As per the detail report of PHED , these tube wells are reported to yield at 8.5 " with 90^0 V notch, thus 100m^3/hr yield with moderate drawdown is expected.
- The total annual ground water recharges for Supaul district is 82421 ha m or 824 MCM and total annual extractable ground water resource in the district is 74179 ha m or 742 MCM. Net ground water availability for future uses in the district is 430 MCM. Therefore, a major share of net ground water availability in the district is still available for future development in the district. The stage of ground water extraction on an average in the district is 40%. All the blocks are categorised as safe in terms of level of ground water development.
- The shallow water table imparts additional potential resource in the district. Total additional potential resource is estimated as 478 MCM. This additional resource along with the resource in the dynamic zone in the district constitutes huge ground water reserve.
- Overall chemical quality of ground water in the district is potable; however, concentration of Fe in ground water above permissible limit is reported. Ground water As contamination above 10 ppb has been reported from few blocks in the eastern and central part of the district.
- As per 2011 census, demand in the drinking and domestic sector is 68.13 MCM. The above demand can be met from 2880 TW as per the proposed design discharge of 10.8m^3/hr for 150 mm diameter well for 6 hr/day running. However, considering the huge potentiality of the underground aquifer in the district, the above demand can be met safely from 311 TW, for heavy duty deep tube well with design discharge of 100m^3/hr. As per the information from district PHED about 2900 schemes has been taken up in the district.
- The present depth of installation of the tube wells for drinking domestic sector in the district are 80- 100 m depth.

- Total cultivable area in the district is 187500, about 90000 ha is net irrigated area; 50% of cultivable area. Further 97500 ha area may be brought under assured irrigation.
- In order to put more thrust on ground water regime in the district for lowering of ground water level 90% of the development may be targeted. This provides additional resource of 35578.40 ham which may be planned for further irrigation development through construction of additional shallow and deep tube well for irrigation uses.
- 8895 STW and 988 DTW may be constructed in the district to accomplish 90% development. However, installation of proposed structures should always be implemented in phases as per the actual site specific feasibility. The regular monitoring of ground water regime may be continued to identify any significant reflection in water level, if any.
- In addition, resource due to shallow water table area in the district imparts additional resource. Therefore, even if accelerated ground water development to the extent of 90% is attempted the level of development still maintain within a desirable limit.
- The additional resource for accelerated development may create further irrigation potential of 62748 ha, thus on an average 83% cultivable area may be brought under assured irrigation in the district.
- The shift from practice of canal irrigation in Kosi command area is recommended. The seepage from the perennial unlined canal and the water from surface irrigation network contribute additional resource to the ground water in the district which aggravate the problem of shallow water level and water logging in the district. Surface irrigation in the district may be replaced by accelerated ground water irrigation. After suitable future studies the canal water may be arranged to be diverted to the water scare area in the further downstream.

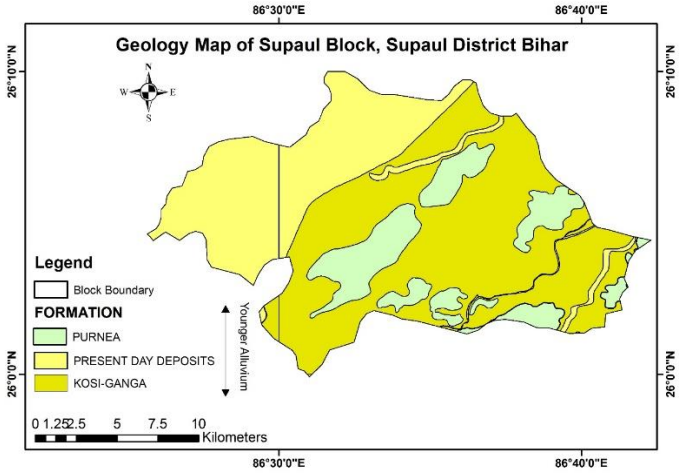
CHAPTER-8

8.0 Block wise Aquifer Maps and Management Plans

BLOCK: Supaul

1.0 Salient Information

Name of the Block/Area	**Supaul**/309.59 sq. km
District/State	Supaul/Bihar
Population	Rural: -294761; Urban: -65437; Total=360198
Rainfall	Average Monsoon Rainfall: - 956.72 Average Non- Monsoon Rainfall: - 119.96
Agriculture and Irrigation	Principal crops: - Rice, Sugarcane, Paddy, Maize, Pulses, Oilseeds etc Gross cropped area (ha): -34474.89 Net sown area: -20769 Irrigation practices: - Surface water by canal Ground water by Tube well and Borewell Cropping Intensity: - 166 Number and Types of abstraction structures: - STW: - 744, MDTW: - 165, DTW: - 0
Geology	Major formations include Present Day deposits and Diara formation (Late Holocene to Recent) in the western part of the block, while Kosiganga formation (Holocene) dominates the lithology in the eastern part, with sporadic occurrences of Purnea formation (Holocene) in the area
Geomorphology	Major Physiographic units- Older Flood Plain, Channel Bar, Younger Alluvial Plain. Presence of Channel Bar/Channel Island, Natural levees, Oxbow lakes. Area dominated by third and second order streams. Major Drainage: - Kosi River.
Groundwater resources availability and extraction	Annual Ground Water Resources (Ham)- 8776.05 Net Ground Water Availability for future use (Ham)- 5769.96 Ground water extraction (Ham)- 2901.77
Existing and future water demand	846.02 Ham/1920.75 Ham for drinking and irrigation sectors
Water level behaviour	Pre-monsoon SWL- 1.85 to 4.5 mbgl Post-monsoon SWL- 1.75 to 3.30 mbgl



Fig,54. Geological Map of the Block

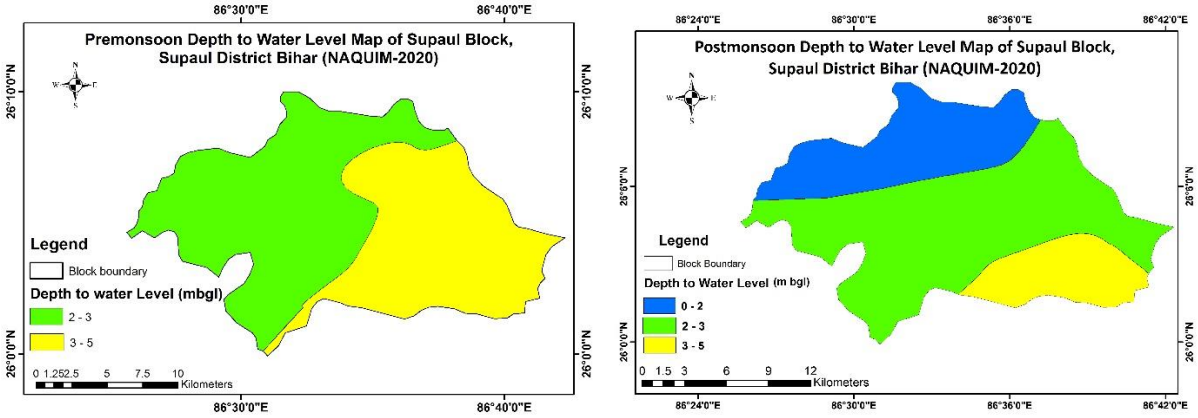


Fig.55 Pre and Post monsoon Depth to Water Level Map of Block

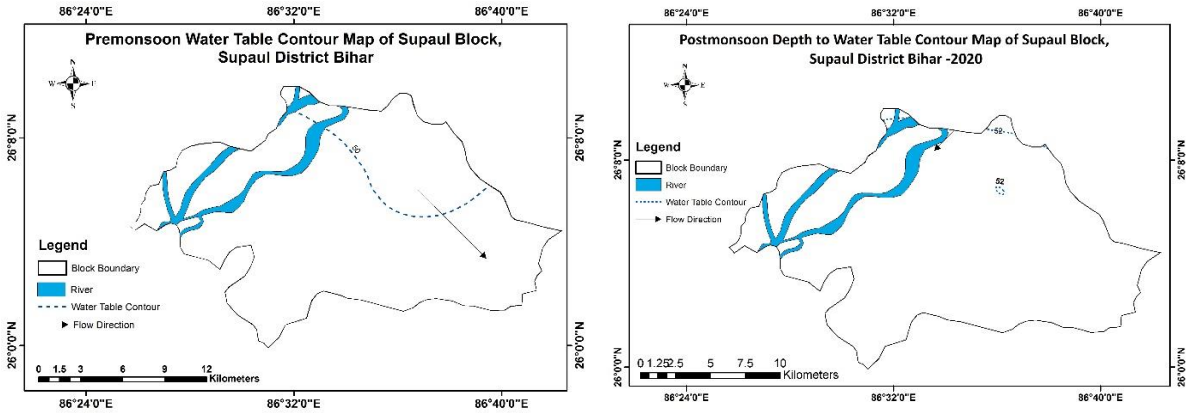


Figure 56. Pre and Post monsoon Water Table Contour Map.

2. Aquifer Disposition

Number of aquifers	01; up to the explored depth of 85 m(?)
3D aquifer disposition	Surface clay 5-7 m thick Single aquifer of fine, medium and coarse sands down to explored depth, mostly unconfined

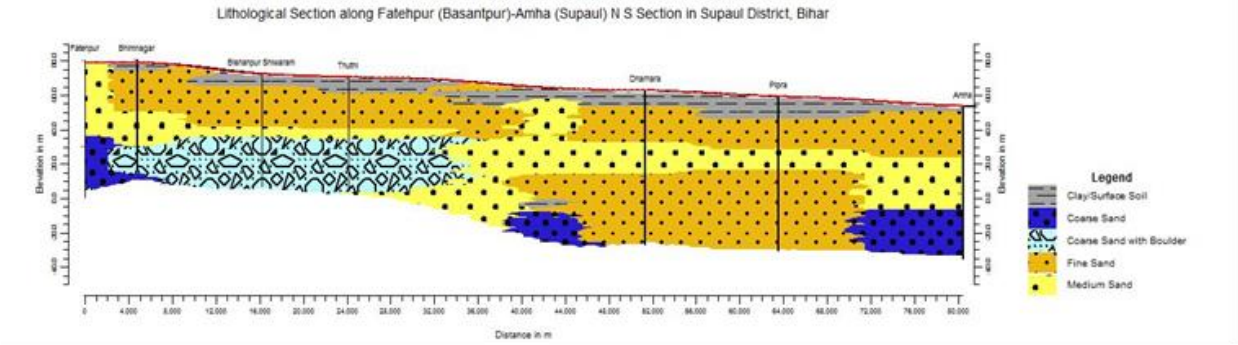


Fig57.Lithology Disposition around Supaul Block

3.0 Ground water resources, extraction, contamination, and other issues

Ground water Resource/Categorization Availability	SOD:33.06%; Safe
Chemical quality of ground water and contamination	Potable

4.0. Supply Side Interventions

Ground Water Development Strategies-	Number of STW and DTW may be proposed for irrigation uses - STW – 1223, DTW - 136
Prospects of Artificial Recharge	Considering shallow water table and frequent flooding artificial recharge to ground water is not recommended rather accelerated pumping and increased ground water development is encouraged. However, in urban area of Supaul roof top rain water harvesting for conservation may be practiced.

Water Quality Management	Ground water from the tube wells are to be tested for Fe/As before drinking water supply at domestic and community level.

5.0. Demand side Interventions

Demand side management in drinking and domestic sectors	Considering draft of one TW 10.8 m3/hr, for 150 mm diameter well for 6 hr/day, 463 TW may be required. For projected population for 2025 additional 185 Tw may be required. Govt. of Bihar has already taken up the installation of Tw for PWSS in the block
Demand side management in Irrigation sectors	Crop rotations, more water intense crops may be promoted. Additional irrigation potential created 8097 ha Therefore 78% of cultivable area can be brought under assured irrigation
Demand side intervention in surface irrigation	Considering the intense water logging in the area canal irrigation/ surface water irrigation is discouraged as far as possible
Other intervention proposed, if any	Water quality monitoring and Surveillance Capacity Building and Awareness generations for As contamination in ground water

BLOCK: Kisanpur

2.0 Salient Information

Name of the Block/Area	**Kisanpur** /196.69 sq. km
District/State	Kisanpur/Bihar
Population	Rural: -167669; Urban: -0; Total=167669
Rainfall	Average Monsoon Rainfall: - 956.72 Average Non- Monsoon Rainfall: - 119.955
Agriculture and Irrigation	Principal crops: - Cereals, Pulses, Oilseeds, Fibre etc Gross cropped area (ha): - 19938 Net sown area: - 12781 Irrigation practices: - Surface water by canal Ground water by Tube well Cropping Intensity: - 156 <u>Number and Types of abstraction structures</u>: - STW: - 1015, MDTW: - 41, DTW: - 0
Geology	Major formations include Younger Alluvium which includes Present Day deposits, Diara formation (Late Holocene to Recent) in the western and central part of the block, while Kosiganga formation (Holocene) dominates the lithology in the eastern part.
Geomorphology	Major Physiographic units (from west to east) are Channel Bar at the western end, laterally abutting Active flood plain then Ridges. This is followed by Older Alluvium in the east. Younger Alluvium is seen in the northern reaches of the block. Area is dominated by second order streams. Major Drainage: - Kosi River.
Groundwater resources availability and extraction	Annual Ground Water Resources (Ham)- 6149.19 Net Ground Water Availability for future use (Ham)- 3467.91 Ground water extraction (Ham)- 2645.66
Existing and future water demand	288.86Ham/2230.8 Ham for drinking and irrigation sectors
Water level behaviour	Pre-monsoon SWL- 2.3 to 2.75 mbgl Post-monsoon SWL- 1.45 to 2.0 mbgl

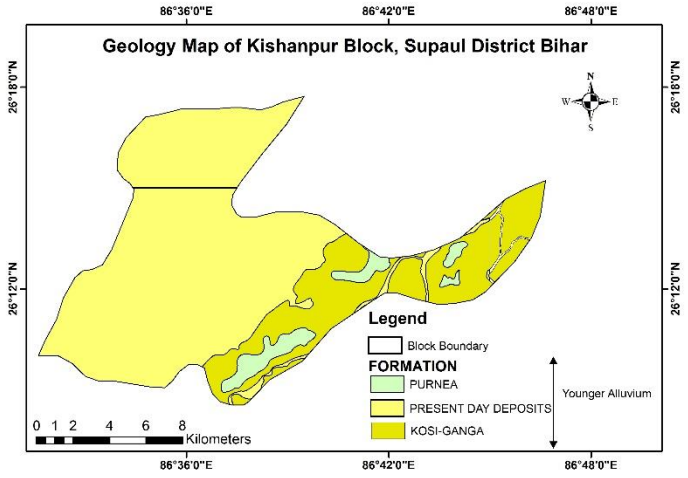


Fig58. Geological Map of Block

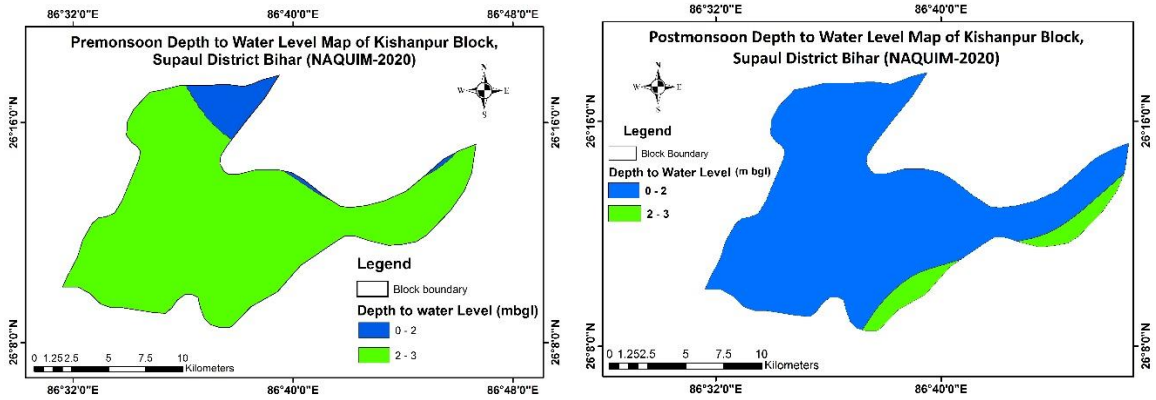


Fig.59 Pre and Post monsoon Depth to Water Level Map of Block

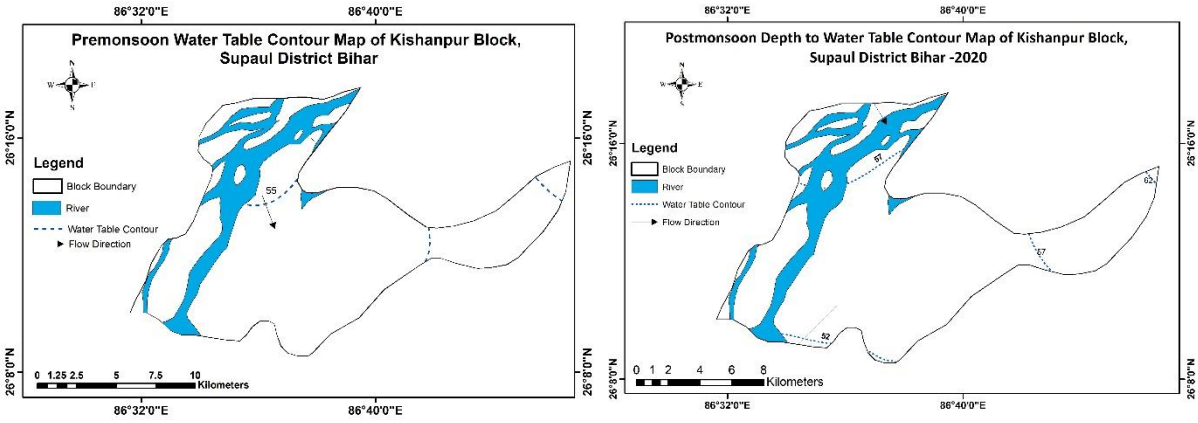


Figure 60. Pre and Post monsoon Water Table Contour Map.

2. Aquifer Disposition

Number of aquifers	01; up to the explored depth of 85 m
3D aquifer disposition	Surface clay 08-10 m thick Single aquifer of fine, medium followed by fine sands to the explored depth, mostly unconfined

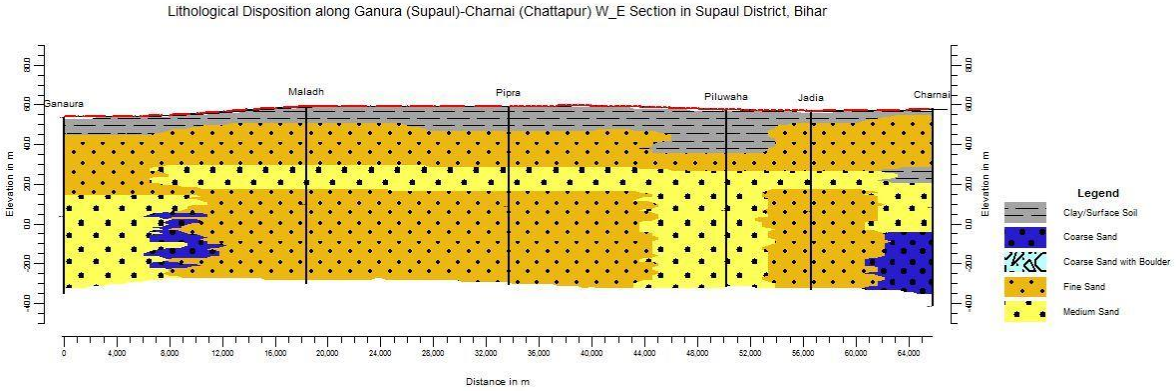


Fig61. Lithology Disposition around Kishanpur Block

3.0 Ground water resources, extraction, contamination, and other issues

Ground water Resource/Categorization Availability	SOD: 43.02%; Safe
Chemical quality of ground water and contamination	Potable

4.0. Supply Side Interventions

Ground Water Development Strategies-	Number of STW and DTW may be proposed for irrigation uses - STW – 713, DTW - 79
Prospects of Artificial Recharge	Considering shallow water table and frequent flooding artificial recharge to ground water is not recommended rather accelerated pumping and increased ground water development is encouraged. However, in urban area roof top rain water harvesting for conservation may be practiced.

Water Quality Management	Ground water from the tube wells are to be tested for Fe/As before drinking water supply at domestic and community level.

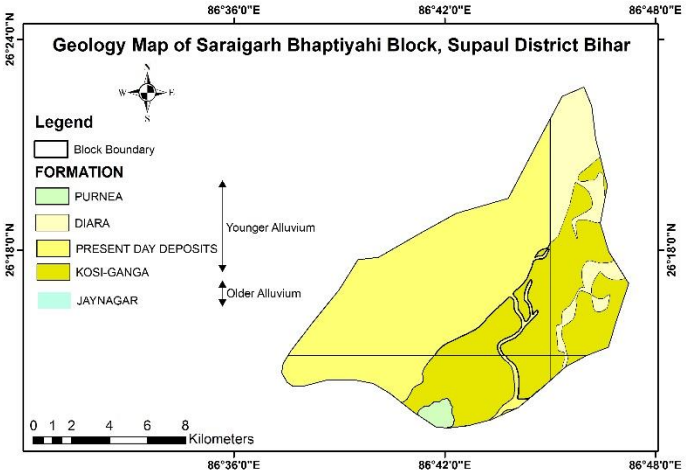
5.0. Demand side Interventions

Demand side management in drinking and domestic sectors	Considering draft of one TW 10.8 m3/hr, for 150 mm diameter well for 6 hr/day, 217 TW may be required. For projected population for 2025 additional 87 Tw may be required. Govt. of Bihar has already taken up the installation of Tw for PWSS in the block
Demand side management in Irrigation sectors	Crop rotations, more water intense crops may be promoted. Additional irrigation potential created 5128.262 ha Therefore 79% of cultivable area can be brought under assured irrigation
Demand side intervention in surface irrigation	Considering the intense water logging in the area canal irrigation/ surface water irrigation is discouraged as far as possible
Other intervention proposed, if any	Water quality monitoring and Surveillance Capacity Building and Awareness generations for As contamination in ground water

BLOCK: Saraigarh

Salient Information

Name of the Block/Area	**Saraigarh** /206.41 sq. km
District/State	Supaul /Bihar
Population	Rural: -122772; Urban: -0; Total=122772
Rainfall	Normal Monsoon: - 956.72 Non- Monsoon: - 119.96
Agriculture and Irrigation	Principal crops: - Cereals, Pulses, Oilseeds, Fibre etc Gross cropped area (ha): - 15049 Net sown area: - 9585 Irrigation practices: - Surface water by canal Ground water by Tube well and Borewell Cropping Intensity: - 157 <u>Number and Types of abstraction structures</u>: - STW: - 226, MDTW: - 197, DTW: - 0
Geology	Major formations include Younger Alluvium which includes Present Day deposits, Diara formation (Late Holocene to Recent) in the western and central part of the block, while Kosiganga formation (Holocene) dominates the lithology in the eastern part.
Geomorphology	Major Physiographic units (from west to east) are Channel Bar at the western end, laterally abutting Active flood plain then Ridges. This is followed by Older Flood plain followed by Paleochannel in the east. Paleochannel is seen from south to north, at the eastern margin of the block. Area is dominated by first and second order streams. Major Drainage: - Kosi River.
Groundwater resources availability and extraction	Annual Ground Water Resources (Ham)- 5087.02 Net Ground Water Availability for future use (Ham)- 3902.33 Ground water extraction (Ham)- 1158.61
Existing and future water demand	211.51Ham/893.1Ham for drinking and irrigation sectors
Water level behaviour	Pre-monsoon SWL- 1.9 to 3.07 mbgl Post-monsoon SWL- 0.86 to 1.4 mbgl



Fig,62. Geological Map of Block

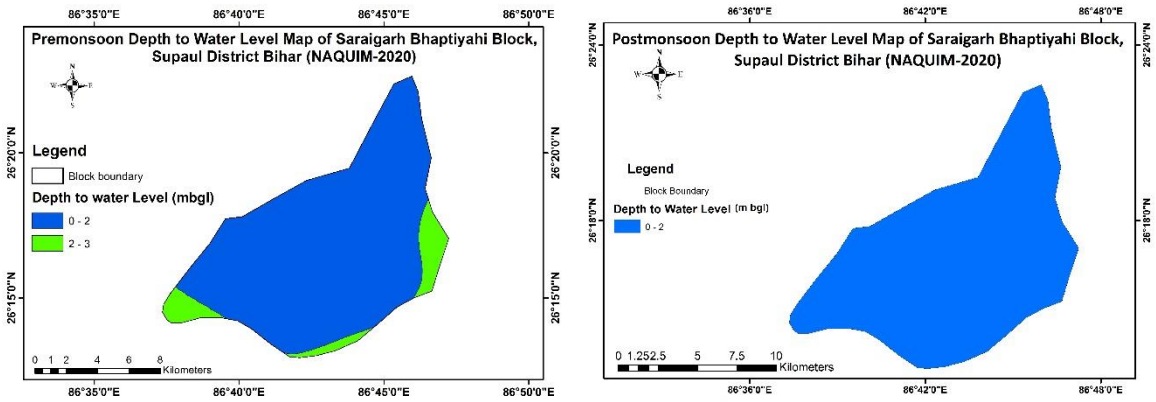


Fig.63 Pre and Post monsoon Depth to Water Level Map of Block

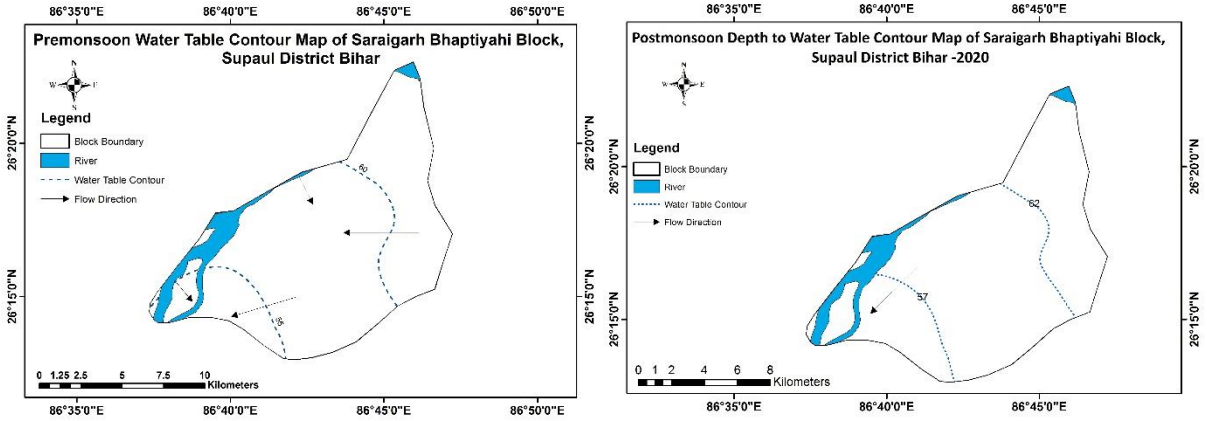


Figure 64. Pre and Post monsoon Water Table Contour Map.

2. Aquifer Disposition

Number of aquifers	01; up to the explored depth of 75 m
3D aquifer disposition	Single aquifer of fine, medium and coarse sand to the explored depth, mostly unconfined

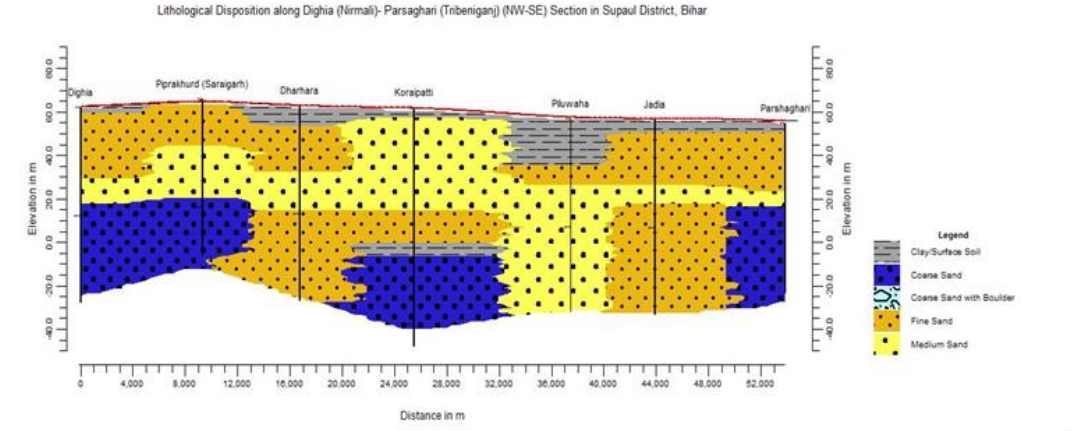


Fig65. Lithology Disposition around Saraigarh Block

3.0 Ground water resources, extraction, contamination, and other issues

Ground water Resource/Categorization Availability	SOD: 22.78%; Safe
Chemical quality of ground water and contamination	Potable

4.0. Supply Side Interventions

Ground Water Development Strategies-	Number of STW and DTW may be proposed for irrigation uses - STW – 848, DTW - 94
Prospects of Artificial Recharge	Considering shallow water table and frequent flooding artificial recharge to ground water is not recommended rather accelerated pumping and increased ground water development is encouraged. However, in urban area roof top rain water harvesting for conservation may be practiced.

Water Quality Management	Ground water from the tube wells are to be tested for Fe/As before drinking water supply at domestic and community level.

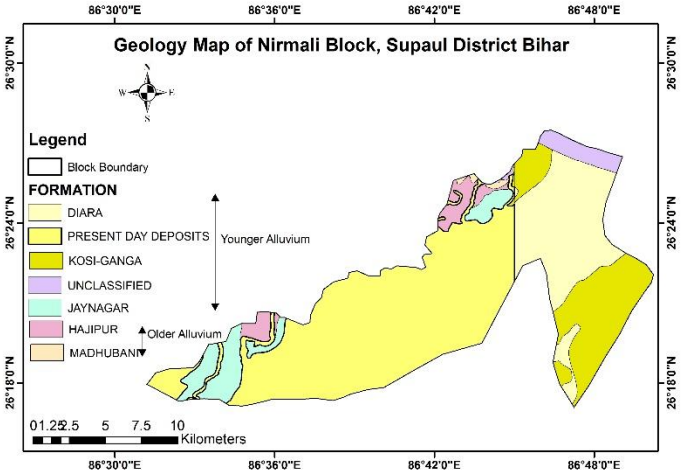
5.0. Demand side Interventions

Demand side management in drinking and domestic sectors	Considering draft of one TW 10.8 m3/hr, for 150 mm diameter well for 6 hr/day, 158 TW may be required. For projected population for 2025 additional 63 Tw may be required. Govt. of Bihar has already taken up the installation of Tw for PWSS in the block
Demand side management in Irrigation sectors	Crop rotations, more water intense crops may be promoted. Additional irrigation potential created 6364.236 ha Therefore 99 % of cultivable area can be brought under assured irrigation
Demand side intervention in surface irrigation	Considering the intense water logging in the area canal irrigation/ surface water irrigation is discouraged as far as possible
Other intervention proposed, if any	Water quality monitoring and Surveillance Capacity Building and Awareness generations for As contamination in ground water

BLOCK: Nirmali

Salient Information

Name of the Block/Area	Nirmali /129.35 sq. km
District/State	Supaul /Bihar
Population	Rural: -78246; Urban: -20189; Total=98435
Rainfall	Normal Monsoon: - 956.72 Non- Monsoon: - 119.96
Agriculture and Irrigation	Principal crops: - Cereals, Pulses, Oilseeds, Fibre etc Gross cropped area (ha): - 9617.43 Net sown area: - 5592 Irrigation practices: - Surface water by tanks and ponds Ground water by Tube well Cropping Intensity: - 172 Number and Types of abstraction structures: - STW: - 389, MDTW: - 16, DTW: - 0
Geology	Major formations include Younger Alluvium which includes Present Day deposits, Hajipur formation (Pleistocene to early Holocene) and Jaynagar formation () as isolated exposures in western and north-western part of the block
Geomorphology	Major Physiographic units (from west to east) are Older Alluvium, with isolated Point bars, laterally abutting Channel Bars. Area is dominated with mostly first and second order streams. Major Drainage: - Sapt Kosi River.
Groundwater resources availability and extraction	Annual Ground Water Resources (Ham)- 4456.94 Net Ground Water Availability for future use (Ham)- 3269.26 Ground water extraction (Ham)- 1158.19
Existing and future water demand	239.15 Ham/856.05 Ham for drinking and irrigation sectors
Water level behaviour	Pre-monsoon SWL- 1.9 to 3.68 mbgl Post-monsoon SWL- 1.1 to 1.5 mbgl



Fig,66. Geological Map of Block

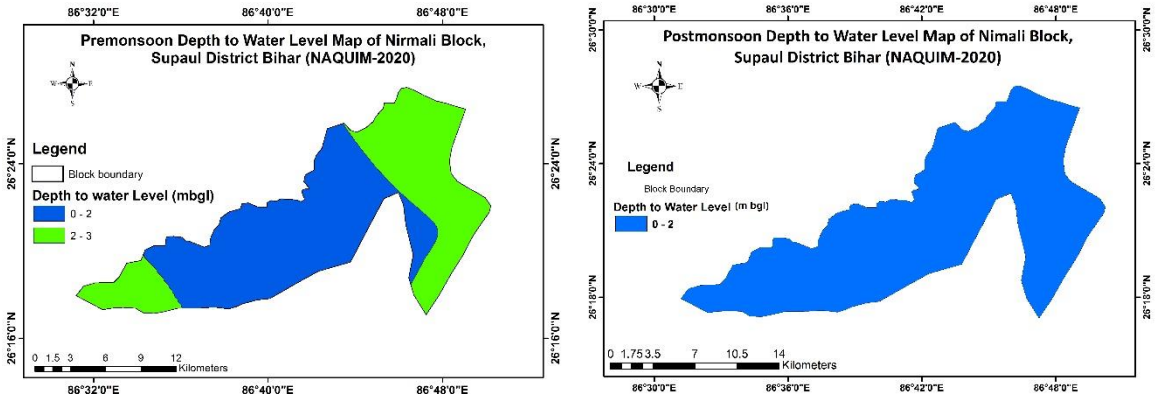


Fig.67 Pre and Post monsoon Depth to Water Level Map of Block

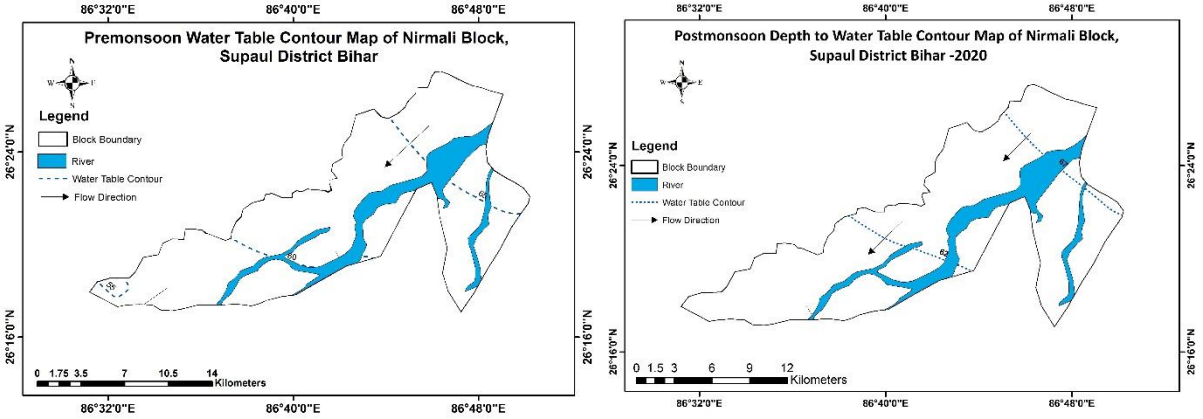


Figure 68. Pre and Post monsoon Water Table Contour Map.

2. Aquifer Disposition

Number of aquifers	01; up to the explored depth of 85 m
3D aquifer disposition	Surface clay 02-05 m thick Single aquifer of fine, medium and coarse sand to the explored depth, mostly unconfined

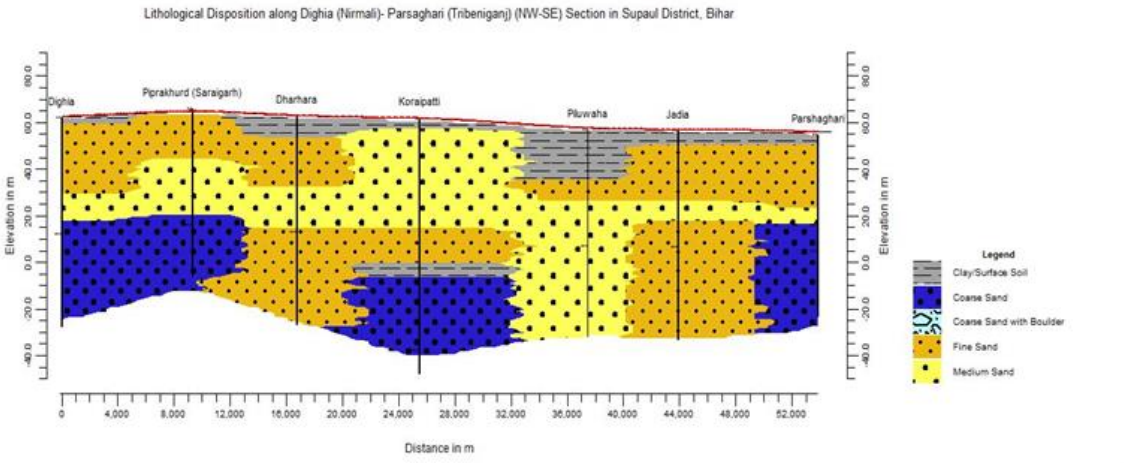


Fig69. Lithology Disposition around Nirmali Block

3.0 Ground water resources, extraction, contamination, and other issues

Ground water Resource/Categorization Availability	SOD: 25.99%; Safe
Chemical quality of ground water and contamination	Potable

4.0. Supply Side Interventions

Ground Water Development Strategies-	Number of STW and DTW may be proposed for irrigation uses - STW – 706, DTW - 78
Prospects of Artificial Recharge	Considering shallow water table and frequent flooding artificial recharge to ground water is not recommended rather accelerated pumping and increased ground water development is encouraged. However, in urban area roof top rain water harvesting for conservation may be practiced.

Water Quality Management	Ground water from the tube wells are to be tested for Fe/As before drinking water supply at domestic and community level.

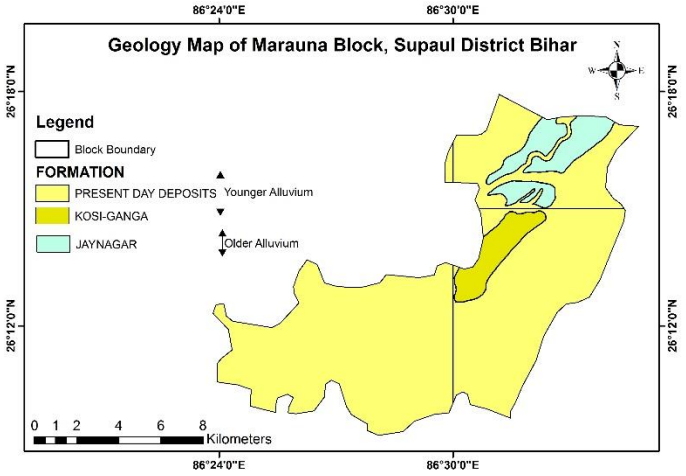
5.0. Demand side Interventions

Demand side management in drinking and domestic sectors	Considering draft of one TW 10.8 m3/hr, for 150 mm diameter well for 6 hr/day, 127 TW may be required. For projected population for 2025 additional 51 Tw may be required. Govt. of Bihar has already taken up the installation of Tw for PWSS in the block
Demand side management in Irrigation sectors	Crop rotations, more water intense crops may be promoted. Additional irrigation potential created 5168.832 ha Therefore 119 % of cultivable area can be brought under assured irrigation
Demand side intervention in surface irrigation	Considering the intense water logging in the area canal irrigation/ surface water irrigation is discouraged as far as possible
Other intervention proposed, if any	Water quality monitoring and Surveillance Capacity Building and Awareness generations for As contamination in ground water

BLOCK: Marauna

Salient Information

Name of the Block/Area	Marauna /166.57 sq. km
District/State	Supaul /Bihar
Population	Rural: -145136; Urban: -0; Total=145136
Rainfall	Normal Monsoon: - 956.72 Non- Monsoon: - 119.96
Agriculture and Irrigation	Principal crops: - Cereals, Pulses, Oilseeds, Fibre etc Gross cropped area (ha): - 16926 Net sown area: - 10384 Irrigation practices: - Surface water by tanks and ponds Ground water by Tube well and Borewell Cropping Intensity: - 163 Number and Types of abstraction structures: - STW: - 231, MDTW: - 130, DTW: - 0
Geology	Major formations include Younger Alluvium which includes Present Day deposits, Diara Formation (Late Holocene to Recent) Kosi Ganga formation (Holocene). Older Alluvium formations like Jaynagar Formation and Hajipur formations are observed in north eastern part of the block.
Geomorphology	Major Physiographic units (from west to east) are Older Alluvium, with isolated Point bars, laterally abutting Channel Bars. Area is dominated with mostly first order streams. Major Drainage: - Sapt Kosi River.
Groundwater resources availability and extraction	Annual Ground Water Resources (Ham)- 4121.57 Net Ground Water Availability for future use (Ham)- 3031.31 Ground water extraction (Ham)- 1059.43
Existing and future water demand	250.04 Ham/764.4 Ham for drinking and irrigation sectors
Water level behaviour	Pre-monsoon SWL- 2.1 to 3.87 mbgl Post-monsoon SWL- 0.98 to 1 mbgl



Fig,70. Geological Map of Block

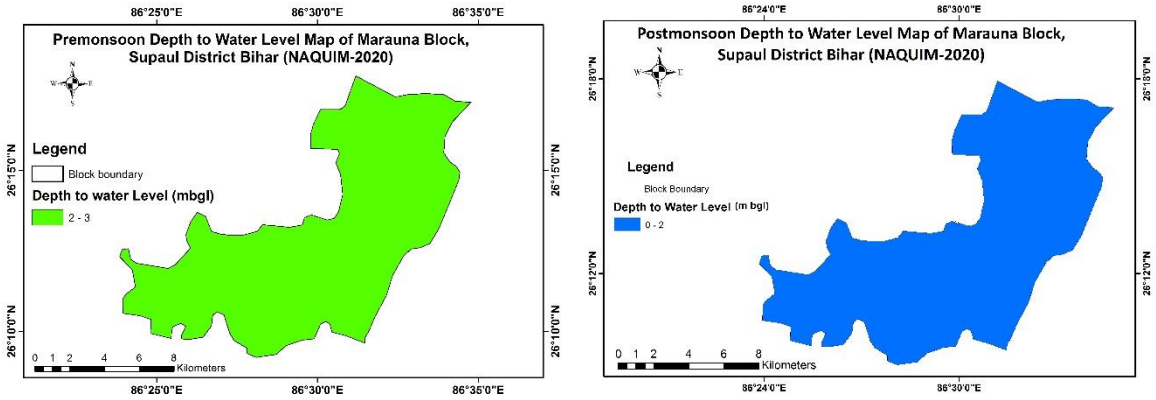


Fig.71 Pre and Post monsoon Depth to Water Level Map of Block

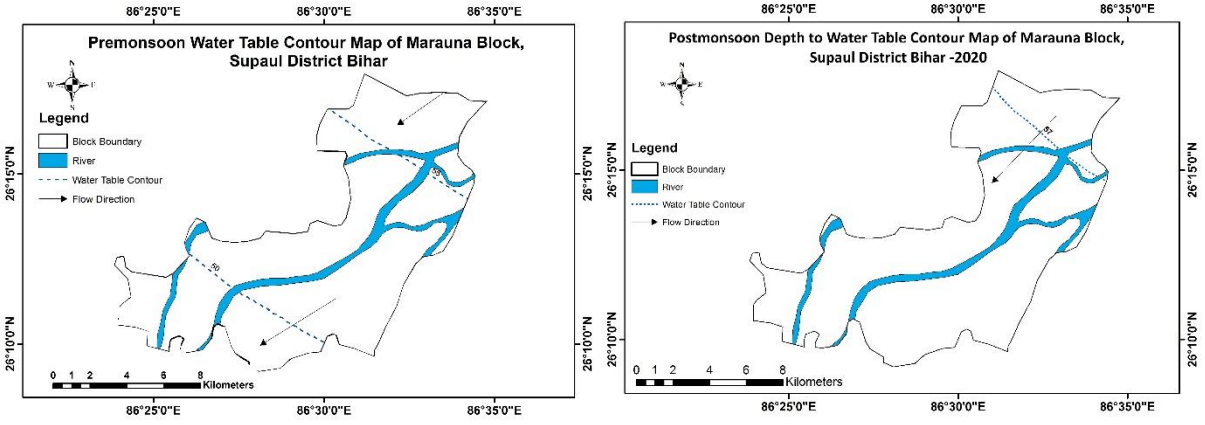


Figure 72. Pre and Post monsoon Water Table Contour Map.

2. Aquifer Disposition

Number of aquifers	01; up to the explored depth of 85 m
3D aquifer disposition	Surface clay 05-10 m thick Single aquifer of fine, medium sand to the explored depth, mostly unconfined

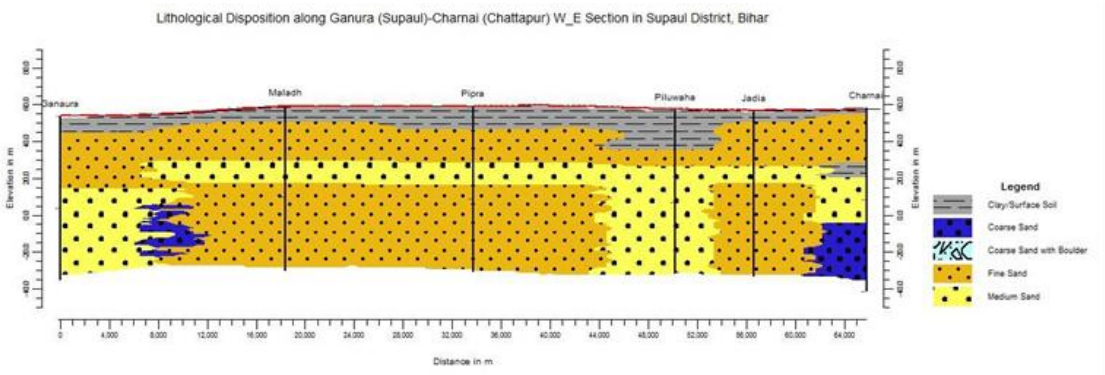


Fig 73 Lithology Disposition around Marauna Block

3.0 Ground water resources, extraction, contamination, and other issues

Ground water Resource/Categorization Availability	SOD: 25.7%; Safe
Chemical quality of ground water and contamination	Potable

4.0. Supply Side Interventions

Ground Water Development Strategies-	Number of STW and DTW may be proposed for irrigation uses - STW – 655, DTW - 73
Prospects of Artificial Recharge	Considering shallow water table and frequent flooding artificial recharge to ground water is not recommended rather accelerated pumping and increased ground water development is encouraged. However, in urban area roof top rain water harvesting for conservation may be practiced.
Water Quality Management	Ground water from the tube wells are to be tested for Fe/As before drinking water supply at domestic and community level.

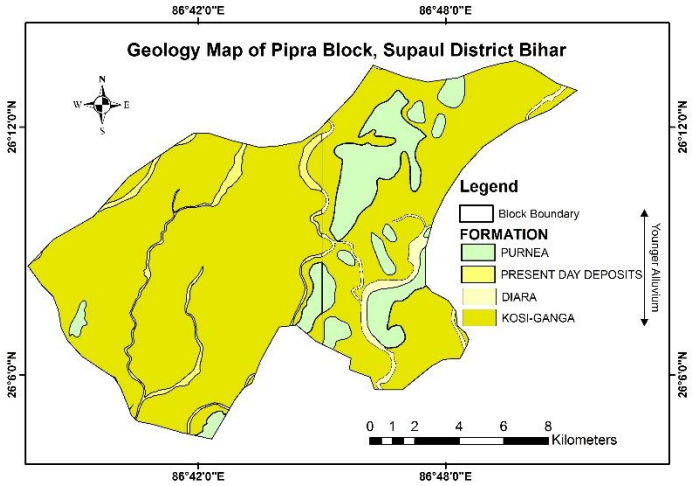
5.0. Demand side Interventions

Demand side management in drinking and domestic sectors	Considering draft of one TW 10.8 m3/hr, for 150 mm diameter well for 6 hr/day, 189 TW may be required. For projected population for 2025 additional 76 Tw may be required. Govt. of Bihar has already taken up the installation of Tw for PWSS in the block
Demand side management in Irrigation sectors	Crop rotations, more water intense crops may be promoted. Additional irrigation potential created 4738.226 ha Therefore, 83 % of cultivable area can be brought under assured irrigation
Demand side intervention in surface irrigation	Considering the intense water logging in the area canal irrigation/ surface water irrigation is discouraged as far as possible
Other intervention proposed, if any	Water quality monitoring and Surveillance Capacity Building and Awareness generations for As contamination in ground water

BLOCK: Pipra

Salient Information

Name of the Block/Area	Pipra /197.51sq. km
District/State	Supaul /Bihar
Population	Rural: -201399; Urban: -0; Total=201399
Rainfall	Normal Monsoon: - 956.72 Non- Monsoon: - 119.96
Agriculture and Irrigation	Principal crops: - Cereals, Pulses, Oilseeds, Fibre etc Gross cropped area (ha): - 22877.34 Net sown area: - 12780.64 Irrigation practices: - Surface water by tanks and ponds Ground water by Tube well and Cropping Intensity: - 179% Number and Types of abstraction structures: - STW: - 2059, MDTW: - 0, DTW: - 0
Geology	Major formations include Younger Alluvium which includes Kosi Ganga formation (Holocene) and Purnea Formation (Holocene) occurs as isolated parallel exposures in the block.
Geomorphology	Major Physiographic units include younger alluvium plains along with Paleochannels, which are present in the northern part of the block. Area is dominated with mostly second order streams. Major Drainage: - Barhar Dhar River.
Groundwater resources availability and extraction	Annual Ground Water Resources (Ham)- 7094.77 Net Ground Water Availability for future use (Ham)- 2120.57 Ground water extraction (Ham)- 4931.42
Existing and future water demand	346.97 Ham/4350.45 Ham for drinking and irrigation sectors
Water level behaviour	Pre-monsoon SWL- 3.2 to 4.5 mbgl Post-monsoon SWL- 1.25 to 4.3 mbgl



Fig,74. Geological Map of Block

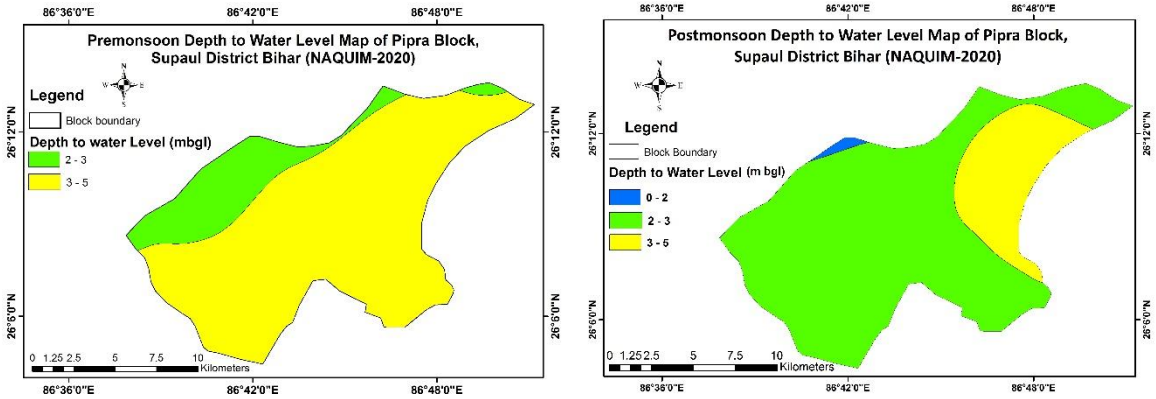


Fig.75 Pre and Post monsoon Depth to Water Level Map of Block

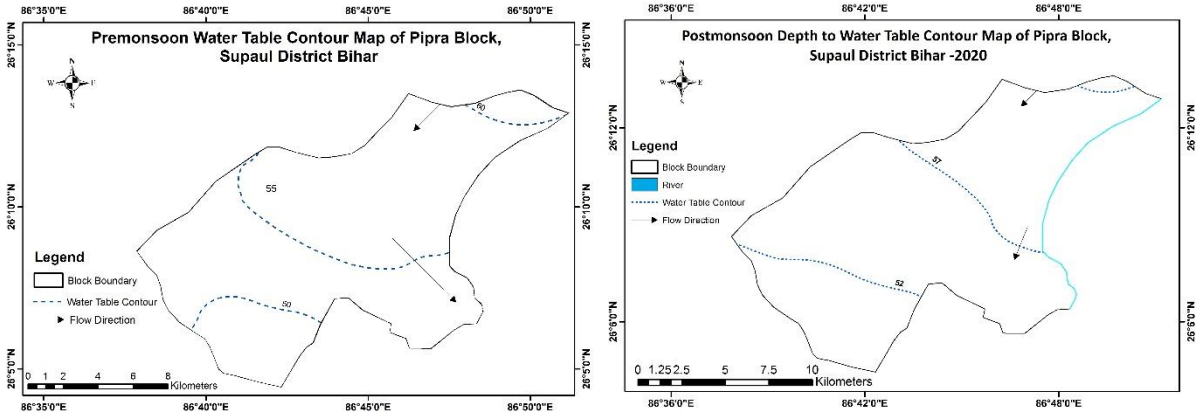


Fig. 76. Pre and Post monsoon Water Table Contour Map.

2. Aquifer Disposition

Number of aquifers	01; up to the explored depth of 85 m
3D aquifer disposition	Surface clay 05-10 m thick Single aquifer of fine, medium sand followed fine sands to explored depth, mostly unconfined

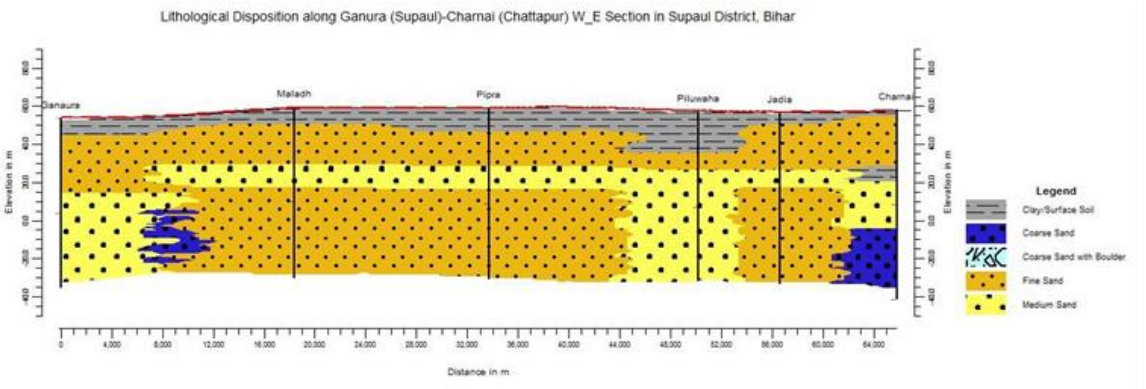


Fig.77. Lithology Disposition around Pipra Block

3.0 Ground water resources, extraction, contamination, and other issues

Ground water Resource/Categorization Availability	SOD: 69.51%; Safe
Chemical quality of ground water and contamination	Potable

4.0. Supply Side Interventions

Ground Water Development Strategies-	Number of STW and DTW may be proposed for irrigation uses - STW – 353, DTW - 39
Prospects of Artificial Recharge	Considering shallow water table and frequent flooding artificial recharge to ground water is not recommended rather accelerated pumping and increased ground water development is encouraged. However, in urban area roof top rain water harvesting for conservation may be practiced.

Water Quality Management	Ground water from the tube wells are to be tested for Fe/As before drinking water supply at domestic and community level.

5.0. Demand side Interventions

Demand side management in drinking and domestic sectors	Considering draft of one TW 10.8 m^3/hr, for 150 mm diameter well for 6 hr./day, 259 TW may be required. For projected population for 2025 additional 104 Tw may be required. Govt. of Bihar has already taken up the installation of Tw for PWSS in the block
Demand side management in Irrigation sectors	Crop rotations, more water intense crops may be promoted. Additional irrigation potential created 5168.832 ha Therefore 61 % of cultivable area can be brought under assured irrigation
Demand side intervention in surface irrigation	Considering the intense water logging in the area canal irrigation/ surface water irrigation is discouraged as far as possible
Other intervention proposed, if any	Water quality monitoring and Surveillance Capacity Building and Awareness generations for As contamination in ground water

BLOCK: Triveniganj

Salient Information

Name of the Block/Area	**Triveniganj** /320.97 sq. km
District/State	Supaul /Bihar
Population	Rural: -322477; Urban: -0; Total=322477
Rainfall	Normal Monsoon: - 956.72 Non- Monsoon: - 119.96
Agriculture and Irrigation	Principal crops: - Cereals, Pulses, Oilseeds, Fibre etc Gross cropped area (ha): - 47017 Net sown area: - 21567 Irrigation practices: - Surface water by tanks and ponds Ground water by Tube well Cropping Intensity: - 218% <u>Number and Types of abstraction structures</u>: - STW: - 671, MDTW: - 80, DTW: - 0
Geology	Major formations include Younger Alluvium which includes Present Day deposits, Kosi Ganga formation (Holocene). Purnea Formation(Holocene) occurs as isolated parallel exposures in the block.
Geomorphology	Major Physiographic units includes younger alluvium plains along with few paleochannels, which are present in the northern part of the block. Area is dominated with mostly first and second order streams. Major Drainage: - Kosi Dhar River.
Groundwater resources availability and extraction	Annual Ground Water Resources (Ham)- 9755 Net Ground Water Availability for future use (Ham)- 7435.63 Ground water extraction (Ham)- 2250.86
Existing and future water demand	555.56 Ham/1587.3 Ham for drinking and irrigation sectors
Water level behaviour	Pre-monsoon SWL- 2.89 to 3.89 mbgl Post-monsoon SWL- 1.95 to 2.95 mbgl

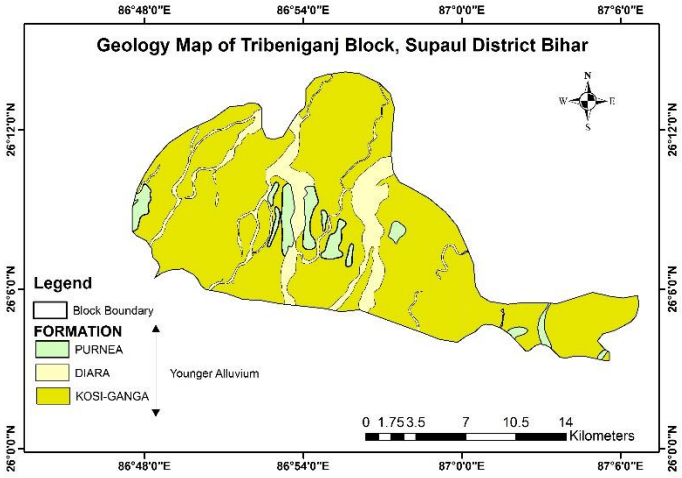


Fig78. Geological Map of Block

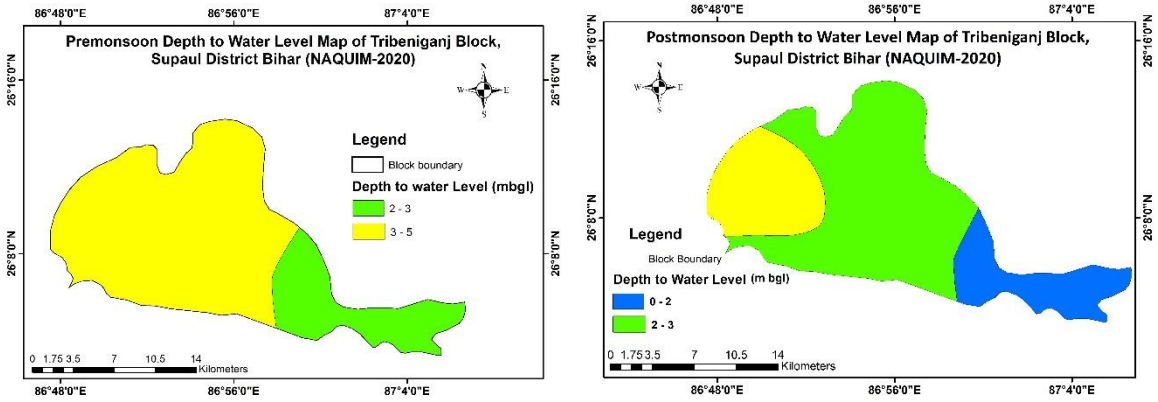


Fig.79 Pre and Post monsoon Depth to Water Level Map of Block

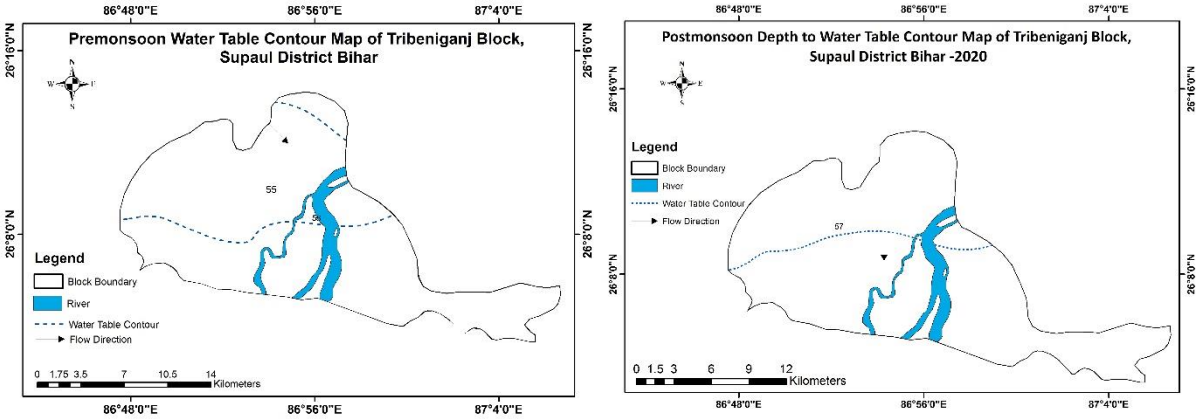


Figure 80. Pre and Post monsoon Water Table Contour Map.

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2. Aquifer Disposition

Number of aquifers	01; up to the explored depth of 80 m(?)
3D aquifer disposition	Surface clay 15-20 m thick Single aquifer of fine, medium sand followed fine sands by down to explored depth, mostly unconfined

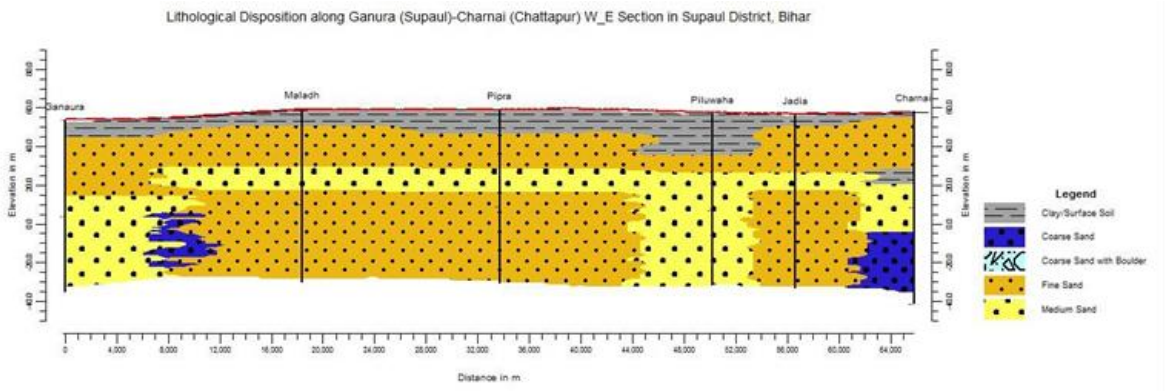


Fig81. Lithology Disposition around Triveniganj Block

3.0 Ground water resources, extraction, contamination, and other issues

Ground water Resource/Categorization Availability	SOD: 23.07%; Safe
Chemical quality of ground water and contamination	Potable

4.0. Supply Side Interventions

Ground Water Development Strategies-	Number of STW and DTW may be proposed for irrigation uses - STW – 1615, DTW - 179
Prospects of Artificial Recharge	Considering shallow water table and frequent flooding artificial recharge to ground water is not recommended rather accelerated pumping and increased ground water development is encouraged. However, in urban area roof top rain water harvesting for conservation may be practiced.

Water Quality Management	Ground water from the tube wells are to be tested for Fe/As before drinking water supply at domestic and community level.

5.0. Demand side Interventions

Demand side management in drinking and domestic sectors	Considering draft of one TW 10.8 m3/hr, for 150 mm diameter well for 6 hr/day, 415 TW may be required. For projected population for 2025 additional 45 Tw may be required. Govt. of Bihar has already taken up the installation of Tw for PWSS in the block
Demand side management in Irrigation sectors	Crop rotations, more water intense crops may be promoted. Additional irrigation potential created 11809.14 ha Therefore 90 % of cultivable area can be brought under assured irrigation
Demand side intervention in surface irrigation	Considering the intense water logging in the area canal irrigation/ surface water irrigation is discouraged as far as possible
Other intervention proposed, if any	Water quality monitoring and Surveillance Capacity Building and Awareness generations for As contamination in ground water

BLOCK: Chattapur

Salient Information

Name of the Block/Area	**Chattapur** /312.75 sq. km
District/State	Supaul /Bihar
Population	Rural: -286456; Urban: -0; Total=286456
Rainfall	Normal Monsoon: - 956.72 Non- Monsoon: - 119.96
Agriculture and Irrigation	Principal crops: - Cereals, Pulses, Oilseeds, Fibre etc Gross cropped area (ha): - 26823 Net sown area: - 18372 Irrigation practices: - Surface water by tanks and ponds Ground water by Tube well Cropping Intensity: - 146% <u>Number and Types of abstraction structures</u>: - STW: - 2335, MDTW: - 95, DTW: - 0
Geology	Major formations are Younger Alluvium which includes Kosi Ganga formation (Holocene) for most of the area, along with Present Day Deposits in the western part of block.
Geomorphology	Major Physiographic units includes younger alluvium plains, active flood plains along with Paleochannels, which are present in the northern part of the block. Area is dominated with mostly second order streams. Major Drainage: - Barhar Dhar River.
Groundwater resources availability and extraction	Annual Ground Water Resources (Ham)- 10618.88 Net Ground Water Availability for future use (Ham)- 4684.32 Ground water extraction (Ham)- 5873.71
Existing and future water demand	493.51 Ham/5101.2 Ham for drinking and irrigation sectors
Water level behaviour	Pre-monsoon SWL- 2.14 to 4.0 mbgl Post-monsoon SWL- 1.0 to 2.41 mbgl

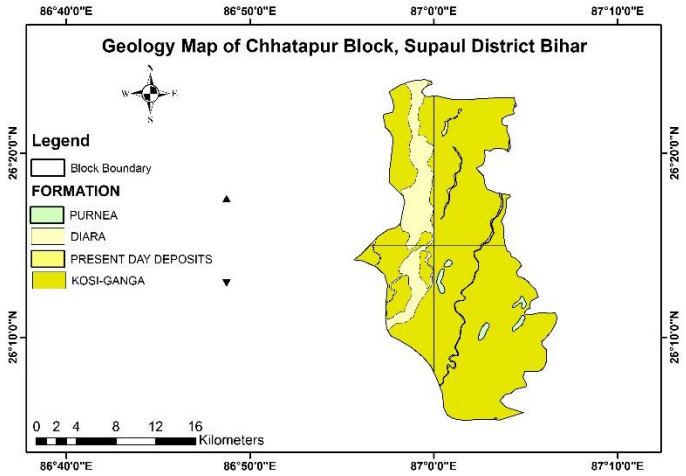


Fig82. Geological Map of Block

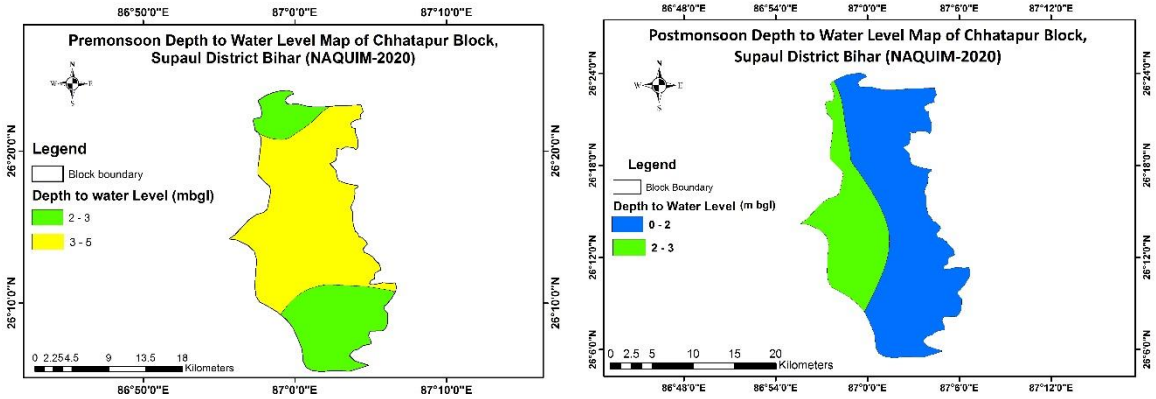


Fig.83 Pre and Post monsoon Depth to Water Level Map of Block

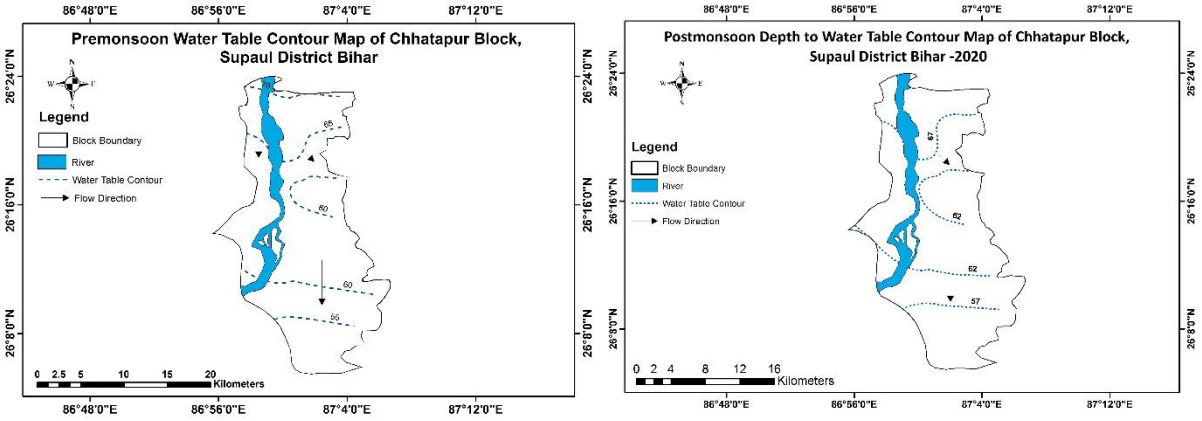


Figure 84. Pre and Post monsoon Water Table Contour Map.

2. Aquifer Disposition

Number of aquifers	01; up to the explored depth of 100 m(?)
3D aquifer disposition	Surface clay 0.5-1 m thick Single aquifer of fine, medium and coarse sands, boulders below 30 m depth in the northern parts of the block, mostly unconfined

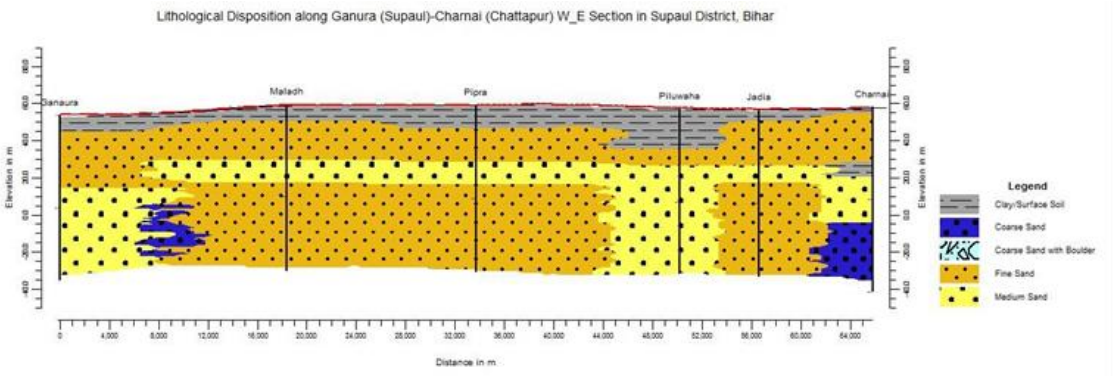


Fig85. Lithology Disposition around Chattapur Block

3.0 Ground water resources, extraction, contamination, and other issues

Ground water Resource/Categorization Availability	SOD: 55.31 %; Safe
Chemical quality of ground water and contamination	Potable

4.0. Supply Side Interventions

Ground Water Development Strategies-	Number of STW and DTW may be proposed for irrigation uses - STW – 906, DTW - 101
Prospects of Artificial Recharge	Considering shallow water table and frequent flooding artificial recharge to ground water is not recommended rather accelerated pumping and increased ground water development is encouraged. However, in urban area roof top rain water

	harvesting for conservation may be practiced.
Water Quality Management	Arsenic, more than the permissible limit has been reported from few area in the block. Ground water from the tube wells are to be tested for Fe/As before drinking water supply at domestic and community level.

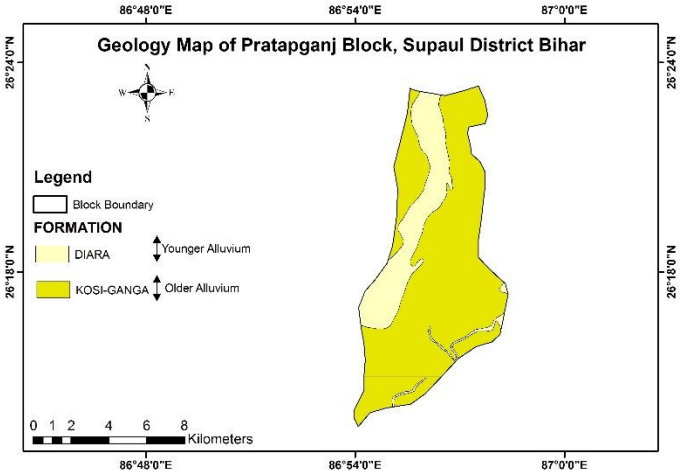
5.0. Demand side Interventions

Demand side management in drinking and domestic sectors	Considering draft of one TW 10.8 m^3/hr, for 150 mm diameter well for 6 hr/day, 373 TW may be required. For projected population for 2025 additional 149 Tw may be required. Govt. of Bihar has already taken up the installation of Tw for PWSS in the block
Demand side management in Irrigation sectors	Crop rotations, more water intense crops may be promoted. Additional irrigation potential created 6257.844 ha Therefore, 74 % of cultivable area can be brought under assured irrigation
Demand side intervention in surface irrigation	Considering the intense water logging in the area canal irrigation/ surface water irrigation is discouraged as far as possible
Other intervention proposed, if any	Water quality monitoring and Surveillance Capacity Building and Awareness generations for As contamination in ground water

BLOCK: Pratapganj

Salient Information

Name of the Block/Area	Pratapganj /110.8 sq. km
District/State	Supaul /Bihar
Population	Rural: -106884; Urban: -0; Total=106884
Rainfall	Normal Monsoon: - 956.72 Non- Monsoon: - 119.96
Agriculture and Irrigation	Principal crops: - Cereals, Pulses, Oilseeds, Fibre etc Gross cropped area (ha): - 17972.77 Net sown area: - 18372.17 Irrigation practices: - Surface water by tanks and ponds Ground water by Tube well Cropping Intensity: - 250% Number and Types of abstraction structures: - STW: - 492, MDTW: - 10, DTW: - 0
Geology	Major formations include Younger Alluvium which includes Present Day deposits, Kosi Ganga formation (Holocene) as parallel exposures in the block.
Geomorphology	Major Physiographic units includes Paleochannels along with younger alluvium plains on the eastern side of the block. Area is dominated with mostly second order streams. Major Drainage: - Kosi Dhar River.
Groundwater resources availability and extraction	Annual Ground Water Resources (Ham)- 3365.80 Net Ground Water Availability for future use (Ham)- 2035.15 Ground water extraction (Ham)- 1307.94
Existing and future water demand	184.14 Ham/1060.8 Ham for drinking and irrigation sectors
Water level behaviour	Pre-monsoon SWL- 2.3 to 3.98 mbgl Post-monsoon SWL- 1.15 to 2.7 mbgl



Fig,86. Geological Map of Block

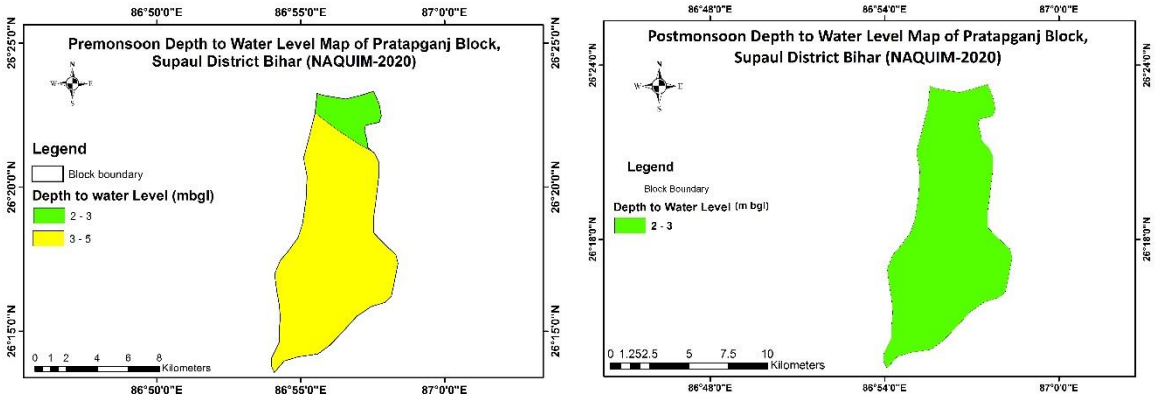


Fig.87 Pre and Post monsoon Depth to Water Level Map of Block

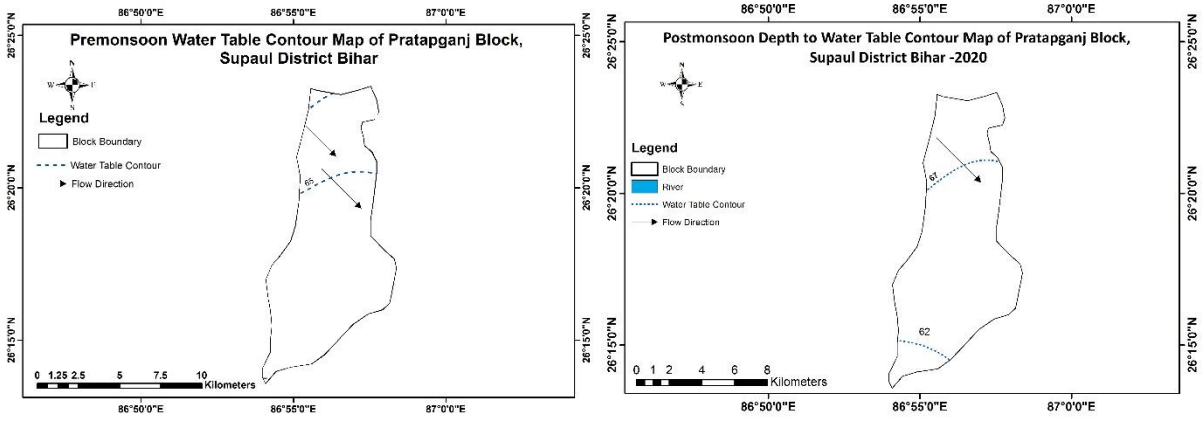


Figure 88. Pre and Post monsoon Water Table Contour Map.

2. Aquifer Disposition

Number of aquifers	01; up to the explored depth of 75 m(?)
3D aquifer disposition	Surface clay 3-5 m thick Single aquifer of fine, medium and coarse sands with boulder down to explored depth, mostly unconfined

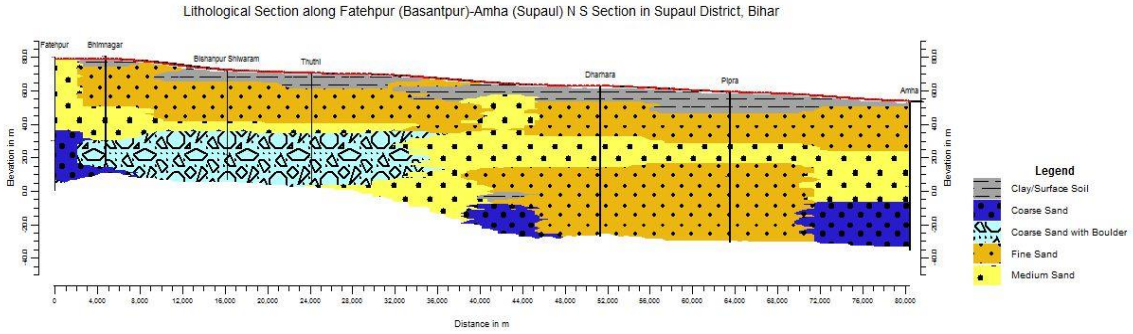


Fig89. Lithology Disposition around Pratapganj Block

3.0 Ground water resources, extraction, contamination, and other issues

Ground water Resource/Categorization Availability	SOD: 55.31%; Safe
Chemical quality of ground water and contamination	Potable

4.0. Supply Side Interventions

Ground Water Development Strategies-	Number of STW and DTW may be proposed for irrigation uses - STW – 425, DTW - 47
Prospects of Artificial Recharge	Considering shallow water table and frequent flooding artificial recharge to ground water is not recommended rather accelerated pumping and increased ground water development is encouraged.

	However, in urban area roof top rain water harvesting for conservation may be practiced.
Water Quality Management	Arsenic, more than the permissible limit has been reported from few area in the block . Ground water from the tube wells are to be tested for Fe/As before drinking water supply at domestic and community level.

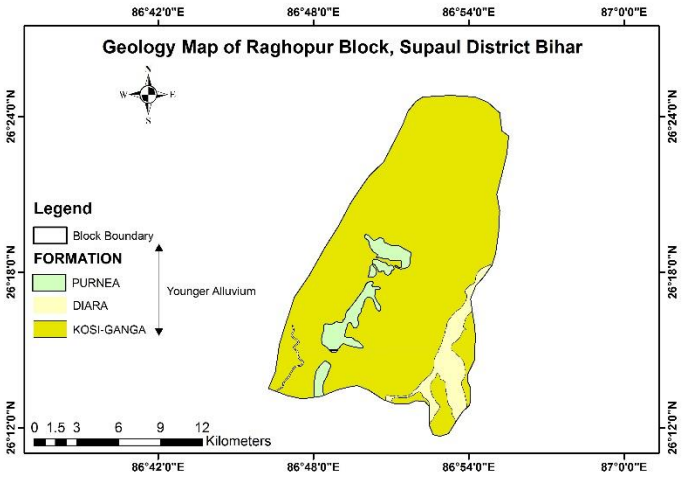
5.0. Demand side Interventions

Demand side management in drinking and domestic sectors	Considering draft of one TW 10.8 m3/hr, for 150 mm diameter well for 6 hr/day, 138 TW may be required. For projected population for 2025 additional 55 Tw may be required. Govt. of Bihar has already taken up the installation of Tw for PWSS in the block
Demand side management in Irrigation sectors	Crop rotations, more water intense crops may be promoted. Additional irrigation potential created 6257.844 ha Therefore 80 % of cultivable area can be brought under assured irrigation
Demand side intervention in surface irrigation	Considering the intense water logging in the area canal irrigation/ surface water irrigation is discouraged as far as possible
Other intervention proposed, if any	Water quality monitoring and Surveillance Capacity Building and Awareness generations for As contamination in ground water

BLOCK: Raghopur

Salient Information

Name of the Block/Area	Raghopur /208.09 sq. km
District/State	Supaul /Bihar
Population	Rural: -215643; Urban: -0; Total=215643
Rainfall	Normal Monsoon: - 956.72 Non- Monsoon: - 119.96
Agriculture and Irrigation	Principal crops: - Cereals, Pulses, Oilseeds, Fibre etc Gross cropped area (ha): - 21423.54 Net sown area: - 14378.28 Irrigation practices: - Surface water by tanks and ponds Ground water by Tube well Cropping Intensity: - 149% Number and Types of abstraction structures: - STW: - 389, MDTW: - 16, DTW: - 0
Geology	Major formations include Younger Alluvium which includes Present Day deposits, Kosi Ganga formation (Holocene) as parallel exposures in the block.
Geomorphology	Major Physiographic units includes Paleochannels along with active flood plains on the eastern side of the block. Area is dominated with mostly first order streams. Major Drainage: - Kosi Dhar River.
Groundwater resources availability and extraction	Annual Ground Water Resources (Ham)- 6700.75 Net Ground Water Availability for future use (Ham)- 3829.88 Ground water extraction (Ham)- 2825.06
Existing and future water demand	371.51 Ham/2318.55 Ham for drinking and irrigation sectors
Water level behaviour	Pre-monsoon SWL- 1.85 to 4.5 mbgl Post-monsoon SWL- 1.75 to 3.3 mbgl



Fig,89. Geological Map of Block

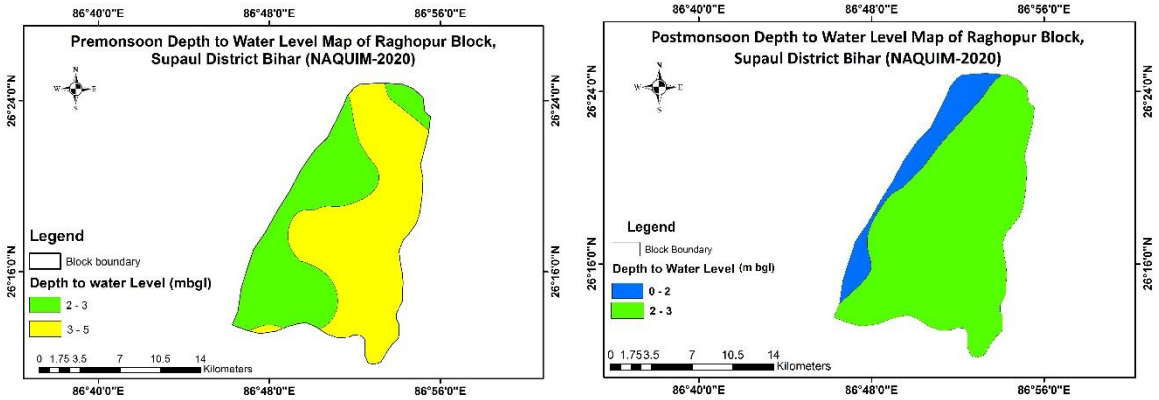


Fig.90 Pre and Post monsoon Depth to Water Level Map of Block

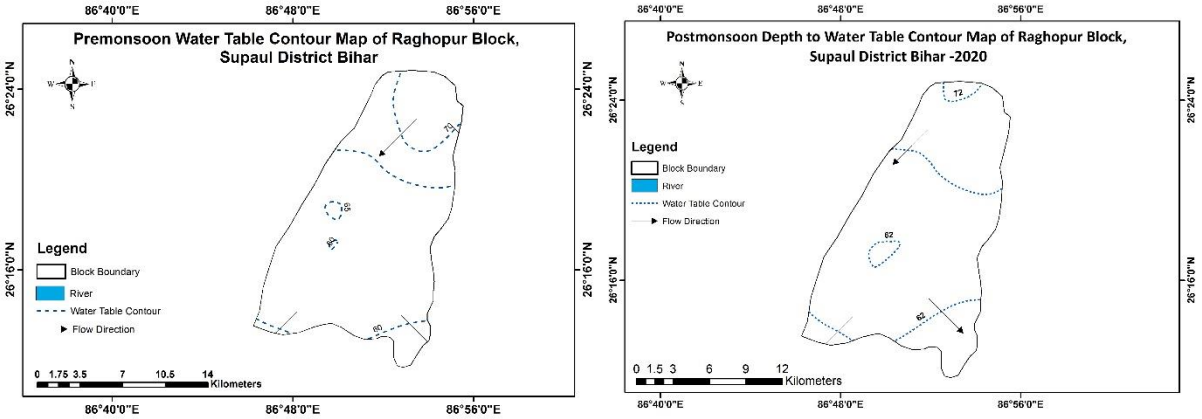


Figure 91. Pre and Post monsoon Water Table Contour Map.

2. Aquifer Disposition

Number of aquifers	01; up to the explored depth of 85 m(?)
3D aquifer disposition	Surface clay 5-7 m thick Single aquifer of fine, medium followed by fine sands down to explored depth, mostly unconfined

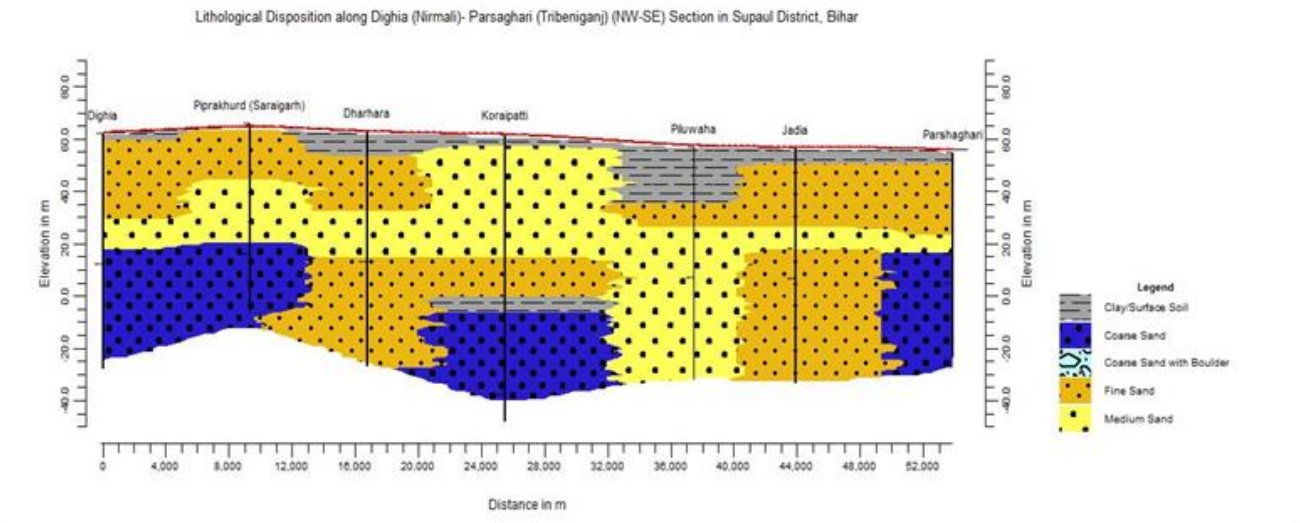


Fig92. Lithology Disposition around Raghopur Block

3.0 Ground water resources, extraction, contamination, and other issues

Ground water Resource/Categorization Availability	SOD: 42.16%; Safe
Chemical quality of ground water and contamination	Potable

4.0. Supply Side Interventions

Ground Water Development Strategies-	Number of STW and DTW may be proposed for irrigation uses - STW – 790, DTW - 88
Prospects of Artificial Recharge	Considering shallow water table and frequent flooding artificial recharge to ground water is not recommended rather accelerated pumping and increased ground water

	development is encouraged. However, in urban area roof top rain water harvesting for conservation may be practiced.
Water Quality Management	Ground water from the tube wells are to be tested for Fe/As before drinking water supply at domestic and community level.

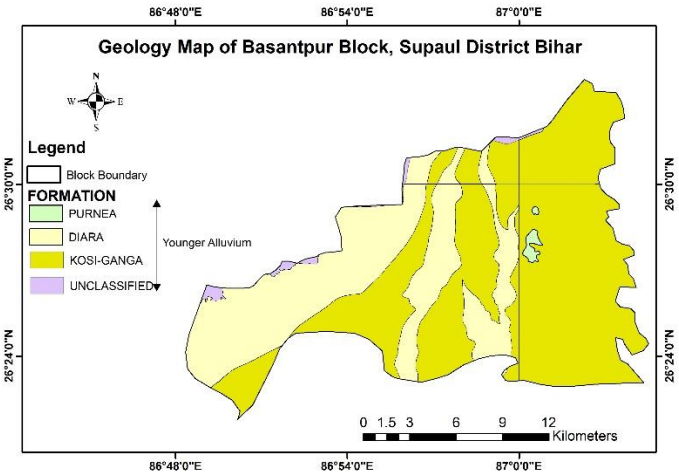
5.0. Demand side Interventions

Demand side management in drinking and domestic sectors	Considering draft of one TW 10.8 m3/hr, for 150 mm diameter well for 6 hr/day, 280 TW may be required. For projected population for 2025 additional 112 Tw may be required. Govt. of Bihar has already taken up the installation of Tw for PWSS in the block
Demand side management in Irrigation sectors	Crop rotations, more water intense crops may be promoted. Additional irrigation potential created 5576.59 ha Therefore 78 % of cultivable area can be brought under assured irrigation
Demand side intervention in surface irrigation	Considering the intense water logging in the area canal irrigation/ surface water irrigation is discouraged as far as possible
Other intervention proposed, if any	Water quality monitoring and Surveillance Capacity Building and Awareness generations for As contamination in ground water

BLOCK: Basantpur

Salient Information

Name of the Block/Area	Basantpur /251.53 sq. km
District/State	Supaul /Bihar
Population	Rural: -182075; Urban: -19932; Total=202007
Rainfall	Normal Monsoon: - 956.72 Non- Monsoon: - 119.96
Agriculture and Irrigation	Principal crops: - Cereals, Pulses, Oilseeds, Fibre etc Gross cropped area (ha): - 18340.21 Net sown area: - 11183.06 Irrigation practices: - Surface water by tanks and ponds Ground water by Tube well Cropping Intensity: - 164% <u>Number and Types of abstraction structures</u>: - STW: - 676, MDTW: - 1208, DTW: - 0
Geology	Major formations include Younger Alluvium which includes Present Day deposits, Kosi Ganga formation (Holocene) as parallel exposures in northern part of the block, Purnea formation (Holocene) as isolated outcrops.
Geomorphology	Major Physiographic units includes paleochannels in the south along with older flood plains in west, younger flood plains on the eastern side of the block. Area is dominated with mostly first order streams. Major Drainage: - Sapt Kosi River.
Groundwater resources availability and extraction	Annual Ground Water Resources (Ham)- 8052.79 Net Ground Water Availability for future use (Ham)- 3449.96 Ground water extraction (Ham)- 4551.45
Existing and future water demand	416.7 Ham/3909.75 Ham for drinking and irrigation sectors
Water level behaviour	Pre-monsoon SWL- 1.95 to 2.88 mbgl Post-monsoon SWL- 0.9 to 2.1 mbgl



Fig,93. Geological Map of Block

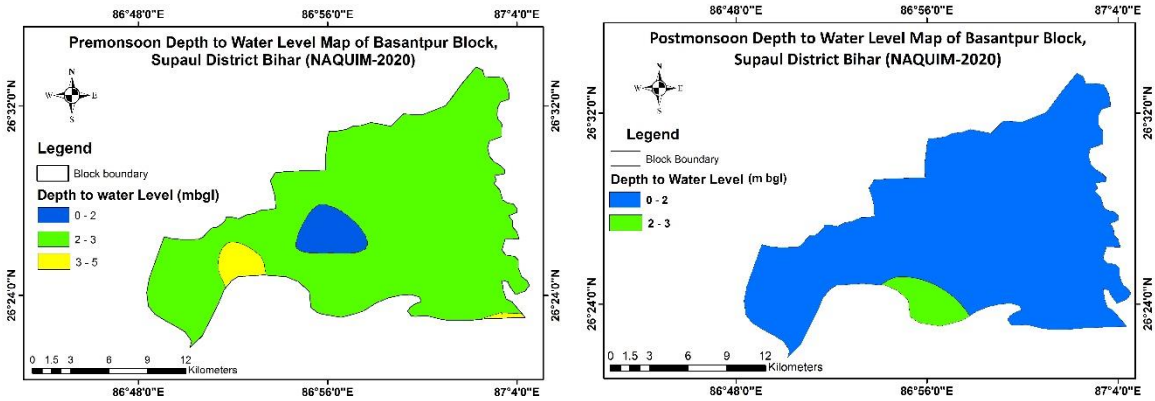


Fig.94 Pre and Post monsoon Depth to Water Level Map of Block

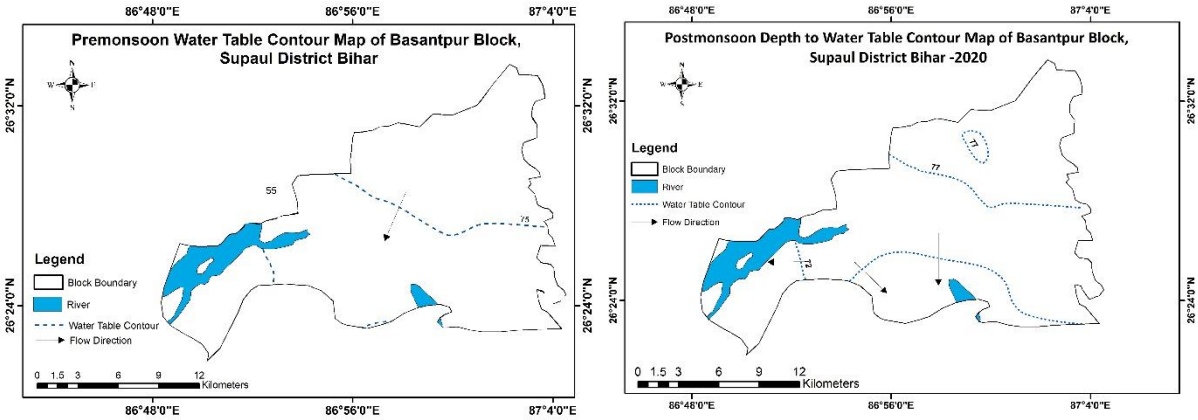


Figure 95. Pre and Post monsoon Water Table Contour Map.

2. Aquifer Disposition

Number of aquifers	01; up to the explored depth of 80 m
3D aquifer disposition	Single aquifer of medium and coarse sands, boulders below 30 m depth down to explored depth, mostly unconfined

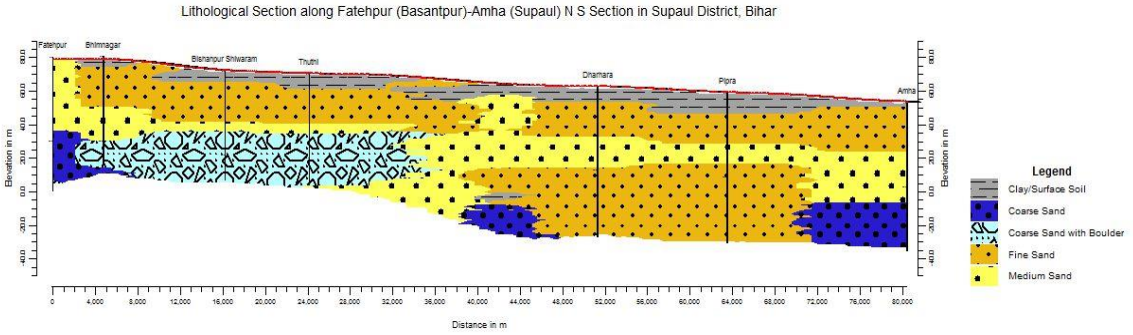


Fig96. Lithology Disposition around Basantpur Block

3.0 Ground water resources, extraction, contamination, and other issues

Ground water Resource/Categorization Availability	SOD: 56.52 %; Safe
Chemical quality of ground water and contamination	Potable

4.0. Supply Side Interventions

Ground Water Development Strategies-	Number of STW and DTW may be proposed for irrigation uses - STW – 661, DTW - 73
Prospects of Artificial Recharge	Considering shallow water table and frequent flooding artificial recharge to ground water is not recommended rather accelerated pumping and increased ground water development is encouraged. However, in urban area roof top rain water harvesting for conservation may be practiced.
Water Quality Management	Ground water from the tube wells are to be tested for Fe/As before drinking water supply at domestic and community level.

5.0. Demand side Interventions

Demand side management in drinking and domestic sectors	Considering draft of one TW 10.8 m3/hr, for 150 mm diameter well for 6 hr/day, 263 TW may be required. For projected population for 2025 additional 105 Tw may be required. Govt. of Bihar has already taken up the installation of Tw for PWSS in the block
Demand side management in Irrigation sectors	Crop rotations, more water intense crops may be promoted. Additional irrigation potential created 4455.962 ha Therefore 79 % of cultivable area can be brought under assured irrigation
Demand side intervention in surface irrigation	Considering the intense water logging in the area canal irrigation/ surface water irrigation is discouraged as far as possible
Other intervention proposed, if any	Water quality monitoring and Surveillance Capacity Building and Awareness generations for As contamination in ground water

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