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

MAU DISTRICT
UTTAR PRADESH

उत्तरी क्षेत्र, लखनऊ

Northern Region, Lucknow

जल शक्ति मंत्रालय

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REPORT ON

AQUIFER MAPPING AND MANAGEMENT PLANS OF

MAU DISTRICT,

UTTAR PRADESH STATE

AQUIFER MAPPING AND MANAGEMENT PLANS OF MAU DISTRICT, UTTAR PRADESH STATE

CONTRIBUTORS

Author	**:**	**Tejas.Y.Mankikar, Scientist-B (Hydrogeology)**
Aquifer management Plans	**:**	**Tejas.Y.Mankikar, Scientist-B (Hydrogeology)**
Groundwater Exploration	**:**	**Udaya Bhan Singh, Scientist-B (Hydrogeology);** **Sujatro Ray Chowdhuri, Scientist-B (Hydrogeology)**
Analysis of Geophysical data and interpretation	**:**	**Dr. Shashikant Singh, Scientist-B (Geophysics)**
		Anirudh Singh, Asst. Geophysicist
Chemical Analysis	**:**	**K.S.Rana, Scientist-B (Chemist) & O I/c Regional Chemical Laboratory**
	:	**K.G.Bhartariya, Scientist-B (Chemist)**
	:	**Dr. Supriya Singh, Scientist-B (Chemist)**

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DISTRICT AT A GLANCE

1		**GENERAL INFORMATION**		
	i	**Geographical Area (km^2)**	:	1,713
	ii	**Administrative Divisions**		
	a	Number of Tehsils	:	4
	b	Number of Blocks	:	9
	c	Number of Towns and Urban areas	:	14
	d	Number of Villages	:	1,621
	iii	**Population (As per 2011 census)**	:	22,05,968
	a	No. of Males	:	11,14,709
	b	No. of Females	:	10,91,259
	c	Population Density (People per km^2)	:	1,288
	d	Urban Population	:	4,99,208
	e	Rural Population	:	17,06,760
	iv	**Literacy Rate (As per 2011 census)**	:	73.10 %
	v	**Climate**	:	
	a	Annual Precipitation (mm)	:	1050
	b	Minimum Temperature (°C)	:	9
	c	Maximum Temperature (°C)	:	42
2		**Geomorphology**		
	i	**Major Physiographic Units**	:	(i)Older alluvium deposited by the rivers Ganga and Ghaghara, characterised by abandoned channels, meander scrolls and surface water divide. (ii) Newer alluvium deposited by the rivers Ghaghara and Tons.
	ii	**Major Drainages**	:	Ghaghara and Tons with Choti Sarju, a tributary of Tons river.
3		**Land Use (Ha)**		
	i	**Forest Area**	:	560
	ii	**Fallow Land**	:	18.239
	iii	**Gross Area Sown**	:	2,00,000

	iv	**Net Area sown**	:	1,19,056
	v	**Gross Area irrigated**	:	1,18,236
	vi	**Net Area irrigated**	:	1,14,689
4		**Major Soil Types**	:	Khachari, Khadar and Bangar.
5		**Area under Principal Crops (2020) in km^2**		
	i	**Rabi**	:	984.73
	ii	**Kharif**	:	967.55
	iii	**Zaid**	:	18.52
6		**Sources of Irrigation [1]**		
	i	No. of Dug wells	:	0
	ii	No. of Tube wells	:	1,829 (Government)
			:	1,05,717 (Private)
	iii	Canals	:	7,143 Ha
	iv	Other sources	:	0
7		**No. of Groundwater Monitoring Stations of CGWB (2019)**		
	i	**No. of Dug wells**	:	9
	ii	**No. of Piezometers**	:	Nil
8		**Hydrogeology and Aquifer Group**		
	a	Major Water bearing formation	:	Quaternary sediments comprising older and younger alluvium deposited over Vindhyan plateau.
	b	Pre-monsoon Depth to water level during May 2019	:	4.70 - 7.53 mbgl
	c	Post-monsoon Depth to water level during Nov’2019	:	1.04 - 4.85 mbgl
	d	Decadal Water Level trend (2009-2018)	:	Rise (m) = 0.00-0.05
			:	Fall (m) = 0.05-0.14
9		**Ground Water Exploration by CGWB**		
	a	No. of wells drilled (OW, EW, PZ, SH) [Total]	:	EW – 3, OW - 3
	b	Depth Range (mbgl)	:	200 - 300
	c	Discharge (lpm)	:	1,000 - 2,993
	d	Storativity (S)	:	$1.62*10^{-3}$ to $1.24*10^{-3}$
	e	Transmissivity (m^2/day)	:	161.45 to 1,112.62 m^2/day

10		**Ground Water Quality**		
	i	**Type of Water**	:	Mainly fresh water
	ii	**Presence of Trace Metals**	:	Arsenic sporadically present in unconfined aquifer.
11		**Dynamic Ground Water Resources (2020) [in Ham]**		
	a	Annual Replenishable Ground Water Resources	:	46,121.39
	b	Current Annual Ground Water Extraction	:	30,293.36
	c	Annual GW allocation for Domestic use as on 2025	:	14,783.86
	d	Stage of Ground Water Development	:	65.81%
12		**Artificial Recharge and Rainwater Harvesting Projects Implemented**		
	a	Projects completed by CGWB (Amount in INR)	:	Nil
	b	Projects under technical guidance of CGWB (Nos.)	:	Nil
13		**Ground Water Control and Regulation**		
	a	No. of Over-Exploited blocks	:	Nil
	b	No. of Critical blocks	:	Nil
	c	No. of Semi-Critical blocks	:	Nil
	d	No. of Notified blocks	:	Nil
14		**Major Ground Water Issues and Problems**	:	(i) Declining rainfall will result in lesser recharge of groundwater. (ii) Elevated levels of Fluoride in 3rd aquifer. (iii) Over-exploitation of groundwater, mainly for agriculture. (iv) Sporadic occurrence of Manganese, Iron and Arsenic in unconfined aquifer.

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1. INTRODUCTION

1.1 Objectives: Considering the existing issues of ground water over-exploitation, contamination and other related issues, Central Ground Water Board under MoWR, RD & GR has embarked upon the new initiative of Aquifer Mapping and Management Programme. The programme was initiated under Ground Water Management and Regulation Plan Scheme of XII plan. Major objectives of the programme are:

- Delineation and characterization of aquifers in three dimensions,
- Evaluation of aquifers, groundwater regime behaviour, hydraulic characteristics and hydrogeochemistry of aquifer groups on 1:50,000 scale,
- Identification and quantification of issues,
- Development of management plans to ensure sustainability of ground water resources.

Under the initiative, management plans for each aquifer system are being prepared suggesting various interventions to optimize ground water withdrawal and identifying aquifers with portable groundwater for drinking purpose in quality affected areas. The management options also include identification of feasible area for artificial recharge to ground water and water conservation which help in arresting declining water levels besides demand side management option including crop diversification, increasing water use efficiency etc **[1]**.

1.2 Approach and Methodology :

A multidisciplinary approach using advanced tools and techniques including remote sensing, GIS, geophysical techniques, ground water modelling etc. is being followed for preparation of aquifer maps and development of management plans.

A multi-tier evaluation process has been put in place to ensure quality of outputs. The aquifer maps and management plans prepared by the team of officers are reviewed by the Regional Directors of the respective regions of CGWB. The revised maps and management plans are later presented before the concerned members of CGWB at the central headquarters level. Subsequently the maps and management plans are presented before the National level expert committee (NLEC) constituted for this purpose. Domain specialists, who are part of the expert committee, include ground water specialists from JNU, Delhi; IIT, Roorkee; retired Chairman of CGWB; Agriculture Scientists etc. Agriculture scientists of ICAR have also been associated in finalization of management plans for each State. In order to coordinate on various issues related to aquifer mapping, between the State and Union Government, State Ground Water Coordination Committee (SGWCC) has been formed in each state and UT, headed by the principal secretary of the concerned department. The outputs are shared and deliberated in State Ground Water Coordination Committee with an objective to have mutual agreement on the proposed aquifer-wise ground water management plans which can be implemented by State Government **[2]**.

The flow chart of the methodology is given below in Figure 1 -

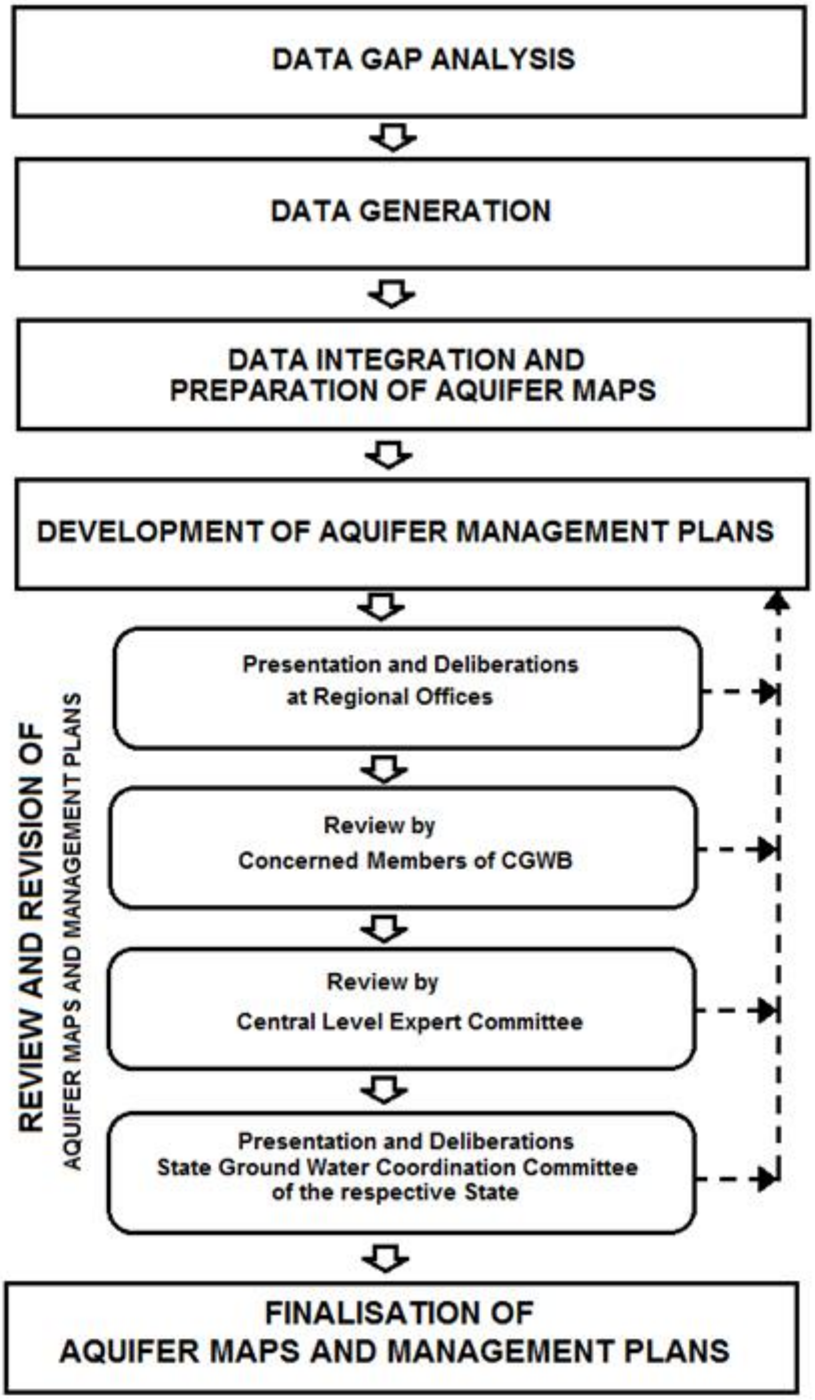


Figure 1: Flow chart of NAQUIM

1.3 Study Area :

Mau was carved out as a separate district from Azamgarh on 19 November 1988. It is situated in the south-eastern part of the state with headquarters in Maunath Bhanjan. The district is surrounded by Ghazipur district to the south, Ballia district to the east, Azamgarh district in the west, and Gorakhpur and Deoria districts to the north.

From historical and archaeological point of views, Mau is one of the oldest places in the region. Ancient cultural and archaeological remains have been found at multiple places in the area giving enough evidence of long history of human habitation in the area. The known archaeological history of Mau is about 1500 years old, when the entire area was covered by dense forest. The Naths who used to live along Tamsa river, are considered to be the oldest inhabitants and the rulers of the area **[3]**.

Location map of Mau district has been attached as Figure 2 below.

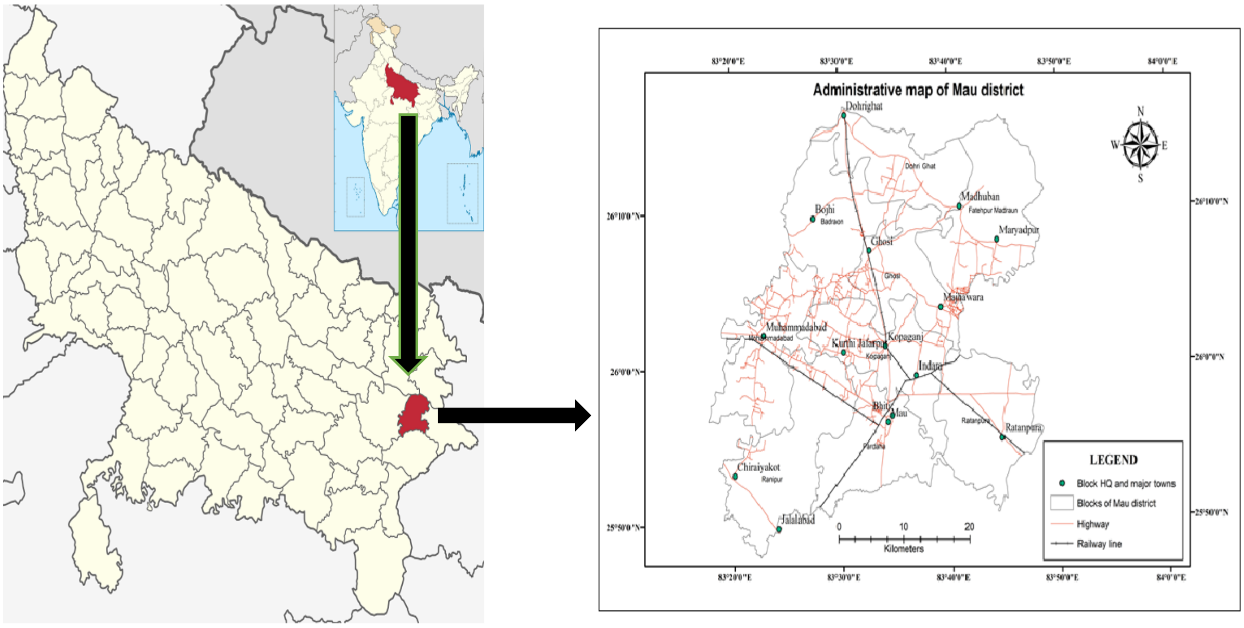


Figure 2: Location map of Mau district

1.4 Data Availability

The data pertaining to various attributes of ground water were collected from available literatures of Central Ground Water Board, State Departments and other agencies. The compiled data were plotted on 1:50,000 scale map and data gap analysis carried out for ascertaining additional requirement of Hydrogeological, Hydrological, Hydrochemical and Geophysical studies. The summarized details are tabulated below.

Table 1: Status of Data availability, data gap and data generation

Sl. No.	Parameter(s)	Data Required	Data Available	Data Gap	Data Generation
1.	Rainfall Data	IMD Meteorological station in the study area	No. Data obtained from European Space Agency.	No.	No.
2.	Soil	Soil Map and Soil infiltration test data.	Soil shape file available from U.P.R.S.A.C	Soil infiltration test data.	Soil infiltration across the study area.
3.	Land Use/ Land cover	Land Use/Land cover pattern	Land Use/ Land cover shape file available from U.P.R.S.A.C	No.	No.
4.	Geomorphology	Digitized Geomorphological map	District Resource Map available from G.S.I	No.	Map generated on GIS platform.
5.	Geology	Digitized Geological map	District Resource Map available from G.S.I	No.	Map generated on GIS platform.
6.	Exploration Data	EW in each quadrant	Available from old CGWB & UPGWD records	Yes	Carried out in 3 blocks.
7.	Aquifer Parameters	Aquifer parameters in all the quadrants	From 3 exploratory wells under NAQUIM	Yes	Data to be generated.

1.5 Climate and Rainfall:

The climate of the study area is classified as sub-tropical temperate. It is categorized as '**Cwa**' according to **Köppen–Geiger climate classification system [4].**

- The first letter '**C**' indicates that the area has temperate climate .i.e average temperature in the winter is above 0°C but below 18°C.
- The second letter '**w**' denotes at majority of the rainfall is received from the monsoon operating over the area and the area is characterized by dry winter, wherein minimal precipitation takes place in winter.
- The third letter '**a**' indicates the degree of summer heat where the warmest monthly average temperature is above 22°C.

Cwa = Monsoon-influenced humid subtropical climate; coldest month averaging above 0 °C (32 °F) (or −3 °C (27 °F)), at least one month's average temperature above 22 °C (71.6 °F), and at least four months averaging above 10 °C (50 °F). At least ten times as much rain in the wettest month of summer as in the driest month of winter (alternative definition is 70% or more of average annual precipitation is received in the warmest six months).

The average annual rainfall in district is 1050 mm. nearly 90% of rainfall received between the months of June to September. The maximum rainfall recorded during month of July and August from south-west monsoon. The temperature begins to rise in March and its reaches the peak in the months of May & June when the Mercury touches nearly 45.4° C. January is the coldest month when the minimum temperature comes down to approximately 5°C.mThe relative humidity is highest during south-west monsoon ranging between 83% to 87% with lowest around 32% during peak summer month of April.

Rainfall – The precipitation data for Mau district for the period 1971-2020 was obtained from Sentinel series of satellites operated by European Space Agency and is represented below in the form of a graph. Data has been attached under Annexure 1.

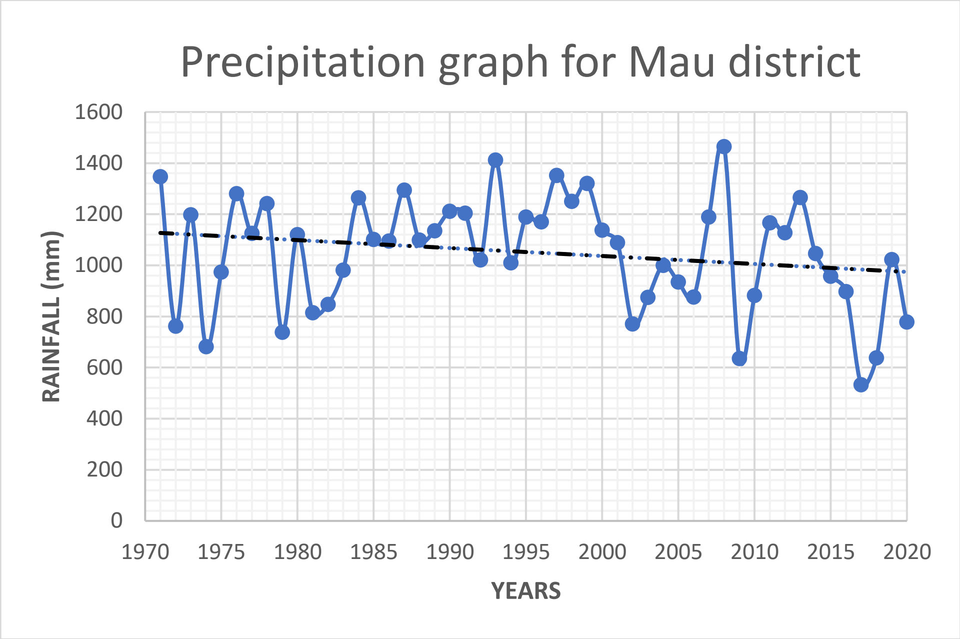


Figure 3: Precipitation graph of Mau district (1971 – 2020) [Source: European Space Agency]

1.6 Geomorphology and Geology

1.6.1 Geomorphology

Geomorphologically, the terrain is a part of Ganga plain that can be differentiated into lowland and upland. The upland is known as Varanasi Plain and occupies Ganga-Ghaghara interflue with elevation of 68 – 79 m.a.m.s.l (metres above mean sea level). Varanasi plain comprises of deposits of silt and clay with relict fluvial features such as palaeochannels. This plain has a gentle slope to the east.

The lowland with elevation of 66 – 74 m.a.m.s.l (metres above mean sea level) consisting of Active Flood Plain and Terrace Plain. Active Flood Plain of Ghaghara river is wide, sandy and slopes eastwards, whereas that of Choti Sarju is narrow, silty and slopes towards south-east. One level of Older Flood Plain is developed both along Ghaghara and Choti Sarju rivers. The Older Flood Plain is depositional and has preserved sediments deposited by present rivers during the process of incision. However, the Older Flood Plain along Tons river is erosional. The Lacustrine Plain is almost flat and contains numerous water bodies. It occupies ground depression over Varanasi Plain and Geophysical studies have indicated Basement rocks, sloping northwards between the depths of 800 to 1,700m.

The Ghaghara Plains have two soil-geomorphic units viz. Old and Young Plains. Both the plains are sub-parallel to the presently active floodplain and start from and end at the Ghaghara River. The floodplains of the Ganga and Ghaghara are very wide, ranging from 20 to 40 km and the width of smaller streams ranges between 1 and 3 km with the exception of the Tons River floodplain.

Smaller alluvial streams are meandering in nature because of low slopes of the interfluve and fine grained nature of the material transported by them. Due to high migration rate of streams, numerous meander scars, abandoned channels and oxbow lakes are observed in their floodplains. Calcium carbonate-rich muds are being deposited in water bodies and strong salt-efflorescence is observed around the periphery of water bodies [**5**]. Luminescence ages of soil-geomorphic units have revealed an age of 3.1 to 1.8 ka. The master slope of the area is mainly towards north to north-eastern side.

Geomorphological map of the district has been attached as Figure 4 below.

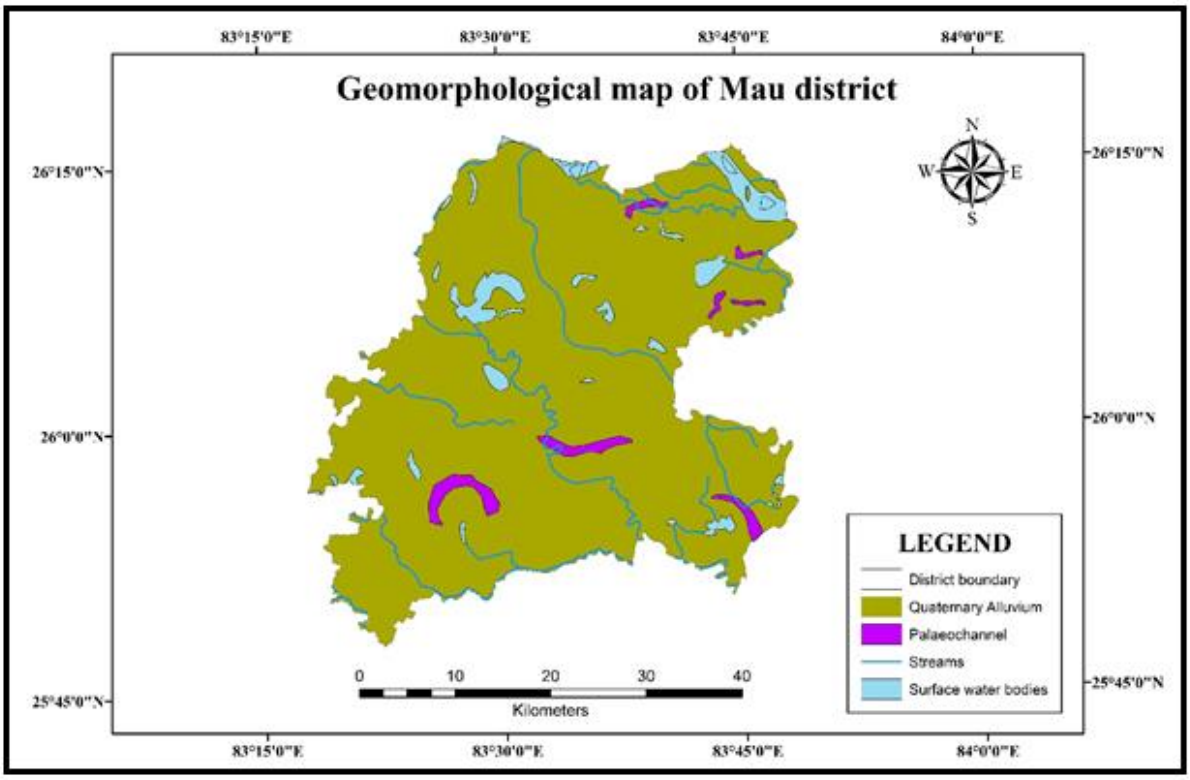


Figure 4: Geomorphological map of Mau district [Source: District Resource Map by GSI]

1.6.2 Geology

Geologically, the area comprises Quaternary sediments represented by Older alluvium and Newer alluvium .Older alluvium consists of oxidized sediments (brown, yellow and khakhi colour). Newer alluvium consists of non-oxidized sediments (grey and khakhi colour).

Varanasi plain comprises Older alluvium and is of Middle to Late Pleistocene age and has been extensively studied. The sediments comprise polycyclic sequence of silt, clay with calcareous concretions (Kankar) and subordinate micaceous sand beds, upto a depth of 590 mbgl (metres below ground level). The sedimentation terminated in late Upper Pleistocene due to onset of cool climate during last glaciation period that resulted in withdrawal of drainage and development of residual lakes.

Newer alluvium of Holocene age occupies the low-lands and is divisible into Channel alluvium and Terrace alluvium.

Loose sands of point and channel bars and mud of floodplain constitute Channel alluvium along the Ghaghara river. These sediments are non-oxidized compared to oxidized sediments of Older alluvium.

The Terrace alluvium comprises sequence of sand, silt and clay well developed on the depositional terrace.

Clay and silt make up the Lacustrine deposit. Deposits are seen in many palaeo-drainage lines represented by cut-off meander loops (ox-bow lakes). Thin layers of mud occurring in palaeochannels are homotaxial to Newer alluvium [**6, 7**].

Geological map of the district has been digitized from District Resource Map provided by GSI **[8]** and has been attached as Figure 5 below.

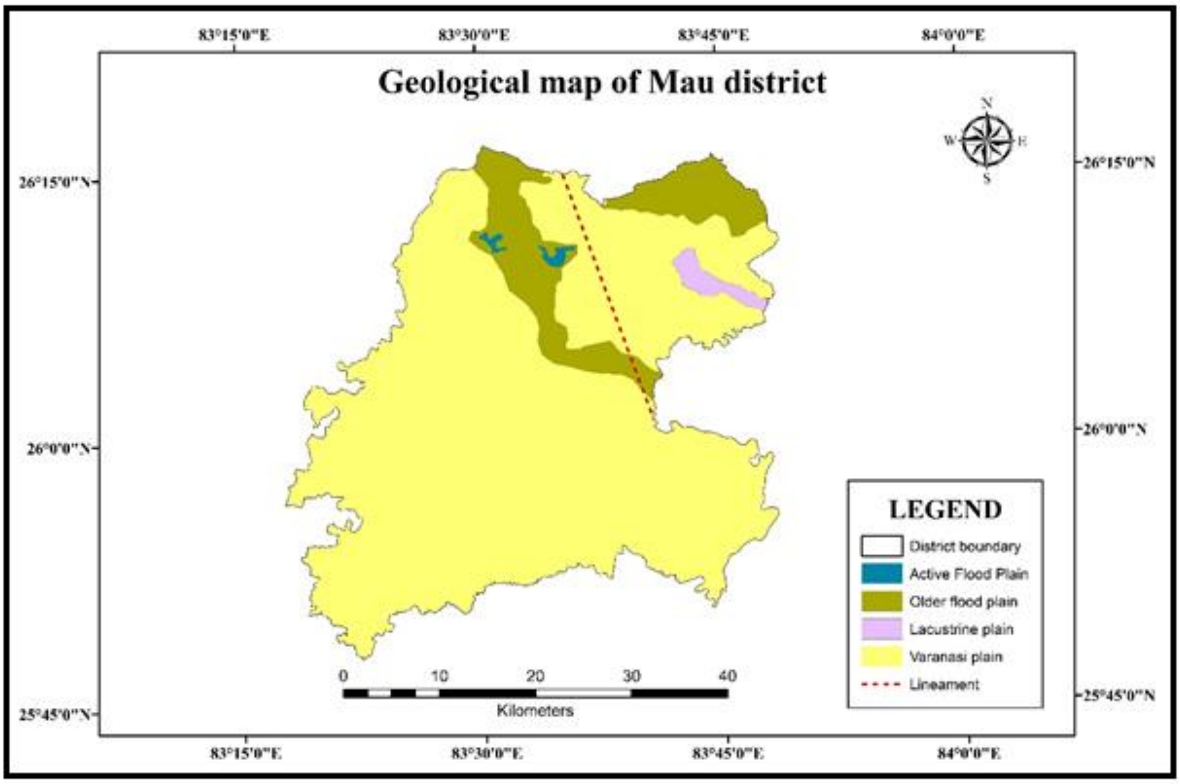


Figure 5: Geological map of Mau district [Source: District Resource Map by GSI]

1.7 Soil, Land use and cropping pattern:

1.7.1 Soil

The soils present in Mau district have been depicted in Figure 6 below –

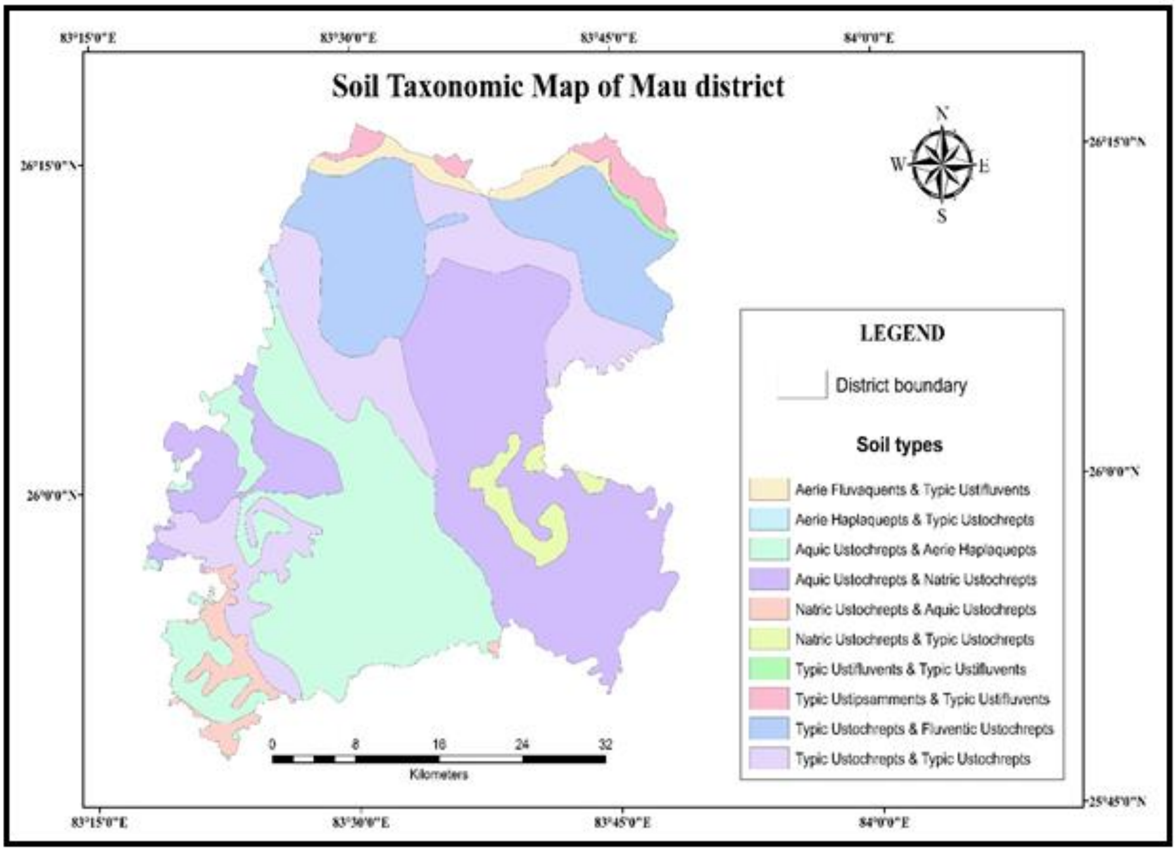


Figure 6: Soil taxonomic map of Mau district [Source: U.P.R.S.AC. Layer]

The description of soils have been summarized below:

(i) Aerie Fluvaquents & Typic Ustifluvents: Deep, poorly drained, coarse loamy, calcareous soils on very gentle slopes with loamy surface and severe flooding. They are observed as a thin patch along the course of Ghaghara river to the northern portion of the district.

(ii) Aerie Haplaquepts & Typic Ustochrepts: Deep, poorly drained, fine loamy, calcareous soils on nearly level to level plain with loamy surface and nature is slightly saline to moderately sodic.

(iii) Aquic Ustochrepts & Aerie Haplaquepts: Deep, imperfectly drained, fine loamy, calcareous soils on nearly level to level plain with loamy surface, and nature is moderately saline to strongly sodic.

(iv) Aquic Ustochrepts & Natric Ustochrepts: Deep imperfectly drained, fine silty soils on nearly level to level plain with loamy surface and nature is slightly saline to strongly sodic.

(v) Natric Ustochrepts & Aquic Ustochrepts: Deep, imperfectly drained, fine loamy, calcareous soils on nearly level to level plain with loamy surface, and nature is moderately saline to strongly sodic.

(vi) Natric Ustochrepts & Typic Ustochrepts: Deep, imperfectly drained, fine loamy, calcareous soils on nearly level to level plain with loamy surface, and nature is moderately saline and strongly sodic.

(vii) Typic Ustifluvents & Typic Ustifluvents: Deep, well drained, coarse loamy, calcareous soils on nearly level to level plain with loamy surface and moderate flooding.

(viii) Typic Ustipsamments & Typic Ustifluvents: Deep, excessively drained soils on very gentle slopes with sandy surface and moderate flooding.

(ix) Typic Ustochrepts & Fluventic Ustochrepts: Deep, well drained, fine silty soils on very gentle slopes with loamy surface and slight erosion.

(x) Typic Ustochrepts & Typic Ustochrepts: Deep, well drained, fine loamy soils on nearly level to level plain with loamy surface.

1.7.2 Land use pattern and land use cover

The details of Land use pattern and Land use cover have been tabulated as Annexure - 2 **[9]**. Pictorial depiction of the data has been attached for visualization as Figure 7 below.

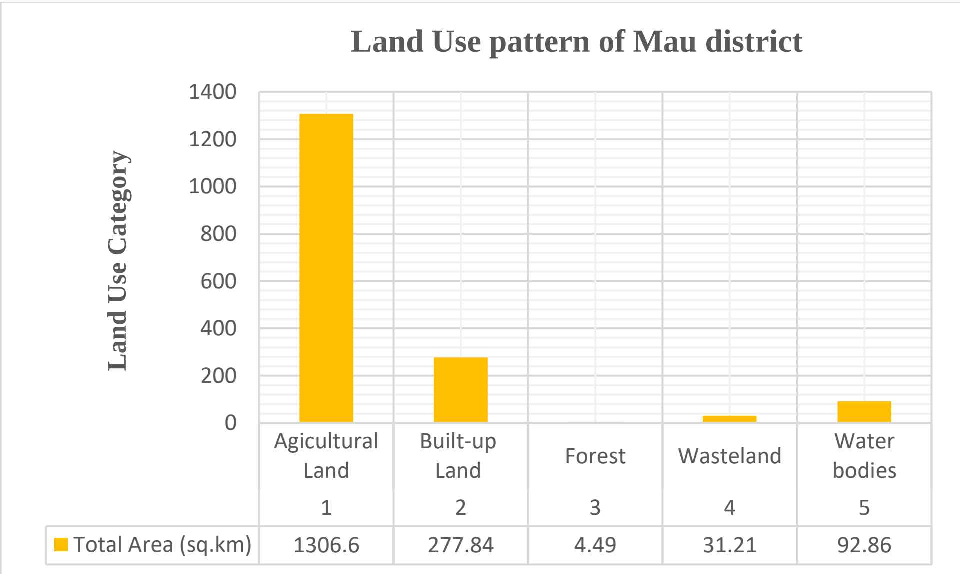


Figure 7: Land use pattern of the district

Perusal of the data shows that major portion of the geographical area is occupied by agricultural land as opposed to habitation and forests.

- 76.27% of the total geographical area is fertile agricultural land.
- 16.21% of the total geographical area is occupied by habitation.
- Forests occupy a measly 0.26% of total geographical area.
- Non-cultivable land occupies 1.82% of total geographical area.

- Rest of total geographical area is occupied by water bodies like rivers, lakes, ponds etc.

The Land Use & Land Cover map of Maunath Bhanjan district was digitized from map layer provided by RSAC, U.P. state government and has been attached as Figure 8 below.

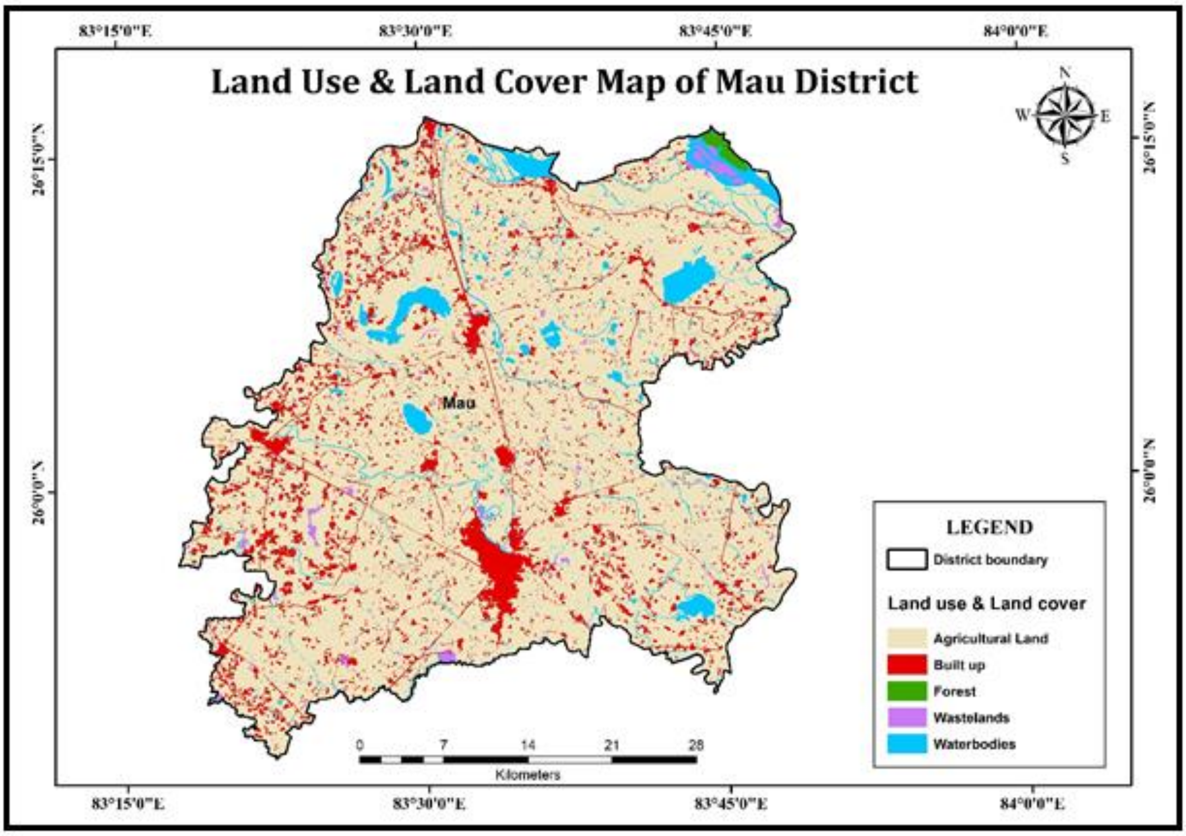


Figure 8: Land use and Land cover map of Mau district [Source: U.P.R.S.AC. Layer]

1.7.3 Cropping pattern

Kharif crops that are rain-fed are sown between 1st week of June to 4th week of July whereas Kharif crops irrigated by either canals or groundwater are sown between 3rd week of June to 2nd week of August, depending on the crop type. Rabi crops that are rain-fed are sown between 1st week of October to 2nd week of November whereas Rabi crops irrigated by either canals or groundwater are sown between 2nd week of November to 4th week of December, depending on the crop type.

Kharif crops cultivated include Rice, Sugarcane, Brinjal, Sponge gourd, Chillies etc.

Rabi crops cultivated include Wheat, Gram, Peas, Barley and Mustard.

Zaid crops cultivated include Bitter Gourd, Watermelon, Muskmelon, seasonal fruits and vegetables **[9]**.

Details of cropping pattern have been attached as Table 2 below.

Table 2: Details of cropping pattern in Mau district

Sl. No.	Name of Block	Crop type	Kharif area (Ha)			Rabi area (Ha)			Summer crop (Ha)			Total area (Ha)		
			Irrigated	Rainfed	Total	Irrigated	Rainfed	Total	Irrigated	Rainfed	Total	Irrigated	Rainfed	Total
1.	Dohari Ghat	(a) Cereals	8833	160	8993	9249	0	9249	0	0	0	18082	160	18242
		(b) Coarse Cereals	35	36	71	135	0	135	36	0	36	206	36	242
		(c) Pulses	1	304	305	182	38	220	15	0	15	198	342	540
		(d) Oil seeds	20	23	43	67	2	69	0	0	0	87	25	112
		(e) Other crops	816	16	832	276	0	276	31	0	31	1123	16	1139

2.	Fatehpur Madaon	(a) Cereals	8061	94	8155	10063	0	10063	0	0	0	18124	94	18218
		(b) Coarse Cereals	10	26	36	303	0	303	75	0	75	388	26	414
		(c) Pulses	1	326	327	390	38	428	30	0	30	421	364	785
		(d) Oil seeds	0	0	0	0	0	0	0	0	0	0	0	0
		(e) Other crops	558	11	569	277	0	277	57	0	57	892	11	903
3.	Ghosi	(a) Cereals	9238	29	9267	9781	0	9781	0	0	0	19019	29	19048
		(b) Coarse Cereals	2	6	8	113	0	113	6	0	6	121	6	127
		(c) Pulses	1	53	54	95	33	128	2	0	2	98	86	184
		(d) Oil seeds	19	23	42	33	1	34	0	0	0	52	24	76
		(e) Other crops	578	14	592	223	0	223	25	0	25	826	14	840
4.	Badraon	(a) Cereals	9593	122	9715	9546	0	9546	0	0	0	19139	122	19261
		(b) Coarse Cereals	10	44	54	116	0	116	4	0	4	130	44	174
		(c) Pulses	1	220	221	135	16	151	4	0	4	140	236	376
		(d) Oil seeds	75	75	150	54	0	54	0	0	0	129	75	204
		(e) Other crops	1039	11	1050	274	0	274	25	0	25	1338	11	1349
5.	Kopaganj	(a) Cereals	9551	45	9596	10853	0	10853	0	0	0	20404	45	20449
		(b) Coarse Cereals	18	6	24	288	0	288	22	0	22	328	6	334

		(c) Pulses	1	225	226	254	23	277	9	0	9	264	248	512
		(d) Oil seeds	151	108	259	0	0	0	0	0	0	151	108	259
		(e) Other crops	485	7	492	374	0	374	38	0	38	897	7	904
6.	Pardaha	(a) Cereals	9150	86	9236	9003	0	9003	0	0	0	18153	86	18239
		(b) Coarse Cereals	26	14	40	241	0	241	10	0	10	277	14	291
		(c) Pulses	1	322	323	252	12	264	10	0	10	263	334	597
		(d) Oil seeds	1	5	6	0	0	0	0	0	0	0	0	0
		(e) Other crops	480	3	483	238	0	238	25	0	25	743	3	746
7.	Ratanpura	(a) Cereals	12199	49	12248	11888	0	11888	0	0	0	24087	49	24136
		(b) Coarse Cereals	6	6	12	301	0	301	3	0	3	310	6	316
		(c) Pulses	1	170	171	219	62	281	8	0	8	228	232	460
		(d) Oil seeds	24	19	43	0	0	0	0	0	0	24	19	43
		(e) Other crops	558	5	563	304	0	304	24	0	24	886	5	891
8.	Mohammadabad Gohna	(a) Cereals	9387	140	9527	9255	0	9255	0	0	0	18642	140	18782
		(b) Coarse Cereals	35	37	72	282	0	282	14	0	14	331	37	368
		(c) Pulses	1	353	354	671	27	698	0	0	0	672	380	1052
		(d) Oil seeds	0	0	0	8	0	8	0	0	0	8	0	8

		(e) Other crops	944	8	952	330	0	330	51	0	51	1325	8	1333
9.	Ranipur	(a) Cereals	14798	58	14856	13911	0	13911	0	0	0	28709	58	28767
		(b) Coarse Cereals	14	23	37	432	0	432	2	0	2	448	23	471
		(c) Pulses	2	328	330	590	2	592	4	0	4	596	330	926
		(d) Oil seeds	0	0	0	26	0	26	0	0	0	26	0	26
		(e) Other crops	927	13	940	355	0	355	30	0	30	1312	13	1325
TOTAL			**97651**	**3623**	**101274**	**101387**	**254**	**101641**	**560**	**0**	**560**	**199598**	**3877**	**203475**

1.8 Hydrology and Drainage of the study area

The district is drained by 3 major rivers – Ghaghara, Choti Sarju and Tons.

The Ghaghara is a major tributary of the Ganga river and flows mainly at the northern boundary of the district. It has numerous, smaller tributaries whose contribution to Ghaghara is almost insignificant. Ghaghara enters the district through Dohari ghat block.

Tons river drains the west-central, central and south-east part of the district. It enters the district at Mohammadabad block and has a total flow length of 60 kms in the district.

Drainage map of the district has been attached as Figure 9 below.

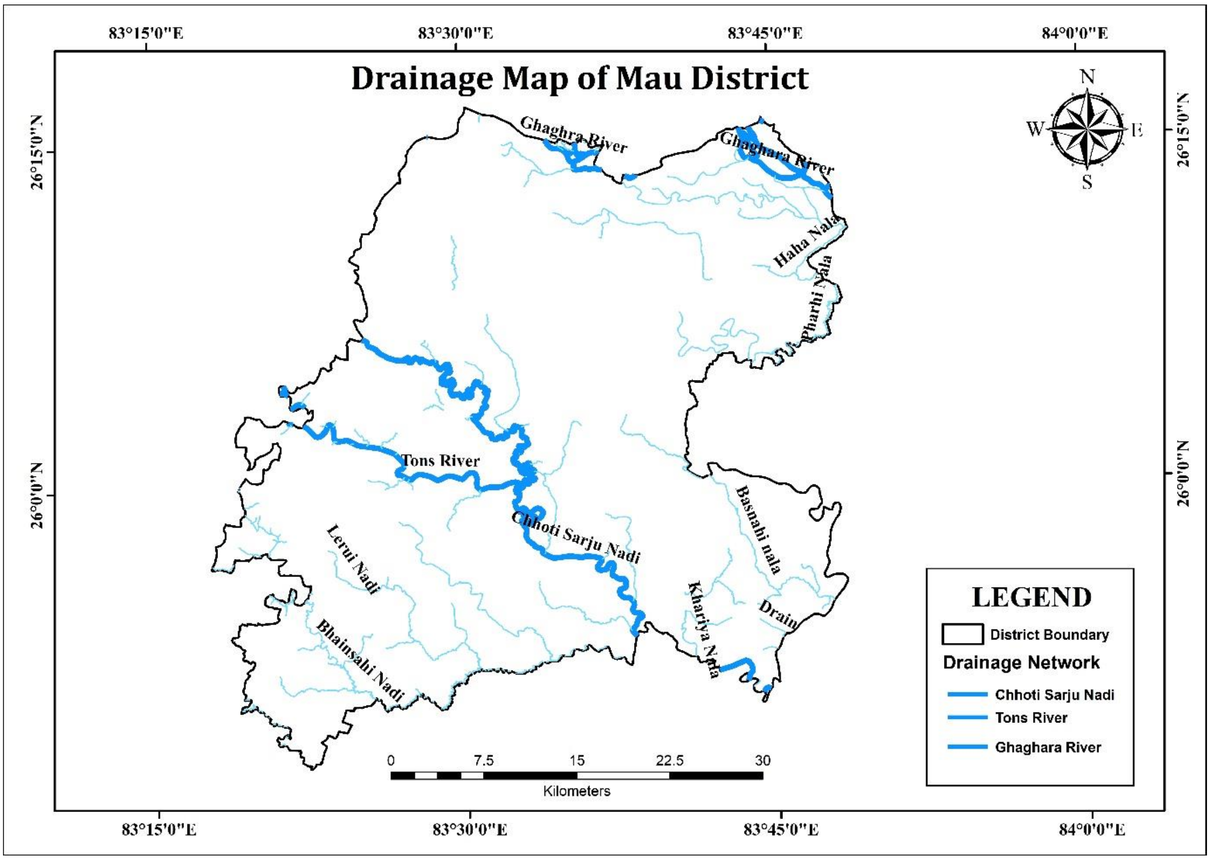


Figure 9: Drainage map of Mau district [Source: U.P.R.S.AC. Layer]

1.9 Irrigation

The only major lift canal in the district has been built on Ghaghara river in Dohari Ghat block and the details have been summarized below **[10]** -

- Name of canal - Chaudhary Charan Singh canal.
- Total capacity = 660 cusecs.
- Year of construction = 1956.
- Total length of main canal = 4.80 kms.
- Length of feeder canals = 350 kms.
- Installed pumps = 10 Nos.
- Standby pumps = 2*60 Nos.
- Total capacity of all pumps = 5,215 BHP.
- Capacity of Electrical sub-stations = 132/33 KV + 33/6 & 33/3.3 KV.
- Irrigation capacity = 55,000 Ha.

The summarized details of Irrigated area and Rain-fed area has been tabulated below in Table 3 **[9]**.

Table 3: Summarized details of Irrigated and Rain-fed area of Mau district.

Sl. No.	Name of Block	Gross Irrigated Area (Ha)	Net Irrigated Area (Ha)	Rainfed Area (Ha)
1	Dohari Ghat	19696	11641	579
2	Fatehpur Madaon	19825	13883	495
3	Ghosi	20116	10694	159
4	Badraon	20876	12018	488
5	Kopaganj	22044	12633	414
6	Pardaha	19437	11413	442
7	Ratanpura	25535	14402	311
8	Mohammadabad Gohna	20978	11913	565
9	Ranipur	31091	17046	424
	TOTAL	**199598**	**115643**	**3877**

Other details of irrigation have been given as Annexures – 3 and 4 respectively.

1.10 Prevailing water conservation and recharge practices

None

2. DATA COLLECTION, INTEGRATION AND AQUIFER MAPPING

2.1 Aquifer Geometry

To understand the lithological framework and sub-surface disposition of aquifers in the study area, the lithological data of wells drilled by CGWB, UPGWD were first compiled, redefined as per ROCKWORKS software format and then plotted for visualization of aquifer disposition.

The major lithology is Quaternary alluvium underlain by Vindhyan basement. Quaternary alluvium is divided into Older and Newer alluvium. Older alluvium consists of oxidized sediments of polycyclic sequence of silt, clay with calcareous concretions (kankar) and micaceous beds. Newer alluvium was deposited by annual flooding of Ghaghara river and has non-oxidized sediments made of alternate clay and sand layers.

Three aquifer groups were identified visually upon generation of 2-D and 3-D models and fence diagrams. Quality of formation water is good barring the occurrence of Iron at few places in the unconfined aquifer.

2-D and 3-D aquifer disposition plots of Mau district have been attached below.

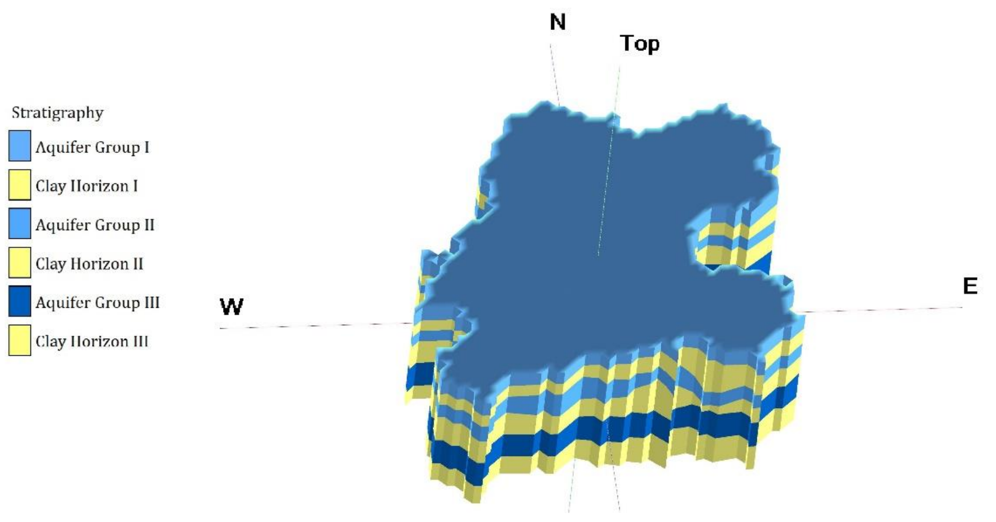


Figure 10: 3-D aquifer disposition of Mau district

The thickness of Aquifer Group – 1 extends down to 52 mbgl (metres below ground level) from the ground surface. It is separated from the Aquifer Group – 2 by a clay horizon. Aquifer Group – 2 is observed between 70 to 152 mbgl (metres below ground level). It is further separated from Aquifer Group - 3 by a clay horizon with thickness greater than the one separating Aquifers 1 and 2. Aquifer group – 3 is observed between the depths of 190 to 240 mbgl (metres below ground level) and a third clay horizon extends down to 300 mbgl.

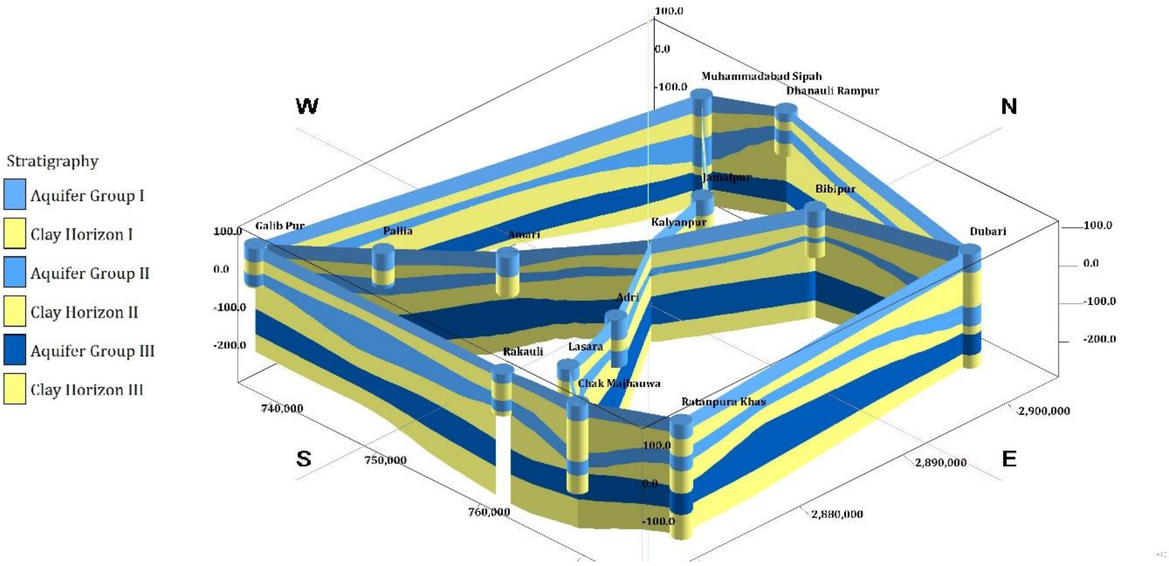


Figure 11: Fence diagram of Mau district

As visualized from the Fence diagram, the thickness of Aquifer Group – 1 appears to be near constant from North to South and East to West directions and appears to taper in the central portion. The thickness of Clay Horizon 1 separating Aquifer Groups 1 and 2 increases from West to East as well as from South to Northern portion of the district.

The thickness of Aquifer Group – 2 appears to increase towards Southern direction from the North and the opposite trend is seen from East to West directions. The thickness of Clay Horizon 2 separating Aquifer Groups 2 and 3 decreases from West to East and appears to be nearly constant from South to North portion of the district.

The thickness of Aquifer Group – 3 is tapered at the northern portion of the district and attains maximum thickness in the central portion of the district and tapers towards the East, West and South portions of the district.

(i) Badraon block: The first aquifer group has a thicker areal extent compared to that of second aquifer group. Second aquifer has considerable thickness in the central portion of the block and tapers at both western and eastern parts. Third aquifer group has considerable thickness when compared to second aquifer group and appears to increase in thickness from west to east. Second and third aquifer groups are separated by considerably thick clay layers and occur in semi-confined condition. Fence diagram has been attached below as Figure 12.

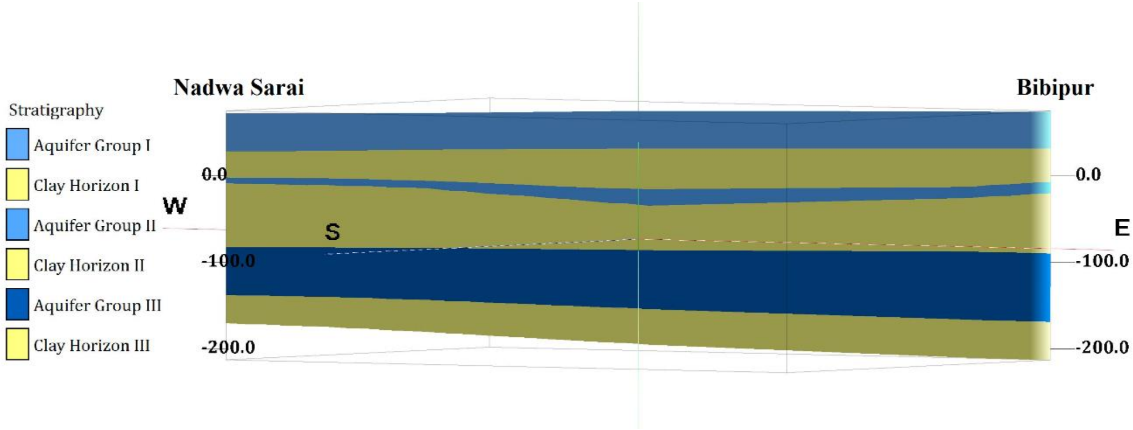


Figure 12: Fence diagram of Badraon block

(ii) Dohari Ghat block: The first aquifer group has a thicker areal extent compared to that of second aquifer group. Third aquifer group has considerable thickness when compared to second aquifer group. Second and third aquifer groups are separated by considerably thick clay layers and occur in semi-confined condition. Thickness of aquifer groups appear to be nearly constant from west to east. Fence diagram has been attached below as Figure 13.

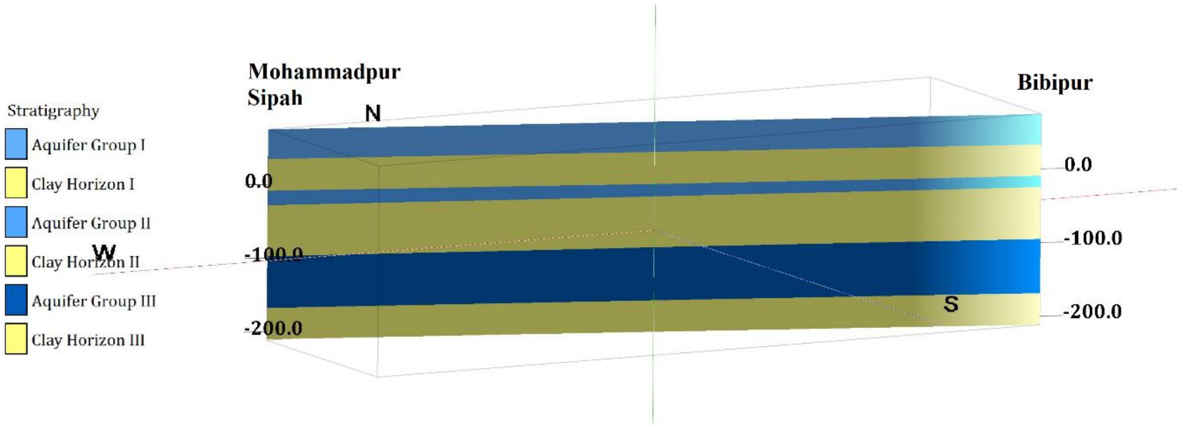


Figure 13: Fence diagram of Dohari Ghat block

(iii) Ghosi block: Aquifer disposition in Ghosi block is similar to that of Badraon and Dohari Ghat blocks. Only the areal thickness of third aquifer group appears to decrease from south to north whereas the other aquifer groups appear to possess uniform thickness. Second and third aquifer groups occur in semi-confined condition whereas the first aquifer group occurs in unconfined aquifer. Fence diagram has been attached below as Figure 14.

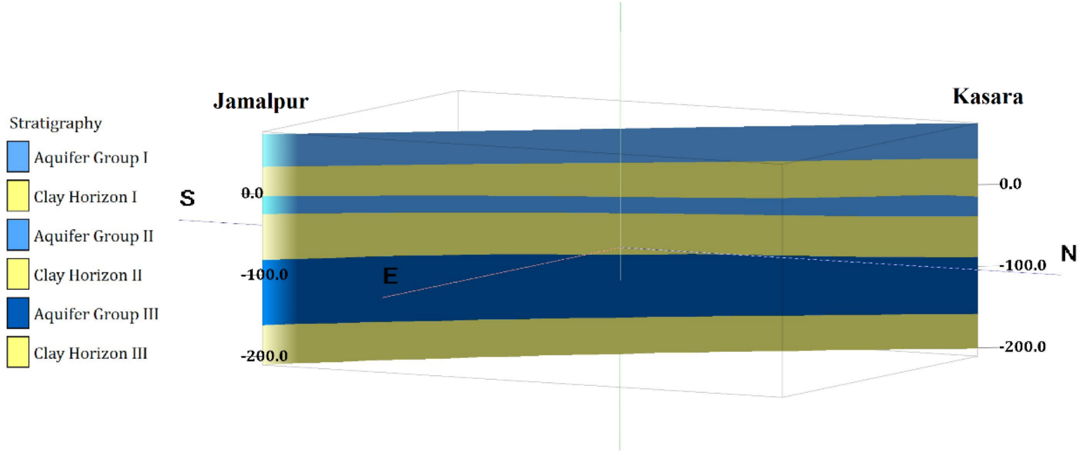


Figure 14: Fence diagram of Ghosi block

(iv) Kopaganj block: First aquifer group occurs in unconfined condition and appears to increase in thickness from south to north. Second aquifer group tapers and ceases to exist in the centre of the block. A very thin patch of it re-appears in the northern portion of the district. Third aquifer group occurs in semi-confined condition and thickness decreases from south to north. Fence diagram has been attached below as Figure 15.

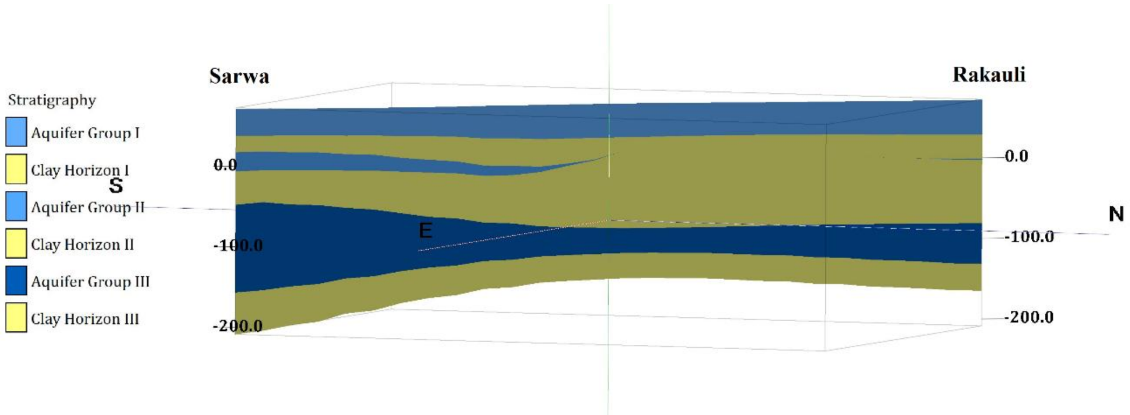


Figure 15: Fence diagram of Kopaganj block

(v) Fatehpur Madaon block: Aquifer disposition in Fatehpur Madaon block is similar to that of Badraon, Dohari Ghat and Ghosi blocks from west to east. The first aquifer group occurs in unconfined condition whereas the second and third aquifer groups appear in semi-confined condition as they are separated by thick clay layers. Fence diagram has been attached below as Figure 16.

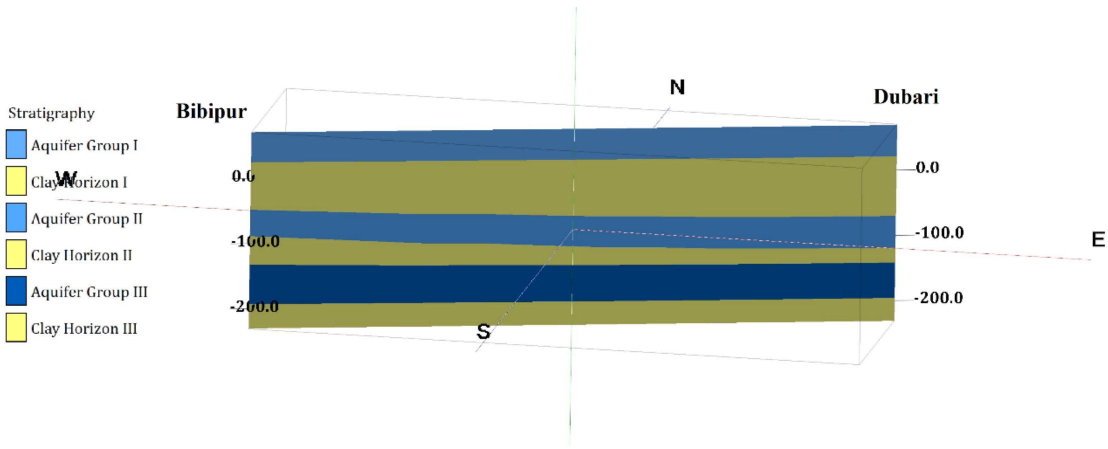


Figure 16: Fence diagram of Fatehpur Madaon block

(vi) Mohammadabad block: Aquifer disposition in block is similar to that of Badraon, Dohari Ghat, Ghosi and Fatehpur Madaon blocks from south to north. The first aquifer group occurs in unconfined condition whereas the second and third aquifer groups appear in semi-confined condition as they are separated by thick clay layers. The clay layer beneath third aquifer group appears to decrease from south to north. Fence diagram has been attached below as Figure 17.

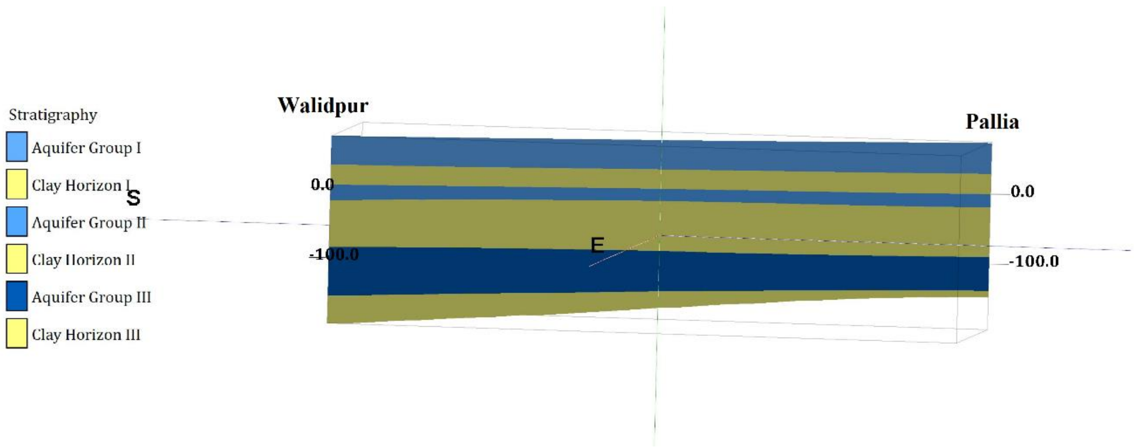


Figure 17: Fence diagram of Mohammadabad block

(vii) Pardaha block: First aquifer occurs in unconfined condition and appears to possess uniform thickness from south-west to north-east. The thickness of second and third aquifer groups increase in the aforesaid direction and appear to taper in the central portion of the block and both occur in semi-confined condition.

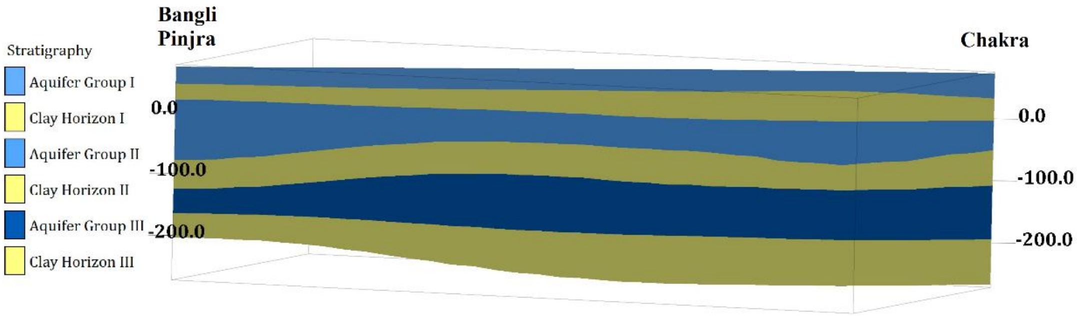


Figure 18: Fence diagram of Pardaha block

(viii) Ratanpura block: First aquifer group appears to possess uniform thickness and occurs in unconfined condition. It is separated from second aquifer group that occurs in semi-confined condition by a clay layer that increases from west to east. Thickness of third aquifer group decreases from west to east which is corroborated by increase in clay layer separating second and third aquifer groups.

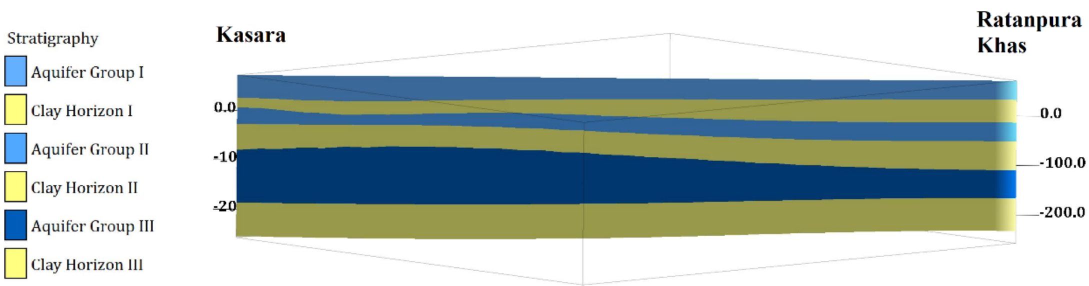


Figure 19: Fence diagram of Ratanpura block

(ix) Ranipur block: The thickness of the three aquifer groups appear to be near constant and the second aquifer group is seen to be much closer to first aquifer in the north-east portion of the block as opposed to the south-west portion. First aquifer occurs in unconfined condition whereas the second and third aquifer groups occur in semi-confined condition.

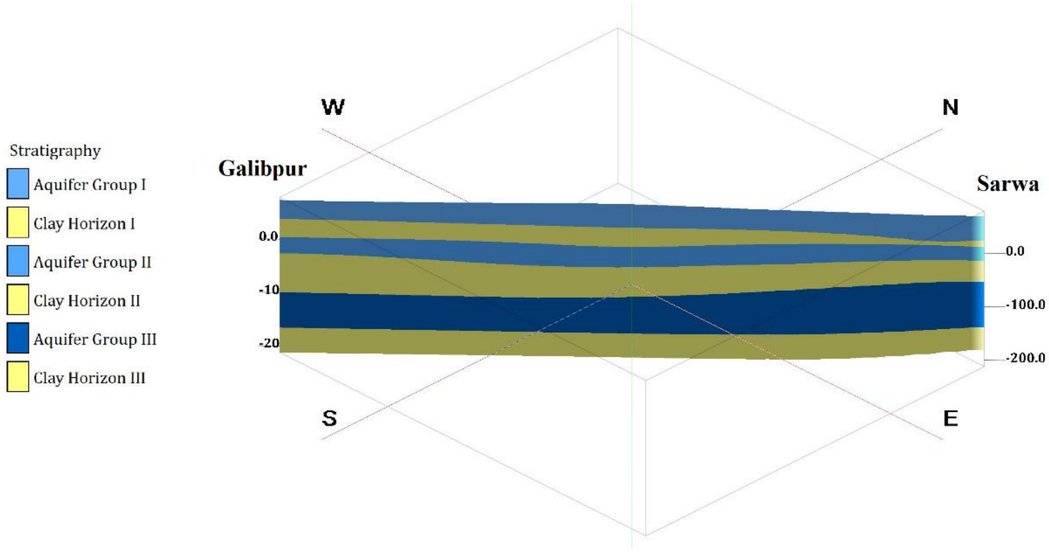


Figure 20: Fence diagram of Ranipur block

2.2 Ground water scenario

Groundwater in the district occurs in aquifer system mainly made of alluvial sediments deposited by the Ghaghara river and its tributaries. Granular zones comprise fine grained sand to silty sand with occurrence of calcareous concretions (kankar) and possess moderate transmissivity and permeability. Clay layers act as barriers separating the three aquifer groups in the district and possess insignificant transmissivity and permeability, resulting in clay acting as confining layers.

Hydrogeological map of the study area has been attached as Figure 21 below. Perusal reveals that the groundwater flow is mainly towards the Ghaghara river and its tributaries, Tons and Choti Sarju.

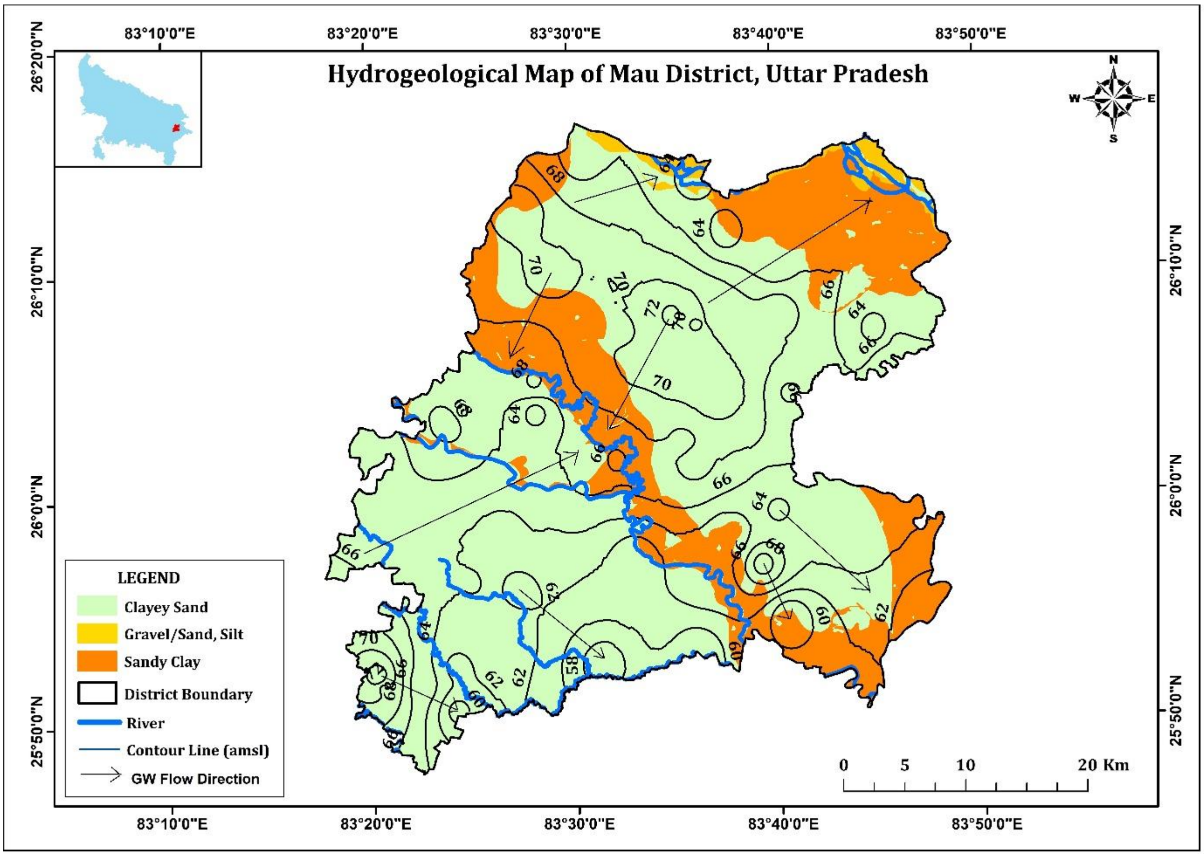


Figure 21: Hydrogeological map of the study area

2.3 Depth to Water level

Pre-monsoon and post-monsoon water level data were collected from the key wells and piezometers in the district for 2019. The depth to water level data and fluctuation data has been attached as Annexure-6. Depth to water level maps were prepared for pre-monsoon and post-monsoon period have been below as Figures 22 and 23.

Pre-monsoon depth to water level varies between 1.35 mbgl to 15.10 mbgl and post-monsoon depth to water level varies between 0.40 mbgl to 10.70 mbgl.

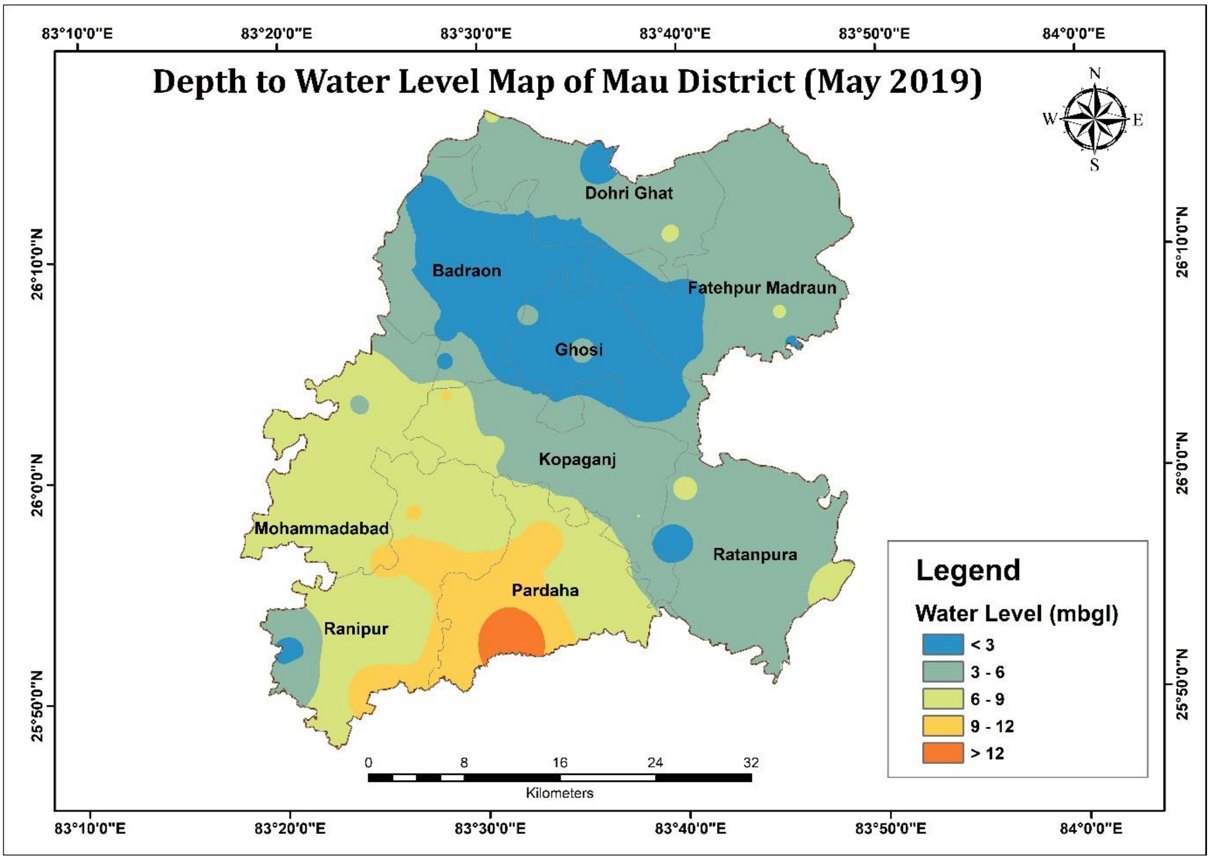


Figure 22: Pre-monsoon depth-to-water level map of Mau district (2019)

A perusal of the depth to water level contour map for the period May 2019 reveals that the water level that most of the district displays water level in the range of 5 – 10 mbgl.

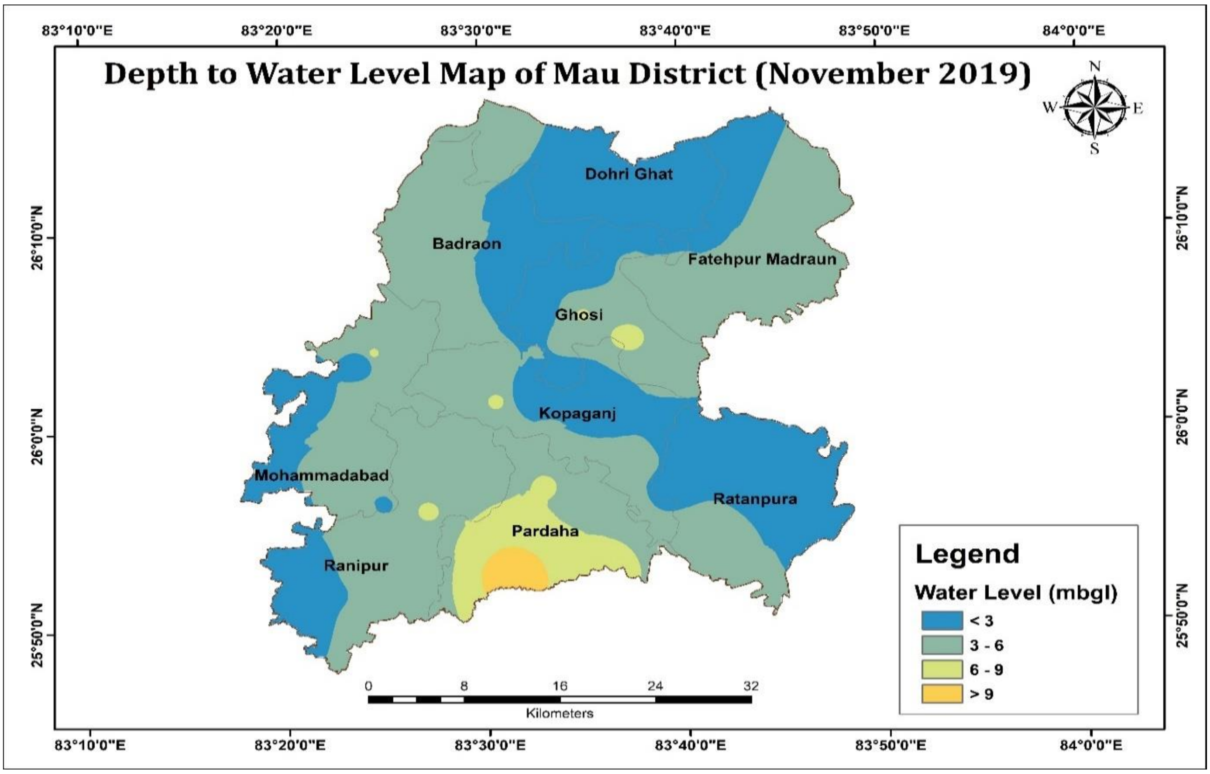


Figure 23: Post-monsoon depth-to-water level map of Mau district (2019)

A perusal of depth to water level contour map for the period November 2019 reveals water level becomes shallower owing to recharge of aquifer from rainfall and majority of the area has water level <10 mbgl.

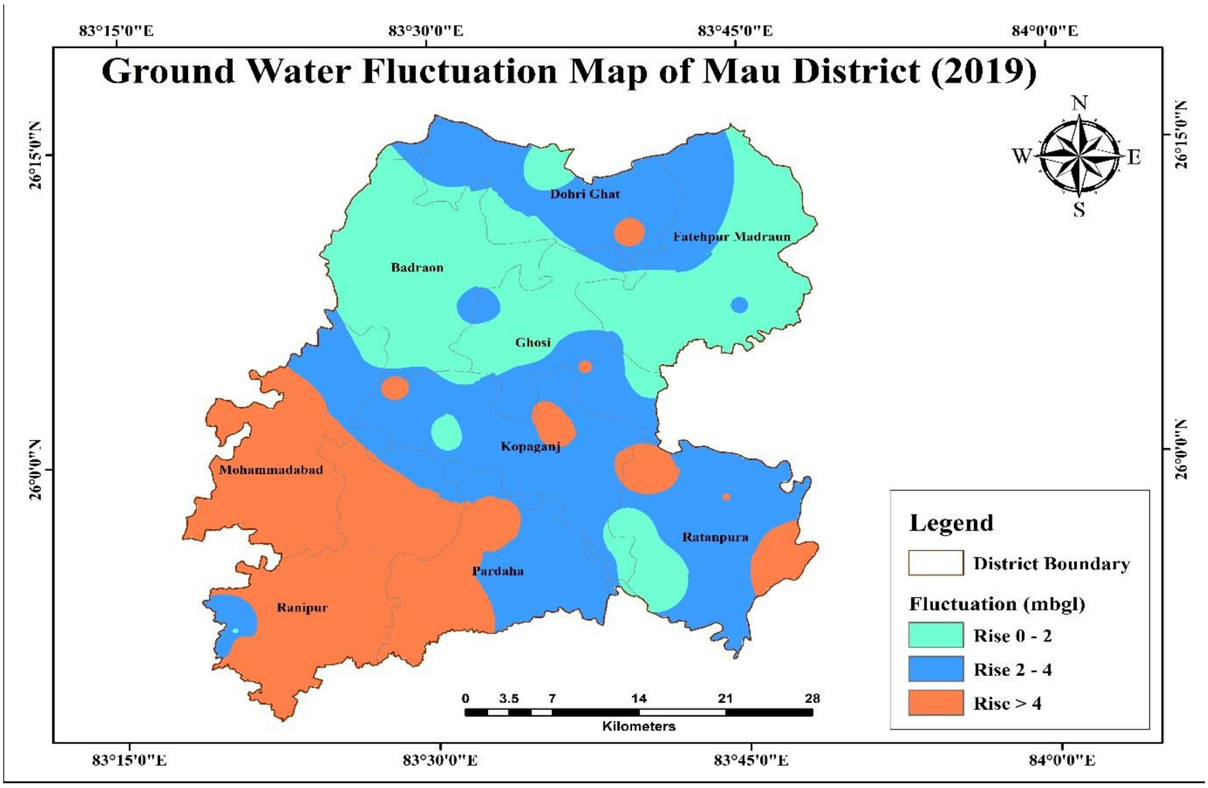


Figure 24: Water level fluctuation map of Mau district

Perusal of the map reveals that the water level is mainly rising between 0 mbgl to > 4 mbgl across the district. Parts of Badraon, Dohari Ghat, Fatehpur Madaon, Kopaganj and Ratanpura blocks display rise in water level between 0-2 mbgl. Parts of Dohari Ghat, Fatehpur Madaon, Kopaganj, Ranipur, Pardaha and Ratanpura blocks show water level rise between 2-4 mbgl. Other blocks display water level rise > 4 mbgl.

2.4 Long term water level trend

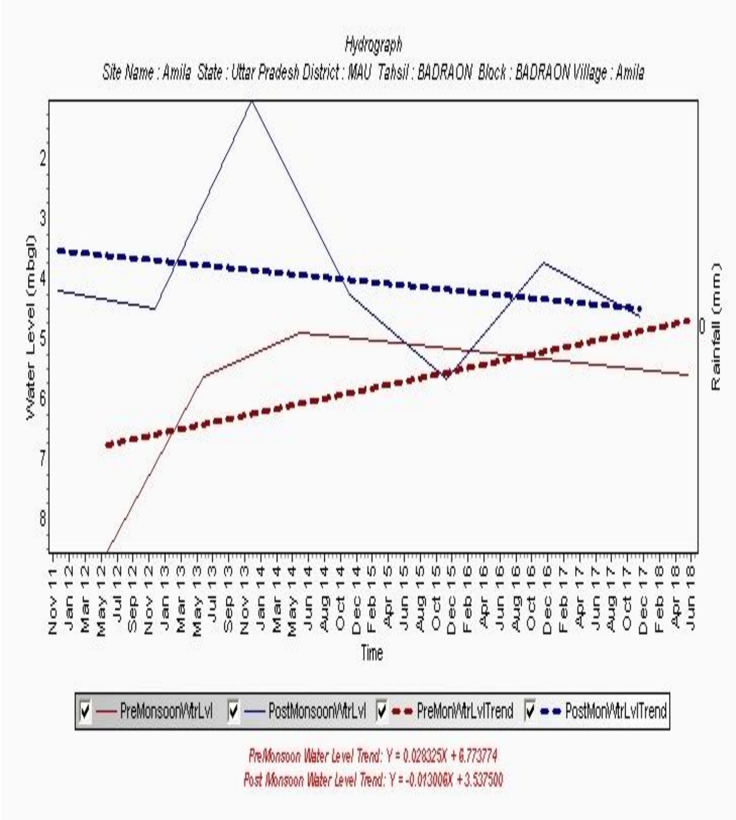
Long term fluctuation of the dug wells monitored from 2010 to 2019 was computed and has been tabulated below as Table 4.

Table 4: Long term water level fluctuation (2010 – 2019)

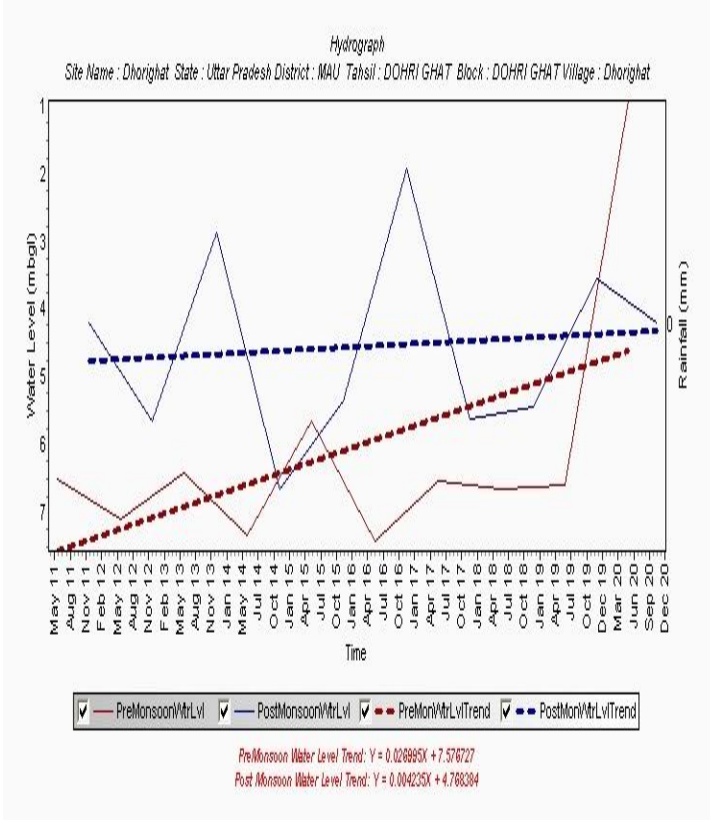
Location	Pre Monsoon		Post Monsoon		Annual	
	Rise (m/year)	Fall (m/year)	Rise (m/year)	Fall (m/year)	Rise (m/year)	Fall (m/year)
Dhorighat	0.0022		0.0174		0.0336	
Jejawali		0.1008		0.2113		0.1479
Amila				0.0151	0.0501	
Ghosi		0.0312		0.0049	0.0079	
Kapaganj			0.0535			0.0561
Ghinahapur				0.402		

Perusal of Table reveals that two wells (Jejawali, Ghosi) display falling trend in all the wells during pre-monsoon period. The range of decline is 0.1008 to 0.0312m/year. Four wells display falling trend during post monsoon period in all the wells. The range of decline 0.0049 at Ghosi to 0.402m/year at Ghinahapur.

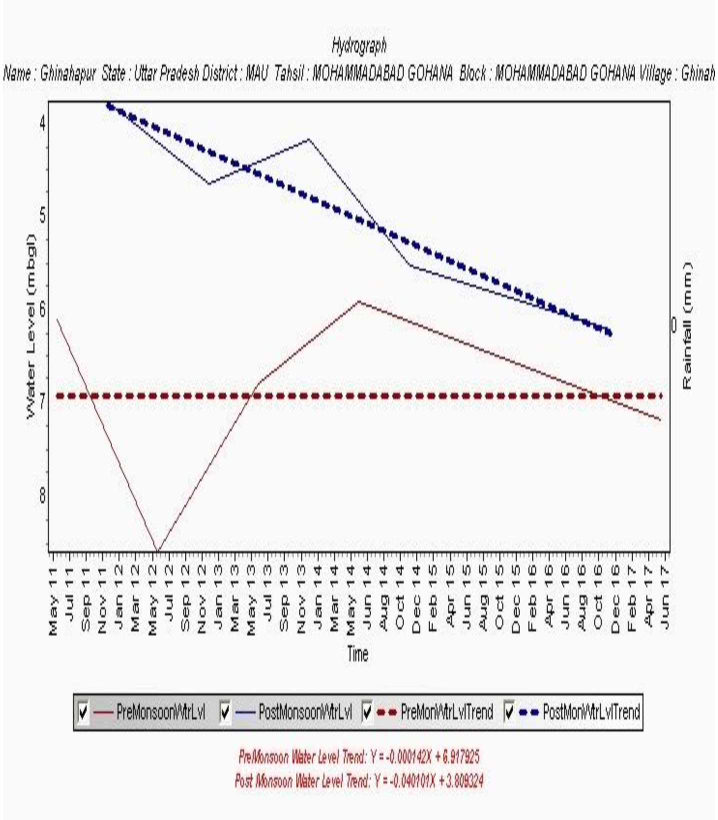
The hydrographs of the monitoring stations have been attached below.



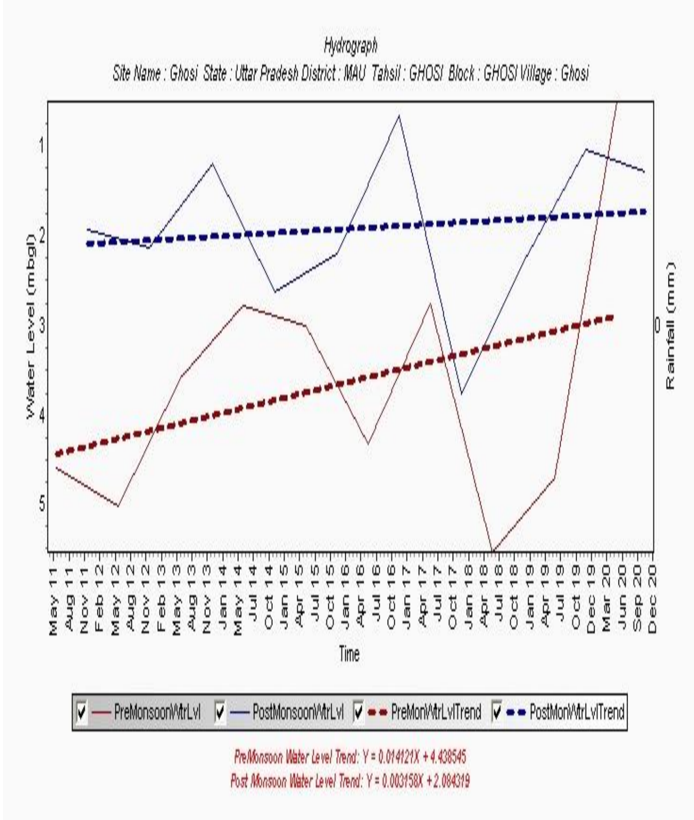
(a) Hydrograph of Amila station at Badraon block



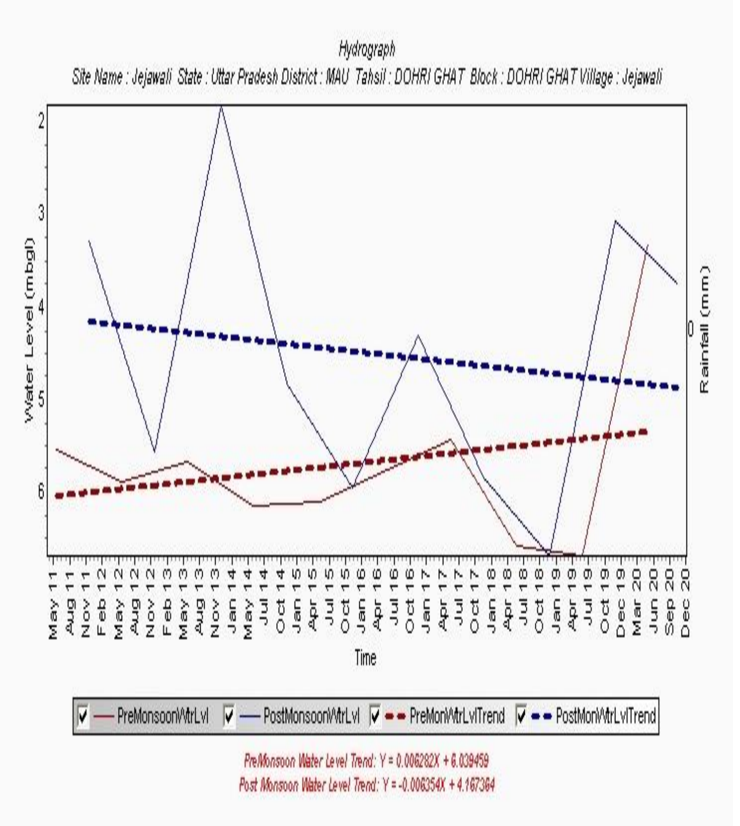
(b) Hydrograph of Dohari Ghat station at Dohari Ghat block



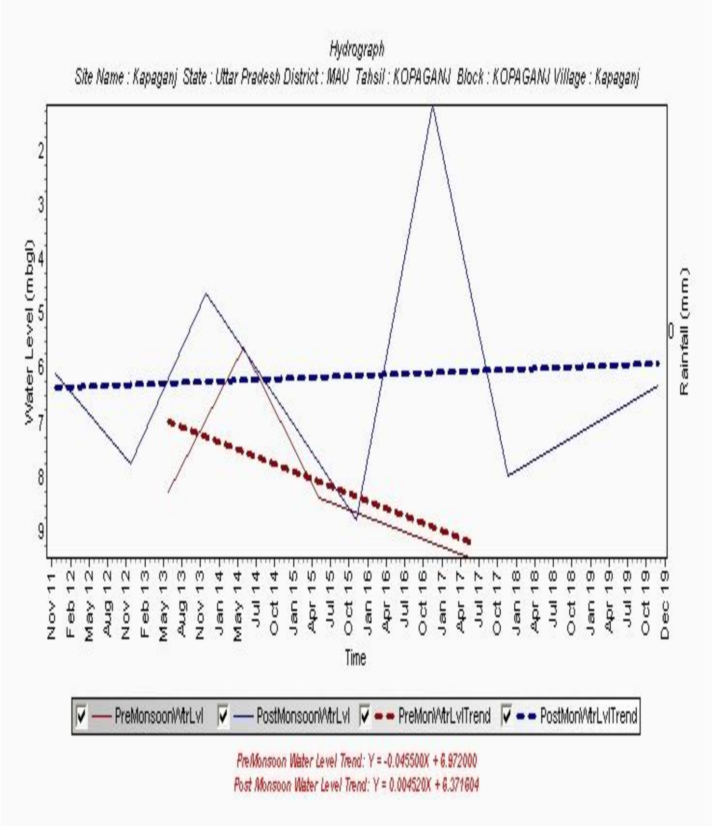
(c) Hydrograph of Mohammadabad Gohna station at Mohammadabad block



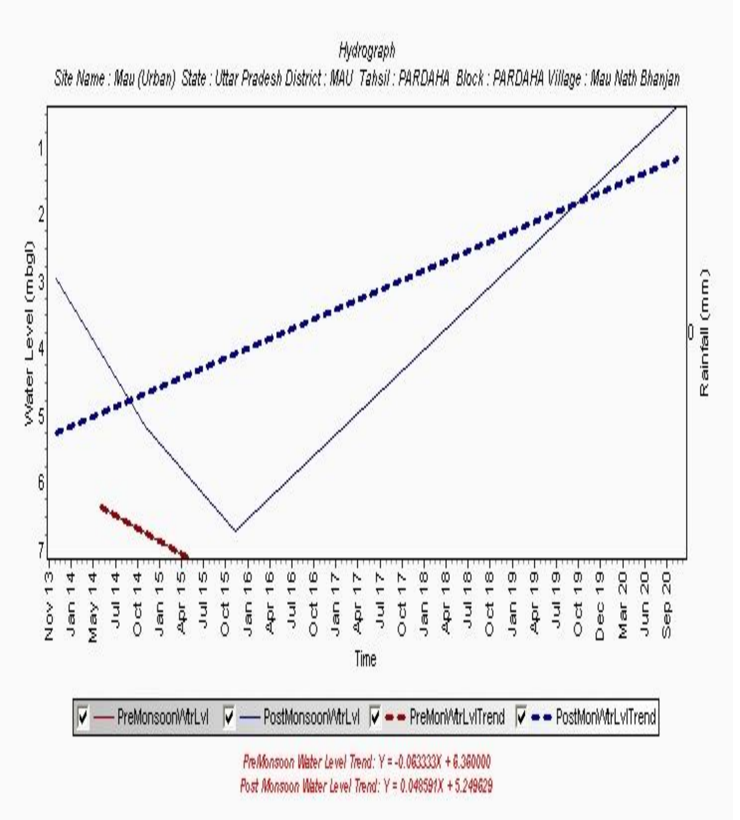
(d) Hydrograph of Ghosi station at Ghosi block



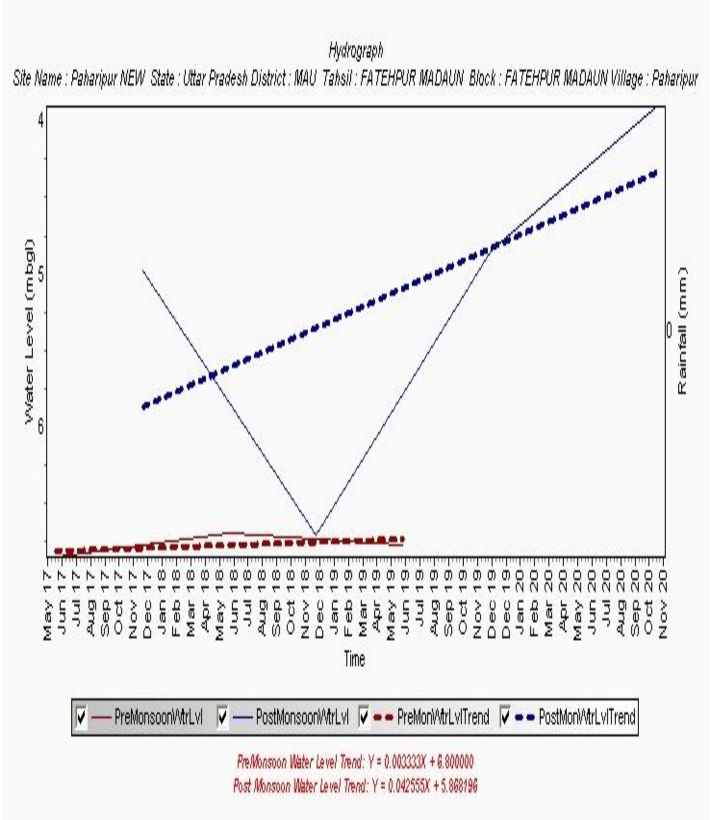
(e) Hydrograph of Jejawali station at Doharighat block



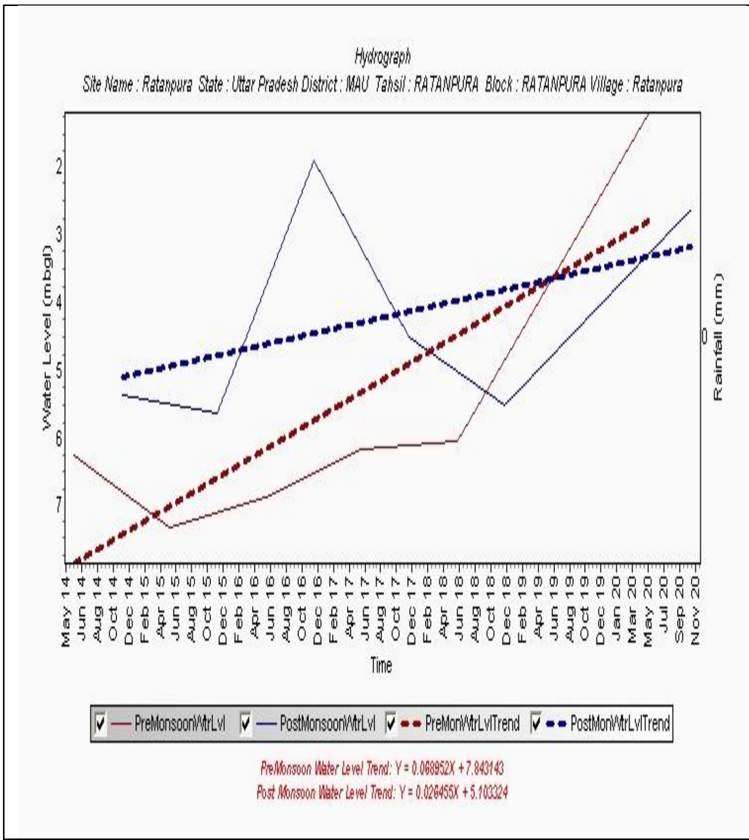
(f) Hydrograph of Kopaganj station at Kopaganj block



(g) Hydrograph of Pardaha station at Pardaha block



(h) Hydrograph of Paharipur station at Fatehpur Madaon block



(i) Hydrograph of Ratanpura station at Ratanpura block

Figure 25: Hydrograph of water level monitoring stations in the study area

Perusal of hydrographs reveal that majority of groundwater monitoring stations display rising trend both during the pre-monsoon as well as the post-monsoon seasons. The hydrograph stations at Mohammadabad Gohna and Jejawali in Mohammadabad and Dohari Ghat blocks display falling trend during the post-monsoon indicating that the extraction of groundwater exceeds the recharge by rainfall and other sources to the first aquifer.

2.5 Groundwater Quality

The concentration of elements in groundwater is governed by many factors .i.e.

i. Nature of formation,
ii. Minerals present in the rock,
iii. Characteristics of soil,
iv. Anthropogenic activities like Irrigation run-off, Discharge of effluents, Industrial and domestic activities etc.

In order to have a clear picture and to study the hydrochemistry of groundwater, the analytical data of monitored wells and hand pumps were analysed by the NABL accredited Regional Chemical Laboratory at Lucknow.

2.5.1 Groundwater sampling

Pre-monsoon sampling was carried out in June 2019 for determination of basic parameters and trace metals for demarcation of areas with spurious water quality.

2.5.2 General Aspects of unconfined aquifer

18 groundwater samples were collected during the pre-monsoon season in 2019 for analysis of basic parameters and trace metals. The analysed data has been attached as Annexures 7 and 8.

The analysed data was plotted on trilinear Hill-Piper diagram **[12]** to ascertain hydrochemical facies.

- 86.66% of samples lie on Mg^{2+}- HCO_3^- quadrant indicating (Ca^{2+} + Mg^{2+}) > (Na^+ + K^+) and groundwater is shallow and fresh in nature, recharged directly by precipitation.
- 6.66% of samples lie on Na^+ - HCO_3^- quadrant indicating (Cl^- + SO_4^{2-}) > (CO_3^{2-} + HCO_3^-) and represent groundwater influenced by ion exchange.
- 6.66% of samples lie on Ca-Mg-Cl mixed quadrant indicating (Ca^{2+} + Mg^{2+}) + (CO_3^{2-} + HCO_3^-) > (Na^+ + K^+) + (Cl^- + SO_4^{2-}) and represent groundwater influenced by reverse ion exchange.

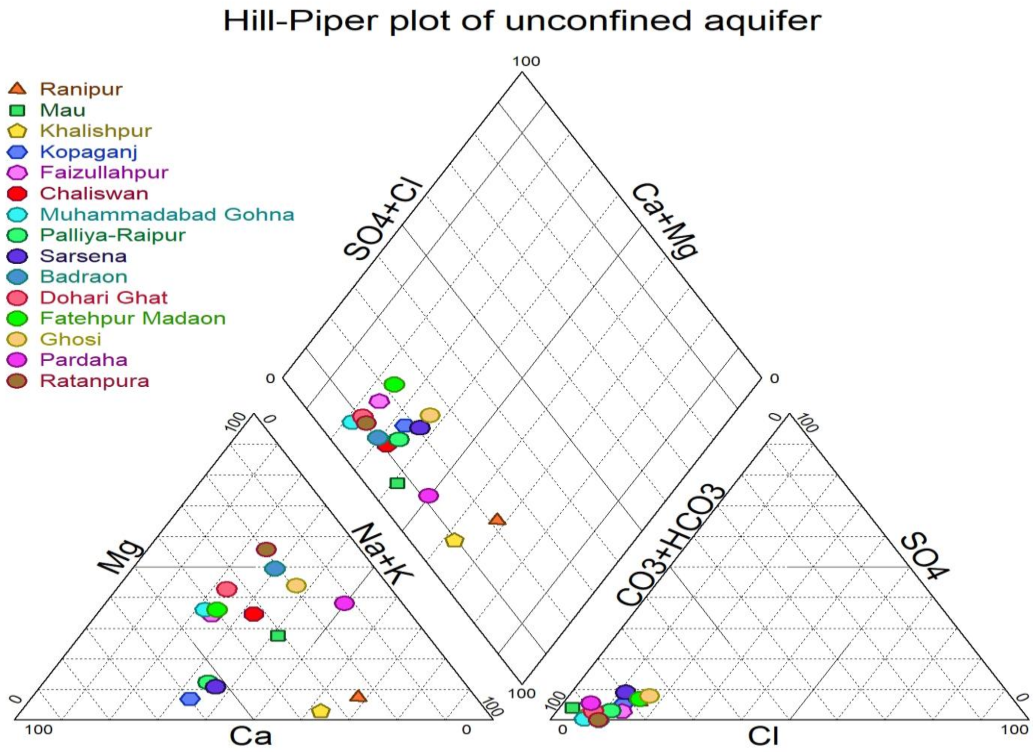


Figure 26: Trilinear Hill-Piper plot of unconfined aquifer

2.5.3 Classification with respect to agricultural use

As prescribed by IS 11624-1986 **[12]**, the water quality of unconfined aquifer has been classified with respect to agricultural standards and has been classified below.

(i) Total salt concentration – It is expressed as Electrical Conductivity (EC) and in relation to the hazardous effect on soils, the classification is given below in Table 5.

Table 5: Summarized table of GW samples w.r.t EC

Sl.No.	Class	Range of EC (µS/cm)	No. of samples
1.	Low	0 – 1,500	15
2.	Medium	1,500 – 3,000	-
3.	High	3,000 – 6,000	-
4.	Very High	>6,000	-

All the samples lie within the ambit of 'Low' class with reference to EC and pose no problem for irrigation.

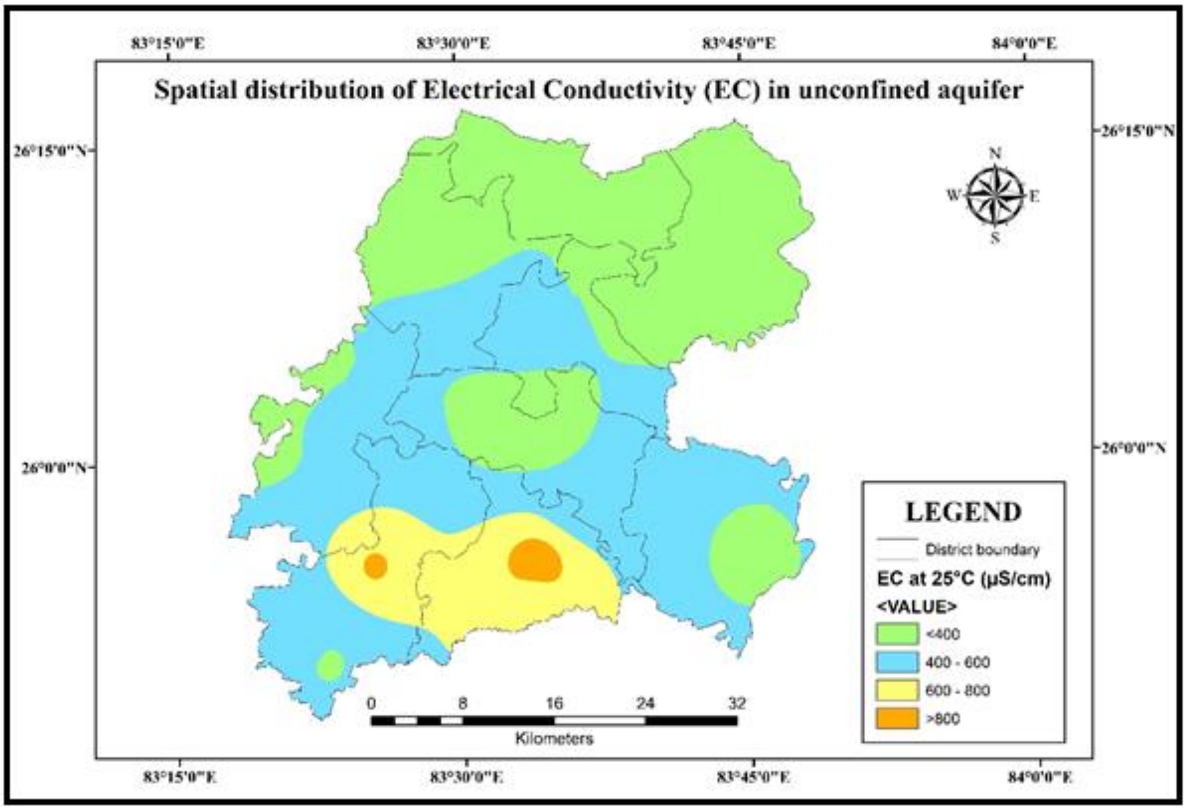


Figure 27: Spatial distribution map of Electrical Conductivity (EC) of unconfined aquifer

(ii) Residual Sodium Carbonate – It is defined with respect to hazardous effects of Bicarbonate ion concentration on soil and calculated by the following formula where all constituents are in meq/l:

$$RSC = (CO_3^{2-} + HCO_3^{-}) - (Ca^{2+} + Mg^{2+})$$

The classification as per standard is tabulated in Table 6 below.

Table 6: Summarized table of GW samples w.r.t RSC

Sl.No.	Class	Range of RSC (meq/l)	No. of samples
1.	Low	< 1.5	11
2.	Medium	1.5 – 3.0	2
3.	High	3.0 – 6.0	2
4.	Very High	> 6.0	-

Eleven samples (73.33% of total samples) lie within the ambit of ‘Low’ class with reference to RSC and pose no problem for irrigation. Two samples (13.33% of total samples) lie within the ambit of ‘Medium’ class and the soil requires some treatment prior to application of groundwater for irrigation. Two samples (13.33% of total samples) lie within the ambit of ‘High’ class and can be used under exceptional circumstances.

(iii) Sodium Adsorption Ratio – It is an irrigation water quality parameter used in the management of sodium affected soils. It is an indicator of suitability of water for use in agricultural irrigation, as determined from the concentrations of main alkaline and alkaline earth cations present in groundwater. It is also a diagnostic parameter for the sodicity hazard of a soil, as determined from analysis of pore water extracted from the soil.

It is calculated from the following formula.

$$SAR = \frac{Na}{\sqrt{(Ca+Mg)/2}}$$

Table 7: Summarized table of GW samples w.r.t SAR

Sl.No.	Class	Range of SAR (meq/l)	No. of samples
1.	Low	<10	15
2.	Medium	10 - 18	-
3.	High	18 - 26	-
4.	Very High	> 26	-

All the samples lie within the ambit of ‘Low’ class with reference to SAR and there is negligible chance of development of soil salinity.

2.5.4 Note on Trace elements

(i) Total Chromium as Cr: No Chromium was found in any sample.

(ii) Copper: No Copper was found in any sample.

(iii) Iron: Only three samples (20% of total samples) namely Khalishpur, Badraon and Dohari Ghat display values of Iron greater than 0.3 mg/l, which is acceptable limit as per BIS 10500:2012-2nd Revision.

(iv) Manganese: Only three samples (20% of total samples) namely Khalishpur, Sarsena and Ghosi display values higher than acceptable limit of Manganese defined at 0.1 mg/l but lesser than permissible limit defined at 0.3 mg/l as per BIS 10500:2012-2nd Revision.

(v) Zinc: All samples have Zinc content within acceptable limit as per BIS 10500:2012-2nd Revision.

(vi) Total Arsenic as As: Only one sample, Sarsena from Ranipur block displays Arsenic higher than acceptable limit but lesser than permissible limit as per BIS 10500:2012-2nd Revision.

(vii) Lead: All samples have Lead content within acceptable limit as per BIS 10500:2012-2nd Revision.

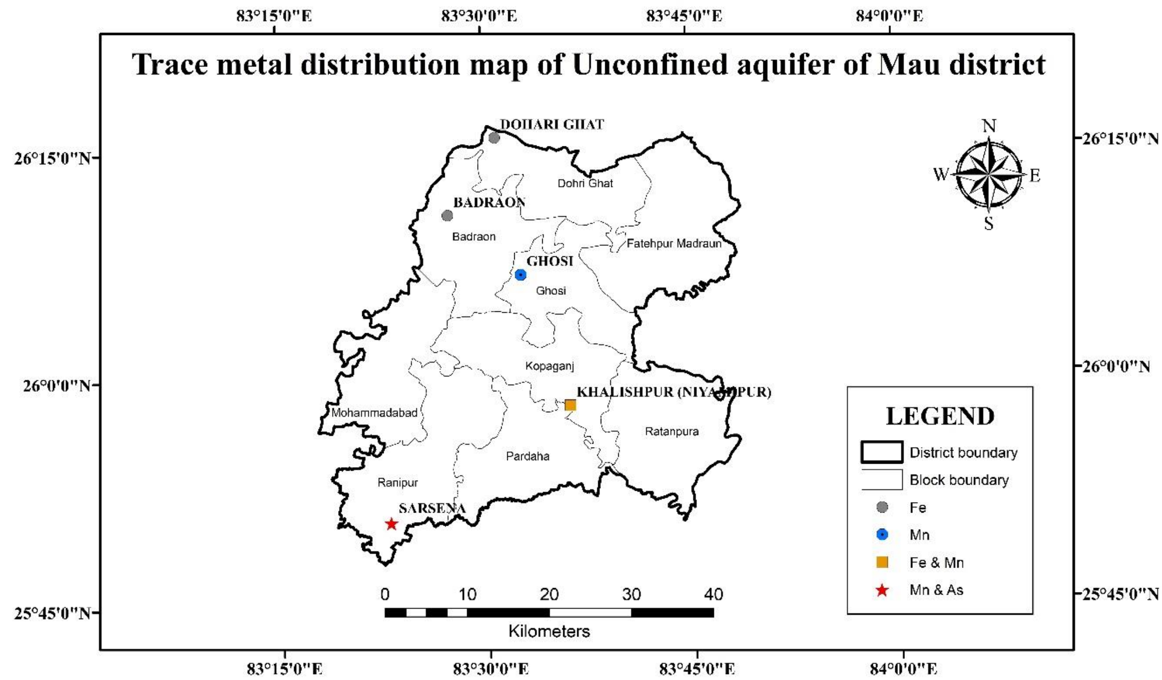


Figure 28: Map of Trace metal distribution in unconfined aquifer of Mau district

2.5.5 Uranium sampling -

Sampling for Uranium in groundwater was carried out during the pre-monsoon Ground water monitoring during May 2019 for ascertaining the amount of Uranium present. The data after analysis by ICP-MS is depicted below as Figure 29. According to the figure, all 9 blocks of Mau district display Uranium concentration well beneath the permissible limit of 30µg/litre as mandated by USEPA **[13]**.

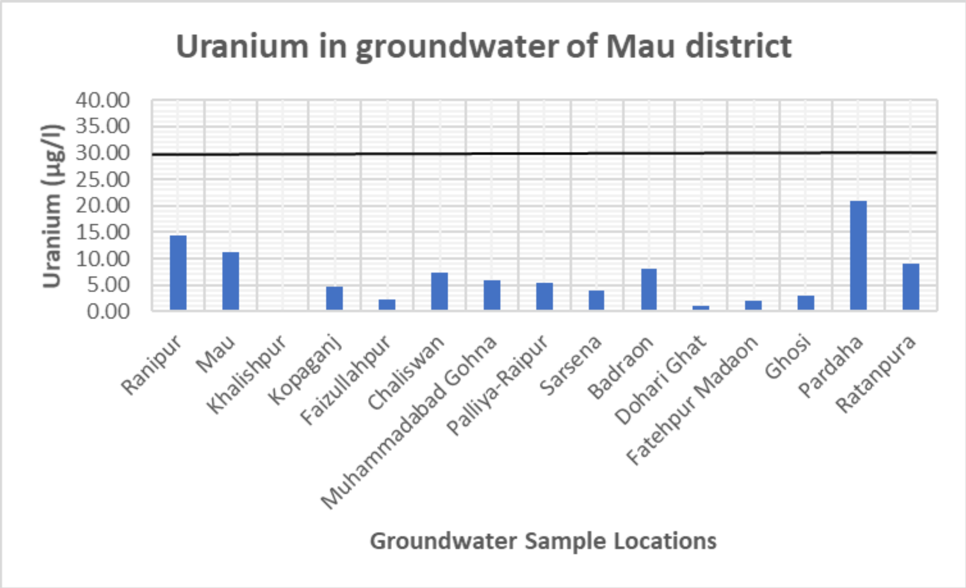


Figure 29: Chart of GW samples displaying Uranium content against USEPA standard

2.5.6 General hydrochemistry of deeper aquifers

6 groundwater samples were collected in May 2019 when pumping tests were carried out to determine aquifer parameters. 3 samples were earmarked for determination of basic parameters, namely pH, EC, Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, HCO_3^{-}, CO_3^{2-}, SO_4^{2-}, Cl^{-}, F^{-} and PO_4^{3-}. 3 samples were earmarked for analysis of trace metals, namely Fe, Mn, Cu, Cr, Zn, Pb, As and U by ICP-MS. After obtaining the results of chemical analyses, the samples were plotted on trilinear Hill-Piper plot **[11]** and the samples were classified into different hydrochemical facies based on dominant cations and anions –

- 33.3% of samples lie on Mg^{2+}- HCO_3^{-} quadrant indicating (Ca^{2+} + Mg^{2+}) > (Na^{+} + K^{+}) and groundwater is shallow and fresh in nature, recharged directly by precipitation.
- 66.6 % of samples lie on Na^{+} - HCO_3^{-} quadrant indicating (Cl^{-} + SO_4^{2-}) > (CO_3^{2-} + HCO_3^{-}) and represent groundwater influenced by ion exchange.

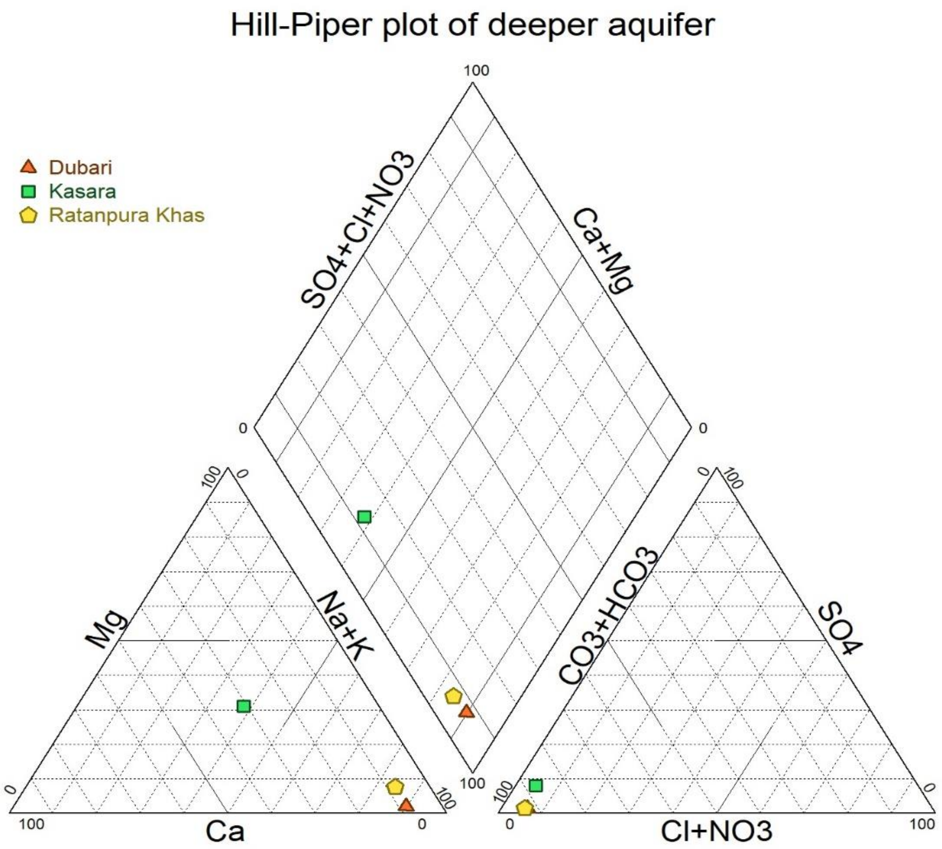


Figure 30: Trilinear Hill-Piper plot of deeper aquifer

2.5.7 Classification with respect to agricultural use

As prescribed by IS 11624-1986 **[12]**, the water quality of deeper aquifer has been classified with respect to agricultural standards and has been classified below.

(i) Total salt concentration – It is expressed as Electrical Conductivity (EC) and in relation to the hazardous effect on soils, the classification is given below in Table 8.

Table 8: Summarized table of GW samples w.r.t EC

Sl.No.	Class	Range of EC (µS/cm)	No. of samples
1.	Low	0 – 1,500	3
2.	Medium	1,500 – 3,000	-
3.	High	3,000 – 6,000	-
4.	Very High	>6,000	-

All the samples lie within the ambit of ‘Low’ class with reference to EC and pose no problem for irrigation.

(ii) Residual Sodium Carbonate – It is defined with respect to hazardous effects of Bicarbonate ion concentration on soil and calculated by the following formula where all constituents are in meq/l:

$$RSC = (CO_3^{2-} + HCO_3^{-}) - (Ca^{2+} + Mg^{2+})$$

The classification as per standard is tabulated in Table 9 below.

Table 9: Summarized table of GW samples w.r.t RSC

Sl.No.	Class	Range of RSC (meq/l)	No. of samples
1.	Low	< 1.5	-
2.	Medium	1.5 – 3.0	1
3.	High	3.0 – 6.0	-
4.	Very High	> 6.0	2

Only one sample (33.3% of total samples) from Kasara lies in ‘Medium’ class with reference to RSC and the soil requires some treatment prior to application of groundwater for irrigation. Two samples (66.6% of total samples), namely Dubari and Ratanpura Khas lie in ‘Very High’ class with reference to RSC and are completely unfit for agricultural purpose.

(iii) Sodium Adsorption Ratio – It is an irrigation water quality parameter used in the management of sodium affected soils. It is an indicator of suitability of water for use in agricultural irrigation, as determined from the concentrations of main alkaline and alkaline earth cations present in groundwater. It is also a diagnostic parameter for the sodicity hazard of a soil, as determined from analysis of pore water extracted from the soil.

It is calculated from the following formula.

$$SAR = \frac{Na}{\sqrt{(Ca+Mg)/2}}$$

Table 10: Summarized table of GW samples w.r.t SAR

Sl.No.	Class	Range of SAR (meq/l)	No. of samples
1.	Low	<10	3
2.	Medium	10 - 18	-
3.	High	18 - 26	-
4.	Very High	> 26	-

All three samples lie in ‘Low’ category with reference to S.A.R and there is negligible chance of development of soil salinity.

2.5.8 Note on Trace metals

(i) Total Chromium as Cr: No detectable Chromium was found in any sample

(ii) Copper: No detectable Copper was found in any sample.

(iii) Iron: 2 samples, namely Kasara and Ratanpura Khas display Iron content greater than permissible limit.

(iv) Manganese: Only one sample, namely Kasara displays higher than acceptable limit of Manganese defined at 0.1 mg/l but lesser than permissible limit defined at 0.3 mg/l as per BIS 10500:2012-2nd Revision. Other two samples display values lesser than 0.1 mg/l.

(v) Zinc: No detectable Zinc was found in any sample.

(vi) Total Arsenic as As: No detectable Arsenic was found in any sample.

(vii) Lead: No detectable Lead was found in any sample.

(viii) Uranium: All three samples display Uranium concentration well beneath the permissible limit of 30µg/litre as mandated by USEPA (2014).

Table 11: Comparison of GW quality of 3 aquifers										
Constituents	Limits as per BIS 10500-2012: 2nd Revision	Aquifer – I			Aquifer – II			Aquifer – III		
		Min	Max	No. of Samples above MPL	Min	Max	No. of Samples above MPL	Min	Max	No. of Samples above MPL
pH	6.5 – 8.5	7.07	8.46	-	8.18	-	-	8.44	-	-
EC (µS/cm)	No limits	427	880	-	780	-	-	880	900	-
Calcium	75 -200 mg/l	24	58	-	56	-	-	16	-	-
Magnesium	30 – 100 mg/l	2	46	-	34.04	-	-	2.43	9.72	-
Potassium	No limits	1	5.4	-	2.9	-	-	1.6	1.8	-
Sodium	No limits	24	120	-	78	-	-	200	202	-
Carbonate	No limits	0	36	-	0	-	-	48	60	-
Bicarbonate	No limits	221	549	-	475.8	-	-	463.6	506.3	-
Chloride	250 – 1,000 mg/l	7	43	-	14.2	-	-	21.3	-	-
Sulphate	200 – 400 mg/l	0	27	-	34	-	-	6.6	7.2	-
Nitrate	45 mg/l (acceptable)	0	15	-	-	-	-	-	-	-
Fluoride	1.0 mg/l (acceptable); 1.5 mg/l (permissible)	0.14	0.77	-	0.51	-	-	1.46	1.74	1
Arsenic	0.01 mg/l (acceptable)	0.00	0.03	-	-	-	-	0.002	0.003	-

	0.05 mg/l (permissible)									
Chromium	0.05 mg/l (acceptable)	-	-	-	0.002	-	-	0.00	0.002	-
Iron	1.0 mg/l (acceptable); 1.5 mg/l (permissible)	0.00	4.16	3	1.89	-	1	0.17	2.2	1
Manganese	0.1 mg/l (acceptable); 0.3 mg/l (permissible)	0.00	0.25	-	0.16	-	-	0.01	0.06	-
Copper	0.05 mg/l (acceptable); 1.5 mg/l (permissible)	0.00	-	-	-	-	-	-	-	-
Zinc	5 mg/l (acceptable); 15 mg/l (permissible)	0.00	1.46	-	-	-	-	-	-	-
Lead	0.01 mg/l (acceptable)	0.00	0.001	-	0.001	-	-	0.0005	-	-
Uranium*	30 µg/l	0.00	21.00	-	8.78	-	-	3.02	5.05	-

* USEPA standards (2014)

2.6 Aquifer Characteristics

Based on available exploratory data, three aquifer groups were demarcated in the district.

- First aquifer group is unconfined in nature and lithology mainly includes fine to medium grained sand.
- Second aquifer group is semi-confined in nature and lithology mainly includes fine grained sand.
- Third aquifer group is semi-confined in nature and includes fine to very fine grained sand.

The data available from exploratory drilling summarizing the depth of aquifer groups, feasible extraction structure, discharge and other details have been summarized below.

Table 12: Summarized details of Aquifer groups in the district

Aquifer	Group – 1 [AL03]	Group – 2 [AL03]	Group – 3 [AL03]
Formation	Sand, silt & clay.	Sand, silt & clay.	Sand, silt & clay.
Abstraction Structure	Dug well, Indian Mk.II hand-pump	Tubewell	Tubewell
Depth Range (mbgl)	0 - 52	70 - 152	190 - 240
Discharge (lpm)	50 – 100	1,517	1,1119 – 1,173
Transmissivity	-	1112.62 m^2/day	180 – 440 m^2/day
S_Y / S	0.10	$1.31*10^{-3}$	$1.29 – 1.54*10^{-3}$
Groundwater suitability	Sporadic occurrence of Iron, Manganese & Arsenic. Suitable for irrigation and domestic purposes.	Suitable for irrigation and domestic purposes.	Fluoride higher than permissible limit. Suitable for irrigation purposes.

3. GROUNDWATER RESOURCE POTENTIAL

Stage of Groundwater Development:

The current stage of Groundwater Development of Maunath Bhanjan district has been pegged at 65.81% as per GWRE 2020, which is categorized as Safe. All the 9 blocks of the district have been categorized as "Safe" as their Stage of GW Development lies in the narrow range of 61.26% - 69.56%. Ratanpura block lies at the lower end of the scale displaying 61.26% Stage of GW Development whereas Mohammadabad block lies at the extreme end of scale with 69. 65% of GW Development. Pardaha block has the lowest groundwater availability whereas Ghosi block has the highest groundwater availability.

The groundwater resource potential of the district (block-wise) has been calculated on the methodology given in Groundwater Estimation Committee (GEC) Report 2020 **[14]**.

Table 13: Block wise Groundwater resource of Maunath Bhanjan district (As on 31-03-2021) based on GEC-2020 Methodology.

Sl. No	Block	Annual Extractable Groundwater Resource (Ham)	Ground Water Extraction for Irrigation Use (Ham)	Ground Water Extraction for Domestic And Industrial Use (Ham)	Total Groundwater Extraction (Ham)	Net Groundwater Availability for future use (Ham)	Annual GW Allocation for Domestic Use as on 2025	Stage of Ground Water Development (%)	Category
1	**Badraon**	**4451.80**	**2404.08**	**512.052**	**2916.13**	**1451.83**	**595.88**	**65.50**	**Safe**
2	**Dohari Ghat**	**5016.85**	**2819.28**	**496.57**	**3315.85**	**1637.67**	**559.89**	**66.09**	**Safe**
3	**Fatehpur Madaon**	**6178.67**	**3261.88**	**588.69**	**3850.58**	**2230.51**	**686.29**	**62.32**	**Safe**
4	**Ghosi**	**6539.18**	**3854.80**	**544.33**	**4399.13**	**2037.62**	**646.76**	**67.27**	**Safe**
5	**Kopaganj**	**5396.79**	**2030.05**	**1564.07**	**3594.13**	**1504.00**	**1862.74**	**66.60**	**Safe**
6	**Mohamm-adabad**	**4072.58**	**2128.80**	**703.98**	**2832.78**	**1122.66**	**821.11**	**69.56**	**Safe**
7	**Pardaha**	**3517.82**	**1952.40**	**406.46**	**2358.86**	**1104.34**	**461.08**	**67.05**	**Safe**
8	**Ranipur**	**5940.80**	**3321.60**	**637.22**	**3958.83**	**1869.72**	**749.48**	**66.64**	**Safe**
9	**Ratanpura**	**5006.90**	**2530.80**	**536.27**	**3067.07**	**1825.51**	**650.59**	**61.26**	**Safe**
	TOTAL	46121.39	24303.69	5989.67	30293.36	14783.86	7033.82	65.81	**Safe**

Map displaying the block-wise categorization as well as Stage of Groundwater Development has been attached below as Figure 31.

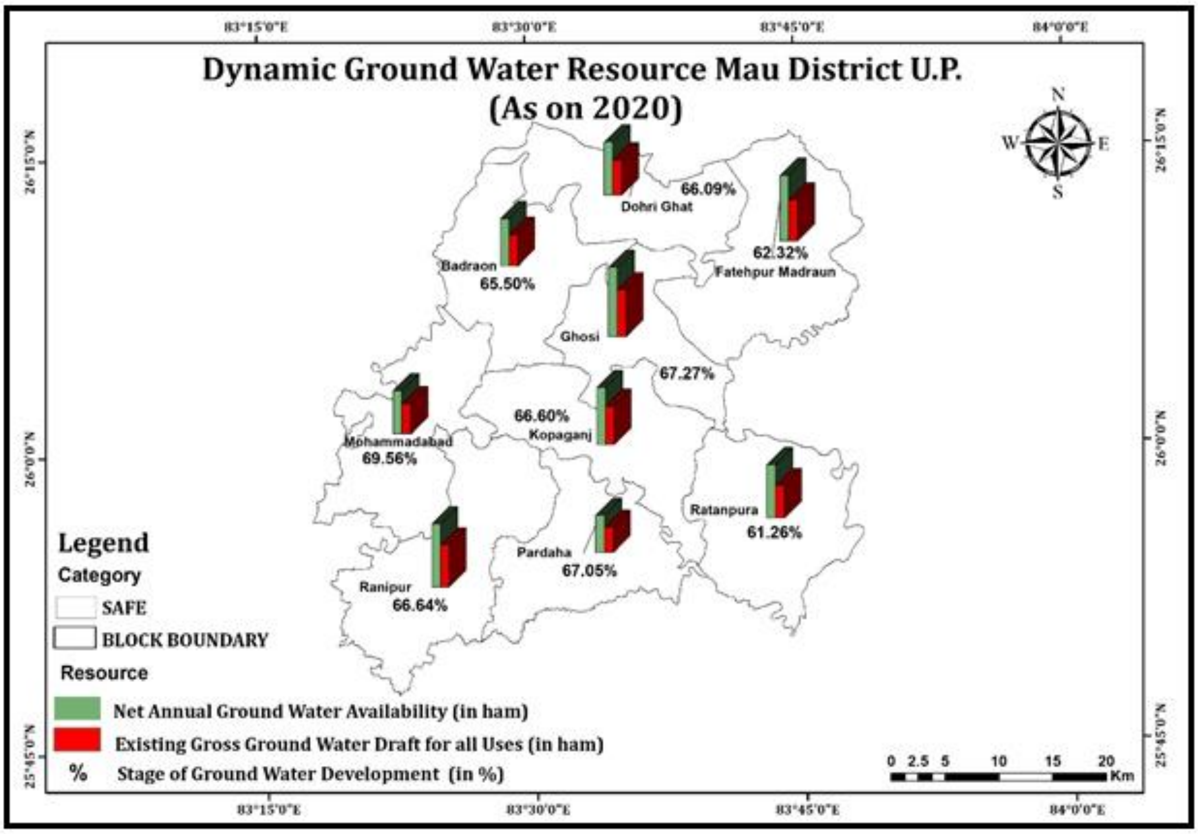


Figure 31: Map displaying the Groundwater Resource of Mau district as per GEC-2020

4. GROUNDWATER RELATED ISSUES

4.1 Identification of issues

(i) High contribution of groundwater towards irrigation: The contribution of surface water from existing canal network towards irrigation ranges from 25.6% in Ghosi block to a paltry 2.1% in Ranipur block. The balance is made up by harnessing groundwater. The blocks of Mohammadabad Gohna, Ratanpura and Pardaha are entirely reliant on groundwater for irrigation **[15]**.

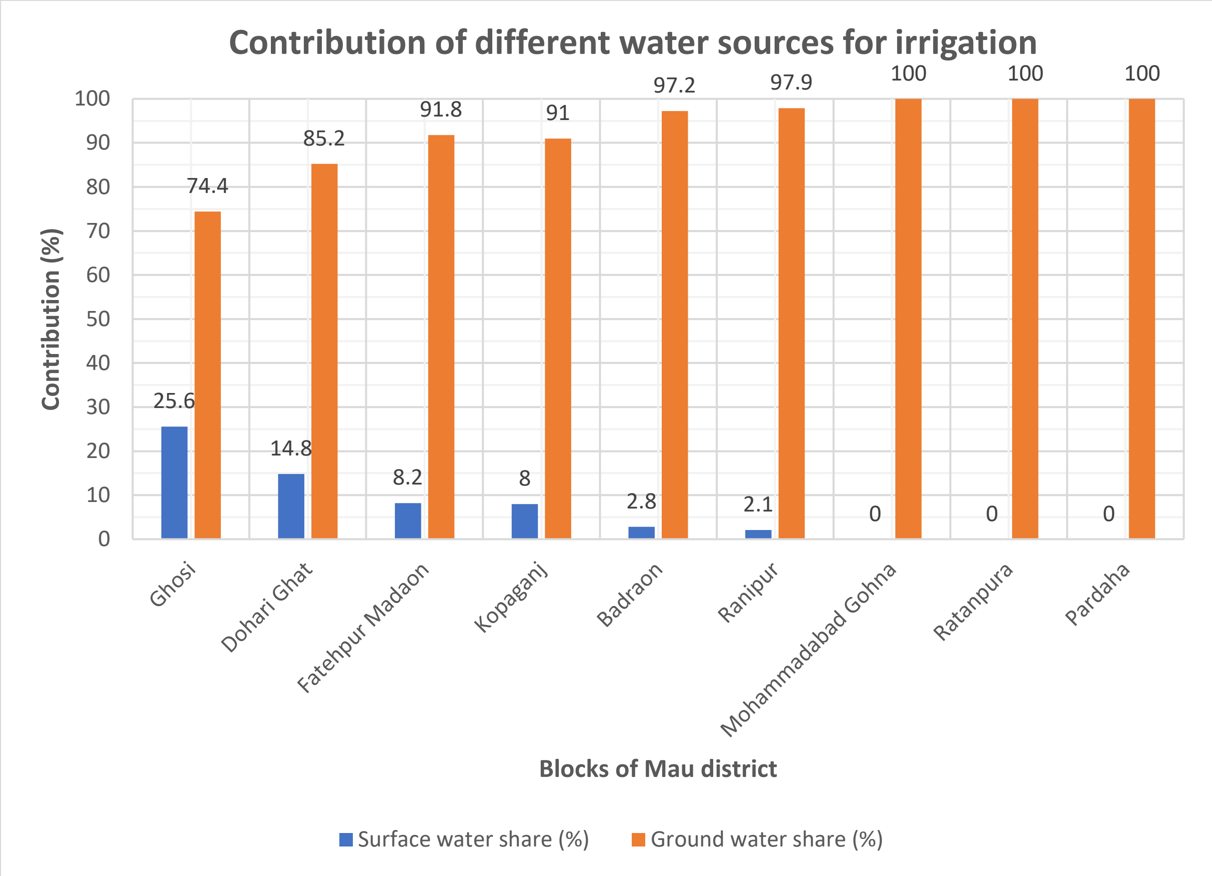


Figure 32: Graph displaying contribution of surface and groundwater for irrigation for each block.

(ii) Perusal of rainfall data (1971 – 2020) indicates declining trend that will only result in lesser rainfall recharging underlying aquifers.

4.2 Groundwater quality issues and contamination

(i) Sporadic occurrence of Iron, Manganese and Arsenic in the unconfined aquifer.

(ii) Elevated levels of Fluoride in third aquifer.

4.3 Miscellaneous issues

(i) Farmers in the district possess intermediate to low knowledge of vegetable cultivation practices **[16]**.

5. MANAGEMENT STRATEGIES

Management strategies have to be adopted and implemented by the concerned agencies in a timely fashion to prevent the increasing pressure on groundwater resources and to increase the availability of the aforesaid resource. Management strategies have been divided into Demand and Supply side interventions for implementation and tabulated below.

Table 14: Proposed Supply side and Demand side interventions

SUPPLY SIDE INTERVENTIONS	DEMAND SIDE INTERVENTIONS
1. Carrying out de-siltation of streams, ponds, tanks and surface water catchments to increase storage.	1. Promotion of drip and sprinkler/pressurized irrigation to enhance irrigation efficiency as opposed to traditional flood irrigation method.
2. Construction of Rainwater harvesting structures at suitable locations.	2. Introduction of rice crops that can withstand water logging and flooded areas in addition to intense rainfall.
3. Construction and maintenance of Fluoride removal units at places where deeper aquifer is Fluoride affected.	3. Promoting cultivation of pulses with high per hectare yield along with incentives.
4. Construction of deeper tubewells tapping 2nd Aquifer group at locations where quality issues plague the unconfined aquifer	4. Promoting oilseed cultivation with subsidies and incentives.
5. Construction of check dams at suitable locations to increase the quantum of groundwater recharge	5. Providing impetus to horticulture and orchards by Rashtriya Krishi Vikas Yojana by State Government agencies.

5.1 Supply Side Interventions

It has been proposed to adopt such measures only in groundwater stressed blocks in order to increase the quantum of available water by increasing storage, promoting community participation in revival and restoration of traditional water bodies like tanks, ponds etc. and suitable rainwater harvesting structures at urban places. The different interventions have been described below –

1. <u>Carrying out de-siltation of streams, ponds, tanks and surface water catchments to increase storage.</u>

(i) Desilting of traditional water bodies like tanks, ponds etc. will result in increased storage area by capturing surplus rainfall and can be utilized for domestic and irrigation purposes.

2. <u>Construction of Rainwater harvesting structures at suitable locations</u>

Rooftop Rainwater Harvesting : It is a technique wherein rainfall falling onto roof surfaces of houses, schools, colleges, offices and other establishments is diverted via a system of pipes and filter media to a storage tank or recharge underlying aquifer (by Manager Aquifer Recharge techniques). It also requires comparatively less maintenance for operation.

It prevents surplus rainfall from flowing into drains contributing to urban flooding in addition to checking soil erosion besides enhancing the groundwater levels, if not stored in a tank. When stored in a tank or sump, it can help tide over peak water demands during summer.

Amount of rainfall harvested depends on 3 factors –

(i) Quantum of annual Rainfall (mm)
(ii) Rooftop area (m^2)
(iii) Runoff factor (0.2 to 0.8 depending on roofing material)

Formula to calculate harvested rainfall = Quantum of annual Rainfall (mm)* Rooftop area (m^2)* Runoff factor

3. <u>Construction and maintenance of Fluoride removal units</u>

Fluoride removal techniques can be broadly classified into following categories -

(i) Adsorption technique: Fluoride ions onto the surface of an active agent. In the adsorption method, raw water is passed through a bed containing defluoridating material. The material retains fluoride either by physical, chemical or ion exchange mechanisms. The adsorbent gets saturated after a period of operation and requires regeneration. Adsorbents include activated Alumina (Al_2O_3) **[17]**; drumstick seeds **[18]**; vetiver roots **[17]**; tamarind seeds **[19]** and tea ash **[20]**.

(ii) Ion-exchange technique: The different ion exchange materials studied include bone, bone char, anion and cation exchange resins such as carbon, defluoron-1, defluoron-2, etc **[21]**.

(iii) Precipitation technique: chemicals added to raw water cause precipitation of the fluoride salt as insoluble fluorapatite, which is separated from the water. Commonly used materials in precipitation technique are Aluminium salts (e.g. Alum), lime, Poly Aluminium Chloride, Poly Aluminium Hydroxy sulphate and Brushite **[17]**.

- Nalgonda technique: Demonstrated for the first time in the town of Kathri, Nalgonda district, Andhra Pradesh which was developed by developed by National Environmental Engineering Research Institute (NEERI), Nagpur in 1961. It involves involves addition of Aluminium salts, lime and bleaching powder followed by rapid mixing, flocculation, sedimentation, filtration and disinfection. Aluminium salt may be added as aluminium sulphate (alum) or aluminium chloride or combination of these two. . It has low cost compared to other techniques for Fluoride removal and can be used for raw water with Fluoride content of 1.5 mg/l to 20 mg/l. Since the groundwater doesn't possess high TDS, it can be adopted easily **[22]**.
- IISc method: The method uses magnesium oxide, calcium hydroxide and sodium bisulfate. Magnesium oxide removes dissolved fluoride ions from water samples by precipitating fluoride as insoluble magnesium fluoride. The reaction has been given below:

$$MgO + H_2O \rightarrow Mg\,(OH)_2$$
$$2NaF + Mg(OH)_2 \rightarrow MgF_2 + 2\ NaOH$$

A simple to use domestic defluoridation unit was developed for fluoride removal based on IISc Method at Kolar, Karnataka to treat 15 litres of fluoride contaminated water.

4. Construction of deeper tubwells tapping 2nd Aquifer group at locations where quality issues plague the unconfined aquifer.

- Deeper tubewells tapping the 2nd Aquifer group between 70 – 152 mbgl can be constructed at suitable locations where the unconfined aquifer is affected by quality issues like high Iron, Manganese, Arsenic etc.

5. Construction of check dams at suitable locations to increase the quantum of groundwater recharge.

5.2 Demand side interventions

Agriculture is the major consumer of groundwater followed by domestic and industrial needs. There is increasing focus on promoting the use of micro-irrigation practices like sprinkler and drip irrigation as the traditional method of irrigation through canals results in lesser efficiency. The different interventions have been described below –

1. Promoting drip and sprinkler irrigation to enhance crop production.

- It will result in saving the quantum of groundwater applied for irrigation in addition to increasing the farmer's income as it will enable them to go in for one or two additional crops.

- Water losses are as low as 20 – 25% for Drip irrigation and 30 – 40% in Sprinkler irrigation.
- Drip irrigation is suitable for wide spaced crops in addition to irrigating oil seeds, pulses, cotton and wheat crops. Sprinkler irrigation is suitable for closely spaced crops such as fruits, vegetables, spices, flowers, sugarcane etc.
- There must be a thorough survey carried out by the concerned Department (Revenue/Agriculture/Land Holding etc.) to determine the land holdings of small and marginal farmers as majority of the micro-irrigation schemes are implemented on macro scale and most land holdings are small, about 1 hectare or lesser in most cases.

2. <u>Introduction of water-tolerant rice crops</u>

- Popularization of rice varieties like Madhukar for flooded areas and Jal Priya & Jal Lahari varieties for water logged conditions by Krishi Vigyan Kendra among the farmers.
- This problematic areas have been identified by KVK under Thrust Area-1.

3. <u>Promoting cultivation of pulses</u> [23]

- In addition to meeting protein intake, pulses also increase soil fertility through nitrogen fixing bacteria present in root system to the tune of 40 kg/Ha of Nitrogen. It also provides agronomic benefit to the next crop in terms of better soil microenvironment, quality and yield.
- The cultivation of pulses can be given a fillip by integrating it with existing government schemes like Accelerated Pules Production programme and Pulses Development Programme under Rashtriya Krishi Vikas Yojana in addition to Integrated Scheme of Oilseeds, Pulses, Oil Palm and Maize (ISOPOM) scheme.
- The State agriculture department in collaboration with Agriculture University/KVK and NGO’s can sensitize farmers on benefits on cultivation of pulses as inter-crops and inclusion of short duration pulse varieties as cash crop through meetings etc.
- Promoting cultivation of pulses has been identified by KVK under Thrust Area-2.

4. <u>Promoting oilseed cultivation with subsidies and incentives</u> [24]

- India is the second largest importer of oil seeds and the third largest consumer of oilseeds and an amount of ₹74,996 crores is spent on import (2017-18) since the production of oil seeds is insufficient to cater to the needs of the population and includes a 40% import duty.
- Doubling the import duty coupled with incentives to cultivate oilseeds indigenously by integrating Minimum Support Price (MSP) with Minimum Renumerative price (MRP) and according special status to oil seed sector by National Food Security Mission (NFSM) will prove beneficial to the country in the long run.
- Integrated Scheme of Oilseeds, Pulses, Oil Palm and Maize (ISOPOM) – Central government scheme wherein the State government draws up a Five year seed plan

indicating the requirement of each farmer and ICAR has been nominated as the nodal agency. ICAR has the responsibility for procurement and distribution of seeds, weedicides/bio-pesticides, distribution of Gypsum/Pyrite/Liming/Dolomite for lining soils and sprinkler sets in addition to ensuring infrastructural support, technical training to farmers and demonstration of latest agricultural inputs to boost yield.

- The oilseeds covered under this scheme are Groundnuts, Soyabean, Mustard, Rapseed, Sunflower, Sesamum, Safflower, Niger, Castor and Linseed that can be cultivated on suitable soils as decided by State Agricultural Universities.
- Promoting cultivation of oilseeds has been identified by KVK under Thrust Area-2.

5. Providing impetus to horticulture and orchards under Rashtriya Krishi Vikas Yojana

National Agriculture Development Scheme is being operated by Department of Horticulture & Food processing, Government of Uttar Pradesh that covers districts left out of the ambit of National Horticulture Mission (N.H.M). 60% of the budgetary allocation is covered by Central government whereas 40% of budgetary allocation is covered by State government's budget.

5.3 Miscellaneous interventions

1. Formulation of village water security and safety plan under the ambit of National Rural Drinking Water Programme (NRDWP).

The National Rural Drinking Water Quality Monitoring & Surveillance Programme (NDWQM&S) was launched in February 2006 with the prime objective of institutionalization of community participation and involvement of Panchayat Raj Institution (PRI) for water quality monitoring & surveillance of all drinking water sources. The key elements of NDWQM&S are as follows:

- To set-up the district and sub-district drinking water quality testing laboratories (or upgrade the existing ones) for routine and regular testing of water quality of rural drinking water sources.
- To provide field test kits (FTKs) and bacteriological vials to GPs for on the field testing of important general parameters (including Arsenic).
- Awareness generation of the community at large on water quality and health issues.
- Capacity building of five grass root workers in each GP for testing of water sources within their jurisdiction using simple FTKs and confirmation from the nearest water testing laboratory for positively tested samples.
- Conduct sanitary survey by trained Panchayat personnel for the possibility of bacteriological contamination.

Under the programme, 100% funding is provided to all the states for information, education and communication (IEC) activities, human resource development activities, strengthening of district level drinking water quality testing laboratories, procurement of FTK for testing drinking water, travel and transportation cost, data reporting cost, stationery cost, honorarium to district level surveillance coordinators, water testing, documentation and data entry costs to the states for strengthening water quality monitoring facilities as per approved norms for water quality monitoring and surveillance programme and NRDWP guidelines. The WQMS Programme has been subsumed in the NRDWP since the year 2009.

The NRDWP provides grants to all the states for construction of rural water supply schemes with special focus on water-stressed and water quality affected areas, rainwater harvesting and groundwater recharge measures, and for operation and maintenance including minor repairs. Allocated funds are released to the states in three instalments (40%, 40% and 30%, respectively) during each year. Under the NRDWP, powers to plan, approve and implement the water supply schemes which inter alia includes, selection of suitable treatment technologies rest with the states **[25]**.

2. <u>Promoting the cultivation of Brinjal</u>: Technological and other input to bridge the knowledge gap of farmers cultivating Brinjal crop. Tie-up of KVK's with local farmers co-operatives/associations for demonstration of latest techniques in Integrated Pest Management will benefit the farmers. A similar demonstration and subsequent adoption of techniques in 2014 resulted in net income of farmers increasing to INR 2,57,500/Ha [32]. Another study conducted on cost and profit measures of Brinjal crop in Fatehpur Madaon block of Mau district has shown that benefit-cost ratio ranges from 1:1.86 to 1:1.25 and the input cost is highest for farmers with marginal land holdings followed by small land holdings **[26]**.

BLOCK-WISE GROUNDWATWER MANAGEMENT PLANS

5.4 Groundwater Management Plan of Ranipur block

(i) Salient Information

Table 15: Summarized demographic details of Ranipur block

Area (km^2)	288.82
Male Population	145303
Female Population	142756
Population Density (People per km^2)	997
Normal Annual Rainfall (mm)	1050.46
Kharif crop area (Ha)	16163
Rabi crop area (Ha)	15316
Summer crop area (Ha)	36
Canal Command Area (Ha)	493
Non-Canal Command Area (Ha)	16367
Gross irrigated area (Ha)	31091
Net Irrigated Area (Ha)	17046

(ii) Water Level behaviour

Pre-monsoon water level ranges from 2.2 mbgl to 11.8 mbgl and post-monsoon water level ranges from 0.4 mbgl to 5.85 mbgl. Rising trend of 1.8 mbgl to 7.3 mbgl is observed.

(iii) Issues

- Manganese and Arsenic present in unconfined aquifer.
- Groundwater contribution to agriculture is 97.90%.

(iv) Groundwater Management Plan: The proposed groundwater management plan for the block has been tabulated below. Upon implementation, 6.13 MCM of groundwater is expected to be available for additional utilization and Stage of Groundwater Development is expected to decrease by 8.91%. The tentative locations for interventions has been attached as Figure 33 below.

Table 16(a): Summarized details of interventions proposed

Block	Check Dams (Nos.)	Stream Development (kms)	Nala Bunds (kms)	Ponds (Nos.)	On-farm area (Ha)	WUE area (Ha)
Ranipur	2	0	0	10	1775	682

Table 16(b): Projected GW Recharge & savings by supply and demand side management

Net Annual GW Availability (MCM)	Existing GW Draft for all uses (MCM)	Stage of GW Development (%)	Total recharge through interventions (MCM)	Total GW savings through interventions (MCM)	Projected Net GW Availability (MCM)	Projected Stage of GW Development after interventions (%)
59.40	39.58	66.64	1.96	4.17	59.46	57.73

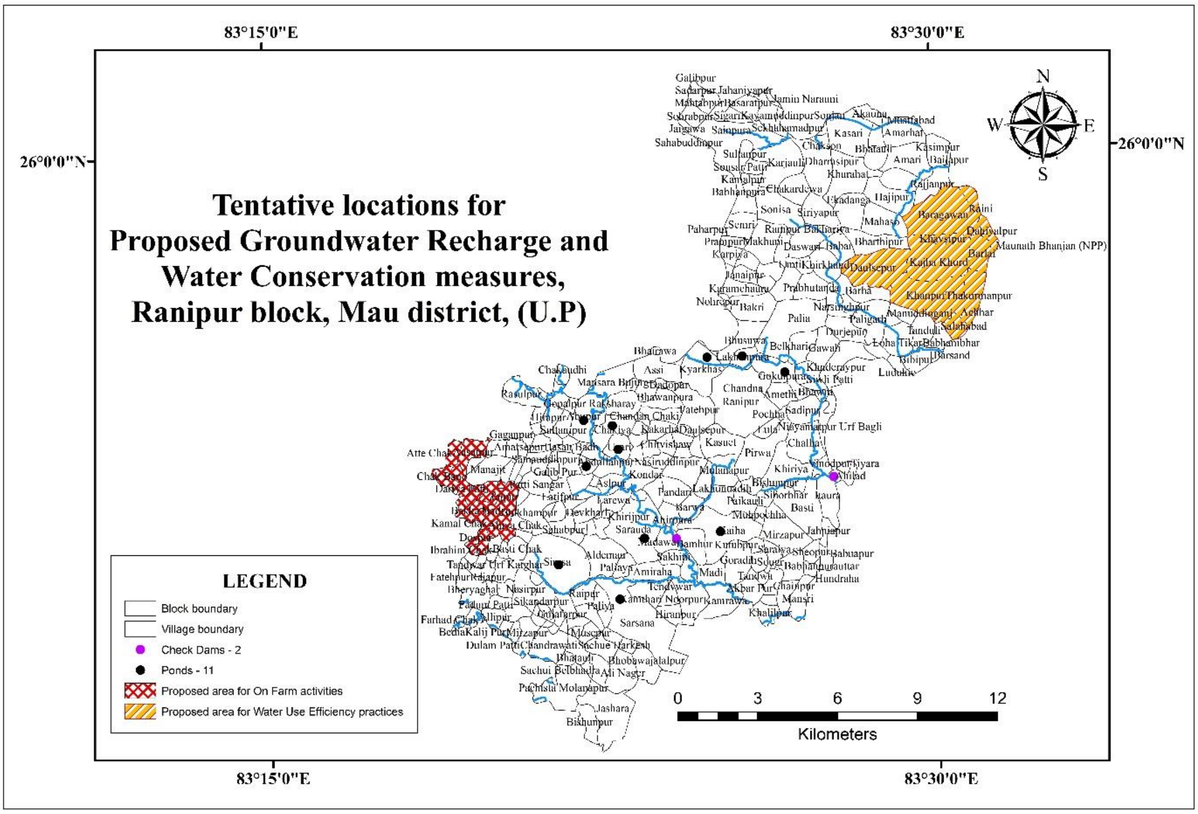


Figure 33: Proposed demand and supply side interventions in Ranipur block

5.5 Groundwater Management Plan of Pardaha block

(i) Salient Information

Table 17: Summarized demographic details of Pardaha block

Area (km^2)	228.01
Male population	282230
Female population	264447
Population Density (People/km^2)	2397
Normal Annual Rainfall (mm)	1050.46
Kharif crop area (Ha)	10088
Rabi crop area (Ha)	9746
Summer crop area (Ha)	45
Canal Command Area (Ha)	0
Non-Canal Command Area (Ha)	11391
Gross irrigated area (Ha)	19437
Net irrigated area (Ha)	11413

(ii) Water Level behaviour

Pre-monsoon water level ranges from 7.3 mbgl to 15.1 mbgl and post-monsoon water level ranges from 5.2 mbgl to 10.7 mbgl. Rising trend of 2.1 mbgl to 4.4 mbgl is observed.

(iii) Issues

- Contribution of Groundwater to irrigation is 100%.

(iv) Groundwater Management Plan: The proposed groundwater management plan for the block has been tabulated below. Upon implementation, 3.21 MCM of groundwater is expected to be available for additional utilization and Stage of Groundwater Development is expected to decrease by 8.25%. The tentative locations for interventions has been attached as Figure 34 below.

Table 18(a): Summarized details of interventions proposed

Block	Check Dams (Nos.)	Stream Development (kms)	Nala Bunds (kms)	Ponds (Nos.)	On-farm area (Ha)	WUE area (Ha)
Pardaha	3	0	0	5	631	1451

Table 18(b): Projected GW Recharge & savings by supply and demand side management

Net Annual GW Availability (MCM)	Existing GW Draft for all uses (MCM)	Stage of GW Development (%)	Total recharge through interventions (MCM)	Total GW savings through interventions (MCM)	Projected Net GW Availability (MCM)	Projected Stage of GW Development after interventions (%)
35.17	23.58	67.05	0.75	2.46	38.38	58.80

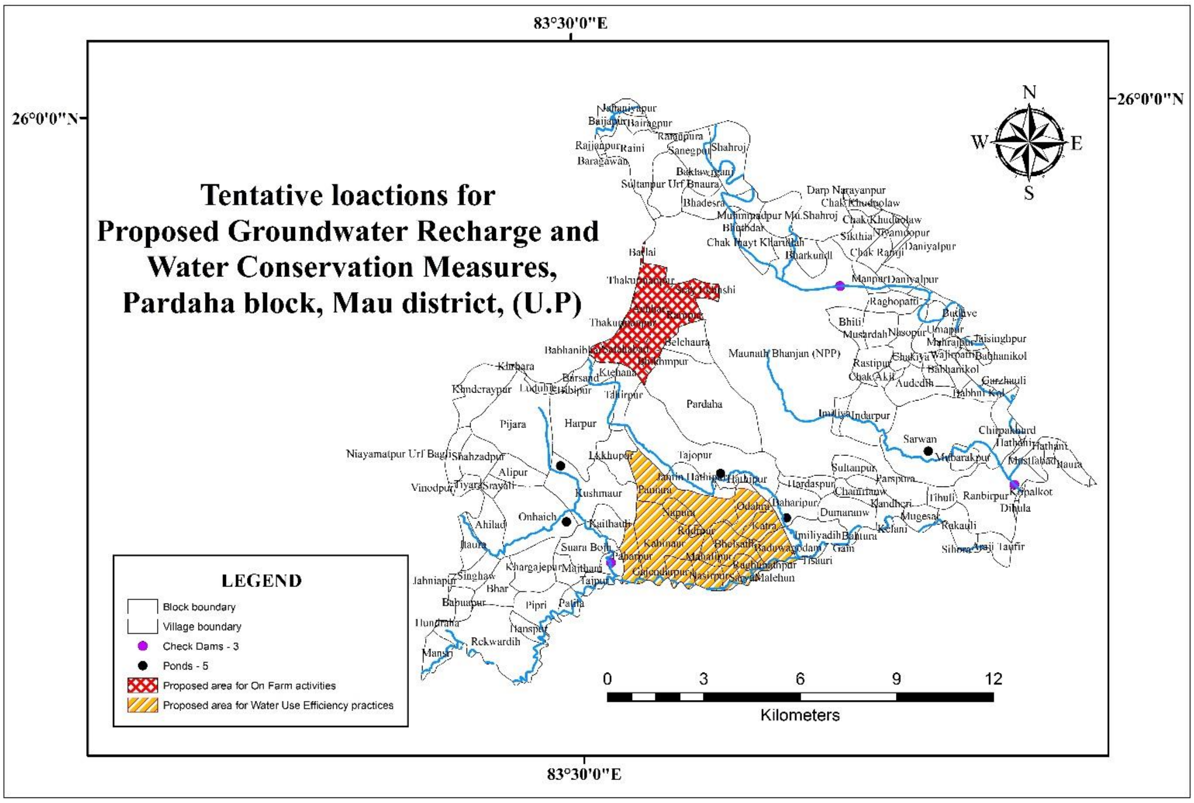


Figure 34: Proposed demand and supply side interventions in Pardaha block

5.6 Groundwater Management Plan of Ratanpura block

(i) Salient Information

Table 19: Summarized demographic details of Ratanpura block

Area (km^2)	248.03
Male population	118632
Female population	113984
Population Density (People/km^2)	937
Normal Annual Rainfall (mm)	1050.46
Kharif crop area (Ha)	13037
Rabi crop area (Ha)	12774
Summer crop area (Ha)	35
Canal Command Area (Ha)	0
Non-Canal Command Area (Ha)	14445
Gross irrigated area (Ha)	25535
Net irrigated area (Ha)	14402

(ii) Water Level behaviour

Pre-monsoon water level ranges from 1.95 mbgl to 7.25 mbgl and post-monsoon water level ranges from 0.8 mbgl to 4.85 mbgl. Rising trend of 0.65 mbgl to 5.6 mbgl is observed.

(iii) Issues

- Contribution of Groundwater to irrigation is 100%.
- 3rd Aquifer group has Fluoride and Iron content exceeding Maximum permissible limit.

(iv) Groundwater Management Plan: The proposed groundwater management plan for the block has been tabulated below. Upon implementation, 4.89 MCM of groundwater is expected to be available for additional utilization and Stage of Groundwater Development is expected to decrease by 8.21%. The tentative locations for interventions has been attached as Figure 35 below.

Table 20(a): Summarized details of interventions proposed

Block	Check Dams (Nos.)	Stream Development (kms)	Nala Bunds (kms)	Ponds (Nos.)	On-farm area (Ha)	WUE area (Ha)
Ratanpura	1	0	0	10	1481	3554

Table 20(b): Projected GW Recharge & savings by supply and demand side management

Net Annual GW Availability (MCM)	Existing GW Draft for all uses (MCM)	Stage of GW Development (%)	Total recharge through interventions (MCM)	Total GW savings through interventions (MCM)	Projected Net GW Availability (MCM)	Projected Stage of GW Development after interventions (%)
50.06	30.67	61.26	1.67	3.22	54.95	53.05

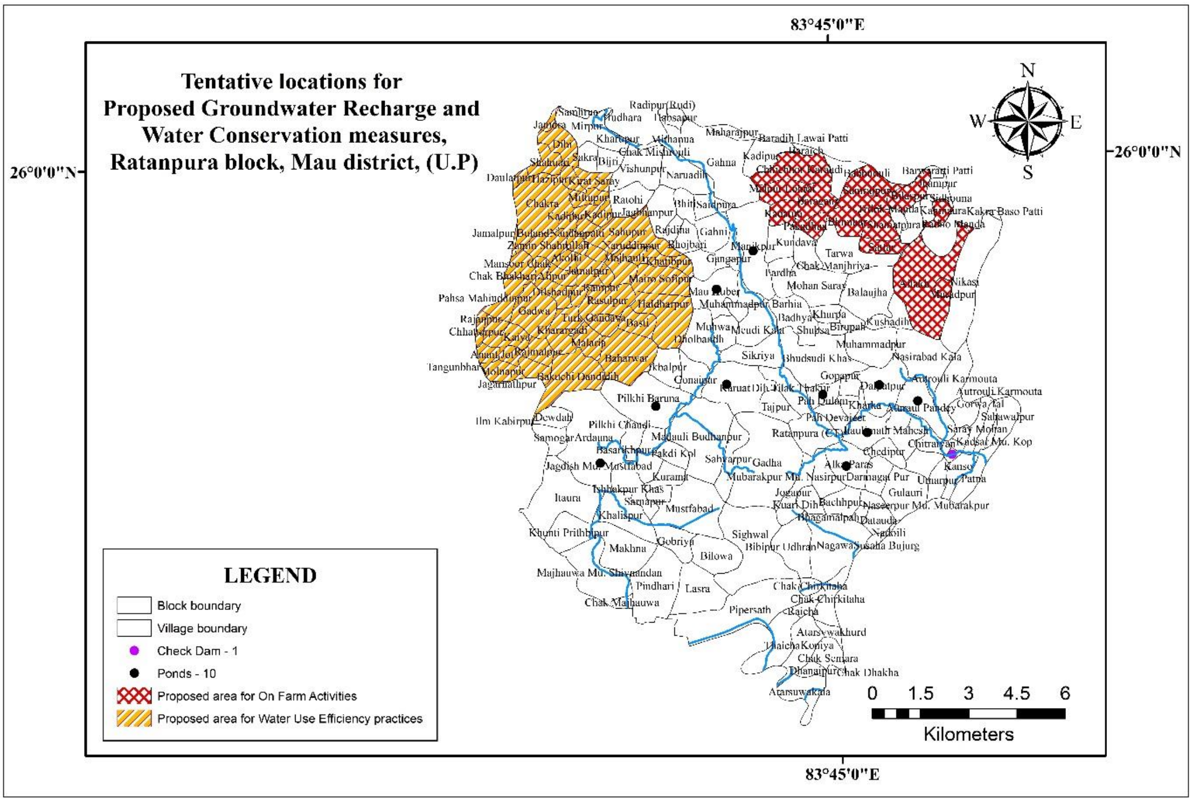


Figure 35: Proposed demand and supply side interventions in Ratanpura block

5.7 Groundwater Management Plan of Mohammadabad Gohna block

(i) Salient Information

Table 21: Summarized demographic details of Mohammadabad Gohna block

Area (km^2)	204.93
Male population	142962
Female population	141319
Population Density (People/km^2)	1387
Normal Annual Rainfall (mm)	1050.46
Kharif crop area (Ha)	10905
Rabi crop area (Ha)	10573
Summer crop area (Ha)	65
Canal Command Area (Ha)	0
Non-Canal Command Area (Ha)	12057
Gross irrigated area (Ha)	20978
Net irrigated area (Ha)	11913

(ii) Water Level behaviour

Pre-monsoon water level ranges from 6.03 mbgl to 9.85 mbgl and post-monsoon water level ranges from 1.5 mbgl to 6.0 mbgl. Rising trend of 3.5 mbgl to 7.75 mbgl is observed.

(iii) Issues

- Contribution of Groundwater to irrigation is 100%.

(iv) Groundwater Management Plan: The proposed groundwater management plan for the block has been tabulated below. Upon implementation, 6.36 MCM of groundwater is expected to be available for additional utilization and Stage of Groundwater Development is expected to decrease by 11.92%. The tentative locations for interventions has been attached as Figure 36 below.

Table 22(a): Summarized details of interventions proposed

Block	Check Dams (Nos.)	Stream Development (kms)	Nala Bunds (kms)	Ponds (Nos.)	On-farm area (Ha)	WUE area (Ha)
Mohammadabad Gohna	0	0	0	17	3290	1533

Table 22(b): Projected GW Recharge & savings by supply and demand side management

Net Annual GW Availability (MCM)	Existing GW Draft for all uses (MCM)	Stage of GW Development (%)	Total recharge through interventions (MCM)	Total GW savings through interventions (MCM)	Projected Net GW Availability (MCM)	Projected Stage of GW Development after interventions (%)
40.72	28.32	69.56	3.55	2.81	47.08	57.64

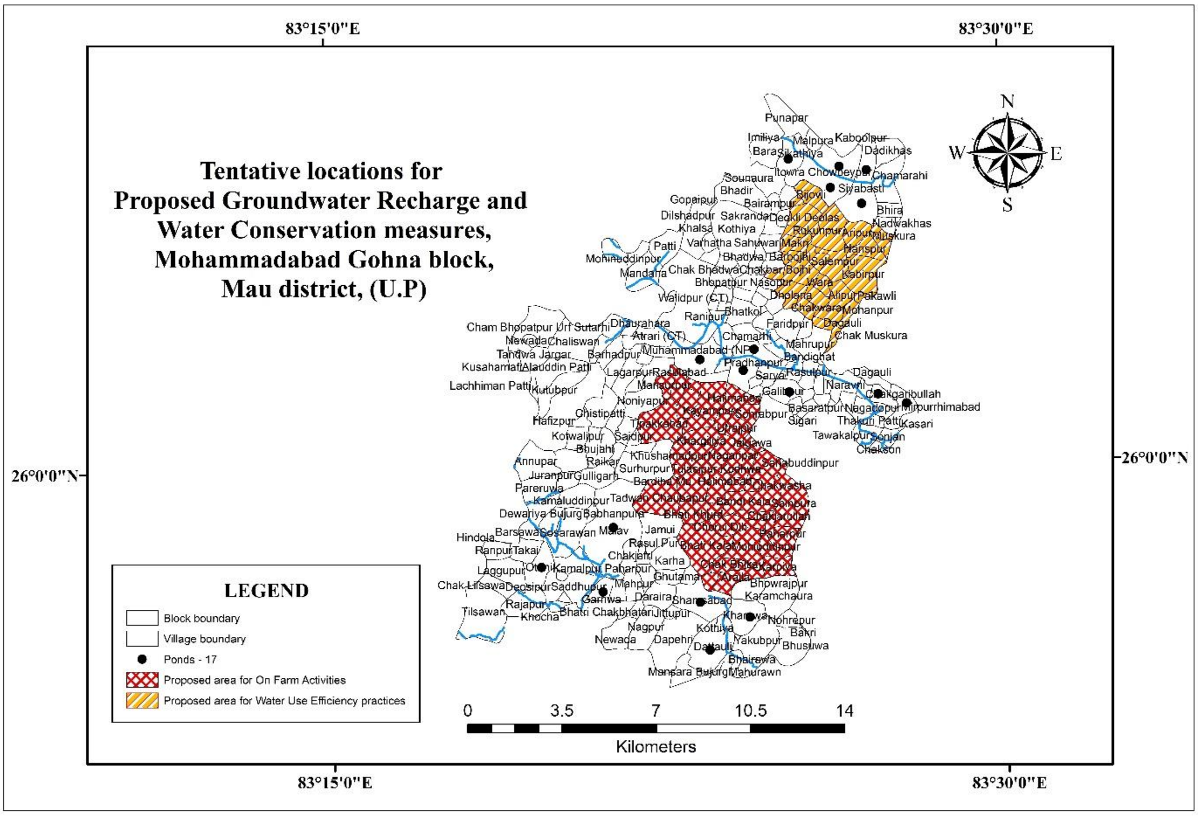


Figure 36: Proposed demand and supply side interventions in Mohammadabad Gohna block

5.8 Groundwater Management Plan of Kopaganj block

(i) Salient Information

Table 23: Summarized demographic details of Kopaganj block

Area (km^2)	231.10
Male population	158843
Female population	151272
Population Density (People/km^2)	1341
Normal Annual Rainfall (mm)	1050.46
Kharif crop area (Ha)	10597
Rabi crop area (Ha)	11792
Summer crop area (Ha)	69
Canal Command Area (Ha)	1452
Non-Canal Command Area (Ha)	11832
Contribution of Groundwater to irrigation	91%
Gross irrigated area (Ha)	22044
Net irrigated area (Ha)	12633

(ii) Water Level behaviour

Pre-monsoon water level ranges from 4.25 mbgl to 9.9 mbgl and post-monsoon water level ranges from 0.8 mbgl to 6.0 mbgl. Rising trend of 1.15 mbgl to 4.3 mbgl is observed.

(iii) Issues

- Iron and Manganese present in unconfined aquifer.
- Iron content in 2nd Aquifer group exceeds Maximum permissible limit.

(iv) Groundwater Management Plan: The proposed groundwater management plan for the block has been tabulated below. Upon implementation, 4.38 MCM of groundwater is expected to be available for additional utilization and Stage of Groundwater Development is expected to decrease by 6.86%. The tentative locations for interventions has been attached as Figure 37 below.

Table 24(a): Summarized details of interventions proposed

Block	Check Dams (Nos.)	Stream Development (kms)	Nala Bunds (kms)	Ponds (Nos.)	On-farm area (Ha)	WUE area (Ha)
Kopaganj	0	0	0	18	1395	2851

Table 24(b): Projected GW Recharge & savings by supply and demand side management

Net Annual GW Availability (MCM)	Existing GW Draft for all uses (MCM)	Stage of GW Development (%)	Total recharge through interventions (MCM)	Total GW savings through interventions (MCM)	Projected Net GW Availability (MCM)	Projected Stage of GW Development after interventions (%)
53.96	35.94	66.60	1.67	2.71	58.34	59.74

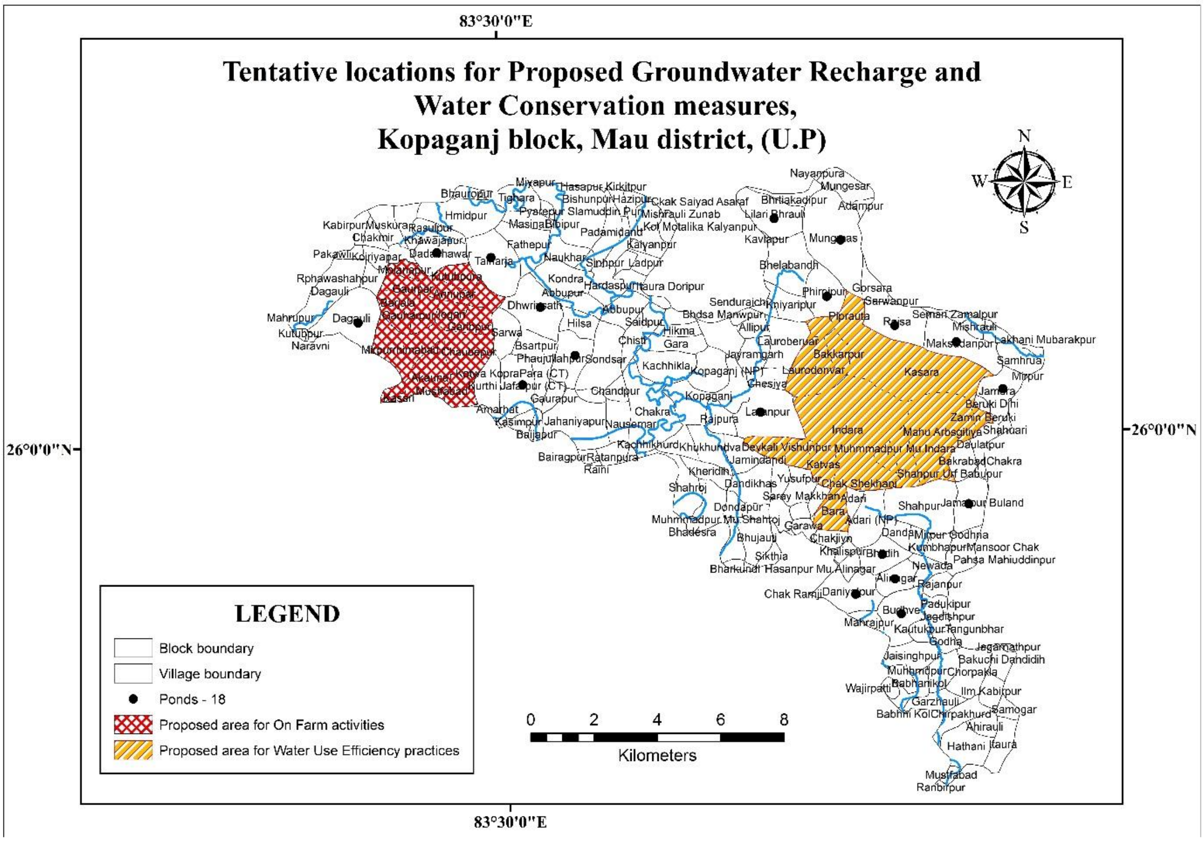


Figure 37: Proposed demand and supply side interventions in Kopaganj block

5.9 Groundwater Management Plan of Ghosi block

(i) Salient Information

Table 25: Summarized demographic details of Ghosi block

Area (km^2)	191.99
Male population	109592
Female population	111429
Population Density (People/km^2)	1151
Normal Annual Rainfall (mm)	1050.46
Kharif crop area (Ha)	9963
Rabi crop area (Ha)	10279
Summer crop area (Ha)	33
Canal Command Area (Ha)	3874
Non-Canal Command Area (Ha)	6797
Gross irrigated area (Ha)	20116
Net irrigated area (Ha)	10694

(ii) Water Level behaviour

Pre-monsoon water level ranges from 1.89 mbgl to 4.7 mbgl and post-monsoon water level ranges from 0.9 mbgl to 5.9 mbgl. Rising trend of 0.25 mbgl to 3.66 mbgl and declining trend of 0.85 mbgl to 4.2 mbgl is observed.

(iii) Issues

- Manganese present in unconfined aquifer.

(iv) Groundwater Management Plan: The proposed groundwater management plan for the block has been tabulated below. Upon implementation, 6.06 MCM of groundwater is expected to be available for additional utilization and Stage of Groundwater Development is expected to decrease by 8.49%. The tentative locations for interventions has been attached as Figure 38 below.

Table 26(a): Summarized details of interventions proposed

Block	Check Dams (Nos.)	Stream Development (kms)	Nala Bunds (kms)	Ponds (Nos.)	On-farm area (Ha)	WUE area (Ha)
Ghosi	0	0	0	14	1009	1125

Table 26(b): Projected GW Recharge & savings by supply and demand side management

Net Annual GW Availability (MCM)	Existing GW Draft for all uses (MCM)	Stage of GW Development (%)	Total recharge through interventions (MCM)	Total GW savings through interventions (MCM)	Projected Net GW Availability (MCM)	Projected Stage of GW Development after interventions (%)
65.39	43.99	67.27	1.22	4.84	71.45	58.78

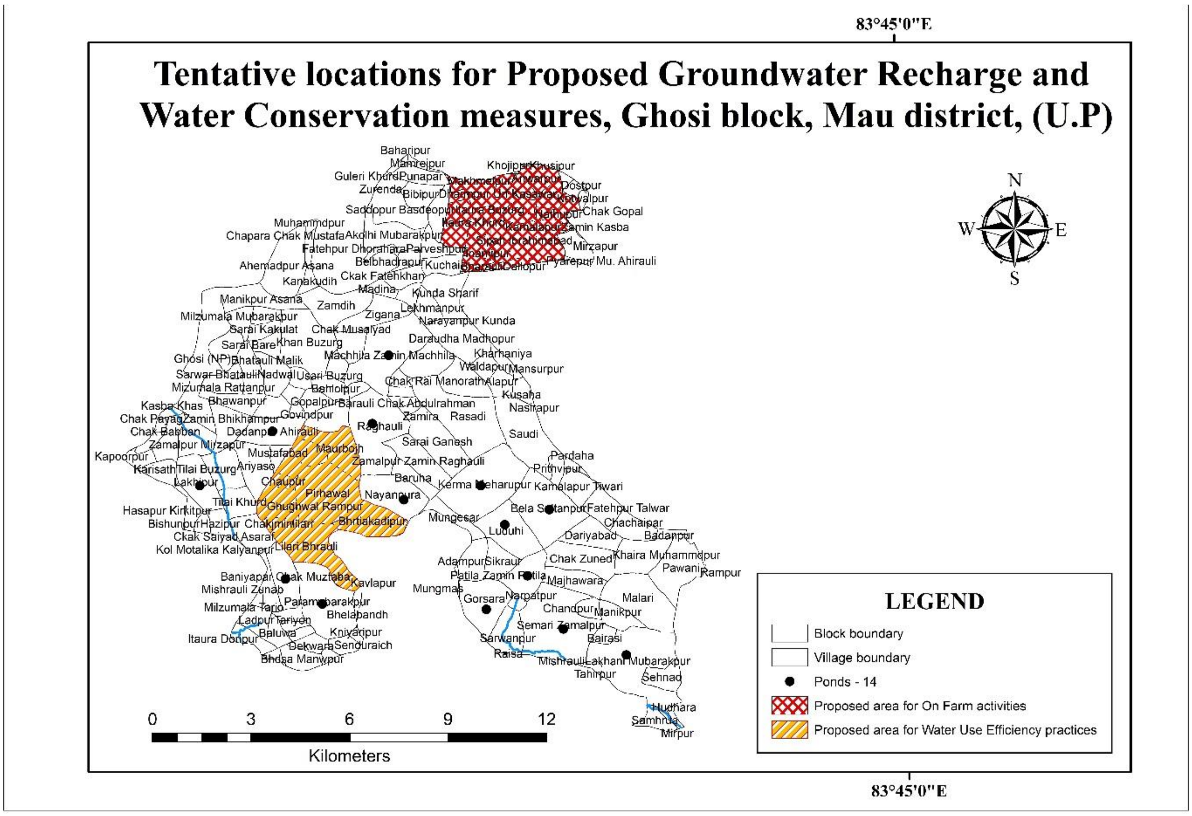


Figure 38: Proposed demand and supply side interventions in Ghosi block

5.10 Groundwater Management Plan of Badraon block

(i) Salient Information

Table 27: Summarized demographic details of Badraon block

Area (km^2)	229.64
Male population	121090
Female population	123331
Population Density (People/km^2)	1064
Normal Annual Rainfall (mm)	1050.46
Kharif crop area (Ha)	11190
Rabi crop area (Ha)	10141
Summer crop area (Ha)	33
Canal Command Area (Ha)	7859
Non-Canal Command Area (Ha)	11557
Gross irrigated area (Ha)	20876
Net irrigated area (Ha)	12018

(ii) Water Level behaviour

Pre-monsoon water level ranges from 2.95 mbgl to 3.9 mbgl and post-monsoon water level ranges from 3.2 mbgl to 3.75 mbgl. Rising trend of 0.45 mbgl to 0.60 mbgl and declining trend of 0.05 mbgl to 0.25 mbgl is observed.

(iii) Issues

- Contribution of Groundwater to irrigation is 97.20%.
- Iron present in unconfined aquifer.

(iv) Groundwater Management Plan: The proposed groundwater management plan for the block has been tabulated below. Upon implementation, 4.98 MCM of groundwater is expected to be available for additional utilization and Stage of Groundwater Development is expected to decrease by 9.28%. The tentative locations for interventions has been attached as Figure 39 below.

Table 28(a): Summarized details of interventions proposed

Block	Check Dams (Nos.)	Stream Development (kms)	Nala Bunds (kms)	Ponds (Nos.)	On-farm area (Ha)	WUE area (Ha)
Badraon	0	0	0	10	1803	2732

Table 28(b): Projected GW Recharge & savings by supply and demand side management

Net Annual GW Availability (MCM)	Existing GW Draft for all uses (MCM)	Stage of GW Development (%)	Total recharge through interventions (MCM)	Total GW savings through interventions (MCM)	Projected Net GW Availability (MCM)	Projected Stage of GW Development after interventions (%)
44.51	29.16	65.50	1.95	3.03	49.49	56.22

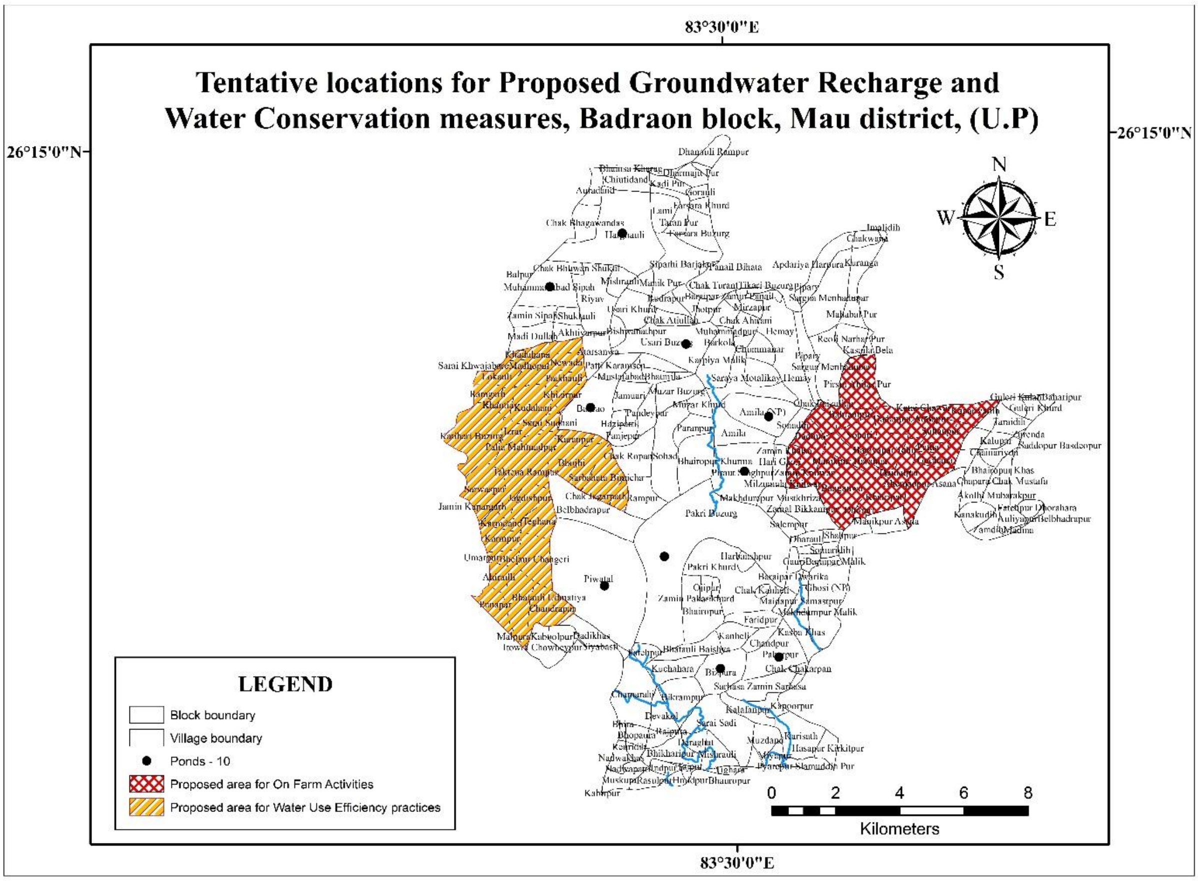


Figure 39: Proposed demand and supply side interventions in Badraon block

5.11 Groundwater Management Plan of Dohari Ghat block

(i) Salient Information

Table 29: Summarized demographic details of Dohari Ghat block

Area (km^2)	205.61
Male population	104208
Female population	107019
Population Density (People/km^2)	1027
Normal Annual Rainfall (mm)	1050.46
Kharif crop area (Ha)	10244
Rabi crop area (Ha)	9949
Summer crop area (Ha)	82
Canal Command Area (Ha)	2425
Non-Canal Command Area (Ha)	9102
Gross irrigated area (Ha)	19696
Net irrigated area (Ha)	11641

(ii) Water Level behaviour

Pre-monsoon water level ranges from 3.75 mbgl to 7.53 mbgl and post-monsoon water level ranges from 1.1 mbgl to 3.87 mbgl. Rising trend of 1.7 mbgl to 4.88 mbgl is observed.

(iii) Issues

- Iron present in unconfined aquifer.
- Contribution of Groundwater to irrigation is 85.20%.

(iv) Groundwater Management Plan: The proposed groundwater management plan for the block has been tabulated below. Upon implementation, 4.82 MCM of groundwater is expected to be available for additional utilization and Stage of Groundwater Development is expected to decrease by 8.47%. The tentative locations for interventions has been attached as Figure 40 below.

Table 30(a): Summarized details of interventions proposed

Block	Check Dams (Nos.)	Stream Development (kms)	Nala Bunds (kms)	Ponds (Nos.)	On-farm area (Ha)	WUE area (Ha)
Dohari Ghat	0	0	0	7	1224	439

Table 30(b): Projected GW Recharge & savings by supply and demand side management

Net Annual GW Availability (MCM)	Existing GW Draft for all uses (MCM)	Stage of GW Development (%)	Total recharge through interventions (MCM)	Total GW savings through interventions (MCM)	Projected Net GW Availability (MCM)	Projected Stage of GW Development after interventions (%)
50.16	33.15	66.09	1.33	3.49	54.98	57.62

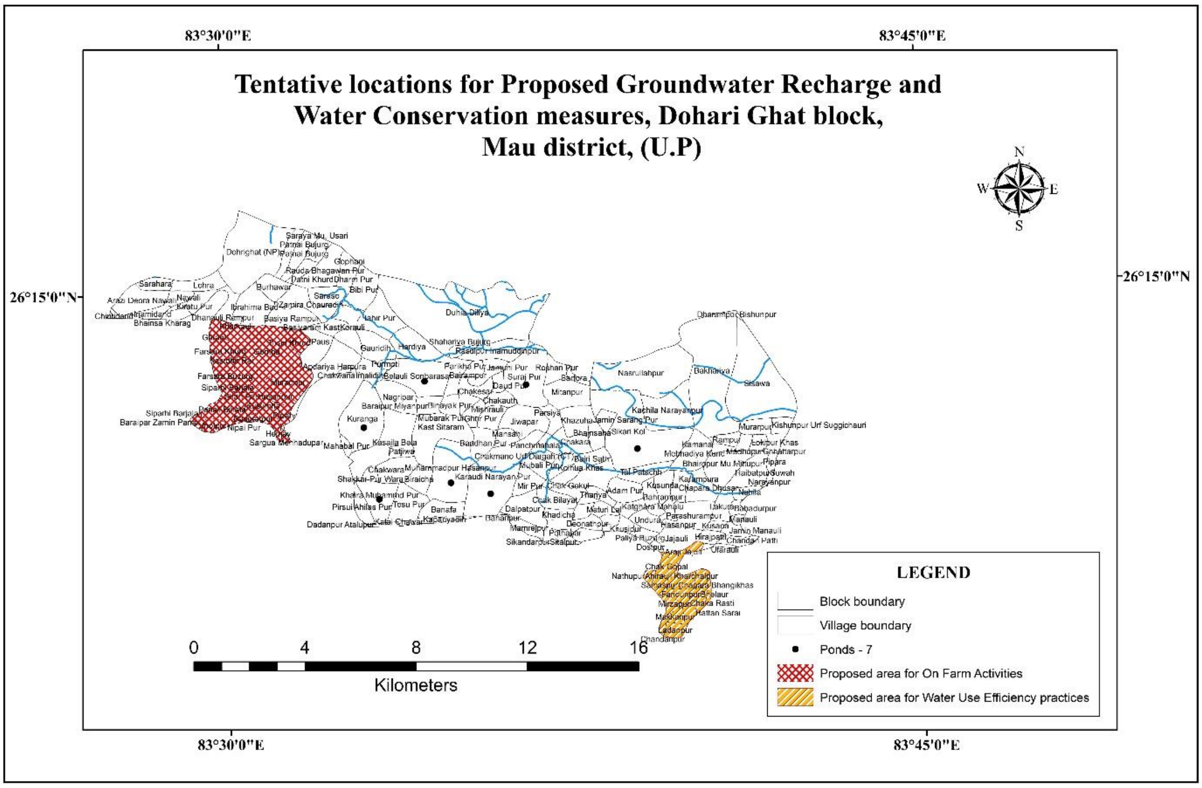


Figure 40: Proposed demand and supply side interventions in Dohari Ghat block

5.12 Groundwater Management Plan of Fatehpur Madaon block

(i) Salient Information

Table 31: Summarized demographic details of Fatehpur Madaon block

Area (km^2)	330.81
Male population	137845
Female population	138501
Population Density (People/km^2)	835
Normal Annual Rainfall (mm)	1050.46
Kharif crop area (Ha)	9087
Rabi crop area (Ha)	11071
Summer crop area (Ha)	162
Canal Command Area (Ha)	1593
Non-Canal Command Area (Ha)	12153
Contribution of Groundwater to irrigation	91.80%
Gross irrigated area (Ha)	19825
Net irrigated area (Ha)	13883

(ii) Water Level behaviour

Pre-monsoon water level ranges from 3.0 mbgl to 7.2 mbgl and post-monsoon water level ranges from 3.1 mbgl to 4.85 mbgl. Rising trend of 0.05 mbgl to 2.35 mbgl and declining trend of 0.10 mbgl is observed.

(iii) Issues

- Contribution of Groundwater to irrigation is 91.80%.
- 3rd Aquifer group has Fluoride exceeding Maximum Permissible limit.

(iv) Groundwater Management Plan: The proposed groundwater management plan for the block has been tabulated below. Upon implementation, 5.80 MCM of groundwater is expected to be available for additional utilization and Stage of Groundwater Development is expected to decrease by 8.11%. The tentative locations for interventions has been attached as Figure 41 below.

Table 32(a): Summarized details of interventions proposed

Block	Check Dams (Nos.)	Stream Development (kms)	Nala Bunds (kms)	Ponds (Nos.)	On-farm area (Ha)	WUE area (Ha)
Fatehpur Madaon	0	0	0	11	1553	1139

Table 32(b): Projected GW Recharge & savings by supply and demand side management

Net Annual GW Availability (MCM)	Existing GW Draft for all uses (MCM)	Stage of GW Development (%)	Total recharge through interventions (MCM)	Total GW savings through interventions (MCM)	Projected Net GW Availability (MCM)	Projected Stage of GW Development after interventions (%)
61.78	38.50	62.32	1.72	4.08	67.58	54.21

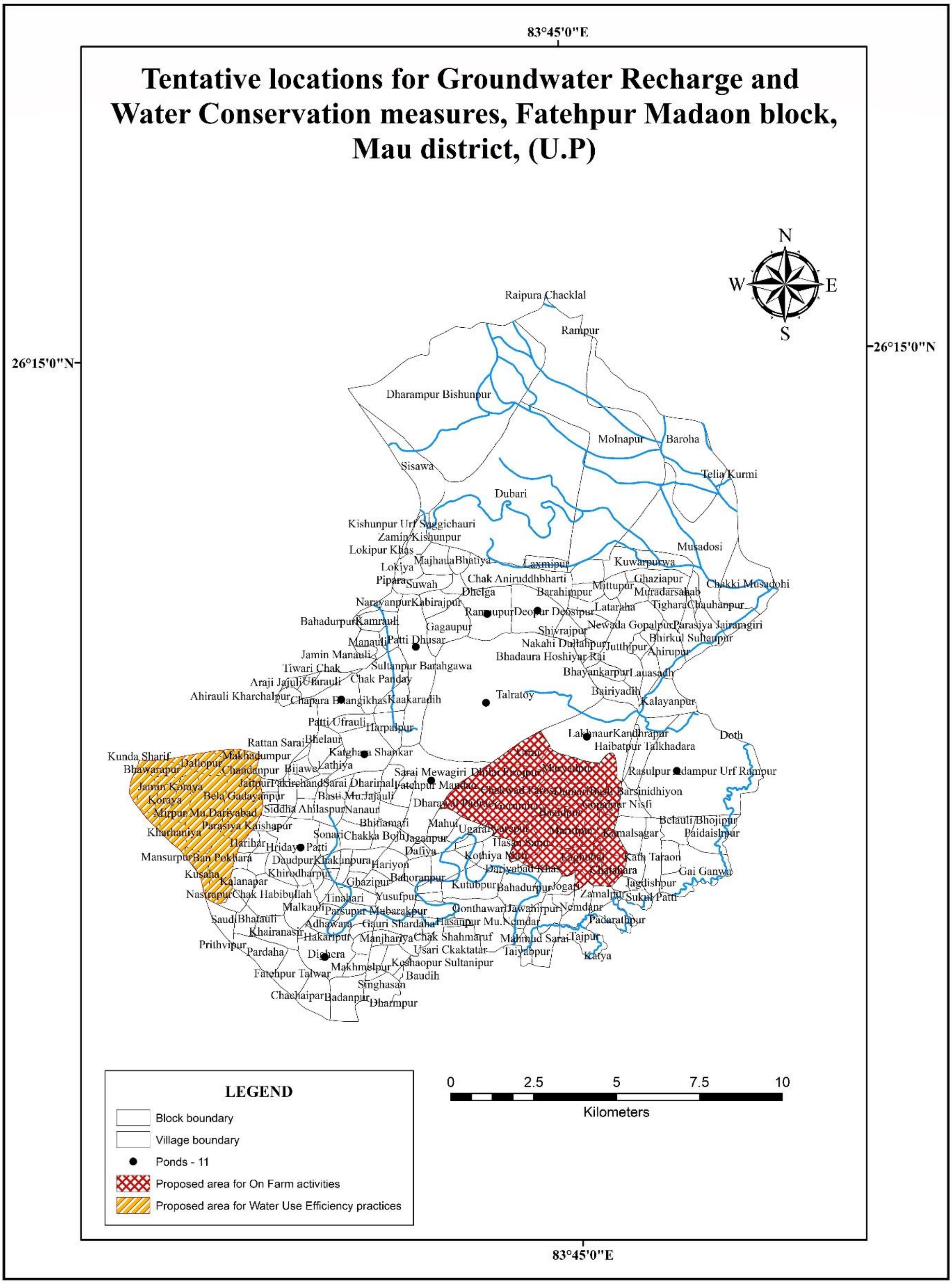


Figure 41: Proposed demand and supply side interventions in Fatehpur Madaon block

6. CONCLUSION

The district occupies a geographic area of 1,713 km^2 and is divided into 9 administrative blocks. The population of the district is 22,05,968 and population density is 1,288 people per square kilometres. The district mainly comprises Quaternary alluvium overlying the Vindhyan Plateau.

Due to the geological and geomorphological setup of the district, the groundwater resources are plentiful in quantity but there are issues of water quality at places. There are reports of sporadic occurrence of Iron, Manganese, Arsenic in the shallow, unconfined aquifer. Other problems include over-use of groundwater for irrigation, declining rainfall coupled with ever-increasing population and presence of high Fluoride in 3rd Aquifer.

Surface water utilization has decreased over the years due to ease in availability of groundwater for domestic, irrigation and miscellaneous purposes.

To augment stressed groundwater resources, address declining groundwater availability and water quality problems, the following interventions have been proposed.

Supply side interventions proposed include:

1. Carrying out de-siltation of streams, ponds, tanks and surface water catchments to increase storage.
2. Construction of Rainwater harvesting structures at suitable locations.
3. Construction and maintenance of Fluoride removal units at places where deeper aquifer is Fluoride affected.
4. Construction of deeper tubewells tapping 2nd Aquifer group at locations where quality issues plague the unconfined aquifer.
5. Construction of check dams at suitable locations to increase the quantum of groundwater recharge.

Demand side interventions proposed include:

1. Promotion of drip and sprinkler/pressurized irrigation to enhance irrigation efficiency as opposed to traditional flood irrigation method.
2. Introduction of rice varieties that can withstand water logging, flooded areas and intense rainfall.
3. Development of new variety of pulses with high per hectare yield and promoting cultivation of pulses with incentives.
4. Diversification of cropping pattern to promote cultivation of oil seeds.
5. Providing impetus to horticulture under Rashtriya Krishi Vikas Yojana.

Apart from Demand side and Supply side interventions, IEC activities must be stepped up that promote emerging farming techniques, water use efficiency techniques, crop rotation etc.

It is envisaged that 102 nos. of ponds, 6 nos. of check dams, 14,161 Ha of area under On-Farm activities and 15,506 Ha of area under Water Use Efficiency practices will result in Groundwater recharge of 15.82 MCM and 30.81 MCM of Groundwater savings through the proposed interventions. The projected net Groundwater availability is expected to rise by 40.56 MCM by successful adoption of the interventions in the study resulting in overall reduction of Stage of Groundwater Development (Projected) in the study area. The details have been summarized and tabulated below.

Table 33: Summary of demand and supply side interventions in Mau district

Block	Check Dams (Nos.)	Stream Development (kms)	Nala Bunds (kms)	Ponds (Nos.)	On-farm area (Ha)	WUE area (Ha)
Ranipur	2	0	0	10	1775	682
Pardaha	3	0	0	5	631	1451
Ratanpura	1	0	0	10	1481	3554
Mohammadabad Gohna	0	0	0	17	3290	1533
Kopaganj	0	0	0	18	1395	2851
Ghosi	0	0	0	14	1009	1125
Badraon	0	0	0	10	1803	2732
Dohari Ghat	0	0	0	7	1224	439
Fatehpur Madaon	0	0	0	11	1553	1139
TOTAL	**6**	**0**	**0**	**102**	**14161**	**15506**

Table 34: Summary of Projected GW Recharge & savings by supply and demand side management in Mau district

Block	Net Annual GW Availability (MCM)	Existing GW Draft for all uses (MCM)	Stage of GW Development (%)	Total recharge through interventions (MCM)	Total GW savings through interventions (MCM)	Projected Net GW Availability (MCM)	Projected Stage of GW Development after interventions (%)
Ranipur	59.40	39.58	66.64	1.96	4.17	59.46	57.73
Pardaha	35.17	23.58	67.05	0.75	2.46	38.38	58.80
Ratanpura	50.06	30.67	61.26	1.67	3.22	54.95	53.05
Mohammadabad Gohna	40.72	28.32	69.56	3.55	2.81	47.08	57.64
Kopaganj	53.96	35.94	66.60	1.67	2.71	58.34	59.74
Ghosi	65.39	43.99	67.27	1.22	4.84	71.45	58.78
Badraon	44.51	29.16	65.50	1.95	3.03	49.49	56.22
Dohari Ghat	50.16	33.15	66.09	1.33	3.49	54.98	57.62
Fatehpur Madaon	61.78	38.5	62.32	1.72	4.08	67.58	54.21
TOTAL	**461.15**	**302.89**	**-**	**15.82**	**30.81**	**501.71**	**-**

ANNEXURE – 1

(RAINFALL DATA OF MAU DISTRICT)

Year	Total Rainfall (mm)	Year	Total Rainfall (mm)	Year	Total Rainfall (mm)
1971	1347.39	1991	1203.48	2011	1167.01
1972	762.39	1992	1020.57	2012	1127.57
1973	1197.88	1993	1411.5	2013	1265.83
1974	681.7	1994	1010.06	2014	1045.78
1975	973.85	1995	1188.62	2015	956.83
1976	1280.15	1996	1169.93	2016	897.72
1977	1125.29	1997	1352.35	2017	532.93
1978	1241.85	1998	1250.14	2018	637.78
1979	738.22	1999	1320.04	2019	1022.58
1980	1120.18	2000	1137.98	2020	777.66
1981	814.06	2001	1089.3		
1982	847.68	2002	770.24		
1983	981.3	2003	874.39		
1984	1263.65	2004	1000.16		
1985	1101.12	2005	934.63		
1986	1094.73	2006	876.08		
1987	1294.67	2007	1189.11		
1988	1099.31	2008	1464.1		
1989	1135.53	2009	634.87		
1990	1211.39	2010	881.62		

ANNEXURE – 2

(DETAILS OF LAND USE PATTERN OF MAU DISTRICT)

Sl. No.	Category	Geographical Area (km^2)	Percentage of total geographical area
1	Agricultural land	1306.60	76.27%
2	Built-up land (Habitation)	277.84	16.21%
3	Forest	4.49	0.26%
4	Wasteland	31.21	1.82%
5	Water bodies	92.86	5.42%
	TOTAL	**1713.00**	**100%**

ANNEXURE – 3

(DETAILS OF COMMAND AND NON-COMMAND AREA)

Sl. No.	Name of Block	Status of Canal Command Area (Ha)			Status of non-Canal Command Area (Ha)			Total Area (Ha)	
		Developed Area	**Underdeveloped Area**	**Total Area**	**Developed Area**	**Underdeveloped Area**	**Total Area**	**Developed Command**	**Underdeveloped Command**
1	Dohari Ghat	1746	679	2425	6189	2913	9102	7935	3592
2	Fatehpur Madaon	1147	446	1593	8264	3889	12153	9411	4335
3	Ghosi	2789	1085	3874	4622	2175	6797	7411	3260
4	Badraon	349	136	485	7859	3698	11557	8208	3834
5	Kopaganj	1045	407	1452	8046	3786	11832	9091	4193
6	Pardaha	0	0	0	7746	3645	11391	7746	3645
7	Ratanpura	0	0	0	9823	4622	14445	9823	4622
8	Mohammadabad Gohna	0	0	0	8199	3858	12057	8199	12057
9	Ranipur	355	138	493	11130	5237	16367	11485	5375
	TOTAL	**7432**	**2890**	**10322**	**71877**	**33824**	**105701**	**79309**	**36714**

ANNEXURE – 4

(DETAILS OF IRRIGATION AND LIFTING DEVICES)

Sl. No.	Name of Block	Source of Irrigation	Surface water irrigation	Ground water irrigation		Water extraction/lifting devices		
			Govt. canals (kms)	Tubewells		Electric pumps	Diesel pumps	Others
				Govt.	Pvt.			
1	Dohari Ghat	Command Area (Ha)	2425	45	9057	1544	7458	55
		Non-command (Ha)	59	16	3290	561	2709	20
2	Fatehpur Madaon	Command Area (Ha)	1593	0	12153	507	11366	280
		Non-command (Ha)	51	22	5636	235	5271	130
3	Ghosi	Command Area (Ha)	3874	38	6759	1204	5521	35
		Non-command (Ha)	101	16	3701	659	3023	19
4	Badraon	Command Area (Ha)	485	240	11317	2666	8626	25
		Non-command (Ha)	57	56	3196	753	2436	7
5	Kopaganj	Command Area (Ha)	1452	0	11832	4456	7189	187
		Non-command (Ha)	44	45	2849	1073	1731	45
6	Pardaha	Command Area (Ha)	0	0	11391	670	7570	151
		Non-command (Ha)	0	26	4162	1341	2766	55
7	Ratanpura	Command Area (Ha)	0	0	14445	5286	8928	231
		Non-command (Ha)	23	37	3506	1283	2167	56

8	Mohammadabad Gohna	Command Area (Ha)	0	58	11999	3354	8549	96
		Non-command (Ha)	0	53	5113	1429	3643	41
9	Ranipur	Command Area (Ha)	493	116	16251	6607	9488	156
		Non-command (Ha)	62	44	4388	1784	2562	42
	TOTAL	**Command Area (Ha)**	**10322**	**497**	**105204**	**26294**	**74695**	**1216**
		Non-command (Ha)	**397**	**315**	**35841**	**9118**	**26308**	**415**

ANNEXURE – 5

(SUMMARIZED DETAILS OF EXPLORATORY WELLS)

Sl. No.	Location	Co-ordinates	Depth drilled (mbgl)	Aquifer	Granular zones tapped (mbgl)	Static Water Level (mbgl)	Discharge (lpm)	Drawdown(m)	Transmissivity (m^2/day)	Storativity	Remarks
1	Bangli Pinjra	25°54'40"N 83°28'40"E	750.70	AL03	362-374 438-447 453-459	9.26	2330	11.29	1226	$2.25*10^{-4}$	
2	Bhawanipur-1	25°54'48"N 83°23'15"E	304.80	AL03	-	-	-	-	-	-	Abandoned due to lack of granular zones
3	Bhawanipur-2	25°54'48"N 83°23'15"E	558.00	AL03	72-74 124-130 145-158 295-302 318-383 394-455	8.52	1514	5.89	999	-	
4	Dharaura	25°51'18"N 83°21'57"E	761.20	AL03	375-387 393-405 426-432 459-471 477-483 513-525	9.08	2210	4.92	2913	-	
5	Haldharpur	25°56'50"N 83°42'50"E	593.12	AL03	-	-	-	-	-	-	Abandoned due to lack of granular zones

6	Lasra	25°52’30”N 83°37’45”E	750.32	AL03	393-399 403-409 442-448 466-472 475-484 499-505 508-514	5.5	2330	11.96	4104	$2.95*10^{-4}$	
7	Mohammadpur Sipah	26°12’50”N 83°26’50”E	687.95	AL03	48-59 68-74 79-96 249-262 283-291 300-325 348-357 417-423 448-482 498-539 558-565	-	-	-	-	-	-
8	Tigra-1	26°00’00”N 83°30’00”E	352.67	AL03	-	-	-	-	-	-	Abandoned due to Caving
9	Tigra-2	26°00’00”N 83°30’00”E	610.00	AL03	-	-	-	-	-	-	Abandoned due to Caving
10	Paharpura	25°56’18”N 83°33’30”E	357.85	AL03	64-70 86-106	7.53	2650	10.5	-	-	
11	Bhitti	25°56’42”N 83°34’38”E	357.75	AL03	88-100 204-218 235-247 262-268	5.68	2993	8.41	355.89		
12	Barlai		340	AL03	64-70 95-121	4.81	1000	6.89	145.14		

					127-135						
13	Kopaganj		201.17	AL03	41.83- 65.83	2.70	1474	6.00	245.67		
14	Dubari	26°11’33”N 83°43’28”E	303	AL03	213-225 236-245 268-283	3.03	1119	18.22	440.98	$1.29*10^{-3}$	NAQUIM Well
15	Kasara	26°01’17”N 83°37’11”E	204	AL03	53-62 128-137 152-158	6.81	1517	4.67	1112.62	$1.31*10^{-3}$	NAQUIM Well
16	Ratanpura Khas	25°55’00”N 83°44’39”E	309	AL03	238-244 250-262 268-271	7.83	1173	18.43	180.06	$1.54*10^{-3}$	NAQUIM Well

ANNEXURE - 6

(WATER LEVEL AND FLUCTUATION DATA OF WATER LEVEL MONITORING STATIONS)

Sl. No.	Block	Location	GWMS Type	Latitude	Longitude	Pre_19	Post_19	Fluctuation
1	Doharighat	Doharighat	DW	26.25000	83.51000	6.60	3.54	-3.06
2	Doharighat	Jejawali	DW	26.18000	83.66000	7.53	2.65	-4.88
3	Fatehpur	Paharipur I	DW	26.12000	83.75000	7.20	4.85	-2.35
4	Ghosi	Ghosi	DW	26.12000	83.54000	4.70	1.04	-3.66
5	Ratanpura	Kansho	PZ	25.91139	83.79027	7.25	1.75	-5.50
6	Fatehpur Madaon	Laghuvai	DW	26.11112	83.76722	4.80	4.75	-0.05
7	Fatehpur Madaon	Padarth Pur	PZ	26.09805	83.76000	3.80	3.90	0.10
8	Ratanpura	Bhimar	DW	25.96917	83.73445	4.82	0.80	-4.02
9	Doharighat	Jajoli	PZ	26.16889	83.66888	5.10	1.10	-4.00
10	Fatehpur Madaon	Shidha Ahilash Pur	PZ	26.13611	83.67028	3.65	3.30	-0.35
11	Fatehpur Madaon	Parasi Narhar Pur	PZ	26.07473	83.67778	4.25	4.10	-0.15
12	Ratanpura	Chakara	PZ	25.98806	83.66722	7.25	1.65	-5.60
13	Ratanpura	Etaura	PZ	25.90750	83.67500	5.87	4.85	-1.02
14	Ratanpura	Molna Pur	PZ	25.94834	83.65389	1.95	1.30	-0.65
15	Doharighat	Kolua Khash	PZ	26.19417	83.62917	5.25	2.65	-2.60
16	Fatehpur Madaon	Mathia	DW	26.13417	83.62306	3.00	3.10	0.10
17	Ghosi	Mugasher Nakta	DW	26.07500	83.62278	2.10	6.30	4.20
18	Kopaganj	Khalishpur	PZ	25.96861	83.62834	6.86	3.80	-3.06
19	Doharighat	Rasoolpur	PZ	26.23389	83.60306	3.75	2.05	-1.70
20	Ghosi	Patila	PZ	26.07583	83.61611	1.90	5.90	4.00
21	Ghosi	Chack Musaid	PZ	26.12639	83.60083	2.10	2.95	0.85

22	Pardaha	Sarwan	PZ	25.88528	83.60000	9.52	6.90	-2.62
23	Pardaha	Vajirpatti	PZ	25.93500	83.60639	7.30	5.20	-2.10
24	Ghosi	Jamdeeh	DW	26.13334	83.58333	1.35	0.90	-0.45
25	Ghosi	Maurboj	PZ	26.09500	83.58445	4.85	5.90	1.05
26	Kopaganj	Dhekwara	PZ	26.03972	83.58945	5.75	1.45	-4.30
27	Kopaganj	Lairo Dounwar	PZ	26.02528	83.59889	5.10	0.80	-4.30
28	Pardaha	Raini	PZ	25.95223	83.55000	10.47	5.70	-4.77
29	Ghosi	Ghosi	DW	26.10167	83.54639	1.89	1.64	-0.25
30	Kopaganj	Bhanwarkol	PZ	26.02750	83.53528	4.25	1.15	-3.10
31	Ghosi	Sarhara Jameen Sa	PZ	26.09222	83.52583	2.00	2.95	0.95
32	Pardaha	Kahinaur	PZ	25.87695	83.52139	15.10	10.70	-4.40
33	Doharighat	Doharighat	DW	26.27222	83.51250	6.92	3.87	-3.05
34	Kopaganj	Basaratpur	PZ	26.02334	83.51139	7.15	6.00	-1.15
35	Badraon	Hadahua	PZ	26.16555	83.48278	2.95	3.20	0.25
36	Badraon	Sarashadi	PZ	26.08667	83.46889	3.70	3.75	0.05
37	Badraon	Dandee	PZ	26.11111	83.46972	3.90	3.30	-0.60
38	Kopaganj	Ekuna	PZ	26.01611	83.47306	8.35	5.05	-3.30
39	Kopaganj	Muskura	PZ	26.06278	83.46972	9.90	4.90	-5.00
40	Badraon	Baniyapar	PZ	26.21333	83.46056	3.85	3.40	-0.45
41	Ranipur	Paliya	PZ	25.93222	83.45056	9.85	5.85	-4.00
42	Ranipur	Siriyapur Sonisa	PZ	25.97500	83.44111	9.65	3.15	-6.50
43	Ranipur	Ranipur Block Campus	PZ	25.90778	83.43028	9.20	4.65	-4.55
44	Mohammadabad	Bara	PZ	26.05861	83.40001	6.03	1.50	-4.53
45	Mohammadabad	Chakbhadwa	PZ	26.06528	83.40861	9.50	6.00	-3.50
46	Mohammadabad	Yakub Pur	PZ	25.93750	83.41639	9.85	2.75	-7.10
47	Ranipur	Padri	PZ	25.87611	83.40167	8.70	4.30	-4.40
48	Ranipur	Kamrvan	PZ	25.84361	83.40194	11.80	4.50	-7.30

49	Ranipur	Larewan	PZ	25.86334	83.37445	8.30	2.70	-5.60
50	Mohammadabad	Chaliswa	PZ	26.03611	83.34417	9.50	1.75	-7.75
51	Ranipur	Chiraiyakot	PZ	25.86166	83.34084	5.35	0.60	-4.75
52	Ranipur	Abboo Pur	PZ	25.86917	83.33723	2.20	0.40	-1.80

ANNEXURE - 7

(BASIC GW QUALITY DATA OF UNCONFINED AQUIFER)

Sl. No.	Location	Block	pH	EC	CO3	HCO3	Cl	F	NO3	SO4	Ca	Mg	Na	K	SiO2	PO4	HCF*
1	Ranipur	Ranipur	7.95	780	0	370	43	0.75	2	22	38	7	120	2	11	0	Ca-Mg-Cl mixed
2	Mau	Mau	8.15	686	0	388	7	0.69	0	13	43	23	64	2	11	0	Mg-HCO3
3	Khalishpur	Kopaganj	8.02	556	0	307	14	0.14	0	6	38	2	77	3	9	0	Na-HCO3
4	Kopaganj	Kopaganj	7.91	482	0	233	21	0.24	10	11	58	4	35	3	13	0	Mg-HCO3
5	Faizullahpur	Kopaganj	8.01	460	0	221	21	0.36	15	6	38	19	24	2	11	0	Mg-HCO3
6	Chaliswan	Mohammadabad	7.97	427	0	228	14	0.47	3	3	28	18	31	2	11	0	Mg-HCO3
7	Muhammadabad Gohna	Mohammadabad	8.01	570	0	320	14	0.77	0	1	48	25	28	1	10	0	Mg-HCO3
8	Palliya-Raipur	Ranipur	7.07	544	0	280	21	0.47	4	8	58	8	41	3	12	0	Mg-HCO3
9	Sarsena	Ranipur	7.86	532	0	254	21	0.19	4	23	56	7	43	3	13	0	Mg-HCO3
10	Badraon	Badraon	8.46	500	36	244	21	0.32	0	0	24	34	37	2.6	28	0	Mg-HCO3
11	Dohari Ghat	Dohari Ghat	8.02	450	0	281	14	0.34	0	7	36	27	25	4.4	32	0	Mg-HCO3
12	Fatehpur Madaon	Fatehpur Madaon	7.96	445	0	244	28	0.23	0	17	40	22	25	5.4	30	0	Mg-HCO3
13	Ghosi	Ghosi	8.14	630	0	329	43	0.69	0	27	28	39	60	3.6	25	0	Mg-HCO3
14	Pardaha	Pardaha	8.24	880	0	549	21	0.67	6.5	27	24	46	113	2	23	0	Mg-HCO3
15	Ratanpura	Ratanpura	8.17	520	0	317	21	0.53	0	0	24	41	33	3.1	28	0	Mg-HCO3

HCF* = Hydrochemical facies

All values in mg/l except for pH and EC at 25°C in µS/cm

ANNEXURE – 8

(TRACE METAL DATA OF UNCONFINED AQUIFER)

Sl. No.	Location	Block	Fe	Mn	Cu	Zn	Cr	As	Pb	U
			(mg/l)				(µg/l)			
1	Ranipur	Ranipur	0.29	0.00	0.00	0.00	0.00	0.25	1.07	14.47
2	Mau	Mau	0.00	0.00	0.00	0.29	0.00	0.33	1.66	11.31
3	Khalishpur	Kopaganj	2.75	0.11	0.00	0.16	0.00	9.24	1.59	0.00
4	Kopaganj	Kopaganj	0.19	0.00	0.00	0.46	0.00	0.20	1.52	4.68
5	Faizullahpur	Kopaganj	0.18	0.00	0.00	0.09	0.00	0.16	1.30	2.35
6	Chaliswan	Mohammadabad	0.07	0.00	0.00	0.00	0.00	0.17	0.00	7.31
7	Muhammadabad Gohna	Mohammadabad	0.29	0.00	0.00	0.55	0.00	0.17	1.01	5.86
8	Palliya-Raipur	Ranipur	0.00	0.00	0.00	0.11	0.00	0.37	0.00	5.41
9	Sarsena	Ranipur	0.00	0.13	0.00	0.00	0.00	36.32	0.00	4.03
10	Badraon	Badraon	1.95	0.00	0.00	1.46	0.00	0.00	0.00	8.00
11	Dohari Ghat	Dohari Ghat	4.16	0.00	0.00	0.00	0.00	5.00	0.00	1.00
12	Fatehpur Madaon	Fatehpur Madaon	0.00	0.00	0.00	0.00	0.00	5.00	0.00	2.00
13	Ghosi	Ghosi	0.00	0.25	0.00	0.64	0.00	0.00	0.00	3.00
14	Pardaha	Pardaha	0.00	0.00	0.00	0.00	0.00	1.00	0.00	21.00
15	Ratanpura	Ratanpura	0.28	0.00	0.00	0.00	0.00	1.00	0.00	9.00

ANNEXURE – 9

(BASIC GW QUALITY DATA OF DEEPER AQUIFERS)

Sl. No.	Location	Block	pH	EC	CO3	HCO3	Cl	F	NO3	SO4	Ca	Mg	Na	K	PO4	HCF*
1	Dubari	Fatehpur Madaon	8.44	900	48	463.6	21.3	1.46	0	6.6	16	2.43	202	1.6	0	Na-HCO3
2	Kasara	Kopaganj	8.18	780	0	475.8	14.2	0.51	0	34	56	34.04	78	2.9	0	Mg-HCO3
3	Ratanpura Khas	Ratanpura	8.44	880	60	506.3	21.3	1.74	0	7.2	16	9.72	200	1.8	0	Na-HCO3

HCF* = Hydrochemical facies

All values in mg/l except for pH and EC at 25°C in µS/cm

ANNEXURE – 10

(TRACE METAL DATA OF DEEPER AQUIFER)

Sl. No.	Location	Block	Fe	Mn	Cu	Zn	Cr	As	Pb	U
			(mg/l)				(µg/l)			
1	Dubari	Fatehpur Madaon	0.17	0.01	0.00	0.00	0.00	3.09	0.51	5.05
2	Kasara	Kopaganj	1.89	0.16	0.00	0.00	2.85	0.00	1.30	8.78
3	Ratanpura Khas	Ratanpura	2.20	0.06	0.00	0.00	2.83	2.70	0.54	3.02

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