केंद्रीय भूमि जल बोर्ड

जल संसाधन, नदी विकास और गंगा संरक्षण विभाग, जल शक्ति मंत्रालय

भारत सरकार

Central Ground Water Board

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

Government of India

AQUIFER MAPPING AND MANAGEMENT OF GROUND WATER RESOURCES

AMROHA DISTRICT, UTTAR PRADESH

उत्तरी क्षेत्र, लखनऊ

Northern Region, Lucknow

REPORT ON

AQUIFER MAPPING AND GROUND WATER MANAGEMENT PLAN IN AMROHA DISTRICT, UTTAR PRADESH (AAP: 2017-18)

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AMROHA DISTRICT AT A GLANCE

1.	**GENERAL INFORMATION**		
i.	Geographical Area (sq km.)	:	2249
ii.	Administrative Divisions	:	
	Number of Block		06
	Number of Panchayat/Villages		601/1133
iii.	Population (2011 census)	:	1840221
iv.	Average Annual Rainfall (mm)	:	758
2.	**GEOMORPHOLOGY**	:	Upper Ganga Plain
	Major Physiographic Units	:	Younger alluvium Older alluvium Flood plain
	Major Drainages	:	Ganga, Ramganga
3.	**LAND USE (Sq. Km.)**		
a)	Forest area	:	210.01
b)	Net area sown	:	1750.63
c)	Cultivable Area	:	2799.20
4.	**MAJOR SOIL TYPES**	:	Sandy loam
5.	**IRRIGATION BY DIFFERENT SOURCES (Numbers of structures)**		
	Tubewells / Borewells	:	72256
	Canals	:	53 km
	Other Sources	:	
	Net Irrigated Area	:	1720.40
	Gross Irrigated Area	:	2443.97
6.	**NUMBER OF GROUND WATER MONITORING WELLS OF CGWB (As on 31-3-2016)**		
	No. of Dugwells	:	8
	No. of Piezometers	:	6
7.	**PREDOMINANT GEOLOGICAL FORMATIONS**	:	Quaternary alluvium
8.	**HYDROGEOLOGY AND AQUIFER GROUP**	:	Quaternary alluvium deposited by Ganga and Yamuna river systems. Ist aquifer down to 134m IInd aquifer depth 145-327 IIIrd aquifer 288-463
	Major water bearing formation	:	Sand, silt and gravel
	Pre-monsoon Depth to water level during May 2018	:	4.16 to 20.30 mbgl

Post-monsoon Depth to water level during Nov 2018	:	3.85 to 17.50 mbgl

9. GROUND WATER EXPLORATION BY CGWB (As on 31-3-2016)

No of wells drilled (EW, OW, PZ, SH, Total)	:	EW-2,
Depth range (m)	:	150-300m
Discharge (litres per minutes)	:	2080
Storativity (S)	:	2.54×10^{-4}
Transmissivity (m^2/day)	:	3007 m^2/day

10. GROUND WATER QUALITY

Presence of chemical constituents more than permissible limit (e.g. EC, F, As, Fe)	:	Iron and Mn (mg/l)
Type of water	:	Good

11. DYNAMIC GROUND WATER RESOURCES (Ham) as on 31 March, 2013

Annual Replenishable Ground Water Resources	:	47037.04
Gross Annual Ground Water Draft	:	49189.05
Provision for Domestic and Industrial Requirement Supply	:	4357.04
Stage of Ground Water Development	:	104.58%

12. GROUND WATER CONTROL AND REGULATION

Number of Over Exploited Blocks	:	4
Number of Critical Blocks	:	0
Number of Semi Critical Blocks	:	2
Number of Safe Blocks	:	0
Number of blocks notified	:	-

13. MAJOR GROUND WATER PROBLEMS AND ISSUES	:	Over-Exploitation of Ground Water and Declining trend in ground water levels. Four (4) blocks fall under **Over Exploited** & one (1) block under **Semi- Critical** category.

1. INTRODUCTION

1.1 General

Jyotiba Phuley Nagar district lies in the west of Moradabad district, south of Bijnor District, north of Budaun District and east of Ghaziabad & Bulandshahar district. The district came into being on 24th April 1997, in the memory of famous social reformer Sant Mahatma Jyotiba Phuley by combining Amroha, Dhanaura and Hasanpur tehsils of Moradabad district, U.P. whose head office is situated in the ancient city Amroha.

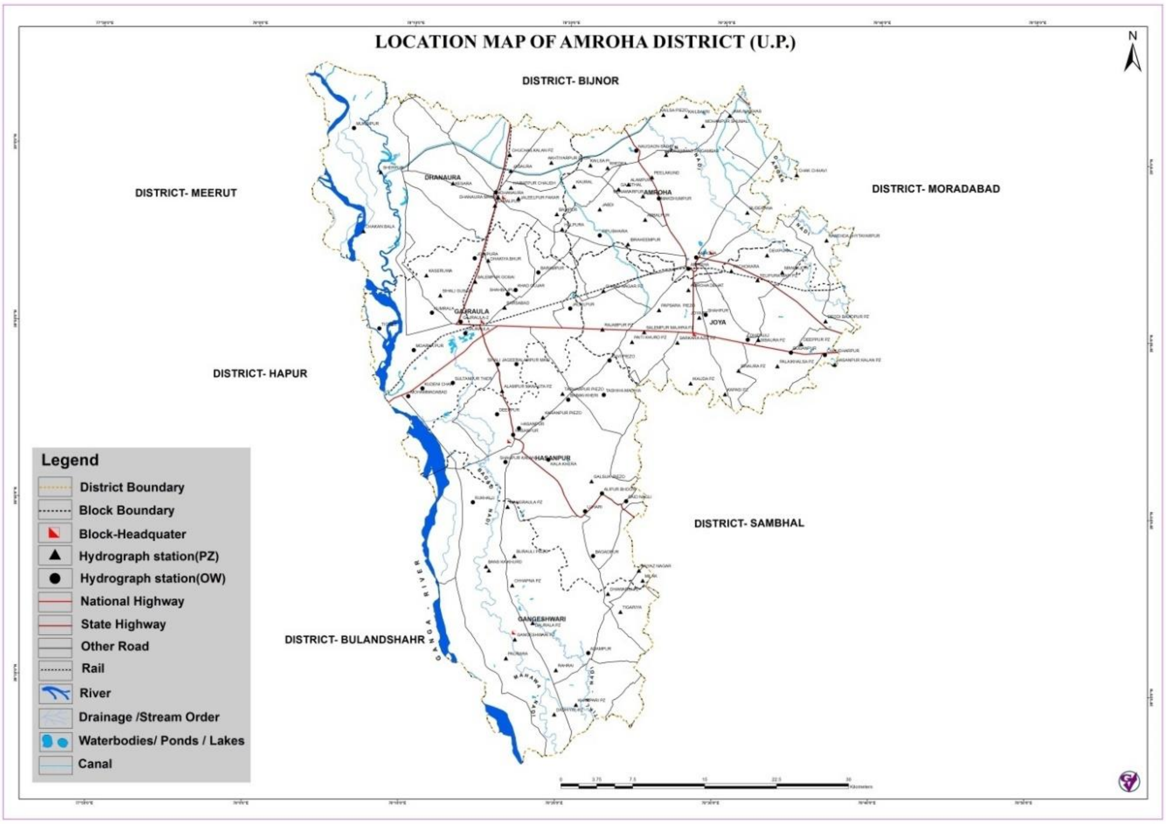
The district consists of 1133 villages, 3 tehsils, 6 blocks. Its geographical area is 2249 Sq. Km. and lies between 28^{0}24'00" and 28^{0}06'00" North latitude, and 78^{0}03'00" and 78^{0}43'00" East longitude and falls in Survey of India Toposheet No. 53L. The headquarter of the district i.e. Amroha is located in the eastern segment of the area. The district in the north is bounded by Bijnor, in the east by Moradabad and in the south by Badaun district. Ganga being its western boundary separated the district from Ghaziabad and Bulandshahar. Geologically the area falls in the Ganga basin. The area is drained by Ganga, Soht and Bagar River. In 2011, the district had population of 18,40,221, of which male and female were 9,63,449 and 8,76,772 respectively.

Irrigation in major part of the district is carried out by means of minor irrigation structures, such as tubewells, ponds etc. There is no canal system prevailing in the area. In district, there are mainly two cropping season, namely Rabi and Kharif. Majority of the area in the district is utilized for agriculture.

1.1.1 RAINFALL AND CLIMATE

The district falls in the subtropical region and the climate is classified as tropical to subtropical type. The climate is characterised by a hot summer and biting cold, winter is associated with general dryness, except during the southwest monsoon where humidity is high. The rainy season extends from end of June to September or mid of October. Extreme temperatures are recorded during winter & summer months. The mean daily maximum temperature is about 400C and the mean daily minimum temperature is about 250C during May and June. The mean monthly maximum relative humidity in the morning and evening is 84% to 74% respectively and is varies from 21% to 84%. Annual average rainfall is 917.40 mm. More than 70% of rainfall is confined in four months of monsoon season. Rainfall distribution pattern is even in the district.

Fig-1: Location map of Amroha District (U.P.)



1.1.2 *S*OIL

The soils of the district can be classified into two major groups based on its texture & composition characteristics.

1. Khader and low land soil
2. Upland or Bangar soil

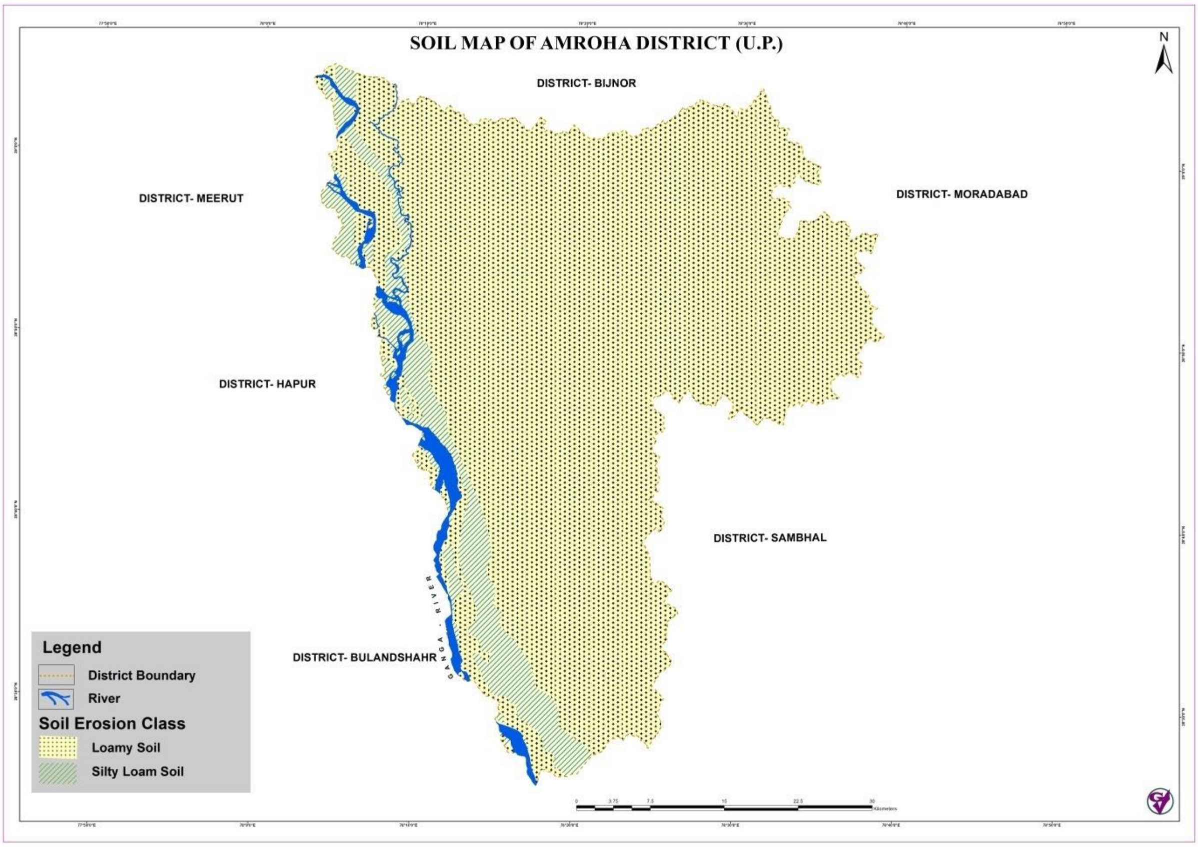
1. Khader and Low Land Soil:

This type of soil is found in low lying land and along the river courses like Ganga & sot. These soils are characterised by generally ash grey to brownish grey on the surface and their texture is some time silty loamy and sometime sandy. The clay contents are low.

2. Upland or Bangar Soil:

These soils occur in upland tract of older alluvium. The soil profile is generally mature, showing good development and alleviation of clay. It can be sub grouped depending upon its topography, occurrence and textural nature into sandy soil, clayey soils and loamy soil.

Fig-2: Soil map of Amroha District (U.P.)



1.1.3GEOMORPHOLOGY

The district has almost monotonous plain with no distinct features except some sand ridges, river valleys and shallow depressions. The maximum and minimum height from sea level is 182.00 m amsl to 208.00m amsl.

Geomorphologically, the district can be divided in to two broad geomorphologic units namely younger and older alluvium.

YOUNGER ALLUVIUM:

The area occupied by younger alluvium in the district can be delineated all along in the flood plains of Ganga. The flood plain can be further differentiated in to two geomorphic units:

1. Newer floodplain
2. Older floodplain

Newer Flood Plain:

The newer flood plain occupies along the river channel and its adjacent area of terrace which are subjected to periodic flooding. These are consists of sand, silt and silty sand with minor clays and form the flood plain of river. Over all, this is narrow zone along the river channel and gets flood regularly during rainy season.

1. Older Flood Plain:

The older flood plain of river Ganga can be delineated over a few kilometers, locally it is known as Khader. Adjacent to river Ganga, the order flood plain is more conspicuous and wide in the eastern side as compared to western side. The zone is characterized by the presence of fluvial land forms such as meander scars, cut off meanders and paleochannels etc. The sediments are fine grained sand and silt with thin clay horizons. The zone can be separated from older alluvium by the presence of natural levees, sand dunes have occurs in the Dhanaura, Bacchrawa and Hasanpur area of thedistrict.

OLDER ALLUVIUM:

It occupies the entire upland or inter fluvial area occurring between the major drainage. The soils are silty, clayey and sandy in varying proportions. The older alluvium can be differentiated into the following geomorphic units:

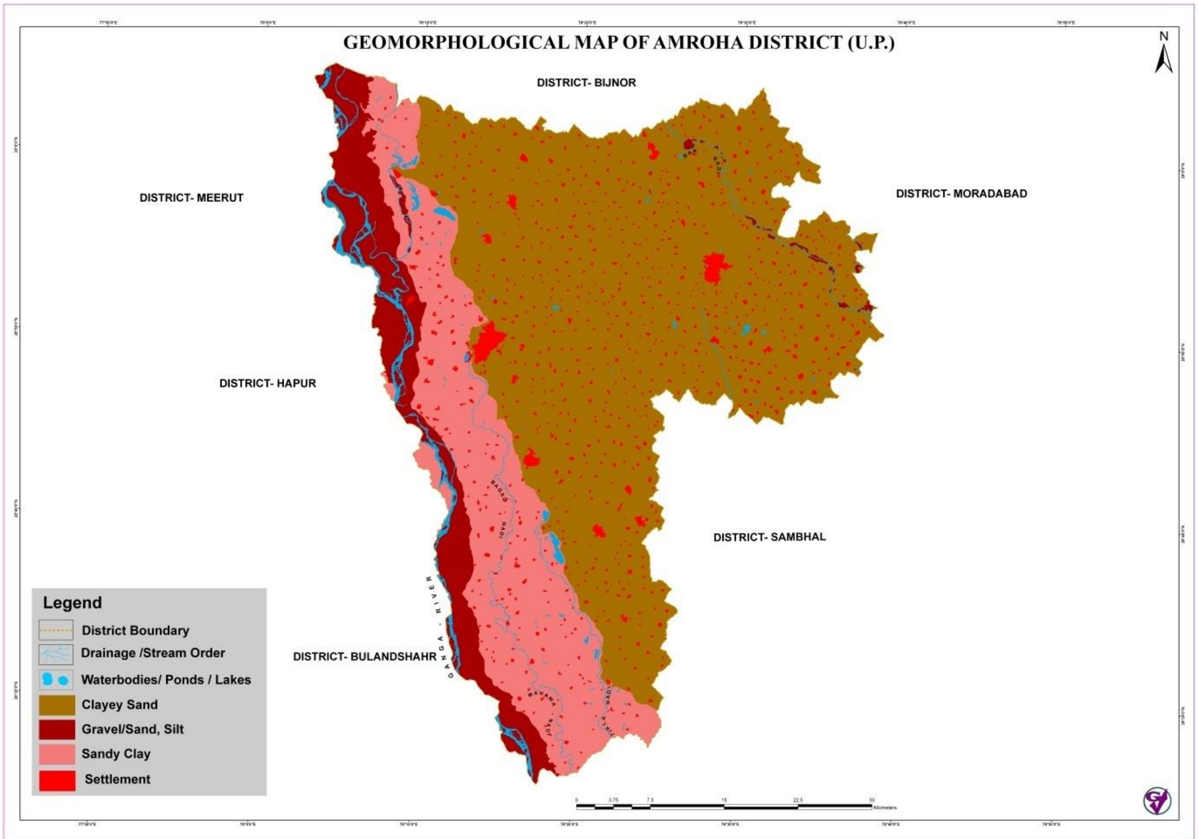
1. Area of Sand Dunes / Sandy Tract:

These occur close to old flood plain of Ganga in the district, extending all along from north to south, having a chain of sand dunes and sand ridges. This unit is characterized by the absence of drainage ways, indication of high permeability.

2. Central Upland Plain or Interfluve Area:

This unit occupies the central part as well as eastern part of the district, and is characterized by presence of well entrenched drainage ways namely, Gangan Ban and Soat. The soils are clayey, but at places sandy soils are also met with.

Fig-3: Geomorphological map of Amroha District (U.P.)



1.1.4 DRAINAGE

The district is drained by two prominent rivers, e.g., Ganga and Ramganga and their tributaries. Sot and Ban are the main tributaries draining the area. Sot joins the Ganga beyond this region whereas Ban is rivulet of the Ramganga.

1.1.5 PHYSIOGRAPHY AND GEOLOGY

Amroha district is a part of Northern Upper Ganga Plain. On the basis of geology, soils, topography, climate and natural vegetation, the district is divided into the following sub micro-regions

Amroha Plains:

The region is a flat plain with little physiographic variation. It covers major part of Amroha, Hasanpur and Dhanaura Tehsils. The highest contour of 200 meters is present along its southern boundary. The slope is gentle and towards south. North-Eastern part is comparatively higher. Sot and Ban are the main tributaries draining the area. Geologically, the region belongs to Alluvium and Dun Gravels (Recent).

Ganga Khadars:

Ganga Khadars is spread over along the Ganga River in north-south direction in Dhanaura and Hasanpur Tehsils and is prone to floods. The slope is very gentle and parallel to the flow direction of Ganga River. There are number of depressions, small rivulet bluffs and dead arms of the river. Contour of 200 meters marks roughly the eastern limit of the region. There are numerous small streams originating from local depressions and after flowing some distance parallel to the Ganga, join it again and most of them are non-perennial. Geologically, the region belongs to alluvium and Dun Gravels (Recent).

Fig-4: Geological map of Amroha District (U.P.)

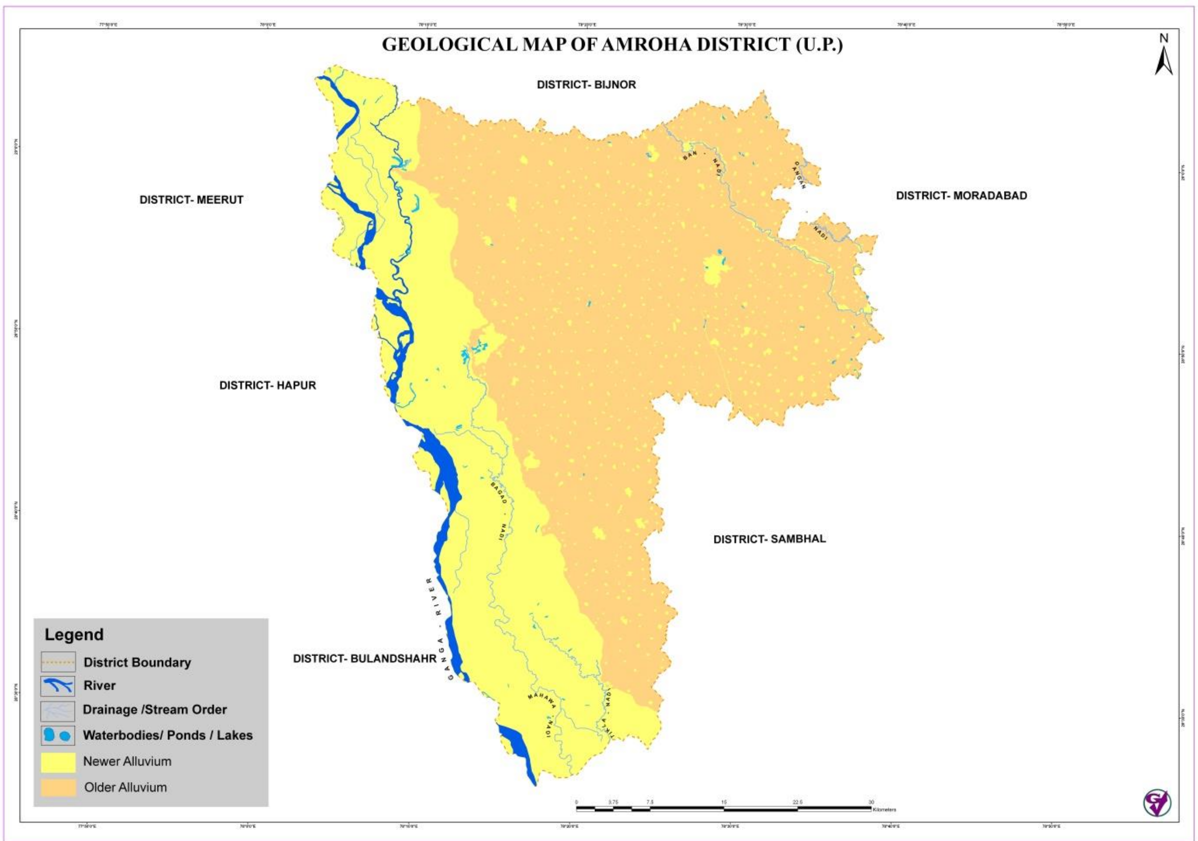
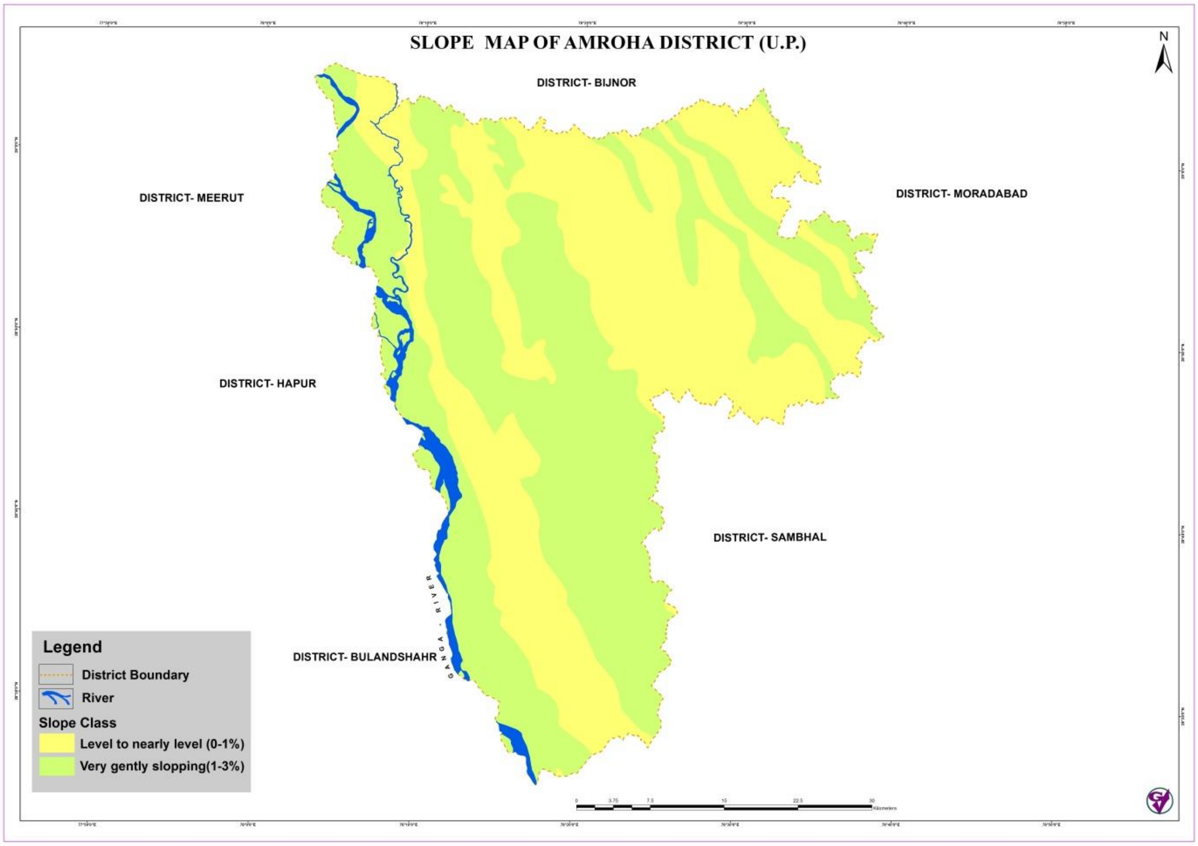


Fig-5: Slope map of Amroha District (U.P.)



1.1.6 AGRICULTURE AND CROPPING PATTERN

The economy of the district is predominantly agriculture. Kharif and Rabi are the two main harvests grown in the district. Wheat occupies the predominant place followed by paddy both in terms of area and production. Sugarcane is the most important commercial crop grown in the district. Other main Kharif crops of the district are Arhar, Urad, Moong. Wheat is the main Rabi crop that is cultivated in the district.

The main non-food crops of the district are sugarcane, oil-seed, ground-nut, potato, onion, garlic and other vegetable and fruits, sun-hemp and tobacco.

Table-1: Details of the Cropping Pattern

Block	Area Sown			Gross Sown area			Area Irrigated		Cropping Intensity	Irrigation intensity
	Net Area Sown	*Area sown more than once*	*Total*	*Rabi*	*Kharif*	*Jayad*	*Net Irrigated*	*Gross Irrigated*		
1. Amroha	29781	15286	45067	14784	26279	3113	28989	38797	151	134
2. Joya	32494	19282	51776	19562	29785	2224	31689	44772	159	141
3. Dhanaura	28840	17770	46610	17798	25099	3508	28042	43113	162	154
4. Gajraula	24171	15183	39354	16054	19708	3377	23221	35403	163	152
5. Hasanpur	29393	15183	44576	21701	18935	4223	28214	36413	152	129
6. Gangeshwari	27488	19168	46656	22736	23282	1161	26894	40018	170	149
Total Rural	172167	101872	274039	112635	143088	17606	167049	238516	159	143
Total Urban	2896	2985	5881	3237	2011	1323	4991	5881	203	118
Total District	**175063**	**104857**	**279920**	**115872**	**145099**	**18929**	**172040**	**244397**	**160**	**142**

(Area in Ha)

Table-2: Details of Area under Different Crops

Block	Rice (Kharif)		Rice (Jayad)		Total Rice		Wheat		Sugarcane	
	Total	*Irrigated*	*Total*	*Irrigated*	*Total*	*Irrigated*	*Total*	*Irrigated*	*Total*	*Irrigated*
1. Amroha	2377	2377	8	8	2385	2385	12180	12180	18944	18944
2. Joya	7004	7004	0	0	7004	7004	15990	15990	15568	15568
3. Dhanaura	2995	2995	0	0	2995	2995	14032	14032	15624	15624
4. Gajraula	3472	3472	0	0	3472	3472	13297	13297	9994	9994
5. Hasanpur	3193	3193	0	0	3193	3193	17696	17696	7037	7037
6. Gangeshwari	4916	4916	0	0	4916	4619	19109	19109	10397	10397
Total Rural	23957	23957	8	8	23965	23965	92304	92304	77564	77564

Total Urban	219	219	0	0	219	219	1384	1384	217	217
Total District	**24176**	**24176**	**8**	**8**	**24184**	**24184**	**93688**	**93688**	**77781**	**77781**

(Area in ha)

1.1.7 IRRIGATION

Rivers and streams for a long time have been used in the district for irrigation. However, due to absence of canal network in the area, the groundwater has emerged as a major source of irrigation.

Table-3: Details of the Distribution of Surface and Ground Water for Irrigation

Blocks	Canal	Tubewell		Well	Pond	Other	Total
		Public	*Private*				
1. Amroha	0	225	25541	3209	0	14	28989
2. Joya	0	215	27255	4208	0	11	31689
3. Dhanaura	0	219	25169	2640	0	14	28042
4. Gajraula	0	185	21581	1442	0	13	23221
5. Hasanpur	0	258	26276	1656	0	24	28214
6. Gangeshwari	0	174	25398	1302	0	20	26894
Total Rural	**0**	**1276**	**151220**	**14457**	**0**	**96**	**167049**
Total Urban	**0**	**10**	**4981**	**0**	**0**	**0**	**4991**
Total District	**0**	**1286**	**156201**	**14457**	**0**	**96**	**172040**

1.2 Aquifer Mapping

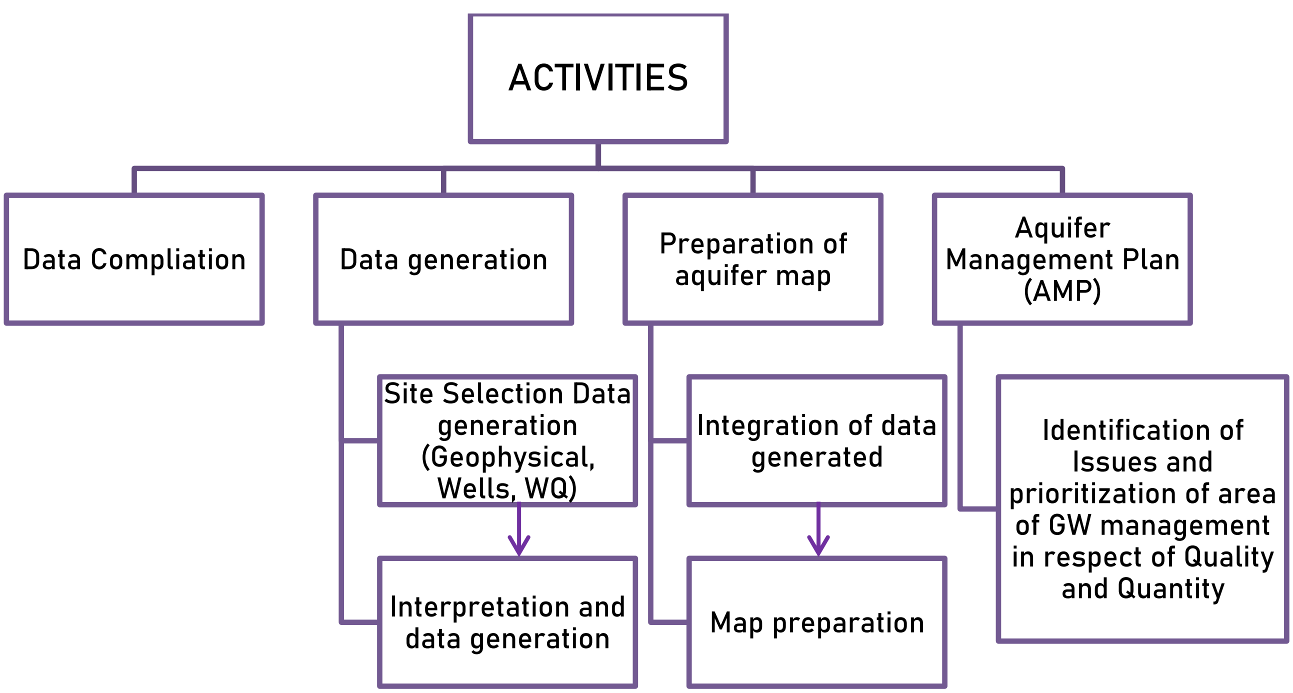
Aquifer mapping is a process wherein a combination of geologic, geophysical, hydrologic and chemical field and laboratory analyses are applied to characterize the quantity, quality and sustainability of ground water in aquifers. There has been a paradigm shift from “groundwater development” to “groundwater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

1.2.1 Objective

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

1.2.2 METHODOLOGY

Various activities of NAQUIM are as follows



2. DATA COLLECTION AND GENERATION

2.1 Hydrogeological Data

2.1.1 GEOLOGY: The district is occupied by geological formations of Quaternary age comprising of recent alluvial deposits belonging to the Ganges alluvial plains. The ground water occurs in a thick zone of saturation in the alluvium both under confined and unconfined conditions. The shallow aquifers, which are unconfined in nature, are being tapped chiefly by open dug well and shallow tubewells. The deeper aquifers, which are underlain by extensive confining clays, occur under confined conditions.

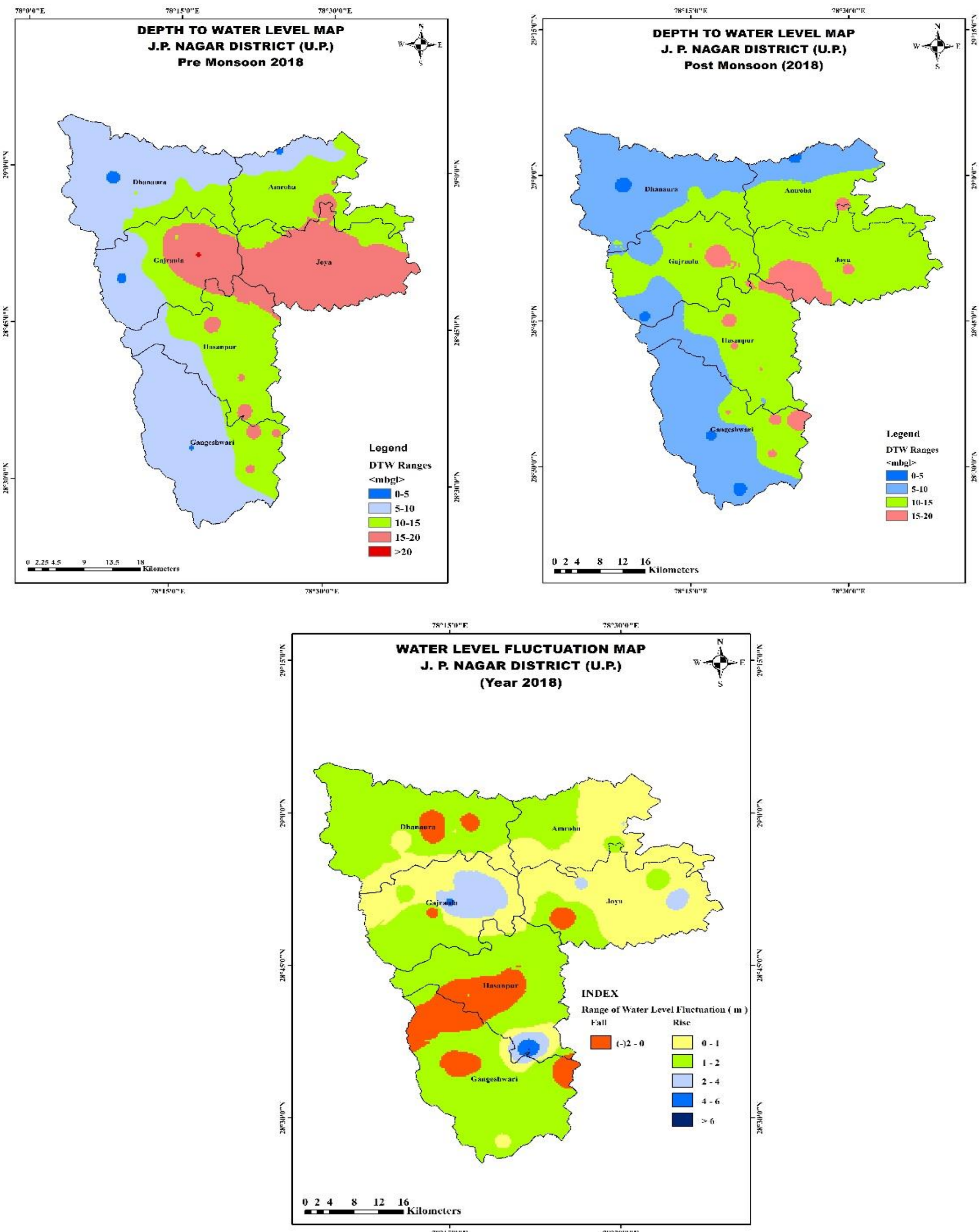
2.1.2 WATER LEVEL BEHAVIOUR: The water level data of all Ground Water Monitoring Wells of 2019 are shown in Table 4:

Table-4: Water Level Data (2019) of GWMW's of Amroha District

Name of GWA Unit (block or/ watershed)		2010	2011	2012	2013	2014	2015	2016
Amroha	Pre-monsoon	10.27	8.80	8.85	9.54	8.72	9.40	10.15
	Post-monsoon	8.81	7.36	8.46	8.25	8.21	9.21	9.69
Dhanora	Pre-monsoon	8.93	7.97	8.12	9.30	8.33	8.65	9.31
	Post-monsoon	7.99	7.96	7.89	8.28	8.43	8.63	8.57
Gangeshwari	Pre-monsoon	4.33	5.29	5.42	6.19	5.63	6.09	6.37
	Post-monsoon	3.28	4.23	5.15	5.03	5.33	5.56	6.07
Gajraula	Pre-monsoon	9.05	9.42	9.14	9.74	9.08	9.65	10.48
	Post-monsoon	8.04	8.07	8.53	8.57	8.96	9.59	9.55
Hasanpur	Pre-monsoon	11.62	11.53	11.87	12.29	12.06	13.47	14.05
	Post-monsoon	10.78	10.63	11.97	11.37	12.18	13.33	13.79
Joya	Pre-monsoon	12.41	12.54	12.32	13.72	12.98	13.86	15.18
	Post-monsoon	11.34	11.02	11.88	12.53	12.93	14.48	14.61

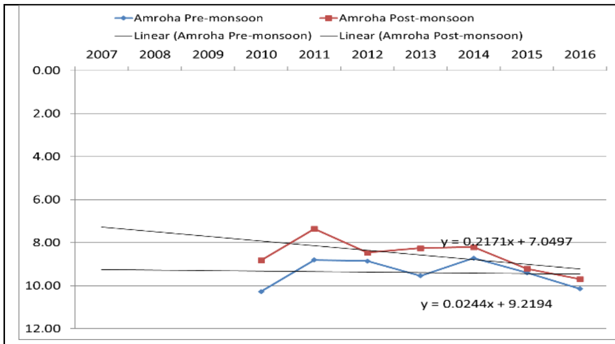
The long term trend in the water level reflected by water level hydrographs is indicative of change in groundwater storage in phreatic zone with time. Some Ground Water Monitoring Stations indicate a rising trend and this may be due to local hydrological conditions prevailing in the area. Whereas hydrographs of few GWOW show declining trend which may be due to over exploitation of ground water and these area require careful management of surface water and conjunctive use of surface water and ground water. For the rest of stations, hydrographs neither indicate any substantial rise nor decline thus indicating that the storage (Dynamic) is being maintained at the normal level which is not disturbed by the present level of ground water development.

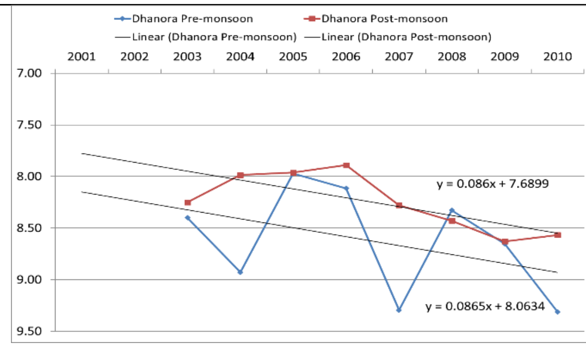
Fig-6: Depth to water Level of Amroha District, Pre-Monsoon (2018)

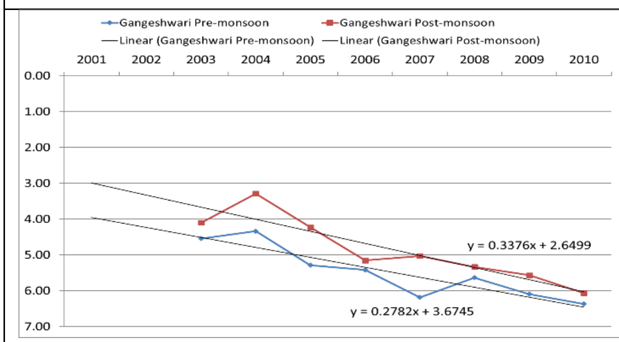


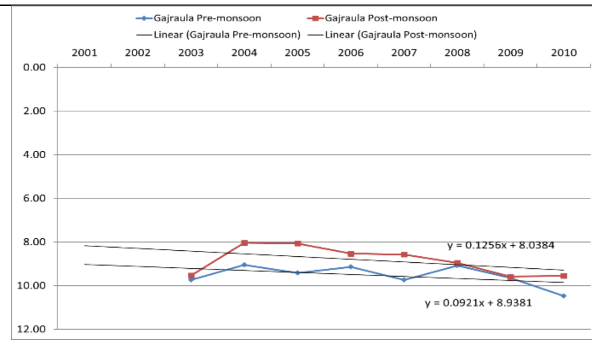
2.1.3 GROUND WATER FLOW: In general the ground water table varies from 188.95 to 208.69 m a.m.s.l. and the regional ground water flow is form north-west to south-east direction.

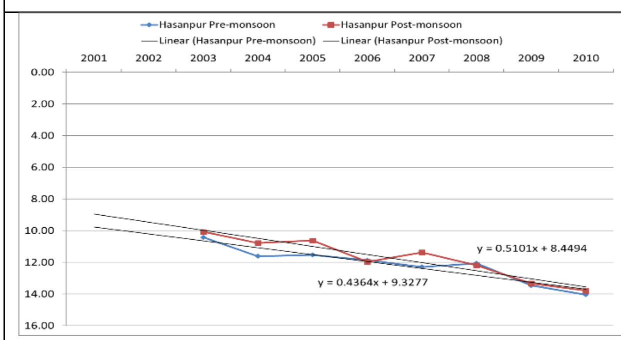
2.1.4 HYDROGRAPHS: The available hydrographs in district and block wise NHS are given below

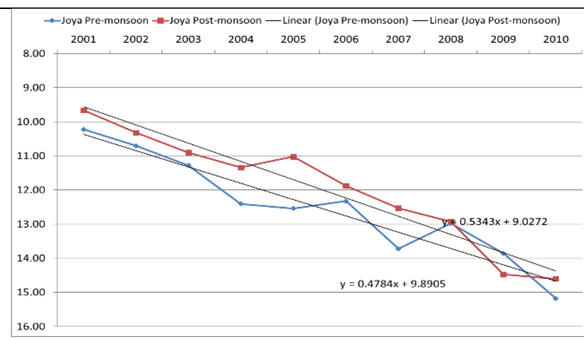












2.2 Exploratory Drilling - Cgwb, State And Private Wells

The lithologs of Exploratory Well/Observation Well/Piezometer/ Productive wells of CGWB, Public Health and Engineering Department (PHED) and private wells have been collected and those supported electrical logs have been used to validation for preparation of aquifer maps. Deeper well data of CGWB have also been utilized. The details are shown in Table-5. The compromised logs derived from lithologs and geophysical well loggings have been taken as reliable data base.

Table 5: Data availability of exploration wells in Amroha district

Sl. No	Source of data	Depth Range (m)			
		< 100	100-200	200-300	>300
1	CGWB	0	1	0	1
Total		**0**	**1**	**0**	**1**

2.3 Ground Water Quality

Chemical data of ground water from shallow aquifer indicates that grounds water is fresh. The ground water sampling is carried out through Ground Water Observation Wells every year during pre-monsoon period by CGWB. The chemical quality data of pre-monsoon. 2016 is used in this report and the main observations are given as below. Give description about EC. Generally ground water is suitable for irrigation purposes and in some areas suitable for drinking purpose also. All the results of chemical analysis of GWOW, 2016 data is shown in Table-6. The constituents above permissible and acceptable limits of Bureau of Indian Standards (BIS), are highlighted in red.

Table 6: Result of chemical analysis of water samples from GWOW in Amroha district

Location	pH	EC	CO_3	HCO_3	Cl	F	NO_3	SO_4	TH	Ca	Mg	Na	K	SiO_2	PO_4
		µS/cm	--------------------------mg/l--												
Dippur	8.35	515	12	128	35	0.26	ND	120	250	60	24	9.5	4.4	18	ND
Didauli	8.5	443	12	183	7.1	0.35	8.5	12	160	20	27	33	10	14	ND
Papsara	7.98	433	NIL	244	18	ND	ND	28	185	32	26	22	5	16	ND
Devipur	7.95	738	NIL	220	14	0.01	ND	195	340	60	46	29	4.8	15	ND
Karanpur Maki	8.45	348	12	171	57	0.12	ND	12	155	40	13	13	4	12	ND
Hasanpur	7.95	746	NIL	207	7.1	0.25	120	64	340	84	32	31	5.3	13	ND
Kalakhera	8.16	305	NIL	171	46	0.42	12	7.2	135	32	13	11	3.4	14	ND
Said Nagli	7.92	568	NIL	195	7.1	0.16	70	28	240	56	24	29	6.5	7.3	ND
Dhawarsi	8.39	322	12	171	11	0.28	1.9	5.1	130	36	9.7	20	3.6	12	ND
Adampur	8.58	499	24	232	11	0.48	ND	27	60	12	7.3	98	2.6	7.9	ND
Chuchera	8.2	555	NIL	342	7.1	0.25	ND	9.9	120	20	17	83	5.4	13	ND
Rehera	8.35	298	6	165	14	0.23	ND	7.2	130	32	12	14	3.3	12	ND

Manuta	7.8	440	NIL	256	14	0.02	23	11	200	40	24	17	5.8	8.6	ND
Khad Gujar	8.48	313	12	146	14	0.19	ND	9.8	75	16	8.5	42	4.9	7.7	ND
Jalalpur Kalna	8.2	425	NIL	207	14	ND	ND	38	165	35	35	28	7	12	ND
Chakanwala	8.6	635	12	189	78	0.01	1.4	53	155	16	28	86	7.9	12	ND
Sherpur	8.35	198	6	85	14	0.17	ND	9	90	24	7.3	5.3	2.4	ND	ND
Dhanama	8.36	445	12	183	25	0.34	26	19	200	40	24	19	3.9	11	ND
Chuchela Kalna	8.45	568	6	140	32	0.25	75	72	190	28	29	52	7	16	ND
Amroha	8.56	497	6	171	14	0.78	3.2	94	180	16	34	40	5.9	9.8	ND
Ibrahimpur	8.38	330	12	146	7.1	0.12	ND	24	140	24	19	15	6.3	11	ND
Makhadoompur	7.98	550	NIL	177	78	0.08	20	25	230	40	32	30	4.5	19	ND

Table 7: Result of heavy metal analysis of water samples from GWOW in Amroha district

Location	Cu	Fe	Mn	Zn	Ag	As
	---------------------mg/l-----------------					
Dippur	ND	2.029	0.446	0.152	0.003	0.025
Didauli	ND	0.146	0.154	0.052	0.003	0.005
Papsara	ND	2.172	0.452	0.604	0.002	0.02
Devipur	ND	ND	0.007	0.015	ND	0.05
Karanpur Maki	ND	0.111	0.195	0.25	0.002	0.005
Hasanpur	ND	0.028	0.012	ND	0.003	0
Kalakhera	ND	0.004	0.431	0.26	0.003	0.05
Said Nagli	ND	0.144	0.078	0.317	0.002	0
Dhawarsi	ND	0.152	0.287	0.313	0.003	0
Adampur	ND	0.128	0.035	0.219	0.002	0
Chuchera	ND	0.227	0.024	0.092	0.003	0.005
Rehera	ND	0.103	0.129	0.131	0.002	0
Manuta	ND	0.086	0.028	0.01	0.002	0.005
Khad Gujar	ND	0.194	0.248	0.201	0.002	0.005
Jalalpur Kalna	ND	2.607	0.256	0.516	0.002	0.005
Chakanwala	ND	1.492	0.191	0.461	0.003	0.05
Sherpur	ND	2.558	0.024	0.143	0.002	0
Dhanama	ND	3.227	0.296	0.104	0.003	0.02
Chuchela Kalna	ND	0.161	0.11	0.277	0.003	0
Amroha	ND	0.318	0.54	0.085	0.003	0
Ibrahimpur	ND	2.079	0.335	0.078	0.003	0
Makhadoompur	ND	1.062	0.026	0.544	0.003	0.05

*ND: Not determined.

3. HYDROGEOLOGY

Geologically the area is underlain by thick fluvial Quaternary sediments, deposited by Ganga River and its tributaries. Sediments comprise sand, silt, clay and kankars (calcareous concretions) in varying proportions. The alluvium is subdivided into Older Alluvial and Younger Alluvial Plain. Older alluvium occupies higher elevation whereas newer alluvium is of recent origin and is restricted to river courses.

Perusal of all available lithological logs of tubewells in the area reveal the complex configuration of alluvium showing alteration from finer to coarser sediments in quick succession. Three aquifer groups has been observed down to depth 350mbgl with two interlayered clay horizon. Top and bottom depth range of each zones given below

Stratigraphic Group	Top depth Ranges (mbgl)	Bottom Depth Ranges (mbgl)
Aquifer Group I	0	96-186
Clay Horizon I	96-186	132-220
Aquifer Group II	132-220	232-320
Clay Horizon II	232-320	272-350

3.1 Aquifer Parameter Ranges:

In Amroha district, the exploration drilling were carried out by CGWB. The aquifer parameters range extracted and given in below Table-8.

Table-8: Summary of exploration and hydraulic details

Exploratory Well	T (m2/day)	S	Discharge (lpm)	Lithology Type	Well Depth/Construction
Amroha District Hospital	3007	$2.54*10^{-4}$	2080	Sand, Silt, Clay & Kankar	150m

3.2 Aquifer Geometry and Disposition:

To understand the lithological frame work and aquifer disposition in the sub surface aquifers, the litholog data of wells drilled by CGWB agencies are used to compile, optimized and modeled into 3D synoptic picture by using the RockWorks16 software. The lithological model has been prepared and shown in Fig-7. The 3D aquifer disposition diagram has been prepared along with distribution of wells in different blocks are shown Fig-9.

Fig-7: Aquifer Map of Amroha District

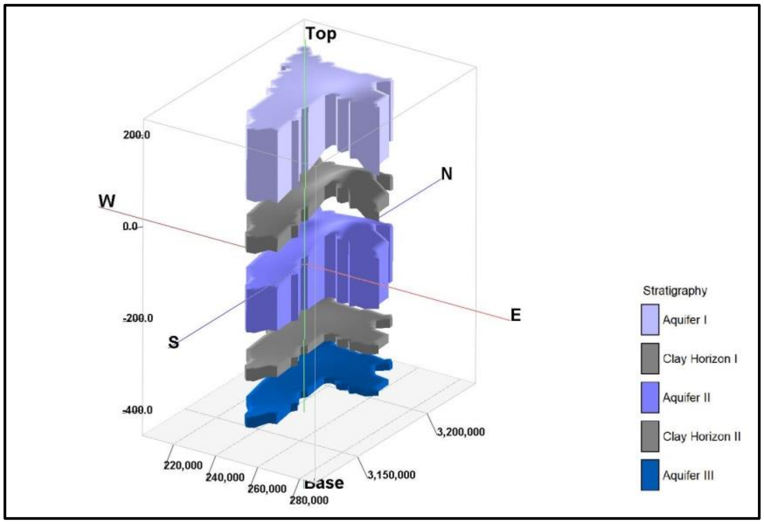
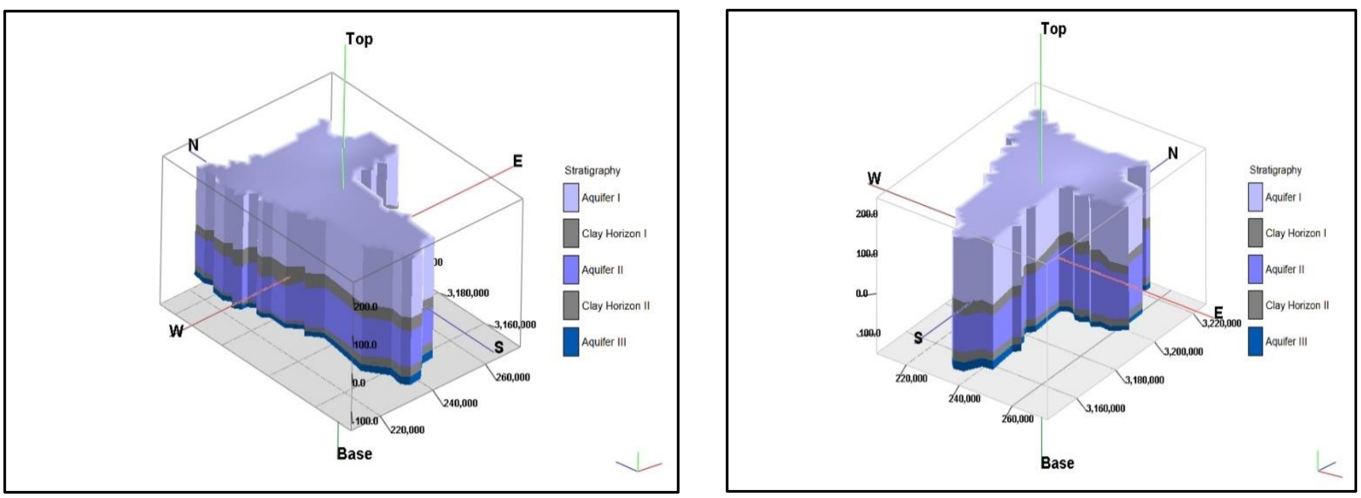
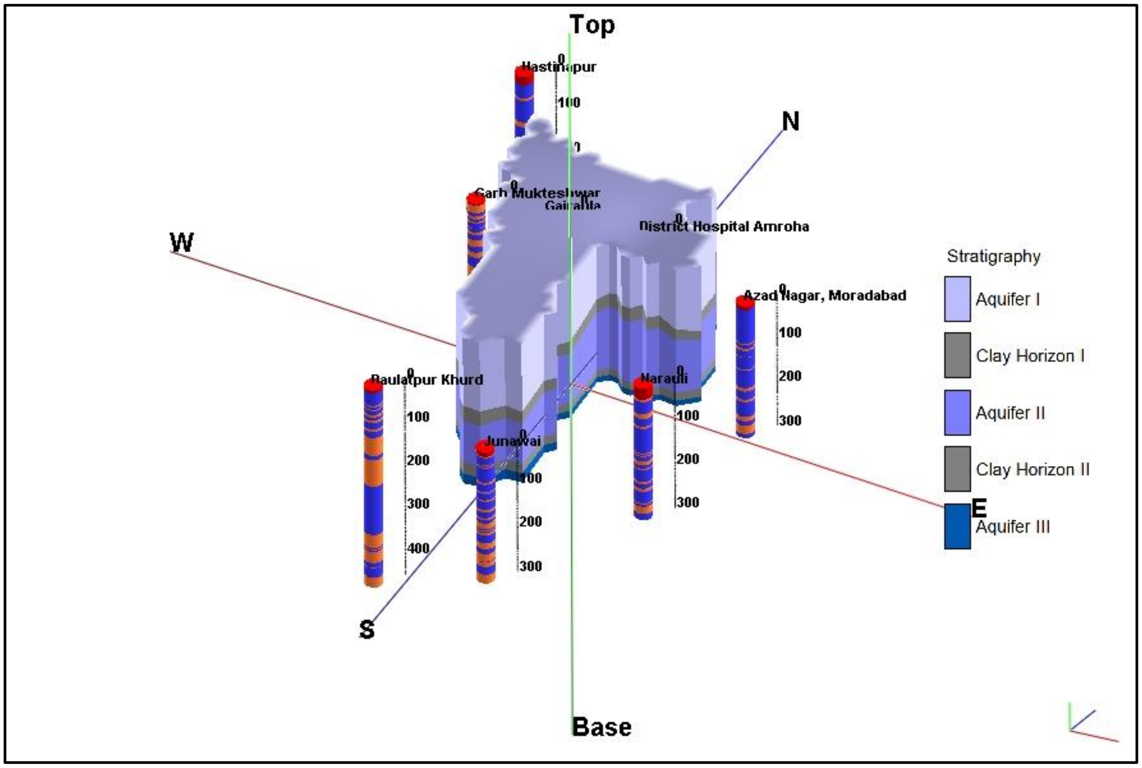


Fig-8: 3-Dimension Lithological Model of Amroha District



The major aquifer system of the Amroha district is alluvial deposits, which are all considered as older alluvium in major aquifer group category and are mainly comprised of sand and clay. The major lithological formations are sand & clay and silt is found admixed with sand and clay. Thick layering of clay with sand at many places can be observed at deeper depths.

Fig-9: Aquifer Map or 3-Dimensional aquifer distribution diagram with used exploratory wells of Amroha District



Majority of the Amroha District falls under the Ganga River Basin; therefore it belongs to a multiple aquifer system up to 300m depth with thin inter-layering of sand and clay. Based on the same criteria, to know the broad picture of the aquifer disposition, inter-relationship of granular zones, nature, geometry and extension of aquifers in the Amroha district, a three-dimensional aquifer model has been prepared (Fig-9).

4. GROUND WATER RESOURCES

Ground water resource estimation of the area have been carried out by taking Dynamic and Static/In-storage resources of aquifer presented upto the depth of 300m. The assessment of dynamic ground water resources of the Amroha has been carried out jointly by CGWB and Ground Water Department, Uttar Pradesh on the basis of Ground Water Estimation Committee (2015) methodology based on data available and as per the revised methodology for the year as on 31st March 2017.

The occurrence of potential aquifers (granular zones) upto 300 m depth has been demarcated on basis of aquifer wise subsurface mapping. The total saturated thickness of granular zones was derived from the exploratory borehole data of a particular block. The granular zones occurring below the zone of water level fluctuation up to the first confined

layer has been considered as static unconfined zone. The ground water resource of this zone has been calculated considering 12% specific yield of the formation. The major data elements considered in this estimation are thickness of granular zones, specific yield/storativity.

4.1 Multiple Aquifer Group Upto Depth of 300 M:

1. Dynamic Resources:

The ground water development in all the blocks has exceeded the available recharge, thus all the blocks have been categorized as over exploited. Stage of ground water development in the Amroha district has been assessed to be 104.58%. The details are explained in below Table-10.

Table-10: Dynamic Ground Water Resource & Development Potential (as on 31.03.2017)

Assessment Unit/ Block	Net Annual Ground Water Availability	Existing Gross Ground Water Draft for irrigation	Existing Gross Ground Water Draft for domestic and industrial water supply	Existing Gross Ground Water Draft for All uses	Provision for domestic, and industrial requirement supply to 2025	Net Ground Water Availability for future irrigation development	Stage of Ground Water Development (%)
Amroha	12536.99	9430.68	1032.09	10462.77	1161.64	1944.67	83.46
Dhanaura	9006.63	8836.05	570.02	9406.07	659.81	-489.22	104.43
Gangeshwari	7051.74	5597.71	586.02	6183.73	727.61	726.42	87.69
Gajraula	6017.68	6029.65	614.89	6644.54	734.09	-746.05	110.42
Hasanpur	5141.69	5044.04	694.21	5738.25	827.34	-729.69	111.60
Joya	7282.30	9893.88	859.80	10753.68	1004.32	-3615.90	147.67
District Total	**47037.04**	**44832.01**	**4357.04**	**49189.05**	**5114.79**	**-2909.76**	**104.58**

2. In-storage Ground Water Resources

As per revised guidelines recommended by the Central Level Expert Group on ground water resources assessment, the resources are separately considered as dynamic and in-storage unconfined. In case of alluvial area, the in-storage resources of unconfined aquifer have been computed based on specific yield of the aquifer as detailed below:

Total Availability of Ground Water Resources = Dynamic Resources + In-storage Resources.

In-storage Ground Water resources (unconfined Aquifer)	=	Thickness of the aquifer (granular/productive zone) below the zone of water level fluctuation down to the bottom layer of unconfined aquifer	x	Sp. Yield of the aquifer	x	Areal extent of the aquifer

Table-11: BLOCK WISE IN-STORAGE GROUND WATER RESOURCES OF FRESH WATER IN UNCONFINED AQUIFER

BLOCK WISE IN-STORAGE GROUND WATER RESOURCES OF FRESH WATER IN AQUIFER									
Sr. No.	Name of Assessment Unit	Type of rock formation	Areal extent (Sq Km)	Average Pre-monsoon Water Level (m bgl)	Average Bottom depth in m bgl considered for isopach map.	Total Thickness of formation below Pre-monsoon Water Level (m) (9-8)	Total thickness of the Granular Zones up to the depth of Fresh Water Zones available (m)	Specific Yield % as taken for estimating Dynamic Resource	In-Storage Ground Water Resources up to the depth of Fresh Water Aquifer (ham) = 6*13*14
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	Amroha	Alluvium	381.1	14.73	134	119.27	100	16	6109
2	Dhanaura	Alluvium	415.6	16.25	134	117.75	99	16	6577
3	Gangeshwari	Alluvium	407.8	11.30	134	122.70	103	16	6725
4	Gajraula	Alluvium	262.7	7.86	134	126.14	106	16	4454
5	Hasanpur	Alluvium	334.3	16.48	134	117.52	99	16	5280
6	Joya	Alluvium	397	7.40	134	126.60	106	16	6755
7	**District Total**	**Alluvium**	**2249**	**12.34**	**134**	**121.66**	**102**	**16**	**36775**

4.2 Ground Water Quality:

Ground water in phreatic aquifer in general, is colourless, odourless and slightly alkaline in nature. It is observed that in general the ground water is suitable for drinking agricultural & industrial purposes in respect of all the constituents viz. EC, CO_3, HCO_3, Cl, F, NO_3, SO_4, TH, Ca, Mg & Na. The specific electrical conductance of ground water in phreatic aquifer ranges from 198-746 micro siemens/cm at 25^0C. Fluoride ranges from ND-0.48 mg/l, which is within permissible limit. Nitrate ranges from ND-120 mg/l and is found in excess of permissible limit (>45mg/l) in only three out of twenty-two samples (Hasanpur, Said Nagli and Chuchela Kalna), which is likely due to return irrigation flow from agricultural fields and often improper waste disposal.

Among trace elements, Iron concentration ranges from ND-3.227 mg/l. Out of the twenty-two samples collected from the district two samples spread over all the blocks show iron value between 0.3-1.0 mg/l & seven samples show iron value >1.0 mg/l. The permissible limit of Iron as per BIS-2012 is 0.30mg/l. The presence of Iron above 1.0 mg/l may lead to deposits in pipes and in the presence of aluminium may lead to dirty water problems. It is more of aesthetic value than toxicity and may be showing in water due to old rusted pipes in the hand pumps. Manganese concentration ranges from 0.007-0.54 mg/l and in four out of twenty two samples it shows value more than the permissible limit (>0.3 mg/l).

4.3 Status of Ground Water Development:

Presently the total ground water draft is 49189.05 ham, which is being used in present for domestic, irrigation & industrial purposes against the ground water availability of 47037.04 ham. Out of 6 blocks, four blocks falls under over exploited category which are Dhanaura, Gajraula, Hasanpur and Joya; and two blocks namely Amroha and Gangeshwari are under Semi-Critical category. The percentage wise development is given in Table-10. Ground water development is basically is peoples programme undertaken through individual and collective efforts from finance obtained as loans from institutional sources or invested by the farmers from their own sources. Ground water development has several advantages over surface water and has become a vital factor in promoting innovating agriculture practices through high yielding varieties of crops. Ground water is widely distributed and provides an assured and dependable source of irrigation input.

4.4 Ground Water Related Issues:

The development of ground water in the district, in general, is high as 4 (four) blocks (Dhanaura, Gajraula, Hasanpur and Joya) out of 6 blocks in the district have been categorised as **Over Exploited** and 2 block (Amroha and Gangeshwari) as Semi-Critical. Overall stage of ground water development in the district is about 104.58%, and the trend analysis of historical ground water level data indicates a long term fall in most of the wells in the district, more pronounced in the OE & Semi-Critical blocks. Based on the factors mentioned, it is inferred that the district in general is vulnerable to various environmental impacts of water level depletion such as declining ground water levels, drying up of shallow wells, and decrease in yield of bore wells and increased expenditure and power consumption for drawing water from progressively greater depths. Excessive use of fertilizers and pesticides in agriculture has also reportedly resulted in localised enrichment of Nitrate in the phreatic aquifer.

4.5 Ground Water Management Strategy:

To arrest the further decline in ground water levels and depletion of ground water resources, there is urgent need to implement both Supply side and Demand side measures which includes artificial recharge and water conservation, On-farm activities and adoption of water use efficiency measures.

Table-11: Ground Water Management Options

GW Management options	
Supply side Interventions	**Demand side Interventions**
○ Construction of check dams/nala bunds ○ Revival and renovation of ponds ○ On farm activities like laser leveling, bench terracing, construction of farm ponds, plantation of forests etc. ○ Government Irrigation and Water Supply tubewell should tap 2nd Aquifer. **However, caution is to be applied to keep piezometric head maintained.** **Scope of supply side interventions is limited due to topography, land availability and also less availability of surplus water.**	◦ Water use efficiency through piped and pressurised irrigation (drip & Sprinkler) ◦ Furrow irrigation with raised bed planting in wide row crops should be practised. ◦ Irrigation in checks in close row crops should be practised ◦ Measures for reducing Evapo-transpiration losses etc. ◦ Diversification of cropping pattern. **Most effective option to reduce ground water withdrawal by 35-40% specially for Sugarcane areas by adopting new irrigation practices**

4.5.1 Supply side Management:

It is proposed to adopt supply side management options in the Over-Exploited and Semi-Critical blocks. There is considerable scope for implementation of Roof Top Rain Water Harvesting in the urban areas of the district. Check dams, cement plugs, renovation of ponds are ideal structures for rain water harvesting in rural areas. Water conservation structures such as check dams, farm ponds, nala bunds etc. result in ground water recharge to the tune of about 40% of the storage capacity considering 3 annual fillings.

It is also proposed to adopt On Farm practices such as laser leveling, bench terracing, construction of farm ponds, afforestation, diversification of crops etc.

4.5.2 Demand side Management:

Agriculture is the major consumer of ground water. There In the district, about 66% irrigation is dependent on ground water. Even in the canal command areas, enough ground water is being used to irrigate the fields. In the major parts of area, flow irrigation is being used. There is urgent need to promote piped and pressurised irrigation practices which can save 25 to 70% of water use in the agriculture. It is proposed to initiate these measures initially in 10% area of each of the over-exploited and critical blocks. It is also proposed to adopt new water saving agricultural practices in areas of sugarcane cultivation in over-exploited and semi-critical blocks. Such practices have the potential of saving 35-40% irrigation water thereby drastically reducing the draft for irrigation leading the change of category of block from OE to safe. The measures adopted for supply side and demand side management in Amroha district will substantially bring down stage of ground water development.

4.5.2.1 Agricultural Practices for Saving Irrigation Water in Sugarcane Cultivation

1. Irrigation Scheduling at Critical Growth Stages of Sugarcane

The initial crop growth stages coincide with hot summer due to which crop requires frequent irrigations. Experimental results have indicated that sugar cane has certain growth stages in its entire crop cycle on which if the crop is not irrigated growth and yields are affected adversely. These stages have been termed “Critical Stages”. Ensuring irrigation at its critical growth stages improves water use efficiency without any loss of yield.

Table-12: Irrigation Schedule

If water is available for the following No. of irrigations	Growth stages on which irrigation to be applied			
	Emergence	**First order of tillering**	**Second order of tillering**	**Third order of tillering**
4	Apply Irrigation	Apply Irrigation	Apply Irrigation	Apply Irrigation
3	-	Apply Irrigation	Apply Irrigation	Apply Irrigation
2	-	-	Apply Irrigation	Apply Irrigation
1	-	-	-	Apply Irrigation

Advantages

- Water Use Efficiency is increased by 35-40%.
- Water saving: Irrigation water is saved up to 30-40 %
- Normal Cane Yield and Quality is obtained.
- Weed infestation is reduced considerably.

2. *Ring Pit Method of Sugarcane Planting*

Sugarcane crop comprise mother shoots & tillers. Since tillers start emerging about 45-60 days after emergence of mother shoots, so these are comparatively weak and result in milliable cane of lesser length, girth & weight. Therefore to accommodate more numbers of mother shoots in the same space, tillers of sugarcane need to be suppressed. To achieve this more number of sets is planted in circular pits at relatively greater depths. Thus mother shoots at large are allowed to grow with very less or no tillers. That is why; this technology is also called “No Tiller Technology”

Advantages

- **Higher Input Use Efficiency:** Water Use Efficiency is increased by 30-40% & nutrient use efficiency by 30-35 % due to their localised application in pits only.
- **Water saving:** Irrigation water is saved up to 30-40 % as only pits are irrigated and inter row spaces are not irrigated.

3. *Skip Furrow Method of Irrigation*

Normally farmers irrigate sugar cane by flooding entire field with water. Considerable amount of waste thus goes waste due to evaporation from wet soil surface. In Skip Furrow method efforts have been made to reduce wet surface area in field. In this technique furrows are made in alternate inter-row space & the crop is irrigated through these furrows. Thus the soil surface of inter-row space remains almost dry; thereby evaporation losses are reduced to the extent of 30-40 %.

Advantages

- Water Use Efficiency is increased by 60-65%.
- Water saving: Irrigation water is saved up to 35-40 %
- Normal Cane Yield and Quality is obtained.
- Weed infestation is reduced considerably.

4. Trash Mulching

Sugarcane trash i.e. dry leaves available after harvesting of the crop is a valuable source of organic matter & water saving. In general farmers burn trash or utilise it for other purposes such as thatching, fuel litter etc. If, it is recycled in the cane field itself it contributes not only in saving precious irrigation water but also adds organic matter as well as other plant nutrients in soil. So it is important to recycle trash by mulching in sugarcane field.

Advantages

- Irrigation water is saved up to 40% as it conserves the soil moisture & reduces evaporation from soil surface.
- Increased availability of nutrients especially Nitrogen and Phosphorus to the plants.
- Mulch also adds large quantity of organic matter thus improves soil health of the soil.

5. Micro Irrigation (Sprinkler/ Drip Irrigation)

Micro irrigation is the frequent application of small quantities of water on, above or through water directly at the root zone of the plant in a uniform and effective way.

Advantages

- Water Use Efficiency can be improved from 50-60 % to 90-95%.
- The consumption of fertilizers can be reduced by 30%.
- Weed infestation is reduced considerably.
- Can be used on undulating topography & on soils having low infiltration rates.

BLOCK WISE AQUIFER MAPS
AND
MANAGEMENT PLAN

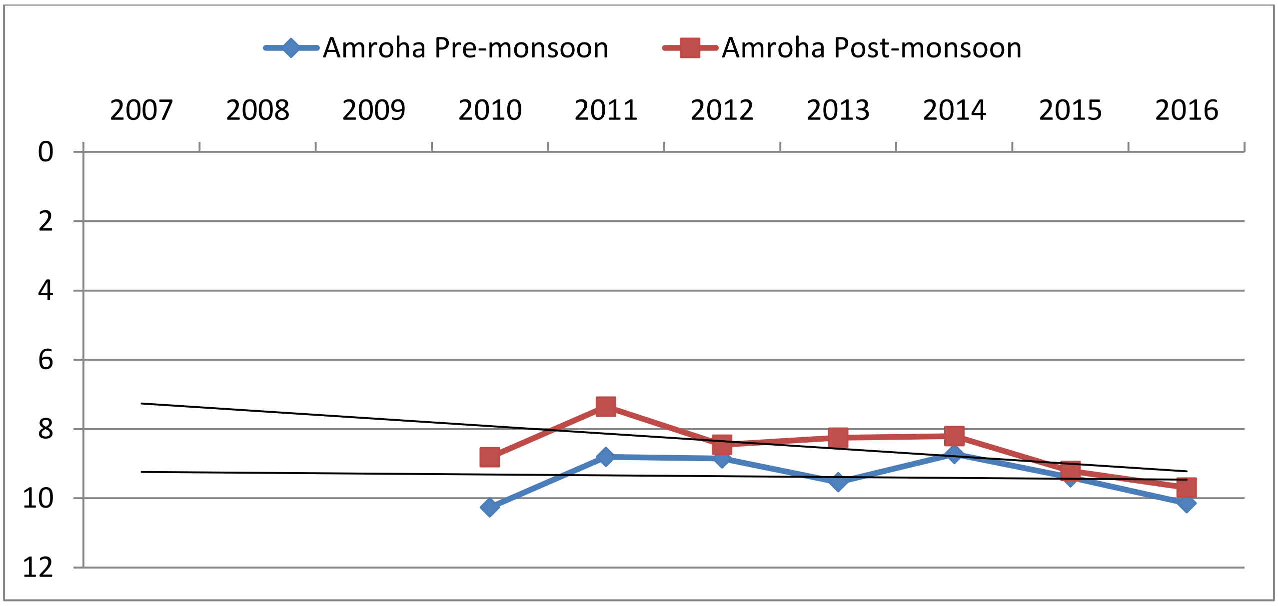
i. AMROHA BLOCK (381.10 sq. km)

Population (2011)	Male-1,20,114 Female-1,08,651 Total-2,28,765
Rainfall 2016 (Amroha Dist.)	733.92 mm
Average Annual Rainfall (Amroha block)	733.92 mm
Agriculture and Irrigation	Major Crops- Rice, Wheat (Dist) Other crops- Sugarcane, Potatoes, Pulses, Oilseeds (Dist) Net Area Sown-297.81 sq. km Total Irrigated Area-297.81 sq. km

Ground Water Resource Availability: Ground Water Resources available in the different group of aquifers. Aquifer I (134m) is very prominent in terms of thickness and geographic extent. Aquifer II is below 140-150m bgl and extends up to 270-280m bgl. Block is categorized as Semi-Critical as per 2017 assessment.

Ground water Extraction: Information regarding the abstraction from different aquifers is not available, but there are drinking water supply tapping combined aquifer and most of the irrigation is carried out by tapping shallow aquifers.

Water level Behaviour (2018): Pre Monsoon-~16.06m bgl &Post Monsoon-~13.91mbgl



Aquifer Disposition: Combined Aquifer System

Aquifer Group	Geology	Type of aquifer	Aquifer Depth Range (mbgl)
Aquifer I	Quaternary alluvial deposits	Unconfined	G.L-134
Aquifer II		Unconfined to Confined	144-278
Aquifer III		Unconfined to Confined	Beyond 290

Aquifer comprises of freshwater only and the main aquifer formation is sand.

The non-aquifer material comprises of clay.

Ground Water Resource, Extraction, Contamination and Other Issues

Ground Water Resource (in mcm)	Dynamic Aquifer I (2017)	125.27
	In-storage Aquifer I (2017)	6109
	Dynamic Aquifer II	0.04
	In-storage Aquifer II	15.56
	Total	6249.87
Ground Water Abstraction (in mcm)	Irrigation (2017)	94.3068
	Domestic & Industrial (2017)	10.3209
Future demand for domestic & industrial use (2025)(in mcm)		11.6164
Chemical quality of ground water		Potable for drinking and irrigation
Other issues		Deeper water level and declining water trend

Ground Water Resource Enhancement

Aquifer wise space available for artificial recharge and proposed interventions	Volume of unsaturated unconfined aquifer
Other intervention proposed	Artificial recharge and watershed management and farm-pit recharge

Demand side Interventions

Advanced irrigation practices	Drip irrigation, use of sprinklers and lining of underground pipelines
Change in cropping pattern	Paddy and Sugarcane cultivation can be replaced with less water intensive crops
Alternate water sources	Tanks, ponds, and canal.
Regulation and control	Over-exploited Category

GROUND WATER MANAGEMENT OPTIONS:

Ground water issues can be addressed by focussing on measures to increase recharge and reducing the draft. It can be managed by a mix of measures such as:

Supply Side Management

• Water conservation and Artificial Recharge to ground water

• On Farm Activities and initiatives for ponds creation by farmers in their farmland.

Demand Side Management

• Adoption of techniques to enhance water Use Efficiency

• Adoption of new irrigation practices in sugarcane cultivation area to save 35-40 % irrigation water

Increasing Storage Capacity and Conservation of Rainfall: Supply Side Management

Recharge / Water Conservation

• Water conservation structures such as check dams, farm ponds, nala bunds etc result in ground water recharge to the tune of about 50% of the storage capacity considering 3 annual fillings. Further construction of recharge trenches in the upstream side of the check dams is also proposed to enhance rate of infiltration by about 30 to 40%.

• The existing ponds and tanks lose their storage capacity as well as the natural ground water recharge due to siltation and encroachment by farmers for agriculture purposes. Through desilting, coupled with providing proper waste weir, the village tanks can be converted into recharge structure.

Watershed development and management

- The development of watershed of Ban Nadi (186.13 sq. km), Ganga River (97.91 sq. km), Karula Nadi (1.91 sq. km)and Gangan Nadi (66.68 sq. km) holds key for the sustainable management of the rain water that can be utilized for artificial recharge of ground water.

On Farm Practices: Supply Side Management

• Levelling of crop field is essential for uniform distribution of water. Laser levelling has been found very effective ensuring saving of 10 to 30% of applied irrigation.

- The in situ farm activities such as contour bunding, land levelling, bench terracing, water harvesting structures, afforestation and diversification of cropping pattern are other measures to increase recharge in the block.

Enhancing Water Use Efficiency:

Demand Side Management

Efficient irrigation

• In flood/furrow irrigation method more than 50% of applied water is wasted through seepage to deeper level, localized inundation causes loss through evaporation and it leaches out the nutrients from the plant.

• Adoption of efficient irrigation practices in sugarcane cultivation area to save 35-40 % irrigation water. Such practices are as under

1. Irrigation Scheduling at Critical Growth Stages of Sugarcane
2. Ring Pit Method of Sugarcane Planting
3. Skip Furrow Method of Irrigation
4. Trash Mulching
5. Micro Irrigation (Sprinkler/ Drip Irrigation

• While through drip & sprinkler irrigation wastage of irrigational water could be minimized. The conveyance losses (mainly seepage & evaporation) can be saved upto 25 to 40% through utilization of HDPE pipes.

• Agriculture department should promote to conserve the soil moisture by reducing ET losses through cultivation of 'Green Manure'

Diversification of cropping pattern

• Horticulture department should promote Baghwani in the area. This will bring in money without high use of water. These will also help conserve soil moisture.

• Alternate cropping system having lower requirement of water are better option.

• Summer paddy and maize need to be avoided which are grown over substantial area in the block.

• Large scale adoption of rice-wheat rotation system & sugarcane cultivation is the main reason of over exploitation of groundwater. Late sown wheat/peas are replaced by spring maize which consumes more water. Suggested cropping pattern are as under.

• **Kharif**- Maize, cotton, sorghum, pulses, groundnut

• **Rabi**- Mustard, gram, pulses, vegetable

• By adopting suggested cropping pattern 20 to 30% of irrigation water saving is possible

Fig-10: Location map of Amroha Block, Amroha District

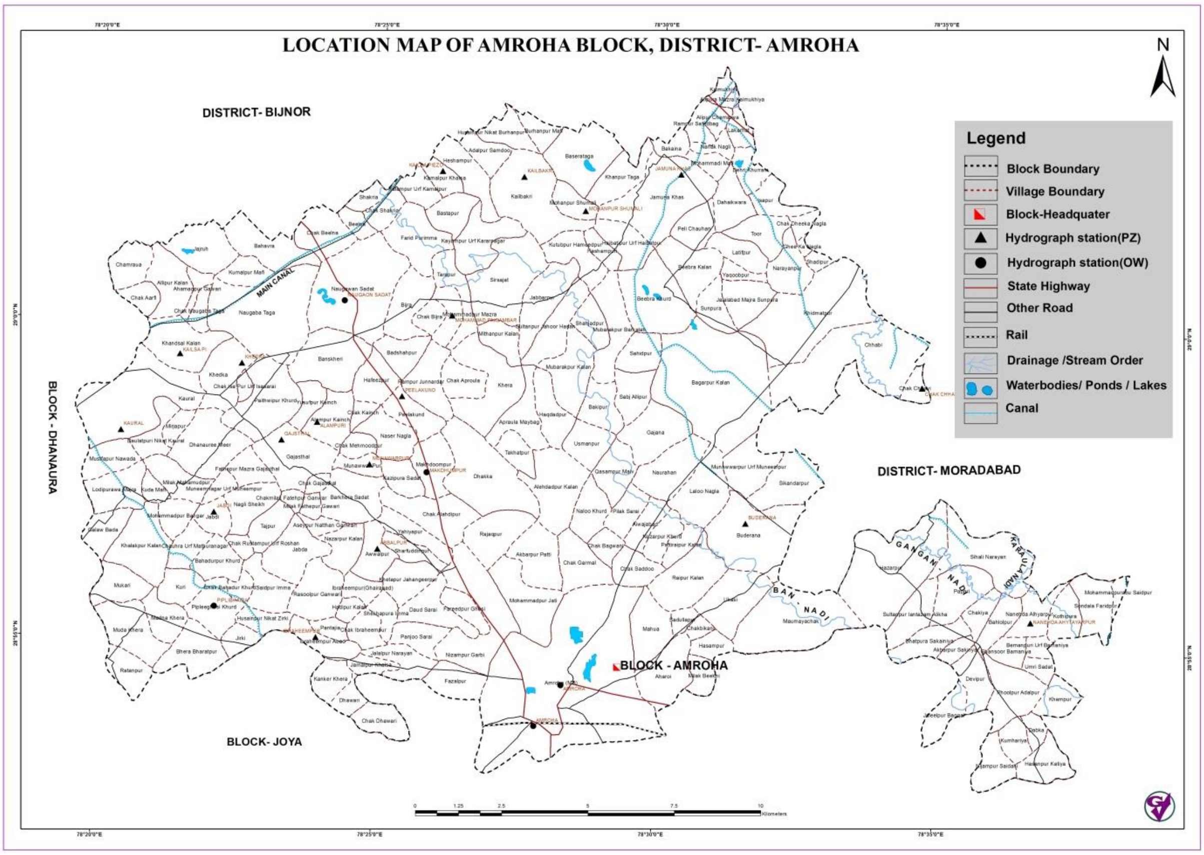


Fig-11: Drainage map of Amroha Block, Amroha District

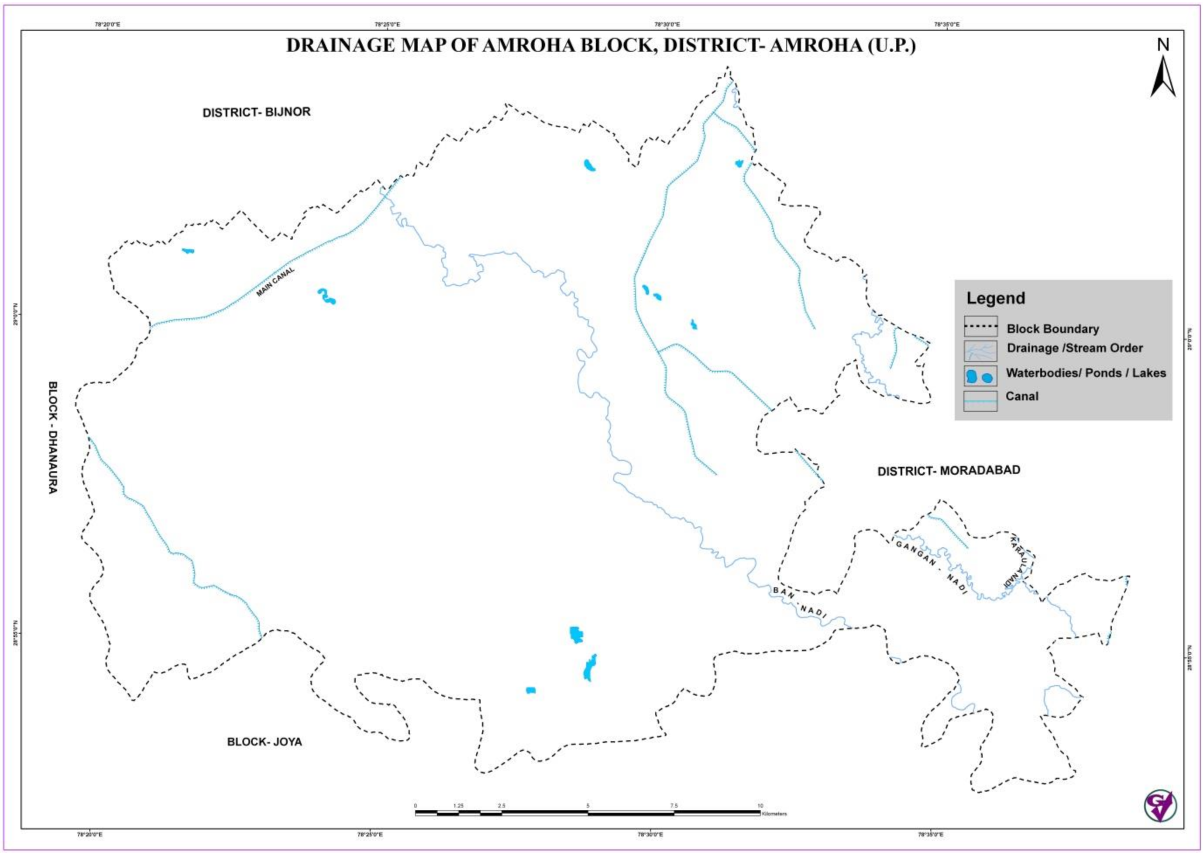


Fig-12: Soil map of Amroha Block, Amroha District

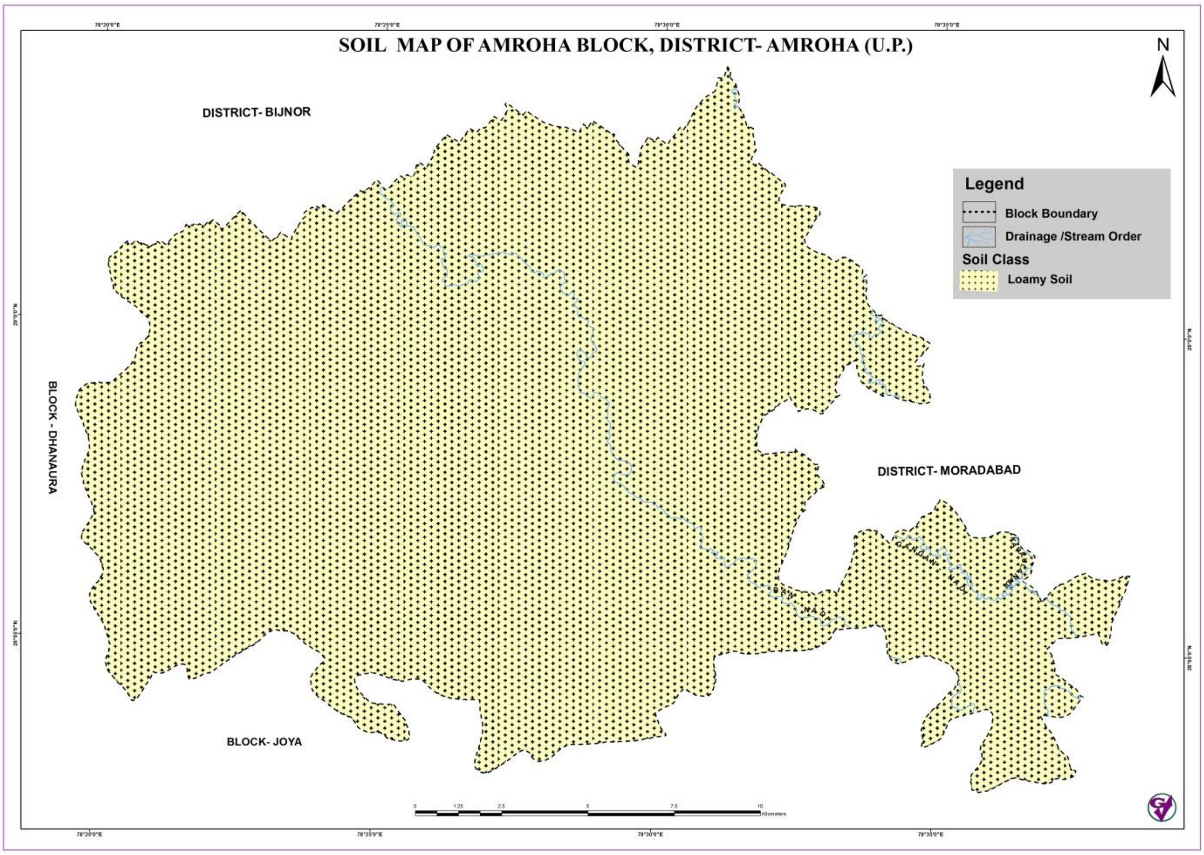


Fig-13: Slope map of Amroha Block, Amroha District

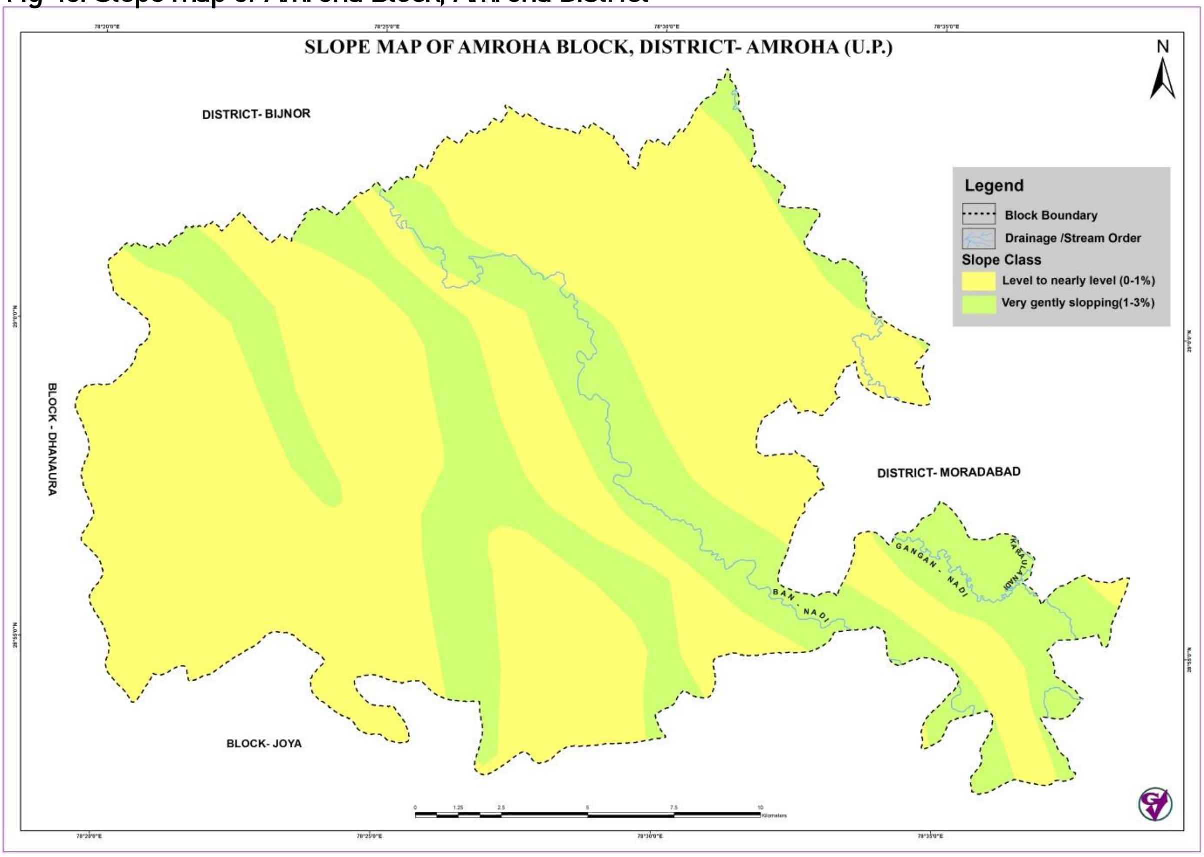


Fig-14: Geological map of Amroha Block, Amroha District

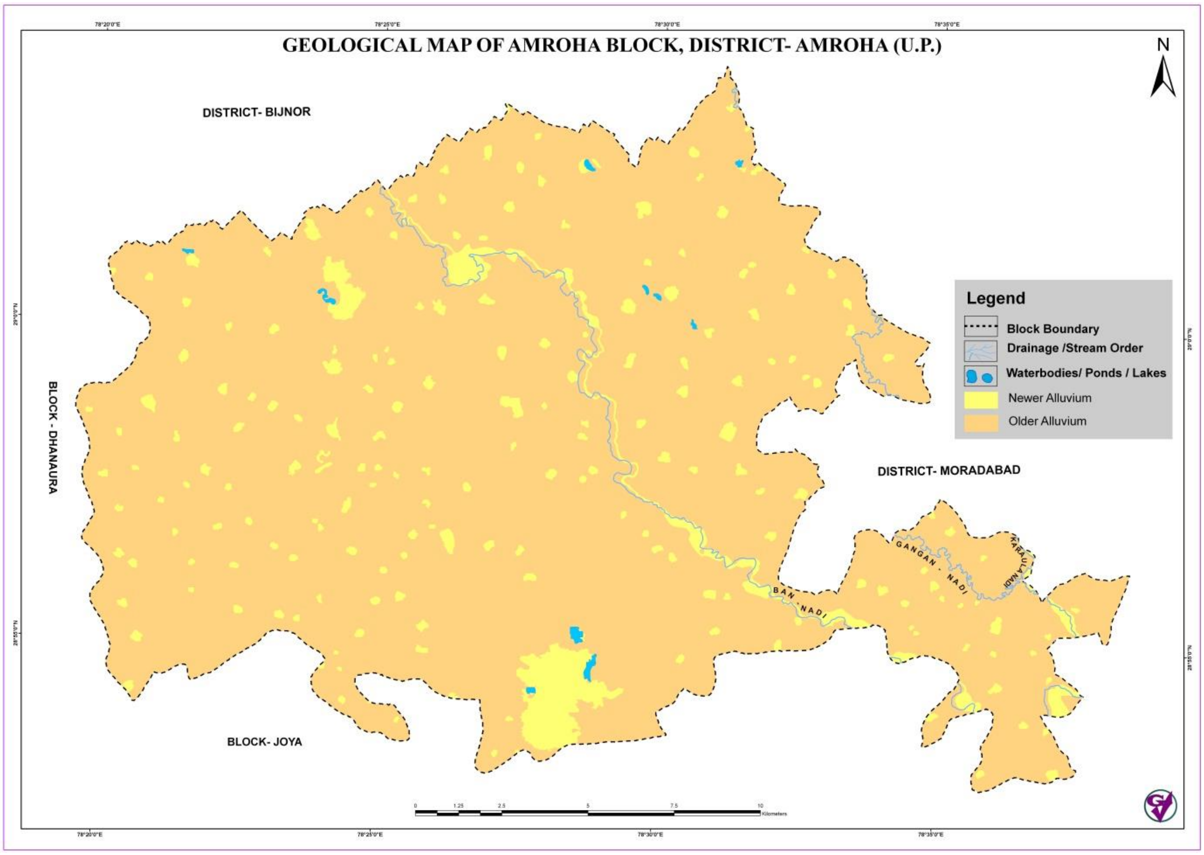


Fig-15: Geomorphological map of Amroha Block, Amroha District

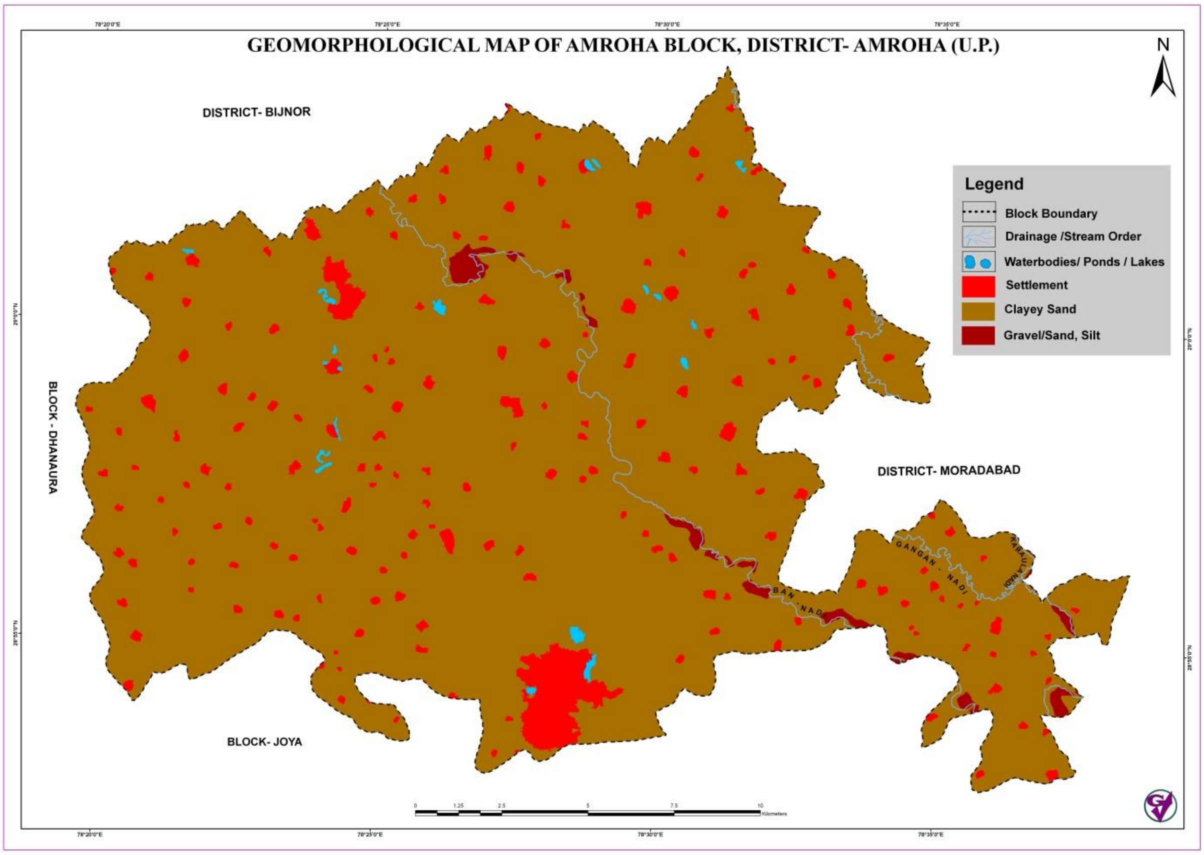
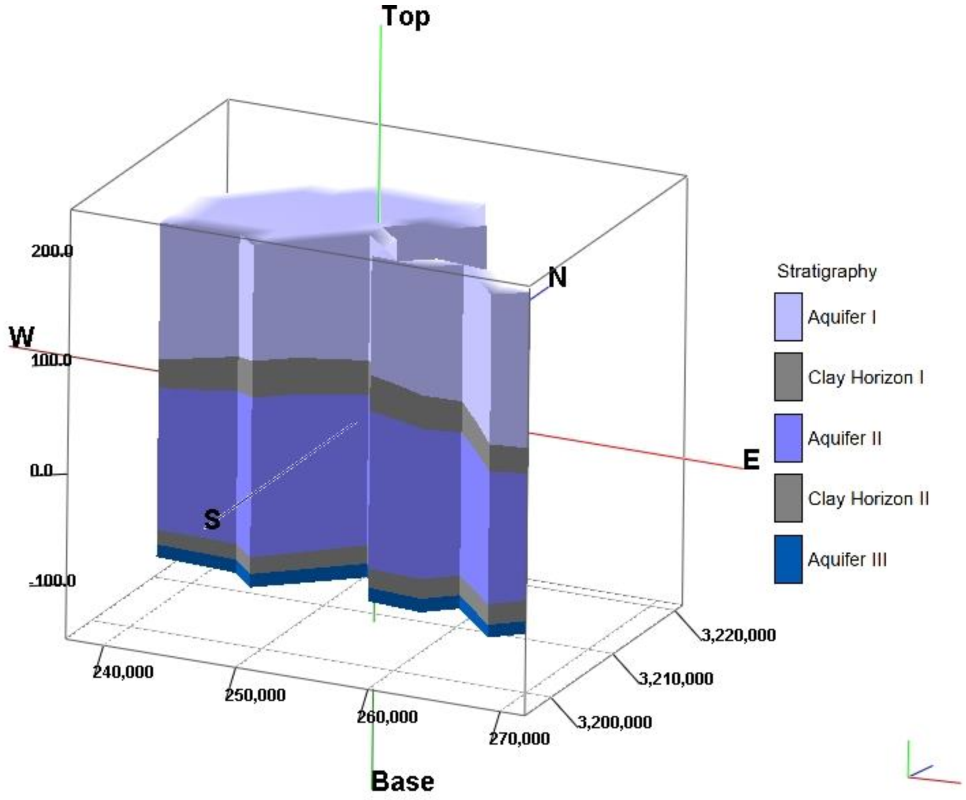


Fig-16: Aquifers disposition map of Amroha Block, Amroha District



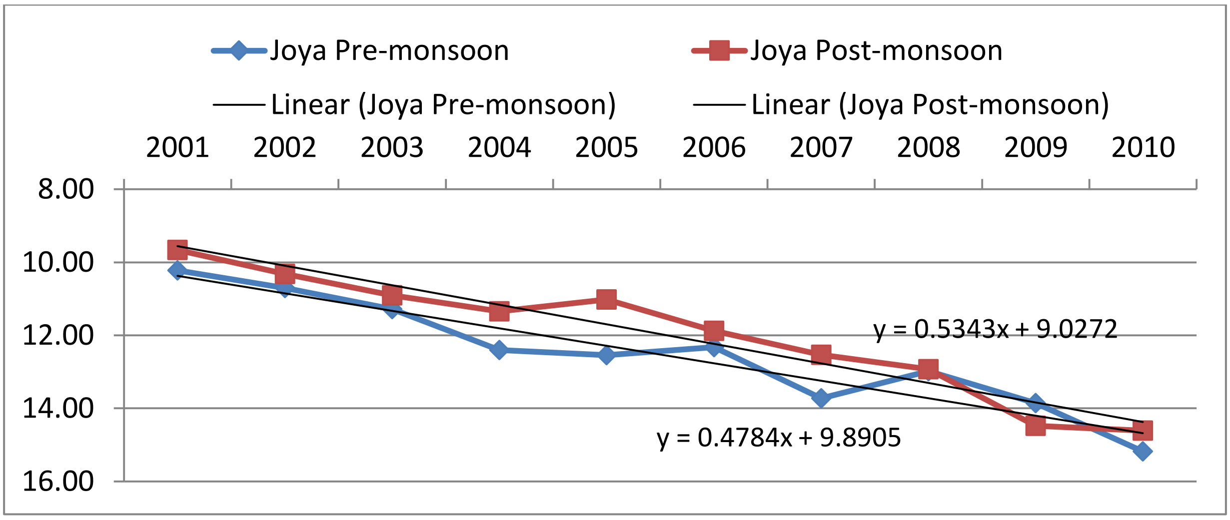
ii. JOYA BLOCK (415.60 sq. km)

Population (2011)	Rural-327079 Urban-18337 Total-228765
Rainfall 2016 (Amroha Dist.)	733.92 mm
Average Annual Rainfall (Joya block)	733.92 mm
Rainfall Infiltration Factor (in fraction)	0.22
Specific Yield (in fraction)	0.16
Agriculture and Irrigation	Major Crops- Rice, Wheat (Dist) Other crops- Sugarcane, Potatoes, Pulses, Oilseeds (Dist) Net Area Sown-324.94 sq. km Net Irrigated Area-316.89 sq. km

Ground Water Resource Availability: Ground Water Resources available in the different group of aquifers. Aquifer I (134m) is very prominent in terms of thickness and geographic extent. Aquifer II is below 140-150m bgl and extends up to 270-280m bgl. Block is categorized as Over-exploited as per 2017 assessment.

Ground water Extraction: Information regarding the abstraction from different aquifers is not available, but there are drinking water supply tapping combined aquifer and most of the irrigation is carried out by tapping shallow aquifers.

Water level Behaviour (2016): Pre Monsoon-~15.20m bgl &Post Monsoon-~14.45mbgl



Aquifer Disposition: Combined Aquifer System

Aquifer Group	Geology	Type of aquifer	Aquifer Depth Range (mbgl)
Aquifer I	Quaternary alluvial deposits	Unconfined	G.L-134
Aquifer II		Unconfined to Confined	144-278
Aquifer III		Unconfined to Confined	Beyond 290

Aquifer comprises of freshwater only and the main aquifer formation is sand.

The non-aquifer material comprise of clay.

Ground Water Resource, Extraction, Contamination and Other Issues

Ground Water Resource (in Ham)	Annual Extractable Ground Water Resources	72.82
	In-storage Aquifer I	6577.00
	Dynamic Aquifer II	0.04
	In-storage Aquifer II	16.97
	Total	6666.83
Ground Water Abstraction (in Ham)	Irrigation (2017)	98.94
	Domestic & Industrial (2017)	6.94
Future demand for domestic & industrial use (2025)(in Ham)		8.27
Net Ground Water Availability for Future use (in Ham)		0.00
Stage of Ground Water Extraction (%)		147.70
Categorization of Block		Over Exploited
Chemical quality of ground water		Potable for drinking and irrigation
Other issues		Deeper water level and declining water trend

Ground Water Resource Enhancement

Aquifer wise space available for artificial recharge and proposed interventions	Volume of unsaturated unconfined aquifer
Other intervention proposed	Artificial recharge and watershed management and farm-pit recharge

Demand side Interventions

Advanced irrigation practices	Drip irrigation, use of sprinklers and lining of underground pipelines
Change in cropping pattern	Paddy and Sugarcane cultivation can be replaced with less water intensive crops
Alternate water sources	Tanks, ponds, canal and river.
Regulation and control	Over-exploited Category

GROUND WATER MANAGEMENT OPTIONS:

Ground water issues can be addressed by focussing on measures to increase recharge and reducing the draft. It can be managed by a mix of measures such as:

Supply Side Management

- Water conservation and Artificial Recharge to ground water
- On Farm Activities and initiatives for ponds creation by farmers in their farmland.

Demand Side Management

- Adoption of techniques to enhance water Use Efficiency
- Adoption of new irrigation practices in sugarcane cultivation area to save 35-40 % irrigation water

Increasing Storage Capacity and Conservation of Rainfall: Supply Side Management

Recharge / Water Conservation

- Water conservation structures such as check dams, farm ponds, nala bunds etc result in ground water recharge to the tune of about 50% of the storage capacity considering 3 annual fillings. Further construction of recharge trenches in the upstream side of the check dams is also proposed to enhance rate of infiltration by about 30 to 40%.
- The existing ponds and tanks lose their storage capacity as well as the natural ground water recharge due to siltation and encroachment by farmers for agriculture purposes. Through desilting, coupled with providing proper waste weir, the village tanks can be converted into recharge structure.

Watershed development and management

- The development of watershed of Ban Nadi (139.67 sq. km), Ganga River (183.01 sq. km) and Gangan Nadi (7.78 sq. km) holds key for the sustainable management of the rain water that can be utilized for artificial recharge of ground water.

On Farm Practices: Supply Side Management

- Levelling of crop field is essential for uniform distribution of water. Laser levelling has been found very effective ensuring saving of 10 to 30% of applied irrigation.
- The in situ farm activities such as contour bunding, land levelling, bench terracing, water harvesting structures, afforestation and diversification of cropping pattern are other measures to increase recharge in the block.

Enhancing Water Use Efficiency:

Demand Side Management

Efficient irrigation

• In flood/furrow irrigation method more than 50% of applied water is wasted through seepage to deeper level, localized inundation causes loss through evaporation and it leaches out the nutrients from the plant.

• Adoption of efficient irrigation practices in sugarcane cultivation area to save 35-40 % irrigation water. Such practices are as under

1. Irrigation Scheduling at Critical Growth Stages of Sugarcane
2. Ring Pit Method of Sugarcane Planting
3. Skip Furrow Method of Irrigation
4. Trash Mulching
5. Micro Irrigation (Sprinkler/ Drip Irrigation

• While through drip & sprinkler irrigation wastage of irrigational water could be minimized. The conveyance losses (mainly seepage & evaporation) can be saved up to 25 to 40% through utilization of HDPE pipes.

• Agriculture department should promote to conserve the soil moisture by reducing ET losses through cultivation of 'Green Manure'

Diversification of cropping pattern

• Horticulture department should promote Baghwani in the area. This will bring in money without high use of water. These will also help conserve soil moisture.

• Alternate cropping system having lower requirement of water are better option.

• Summer paddy and maize need to be avoided which are grown over substantial area in the block.

• Large scale adoption of rice-wheat rotation system & sugarcane cultivation is the main reason of over exploitation of groundwater. Late sown wheat/peas are replaced by spring maize which consumes more water. Suggested cropping pattern are as under.

• **Kharif**- Maize, cotton, sorghum, pulses, groundnut

• **Rabi**- Mustard, gram, pulses, vegetable

• By adopting suggested cropping pattern 20 to 30% of irrigation water saving is possible

Fig-17: Location map of Joya Block, Amroha District

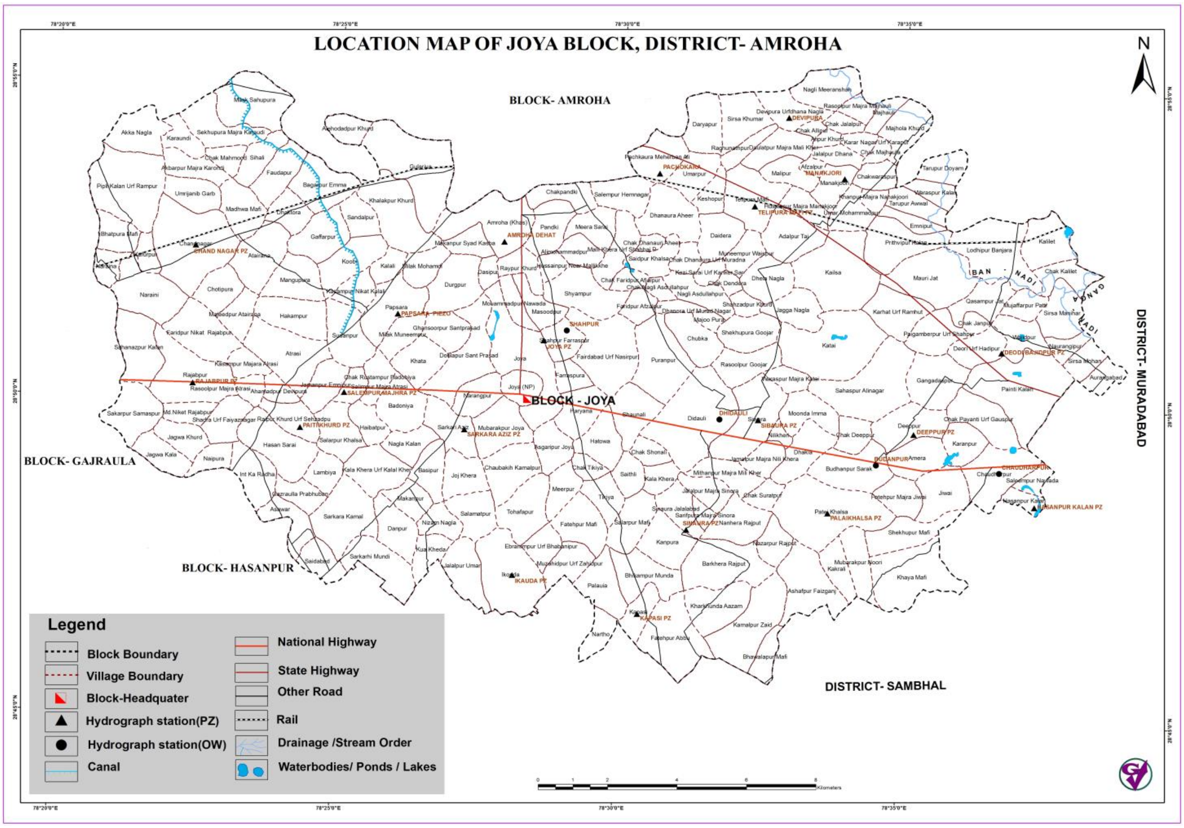


Fig-18: Drainage map of Joya Block, Amroha District

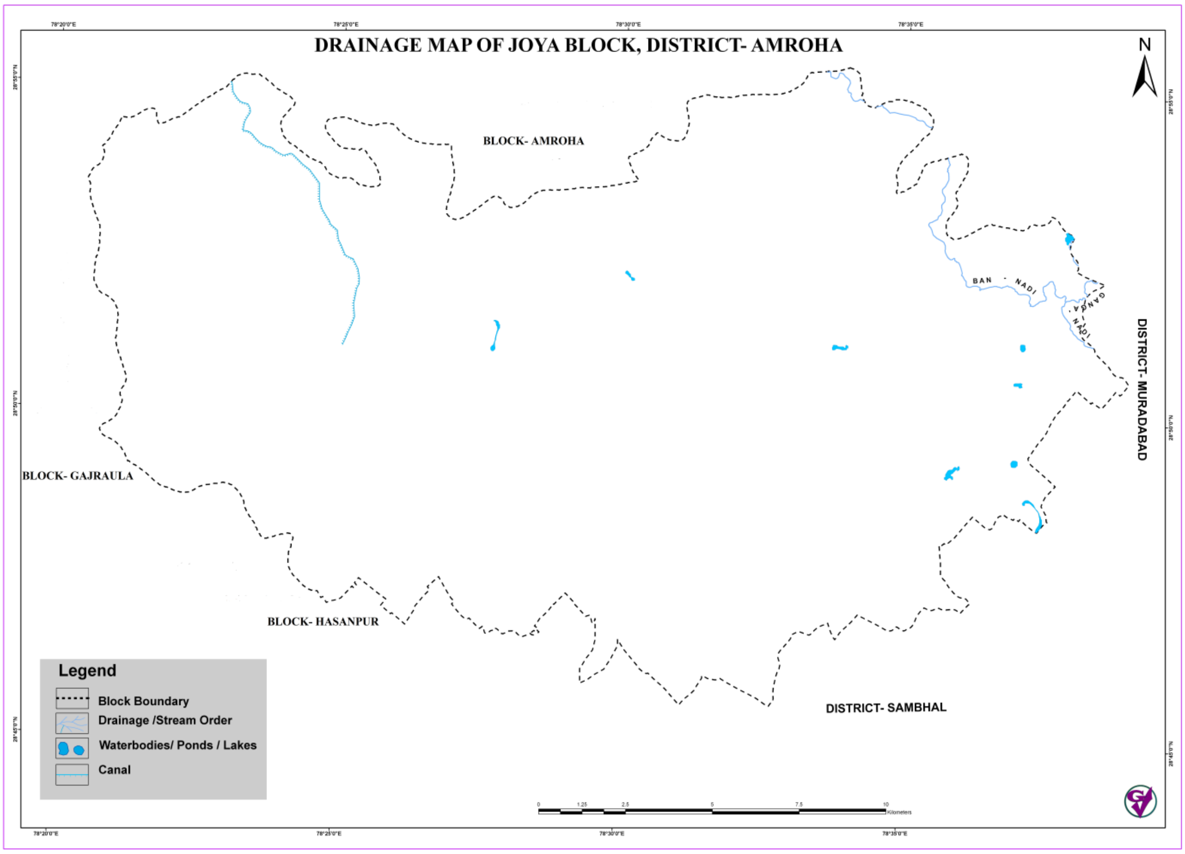


Fig-19: Soil map of Joya Block, Amroha District

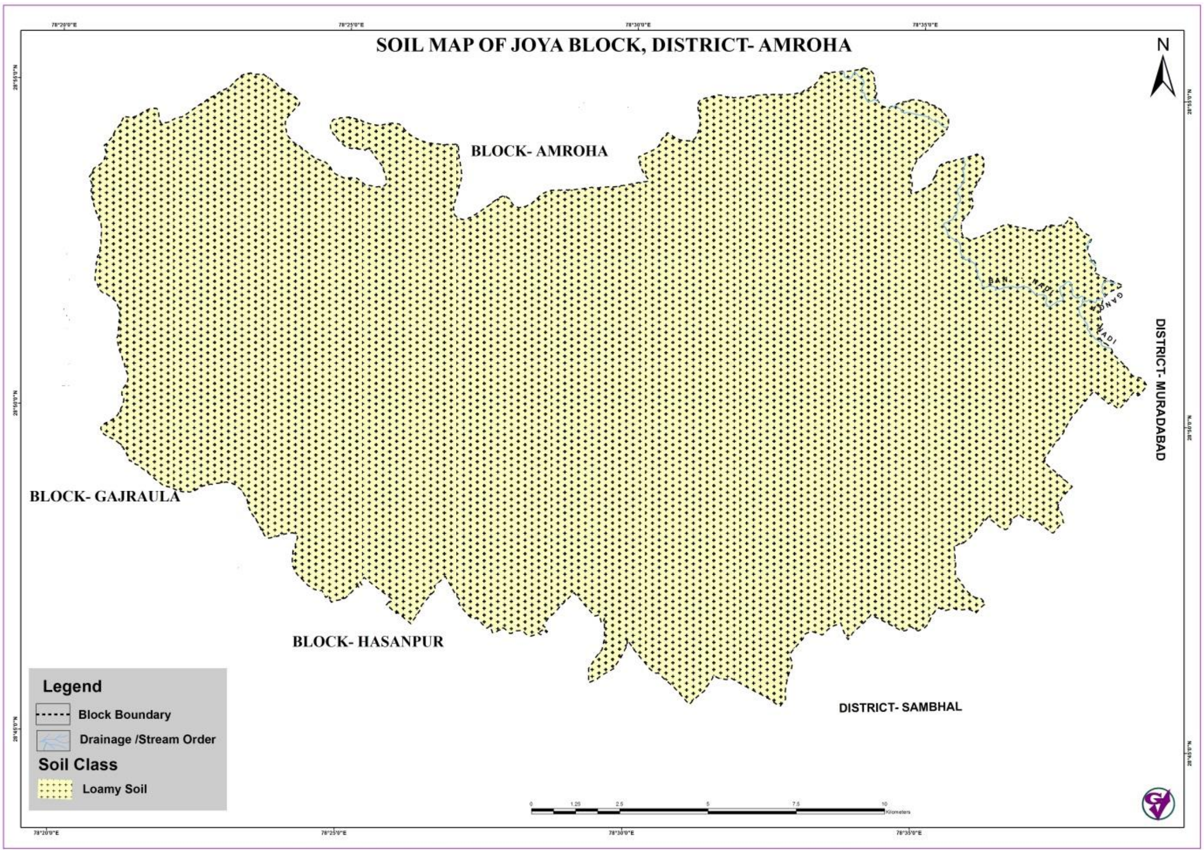


Fig-20: Slope map of Joya Block, Amroha District

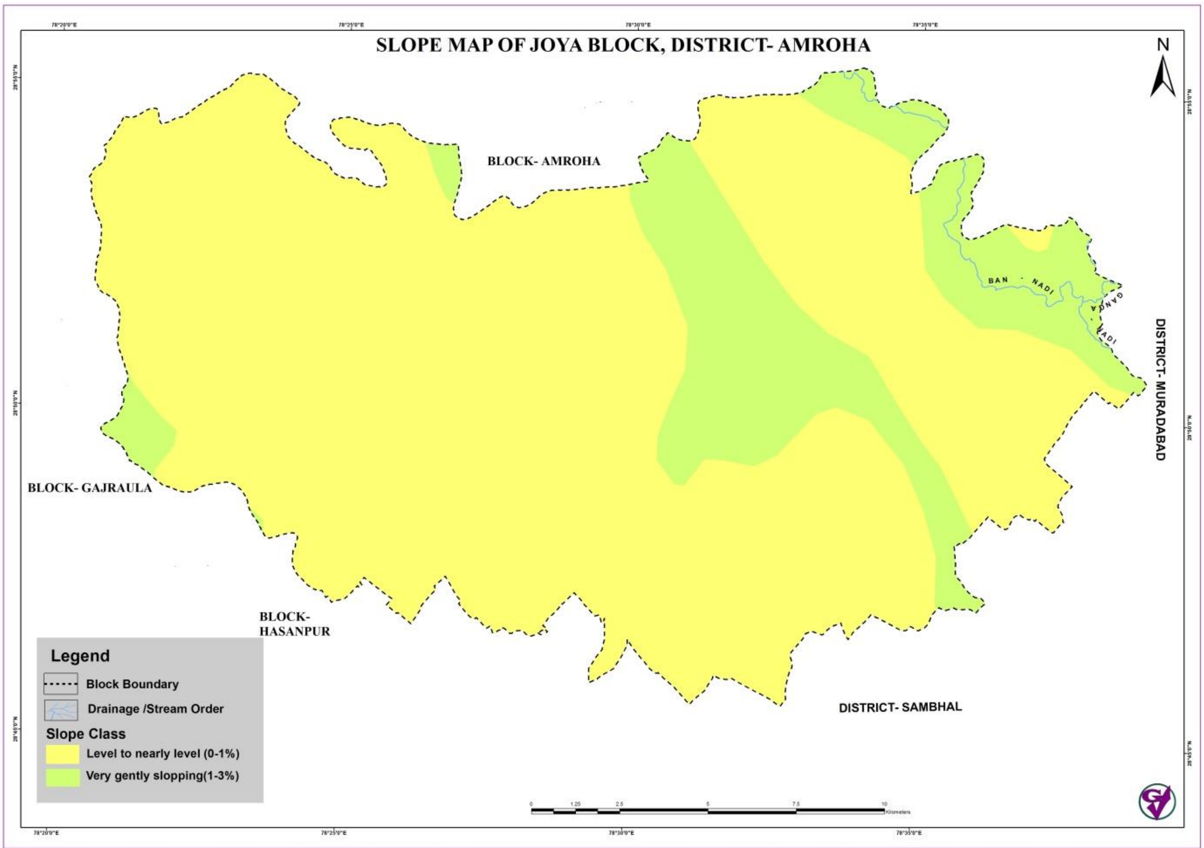


Fig-21: Geological map of Joya Block, Amroha District

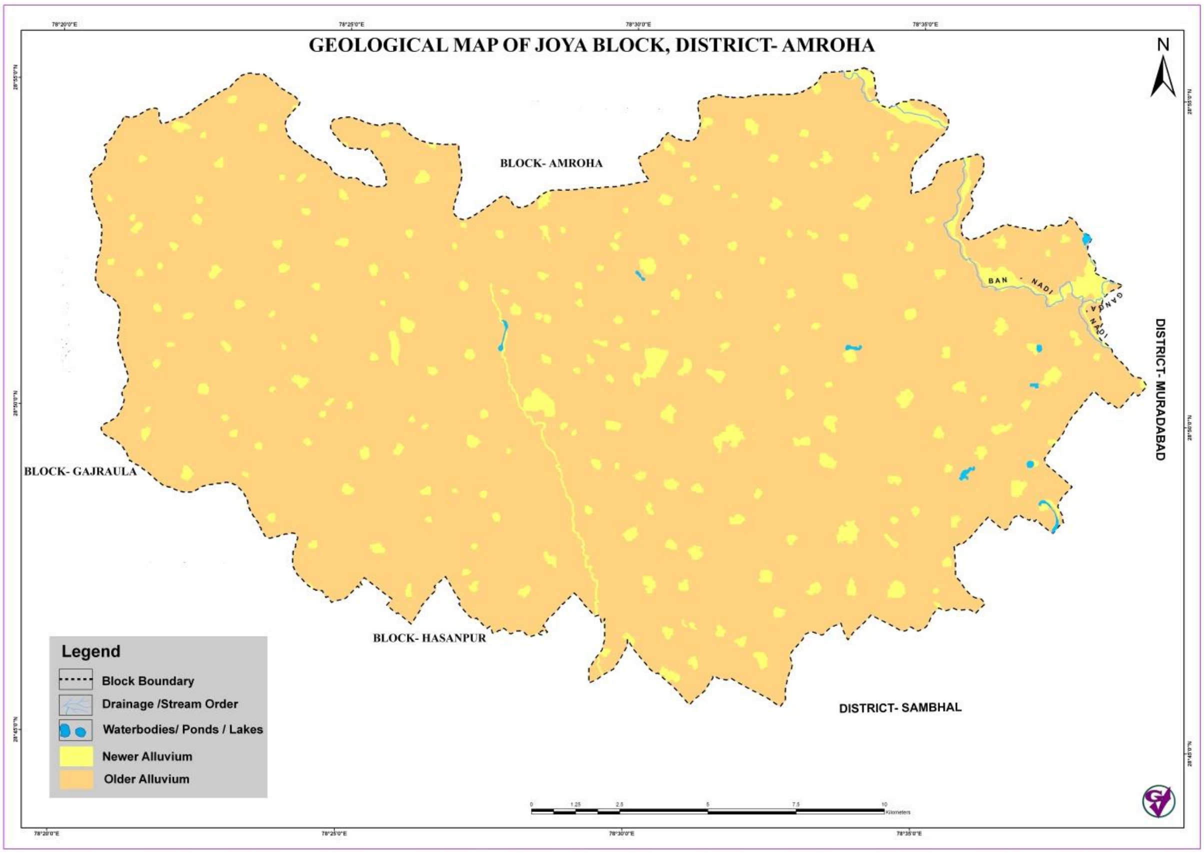


Fig-22: Geomorphological map of Joya Block, Amroha District

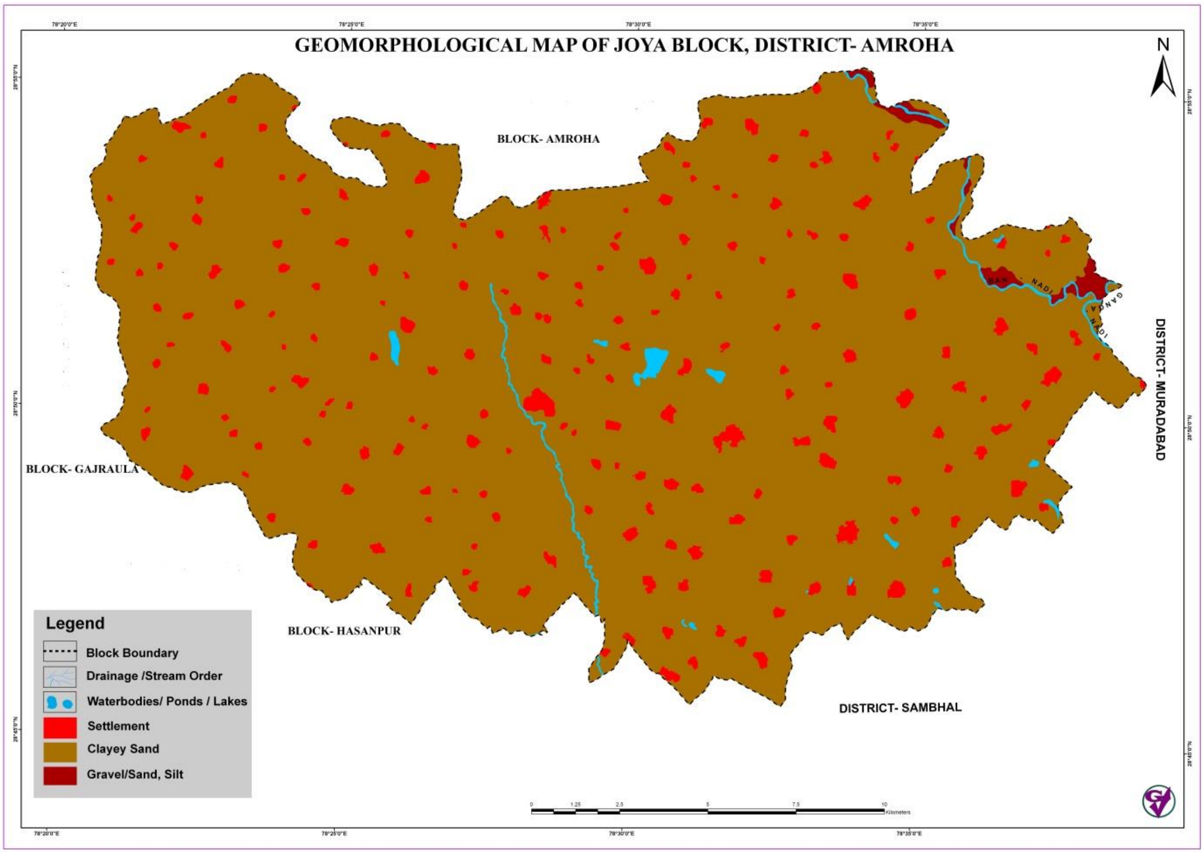
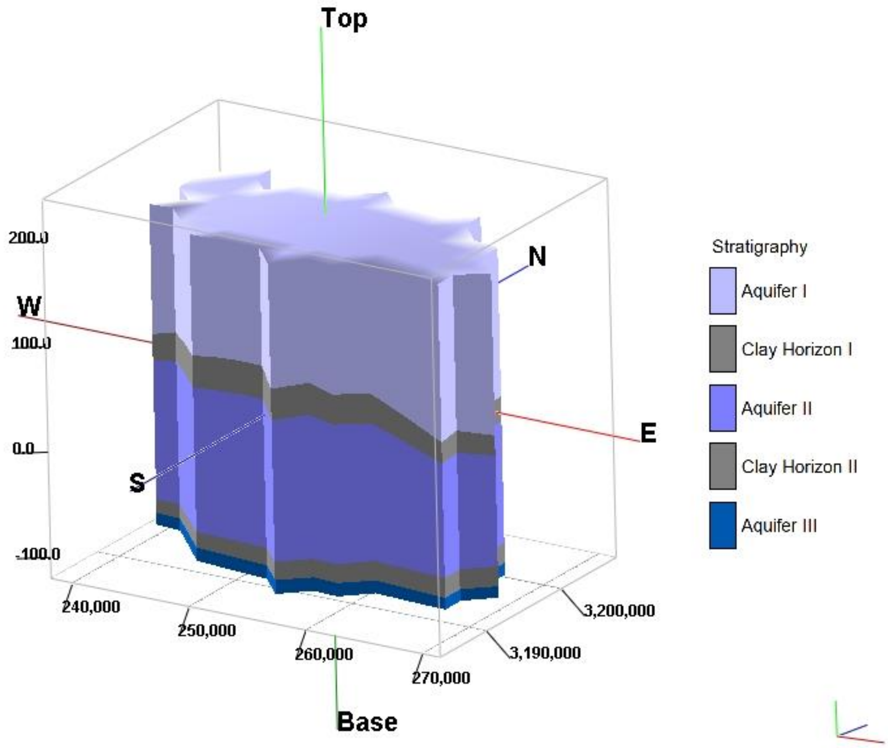


Fig-23: Aquifers disposition map of Joya Block, Amroha District



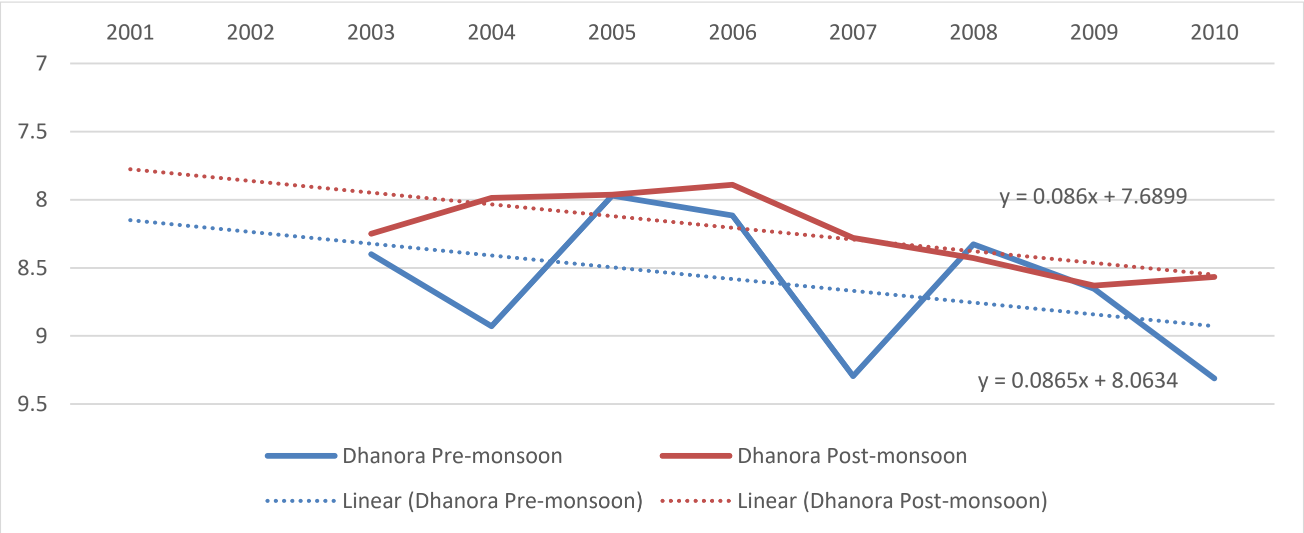
iii. DHANAURA BLOCK (407.80 sq. km)

Population (2011)	Rural-200700 Urban-18337 Total-228765
Rainfall 2017 (Amroha Dist.)	733.92 mm
Average Annual Rainfall (Dhanaura block)	733.92 mm
Rainfall Infiltration Factor (in fraction)	0.22
Specific Yield (in fraction)	0.16
Agriculture and Irrigation	Major Crops- Rice, Wheat (Dist) Other crops- Sugarcane, Potatoes, Pulses, Oilseeds (Dist) Net Area Sown-288.40 sq. km Net Irrigated Area-280.42 sq. km

Ground Water Resource Availability: Ground Water Resources available in the different group of aquifers. Aquifer I (134m) is very prominent in terms of thickness and geographic extent. Aquifer II is below 140-150m bgl and extends up to 270-280m bgl. Block is categorized as Over-exploited as per 2017 assessment.

Ground water Extraction: Information regarding the abstraction from different aquifers is not available, but there are drinking water supply tapping combined aquifer and most of the irrigation is carried out by tapping shallow aquifers.

Water level Behaviour (2016): Pre Monsoon-~15.16m bgl & Post Monsoon-~11.91m bgl.



Aquifer Disposition: Combined Aquifer System

Aquifer Group	**Geology**	**Type of aquifer**	**Aquifer Depth Range (mbgl)**
Aquifer I	Quaternary alluvial deposits	Unconfined	G.L-134
Aquifer II		Unconfined to Confined	144-278
Aquifer III		Unconfined to Confined	Beyond 290

Aquifer comprises of freshwater only and the main aquifer formation is sand.

The non-aquifer material comprises of clay.

Ground Water Resource, Extraction, Contamination and Other Issues

Ground Water Resource (in mcm)	Dynamic Aquifer I (2017)	90.01
	In-storage Aquifer I (2017)	6725
	Dynamic Aquifer II	0.04
	In-storage Aquifer II	16.66
	Total	6812.22
Ground Water Abstraction (in mcm)	Irrigation (2017)	88.36
	Domestic & Industrial (2017)	5.70
Future demand for domestic & industrial use (2025)(in mcm)		6.60
Stage of Ground Water Extraction (%)		104.43
Categorization of Block		Over Exploited
Chemical quality of ground water		Potable for drinking and irrigation
Other issues		Deeper water level and declining water trend

Ground Water Resource Enhancement

Aquifer wise space available for artificial recharge and proposed interventions	Volume of unsaturated unconfined aquifer
Other intervention proposed	Artificial recharge and watershed management and farm-pit recharge

Demand side Interventions

Advanced irrigation practices	Drip irrigation, use of sprinklers and lining of underground pipelines
Change in cropping pattern	Paddy and Sugarcane cultivation can be replaced with less water intensive crops
Alternate water sources	Tanks, ponds, and canal.
Regulation and control	Over-exploited Category

GROUND WATER MANAGEMENT OPTIONS:

Ground water issues can be addressed by focussing on measures to increase recharge and reducing the draft. It can be managed by a mix of measures such as:

Supply Side Management

• Water conservation and Artificial Recharge to ground water

• On Farm Activities and initiatives for ponds creation by farmers in their farmland.

Demand Side Management

• Adoption of techniques to enhance water Use Efficiency

• Adoption of new irrigation practices in sugarcane cultivation area to save 35-40 % irrigation water

Increasing Storage Capacity and Conservation of Rainfall: Supply Side Management

Recharge / Water Conservation

• Water conservation structures such as check dams, farm ponds, nala bunds etc result in ground water recharge to the tune of about 50% of the storage capacity considering 3 annual fillings. Further construction of recharge trenches in the upstream side of the check dams is also proposed to enhance rate of infiltration by about 30 to 40%.

• The existing ponds and tanks lose their storage capacity as well as the natural ground water recharge due to siltation and encroachment by farmers for agriculture purposes. Through desilting, coupled with providing proper waste weir, the village tanks can be converted into recharge structure.

Watershed development and management

• The development of watershed of Bala Nadi (91.63 sq. km) and Ganga River (315.07 sq. km) holds key for the sustainable management of the rain water that can be utilized for artificial recharge of ground water.

On Farm Practices: Supply Side Management

• Levelling of crop field is essential for uniform distribution of water. Laser levelling has been found very effective ensuring saving of 10 to 30% of applied irrigation.

• The in situ farm activities such as contour bunding, land levelling, bench terracing, water harvesting structures, afforestation and diversification of cropping pattern are other measures to increase recharge in the block.

Enhancing Water Use Efficiency:

Demand Side Management

Efficient irrigation

• In flood/furrow irrigation method more than 50% of applied water is wasted through seepage to deeper level, localized inundation causes loss through evaporation and it leaches out the nutrients from the plant.

• Adoption of efficient irrigation practices in sugarcane cultivation area to save 35-40 % irrigation water. Such practices are as under

1. Irrigation Scheduling at Critical Growth Stages of Sugarcane
2. Ring Pit Method of Sugarcane Planting
3. Skip Furrow Method of Irrigation
4. Trash Mulching
5. Micro Irrigation (Sprinkler/ Drip Irrigation

• While through drip & sprinkler irrigation wastage of irrigational water could be minimized. The conveyance losses (mainly seepage & evaporation) can be saved up to 25 to 40% through utilization of HDPE pipes.

• Agriculture department should promote to conserve the soil moisture by reducing ET losses through cultivation of 'Green Manure'

Diversification of cropping pattern

• Horticulture department should promote Baghwani in the area. This will bring in money without high use of water. These will also help conserve soil moisture.

• Alternate cropping system having lower requirement of water are better option.

• Summer paddy and maize need to be avoided which are grown over substantial area in the block.

• Large scale adoption of rice-wheat rotation system & sugarcane cultivation is the main reason of over exploitation of groundwater. Late sown wheat/peas are replaced by spring maize which consumes more water. Suggested cropping pattern are as under.

• **Kharif**- Maize, cotton, sorghum, pulses, groundnut

• **Rabi**- Mustard, gram, pulses, vegetable

• By adopting suggested cropping pattern 20 to 30% of irrigation water saving is possible

Fig-24: Location map of Dhanaura Block, Amroha District

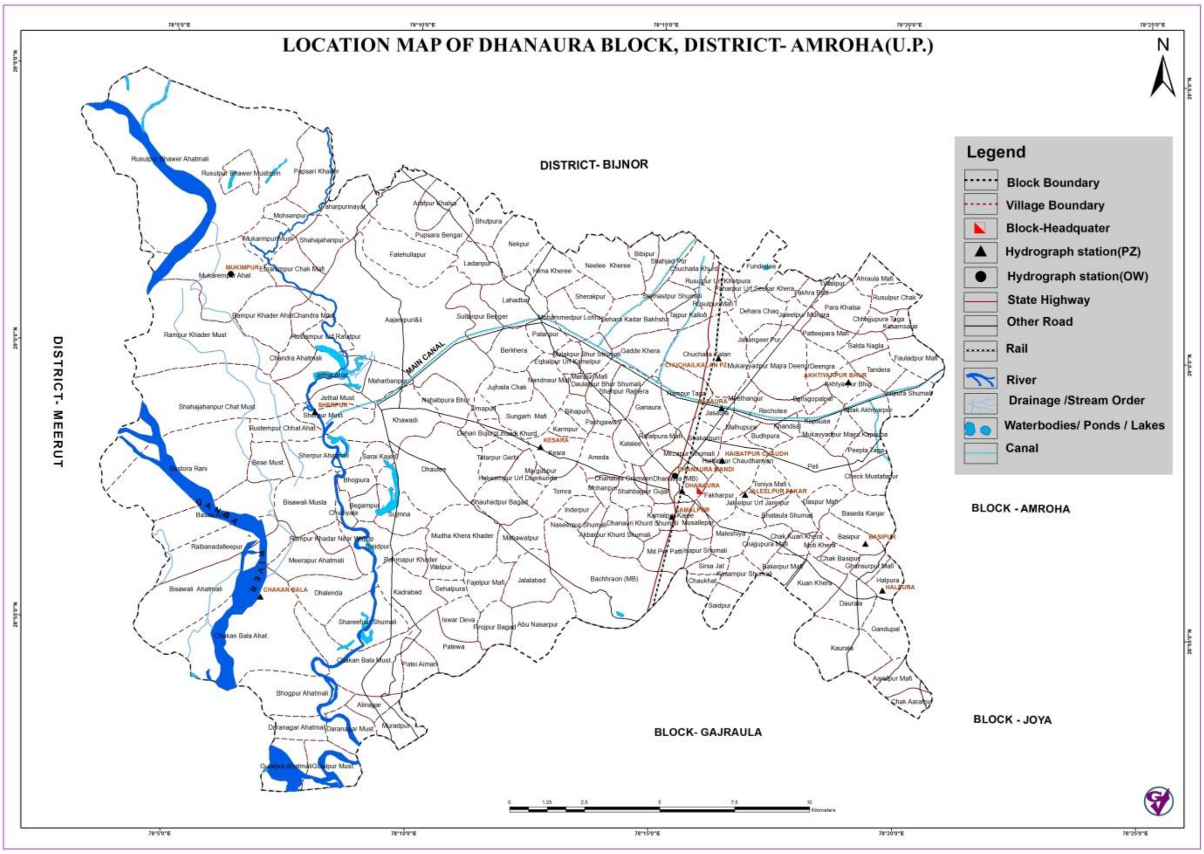


Fig-25: Drainage map of Dhanaura Block, Amroha District

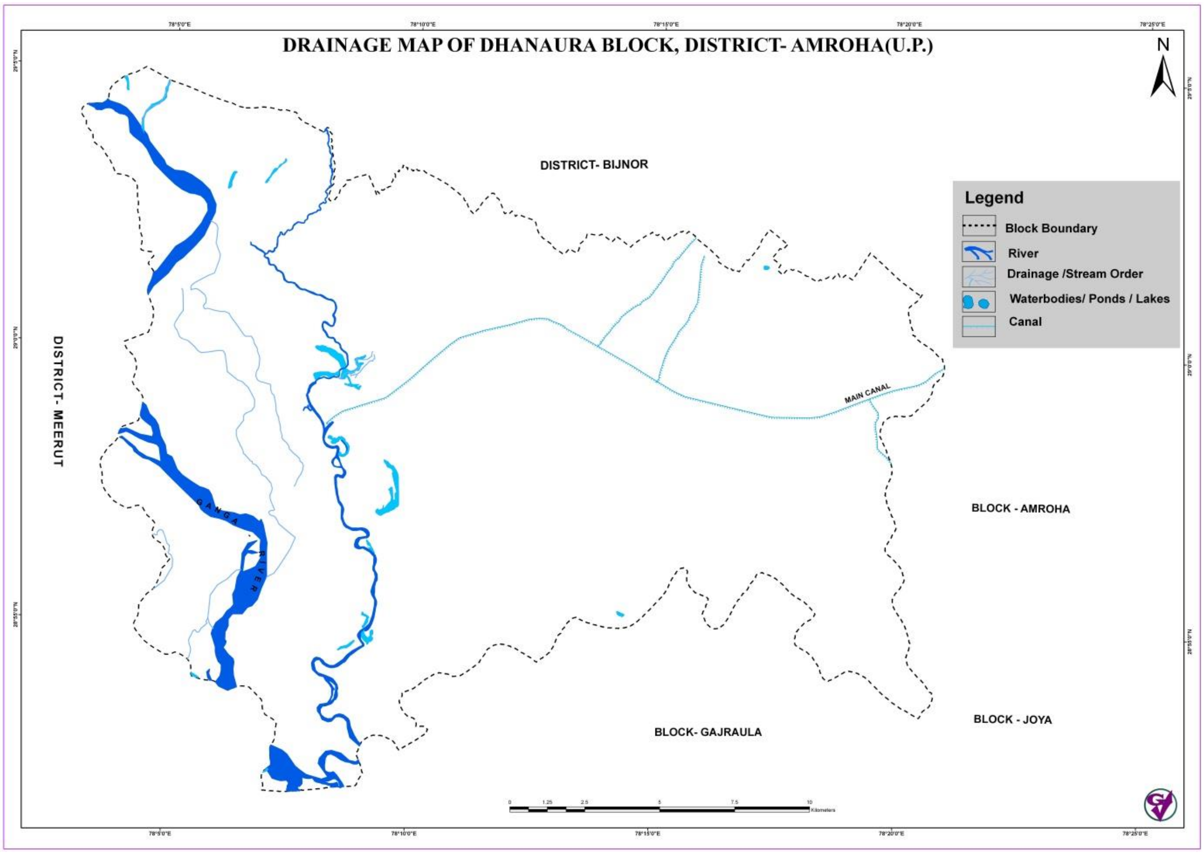


Fig-26: Soil map of Dhanaura Block, Amroha District

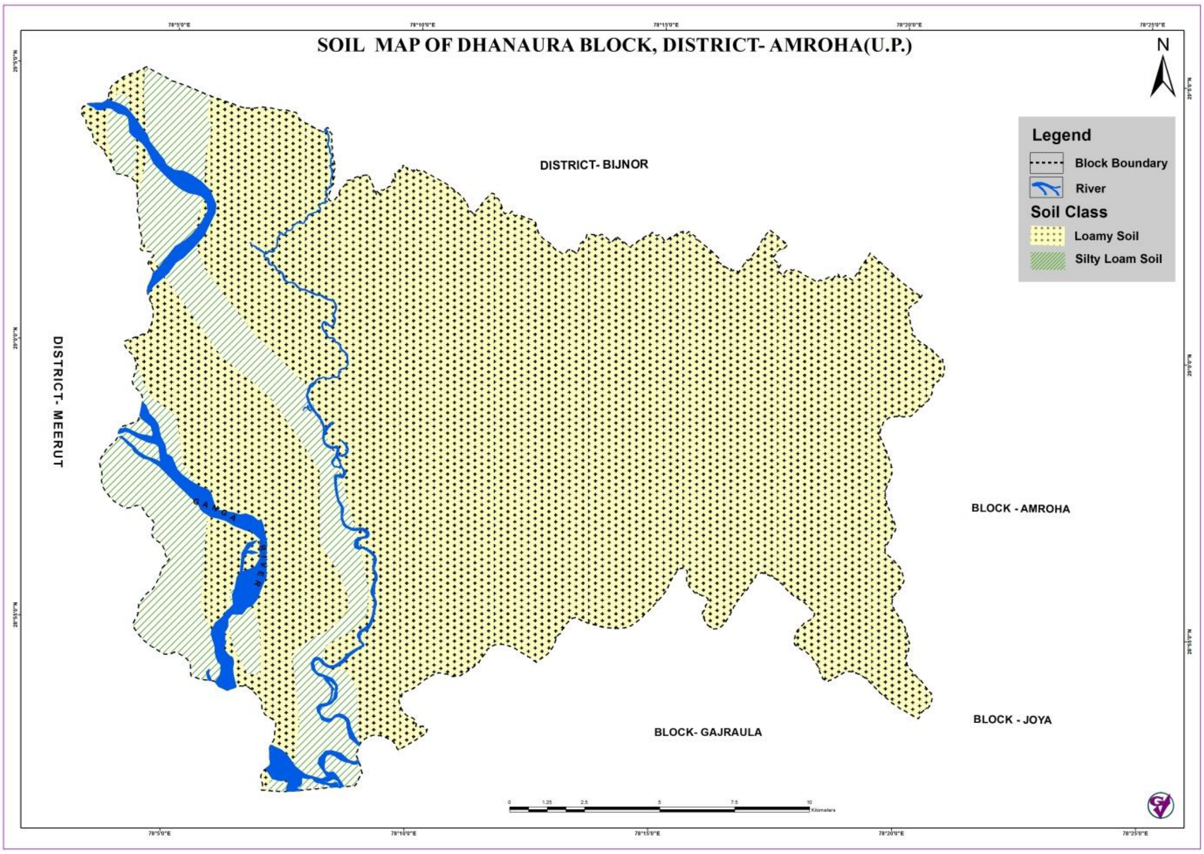


Fig-27: Slope map of Dhanaura Block, Amroha District

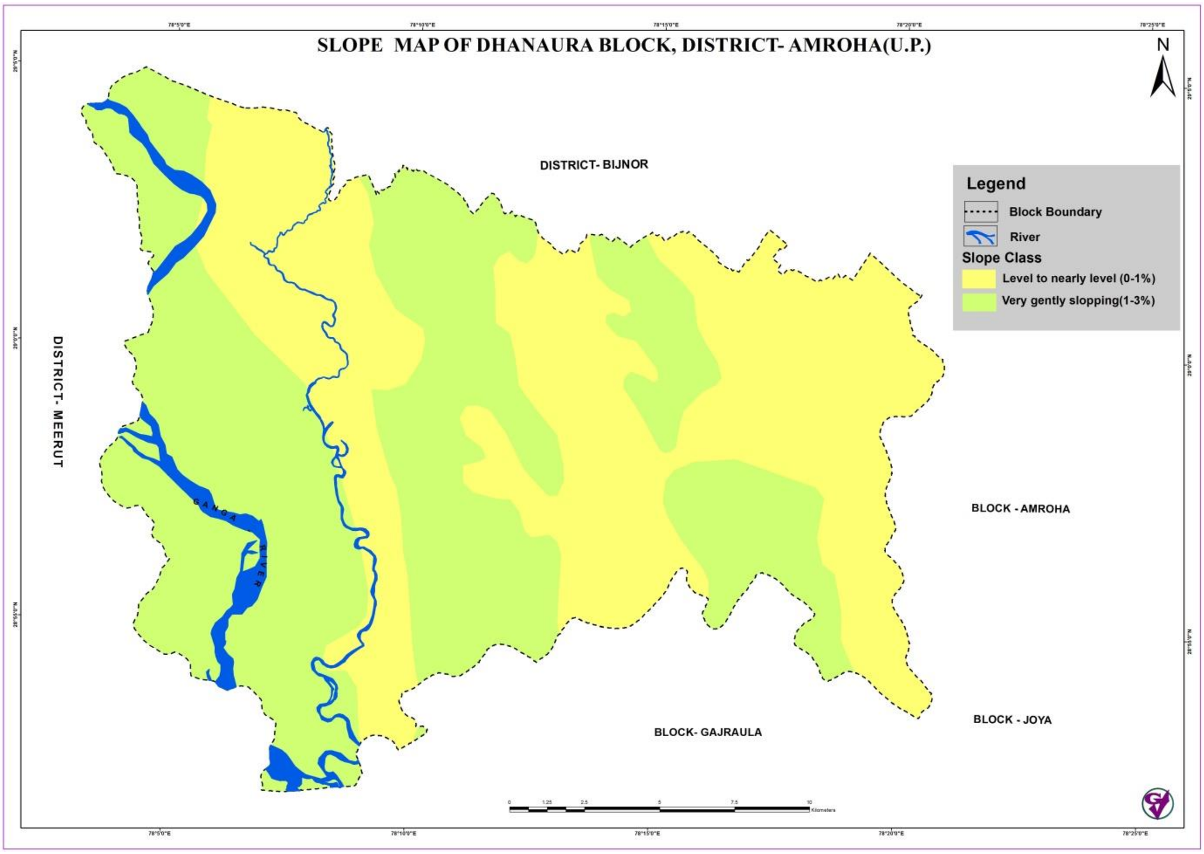


Fig-28: Geological map of Dhanaura Block, Amroha District

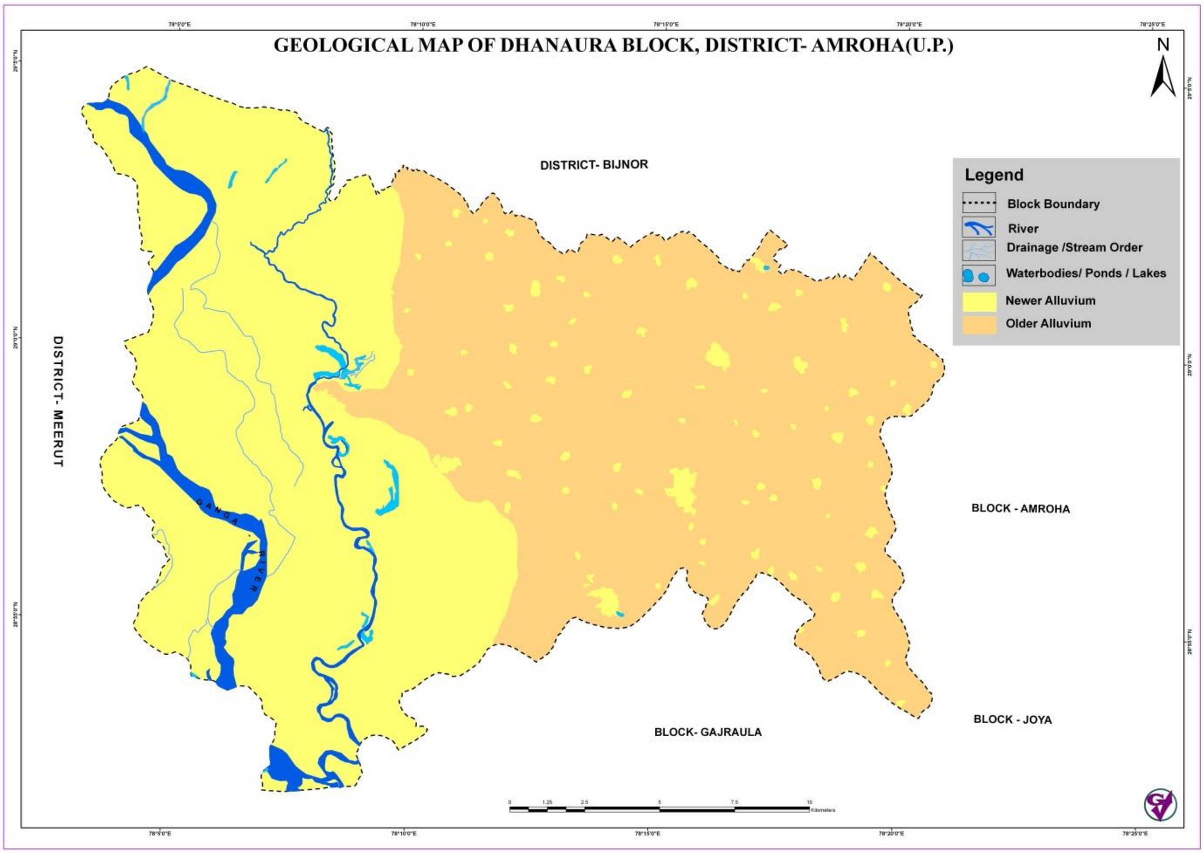


Fig-29: Geomorphological map of Dhanaura Block, Amroha District

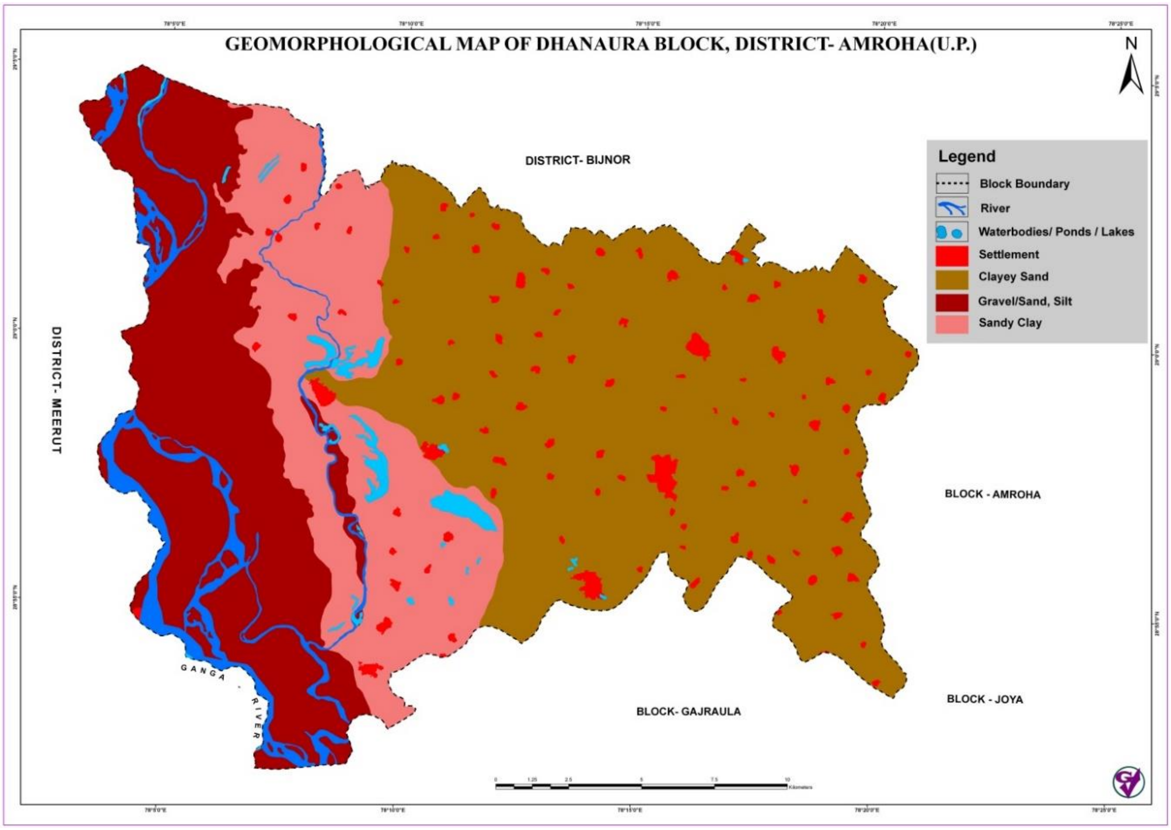
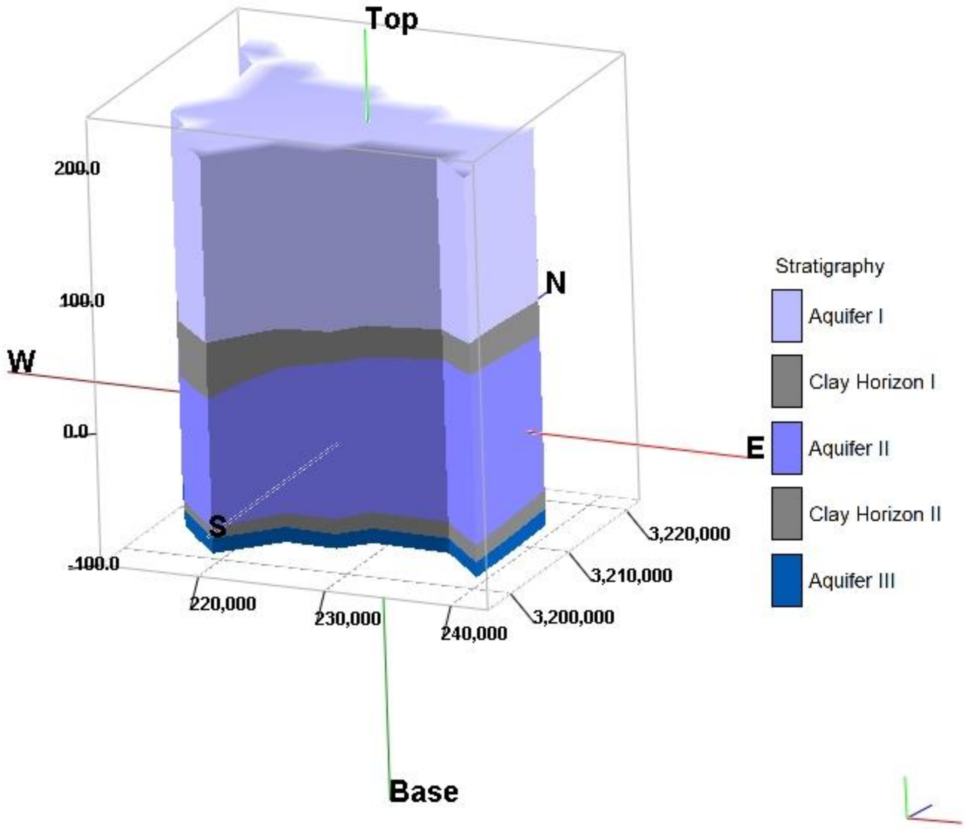


Fig-30: Aquifers disposition map of Dhanaura Block, Amroha District



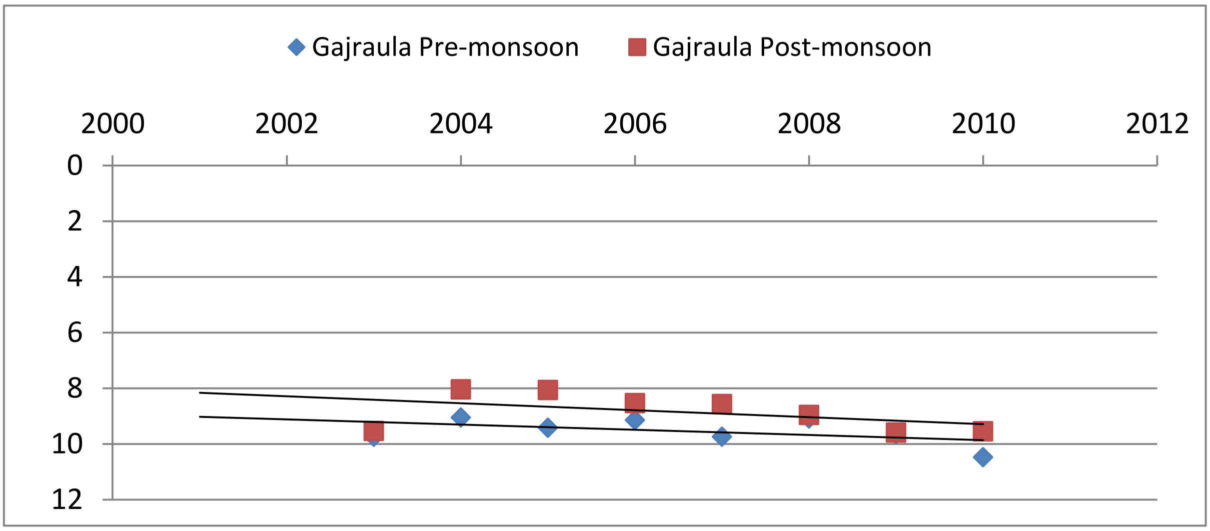
iv. GAJRAULA BLOCK (262.70 sq. km)

Population (2011)	Male-98,708 Female-88,982 Total-1,87,690
Rainfall 2016 (Amroha Dist.)	733.92 mm
Average Annual Rainfall (Gajraula block)	733.92 mm
Rainfall Infiltration Factor (in fraction)	0.22
Specific Yield (in fraction)	0.16
Agriculture and Irrigation	Major Crops- Rice, Wheat (Dist) Other crops- Sugarcane, Potatoes, Pulses, Oilseeds (Dist) Net Area Sown-241.71 sq. km Net Irrigated Area-232.21 sq. km

Ground Water Resource Availability: Ground Water Resources available in the different group of aquifers. Aquifer I (134m) is very prominent in terms of thickness and geographic extent. Aquifer II is below 140-150m bgl and extends up to 270-280m bgl. Block is categorized as Over-exploited as per 2017 assessment having stage of ground water extraction 110.42%.

Ground water Extraction: Information regarding the abstraction from different aquifers is not available, but there are drinking water supply and most of the irrigation is carried out by tapping shallow aquifers.

Water level Behaviour (2018): Pre Monsoon-~13.95m bgl & Post Monsoon-~13.25m bgl



Aquifer Disposition: Combined Aquifer System

Aquifer Group	Geology	Type of aquifer	Aquifer Depth Range (mbgl)
Aquifer I	Quaternary alluvial deposits	Unconfined	G.L-134
Aquifer II		Unconfined to Confined	144-278
Aquifer III		Unconfined to Confined	Beyond 290

Aquifer comprises of freshwater only and the main aquifer formation is sand.

The non-aquifer material comprises of clay.

Ground Water Resource, Extraction, Contamination and Other Issues

Ground Water Resource (in Ham)	Annual Extractable Ground Water Resources	60.18
	In-storage Aquifer I	4454
	Dynamic Aquifer II	0.03
	In-storage Aquifer II	10.73
	Total	4524.94
Ground Water Abstraction (in Ham)	Irrigation (2017)	60.29
	Domestic & Industrial (2017)	6.14
Future demand for domestic & industrial use (2025)(in Ham)		7.34
Net Ground Water Availability for Future use (in Ham)		0.00
Stage of Ground Water Extraction (%)		110.42
Categorization of Block		Over Exploited
Chemical quality of ground water		Potable for drinking and irrigation
Other issues		Deeper water level and declining water trend

Ground Water Resource Enhancement

Aquifer wise space available for artificial recharge and proposed interventions	Volume of unsaturated unconfined aquifer
Other intervention proposed	Artificial recharge and watershed management and farm-pit recharge

Demand side Interventions

Advanced irrigation practices	Drip irrigation, use of sprinklers and lining of underground pipelines
Change in cropping pattern	Paddy and Sugarcane cultivation can be replaced with less water intensive crops
Alternate water sources	Tanks, ponds, canal and river.
Regulation and control	Over-exploited Category

GROUND WATER MANAGEMENT OPTIONS:

Ground water issues can be addressed by focussing on measures to increase recharge and reducing the draft. It can be managed by a mix of measures such as:

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Demand Side Management

• Adoption of techniques to enhance water Use Efficiency

• Adoption of new irrigation practices in sugarcane cultivation area to save 35-40 % irrigation water

Increasing Storage Capacity and Conservation of Rainfall: Supply Side Management

Recharge / Water Conservation

• Water conservation structures such as check dams, farm ponds, nala bunds etc result in ground water recharge to the tune of about 50% of the storage capacity considering 3 annual fillings. Further construction of recharge trenches in the upstream side of the check dams is also proposed to enhance rate of infiltration by about 30 to 40%.

• The existing ponds and tanks lose their storage capacity as well as the natural ground water recharge due to siltation and encroachment by farmers for agriculture purposes. Through desilting, coupled with providing proper waste weir, the village tanks can be converted into recharge structure.

Watershed development and management

• The development of watershed of Bala Nadi (1.32sq. km), Ganga River (193.98 sq. km) and Bagad Nadi (117.23 sq. km) holds key for the sustainable management of the rain water that can be utilized for artificial recharge of ground water.

On Farm Practices: Supply Side Management

• Levelling of crop field is essential for uniform distribution of water. Laser levelling has been found very effective ensuring saving of 10 to 30% of applied irrigation.

• The in situ farm activities such as contour bunding, land levelling, bench terracing, water harvesting structures, afforestation and diversification of cropping pattern are other measures to increase recharge in the block.

Enhancing Water Use Efficiency:

Demand Side Management

Efficient irrigation

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• While through drip & sprinkler irrigation wastage of irrigational water could be minimized. The conveyance losses (mainly seepage & evaporation) can be saved up to 25 to 40% through utilization of HDPE pipes.

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Diversification of cropping pattern

• Horticulture department should promote Baghwani in the area. This will bring in money without high use of water. These will also help conserve soil moisture.

• Alternate cropping system having lower requirement of water are better option.

• Summer paddy and maize need to be avoided which are grown over substantial area in the block.

• Large scale adoption of rice-wheat rotation system & sugarcane cultivation is the main reason of over exploitation of groundwater. Late sown wheat/peas are replaced by spring maize which consumes more water. Suggested cropping pattern are as under.

• **Kharif**- Maize, cotton, sorghum, pulses, groundnut

• **Rabi-** Mustard, gram, pulses, vegetable

• By adopting suggested cropping pattern 20 to 30% of irrigation water saving is possible

Fig-31: Location map of Gajraula Block, Amroha District

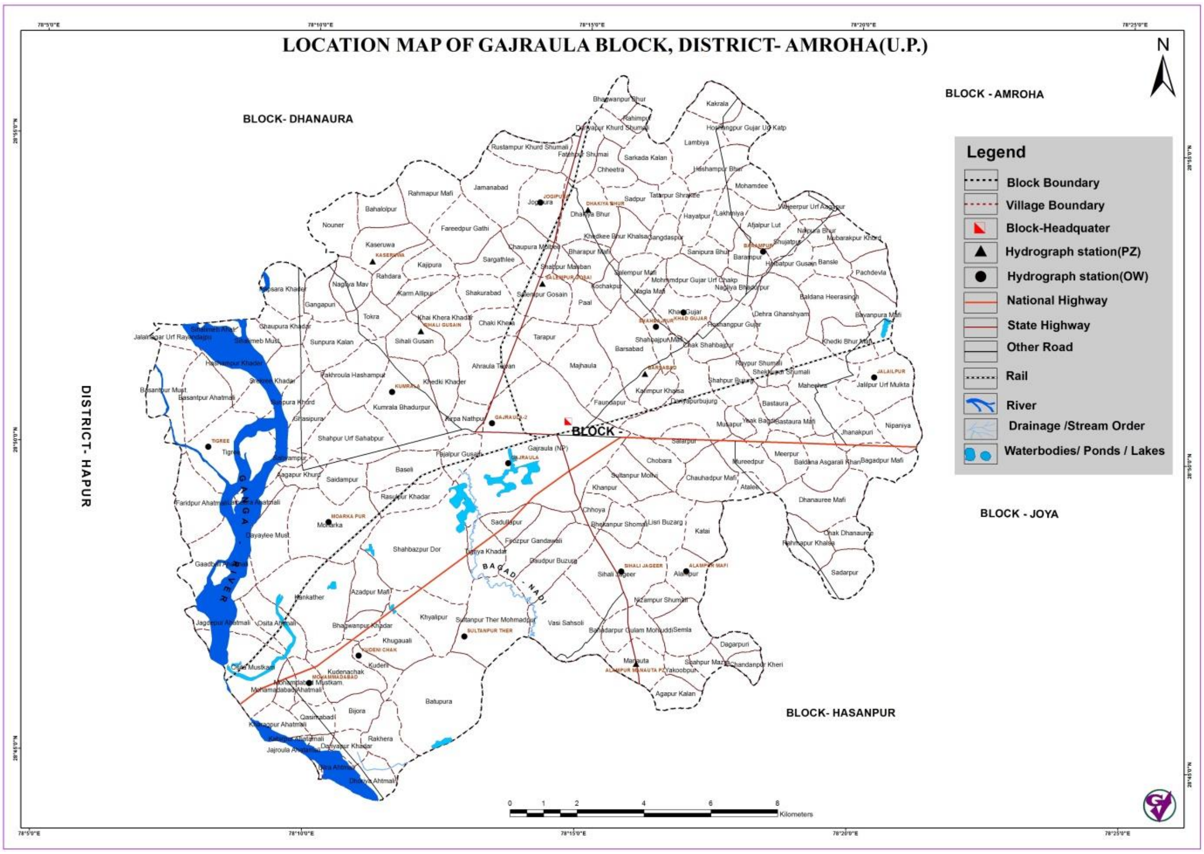


Fig-32: Drainage map of Gajraula Block, Amroha District

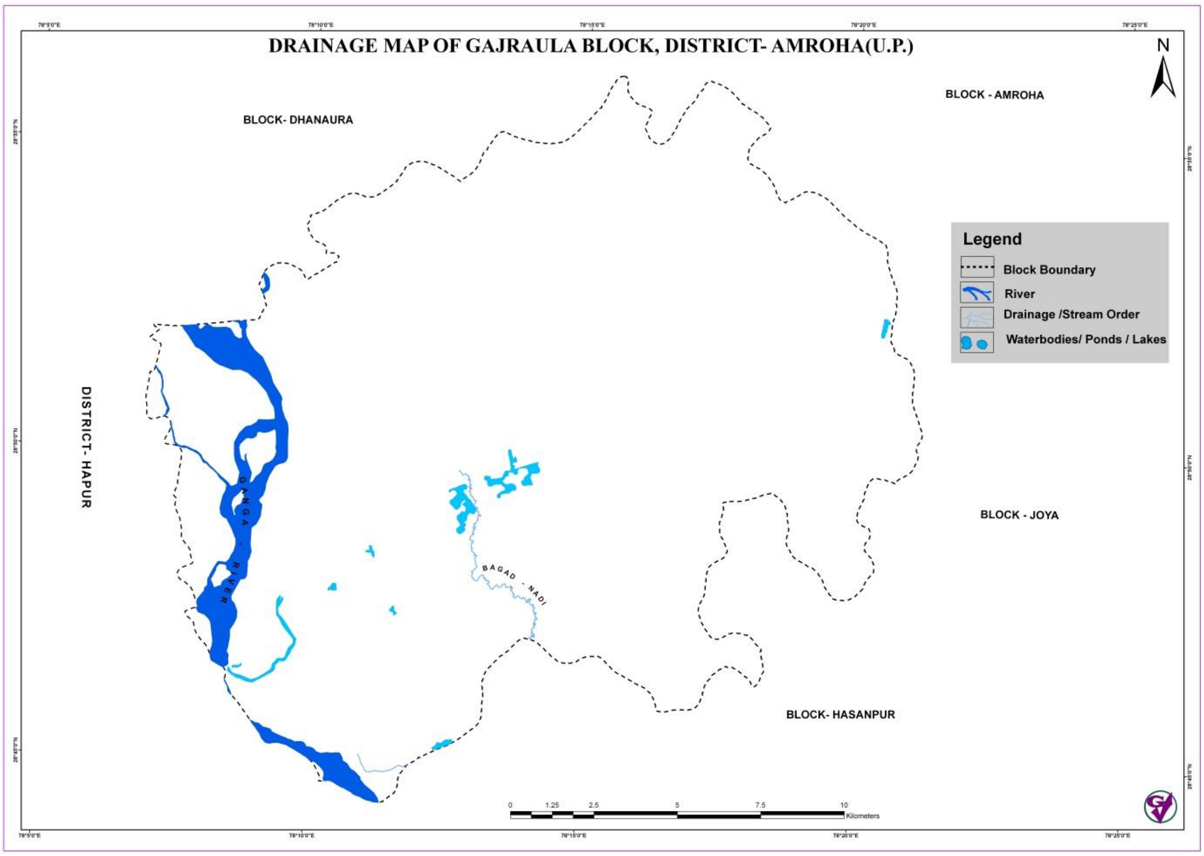


Fig-33: Soil map of Gajraula Block, Amroha District

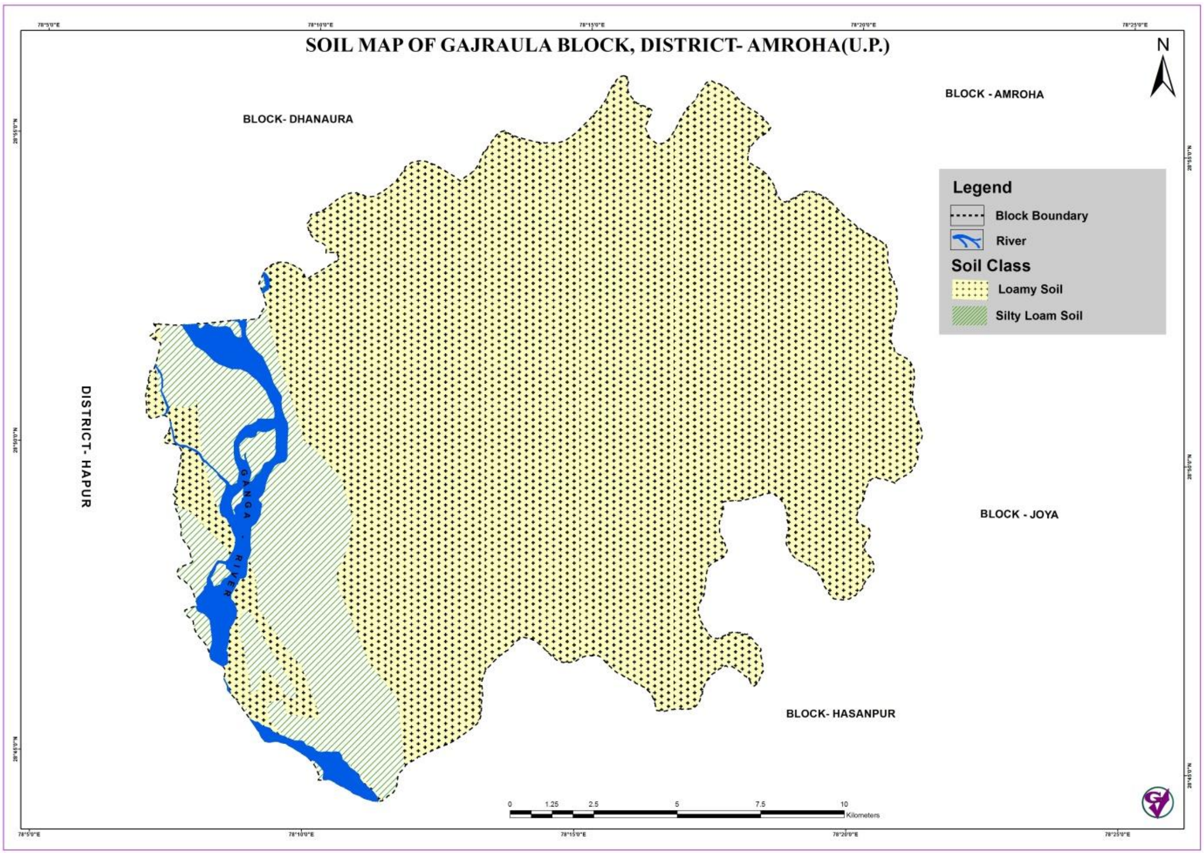


Fig-34: Slope map of Gajraula Block, Amroha District

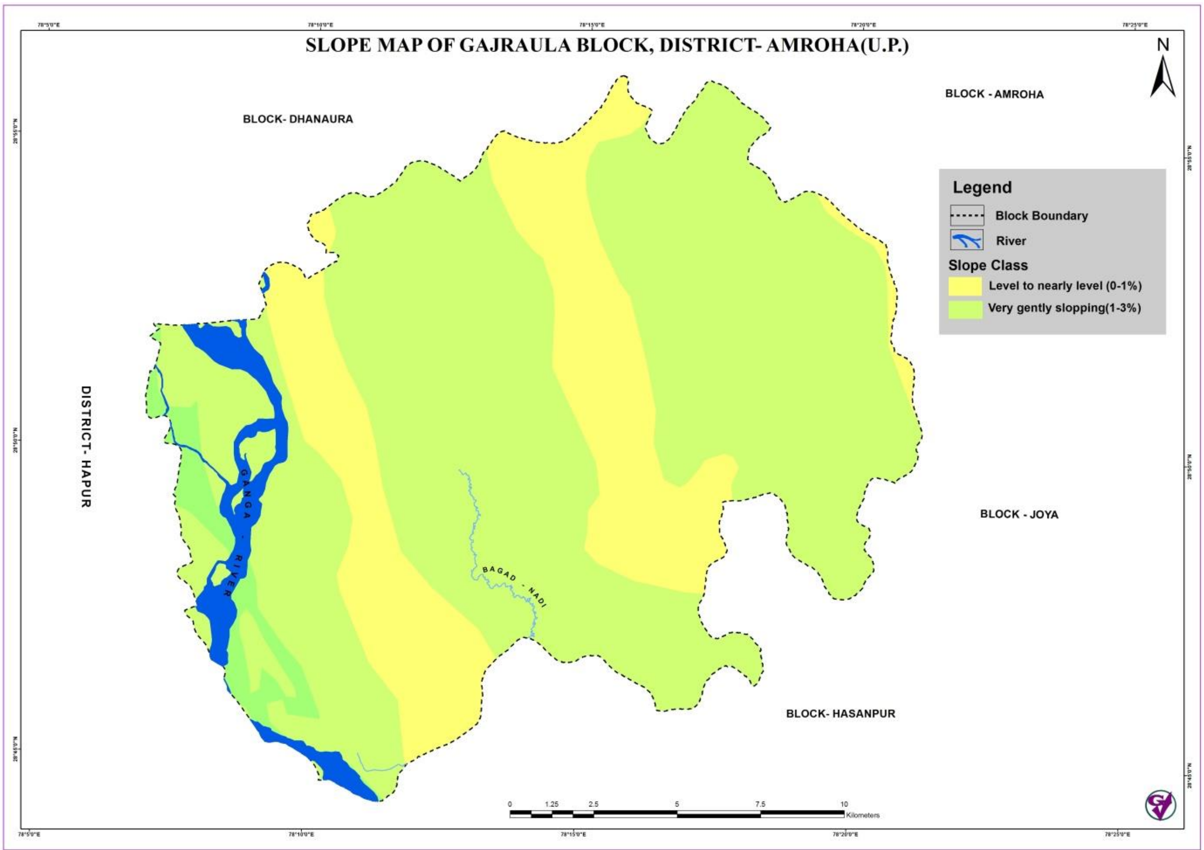


Fig-35: Geological map of Gajraula Block, Amroha District

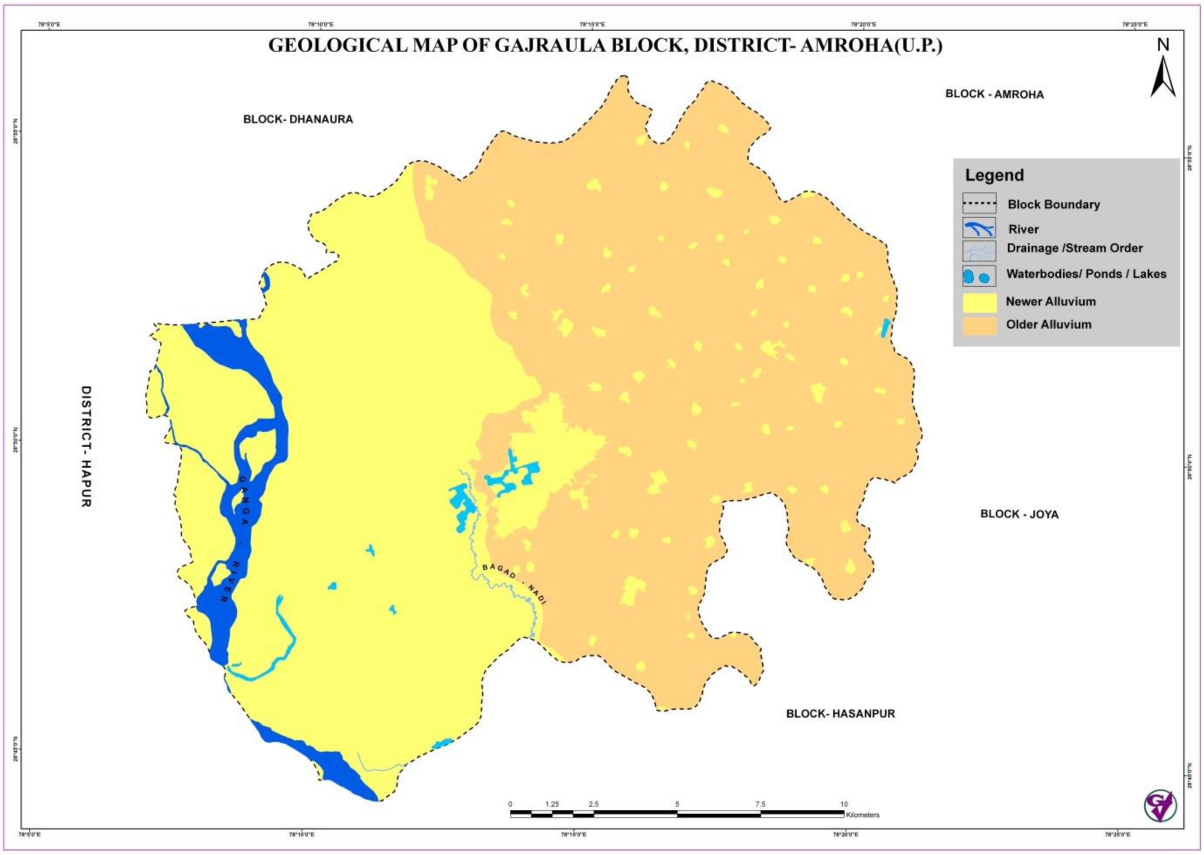


Fig-36: Geomorphological map of Gajraula Block, Amroha District

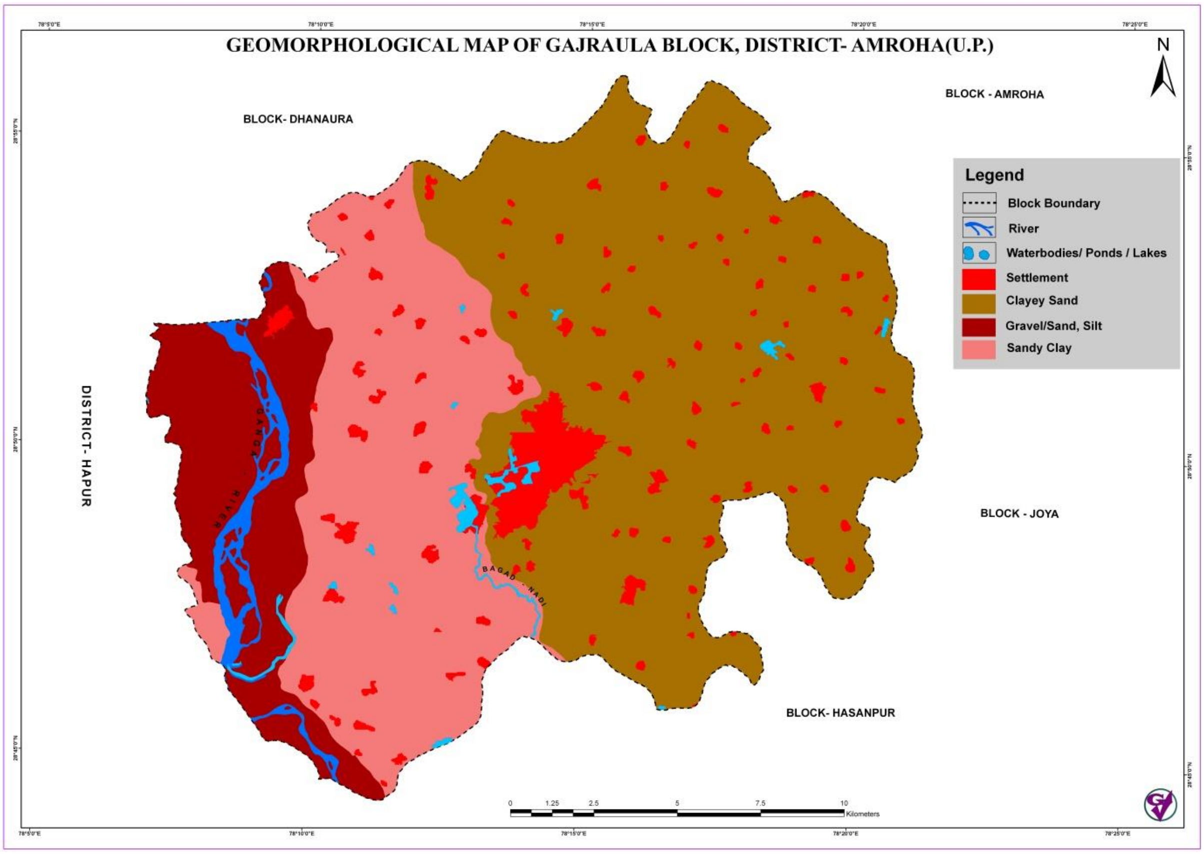
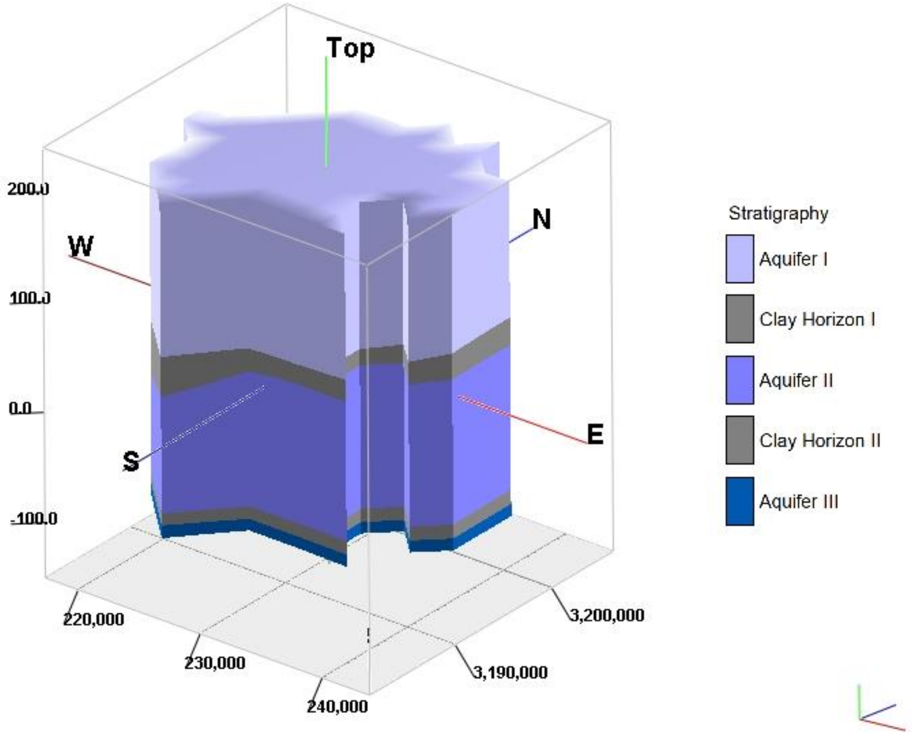


Fig-37: Aquifers disposition map of Gajraula Block, Amroha District



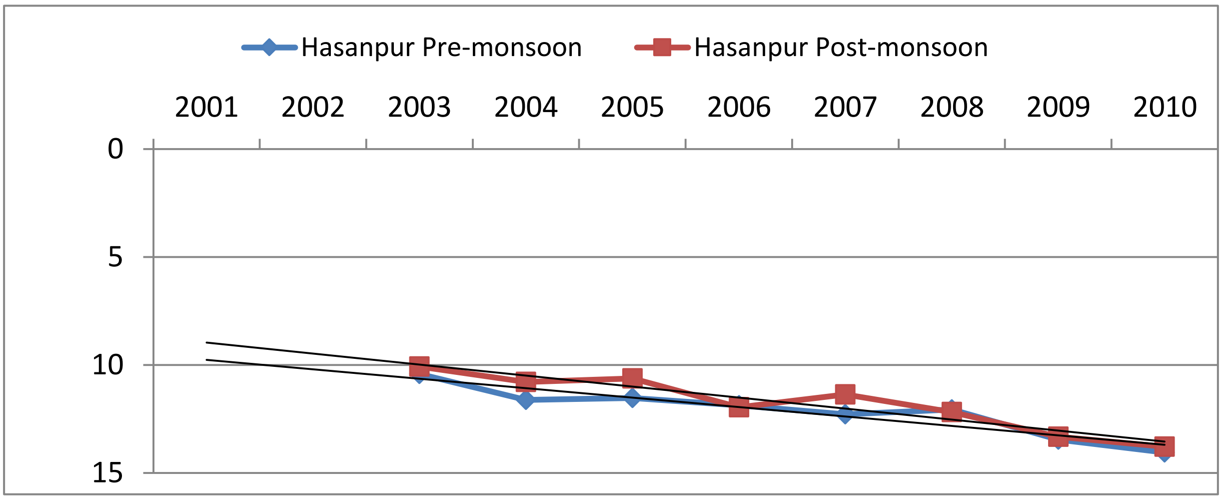
v. HASANPUR BLOCK (334.30 sq. km)

Population (2011)	Male-1,11,902 Female-1,01,293 Total-2,13,195
Rainfall 2017 (Amroha Dist.)	733.92 mm
Average Annual Rainfall (Hasanpur block)	733.92 mm
Rainfall Infiltration Factor (in fraction)	0.22
Specific Yield (in fraction)	0.16
Agriculture and Irrigation	Major Crops- Rice, Wheat (Dist) Other crops- Sugarcane, Potatoes, Pulses, Oilseeds (Dist) Net Area Sown-293.93 sq. km Net Irrigated Area-282.14 sq. km

Ground Water Resource Availability: Ground Water Resources available in the different group of aquifers. Aquifer I (134m) is very prominent in terms of thickness and geographic extent. Aquifer II is below 140-150m bgl and extends up to 270-280m bgl. Block is categorized as Over-exploited as per 2017 assessment.

Ground water Extraction: Information regarding the abstraction from different aquifers is not available, but there are drinking water supply tapping combined aquifer and most of the irrigation is carried out by tapping shallow aquifers.

Water level Behaviour (2016): Pre Monsoon-~16.48m bgl &Post Monsoon-~16.25m bgl. Water level trend during Pre and Post Monsoon shows a significant declining trend to the tune of 53.0 and 43.0 cm/Year respectively.



Aquifer Disposition: Combined Aquifer System

Aquifer Group	Geology	Type of aquifer	Aquifer Depth Range (mbgl)
Aquifer I	Quaternary alluvial deposits	Unconfined	G.L-134
Aquifer II		Unconfined to Confined	144-278
Aquifer III		Unconfined to Confined	Beyond 290

Aquifer comprises of freshwater only and the main aquifer formation is sand.

The non-aquifer material comprises of clay.

Ground Water Resource, Extraction, Contamination and Other Issues

Ground Water Resource (in Ham)	Annual Extractable Ground Water Resources	51.52
	In-storage Aquifer I	5280.00
	Dynamic Aquifer II	0.04
	In-storage Aquifer II	13.65
	Total	5345.11
Ground Water Abstraction (in Ham)	Irrigation (2017)	50.44
	Domestic & Industrial (2017)	6.94
Future demand for domestic & industrial use (2025)(in Ham)		8.27
Net Ground Water Availability for Future use (in Ham)		0.00
Stage of Ground Water Extraction (%)		111.60
Categorization of Block		Over Exploited
Chemical quality of ground water		Potable for drinking and irrigation
Other issues		Deeper water level and declining water trend

Ground Water Resource Enhancement

Aquifer wise space available for artificial recharge and proposed interventions	Volume of unsaturated unconfined aquifer
Other intervention proposed	Artificial recharge and watershed management and farm-pit recharge

Demand side Interventions

Advanced irrigation practices	Drip irrigation, use of sprinklers and lining of underground pipelines
Change in cropping pattern	Paddy and Sugarcane cultivation can be replaced with less water intensive crops
Alternate water sources	Tanks, ponds, canal and river.
Regulation and control	Over-exploited Category

GROUND WATER MANAGEMENT OPTIONS:

Ground water issues can be addressed by focussing on measures to increase recharge and reducing the draft. It can be managed by a mix of measures such as:

Supply Side Management

- Water conservation and Artificial Recharge to ground water
- On Farm Activities and initiatives for ponds creation by farmers in their farmland.

Demand Side Management

- Adoption of techniques to enhance water Use Efficiency
- Adoption of new irrigation practices in sugarcane cultivation area to save 35-40 % irrigation water

Increasing Storage Capacity and Conservation of Rainfall: Supply Side Management

Recharge / Water Conservation

- Water conservation structures such as check dams, farm ponds, nala bunds etc result in ground water recharge to the tune of about 50% of the storage capacity considering 3 annual fillings. Further construction of recharge trenches in the upstream side of the check dams is also proposed to enhance rate of infiltration by about 30 to 40%.

- The existing ponds and tanks lose their storage capacity as well as the natural ground water recharge due to siltation and encroachment by farmers for agriculture purposes. Through desilting, coupled with providing proper waste weir, the village tanks can be converted into recharge structure.

Watershed development and management

- The development of watershed of Bagad Nadi (109.92 sq. km) and Ganga River (246.82 sq. km) holds key for the sustainable management of the rain water that can be utilized for artificial recharge of ground water.

On Farm Practices: Supply Side Management

- Levelling of crop field is essential for uniform distribution of water. Laser levelling has been found very effective ensuring saving of 10 to 30% of applied irrigation.

• The in situ farm activities such as contour bunding, land levelling, bench terracing, water harvesting structures, afforestation and diversification of cropping pattern are other measures to increase recharge in the block.

Enhancing Water Use Efficiency:

Demand Side Management

Efficient irrigation

• In flood/furrow irrigation method more than 50% of applied water is wasted through seepage to deeper level, localized inundation causes loss through evaporation and it leaches out the nutrients from the plant.

• Adoption of efficient irrigation practices in sugarcane cultivation area to save 35-40
% irrigation water. Such practices are as under

1. Irrigation Scheduling at Critical Growth Stages of Sugarcane
2. Ring Pit Method of Sugarcane Planting
3. Skip Furrow Method of Irrigation
4. Trash Mulching
5. Micro Irrigation (Sprinkler/ Drip Irrigation

• While through drip & sprinkler irrigation wastage of irrigational water could be minimized. The conveyance losses (mainly seepage & evaporation) can be saved up to 25 to 40% through utilization of HDPE pipes.

• Agriculture department should promote to conserve the soil moisture by reducing ET losses through cultivation of 'Green Manure'

Diversification of cropping pattern

• Horticulture department should promote Baghwani in the area. This will bring in money without high use of water. These will also help conserve soil moisture.

• Alternate cropping system having lower requirement of water are better option.

• Summer paddy and maize need to be avoided which are grown over substantial area in the block.

• Large scale adoption of rice-wheat rotation system & sugarcane cultivation is the main reason of over exploitation of groundwater. Late sown wheat/peas are replaced by spring maize which consumes more water. Suggested cropping pattern are as under.

• **Kharif**- Maize, cotton, sorghum, pulses, groundnut

• **Rabi**- Mustard, gram, pulses, vegetable

• By adopting suggested cropping pattern 20 to 30% of irrigation water saving is possible

Fig-38: Location map of Hasanpur Block, Amroha District

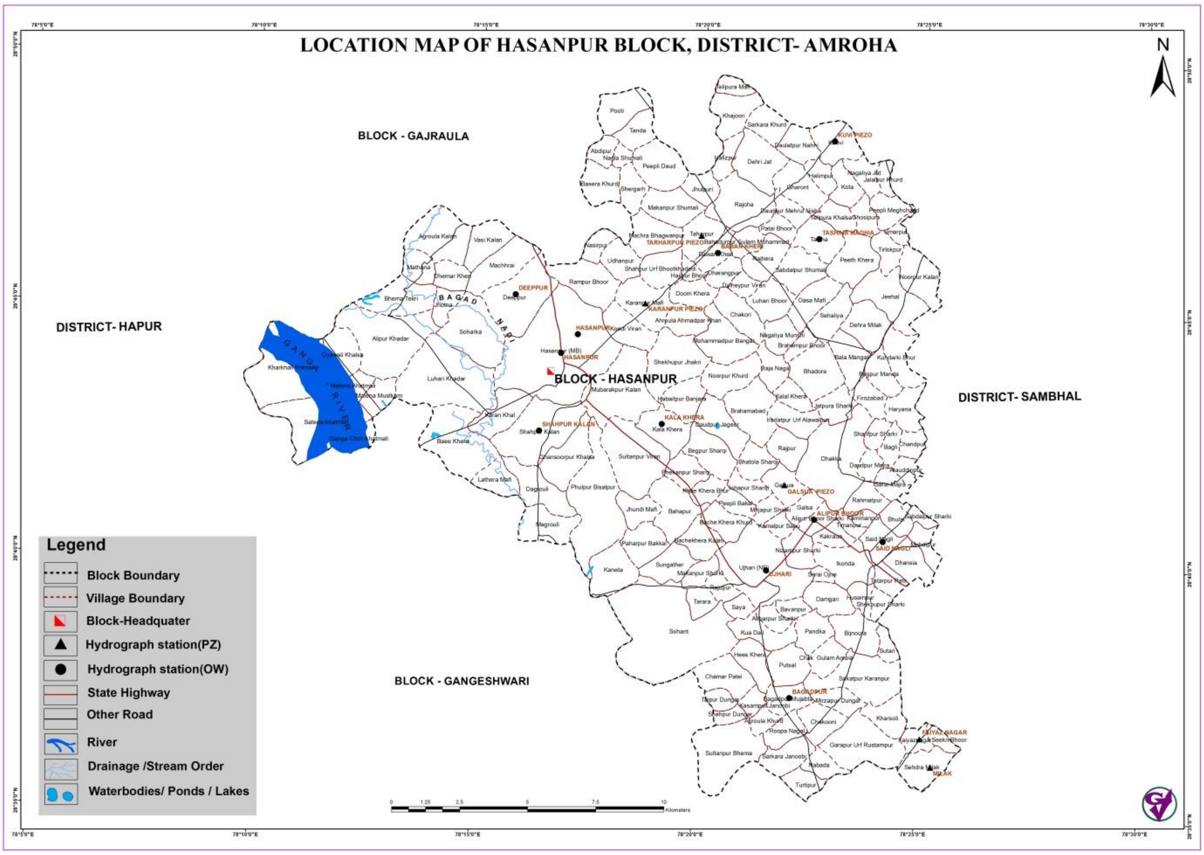


Fig-39: Drainage map of Hasanpur Block, Amroha District

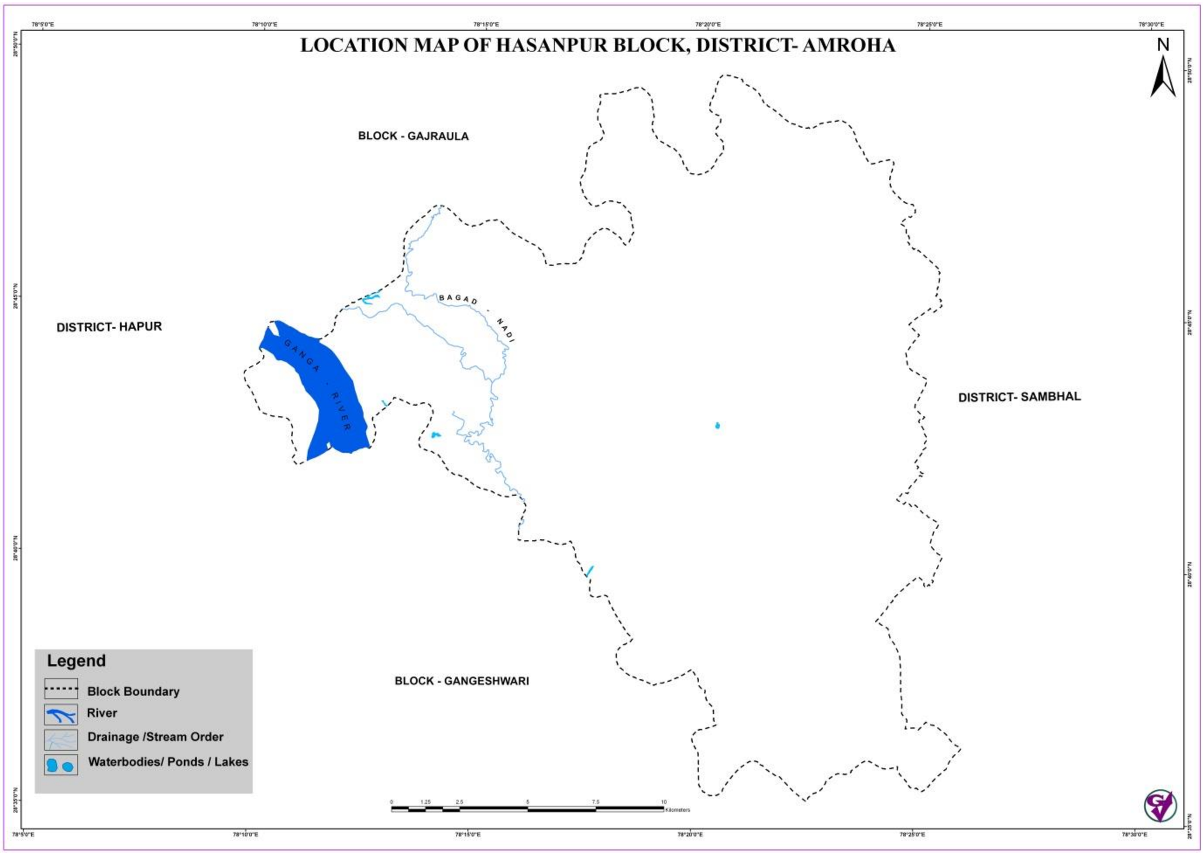


Fig-40: Soil map of Hasanpur Block, Amroha District

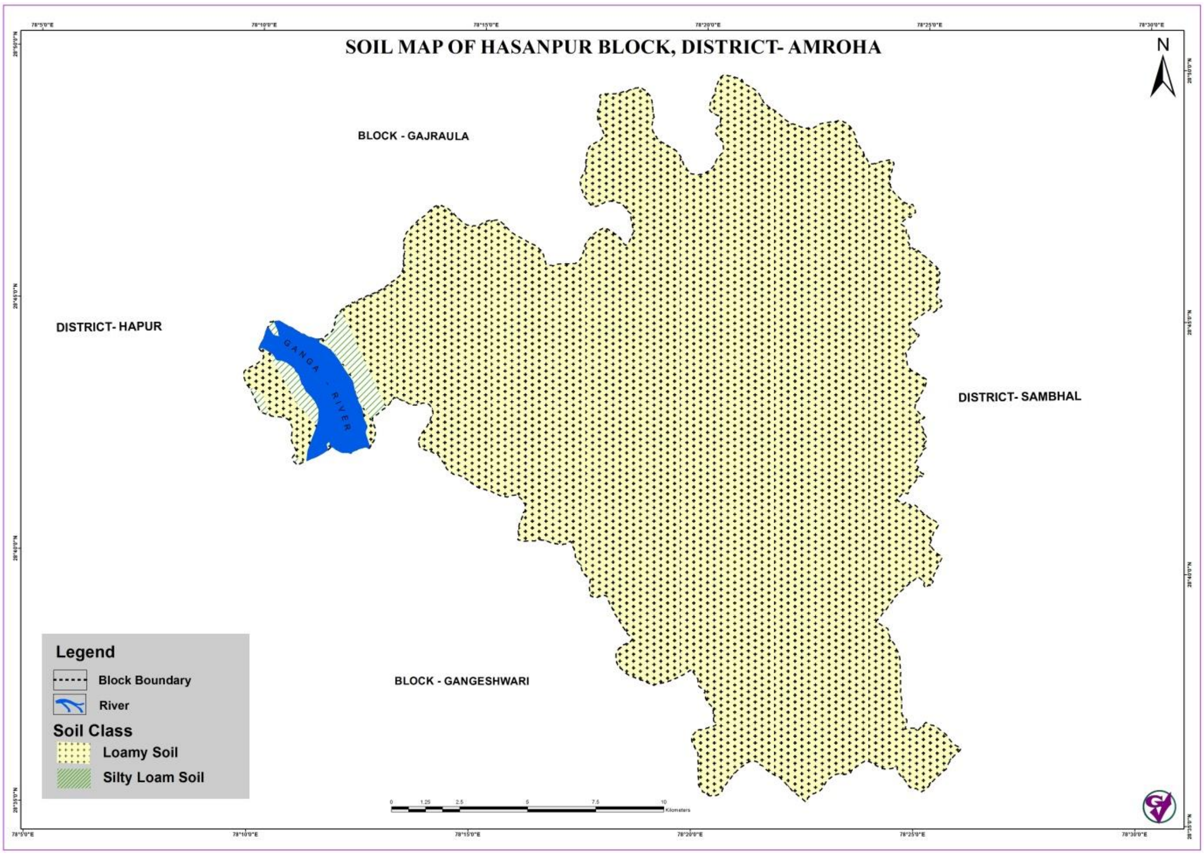


Fig-41: Slope map of Hasanpur Block, Amroha District

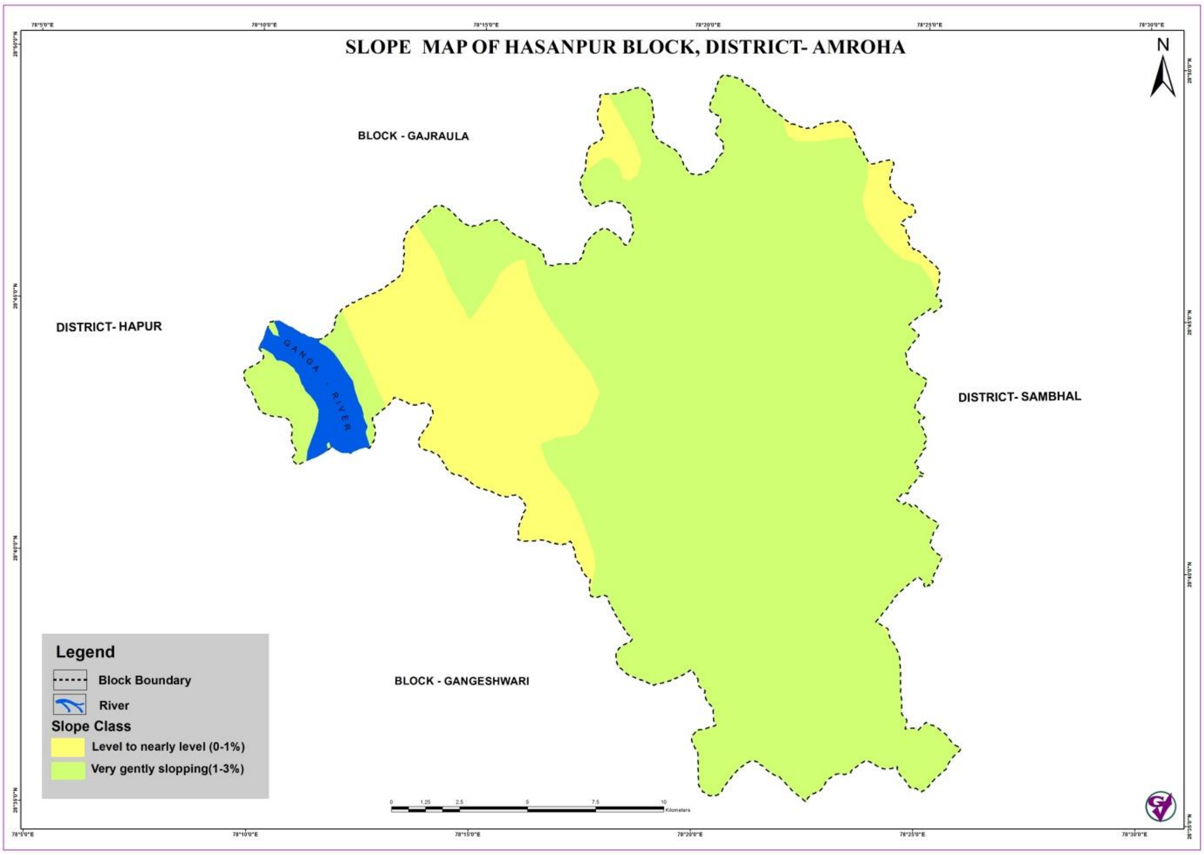


Fig-42: Geological map of Hasanpur Block, Amroha District

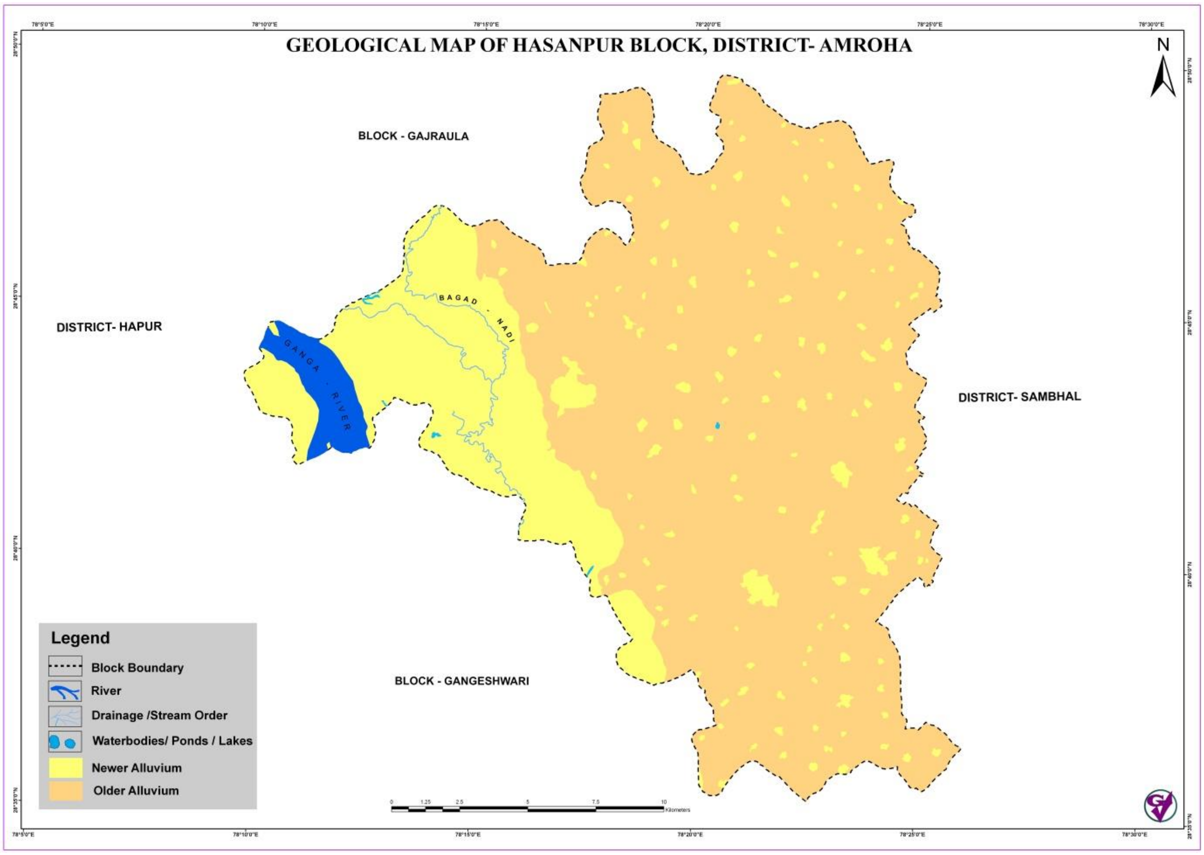


Fig-43: Geomorphological map of Hasanpur Block, Amroha District

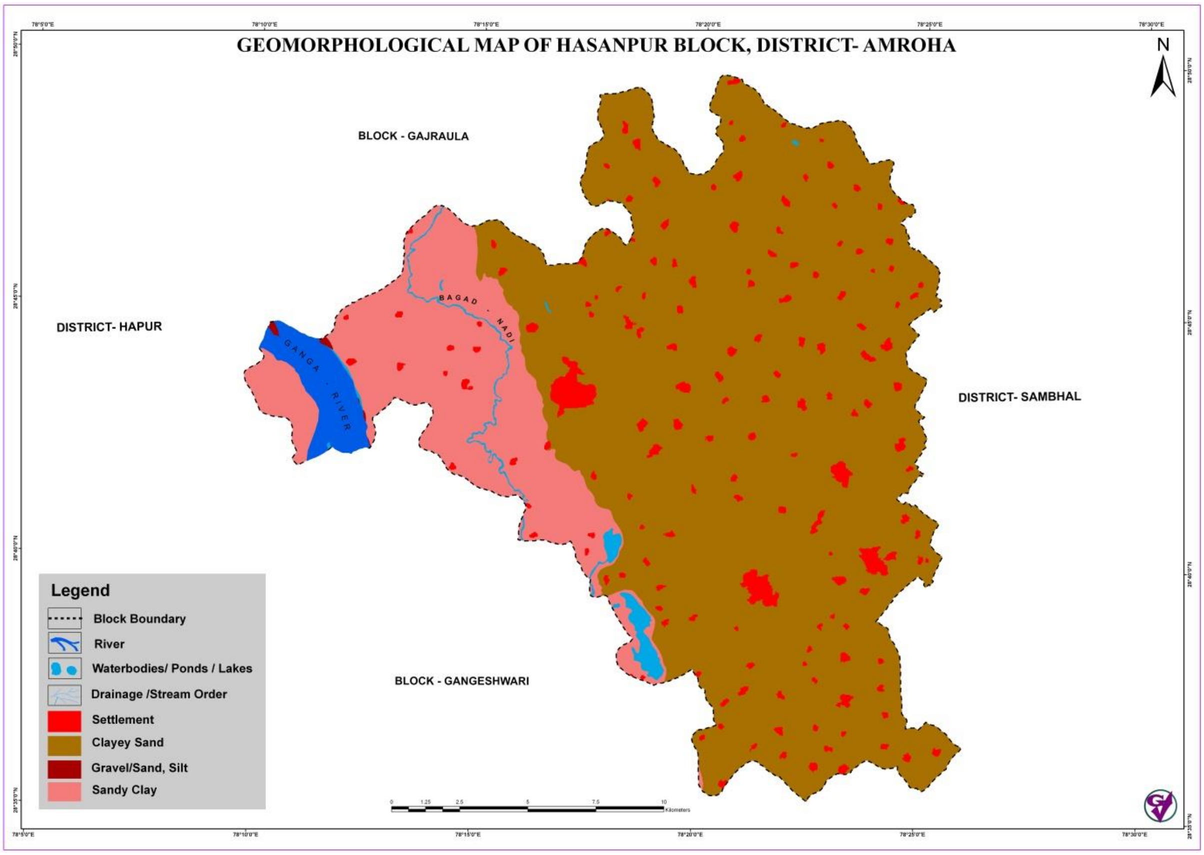
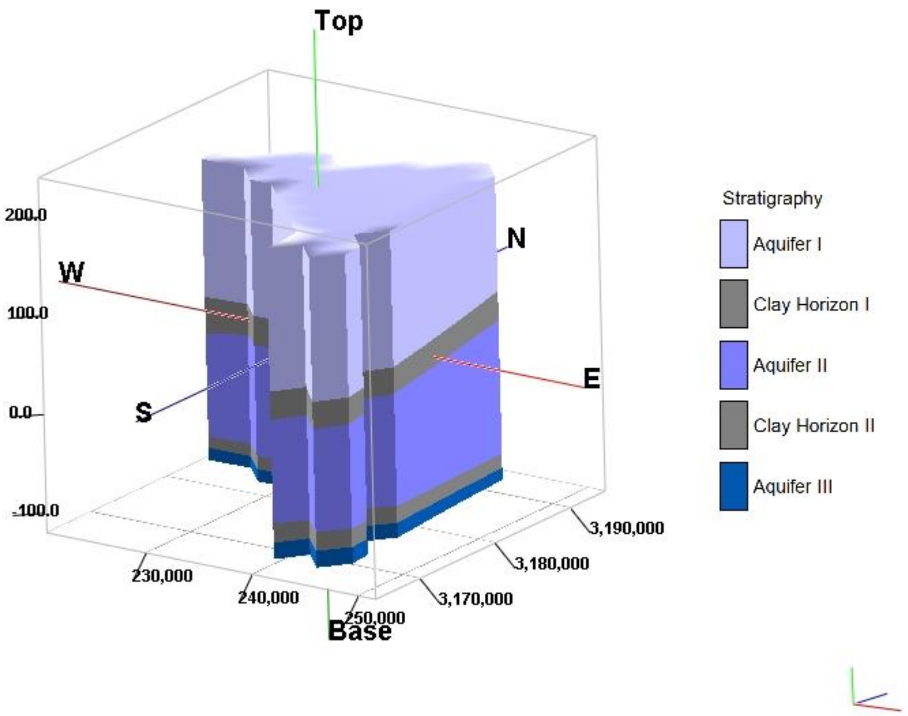


Fig-44: Aquifers disposition map of Hasanpur Block, Amroha District



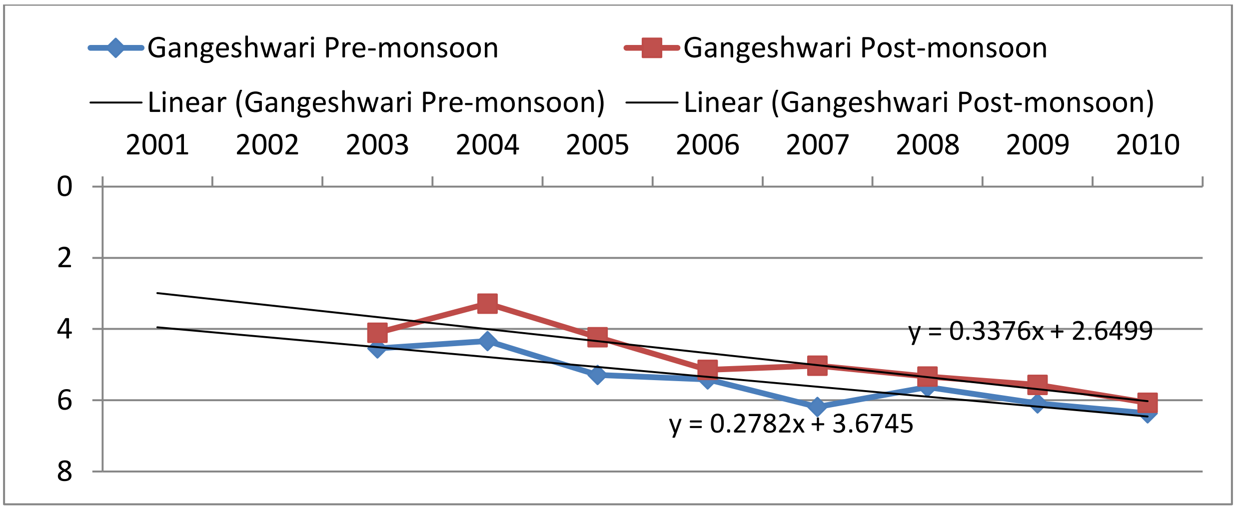
vi. GANGESHWARI BLOCK (397 sq. km)

Population (2011)	Rural-224079 Urban-18337 Total-228765
Rainfall 2016 (Amroha Dist.)	733.92 mm
Average Annual Rainfall (Gangeshwari block)	733.92 mm
Rainfall Infiltration Factor (in fraction)	0.22
Specific Yield (in fraction)	0.16
Agriculture and Irrigation	Major Crops- Rice, Wheat (Dist) Other crops- Sugarcane, Potatoes, Pulses, Oilseeds (Dist) Net Area Sown-274.88 sq. km Net Irrigated Area-268.94 sq. km

Ground Water Resource Availability: Ground Water Resources available in the different group of aquifers. Aquifer I (134m) is very prominent in terms of thickness and geographic extent. Aquifer II is below 140-150m bgl and extends up to 270-280m bgl. Block is categorized as Semi-Critical as per 2017 assessment having stage of ground water extraction 87.69%.

Ground water Extraction: Information regarding the abstraction from different aquifers is not available, but there are drinking water supply tapping combined aquifer and most of the irrigation is carried out by tapping shallow aquifers.

Water level Behaviour (2015): Pre Monsoon-~6.62m bgl &Post Monsoon-~4.90mbgl



Aquifer Disposition: Combined Aquifer System

Aquifer Group	Geology	Type of aquifer	Aquifer Depth Range (mbgl)
Aquifer I	Quaternary alluvial deposits	Unconfined	G.L-134
Aquifer II		Unconfined to Confined	144-278
Aquifer III		Unconfined to Confined	Beyond 290

Aquifer comprises of freshwater only and the main aquifer formation is sand.

The non-aquifer material comprises of clay.

Ground Water Resource, Extraction, Contamination and Other Issues

Ground Water Resource (in Ham)	Annual Extractable Ground Water Resources	70.52
	In-storage Aquifer I	6755
	Dynamic Aquifer II	0.04
	In-storage Aquifer II	16.21
	Total	6841.77
Ground Water Abstraction (in Ham)	Irrigation (2017)	55.98
	Domestic & Industrial (2017)	5.86
Future demand for domestic & industrial use (2025)(in Ham)		7.28
Net Ground Water Availability for Future use (in Ham)		0.00
Stage of Ground Water Extraction (%)		87.69
Categorization of Block		Semi Critical
Chemical quality of ground water		Potable for drinking and irrigation
Other issues		Deeper water level and declining water trend

Ground Water Resource Enhancement

Aquifer wise space available for artificial recharge and proposed interventions	Volume of unsaturated unconfined aquifer
Other intervention proposed	Artificial recharge and watershed management and farm-pit recharge

Demand side Interventions

Advanced irrigation practices	Drip irrigation, use of sprinklers and lining of underground pipelines
Change in cropping pattern	Paddy and Sugarcane cultivation can be replaced with less water intensive crops
Alternate water sources	Tanks, ponds, canal and river.
Regulation and control	Over-exploited Category

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Ground water issues can be addressed by focussing on measures to increase recharge and reducing the draft. It can be managed by a mix of measures such as:

Supply Side Management

- Water conservation and Artificial Recharge to ground water
- On Farm Activities and initiatives for ponds creation by farmers in their farmland.

Demand Side Management

- Adoption of techniques to enhance water Use Efficiency
- Adoption of new irrigation practices in sugarcane cultivation area to save 35-40 % irrigation water

Increasing Storage Capacity and Conservation of Rainfall: Supply Side Management

Recharge / Water Conservation

- Water conservation structures such as check dams, farm ponds, nala bunds etc result in ground water recharge to the tune of about 50% of the storage capacity considering 3 annual fillings. Further construction of recharge trenches in the upstream side of the check dams is also proposed to enhance rate of infiltration by about 30 to 40%.
- The existing ponds and tanks lose their storage capacity as well as the natural ground water recharge due to siltation and encroachment by farmers for agriculture purposes. Through desilting, coupled with providing proper waste weir, the village tanks can be converted into recharge structure.

On Farm Practices: Supply Side Management

- Levelling of crop field is essential for uniform distribution of water. Laser levelling has been found very effective ensuring saving of 10 to 30% of applied irrigation.
- The in situ farm activities such as contour bunding, land levelling, bench terracing, water harvesting structures, afforestation and diversification of cropping pattern are other measures to increase recharge in the block.

Enhancing Water Use Efficiency:

Demand Side Management

Efficient irrigation

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Diversification of cropping pattern

• Horticulture department should promote Baghwani in the area. This will bring in money without high use of water. These will also help conserve soil moisture.

• Alternate cropping system having lower requirement of water are better option.

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• **Kharif**- Maize, cotton, sorghum, pulses, groundnut

• **Rabi**- Mustard, gram, pulses, vegetable

• By adopting suggested cropping pattern 20 to 30% of irrigation water saving is possible

Fig-45: Location map of Gangehwari Block, Amroha District

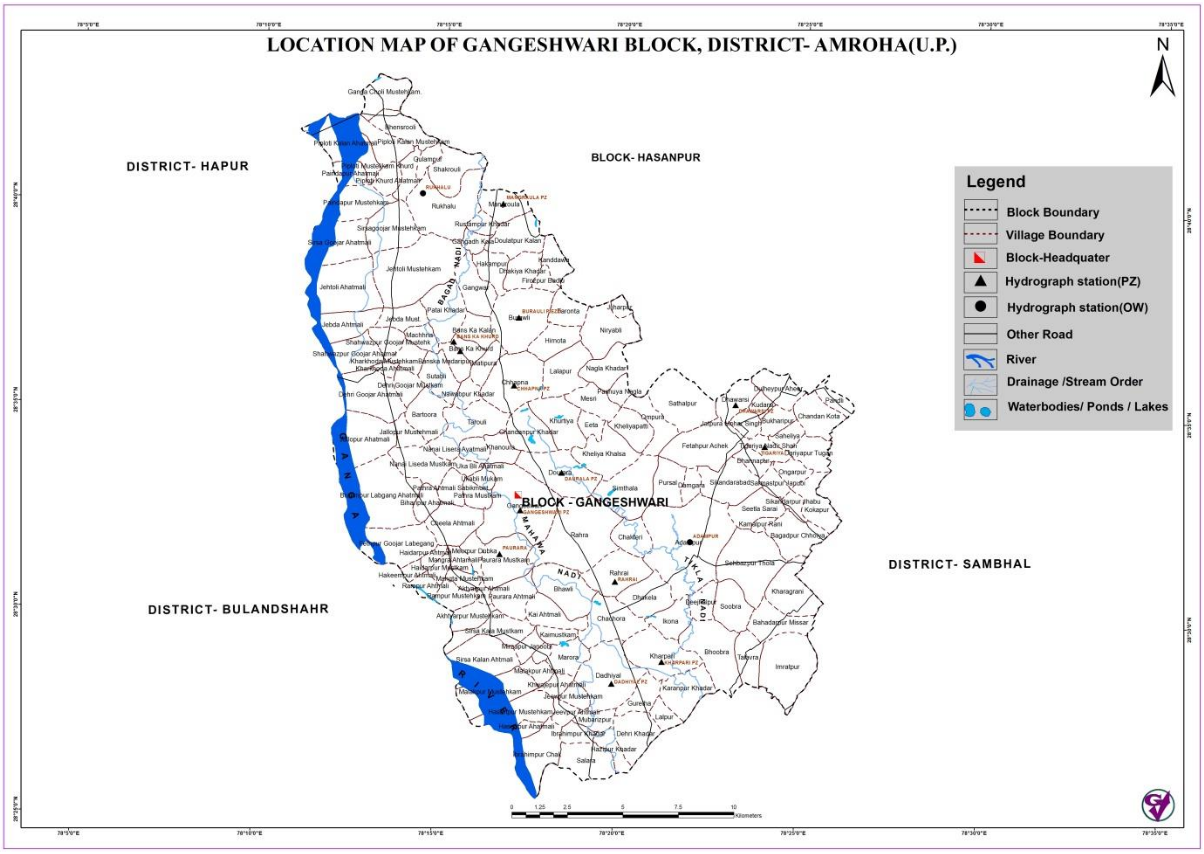


Fig-46: Drainage map of Gangeshwari Block, Amroha District

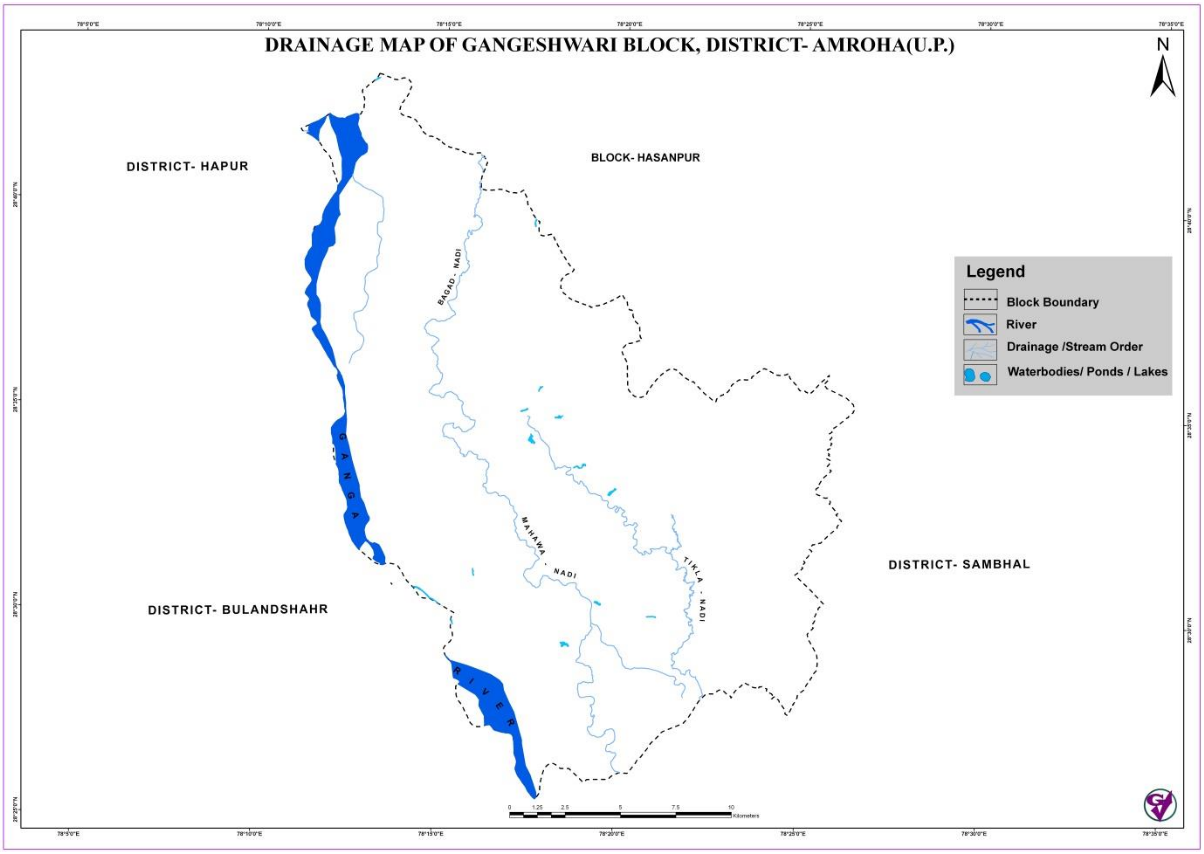


Fig-47: Soil map of Gangeshwari Block, Amroha District

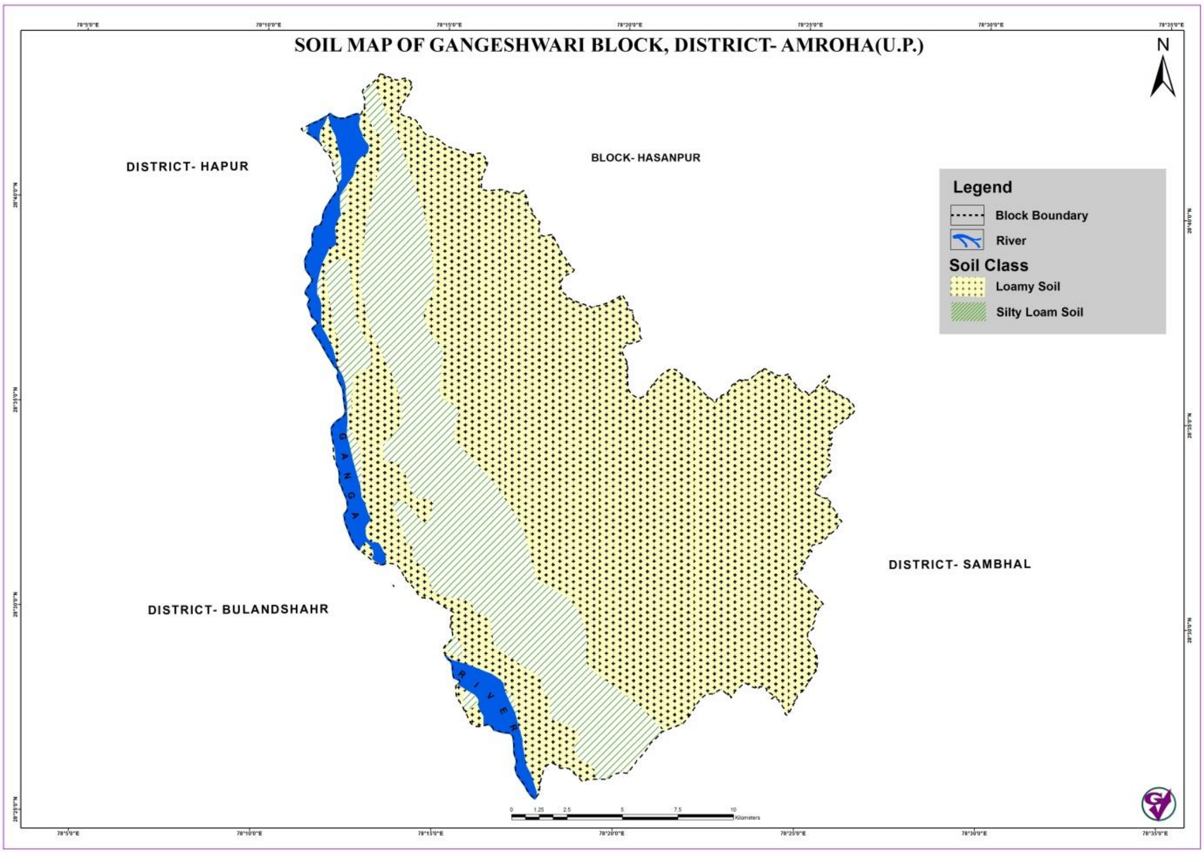


Fig-48: Slope map of Gangeshwari Block, Amroha District

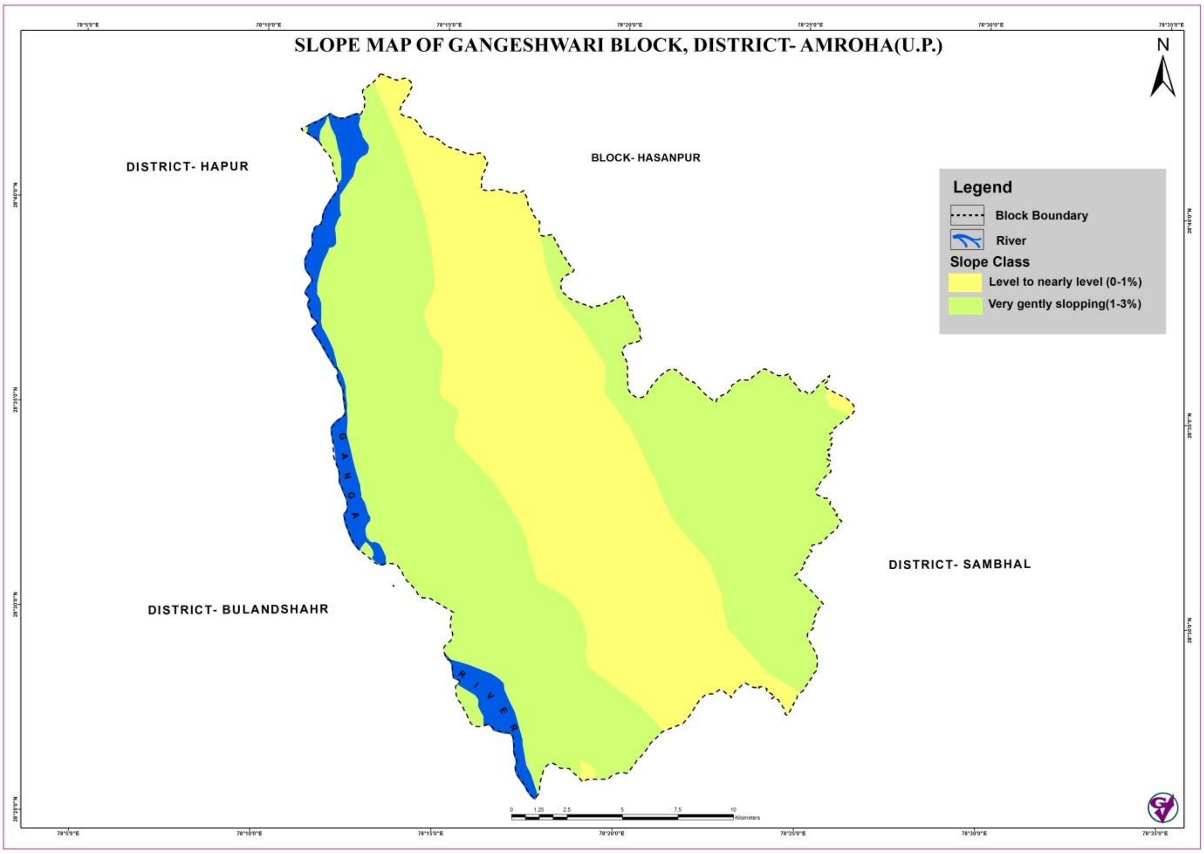


Fig-49: Geological map of Gangeshwari Block, Amroha District

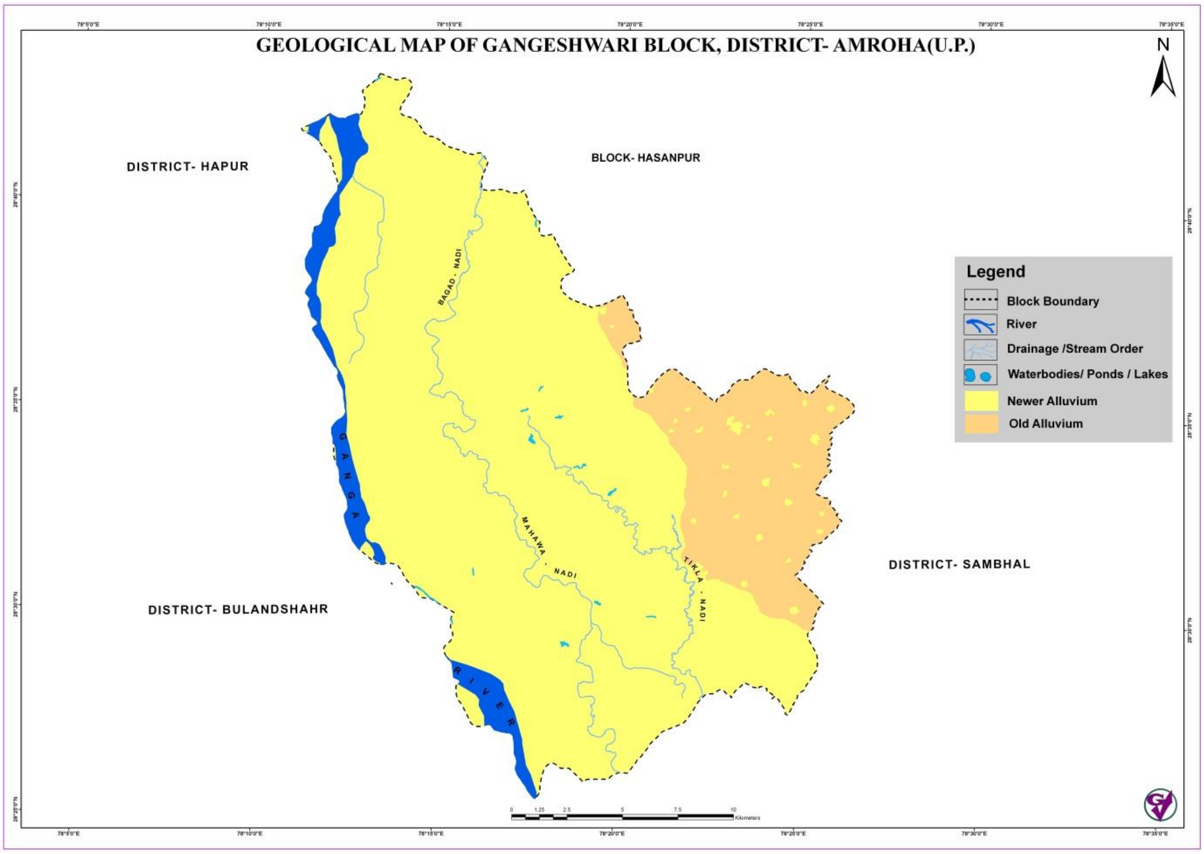


Fig-50: Geomorphological map of Gangeshwari Block, Amroha District

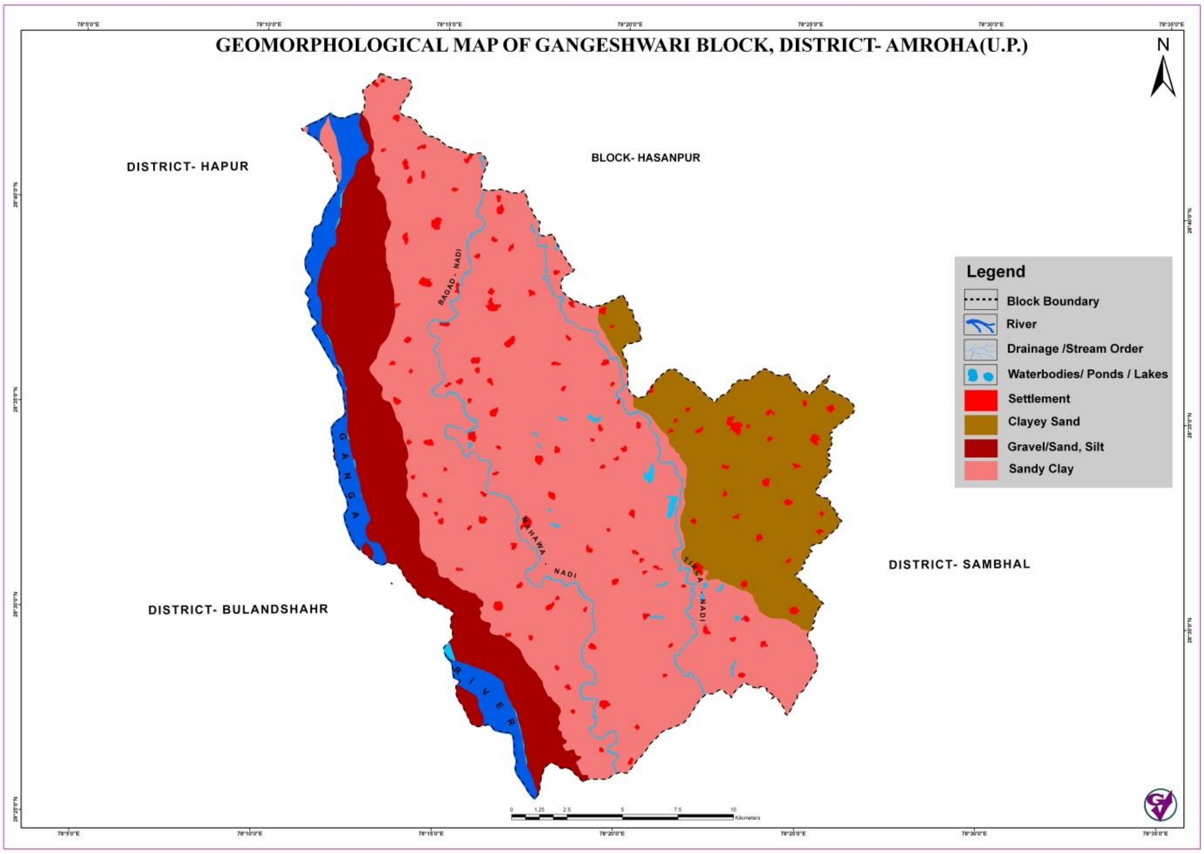
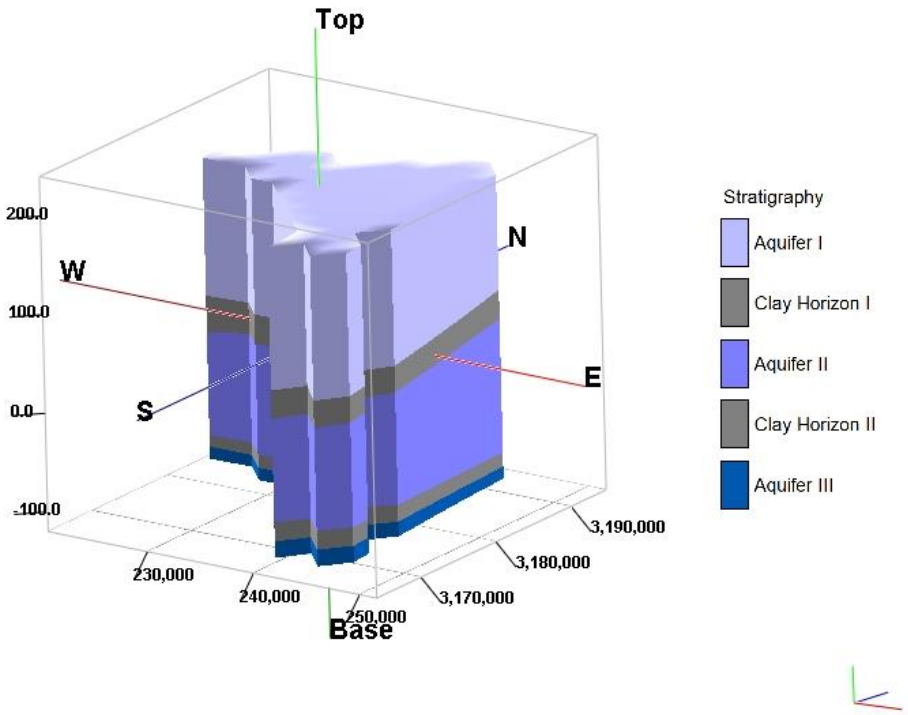


Fig-51: Aquifers disposition map of Gangeshwari Block, Amroha District



11. CONCLUSION

1. Amroha district, covering an area of 2249 sq. km lies in the northwest of Uttar Pradesh. For administrative purposes, the district has been sub-divided into 3- tehsils and 6- developmental blocks.
2. Geologically the area falls in the Ganga basin. The area is drained by Ganga, Soht and Bagar River.
3. The district is drained by two prominent rivers, e.g., Ganga and Ramganga and their tributaries. Sot and Ban are the main tributaries draining the area.
4. The loamy soils of the area are very fertile. About 80% of the total geographical area of the district is cultivated area. The main rabi crops are wheat and oil seeds while paddy and pulses are the main kharif crops. The abundantly produced sugarcane is a perennial crop.
5. Net Area Sown in the district is 175063 ha, Net irrigated area is 172040 and Gross irrigated area is 244397 ha. Tubewell irrigation accounts for about 70% in the area.
6. Annual average rainfall is 917.40 mm. More than 70% of rainfall is confined in four months of monsoon season.
7. The district has almost monotonous plain with no distinct features except some sand ridges, river valleys and shallow depressions. The maximum and minimum height from sea level is 182.00 m amsl to 208.00m amsl.
8. Amroha district is underlain by Quaternary alluvium deposited by Ganga river system. Lithologically the alluvial sediments comprise of sand, silt, clay and kankars in varying proportions.
9. In general the ground water table varies from 188.95 to 208.69 m a.m.s.l. and the regional ground water flow is form north-west to south-east direction.
10. Broadly Aquifer Group I extend down to around 134m, Aquifer Group II extends down to around 270m and Aquifer Group III extends down to 288-300m. At places, the layer separating different aquifer groups pinches out, making the two groups as one continuous aquifer system.
11. Transmissivity of aquifer is 3007 m2/day and Storativity 2.54×10^{-4}. Discharge is 2080 lpm.
12. The total ground water draft is 49189.05 ham, which is being used in present for domestic, irrigation & industrial purposes against the ground water availability of 47037.04ham. Out of 6 blocks, four blocks falls under over exploited category which are Dhanaura, Joya, Gajraula and Hasanpur; and two blocks Amroha and Gangeshwari under Semi-Critical

category. Overall stage of ground water development in the district is about 104.58%.

13. The general Chemical quality of ground water is potable and is fit for domestic and irrigation purposes. Iron is found in water samples of almost all blocks in excess of permissible limit that may be due to the rusting of pipes in handpumps. Localised enrichment of Nitrate in the phreatic aquifer has been observed in a few samples may be due to excessive use of fertilizers in agriculture and disposal of untreated sewage.

12. RECOMMENDATIONS

1. To arrest the further decline in ground water levels and depletion of ground water resources, there is urgent need to implement both Supply side and Demand side measures which includes artificial recharge and water conservation, On-farm activities and adoption of water use efficiency measures.

2. It is proposed to adopt supply side management options only in the Over-Exploited and Critical blocks. There is considerable scope for implementation of Roof Top Rain Water Harvesting in the urban areas of the district. Check dams, cement plugs, renovation of ponds are ideal structures for rain water harvesting in rural areas. Water conservation structures such as check dams, farm ponds, nala bunds etc. result in ground water recharge to the tune of about 40% of the storage capacity considering 3 annual fillings.

3. It is also proposed to adopt On Farm practices such as laser leveling, bench terracing, construction of farm ponds, afforestation, diversification of crops etc.

4. In demand side management there is urgent need to promote piped and pressurised irrigation practices which can save 25 to 70% of water use in the agriculture. It is proposed to initiate these measures initially in 10% area of overexploited & critical blocks. The measures adopted for supply side and demand side management in Amroha district will substantially bring down stage of ground water development.

5. It is also proposed to adopt efficient water saving Irrigation practices viz. (a) Irrigation scheduling at critical growth stages of sugarcane (b) Ring pit method of sugarcane planting (c) Skip furrow method of irrigation & (d) Trash mulching in sugarcane cultivation in over-exploited and semi-critical blocks. Such practices have the potential of saving 35-40% irrigation water thereby drastically reducing the draft for irrigation leading the change of category of block from OE to safe.

6. The dominance of sugarcane cultivation in the area calls for adoption of efficient water saving Irrigation practices and encouragement of demand side management to reduce the draft.

7. Less water consuming varieties of sugarcane viz. CoLK 94184 & CoPK 05191 should be promoted in the district as these two need water 25 days after germination whereas others after 10 to 15 days.

8. Agriculture department should promote to conserve the soil moisture by reducing ET losses through cultivation of 'Green Manure'.

9. Alternate cropping system having lower requirement of water should be encouraged in accordance to the irrigation water availability.

10. Furrow irrigation with raised bed planting in wide row crops should be practised.
11. Irrigation in checks in close row crops should be practised.
12. Drip irrigation (fertigation) in sugarcane and other wide row crops should be practised with mulch in the area.
13. Multiuse of water through integrated farming system.
14. Conjunctive use of surface and groundwater should be encouraged in the district.
15. Besides the above, there is urgent need for participatory ground water management in the area which will further help in bringing more awareness among the common farmers which will reduce the ground water drawal and bring down the stage of ground water development.
16. Industries are extracting ground water to meet their water requirements. This district is having large paper and pulp manufacturing units and also sugar industries. The ground water consumption of these industries is very high. There is urgent need that these industries should upgrade their plant for water efficient processes and adopt recycle and reuse of water in their processes.
17. All efforts should be taken to ensure treatment of waste disposal both solid and liquid from industries and urban areas to prevent pollution of ground water and surface water.

13. ACKNOWLEDGEMENTS

The assignment was carried out under the overall supervision of Sri. Y.B. Kaushik, Ex. Regional Director. The author is grateful to him for his consistent guidance. The author renders his sincere thanks to Shri Pramod Kumar Tripathi (Head of Office) for useful discussions and immense support. The author would like to extend his gratitude to Shri Sujatro Ray Chowdhari, (Scientist-B) for his all-time availability for many stimulating discussions and thoughtful critiques of his work. Thanks are also due to the chemists of the Region for the analysis of the water samples. The valuable contribution of Dr. Vikas Ranjan, Scientist 'C' (Sr. Hydrogeologist) in conceptualization and preparation of the GW management plans is also duly acknowledged.