केंद्रीय भूमि जल बोर्ड

जल संसाधन, नदी विकास और गंगा संरक्षण मंत्रालय

भारत सरकार

Central Ground Water Board

Ministry of Water Resources, River Development and Ganga Rejuvenation

Government of India

Report
on

AQUIFER MAPPING AND GROUND WATER MANAGEMENT PLAN

Muzaffarnagar District, Uttar Pradesh

उत्तरी क्षेत्र, लखनऊ

Northern Region, Lucknow

REPORT ON AQUIFER MAPPING AND GROUND WATER MANAGEMENT PLAN IN MUZAFFARNAGAR DISTRICT, UTTAR PRADESH

(AAP: 2016-17)

Central Ground Water Board, Northern Region, Lucknow

August, 2017

REPORT ON
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MUZAFFARNAGAR DISTRICT AT A GLANCE

1.		**GENERAL INFORMATION**		
	i.	Geographical Area (sq km.)	:	2641.83
	ii.	Administrative Divisions	:	
		Number of Block		09
		Number of Panchayat/Villages		218/736
	iii.	Population (2011 census)	:	2863800
	iv.	Average Annual Rainfall (mm)	:	753
2.		**GEOMORPHOLOGY**	:	Upper Ganga Plain
		Major Physiographic Units	:	Younger alluvium Older alluvium Flood plain
		Major Drainages	:	Ganga, Hindon
3.		**LAND USE (Sq. Km.)**		
	a)	Forest area	:	240.54
	b)	Net area sown	:	2195.17
	c)	Cultivable Area	:	3177.69
4.		**MAJOR SOIL TYPES**	:	Sandy loam
5.		**AREA UNDER PRINCIPAL CROPS Sq. Km.**	:	2571.15 (Wheat, Rice, Sugarcane)
6.		**IRRIGATION BY DIFFERENT SOURCES (Numbers of structures)**		
		Tubewells / Borewells	:	66237
		Canals	:	943 km
		Other Sources	:	
		Net Irrigated Area	:	2168.65
		Gross Irrigated Area	:	3141.80
7.		**NUMBER OF GROUND WATER MONITORING WELLS OF CGWB (As on 31-3-2016)**		
		No. of Dugwells	:	5
		No. of Piezometers	:	9
8.		**PREDOMINANT GEOLOGICAL FORMATIONS**	:	Quaternary alluvium
9.		**HYDROGEOLOGY AND AQUIFER GROUP**	:	Quaternary alluvium deposited by Ganga and Yamuna river systems. Ist aquifer down to 162m 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' 2015	:	3.43 to 16.84 mbgl
Post-monsoon Depth to water level during Nov' 2015	:	2.60 to 17.10 mbgl
Long term water level trend in 10 years (2006-2015) in m/yr	:	Pre-monsoon Fall: 5-54 cm/yr. Post-monsoon
	:	Fall: 14-66 cm/yr.

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

No of wells drilled (EW, OW, PZ, SH, Total)	:	EW-2, PZ-03 (UYP: Titavi, Rohana & Shahpur)
Depth range (m)	:	317 - 463
Discharge (litres per second)	:	33 – 37
Storativity (S)	:	3.14×10^{-3}
Transmissivity (m^2/day)	:	857 – 2204 m^2/day

11. GROUND WATER QUALITY

Presence of chemical constituents more than permissible limit (e.g. EC, F, As, Fe)	:	Iron: 0.044 - 4.07 mg/l
Type of water	:	Good

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

Annual Replenishable Ground Water Resources	:	94377.07
Gross Annual Ground Water Draft	:	62053.10
Provision for Domestic and Industrial Requirement Supply	:	8288.64
Stage of Ground Water Development	:	65.75%

13. GROUND WATER CONTROL AND REGULATION

Number of Over Exploited Blocks	:	3
Number of Critical Blocks		1
Number of Semi Critical Blocks	:	Nil
Number of Safe Blocks		5
Number of blocks notified	:	-

14. MAJOR GROUND WATER PROBLEMS AND ISSUES	:	Over-Exploitation of Ground Water and Declining trend in ground water levels. Three (3) blocks fall under **Over Exploited** & one (1) block under **Critical** category.

REPORT ON
AQUIFER MAPPING AND GROUND WATER MANAGEMENT PLAN IN MUZAFFARNAGAR DISTRICT, UTTAR PRADESH

1.0 INTRODUCTION

1.1 Administrative Details:

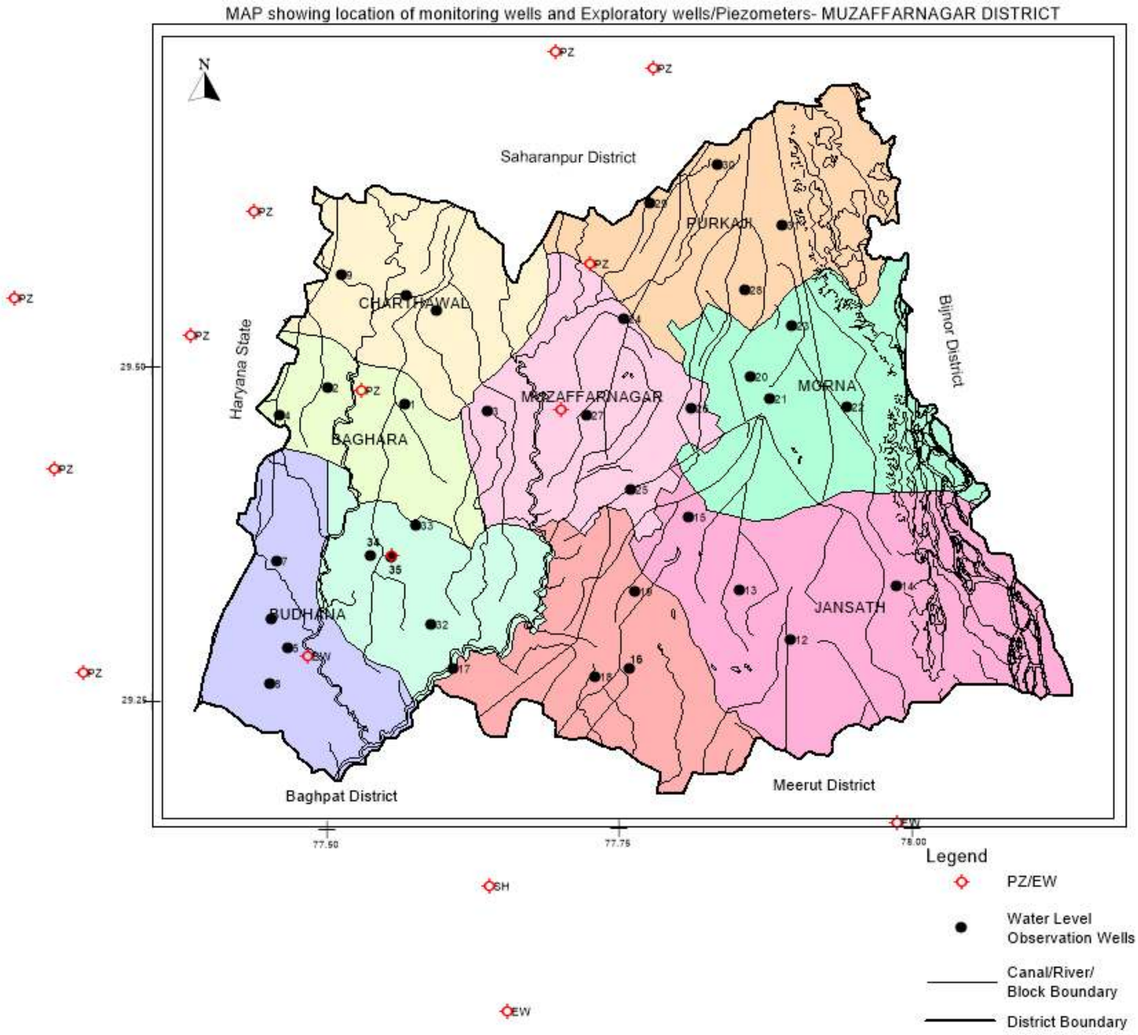
Muzaffarnagar district, covering an area of 2958.08 sq. km lies in the northwest of Uttar Pradesh. It is bounded on the north by the Saharanpur district, Haridwar district of Uttaranchal in the northeast, Bijnor district in the east, Meerut district in the south and Shamli district in the west. The eastern boundary of the district with Bijnor district is divided by river Ganga. The district falls in Survey of India Toposheet No. 53G, covering north latitudes $29^0$10'49.33" and $29^0$42'33.33" and east longitude $77^0$23' 10.06'' and $78^0$08' 13.18''.For administrative purposes, the district has been sub-divided into 03 tehsils and 9 developmental blocks.

Fig-1: Administrative Division of Muzaffarnagar District, U.P.

1.2 Basin and Sub-Basin:

The western half of the district occupies part of Yamuna basin and eastern part of the district the northern part of Ganga basin.

Fig-2: Index Map



1.3 Drainage:

Muzaffarnagar district is drained by rivers Ganga in the east and Hindon in the west. In fact, the drainage pattern of the district is strictly governed by these two major rivers Ganga and Yamuna, which forms western boundary of the Shamli district. Both the rivers in their respective course flow more or less north to south. Major tributary of Ganga is Solani river and that of Yamuna is Hindon and Kali Nadi.

1.4 Cropping Pattern and Irrigation Practices:

Entire district of Muzaffarnagar falls between Ganga and Hindon rivers. 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.

Fig-3: Drainage Map

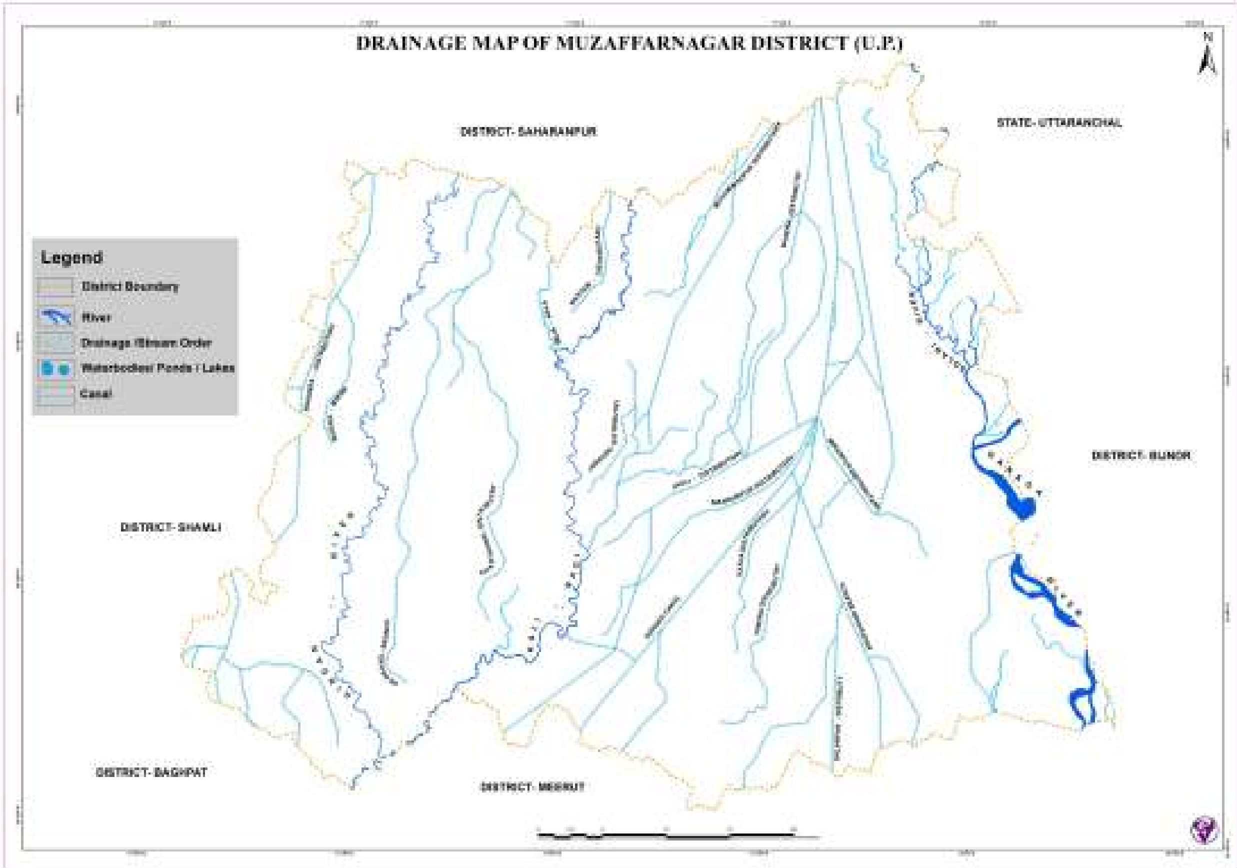


Table-1: Details of the Cropping Pattern

(Area in Ha)

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. Charthawal	22712	11522	34234	7243	24796	1742	23249	32093	151	138
2. Purkaji	22885	11470	34355	7637	25265	1420	21636	29172	150	135
3.Muzaffar-nagar	19192	8625	27817	8070	19117	1635	16890	23031	145	136
4. Baghara	20308	10486	30794	8815	19777	2067	21220	32180	152	152
5. Budhana	27978	13241	41219	13712	25865	2120	29620	38762	147	131
6. Shahpur	18425	7820	26245	11235	12620	1542	20280	27288	142	135
7. Morna	25300	9109	34409	8840	24267	1361	26567	33478	136	126
8. Jansath	32353	10272	42625	10896	29484	2077	27169	45552	132	168
9. Khatauli	26420	9437	35857	11920	20680	2715	26521	37512	136	141
Total Rural	215573	91982	307555	88368	201871	16679	213152	299068	143	140
Total Urban	3944	6270	10214	2485	6535	690	3713	15112	259	407
Total District	**219517**	**98252**	**317769**	**90853**	**208406**	**17369**	**216865**	**314180**	**145**	**145**

Table-2: Details of Area under Different Crops

(Area in ha)

Block	Rice (Kharif)		Rice (Jayad)		Total Rice		Wheat		Sugarcane	
	Total	*Irrigated*	*Total*	*Irrigated*	*Total*	*Irrigated*	*Total*	*Irrigated*	*Total*	*Irrigated*
1. Charthawal	1535	1535	0	0	1535	1535	8265	8086	16420	16220
2. Purkaji	1620	1620	40	40	1660	1660	8352	8352	15925	15652
3. Muzaffarnagar	958	958	0	0	958	958	7778	7778	14632	14580
4. Baghara	867	867	0	0	867	867	7320	7320	15165	15065
5. Budhana	836	834	0	0	836	834	10828	10790	22614	22451
6. Shahpur	885	885	0	0	885	885	7542	7542	12675	12486
7. Morna	1055	1055	0	0	1055	1055	8840	8625	21258	21170
8. Jansath	1720	1720	56	56	1776	1776	8935	8906	23867	23726
9. Khatauli	870	870	0	0	870	870	8562	8214	21437	21437
Total Rural	10346	10344	96	96	10442	10440	76422	75613	163993	162787
Total Urban	420	420	1	1	421	421	1789	1789	4048	3874
Total District	**10766**	**10764**	**97**	**97**	**10863**	**10861**	**78211**	**77402**	**168041**	**166661**

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

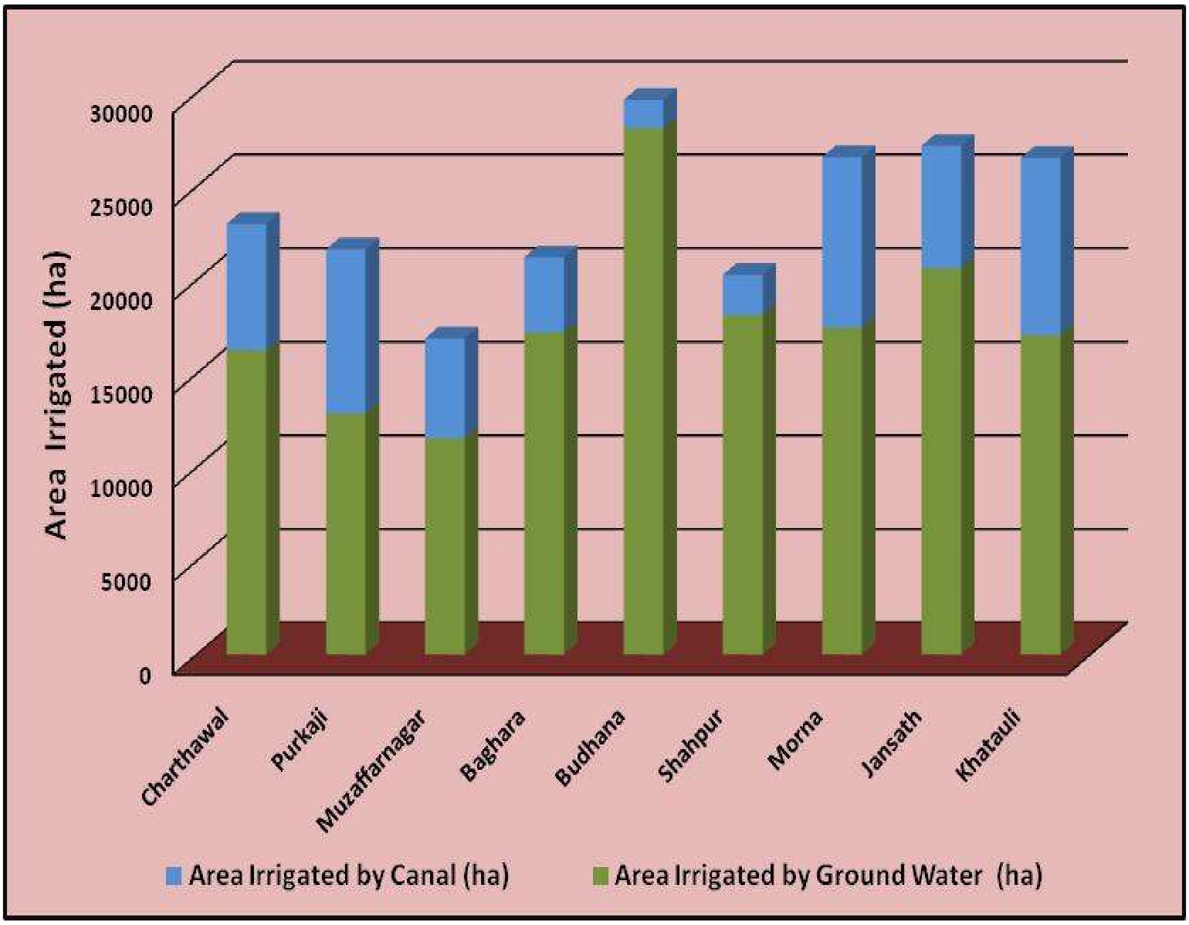
(Area in ha)

Blocks	Canal	Tubewell		Well	Pond	Other	Total
		Public	*Private*				
1. Charthawal	7045	274	13148	2620	0	0	23087
2. Purkaji	9152	335	9426	2521	0	0	21434
3. Muzaffarnagar	5720	305	11405	0	2	4	17436
4. Baghara	4362	219	13550	2452	0	2	20585
5. Budhana	1825	499	24565	2045	0	0	28934
6. Shahpur	2437	269	15149	1920	0	0	19775
7. Morna	9465	265	15232	2044	0	4	27010
8. Jansath	7013	394	20490		8	11	27916
9. Khatauli	9883	423	14545	1532	0	0	26383
Total Rural	**56902**	**2983**	**137510**	**15134**	**10**	**21**	**212560**
Total Urban	**450**	**35**	**3820**	**0**	**0**	**0**	**4305**
Total District	**57352**	**3018**	**141330**	**15134**	**10**	**21**	**216865**

Table-4: Irrigation

Block	Area Irrigated by Canal (ha)	Area Irrigated by Ground Water (ha)	Contribution of GW (%)
Charthawal	6759	16242	71
Purkaji	8777	12859	59
Muzaffarnagar	5342	11546	68
Baghara	4012	17208	81
Budhana	1510	28110	95
Shahpur	2143	18137	89
Morna	9104	17463	66
Jansath	6541	20621	76
Khatauli	9460	17061	64
Total	**53648**	**159247**	**75**

Fig-4: Irrigation from Canal and Ground Water



Muzaffarnagar district is one of the highly developed districts privileged with the Ganga and Eastern canal systems. Besides the Ganga canal & Eastern Yamuna canals, the additional irrigational needs are met by ground water. The maximum canal irrigation is in the Khatauli block followed by Purkaji block whereas it is minimum in Budhana block. 75% of net irrigated area is from ground water. The maximum 95% ground water irrigation is in Budhana Block whereas it is minimum 59% in Purkazi block.

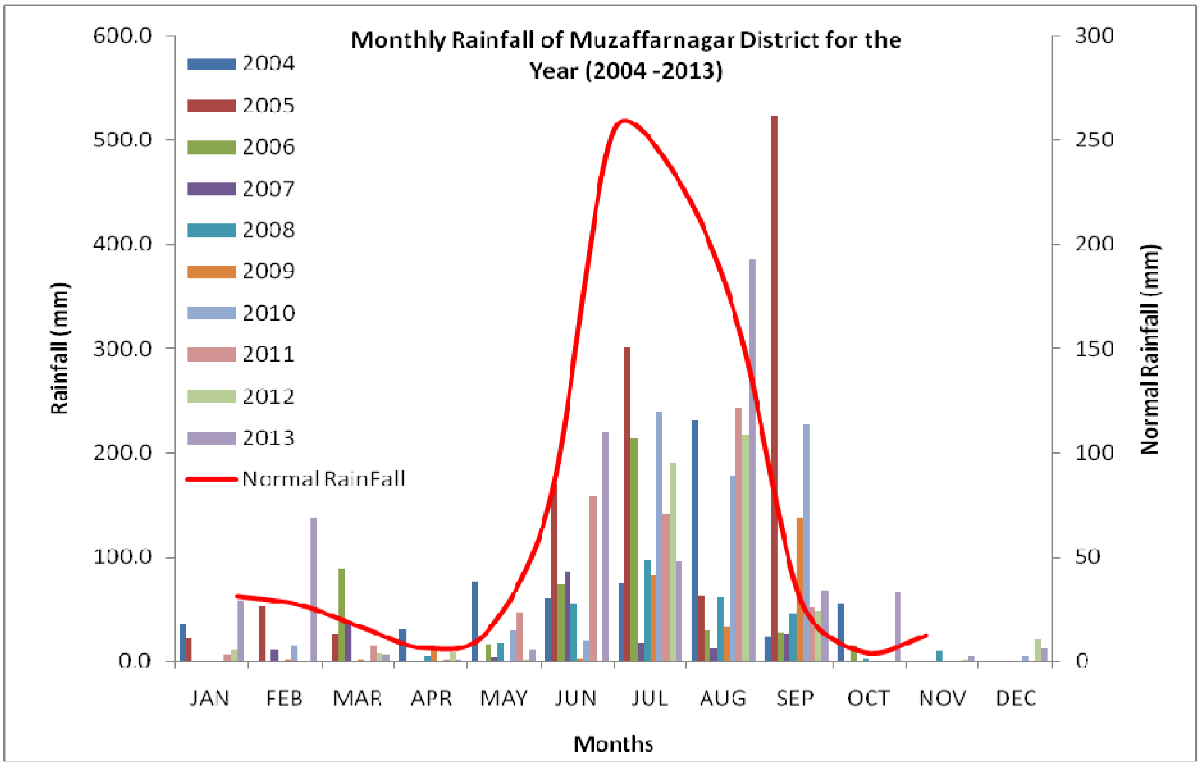
Table-5: Details of the Irrigation Sources

Block	Canal Length	Govt Tube wells	Perma-nent Wells	Rahats	Pump Sets			Total	Ground Pumpset
					Electric Pumps	*Diesel Pumps*	*Others*		
1. Charthawal	88	31	0	0	1629	5586	74	7289	104
2. Purkaji	131	42	0	0	522	4292	22	4836	0
3.Muzaffarnagar	97	13	0	0	1652	5812	651	8115	6
4. Baghara	59	27	1	0	3585	2485	124	6194	108
5. Budhana	47	63	46	0	4396	883	30	5309	172
6. Shahpur	45	35	4	0	3307	1269	20	4596	42
7. Morna	172	27	0	1	1495	5417	184	7096	46
8. Jansath	170	41	42	0	2921	10357	32	13310	0
9. Khatauli	134	42	137	0	1442	7160	57	8659	34
Total District	943	321	230	1	20949	43261	1194	65404	512

2.0 RAINFALL & CLIMATE

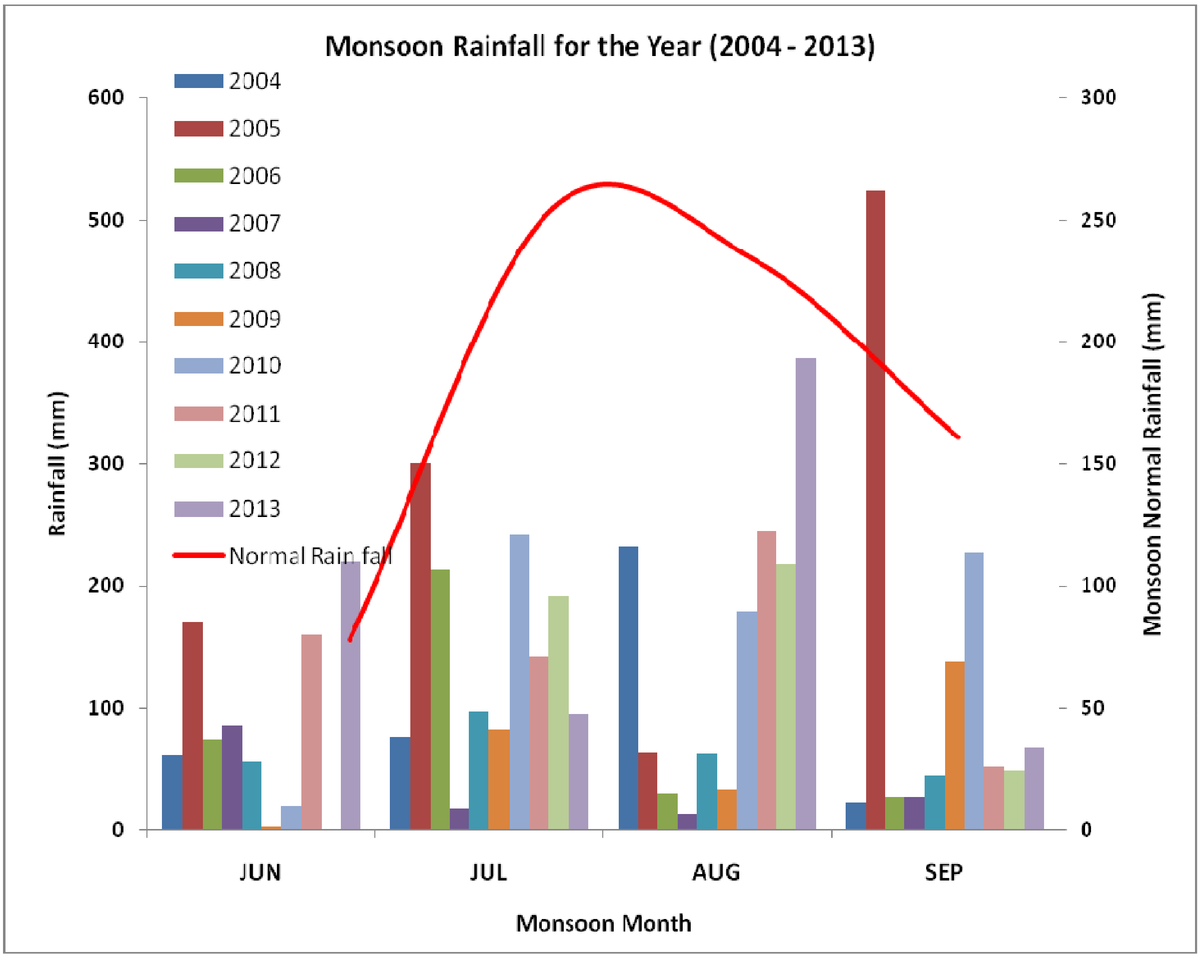
The normal annual rainfall in the district is 869 mm. About 737 mm, 80% of rainfall takes places from June to September. During monsoon surplus water is available for deep percolation to ground water. The climate is sub humid and it is characterised by general dryness except in the brief period during the monsoon season. Summer is hot and winter is pleasant cold season. There is a meteorological observatory at Meerut, which may be taken as representative of meteorological condition. May is the hottest month. The mean daily maximum temperature is about 40^0C, mean daily minimum temperature is about 24^0C and maximum temperature some time rises to 44^0C. With the onset of southern monsoon by the end of June, there is appreciable drop in temperature. January is the coldest month with mean daily temperature at about 20^0C and mean daily minimum at 7^0C.The air is dry during the major parts of the year. In southwest monsoon season, the air is very humid and April and May are usually driest months. The mean monthly relative humidity is 67%. The mean wind velocity is 6.70 Km.p.h. The potential evapotranspiration is 1545.90 mm.

Fig-5:



Monthly Rainfall of Muzaffarnagar District for the Year (2004 -2013)
600.0
500.0
400.0
300.0
200.0
100.0
0.0
Rainfall (mm)
300
250
200
150
100
50
0
Normal Rainfall (mm)
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Normal RainFall
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
Months

Fig-6:



Monsoon Rainfall for the Year (2004 - 2013)
600
500
400
300
200
100
0
Rainfall (mm)
300
250
200
150
100
50
0
Monsoon Normal Rainfall (mm)
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Normal Rain fall
JUN
JUL
AUG
SEP
Monsoon Month

3.0 GEOLOGY, GEOMORPHOLOGY AND SOIL

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 and show quick alteration from finer to coarser at places. 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. The entire Muzaffarnagar district is a flat terrain falling in upper Ganga plain. The highest point in the district is 222.00 m (amsl) in the north and the lowest 201.00 m (amsl) in the south, giving rise to an average slope of about 0.40 m/ km towards south. The district can be sub divided into five geographic units. (Fig: 7, 8 & 9)

a. *Sand Bars:*

It occurs along the courses of Ganga, the characteristic sand bars are changing dynamically during the floods.

b. *Flood Plain:*

It is a flat, low lying poorly drained area adjacent to Ganga and Yamuna rivers forming the flood plains frequently flooded during monsoons season.

c. *Ravines:*

In the western part of the district, this unit is characterised by the deep gullies along the rivers Kali and Hindon. This is probably due to the erosion of unconsolidated material by localised surface run off forming channels and ultimately giving rise to undulating topography and hence the formation of ravines.

d. *Younger Alluvial Plains:*

The gently sloping (southward) and slightly undulating terrain having ox-bow lakes, back swamp and paleo-channels forms this geomorphologic unit along the western bank of Ganga river in the district. This unit is also called Khadar. In the eastern part of the district, the Ganga Khadar (west of river Ganga) is widest (about 20 Kms) in the north and gradually narrows down to 2 km width around the place called Bhokerhedi.

e. *Older Alluvial Plain:*

Older alluvial plain may be divided into two parts-

(i) *Tract between Ganga canal and Kali river:* This is an upland with general slopes from east to west and more considerable than the regional slope of the area i.e. north to south. It is marked by natural levees as sand belt stretching north to south with heights ranging from 3 to 18 m.

(ii) *Tract between Kali and Hindon rivers:* Between these two rivers, the upland slopes down to both rivers and marked by broken grounds which is more pronounce in southern part of the district than that in the northern part.

Land Forms:

(i) *Water logged area: T*he water logged areas have developed along the main Ganga canal due to seepages. In the northern part of the canal, the water logged areas occurs along the western side while that in the southern part of the area water logged area is found in the eastern side of the canal.

(ii) *Back swamp:* The low lying swampy land is formed along the flood plains of Ganga river in the north-eastern part of the district around Majlispur and Farukhpur.

(iii)*Palaeo-channels:* In the western part of the district, cut-off meanders forming ox-bow lakes suggest the buried paleo-channels in the younger alluvial plains.

(iv)*Levee deposit:* These deposits are characteristic of river Ganga in the eastern part of the district which is a older high tracts of the river ranging from 3 to 18 m in height. The prominent levee stretches north-south from Purkaji in the north to Hasanwadi in the south with east-west width ranging from 0.50 to 2.00 m.

The soils of the district are formed by the transport of silt carried by the two rivers, Ganga and Yamuna. The soils are composed of Pleistocene and sub-recent alluvial sediments transported and deposited by river action from the Himalayan region. These alluvial deposits are unconsolidated. There are patches of saline and alkaline lands called “Bhur” areas mostly along the bank of Yamuna and the bank of upper Ganges canal. The stretches of low land along these rivers are called “khadars”. The khadar of Ganges differs from that of Yamuna, in not having wide stretches of settled countries and in having a better clay deposit. Lithologically, sediments consist of clay, silt, fine to coarse sand and kankars (calcareous concretions).

Fig-7: Geological Map of Muzaffarnagar District

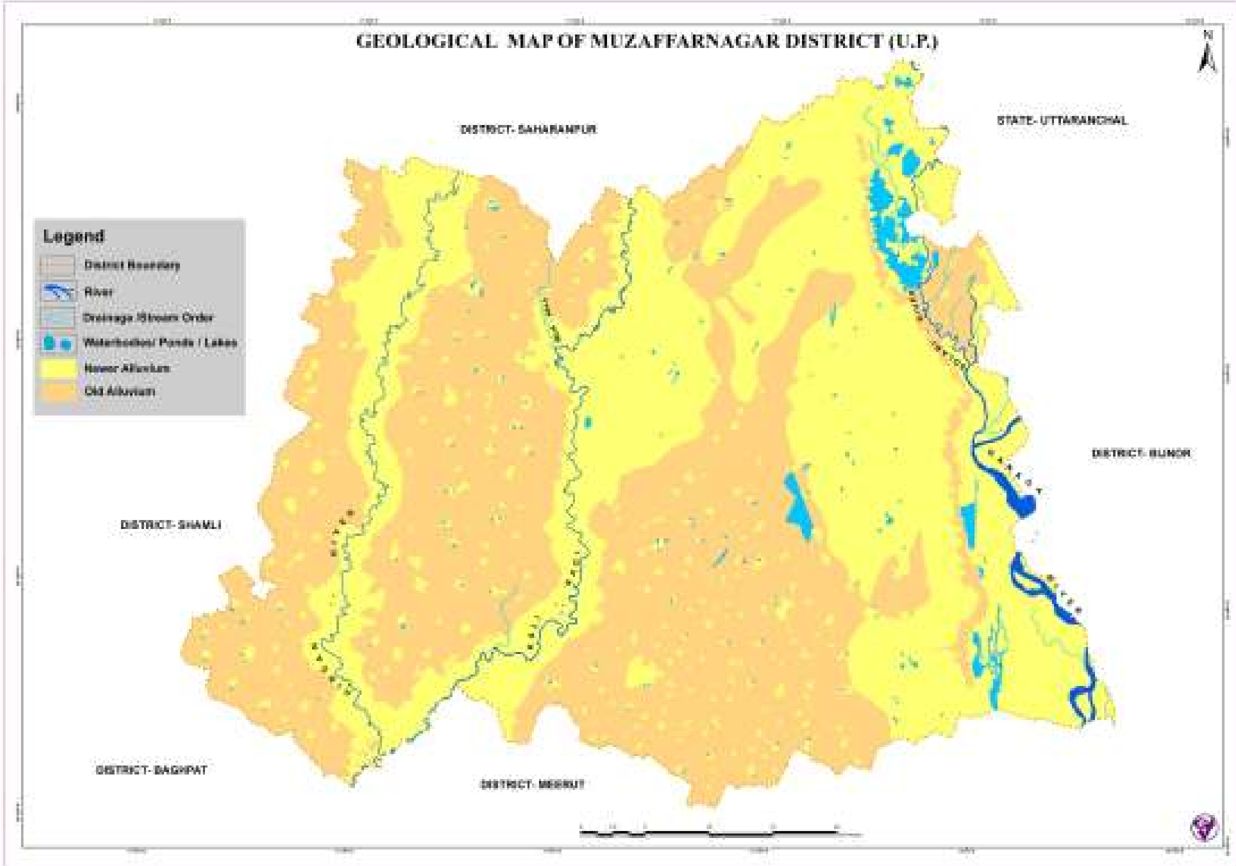


Fig-8: Geomorphological Map of Muzaffarnagar District

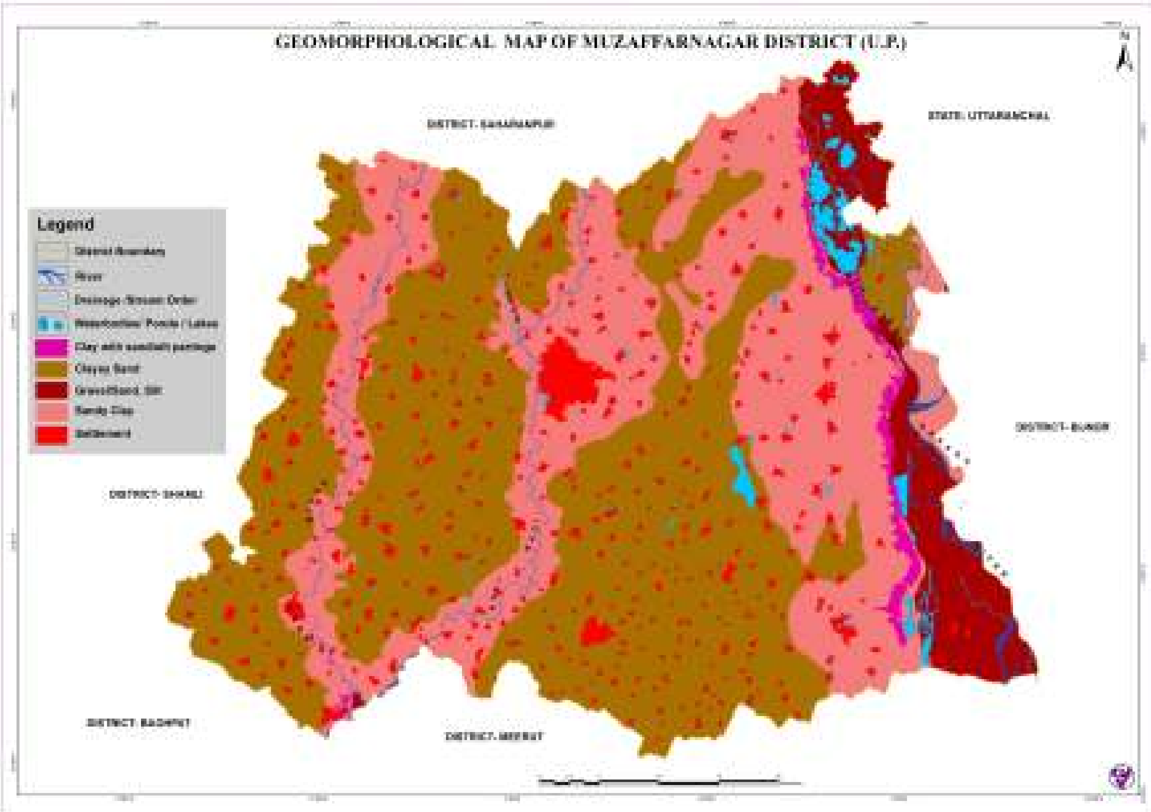
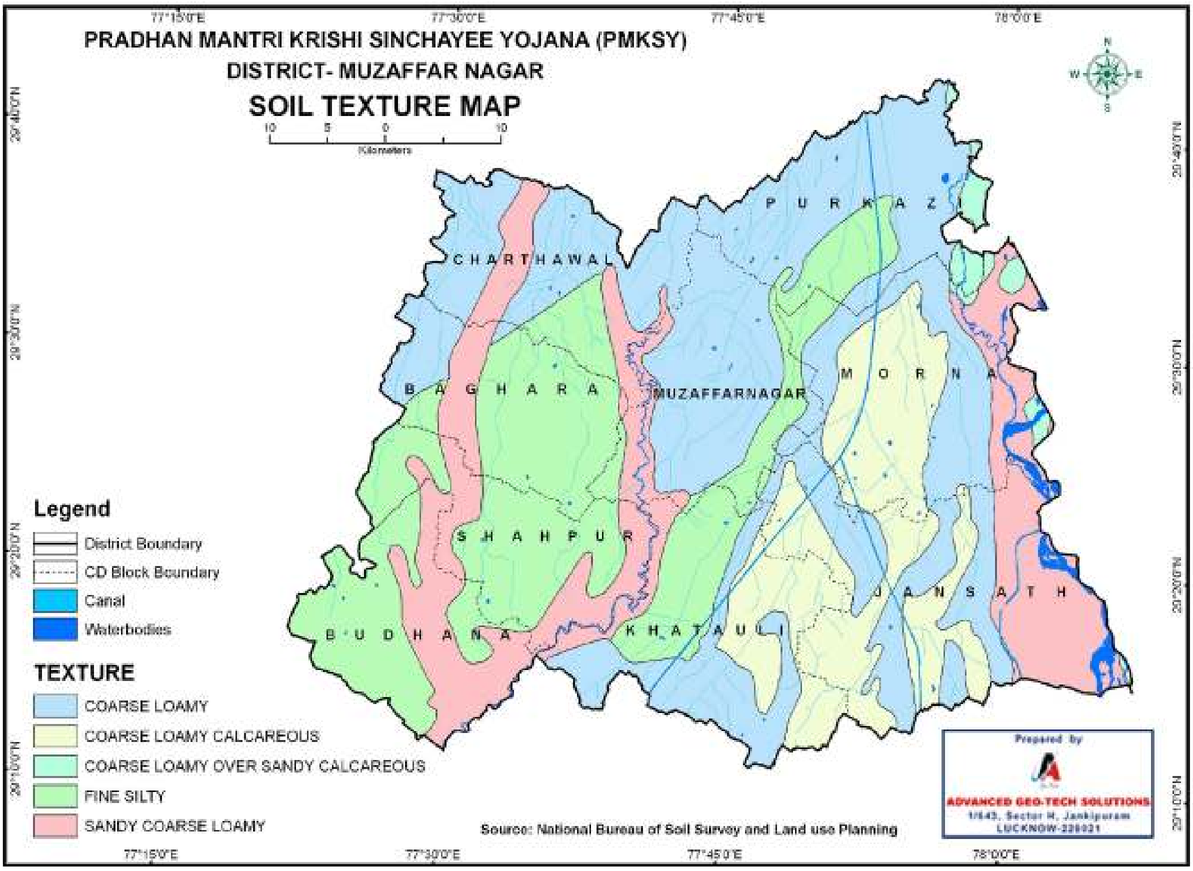


Fig-9: Soil Map of Muzaffarnagar District



4.0 GROUND WATER

4.1 Hydrogeology:

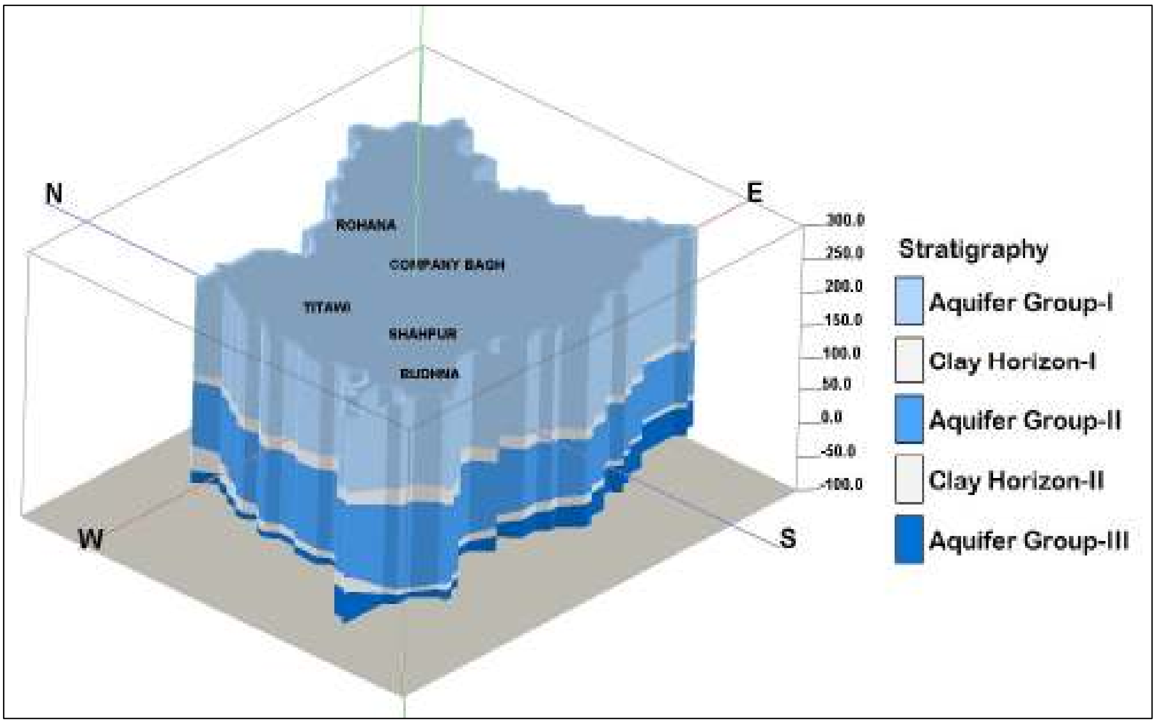
Muzaffarnagar district is underlain by Quaternary alluvium deposited by Ganga and Yamuna river system. Lithologically the alluvial sediments comprise of sand, silt, clay and kankars in varying proportions.

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. By and large there are three distinct groups of aquifers occurring in the area down to 463.00 mbgl. The entire district is underlain by top sandy clay bed ranging in thickness from 5 to 35 and followed by first aquifer with varying in thickness at different places and continues down to 162 mbgl (Bottom between 128 and 162 mbgl). Lithologically, the aquifer comprises medium to coarse sand but gravels and kankars are also encountered sometimes. This aquifer at places can also be sub divided into two sub groups due to the presence of either clay lenses or sub regional clay layers.

The second aquifer occurring at varying depths between 145 mbgl (Top between 145 and 185 mbgl) and 327 mbgl (Bottom between 276 and 327 mbgl) is separated by 10-15 m thick clay layer from the first aquifer. The second group of aquifer consists of finer sediments than that of first one and at places kankar and clay lenses are also found. The separating clay layer at places pinches out merging the first and second aquifer groups. The third aquifer is separated by second aquifer with thick clay layer. The fine grained third aquifer lies between the depths from 288 (Top between 288 and 327 mbgl) to 463 mbgl (Bottom between 445 and 463 mbgl).

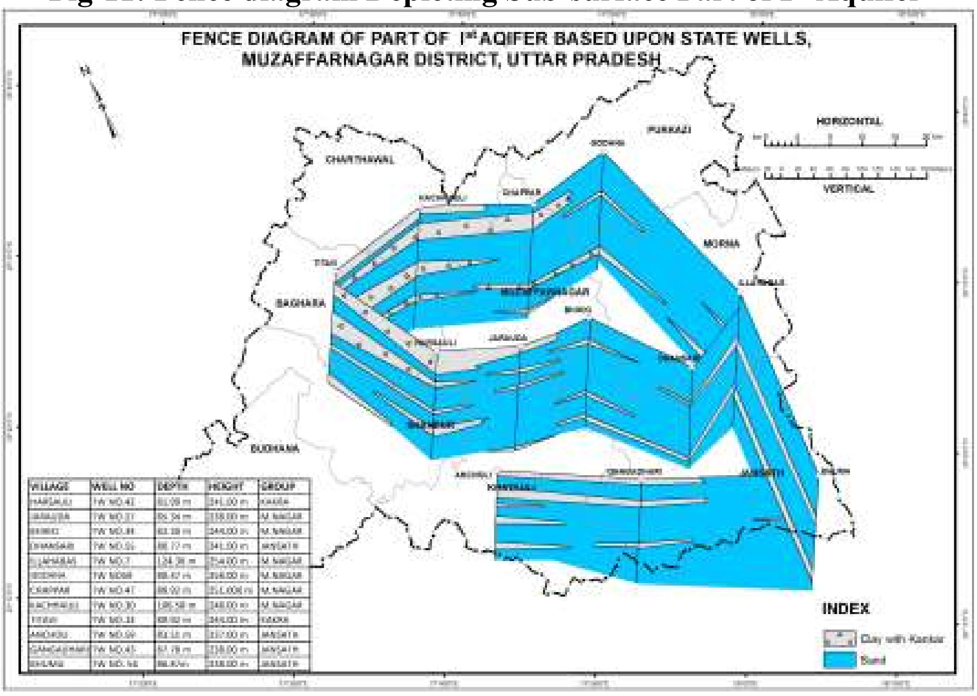
The aquifer material becomes coarser from west to east. The top clay layer is thickest at in the south western part of the district but it is almost absent at Sukratal in the eastern most part of the district. In general it can be observed that the river Ganga has deposited coarser material compared to those deposited by the Yamuna in river system.

Fig-10: 3D- Aquifer Disposition in Muzaffarnagar District



The Figure-10 gives an overview of 3-dimensional disposition of aquifer disposition in Muzaffarnagar district down to 300 m depth.

Fig-11: Fence diagram Depicting Sub-surface Part of Ist Aquifer



The Figure-11 depicts that in eastern part of the district the first aquifer is predominantly sandy in nature whereas sand content decreases towards western part of the district due to clay and kankar intercalations.

Fig-12: Fence Lines for Lithological Section

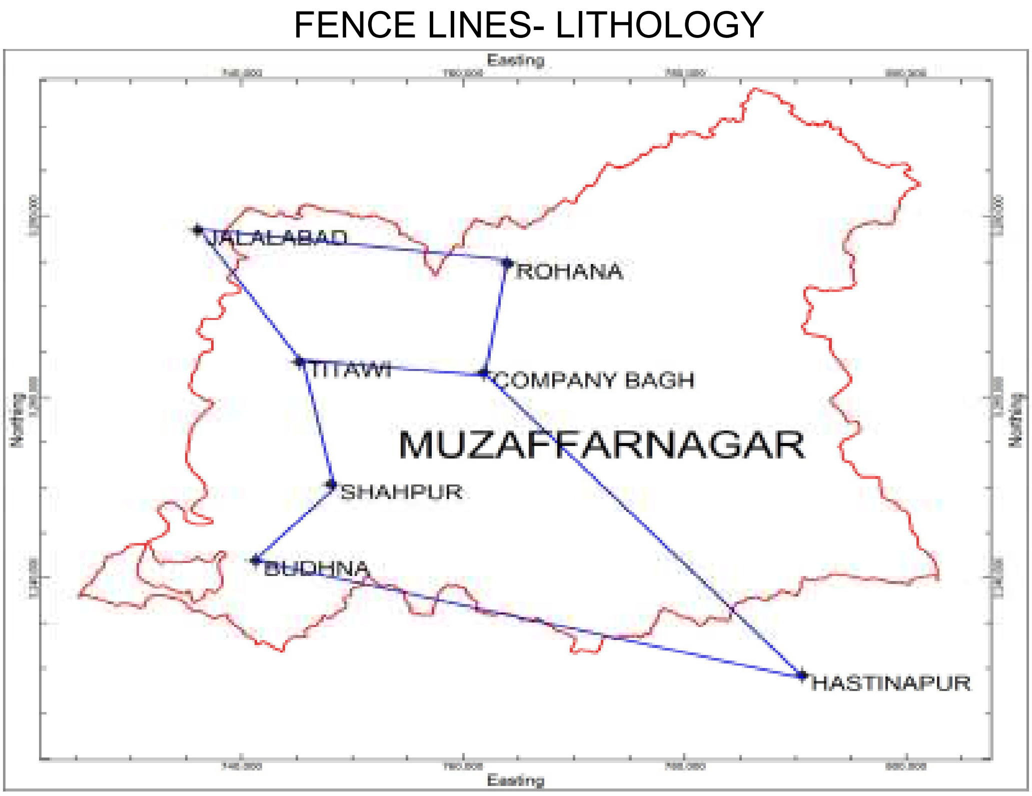


Fig.-12(a): Fence diagram Depicting Sub-surface Regionalised Lithological Variation

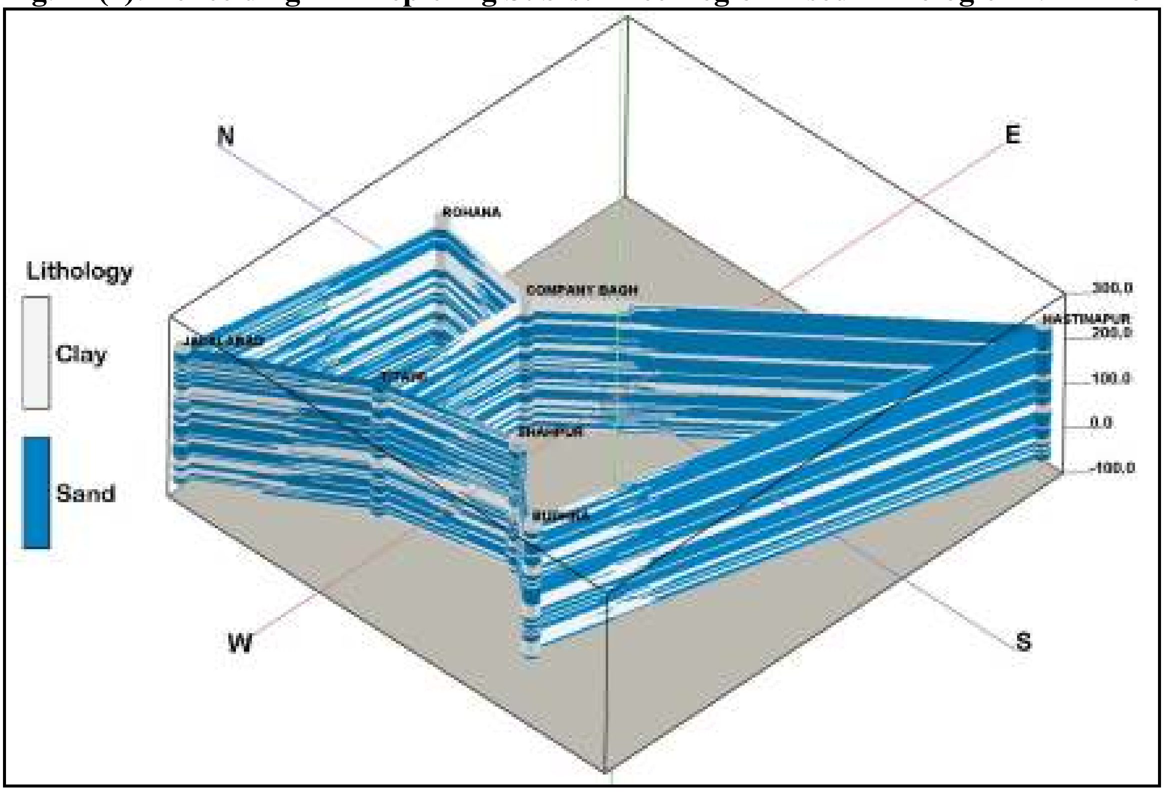


Fig-13: Fence Lines- Stratigraphy

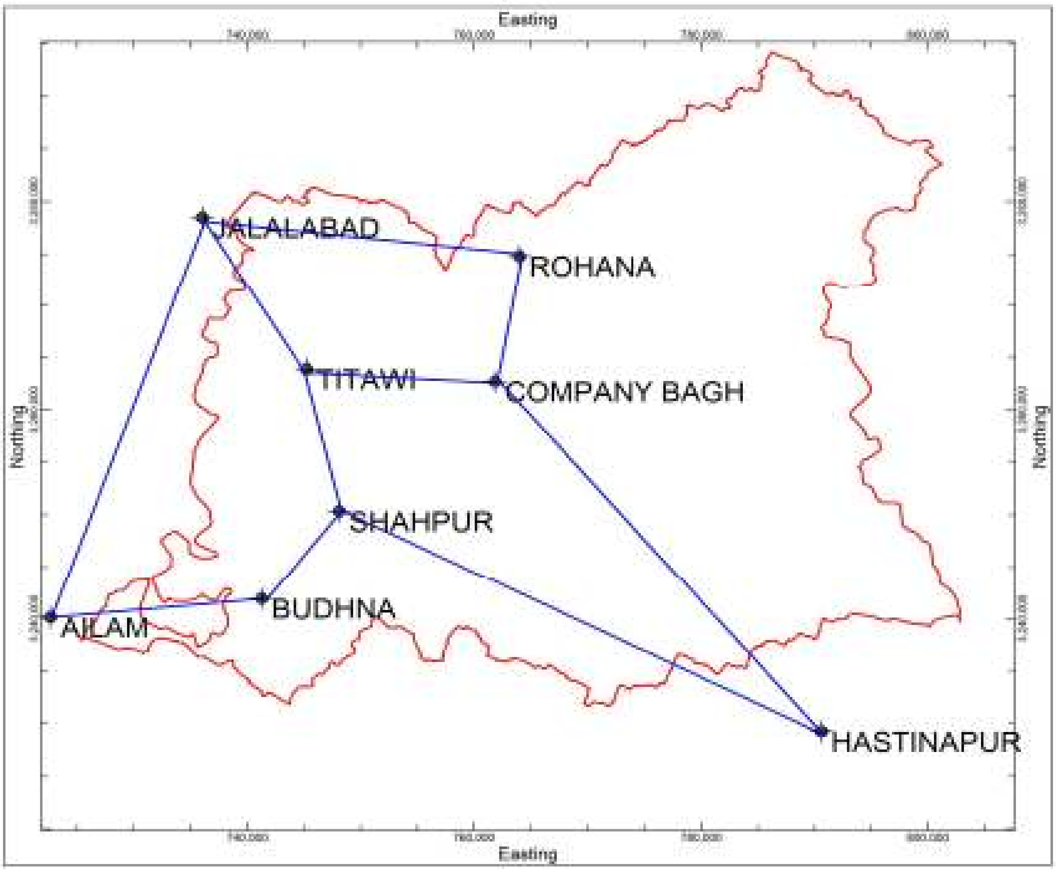
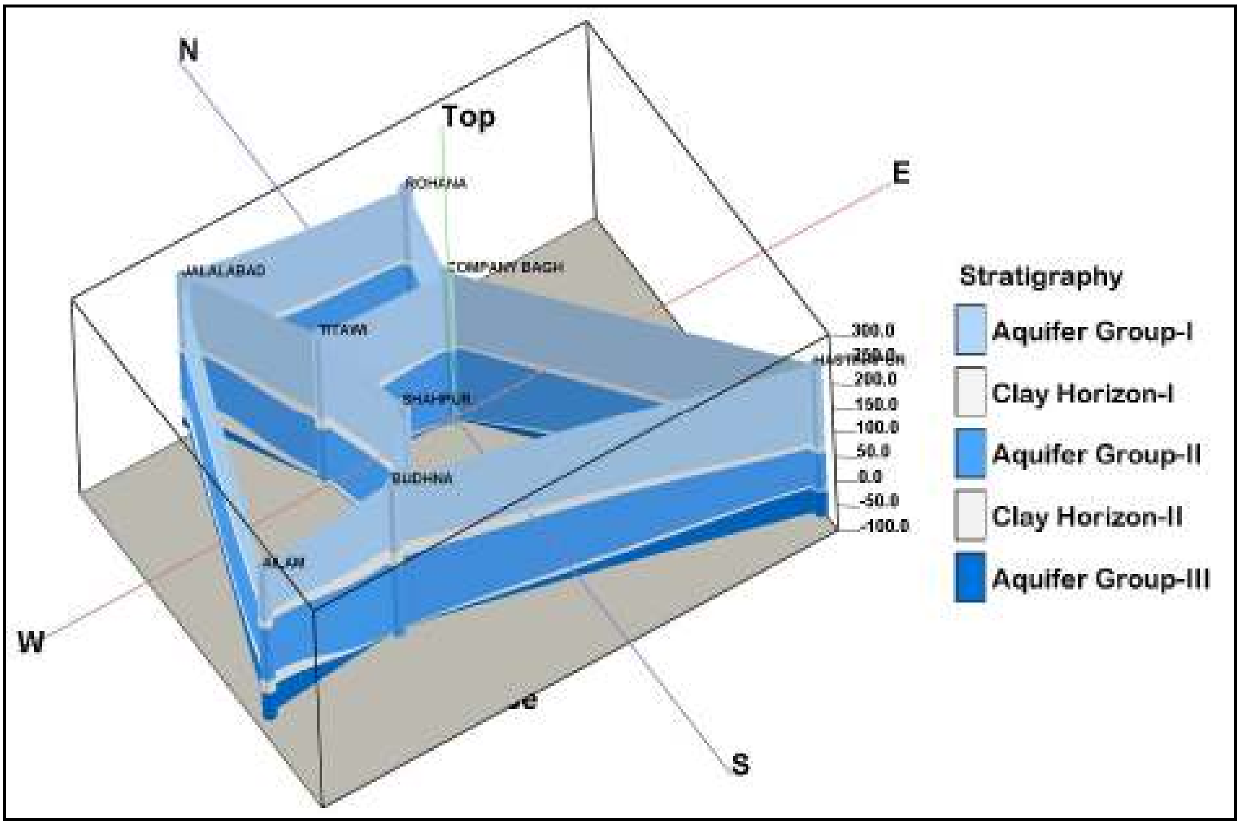


Fig-13(a): Fence diagram Depicting Sub-surface Regionalised Aquifer Groups



Fence diagram in Figure 13 (a) depicts the regionalized aquifer disposition down to 300 m depth in the district that shows first and second aquifer groups are basically encountered within 300 m depth. A very thin part of third aquifer group is encountered within this depth range and it extends beyond 300 m depth.

Fence diagram in Figure 12 (a) depicts an interlayered sequence of sands and clays in the district. It also shows that in eastern part of the district thick sand layers are present whereas thinner sand layers are present towards western part of the district due to clay and kankar intercalations.

Ground Water Condition:

Ground water occurs under phreatic to semi confined and confined conditions. The near surface aquifer is under unconfined / water table condition. The shallow phreatic aquifer is tapped by dugwells. The depth to water level of the CGWB monitoring stations ranges from 3.74 to 18.51 mbgl during pre monsoon whereas it ranges from 3.12 to 17.15 mbgl in post monsoon. The pre & post monsoon water level fluctuation varies from 0.24 to 1.36 m. The depth to water level map of premonsoon 2016 is presented in Figure-14.

Table-6: Water Level of CGWB GWMS (in mbgl)

Monitoring Station	May, 2016	Aug, 2016	Nov, 2016	Jan, 2016
BaghraPz	14.64	13.29	11.7	11.8
Chartawal	9.05	8.79	8.39	8.50
ChartawalPz	-	-	-	9.45
KamalpurPz	-	-	-	17.40
Khatauli 1	5.60	-	-	5.20
Khatauli PZ (GWD)	3.97	1.30	3.12	3.80
Kukra-SadarPz	13.44	13.34	12.94	13.40
MornaPz	18.24	16.84	16.66	17.85
PaldiPz GWD	18.51	17.20	17.15	20.10
Sukratal	3.74	2.84	3.50	3.25

Fig-14: Depth to water level- Premonsoon, 2016, Muzaffarnagar District

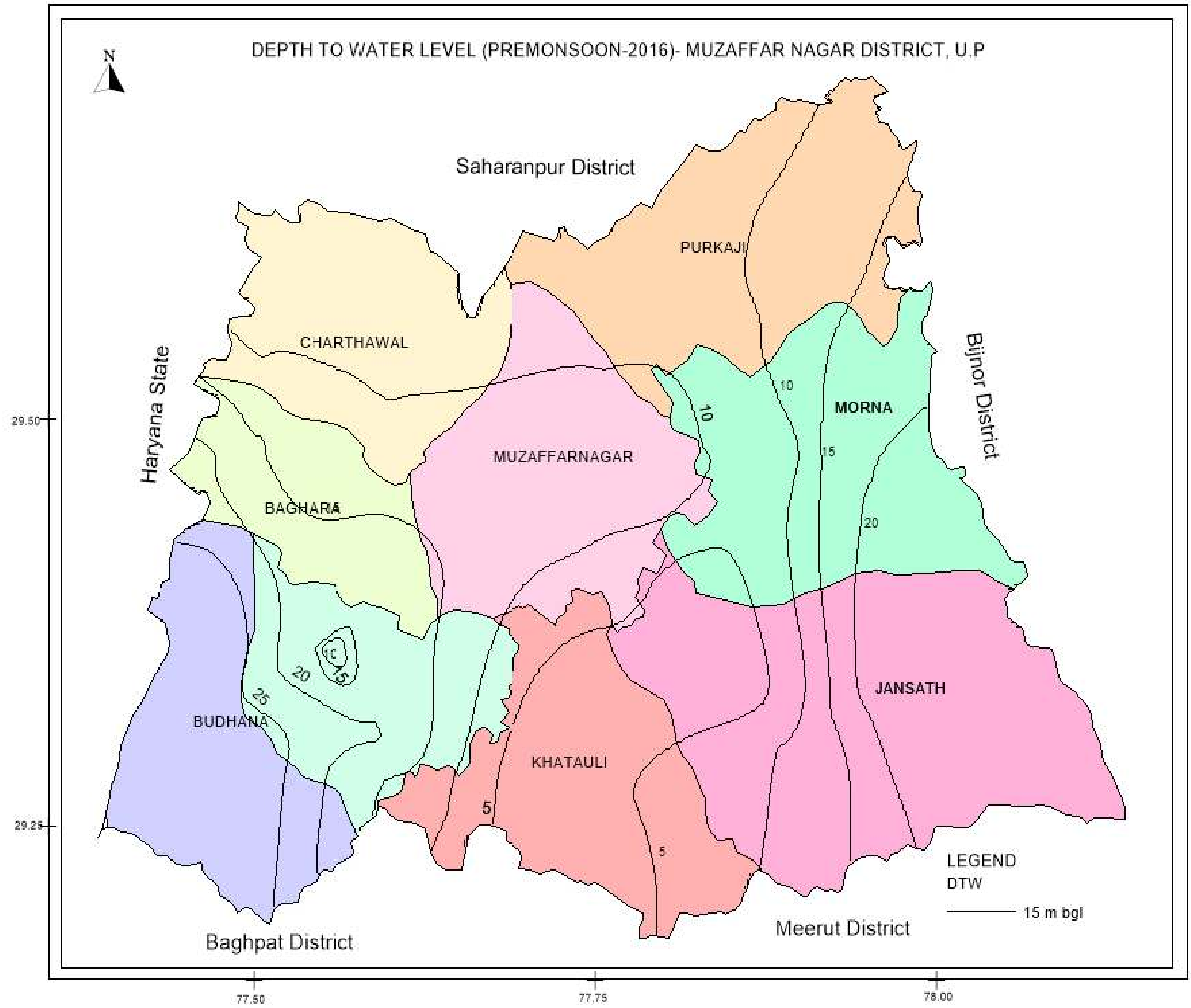


Figure-14 shows that deeper water are observed in the eastern as well as western part of the district whereas relatively shallower water levels are present in the central part of the district.

Figure-15 shows that groundwater flow direction is broadly North- Southwest in western part of the district whereas it is Northwest- Southeast in the eastern part of the district towards Ganga river. It shows that major river system in the district is perennial in nature.

Fig-15: Water Table Elevation- Muzaffarnagar District

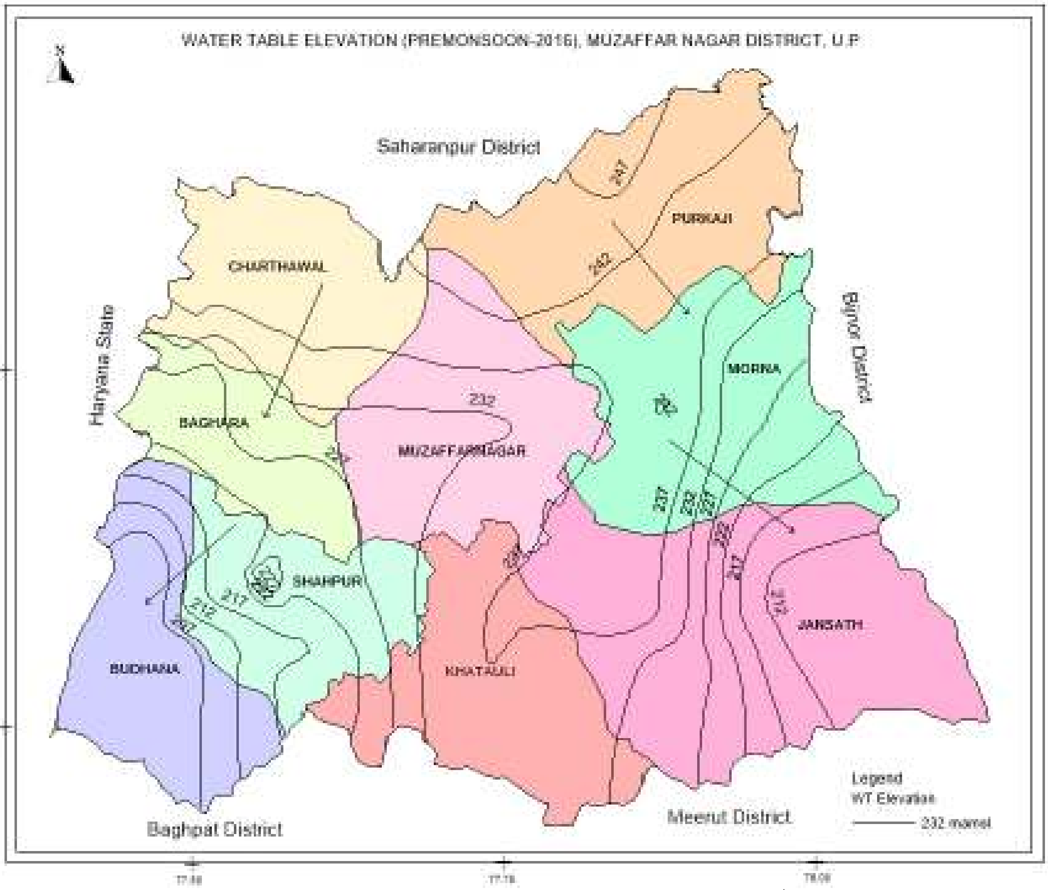


Fig-16: Sand Percentage Distribution in Ist Aquifer

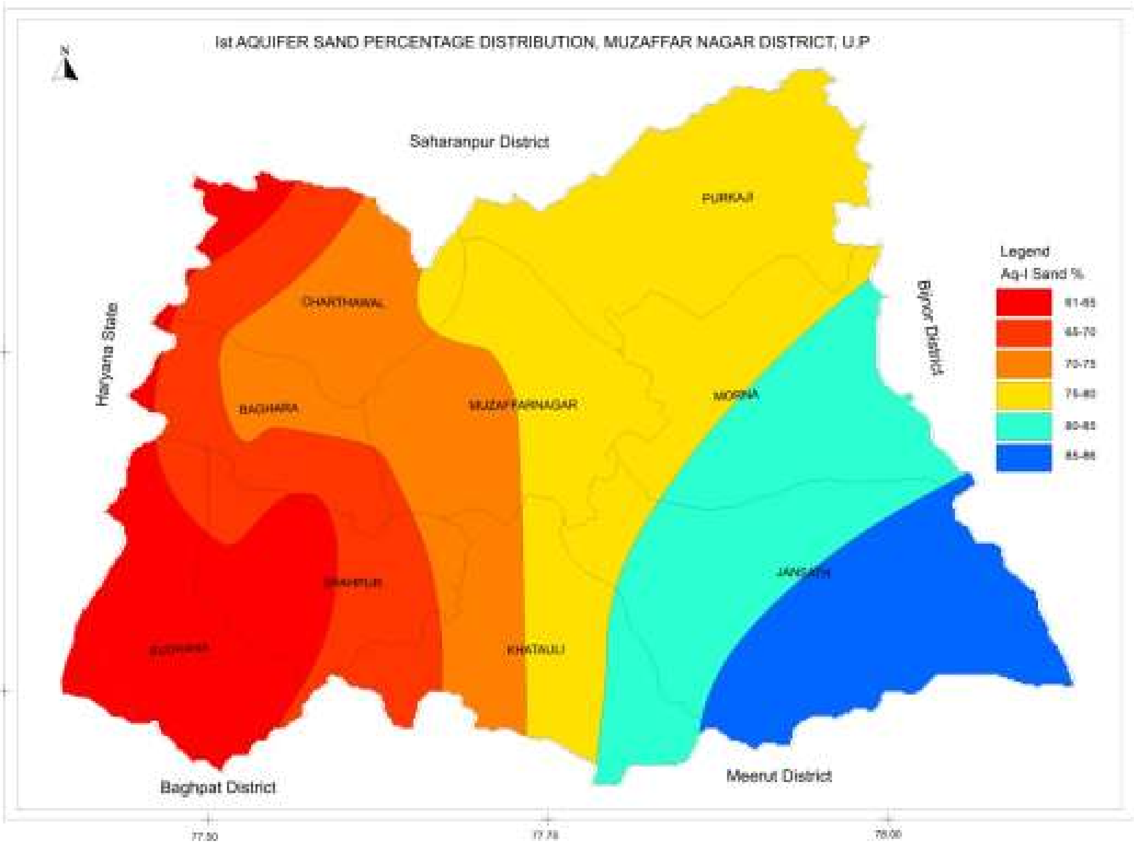


Figure-16 shows that sand percentage in the first aquifer system is on the higher side towards Ganga River in the eastern part of the district ranging between 75 and 85% whereas sand percentage decreases progressively towards Yamuna river in the western part of the district ranging between 65 and 75%.

Fig-17: Sand Percentage Distribution in IInd Aquifer

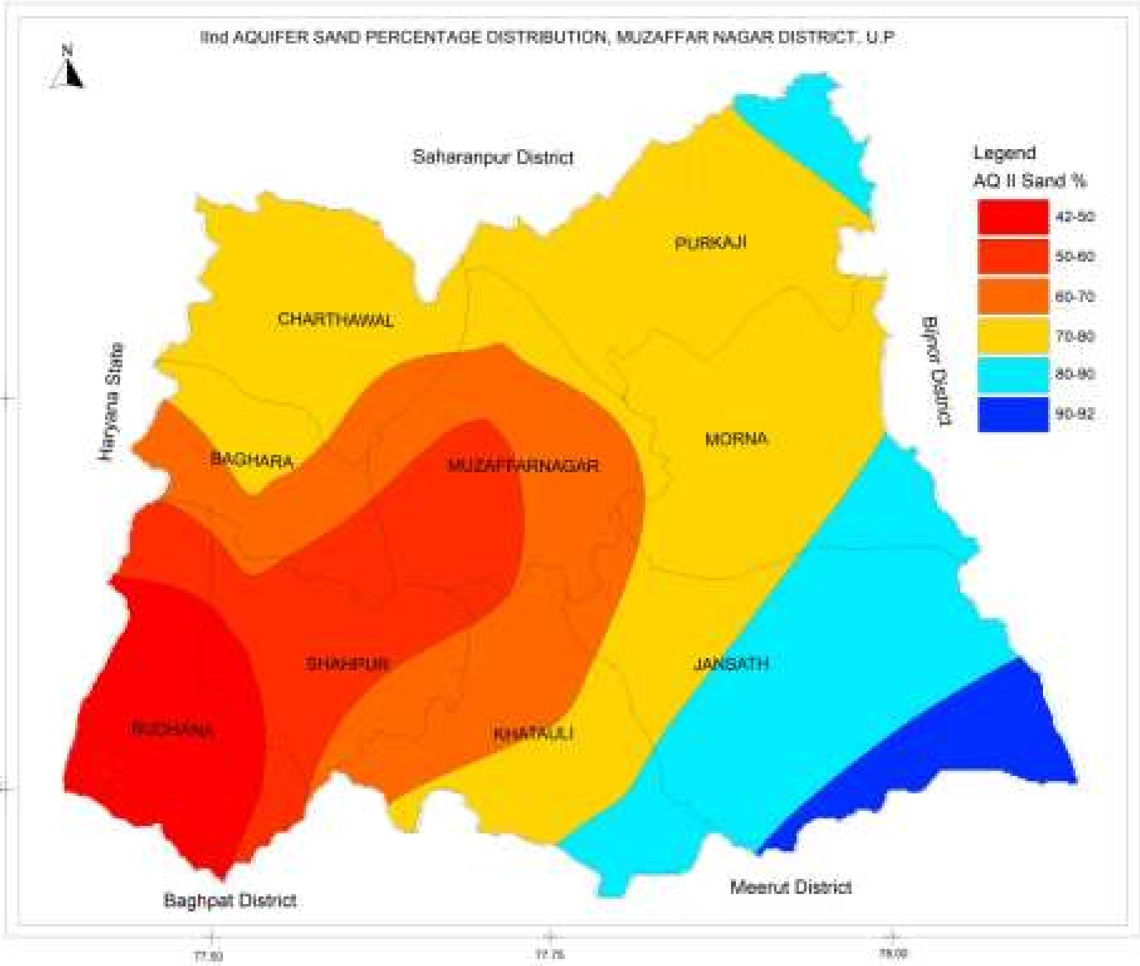


Figure-17 shows that as in the case of first aquifer, the sand percentage in the second aquifer system also is on the higher side towards Ganga River in the eastern part of the district ranging between 75% and 85% whereas sand percentage decreases progressively towards Yamuna river in the western part of the district ranging between 50 and 70%.

Isopachs of first aquifer system in Figure 18 shows that thickness of the aquifer increases towards eastern part of the district towards Ganga river and decreases in western part of the district towards Yamuna river.

Fig-18: Isopach Map of I^st Aquifer

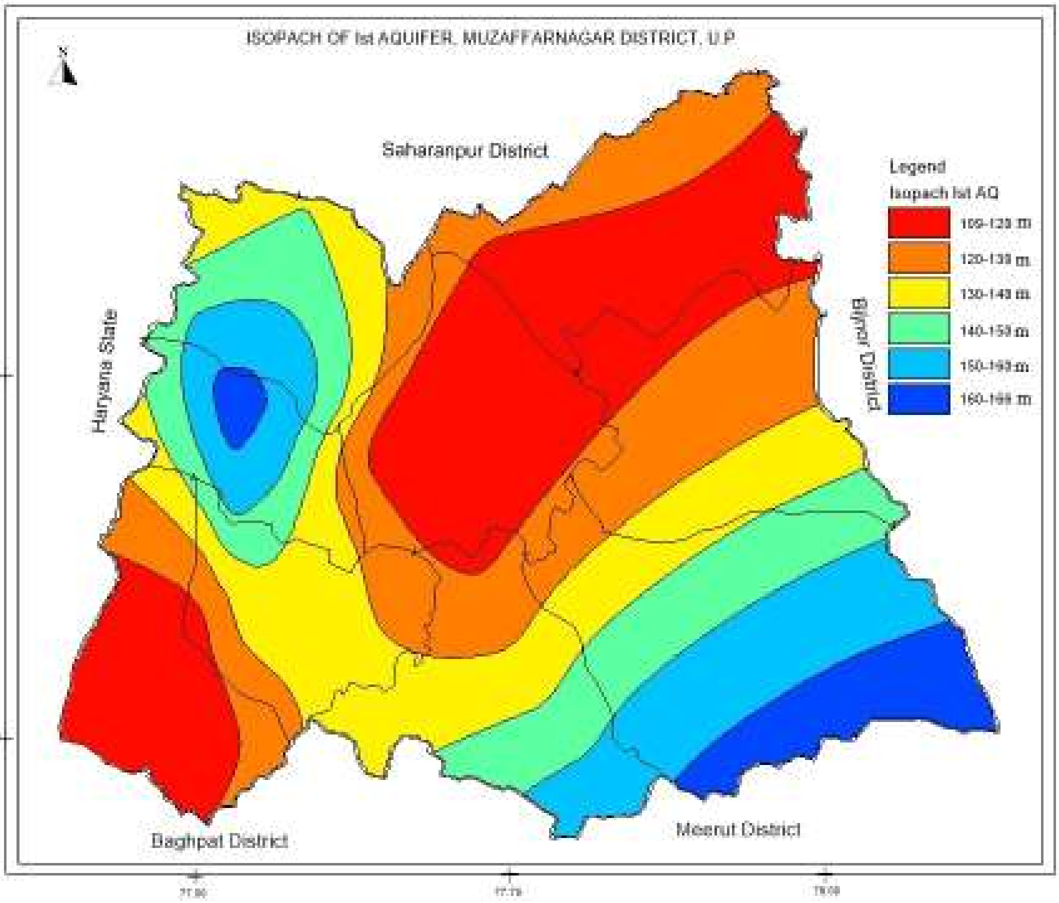
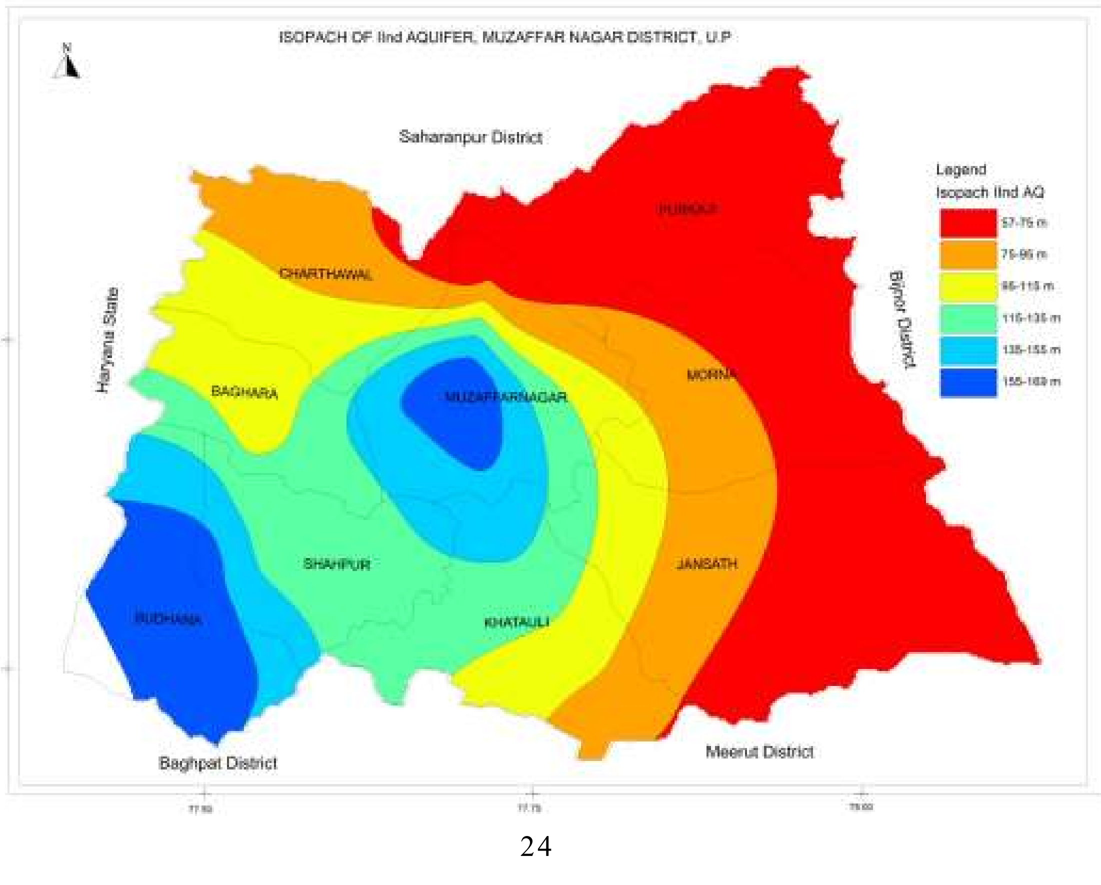


Fig-19: Isopach Map of II^nd Aquifer



Isopachs of Second aquifer system in Figure 19 shows that thickness of the aquifer increases towards western part of the district towards Yamuna river and decreases in eastern part of the district towards Ganga river.

Long Term Water Level Trend:

The long term water level trend for the period 2006-2015 indicates both rise and fall in water level. There was no rise recorded in pre-monsoon year while a fall in water level ranges from 01 to 54 cm per year. There was no rise in water level during post-monsoon period except at Sukratal, while the fall in water level ranges from 0.14 to 66 cm per year.

4.1.2. Aquifer Parameters:

Discharge (liters per second	-	33 - 37
Storativity (S)	-	3.14×10^{-3}
Transmissivity (m^2/day)	-	857 to 2204

Table-7: Long Term Water Level Trend (2006 – 2015) (CGWB GWM Wells)

Block	Pre-Monsoon (m/yr)		Post – Monsoon (m/yr)	
	Rise	Fall	Rise	Fall
Baghra	-	0.3993	-	0.3886
BaghraPz	-	0.5443	-	0.4151
Barla	-	0.2072	-	0.2323
Chartawal	-	0.0582	-	0.1429
ChartawalPz	-	0.1999	-	0.2470
Jansath2	-		-	0.2017
KamalpurPz	-	0.1552	-	-
Kukra-SadarPz	-	0.3506	-	0.4365
MornaPz	-	0.1864	-	0.6663
Sukratal	-	0.0114	0.0378	-

4.2 Ground Water Resource:

Ground water resources have been computed jointly by Central Ground Water Board and Ground Water Department, Govt. of U.P. as on 31st March 2013. The salient features of the computations are furnished below –

Fig-20: Ground Water Resources, As on 31.03.2013

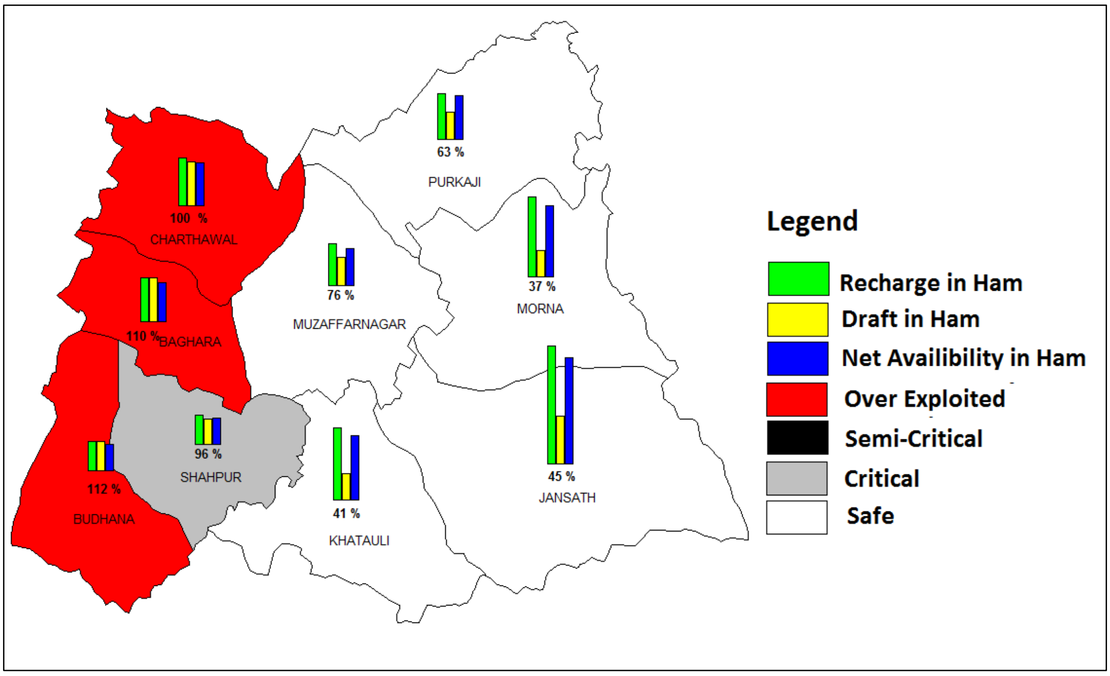


Table-8: Details of Recharge and Natural Discharge (ham)

Sl. No.	Assessment Units - Blocks/ District	Recharge from Rainfall during Monsoon Season	Recharge from Other Sources during Monsoon Season	Recharge from Rainfall during Non-Monsoon Season	Recharge from Other Sources during Non-Monsoon Season	Total Annual Ground Water Recharge	Provision for Natural Discharges	Net Annual Ground Water Availability
1	Bhaghara	3594.97	1644.20	1039.05	2744.42	9022.64	902.26	8120.38
2	Budhana	4054.04	606.65	592.76	778.44	6031.89	603.19	5428.70
3	Charthawal	4148.78	1826.84	1199.12	2726.12	9900.86	990.09	8910.77
4	Jansath	12312.99	3473.86	1626.28	6679.37	24092.50	2409.25	21683.25
5	Khatauli	5198.33	3019.02	1029.88	5539.28	14786.51	1478.65	13307.86
6	Morna	6057.52	3081.37	1200.10	5949.99	16288.98	1628.90	14660.08
7	Muzaffarnagar	3959.14	1462.09	1144.31	2045.99	8611.52	861.15	7750.37
8	Purkaji	4914.60	1085.80	1299.60	2163.57	9463.57	473.18	8990.39
9	Shahpur	3767.47	744.38	550.86	1076.49	6139.19	613.92	5525.27
	Total	**48007.84**	**16944.20**	**9681.94**	**29703.67**	**104337.65**	**9960.59**	**94377.07**

Table-9: Details of Draft for Different Purposes

Sl. No.	Assessment Units - Blocks/ District	Net Annual Ground Water Availability (ham)	Existing Gross Ground Water Draft for Irrigation (ham)	Existing Gross Ground Water Draft for Domestic & Industrial Water Supply (ham)	Existing Gross Ground Water Draft for All Uses (ham)	Provision for Domestic and Industrial Requirement Supply for 2038 (ham)	Net Ground Water Availability for future Irrigation development	Stage of Ground Water Development (%)
1	Bhaghara	8120.38	8532.00	459.54	8991.54	794.58	0.00	110.73
2	Budhana	5428.70	6119.20	0.00	6119.20	798.02	0.00	112.72
3	Charthawal	8910.77	8334.15	656.53	8990.68	1185.81	0.00	100.90
4	Jansath	21683.25	9365.25	541.77	9907.02	1012.47	11305.53	45.69
5	Khatauli	13307.86	4701.56	767.54	5469.10	981.02	7625.28	41.10
6	Morna	14660.08	5168.98	376.07	5545.05	852.07	8639.03	37.82
7	Muzaffarnagar	7750.37	5420.16	541.73	5961.89	1389.44	940.77	76.92
8	Purkaji	8990.39	5220.36	502.53	5722.89	569.38	3200.65	63.66
9	Shahpur	5525.27	5345.73	0.00	5345.73	705.85	0.00	96.75
	Total	**94377.07**	**58207.39**	**3845.71**	**62053.10**	**8288.64**	**31711.26**	**65.75**

Table-10: Static Resource in Aquifer- I in Muzaffarnagar District

Block	Area (sq.km.)	Avg Pre Monsoon DTW (mbgl)	Avg Thick-ness	Thick-ness below WL (m)	Thickness Granular Zones (m)#	Resource in MCM (Area x grainular zone thickness x Sp. Yield**)
Bhaghara	230.9	12.52	145	132.48	92.73	2055.55
Budhana	238.8	28.34	128	99.66	59.80	1370.81
Charthawal	266.47	8.14	140	131.86	85.71	2192.53
Jansath	481.04	8.21	140	131.79	105.43	4868.83
Khatauli	304.63	6.18	140	133.82	100.37	2935.12
Morna	354.98	9.16	130	120.84	96.67	3294.40
Muzaffarnagar	254.29	9.64	130	120.36	90.27	2203.66
Purkaji	288.8	5.86	130	124.14	93.11	2581.32
Shahpur	221.92	13.63	132	118.37	76.94	1639.17
Total Resource Available In Unconfined Aquifer (MCM)						**23141.39**
# Calculated on the basis of % of granular zones for respective block, ** Specific Yield has been taken as 0.096						

Table-11: Static Resource in Confined Aquifer in Muzaffarnagar District (down to 300m)

Block	Area (A) (sq. km.)	Avg. Piezometric head (P) Considered (mbgl)	Avg. Top Conf Aq (TII) (mbgl)	Storativity (S) Considered (*10-3)	Thickness of granular zones (Gr) down to 300 m.	Specific Yield (Sy) Considered	Storage under Pressure (in MCM) A*(TII-P)*S	Storage in Aquifer (in MCM) (A*Gr*Sy)	Total Storage in Deeper Aquifer (in MCM)
Bhaghara	230.9	9	185	3.14	80.5	0.096	127.60	1784.40	1912.00
Budhana	238.8	9	158	3.14	71	0.096	111.72	1627.66	1739.39
Charthawal	266.47	9	147	3.14	107.1	0.096	115.47	2739.74	2855.20
Jansath	481.04	9	145	3.14	124	0.096	205.42	5726.30	5931.72
Khatauli	304.63	9	165	3.14	101.25	0.096	149.22	2961.00	3110.22
Morna	354.98	9	145	3.14	116.25	0.096	151.59	3961.58	4113.17
Muzaffarnagar	254.29	9	150	3.14	97.5	0.096	112.58	2380.15	2492.74
Purkaji	288.8	9	145	3.14	116.25	0.096	123.33	3223.01	3346.34
Shahpur	221.92	9	165	3.14	74.25	0.096	108.71	1581.85	1690.55
Total Storage In Confined Aquifer (Down To 300 M) In MCM							**1205.65**	**25985.68**	**27191.33**

Table-12: Total G.W. Resources in Muzaffarnagar District (down to 300 m) in MCM

Block	Area (sq. km.)	Aquifer-I (Unconfined)			Aq-II (Confined)	Total Storage (MCM)
		Dynamic Resource (MCM)	*Static Storage (MCM)*	*Total Resource (Aq-I) (MCM)*	*Resource (MCM)*	
Bhaghara	230.9	81.20	2055.55	2136.76	1912.00	4048.76
Budhana	238.8	54.29	1370.81	1425.10	1739.39	3164.48
Charthawal	266.47	89.11	2192.53	2281.64	2855.20	5136.84
Jansath	481.04	216.83	4868.83	5085.67	5931.72	11017.39
Khatauli	304.63	133.08	2935.12	3068.20	3110.22	6178.42
Morna	354.98	146.60	3294.40	3441.00	4113.17	7554.16
Muzaffarnagar	254.29	77.50	2203.66	2281.16	2492.74	4773.90
Purkaji	288.8	89.90	2581.32	2671.22	3346.34	6017.56
Shahpur	221.92	55.25	1639.17	1694.42	1690.55	3384.97
Total	**2641.83**	**943.77**	**23141.39**	**24085.16**	**27191.33**	**51276.49**

4.3 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, CO3, HCO3, Cl, F, No3, SO4, TH, Ca, Mg & Na . The specific electrical conductance of ground water in phreatic aquifer ranges from 220-1870 micro siemens/cm at 250C. Fluoride ranges from 0.08-0.99 mg/l, which is within permissible limit. Nitrate ranges from Nd-93 mg/l and is found in excess of permissible limit (>45mg/l) in only two out of thirty four samples (Biralasi, block Charthawal & Dholra, block Baghra), which is likely due to return irrigation flow from agricultural fields and often improper waste disposal.

Among trace elements, Iron concentration ranges from 0.044-4.07 mg/l (Luhsana, bl Budhna). Out of the thirty five samples collected from the district seventeen 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 (Luhsana, block Budhna; Jansath block Jansath; Rasul Sarai, block Khatauli; Bhopa & Sikandarpur, block Morna; Muzaffarnagar, block Muzaffarnagar and Tuglakpur, block Purqazi). 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 Nd-0.403 mg/l and in two out of thirty five samples it shows value more than the permissible limit (>0.3 mg/l) (Biralasi & Chathawal, block Charthawal). Almost all the samples show Zn and copper concentration within the permissible limits.

4.4 Status of Ground Water Development:

Presently ground water is being developed through 94814 private tubewells & borewells in addition to 245 dug wells. The total ground water draft is 62,053.10 ham, which is being used in present for domestic, irrigation & industrial purposes against the ground water availability of 94377.07 ham. Out of 9 blocks, three blocks falls under over exploited category which are Baghara, Budhna, Chathawal, and one block Shahpur under Critical and rest five (5) blocks are under Safe category and presented in Fig-20. The percentage wise development is given in Table-9. 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. Net ground water availability for future irrigation is 31711.26 ham.

5.0 GROUND WATER RELATED ISSUES AND PROBLEMS

The development of ground water in the district, in general, is high as 3 (three) blocks (Baghara, Budhana, Charthawal) out of 9 blocks in the district have been categorised as **Over**

Exploited and 1 block (Shahpur) as **Critical**. Although overall stage of ground water development in the district is about 65%, yet 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 & Critical blocks. Based on the factors mentioned, it is inferred that the district in general could be considered 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.

6.0 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-13:

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.**	◦ 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.
Scope of supply side interventions is limited due to topography, land availability and also less availability of surplus water.	**Most effective option to reduce ground water withdrawal by 35-40% specially for Sugarcane areas by adopting new irrigation practices**

6.1 Supply side Management:

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. It is proposed to construct 11 Check dams of 10,000 cubic m. capacity and 120 nala bunds of 7,500 cubic meter capacity, to revive and renovate 430 ponds and development of 26 Km. stream channel.

It is also proposed to adopt On Farm practices such as laser leveling, bench terracing, construction of farm ponds, afforestation, diversification of crops etc. On farm activities are proposed in an area of 9600 hectare. It is expected that above measures will lead to additional recharge of 15.17 MCM of ground water. Block-wise details are given in Table 14.

6.2 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 estimated that there may be saving of 15.60 MCM of water with this measure. It is also proposed to adopt new water saving agricultural practices in about 61000 Ha. in areas of sugarcane cultivation in over-exploited and 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 Muzaffarnagar district will substantially bring down stage of ground water development. Blockwise details are given in table 15.

6.21 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-14: 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.

Sugarcane Crop grown with 4- Irrigations at 4- Critical growth stages

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 are 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.

Ring Pit Method of Sugarcane Planting

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.

Skip Furrow Method Of Irrigation

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.

Table-15: Proposed Artificial Recharge and WUE Interventions in Muzaffarnagar District

Proposed Interventions in Muzaffarnagar District									
Block	**Check Dams of 10000 cum Capa-city (Nos)**	**Channel/ Stream Develop-ment (Km)**	**Nala Bunds of 7500 cum Capa-city (Nos)**	**Revival of Ponds 50m x 50m x 3m dimen-sion**	**Adoption of new irrigation pra ctices for Sugar cane (Area in ha)**	**On farm Acti-vities (Area in ha)**	**Water Use Efficiency Measures (Area in ha)**	**Project Cost (Crore)**	**Provi-sion for O & M 5% +Impact Assessment 5% (Crore)**
Baghara	2	3	30	105	15000	2300	2300	21.79	2.18
Budhana	3	10	35	105	21000	2400	2400	23.28	2.32
Charthawal	5	10	30	120	12000	2700	2700	25.63	2.56
Shahpur	1	3	25	100	8000	2200	2200	20.68	2.07
Muzaffarnagar	-	-	-	-	5000	-	-	-	-
Jansath	-	-	-	-	-	-	-	-	-
Khatauli	-	-	-	-	-	-	-	-	-
Morna	-	-	-	-	-	-	-	-	-
Purkazi	-	-	-	-	-	-	-	-	-
Total	**11**	**26**	**120**	**430**	**61000**	**9600**	**9600**	**91.38**	**9.13**

Table-16: Summary of Interventions, Expected Benefits and Cost Estimates

Interventions Recommended	
Check Dam of 10000 cum Capacity	11 Nos.
Channel/ Stream Development	26 Km
Nala Bunds of 7500 cum Capacity	120 Nos.
Revival of Ponds of 100mx100mx3m dimensions	430 Nos.
On-farm Activities	9600 ha
Water Use Efficiency (WUE) Measures	9600 ha
Adoption of new Irrigation practices in Sugarcane area	61000 ha.
Piezometers for Impact monitoring	51 Nos.
Expected Benefits	
Expected Annual Recharge	1517.34 ham
Provision for supplemental irrigation	557.34 ham
Conservation from On-farm Activities & WUE Measures	1559.07 ham
Saving from Adoption of new Irrigation practices in Sugarcane area	7450.00 ham
Total Recharge/ Saving	**11083.75 ham**
Cost	
Total Cost	91.38 Crores
Provision for Operation & Maintenance (5%)	4.57 Crores
Impact Assesment (5%)	4.57 Crores
Grand Total	***100.52 Crores***

Table-17: Block-wise Projected Status of Groundwater Resource & Utilization in Muzaffarnagar District after AR Interventions

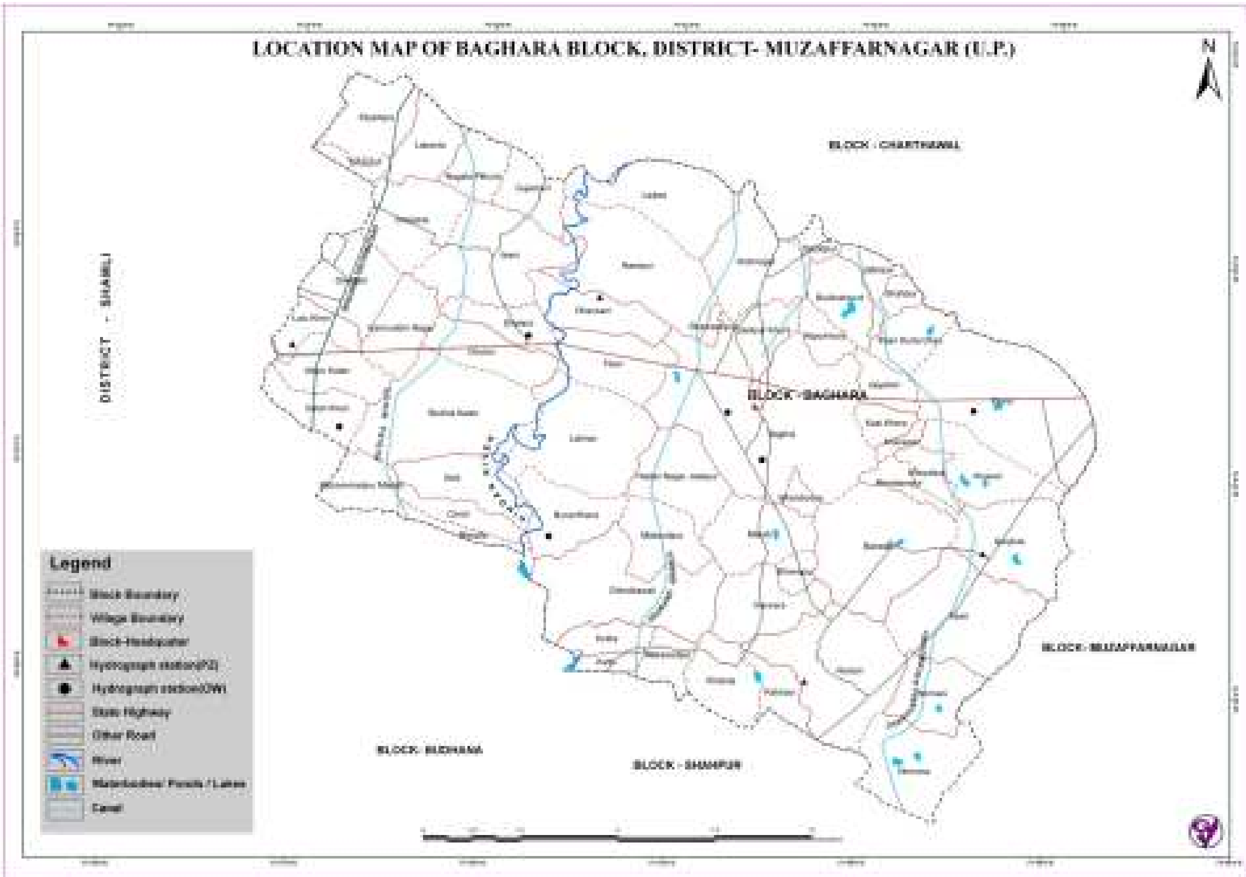
Block	Net G.W. Availa-bility (Ham)	Additional Re-charge from RWH (ham)	Total Net G.W. Availa-bility after intervention (Ham)	Existing G.W Draft for all purpose (ham)	Provision for supplemental irriga-tion (saving of GW draft) (ham)	Conservation of ground water through Micro Irrigation (ham)	Saving of Ground water through Interventions (ham)	Net GW draft after Interventions (ham)	Present stage of G.W. development (%)	Projected stage of G.W. Dev. after AR & WUE Inter-ventions (%)	Saving of GW after adoption of new irriga-tion practices in Sugarcane area (ham)	Final Projected stage of G.W. Dev. after adoption new irrigation practices in Sugarcane area + AR & WUE Intervention (%)
Baghra	8120.38	359.57	8479.95	8991.54	129.57	509.97	639.54	8352.00	110.73	98.49	2450	69.60
Budhna	5428.70	388.50	5817.20	6119.20	148.50	216.70	365.20	5754.00	112.72	98.91	1700	69.69
Charthawal	8910.77	429.90	9340.67	8990.68	159.90	561.08	720.98	8269.70	100.90	88.53	1800	69.26
Shahpur	5525.27	339.37	5864.64	5345.73	119.37	271.33	390.70	4955.03	96.75	84.49	900	69.14
Muzaffarnagar	7750.37	0.00	7750.37	5961.89	0.00	0.00	0.00	5961.89	76.92	-	600	69.18
Jansath	21683.3	0.00	21683.25	9907.02	0.00	0.00	0.00	9907.02	45.69	-	-	-
Khatauli	13307.9	0.00	13307.86	5469.10	0.00	0.00	0.00	5469.10	41.10	-	-	-
Morna	14660.1	0.00	14660.08	5545.05	0.00	0.00	0.00	5545.05	37.82	-	-	-
Purkazi	8990.39	0.00	8990.39	5722.89	0.00	0.00	0.00	5722.89	63.66	-	-	-
Total	**94377.07**	**1517.34**	**95894.41**	**62053.10**	**557.34**	**1559.07**	**2116.41**	**59936.69**	**65.75**	**62.50**	**7450**	**54.73**

7.0 GROUND WATER MANAGEMENT IN OE BAGHARA BLOCK

7.1.0 INTRODUCTION:

Baghra block lies in the Western part of the Muzaffarnagar district encompassing an area of 230.90 Sq Km. It is flanked by Budhna & Shahpur block in the south and Charthawal block in the North (Fig-1).

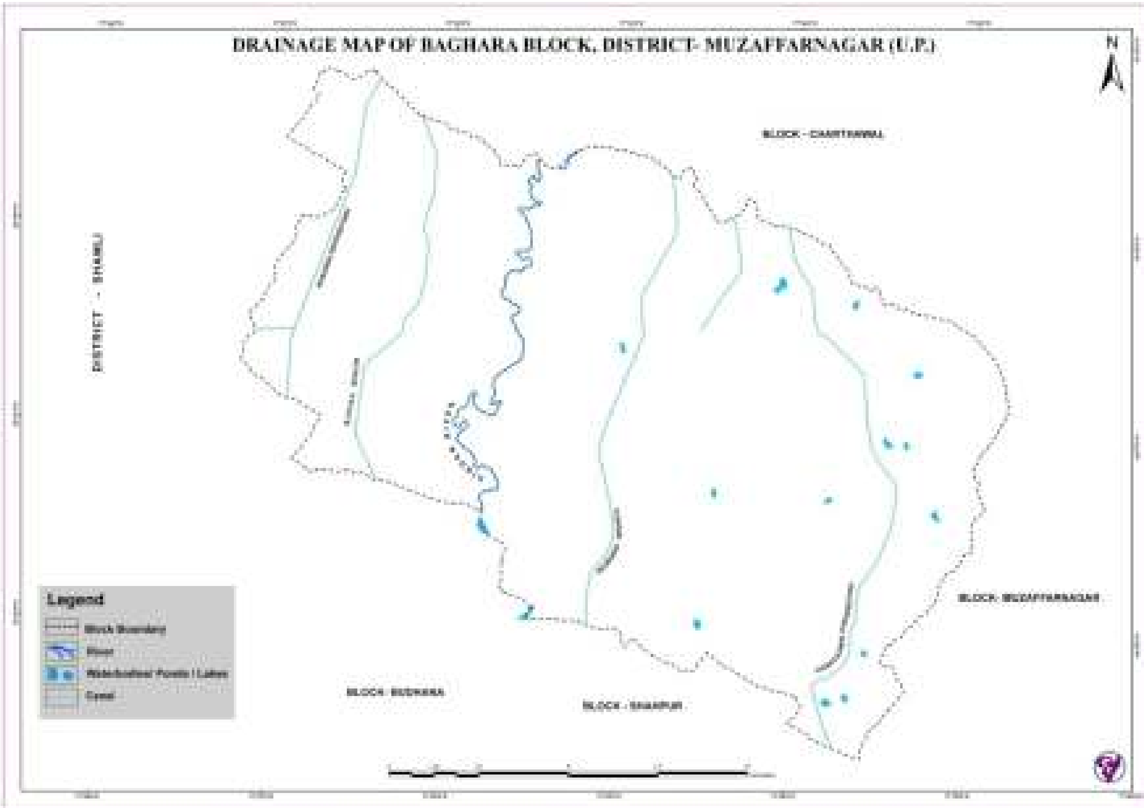
Fig-1



7.1.1 Drainage:

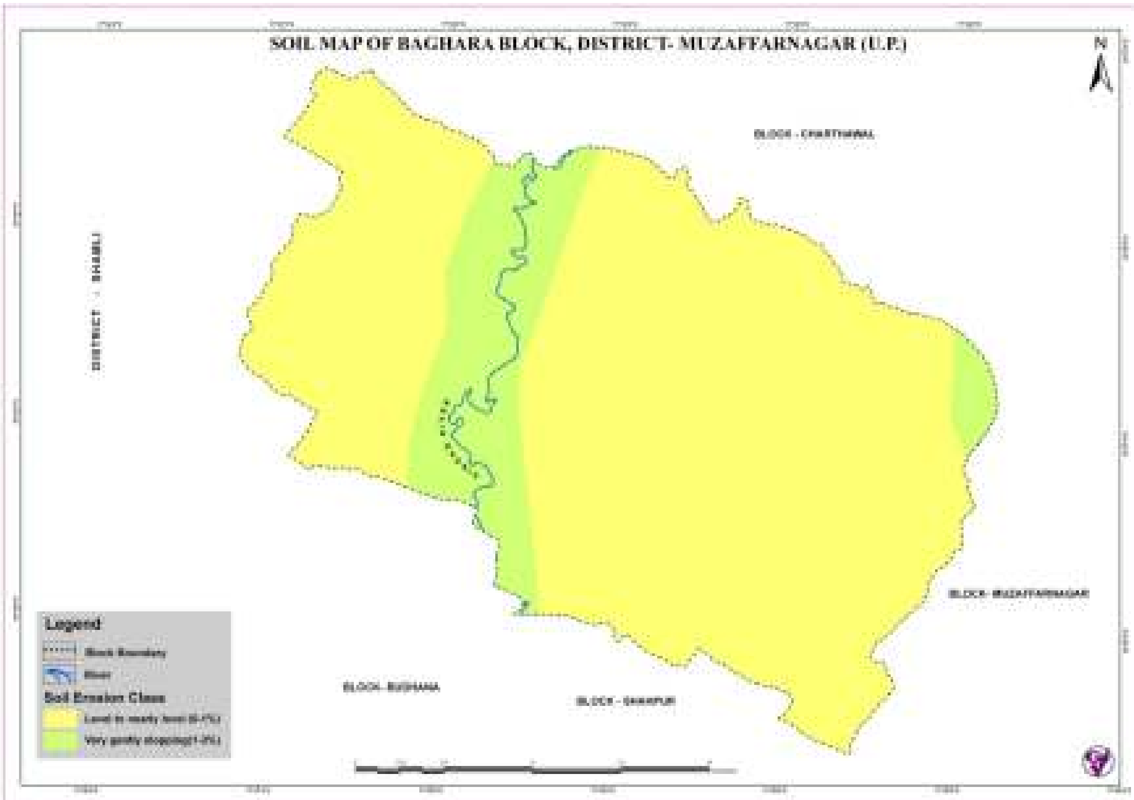
The bock is drained by Hindon river trending North- South and has well developed canal network (Fig-2).

Fig-2



7.1.2 Soil:

Fig-3



7.2.0 GEOLOGY:

Fig-4

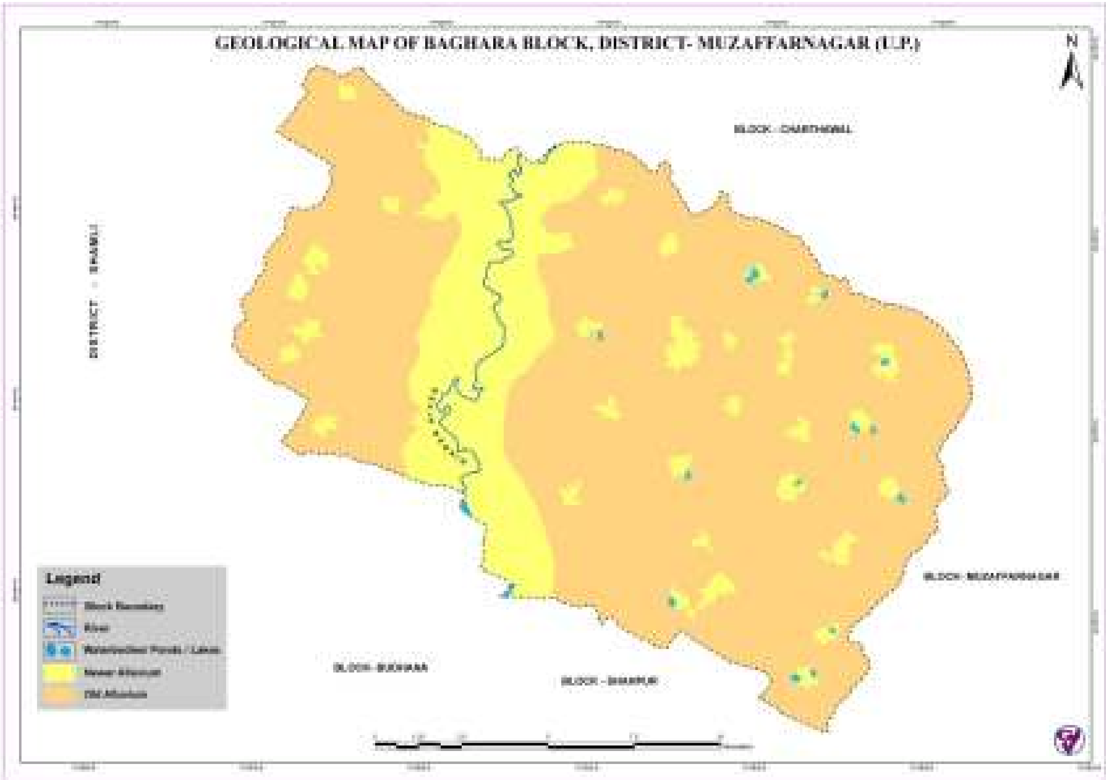
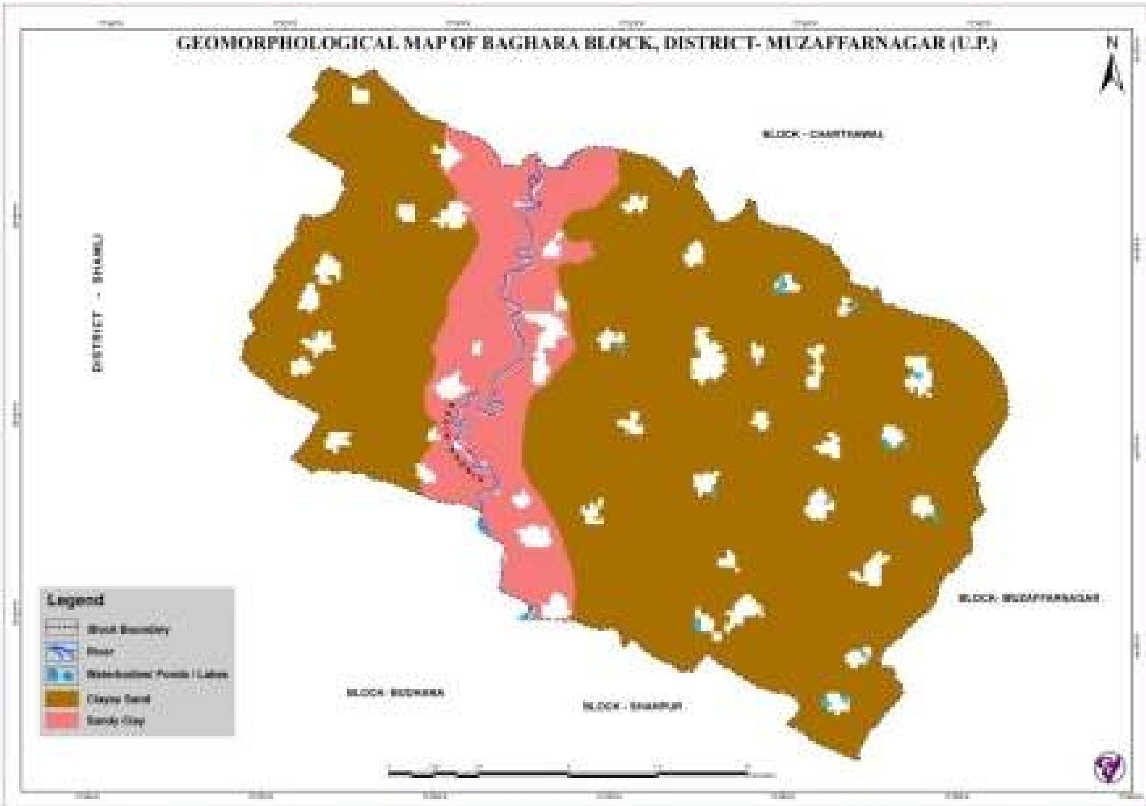


Fig-5



The soils of the block are formed by the transport of silt carried by the two rivers, Ganga and Yamuna. The soils are composed of Pleistocene and sub-recent alluvial sediments transported and deposited by river action from the Himalayan region. Soils are predominantly fine silty and a small part is coarse loamy & sandy coarse loamy (Fig-3).

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 and show quick alteration from finer to coarser at places. 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 (Fig-4).

Geomorphologically the block virtually forms a flat terrain forming a part of Ganga Plains. There are patches of saline and alkaline lands called "Bhur" areas mostly along the bank of Yamuna. The stretches of low land along the rivers are called "khadars". The khadar of Ganges differs from that of Yamuna, in not having wide stretches of settled countries and in having a better clay deposit (Fig-5).

(Figures in Ha.)

Table-1: Agricultural Statistics

	Sown area			**Season-wise Crop Area**			**Irrigated Area**			
Block	*Net Area Sown*	*Area sown more than once*	*Total*	*Rabi*	*Kharif*	*Jayad*	*Net Irrigated*	*Gross Irrigated*	Cropping Intensity	Irrigation intensity
Baghara	20308	10486	30794	8815	19777	2067	21220	32180	152	152

Table-2: Area Under Principal Crops

Rice (Kharif)		**Rice (Jayad)**		**Total Rice**		**Wheat**		**Sugarcane**	
Total	Irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigated
867	867	0	0	867	867	7320	7320	15165	15065

Table-3: Dynamic Ground Water Resource of Muzaffarnagar District, UP (as on 31.3.2013) (Ham)

Net Annual GW Availability	Gross Ground Water Draft for Irrigation	Existing Gross GW Draft for All Uses	Stage of Ground Water Development (%)
8120.38	8532.00	8991.54	110.73

Fig-6: Depth to Water Map

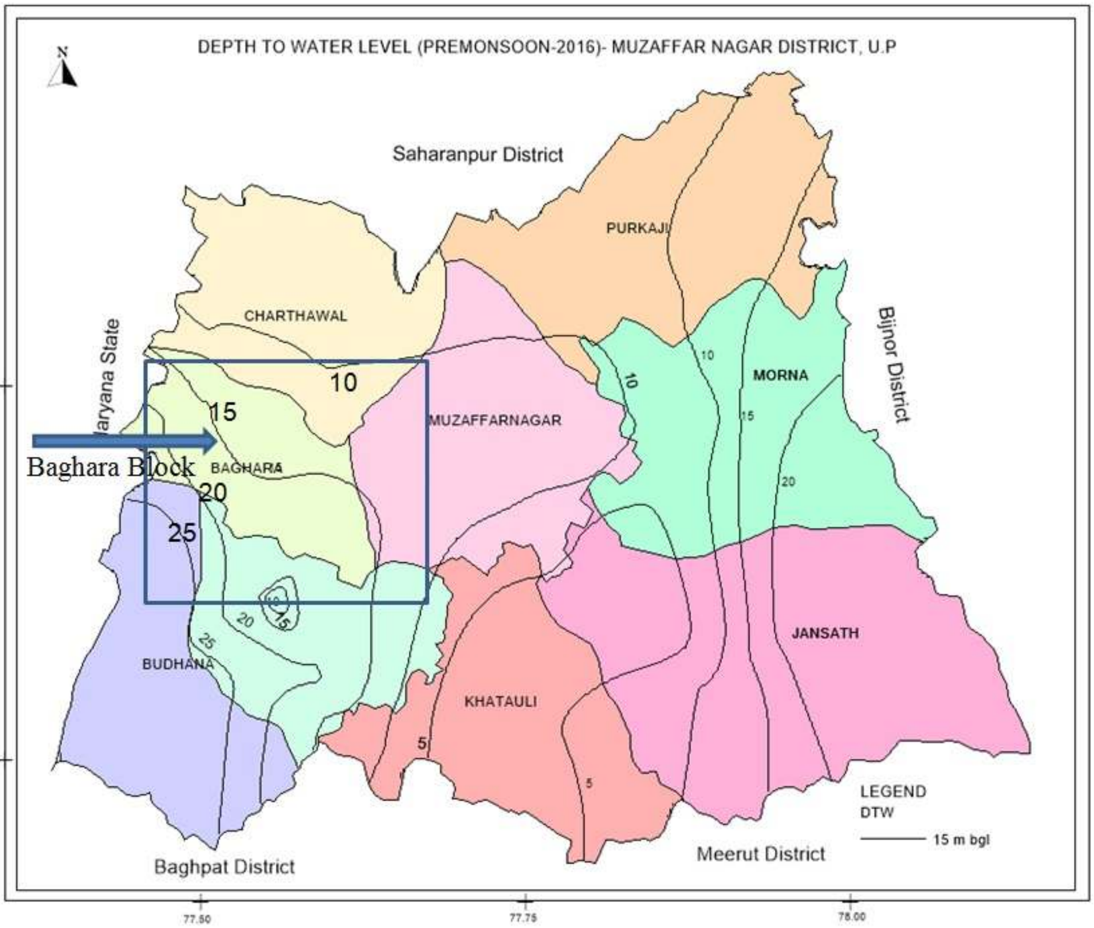
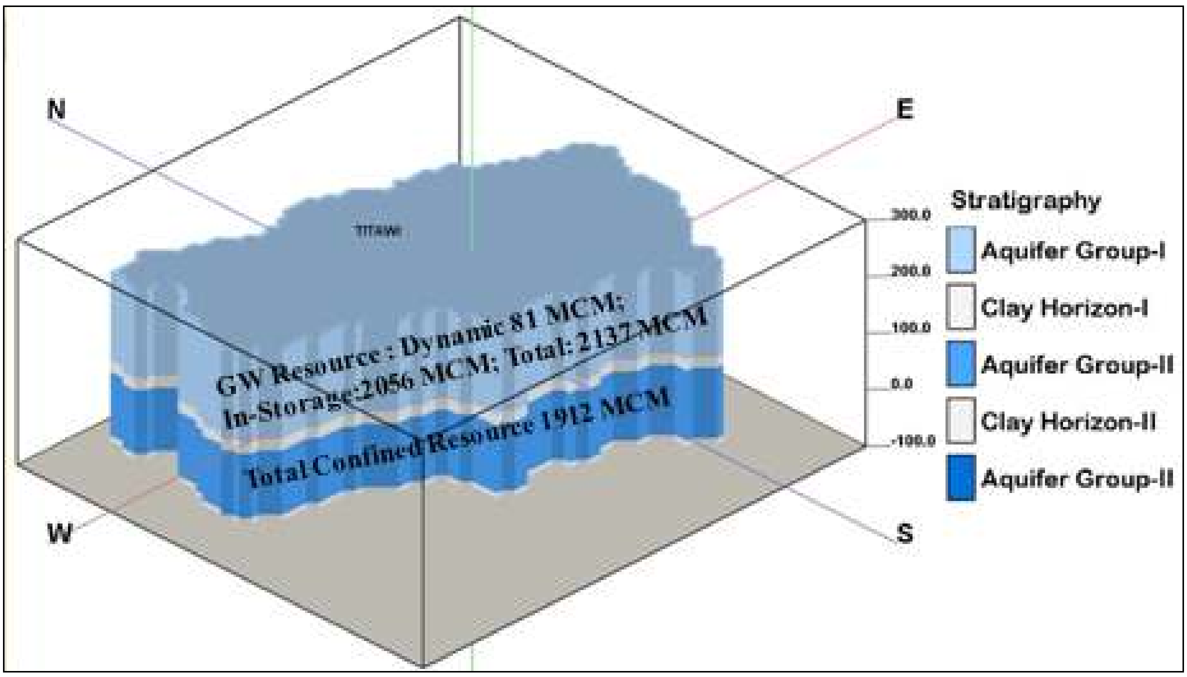


Fig- 7: 3-Dimensional Aquifer Disposition in Baghara Block



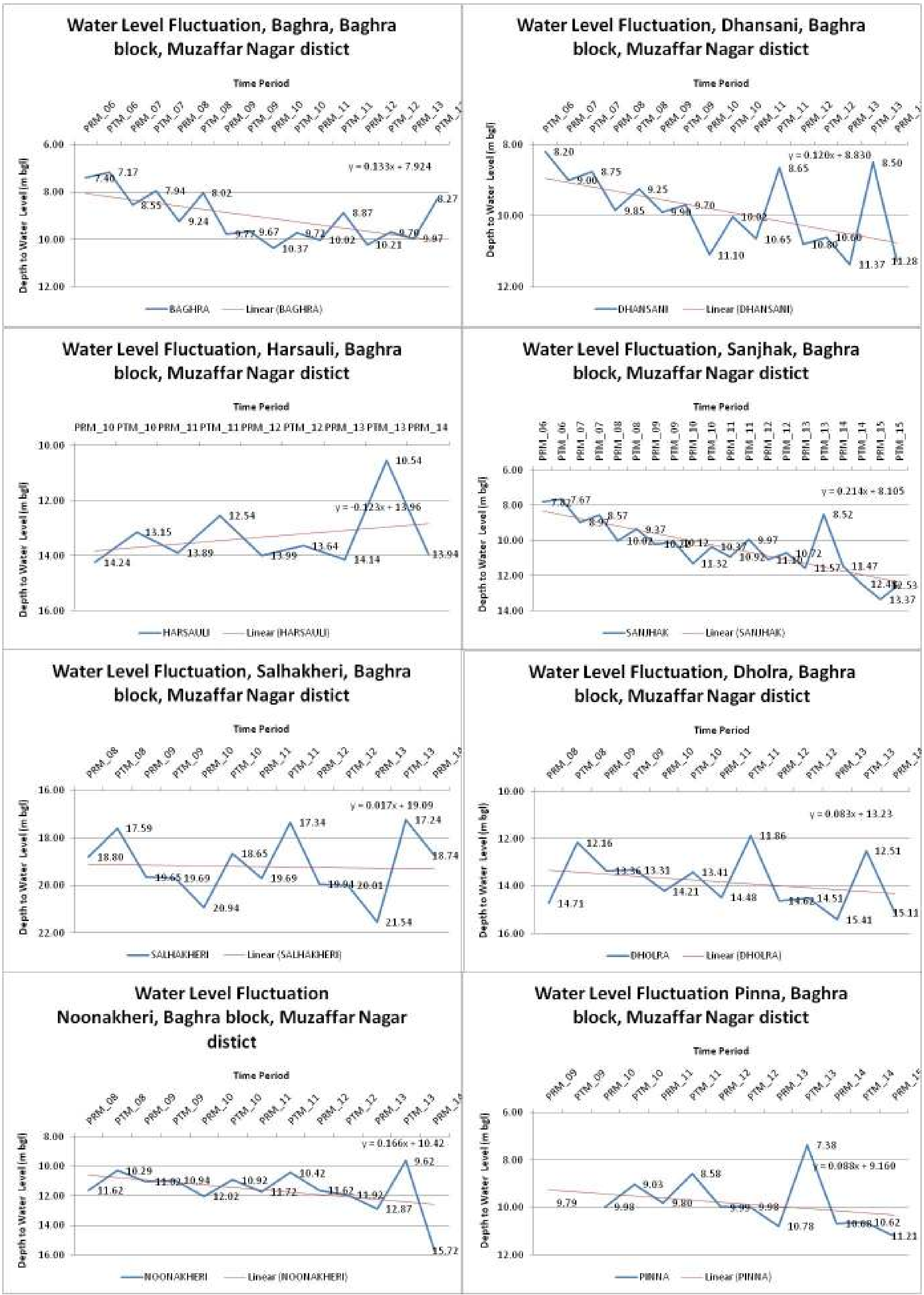
The Figures 6 & 7 give an overview of depth to water and 3-dimensional aquifer disposition in Baghara block down to 300 m depth with dynamic & confined ground water resource.

7.3.0 GROUND WATER ISSUES:

The development of ground water is high in Baghara block and has been categorised as over exploited. The trend analysis of historical ground water level data indicates long term fall in most of the wells in the block.

Based on the factors mentioned, it is inferred that the block in general could be considered 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. Long term ground water trend for most of the wells (State GWD) presents declining trend and has been shown in the following figure.

Fig-8 Long term ground water level trend/fluctuation



7.4.0 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

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

7.4.1 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.

7.4.2 On Farm Practices:

Supply Side Management

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

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

7.4.3 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

7.5.0. PROPOSED INTERVENTIONS IN BAGHARA BLOCK:

Table-4: Proposed Interventions							
Block	**Check Dams of 10000 cum Capacity (Nos)**	**Drain/stream development (length in km x Avg.12m x 3m)**	**Nala Bunds of 7500 cum Capacity (Nos)**	**Revival of Ponds (Avg.) 50m x 50m x 3m dimension**	**On-farm Activities (Area in ha)**	**Adoption of new irrigation pra ctices for Sugar cane (Area in ha)**	**Water Use Efficiency (WUE) Mea-sures (Area in ha)**
Baghara	2	3	30	105	2300	15000	2300

7.6.0 BENEFITS:

Table-5: Summarised Expected Benefits	
Expected Annual Recharge	**3.60 MCM**
Provision for supplemental irrigation	**1.30 MCM**
Conservation from On-farm Activities & WUE Measures	**5.10 MCM**
Total Recharge/ Saving	**10.00 MCM**
Saving from Adoption of new Irrigation practices in S.cane area	**24.50 MCM**
Cost of Interventions	**2397 Lac**

7.7.0 PROJECTED IMPACT AFTER INTERVENTIONS:

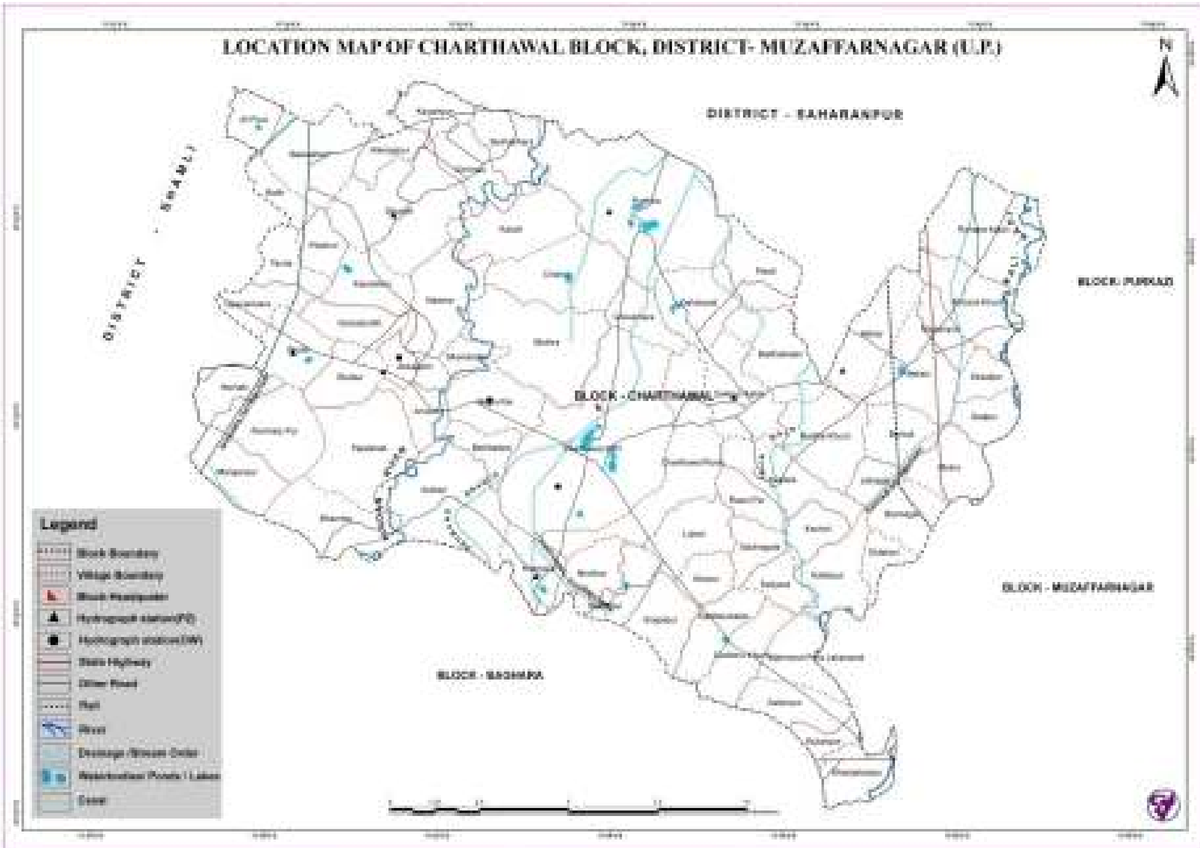
Table-6: Projected Impact On Status Of Groundwater Resource & Development In Baghara Block								
Net G.W. Availability (Ham)	**Additional Recharge from RWH & Re-charge (ham)**	**Total Net G.W. Availability after intervention (Ham)**	**Existing G.W Draft for all purpose (ham)**	**Saving of Ground water through projects (ham)**	**Net GW draft after interventions (ham)**	**Present stage of G.W. development (%)**	**Saving from Adoption of new Irrigation practices in Sugar cane area**	**Projected stage of G.W. Dev. (in %)**
8120.38	359.57	8479.95	8991.54	639.54	8352.00	110.73	2450	69.60

8.0 GROUND WATER MANAGEMENT IN OE CHARTAWAL BLOCK

8.1.0 INTRODUCTION:

Charthawal block lies in the North western part of the Muzaffarnagar district encompassing an area of 266.47 Sq Km. It is flanked by Baghra block in the south and Muzaffarnagar block in the southeast (Fig-1).

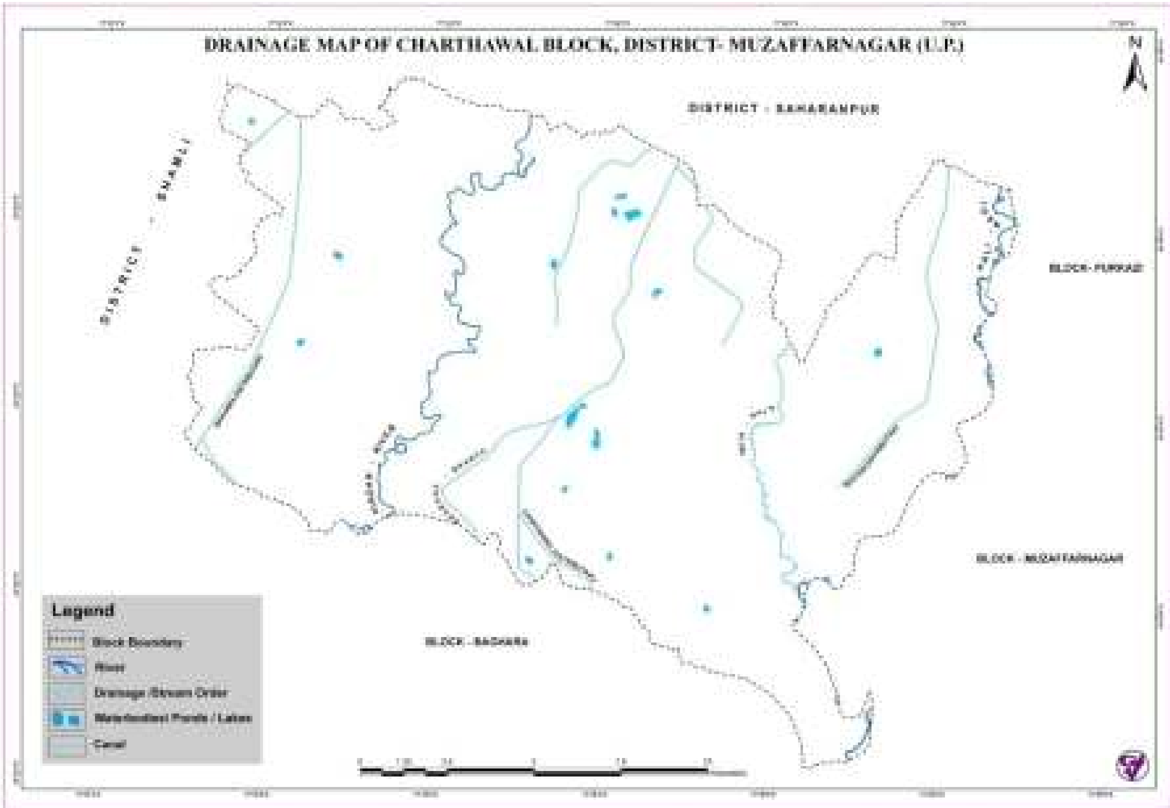
Fig-1



8.1.1 Drainage:

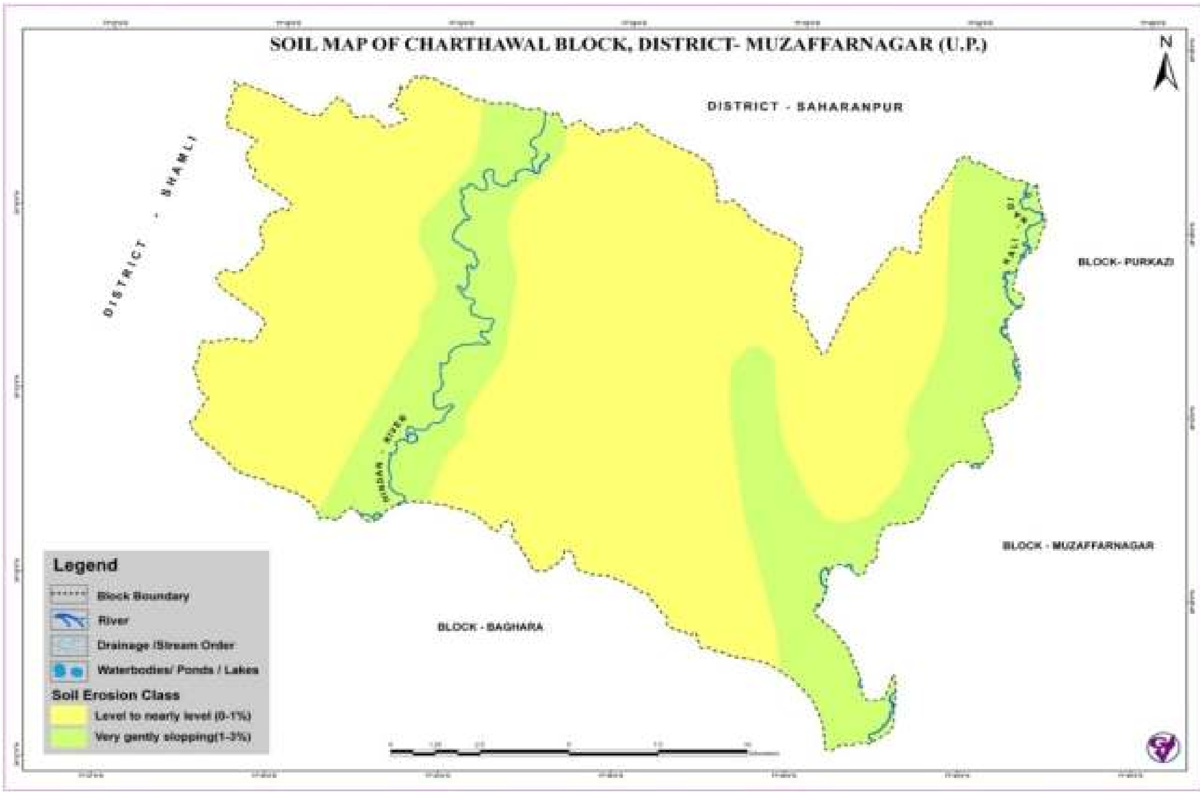
The bock is drained by Hindon river trending North- South, Imlia nala and well developed canal network (Fig-2).

Fig-2



8.1.2 Soil:

Fig-3



8.2.0 GEOLOGY:

Fig-4

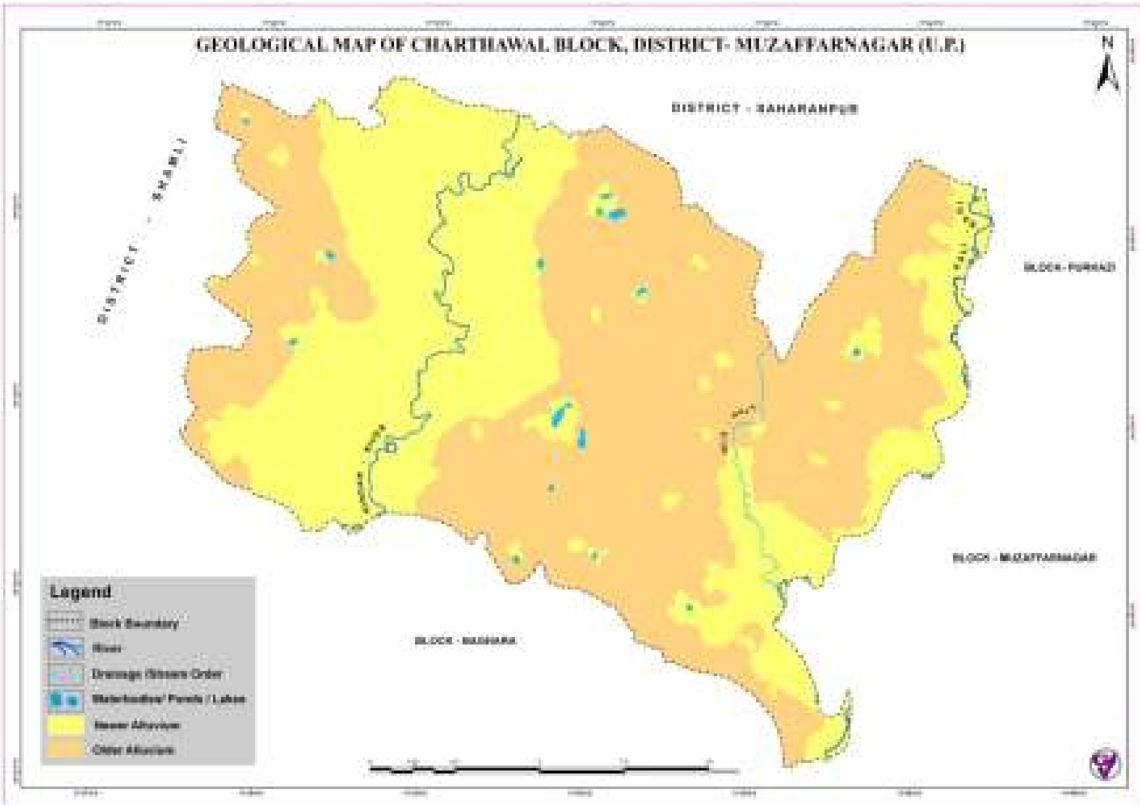
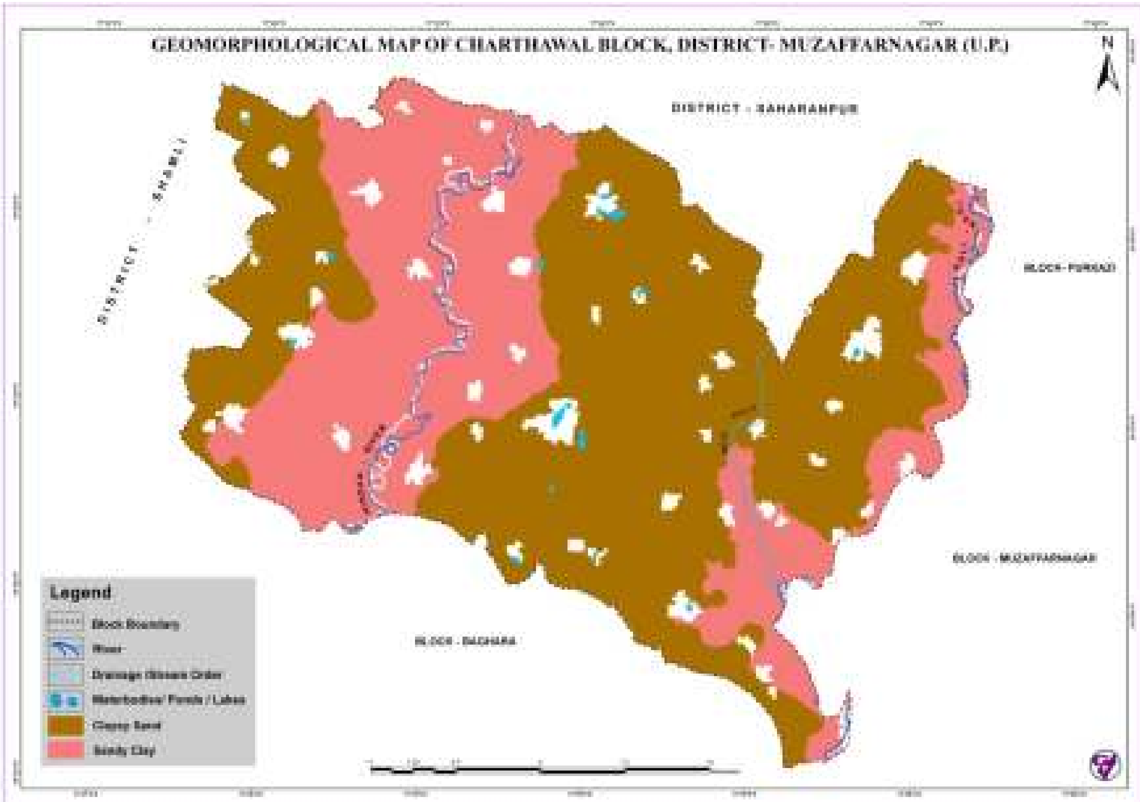


Fig-5



The soils of the block are formed by the transport of silt carried by the two rivers, Ganga and Yamuna. The soils are composed of Pleistocene and sub-recent alluvial sediments transported and deposited by river action from the Himalayan region. Soils are predominantly coarse loamy, fine silty and a small part is sandy coarse loamy along the rivers (Fig-3).

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 and show quick alteration from finer to coarser at places. 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 (Fig-4).

Geomorphologically the block virtually forms a flat terrain forming a part of Ganga Plains. There are patches of saline and alkaline lands called "Bhur" areas mostly along the bank of Yamuna. The stretches of low land along the rivers are called "khadars". The khadar of Ganges differs from that of Yamuna, in not having wide stretches of settled countries and in having a better clay deposit (Fig-5).

(Figures in Ha.)

Table-1: Agricultural Statistics

	Sown area			**Season-wise Crop Area**			**Irrigated Area**			
Block	*Net Area Sown*	*Area sown more than once*	*Total*	*Rabi*	*Kharif*	*Jayad*	*Net Irrigated*	*Gross Irrigated*	Cropping Intensity	Irrigation intensity
Charthawal	22712	11522	34234	7243	24796	1742	23249	32093	151	138

Table-2: Area Under Principal Crops

Rice (Kharif)		**Rice (Jayad)**		**Total Rice**		**Wheat**		**Sugarcane**	
Total	Irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigated
1535	1535	0	0	1535	1535	8265	8086	16420	16220

Table-3: Dynamic Ground Water Resource of Muzaffarnagar District, UP (as on 31.3.2013) (Ham)

Net Annual GW Availability	Gross Ground Water Draft for Irrigation	Existing Gross GW Draft for All Uses	Stage of Ground Water Development (%)
8910.77	8334.15	8990.68	100.90

Fig-6: Depth to Water Map

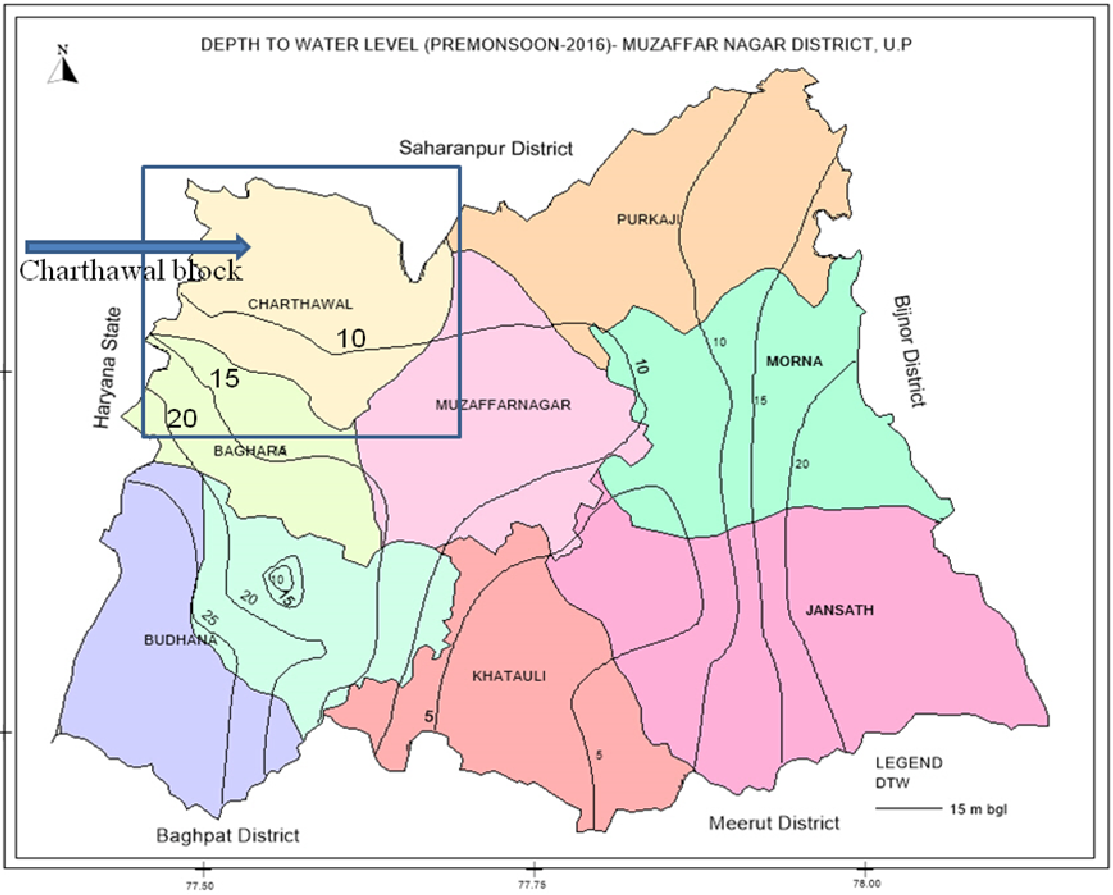
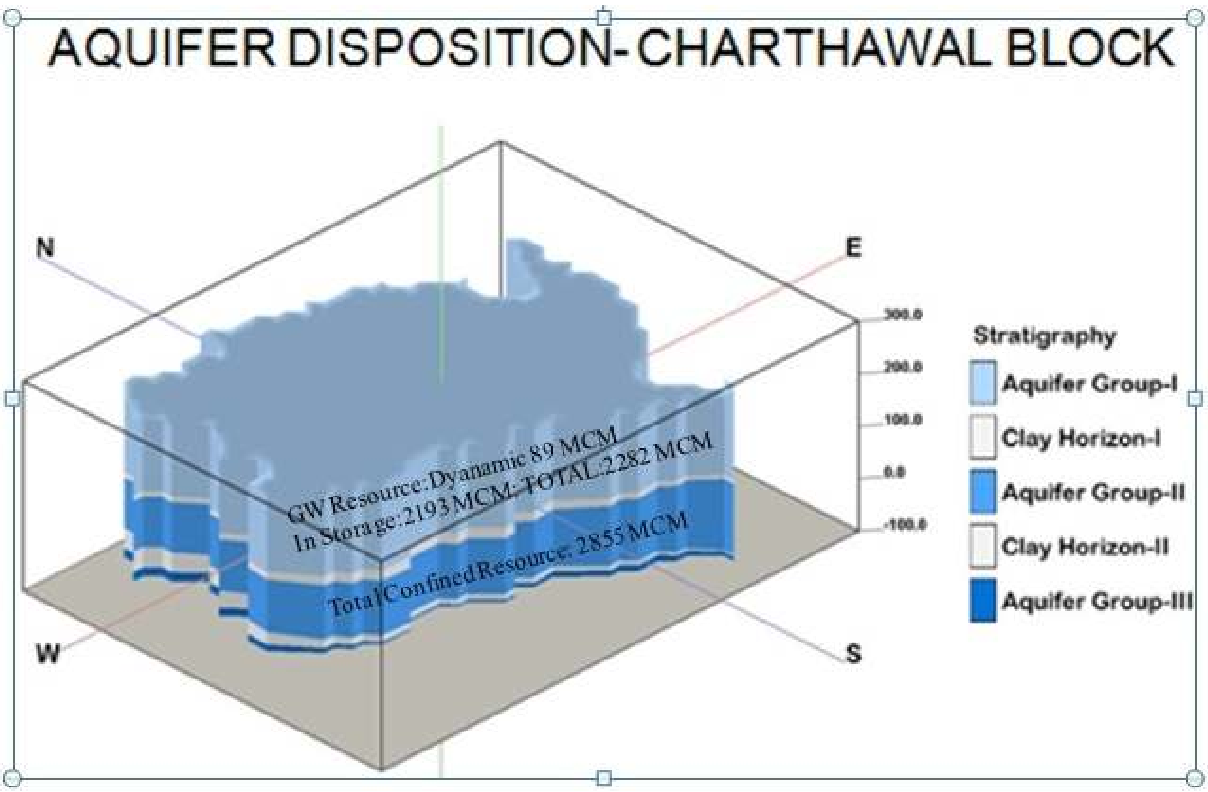


Fig- 7: 3-Dimensional Aquifer Disposition in Charthawal Block



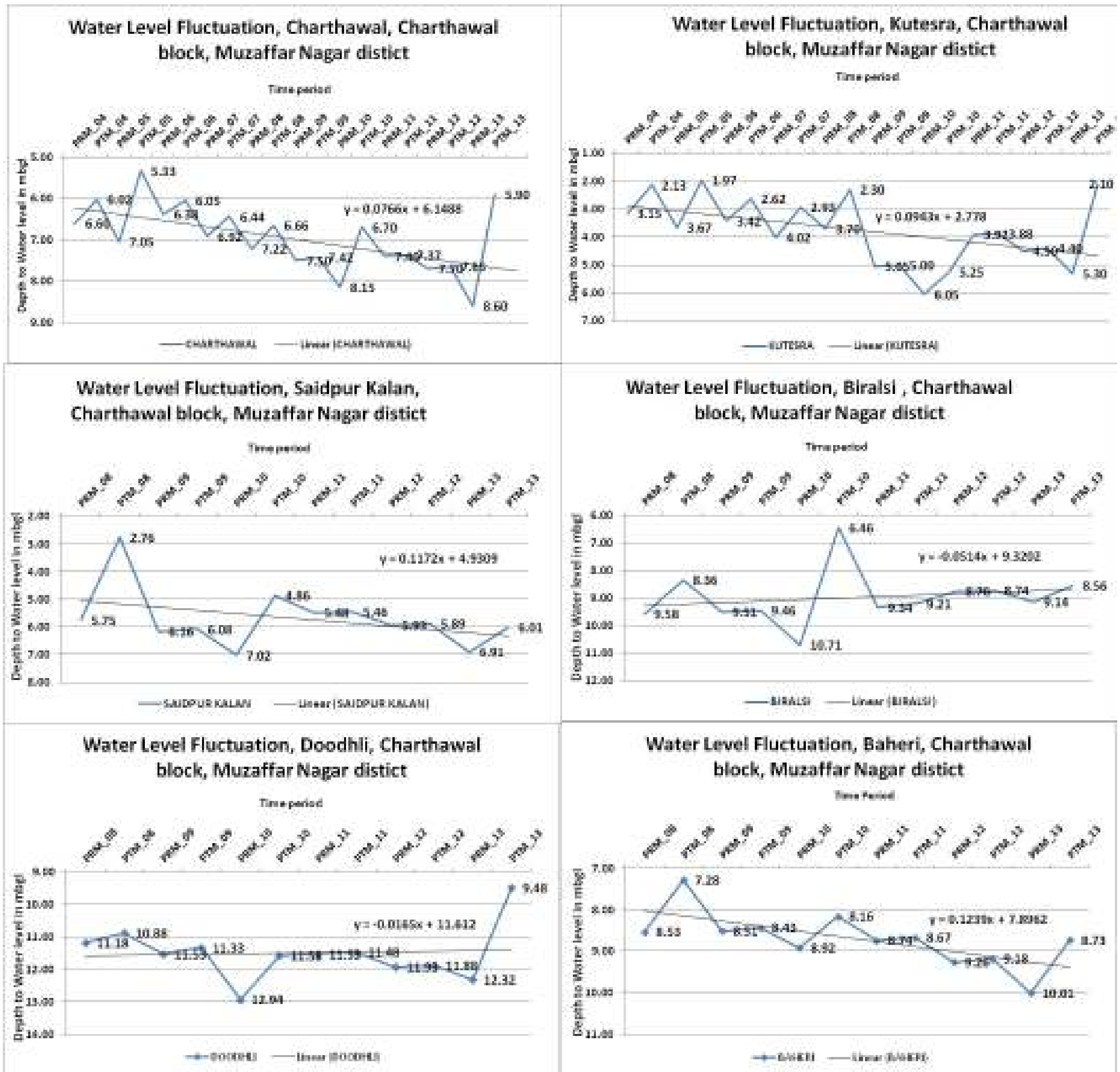
The Figures 6 & 7 give an overview of depth to water and 3-dimensional aquifer disposition in Charthawal block down to 300 m depth with dynamic & confined ground water resource.

8.3.0 GROUND WATER ISSUES:

The development of ground water is high in Charthawal block and has been categorised as over exploited. The trend analysis of historical ground water level data indicates long term fall in most of the wells in the block.

Based on the factors mentioned, it is inferred that the block in general could be considered 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. Long term ground water trend for most of the wells (State GWD) presents declining trend and has been shown in the following figure.

Fig-8 Long term ground water level trend/fluctuation



8.4.0 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

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

8.4.1 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.

8.4.2 On Farm Practices:

Supply Side Management

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

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

8.4.3 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

8.5.0. PROPOSED INTERVENTIONS IN CHARTAWAL BLOCK:

Table-4: Proposed Interventions							
Block	Check Dams of 10000 cum Capacity (Nos)	Drain/stream development (length in km x Avg.12m x 3m)	Nala Bunds of 7500 cum Capacity (Nos)	Revival of Ponds (Avg.) 50m x 50m x 3m dimension	On-farm Activities (Area in ha)	Adoption of new irrigation pra ctices for Sugar cane (Area in ha)	Water Use Efficiency (WUE) Mea-sures (Area in ha)
Charthawal	5	10	30	120	2700	12000	2700

8.6.0 BENEFITS:

Table-5: Summarised Expected Benefits	
Expected Annual Recharge	**4.30 MCM**
Provision for supplemental irrigation	**1.60 MCM**
Conservation from On-farm Activities & WUE Measures	**5.61 MCM**
Total Recharge/ Saving	**11.51 MCM**
Saving from Adoption of new Irrigation practices in S.cane area	**18.00 MCM**
Cost of Interventions	**2819 Lac**

8.7.0 PROJECTED IMPACT AFTER INTERVENTIONS:

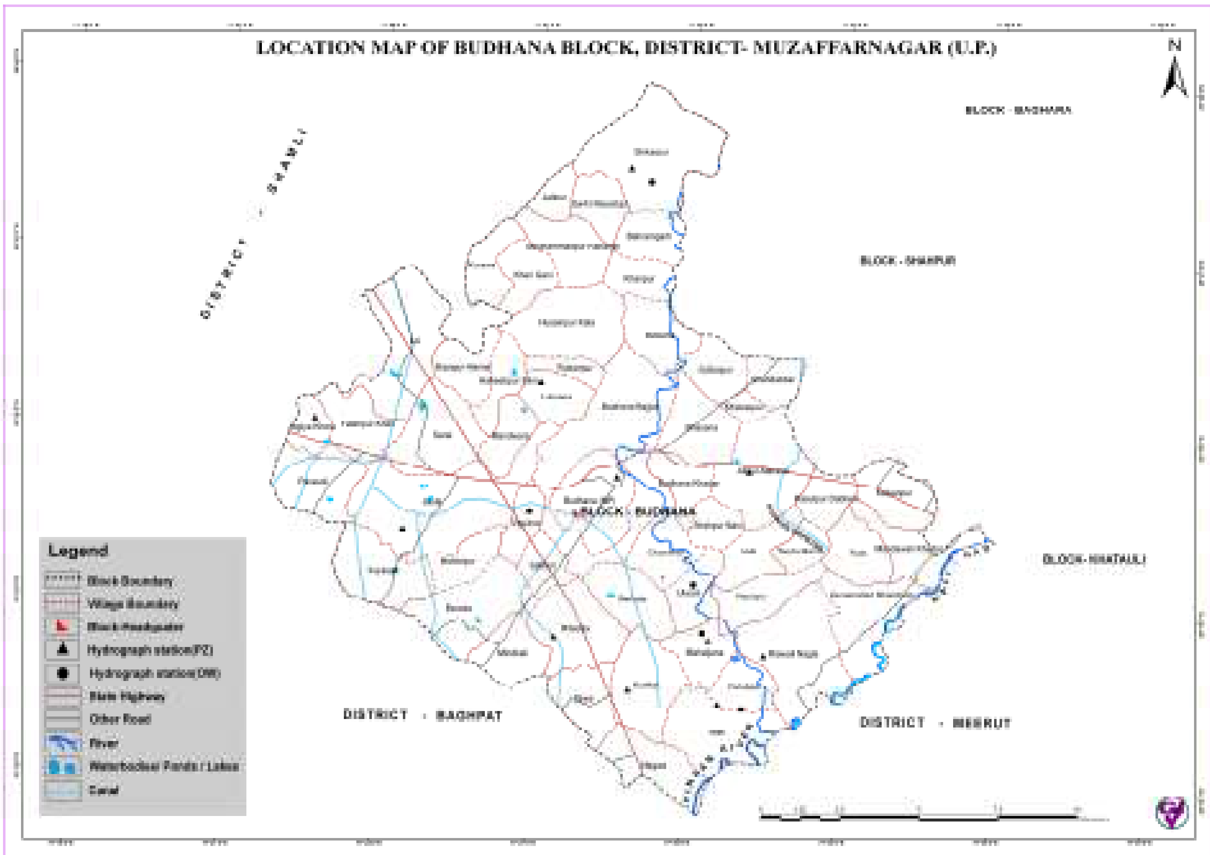
Table-6: Projected Impact On Status Of Groundwater Resource & Development In Chartawal Block								
Net G.W. Availability (Ham)	Additional Recharge from RWH & Re-charge (ham)	Total Net G.W. Availability after intervention (Ham)	Existing G.W Draft for all purpose (ham)	Saving of Ground water through projects (ham)	Net GW draft after interventions (ham)	Present stage of G.W. development (%)	Saving from Adoption of new Irrigation practices in Sugar cane area (ham)	Projected stage of G.W. Dev. (in %)
8910.77	429.90	9340.67	8990.68	720.98	8269.70	100.90	1800	69.26

9.0 GROUND WATER MANAGEMENT IN OE BUDHNA BLOCK

9.1.0 INTRODUCTION:

Budhna block lies in the South-western part of the Muzaffarnagar district encompassing an area of 238.80 Sq Km. It is flanked by Baghra & Shahpur block in the North and East respectively (Fig-1).

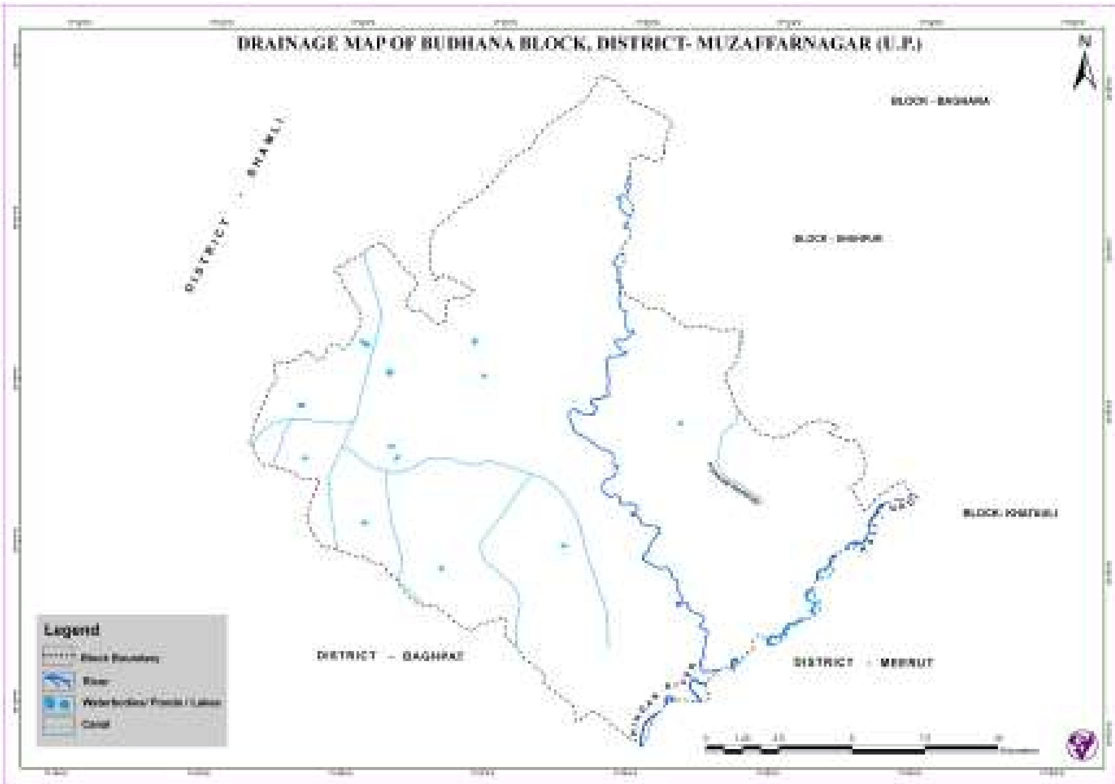
Fig-1



9.1.1 Drainage:

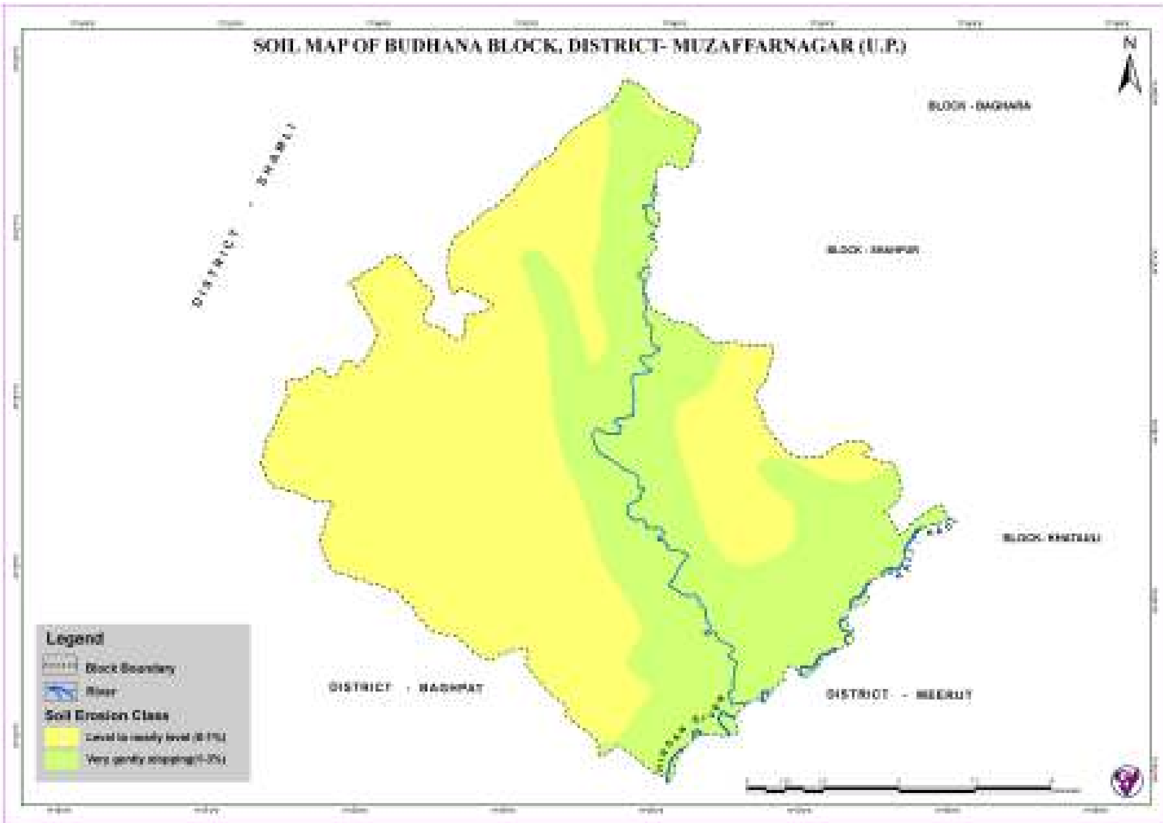
The bock is drained by Hindon river trending North- South- Southeast through the central part of the block and Kali Nadi that follows the south eastern boundary of the block. The block has well developed canal network (Fig-2).

Fig-2



7.1.2 Soil:

Fig-3



9.2.0 GEOLOGY:

Fig-4

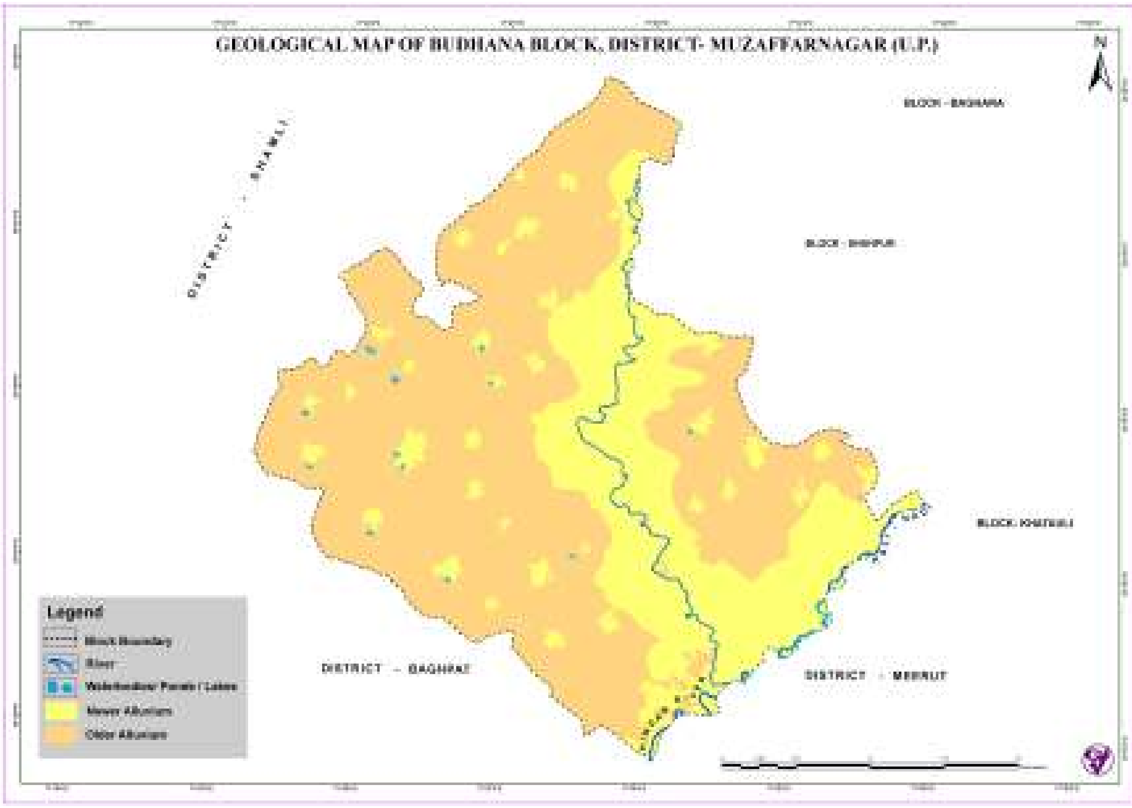
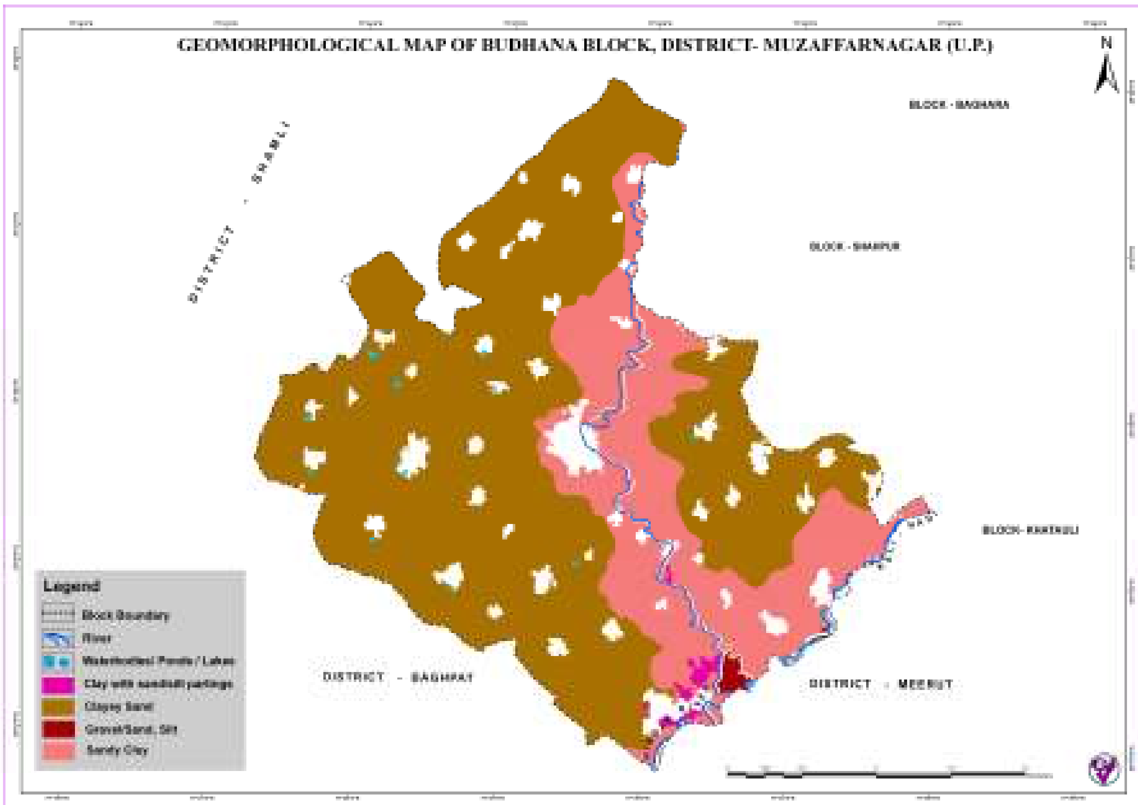


Fig-5



The soils of the block are formed by the transport of silt carried by the two rivers, Ganga and Yamuna. The soils are composed of Pleistocene and sub-recent alluvial sediments transported and deposited by river action from the Himalayan region. Soils are predominantly fine silty and a small part is sandy coarse loamy along the rivers (Fig-3).

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 and show quick alteration from finer to coarser at places. 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 (Fig-4).

Geomorphologically the block virtually forms a flat terrain forming a part of Ganga Plains. There are patches of saline and alkaline lands called "Bhur" areas mostly along the bank of Yamuna. The stretches of low land along the rivers are called "khadars". The khadar of Ganges differs from that of Yamuna, in not having wide stretches of settled countries and in having a better clay deposit (Fig-5).

(Figures in Ha.)

Table-1: Agricultural Statistics

	Sown area			**Season-wise Crop Area**			**Irrigated Area**			
Block	*Net Area Sown*	*Area sown more than once*	*Total*	*Rabi*	*Kharif*	*Jayad*	*Net Irrigated*	*Gross Irrigated*	Cropping Intensity	Irrigation intensity
Budhna	27978	13241	41219	13712	25865	2120	29620	38762	147	131

Table-2: Area Under Principal Crops

Rice (Kharif)		**Rice (Jayad)**		**Total Rice**		**Wheat**		**Sugarcane**	
Total	Irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigated
836	834	0	0	836	834	10828	10790	22614	22451

Table-3: Dynamic Ground Water Resource of Muzaffarnagar District, UP (as on 31.3.2013) (Ham)

Net Annual GW Availability	Gross Ground Water Draft for Irrigation	Existing Gross GW Draft for All Uses	Stage of Ground Water Development (%)
5428.70	6119.20	6119.20	112.72

Fig-6: Depth to Water Map

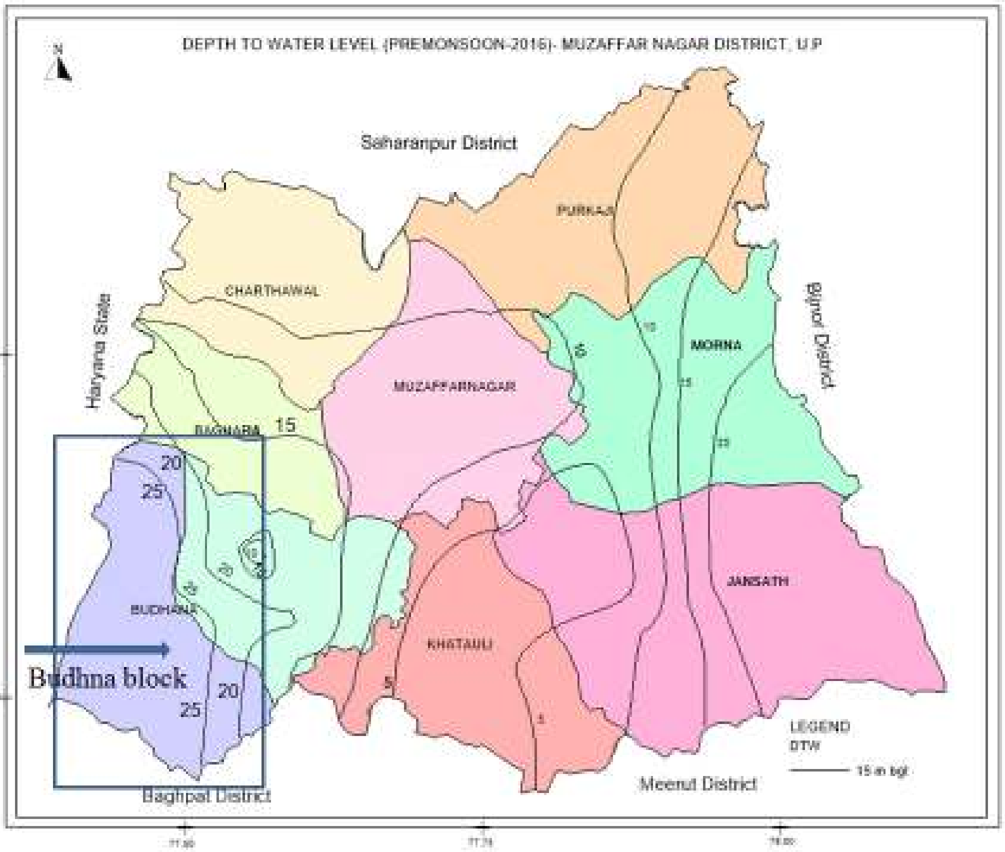
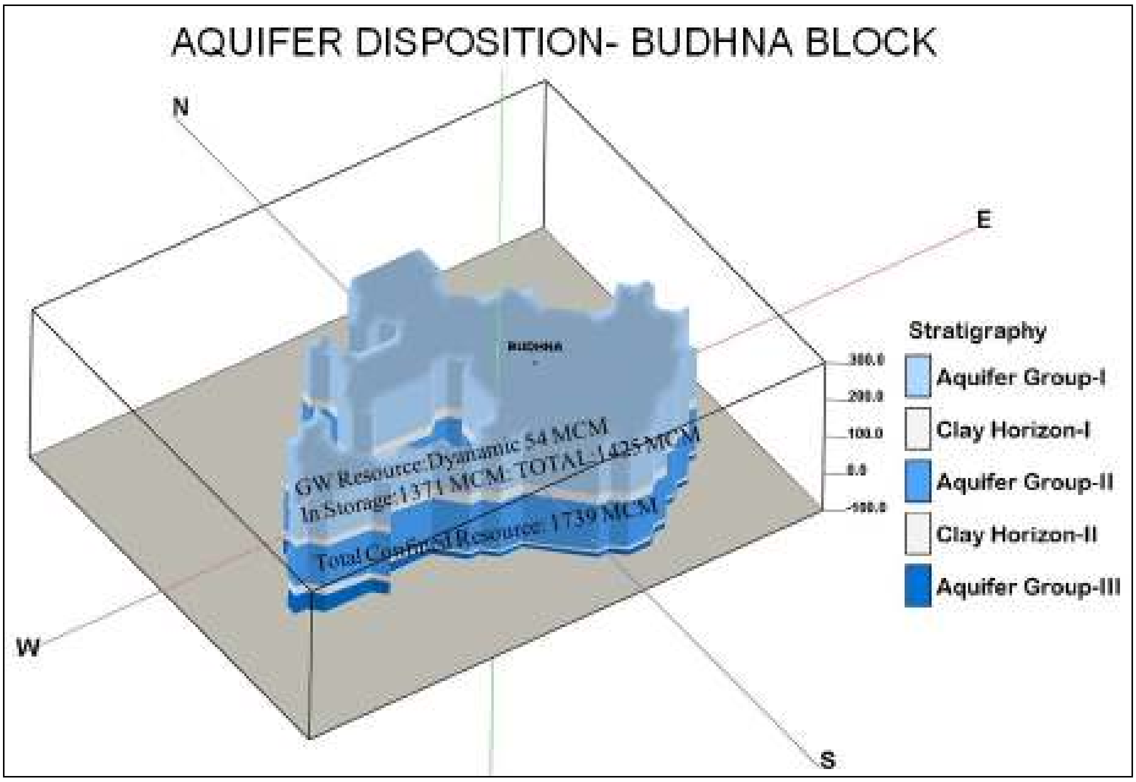


Fig- 7: 3-Dimensional Aquifer Disposition in Budhna Block



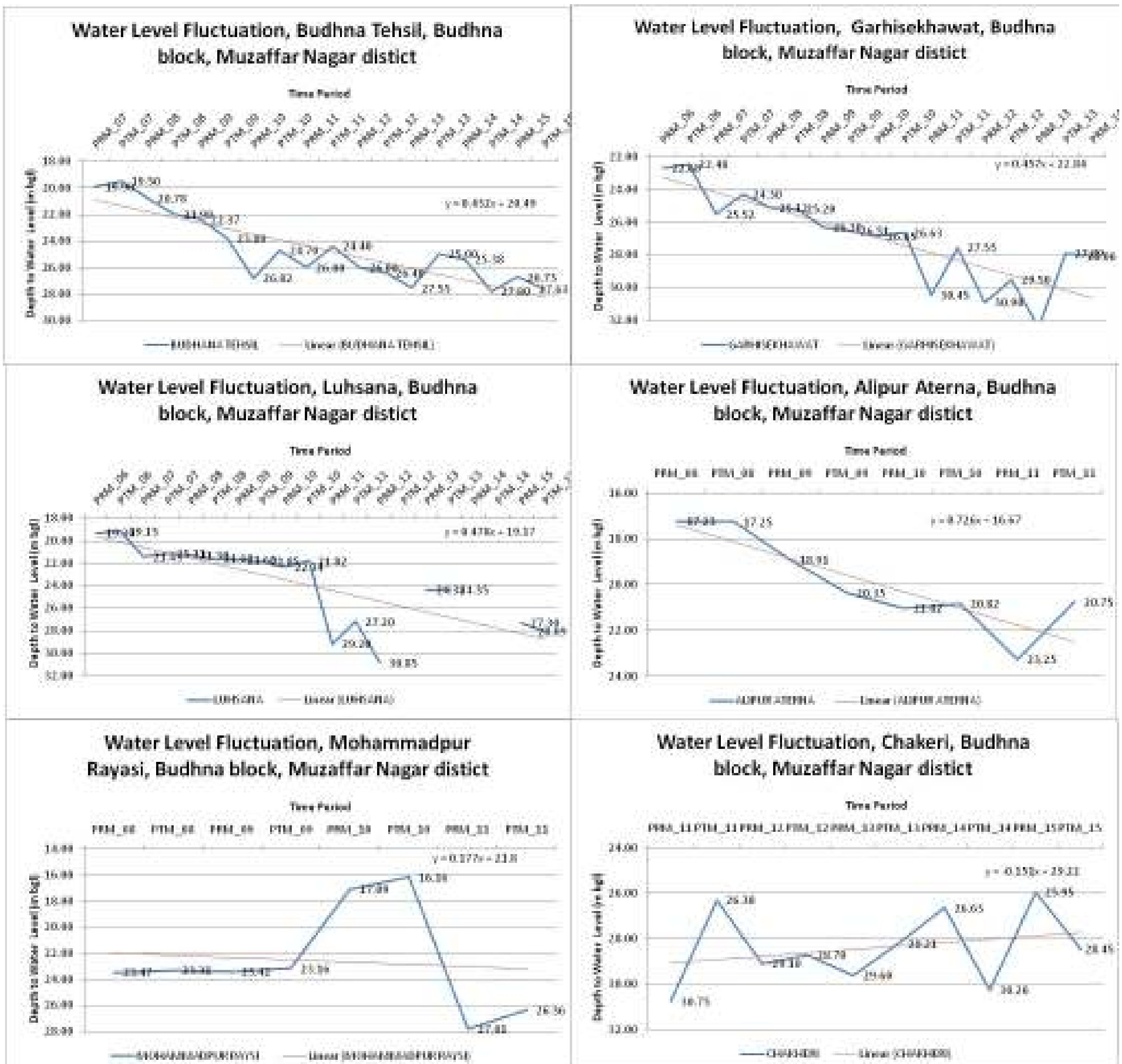
The Figures 6 & 7 give an overview of depth to water and 3-dimensional aquifer disposition in Budhna block down to 300 m depth with dynamic & confined ground water resource.

9.3.0 GROUND WATER ISSUES:

The development of ground water is high in Budhna block and has been categorised as over exploited. The trend analysis of historical ground water level data indicates long term fall in most of the wells in the block.

Based on the factors mentioned, it is inferred that the block in general could be considered 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. Long term ground water trend for most of the wells (State GWD) presents declining trend and has been shown in the following figure.

Fig-8 Long term ground water level trend/fluctuation



9.4.0 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

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

9.4.1 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.

9.4.2 On Farm Practices:

Supply Side Management

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

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

9.4.3 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

9.5.0. PROPOSED INTERVENTIONS IN BUDHNA BLOCK:

Table-4: Proposed Interventions

Block	Check Dams of 10000 cum Capacity (Nos)	Drain/stream development (length in km x Avg.12m x 3m)	Nala Bunds of 7500 cum Capacity (Nos)	Revival of Ponds (Avg.) 50m x 50m x 3m dimension	On-farm Activities (Area in ha)	Adoption of new irrigation pra ctices for Sugar cane (Area in ha)	Water Use Efficiency (WUE) Mea-sures (Area in ha)
Budhna	3	10	35	105	2400	21000	2400

9.6.0 BENEFITS:

Table-5: Summarised Expected Benefits

Expected Annual Recharge	**3.89 MCM**
Provision for supplemental irrigation	**1.49 MCM**
Conservation from On-farm Activities & WUE Measures	**2.17 MCM**
Total Recharge/ Saving	**7.55 MCM**
Saving from Adoption of new Irrigation practices in S.cane area	**17.00 MCM**
Cost of Interventions	**2560 Lac**

9.7.0 PROJECTED IMPACT AFTER INTERVENTIONS:

Table-6: Projected Impact On Status Of Groundwater Resource & Development In Budhna Block

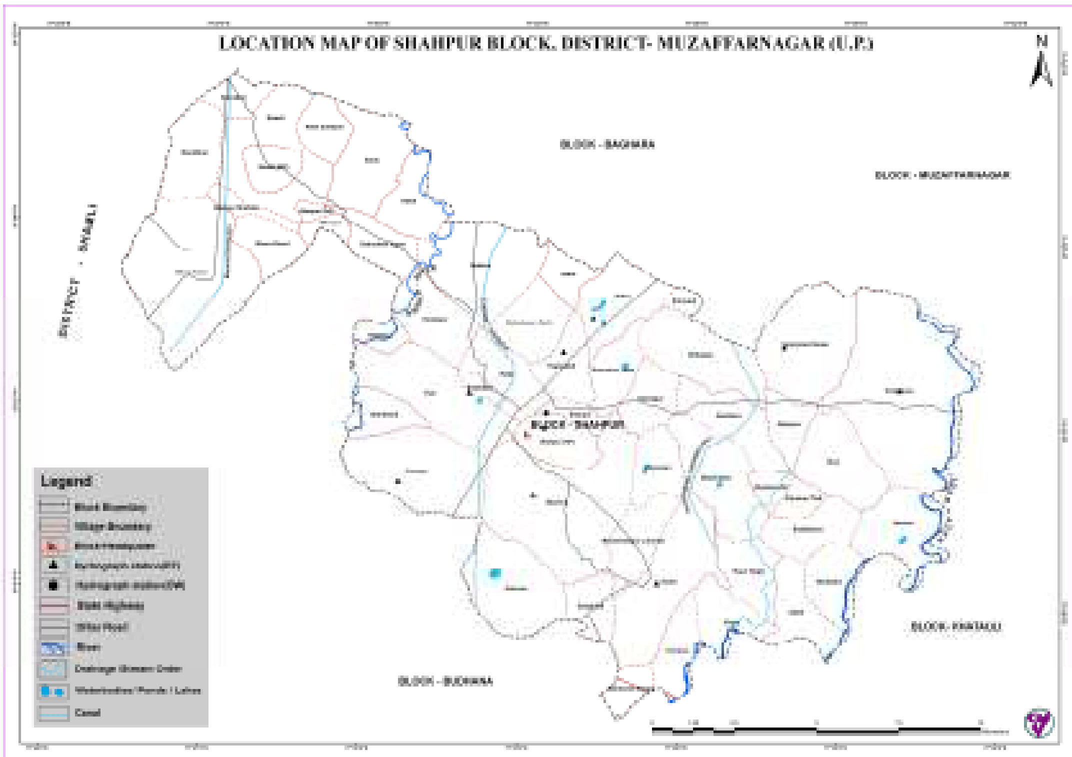
Net G.W. Availability (Ham)	Additional Recharge from RWH & Re-charge (ham)	Total Net G.W. Availability after intervention (Ham)	Existing G.W Draft for all purpose (ham)	Saving of Ground water through projects (ham)	Net GW draft after interventions (ham)	Present stage of G.W. development (%)	Saving from Adoption of new Irrigation practices in Sugar cane area	Projected stage of G.W. Dev. (in %)
5428.70	388.50	5817.20	6119.20	365.20	5754.00	112.72	1700	69.69

10.0 GROUND WATER MANAGEMENT IN CRITICAL SHAHPUR BLOCK

10.1.0 INTRODUCTION:

Shahpur block lies in the southern part of the Muzaffarnagar district encompassing an area of 221.20 Sq Km. It is flanked by Baghra & Muzaffarnagar blocks in the Northwest and Northeast respectively and Budhna & Khatauli blocks in the West and East respectively (Fig-1).

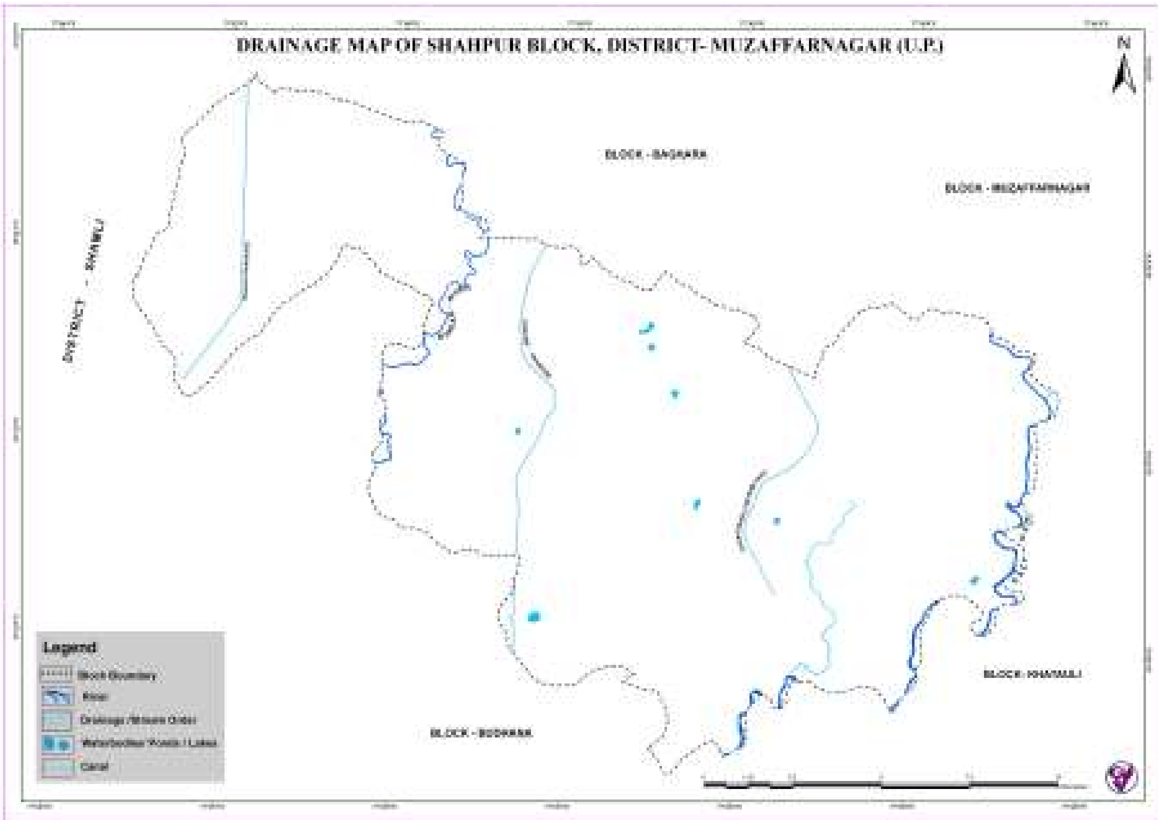
Fig-1



10.1.1 Drainage:

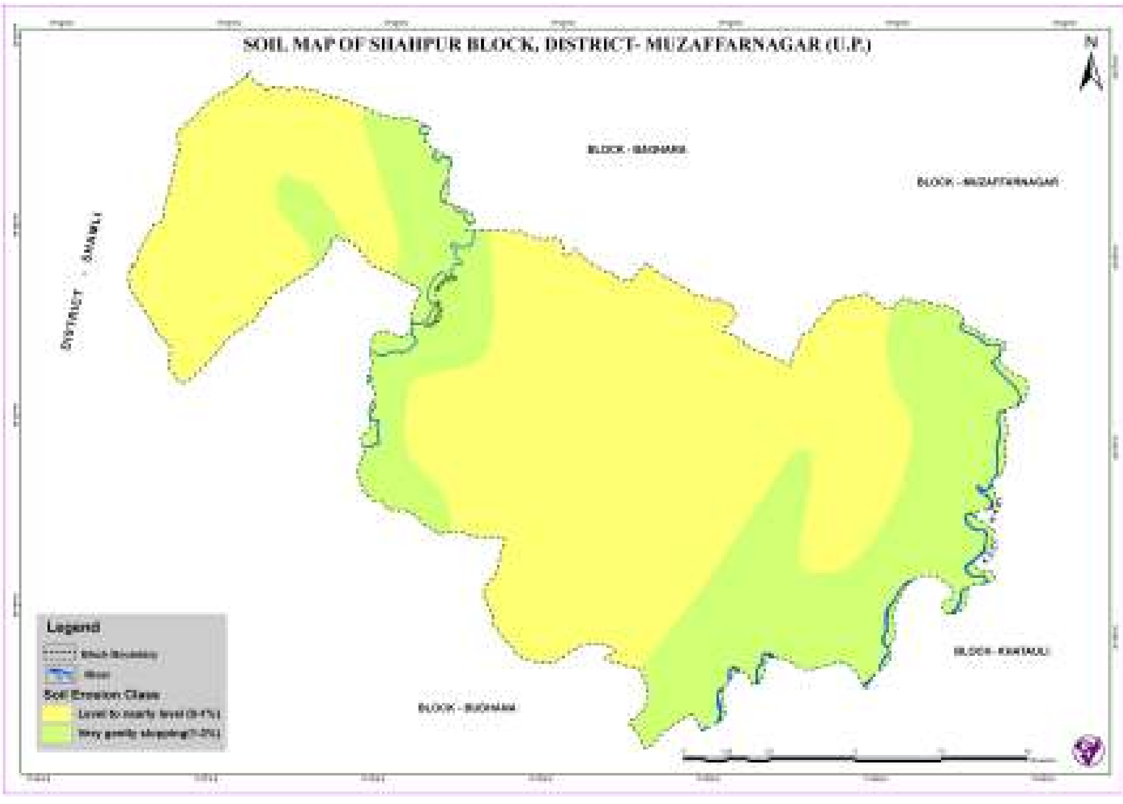
The bock is drained by Hindon river trending North- South through the Western part of the block and Kali Nadi that follows the eastern boundary of the block. The block has well developed canal network (Fig-2).

Fig-2



10.1.2 Soil:

Fig-3



10.2.0 GEOLOGY:

Fig-4

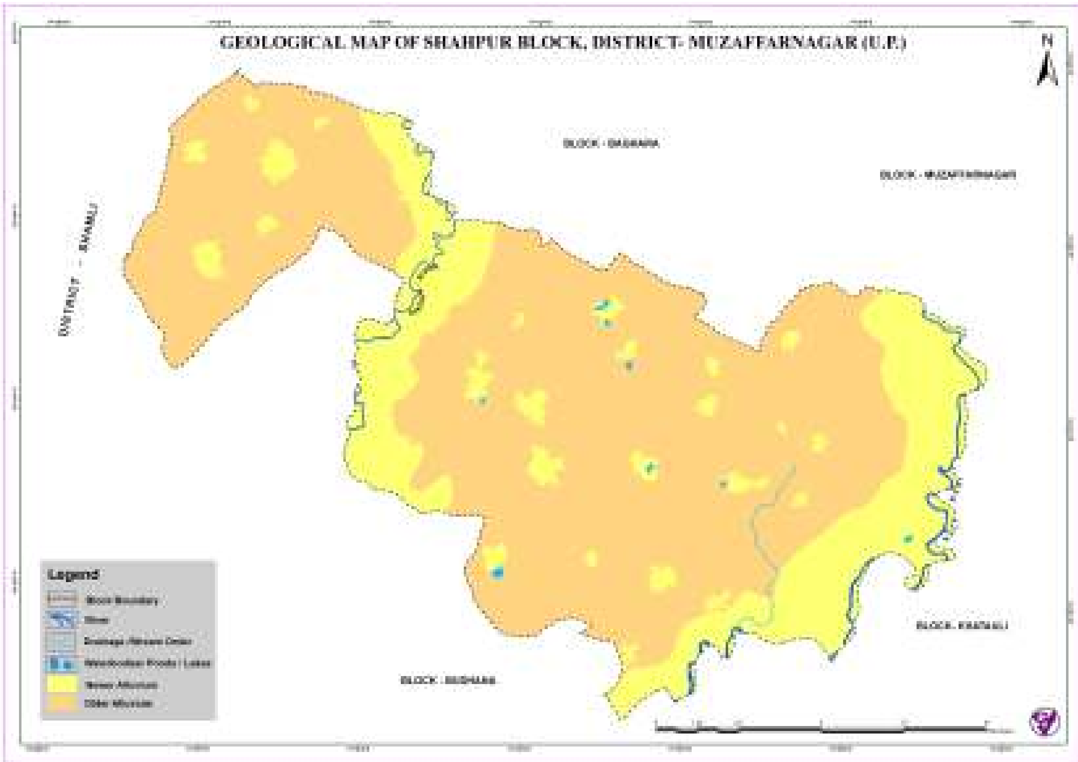
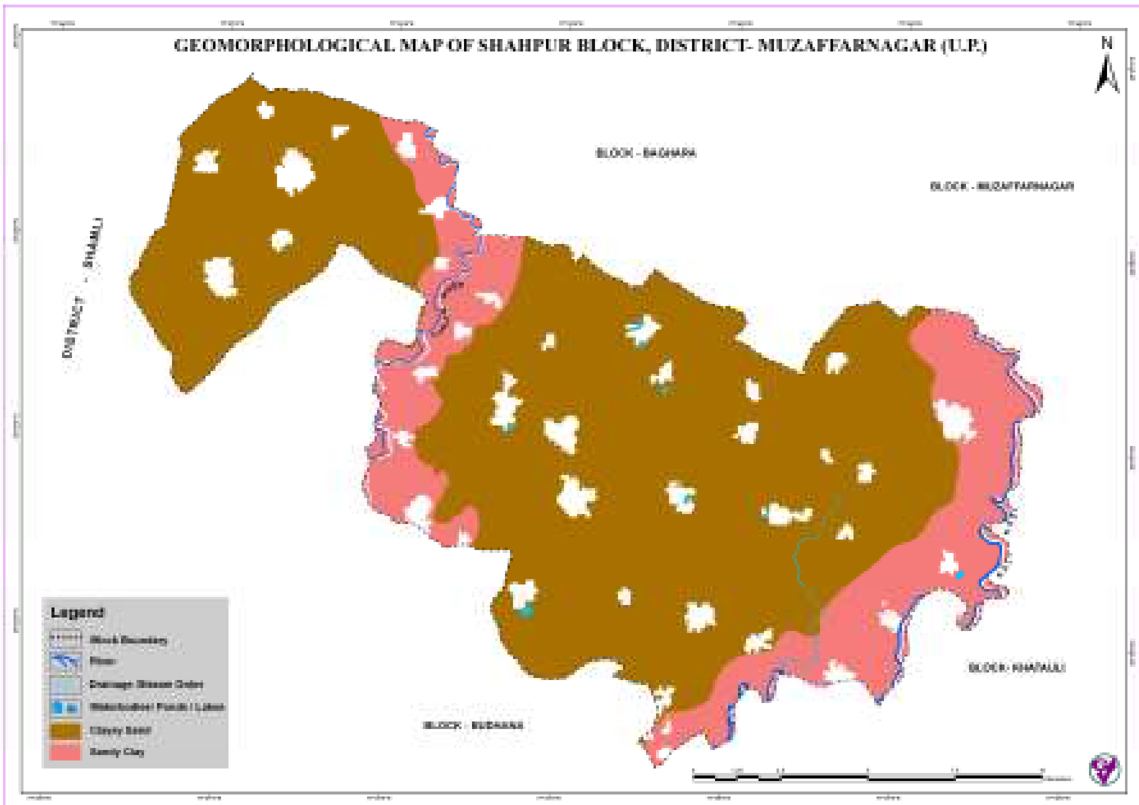


Fig-5



The soils of the block are formed by the transport of silt carried by the two rivers, Ganga and Yamuna. The soils are composed of Pleistocene and sub-recent alluvial sediments transported and deposited by river action from the Himalayan region. Soils are predominantly fine silty and sandy coarse loamy along the rivers (Fig-3).

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 and show quick alteration from finer to coarser at places. 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 (Fig-4).

Geomorphologically the block virtually forms a flat terrain forming a part of Ganga Plains. There are patches of saline and alkaline lands called "Bhur" areas mostly along the bank of Yamuna. The stretches of low land along the rivers are called "khadars". The khadar of Ganges differs from that of Yamuna, in not having wide stretches of settled countries and in having a better clay deposit (Fig-5).

(Figures in Ha.)

Table-1: Agricultural Statistics

	Sown area			**Season-wise Crop Area**			**Irrigated Area**			
Block	*Net Area Sown*	*Area sown more than once*	*Total*	*Rabi*	*Kharif*	*Jayad*	*Net Irrigated*	*Gross Irrigated*	Cropping Intensity	Irrigation intensity
Shahpur	18425	7820	26245	11235	12620	1542	20280	27288	142	135

Table-2: Area Under Principal Crops

Rice (Kharif)		**Rice (Jayad)**		**Total Rice**		**Wheat**		**Sugarcane**	
Total	Irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigated
885	885	0	0	885	885	7542	7542	12675	12486

Table-3: Dynamic Ground Water Resource of Muzaffarnagar District, UP (as on 31.3.2013) (Ham)

Net Annual GW Availability	Gross Ground Water Draft for Irrigation	Existing Gross GW Draft for All Uses	Stage of Ground Water Development (%)
5525.27	5345.73	5345.73	96.75

Fig-6: Depth to Water Map

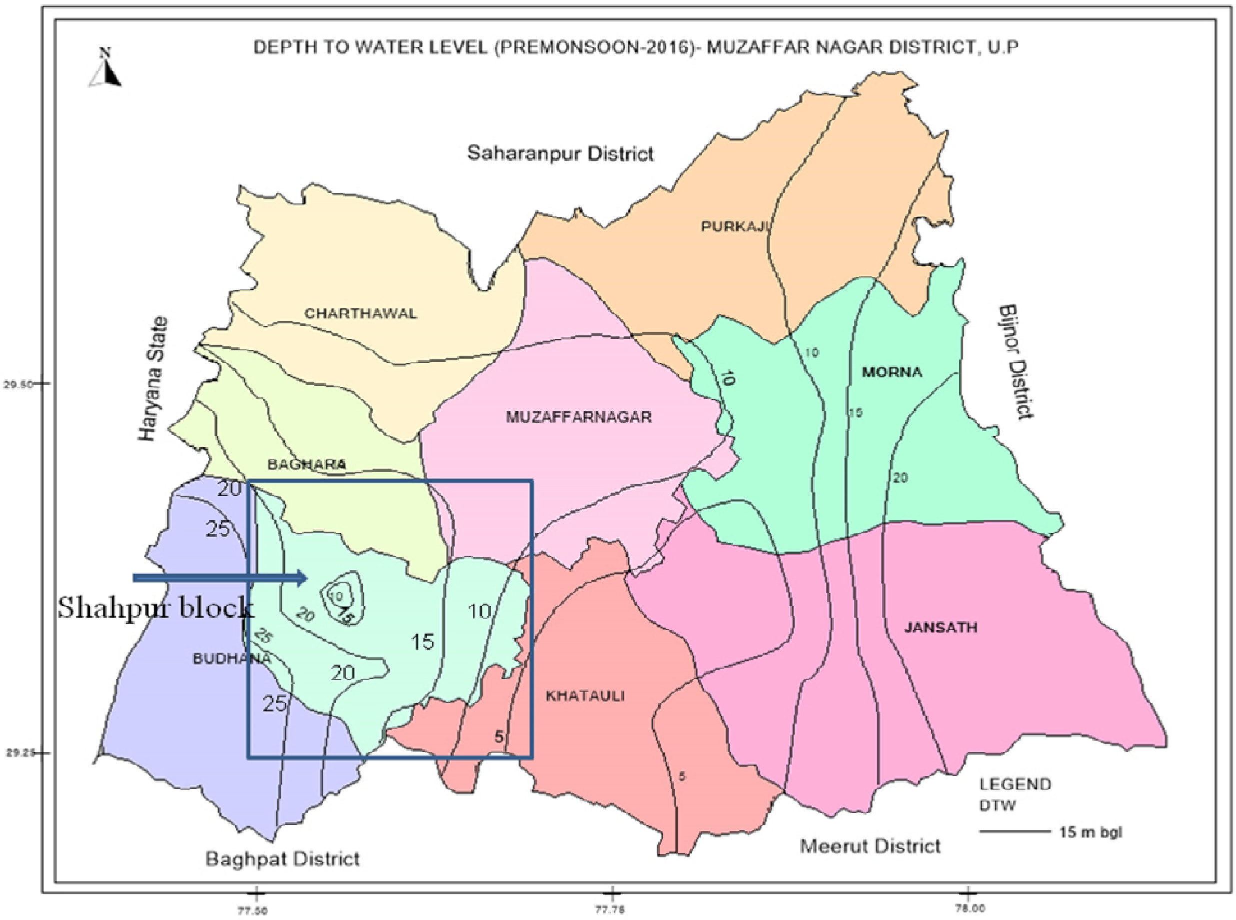
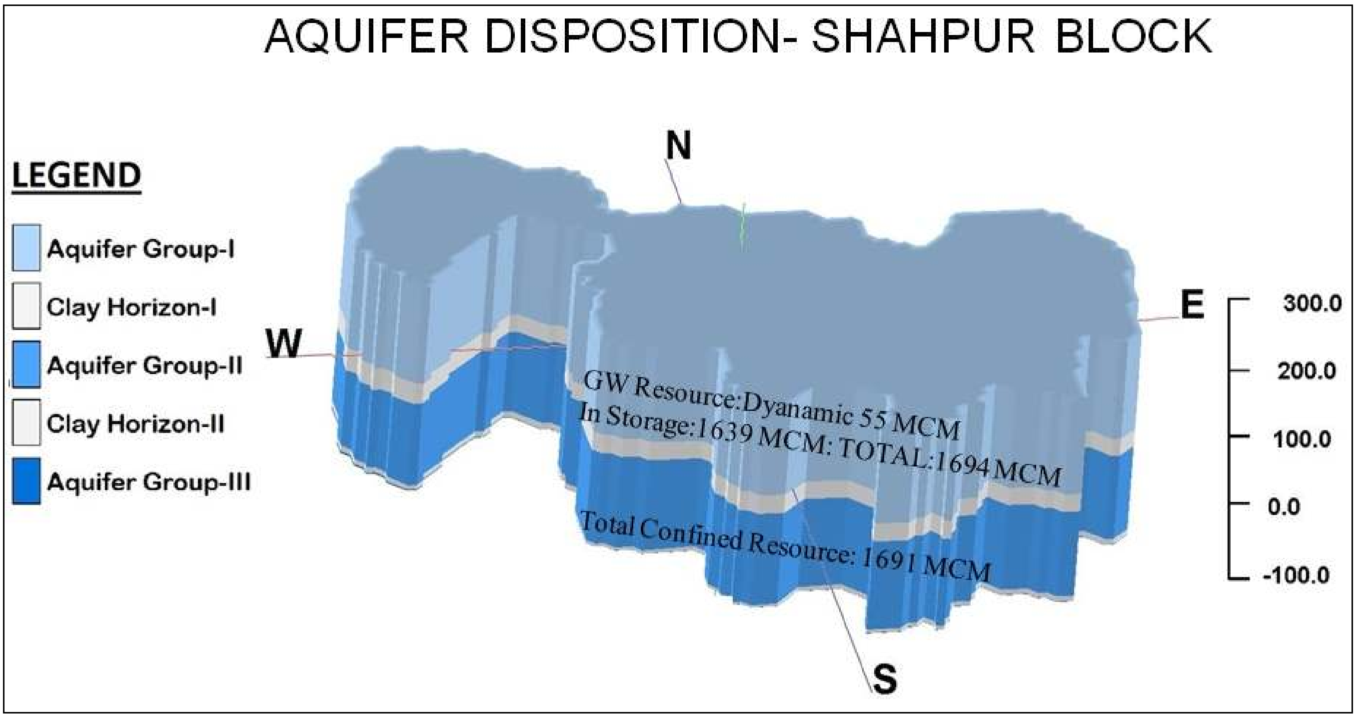


Fig-7: 3-Dimensional Aquifer Disposition in Shahpur Block



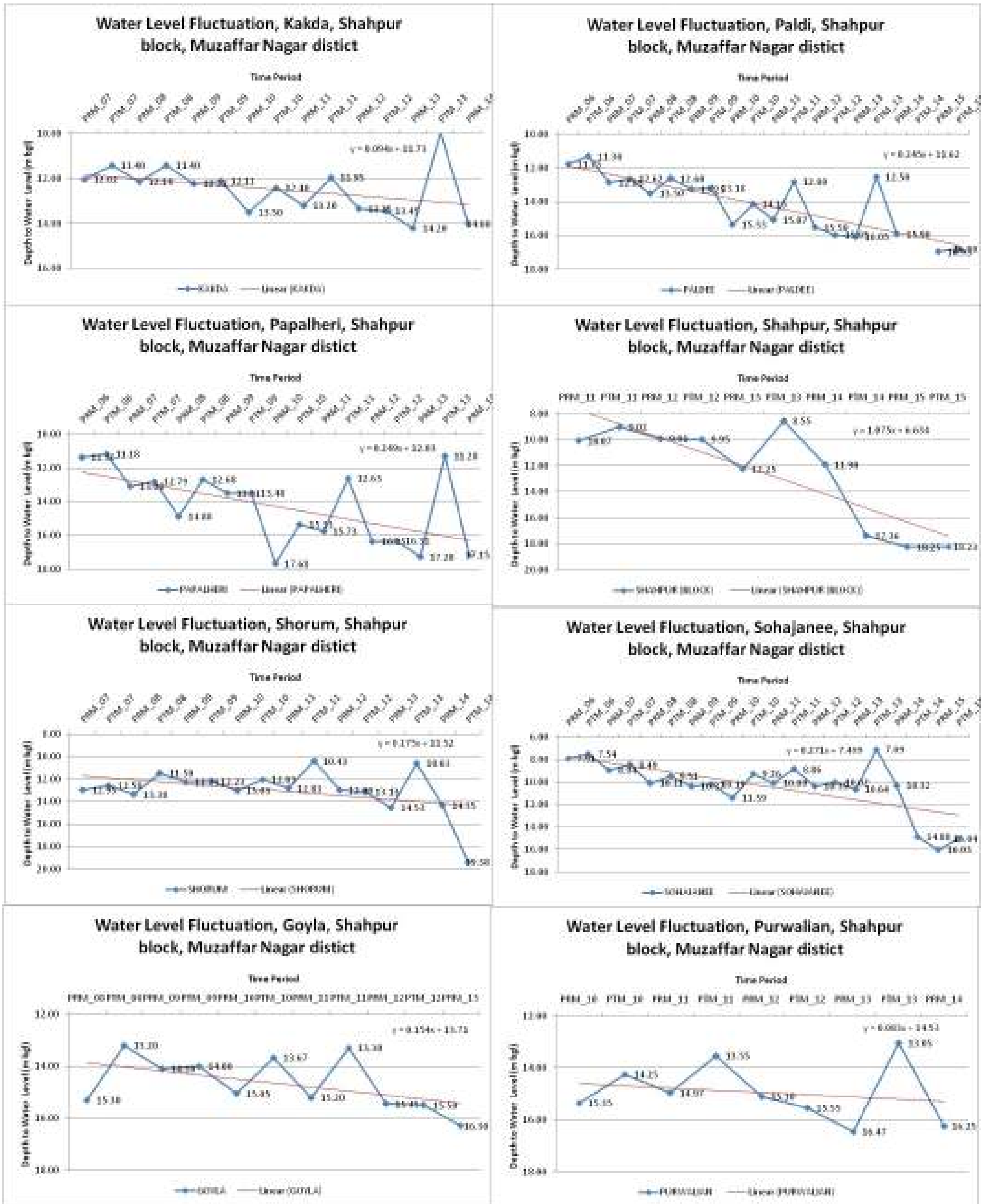
The Figures 6 & 7 give an overview of depth to water and 3-dimensional aquifer disposition in Shahpur block down to 300 m depth with dynamic & confined ground water resource.

10.3.0 GROUND WATER ISSUES:

The development of ground water is relatively high in Shahpur block and has been categorised as critical. The trend analysis of historical ground water level data indicates long term fall in most of the wells in the block.

Based on the factors mentioned, it is inferred that the block in general could be considered 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. Long term ground water trend for most of the wells (State GWD) presents declining trend and has been shown in the following figure.

Fig-8: Long term ground water level trend/fluctuation



10.4.0 GROUND WATER MANAGEMENT OPTIONS:

Ground water issues can be addressed by focusing 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

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

10.4.1 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.

10.4.2 On Farm Practices:

Supply Side Management

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

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

10.4.3 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

10.5.0. PROPOSED INTERVENTIONS IN SHAHPUR BLOCK:

Table-4: Proposed Interventions

Block	Check Dams of 10000 cum Capacity (Nos)	Drain/stream development (length in km x Avg.12m x 3m)	Nala Bunds of 7500 cum Capacity (Nos)	Revival of Ponds (Avg.) 50m x 50m x 3m dimension	On-farm Activities (Area in ha)	Adoption of new irrigation pra ctices for Sugar cane (Area in ha)	Water Use Efficiency (WUE) Mea-sures (Area in ha)
Shahpur	1	3	25	100	2200	8000	2200

10.6.0 BENEFITS:

Table-5: Summarised Expected Benefits

Expected Annual Recharge	**3.39 MCM**
Provision for supplemental irrigation	**1.19 MCM**
Conservation from On-farm Activities & WUE Measures	**2.71 MCM**
Total Recharge/ Saving	**7.29 MCM**
Saving from Adoption of new Irrigation practices in S.cane area	**9.00 MCM**
Cost of Interventions	**2275 Lac**

10.7.0 PROJECTED IMPACT AFTER INTERVENTIONS:

Table-6: Projected Impact On Status Of Groundwater Resource & Development In Shahpur Block

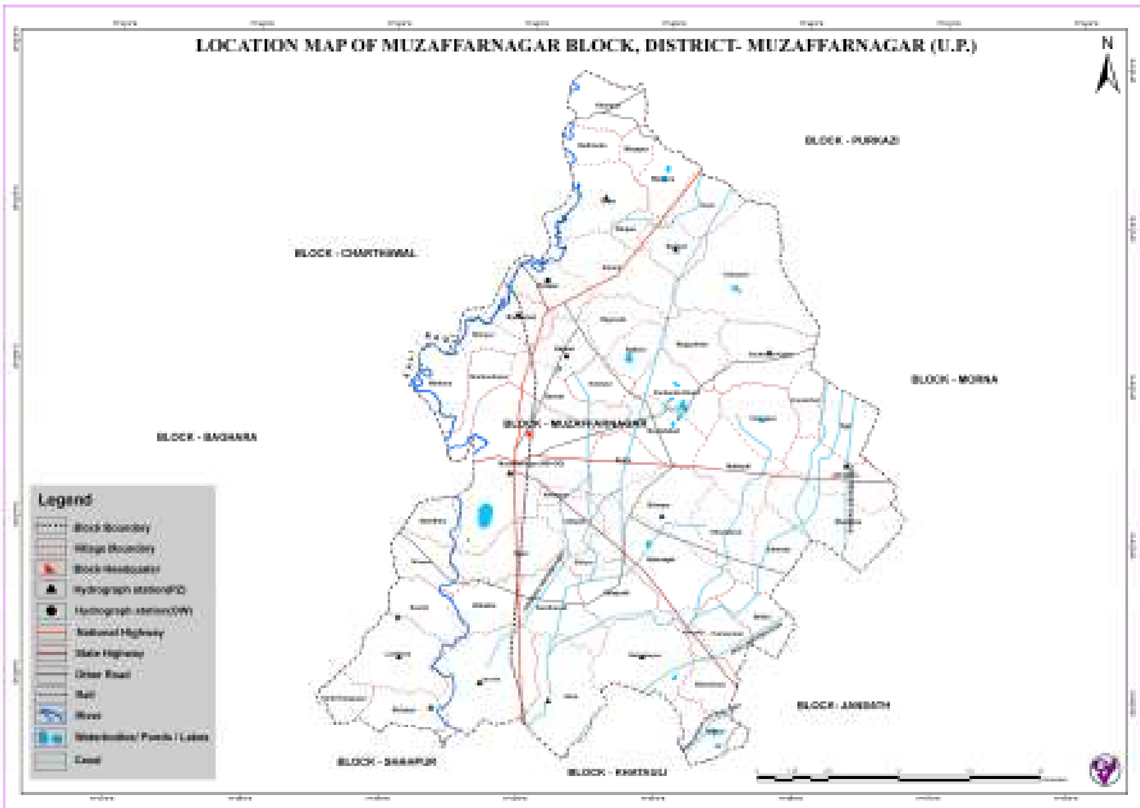
Net G.W. Availability (Ham)	Additional Recharge from RWH & Re-charge (ham)	Total Net G.W. Availability after intervention (Ham)	Existing G.W Draft for all purpose (ham)	Saving of Ground water through projects (ham)	Net GW draft after interventions (ham)	Present stage of G.W. development (%)	Saving from Adoption of new Irrigation practices in Sugar cane area	Projected stage of G.W. Dev. (in %)
5525.27	339.37	5864.64	5345.73	390.70	4955.03	96.75	900	69.14

11.0 GROUND WATER MANAGEMENT IN SAFE MUZAFFARNAGAR BLOCK

11.1.0 INTRODUCTION:

Muzaffarnagar (Kukra Sadar) block lies in the central part of the Muzaffarnagar district encompassing an area of 254.29 Sq Km. It is flanked by Baghra & Charthawal blocks in the Southwest and Northwest respectively and Morna & Purqazi blocks in the Southeast and Northeast respectively (Fig-1).

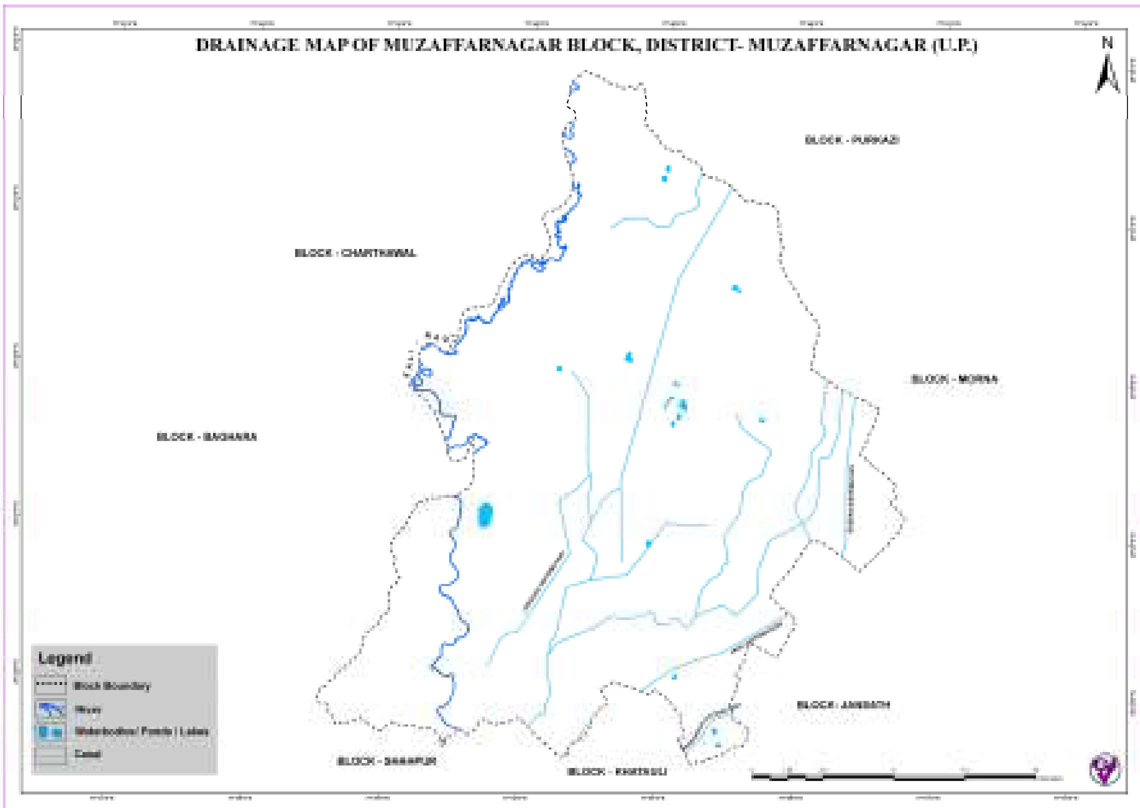
Fig-1



11.1.1 Drainage:

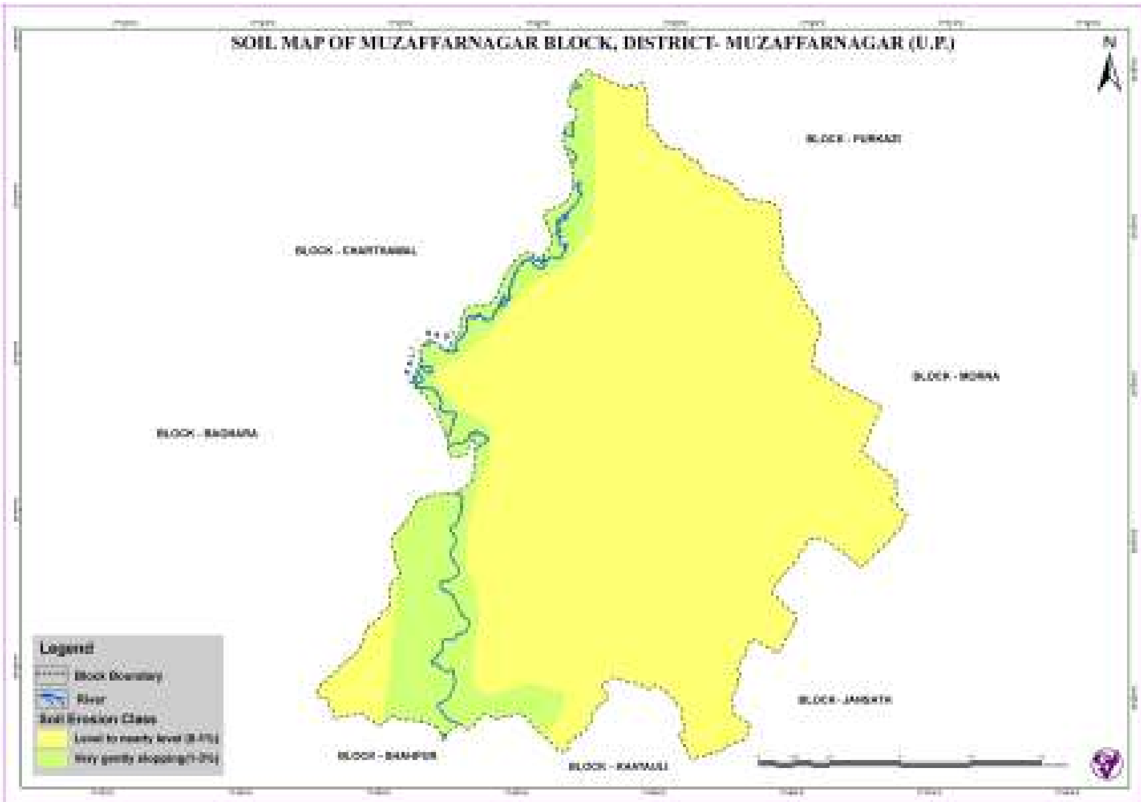
The bock is drained by Kali Nadi almost in north south direction in the western part of the block. The block has well developed canal network (Fig-2).

Fig-2



11.1.2 Soil:

Fig-3



11.2.0 GEOLOGY:

Fig-4

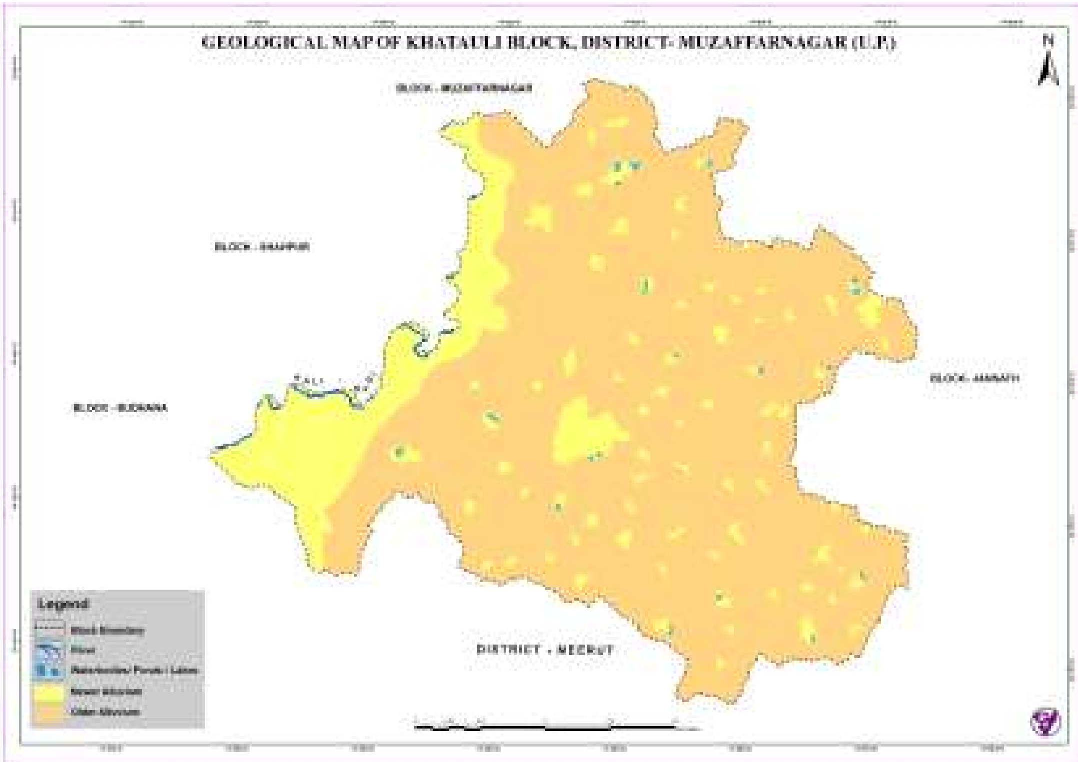
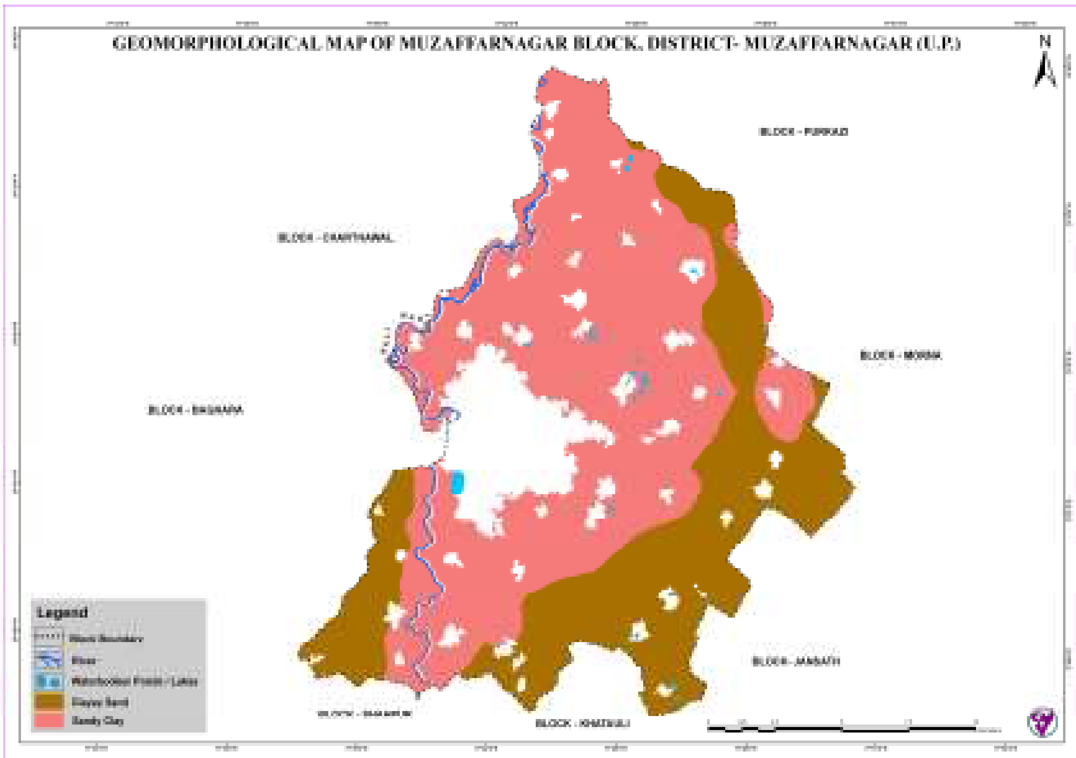


Fig-5



The soils of the block are formed by the transport of silt carried by the two rivers, Ganga and Yamuna. The soils are composed of Pleistocene and sub-recent alluvial sediments transported and deposited by river action from the Himalayan region. Soils are predominantly coarse loamy, sandy coarse loamy & fine silty (Fig-3).

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 and show quick alteration from finer to coarser at places. 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 (Fig-4).

Geomorphologically the block virtually forms a flat terrain forming a part of Ganga Plains. There are patches of saline and alkaline lands called "Bhur" areas mostly along the bank of Yamuna and the bank of upper Ganges canal. The stretches of low land along the rivers are called "khadars". The khadar of Ganges differs from that of Yamuna, in not having wide stretches of settled countries and in having a better clay deposit (Fig-5).

(Figures in Ha.)

Table-1: Agricultural Statistics

	Sown area			Season-wise Crop Area			Irrigated Area			
Block	*Net Area Sown*	*Area sown more than once*	*Total*	*Rabi*	*Kharif*	*Jayad*	*Net Irrigated*	*Gross Irrigated*	Cropping Intensity	Irrigation intensity
Muzaffar nagar	19192	8625	27817	8070	19117	1635	16890	23031	145	136

Table-2: Area Under Principal Crops

Rice (Kharif)		Rice (Jayad)		Total Rice		Wheat		Sugarcane	
Total	Irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigated
958	958	0	0	958	958	7778	7778	14632	14580

Table-3: Dynamic Ground Water Resource of Muzaffarnagar District, UP (as on 31.3.2013) (Ham)

Net Annual GW Availability	Gross Ground Water Draft for Irrigation	Existing Gross GW Draft for All Uses	Stage of Ground Water Development (%)
7750.37	5420.16	5961.89	76.92

Fig-6: Depth to Water Map

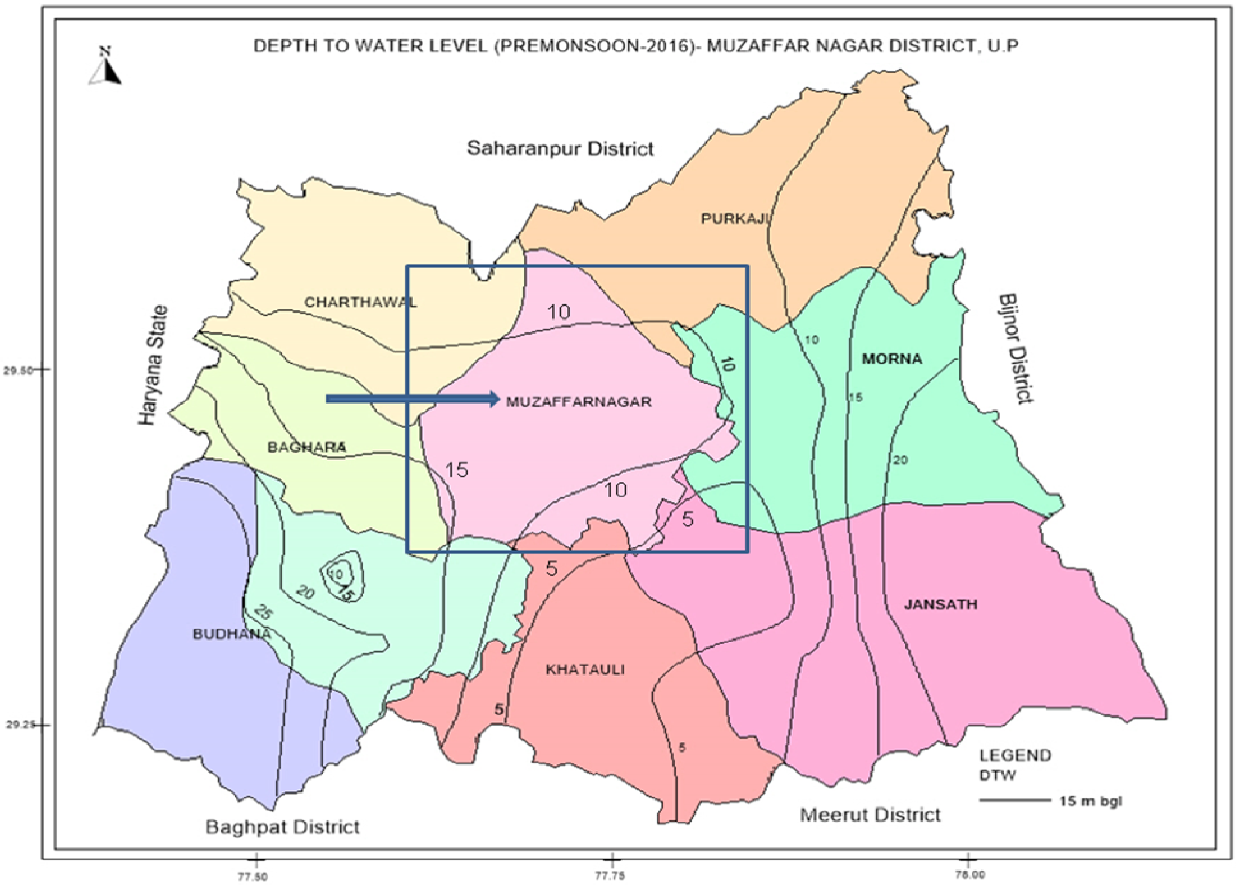
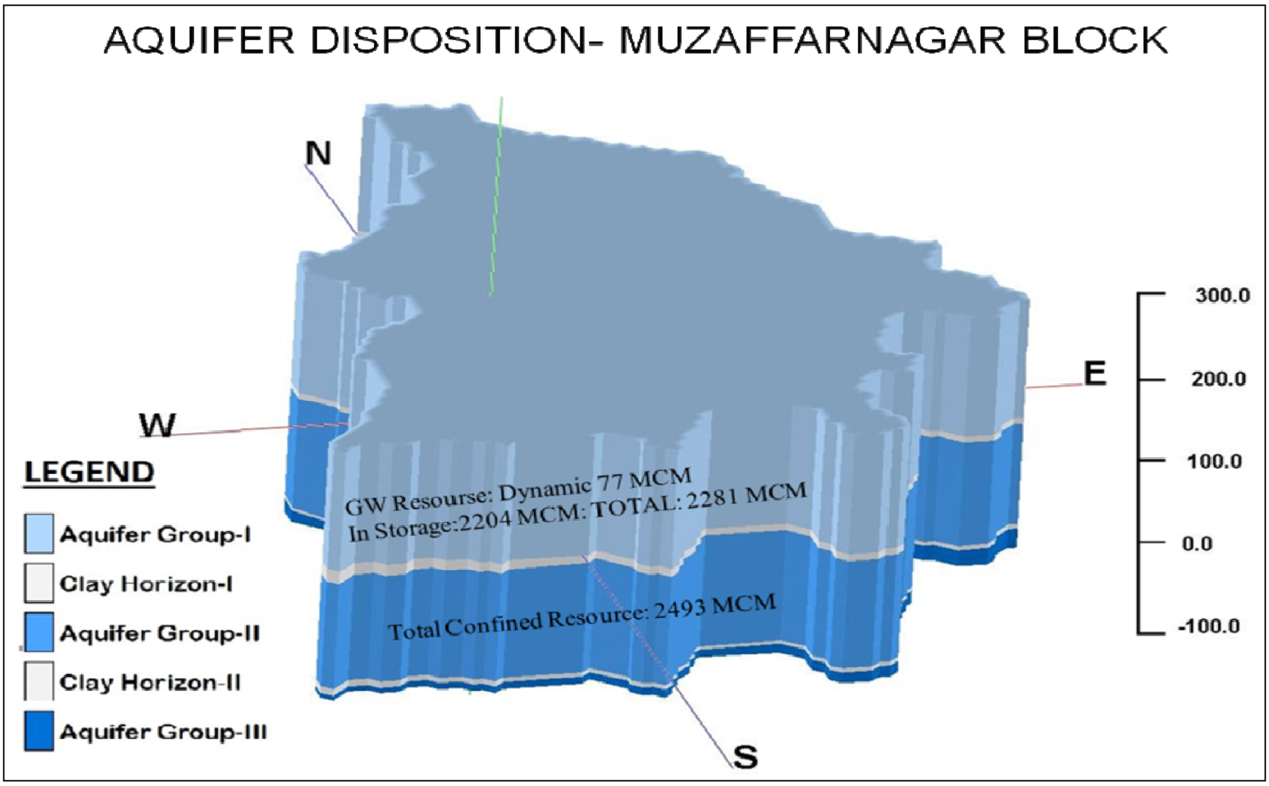


Fig-7: 3-Dimensional Aquifer Disposition in Muzaffarnagar Block



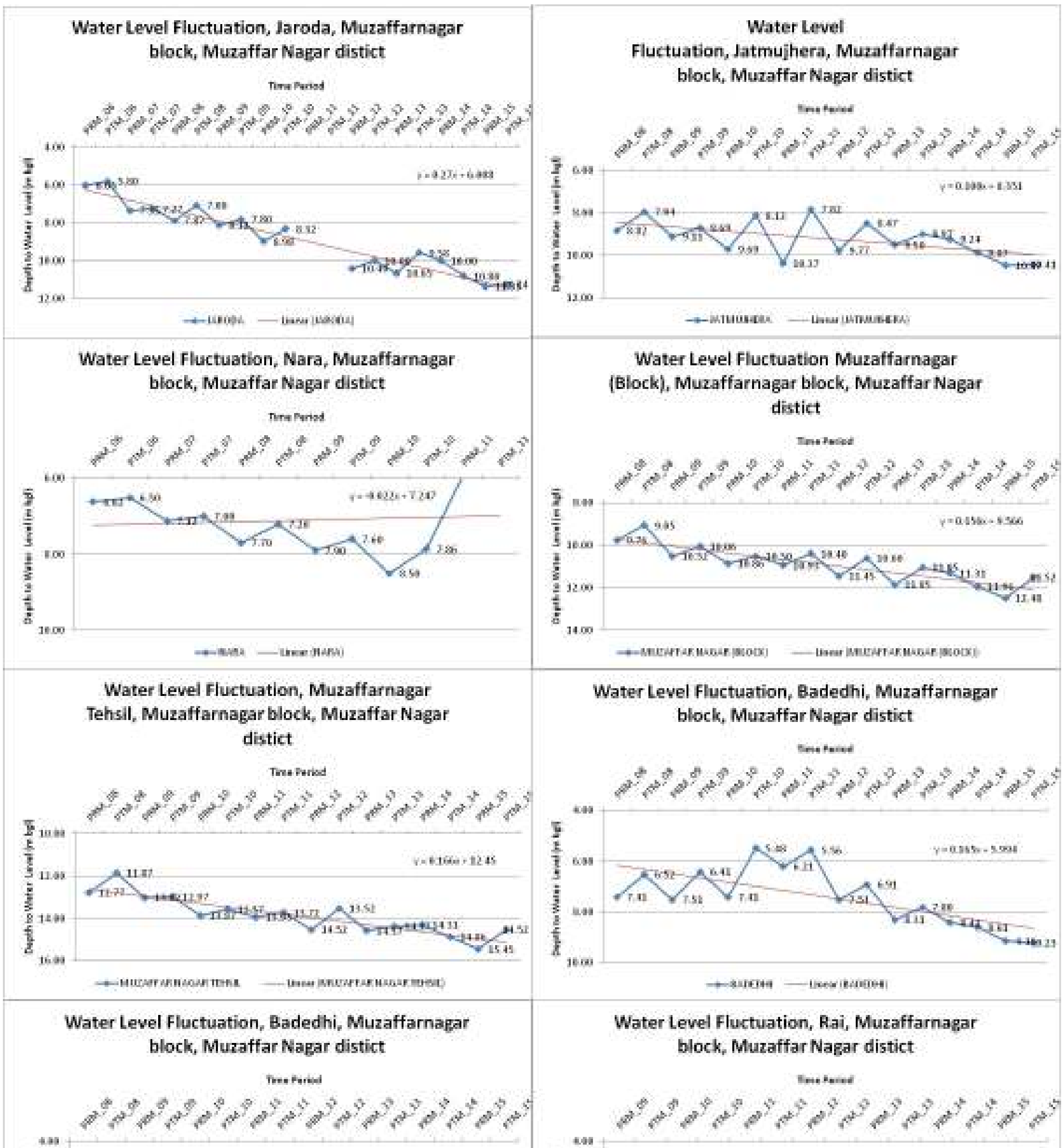
The Figures 6 & 7 give an overview of depth to water and 3-dimensional aquifer disposition in Muzaffarnagar block down to 300 m depth with dynamic & confined ground water resource.

11.3.0 GROUND WATER ISSUES:

Even though the Muzaffarnagar (Kukra Sadar) block falls under 'Safe' category yet it may become 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 due to relatively high stage of ground water development which is about 77%.

Although there is good scope of ground water development in the area as the current category of the block is 'Safe' but the dominance of sugarcane cultivation in the area calls for simultaneous adoption of measures to increase recharge and reducing the draft. Long term ground water trend for most of the wells (State GWD) presents declining trend and has been shown in the following figure.

Fig-8: Long term ground water level trend/fluctuation



11.4.0 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 following measures:

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

11.4.1 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

11.5.0. PROPOSED INTERVENTIONS IN MUZAFFARNAGAR BLOCK:

Table-4: Proposed Interventions							
Block	Check Dams of 10000 cum Capacity (Nos)	Drain/stream development (length in km x Avg.12m x 3m)	Nala Bunds of 7500 cum Capacity (Nos)	Revival of Ponds (Avg.) 50m x 50m x 3m dimension	On-farm Activities (Area in ha)	Adoption of new irrigation pra ctices for Sugar cane (Area in ha)	Water Use Efficiency (WUE) Mea-sures (Area in ha)
Muzaffarnagar	-	-	-	-	-	5000	-

11.6.0 BENEFITS:

Table-5: Summarised Expected Benefits	
Expected Annual Recharge	-
Provision for supplemental irrigation	-
Conservation from On-farm Activities & WUE Measures	-
Total Recharge/ Saving	-
Saving from Adoption of new Irrigation practices in S.cane area	6.0 MCM
Cost of Interventions	Nil

11.7.0 PROJECTED IMPACT AFTER INTERVENTIONS:

Table-6: Projected Impact On Status Of Groundwater Resource & Development In Baghara Block								
Net G.W. Availability (Ham)	Additional Recharge from RWH & Re-charge (ham)	Total Net G.W. Availability after intervention (Ham)	Existing G.W Draft for all purpose (ham)	Saving of Ground water through projects (ham)	Net GW draft after interventions (ham)	Present stage of G.W. development (%)	Saving from Adoption of new Irrigation practices in Sugar cane area (ham)	Projected stage of G.W. Dev. (in %)
7750.37	0.00	7750.37	5961.89	0.00	5961.89	76.92	600	69.18

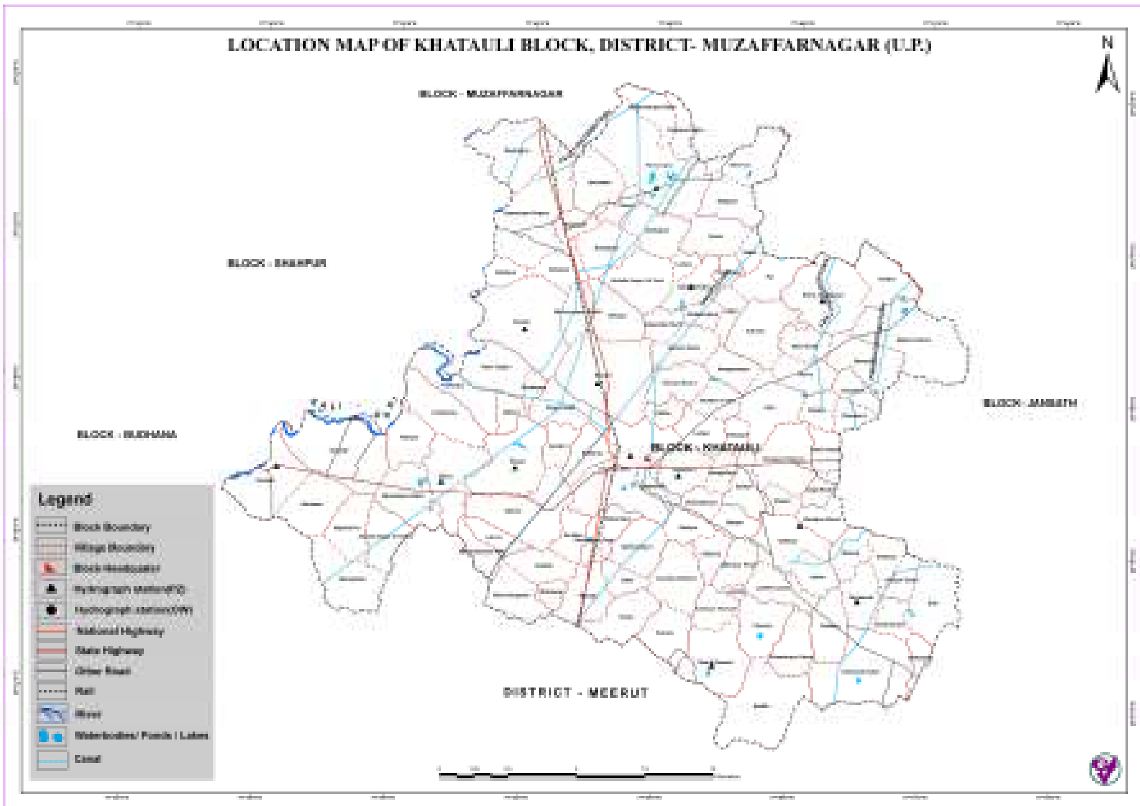
By adopting efficient water saving Irrigation practices in sugarcane cultivation area of 5000 hactare will lead to about 600 ham of saving in ground water irrigation that would lead to fall in high stage of ground water development from 76.92% to 69.18%.

12.0 GROUND WATER MANAGEMENT IN SAFE KHATAULI BLOCK

12.1.0 INTRODUCTION:

Khatauli block lies in the southern part of the Muzaffarnagar district encompassing an area of 304.63 Sq Km. It is flanked by Shahpur & Jansath blocks in the West and East respectively and Muzaffarnagar block in the North (Fig-1).

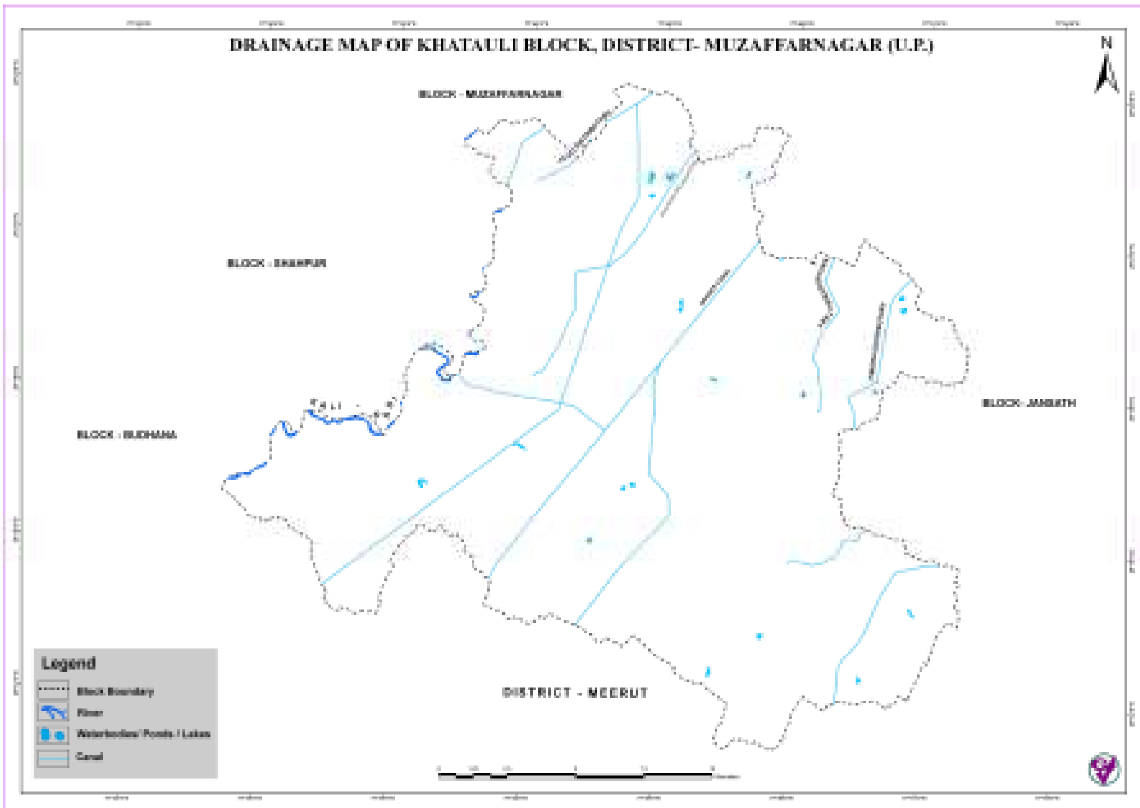
Fig-1



12.1.1 Drainage:

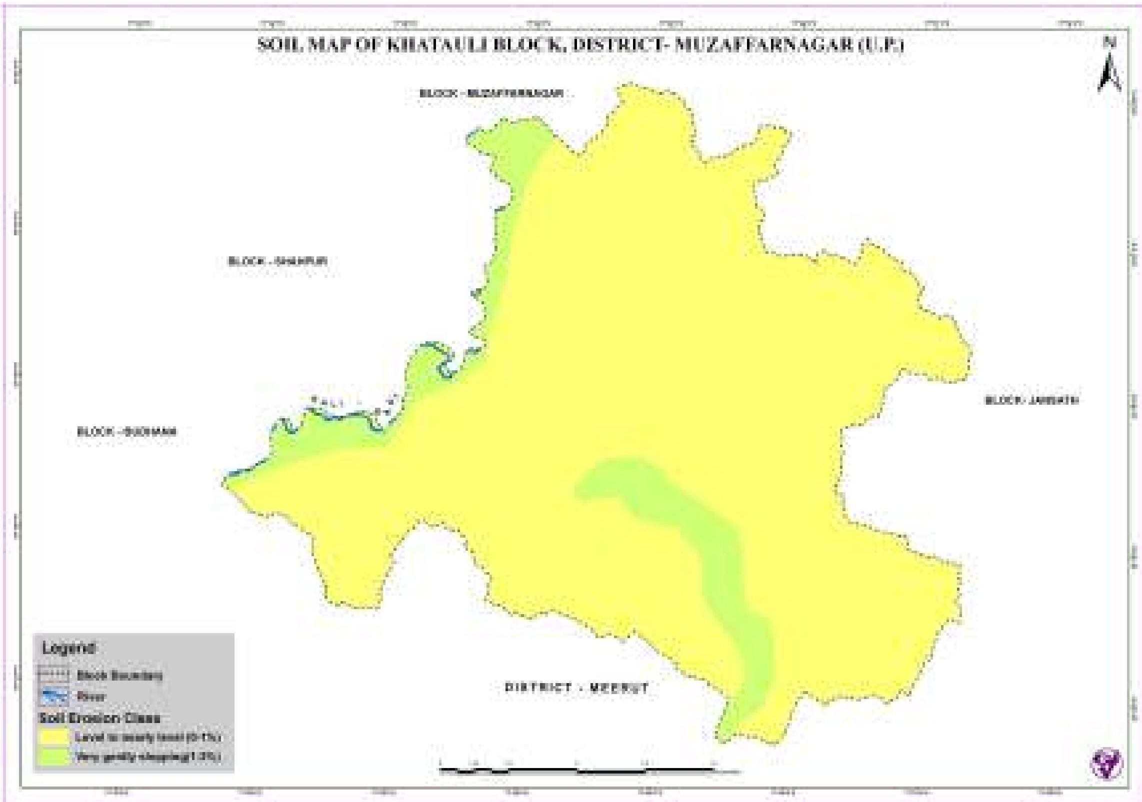
The bock is drained by Kali Nadi that follows the western boundary of the block. The block has well developed canal network (Fig-2).

Fig-2



12.1.2 Soil:

Fig-3



12.2.0 GEOLOGY:

Fig-4

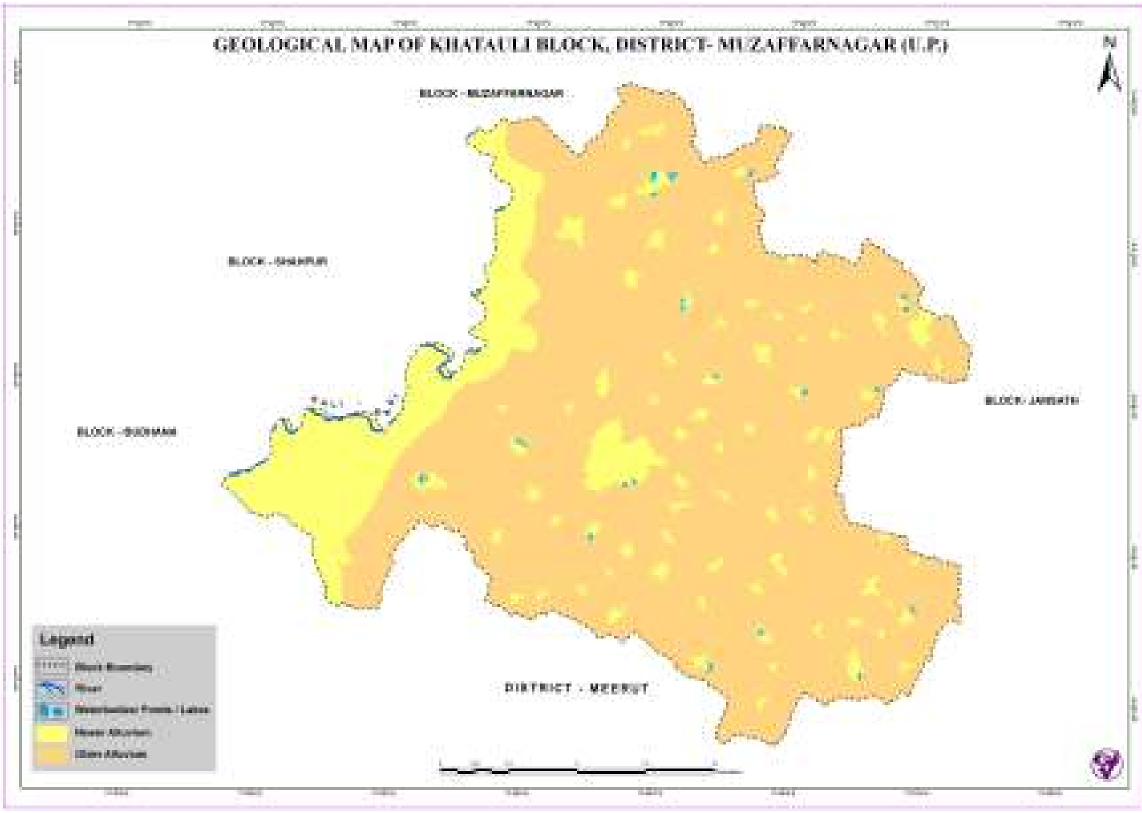
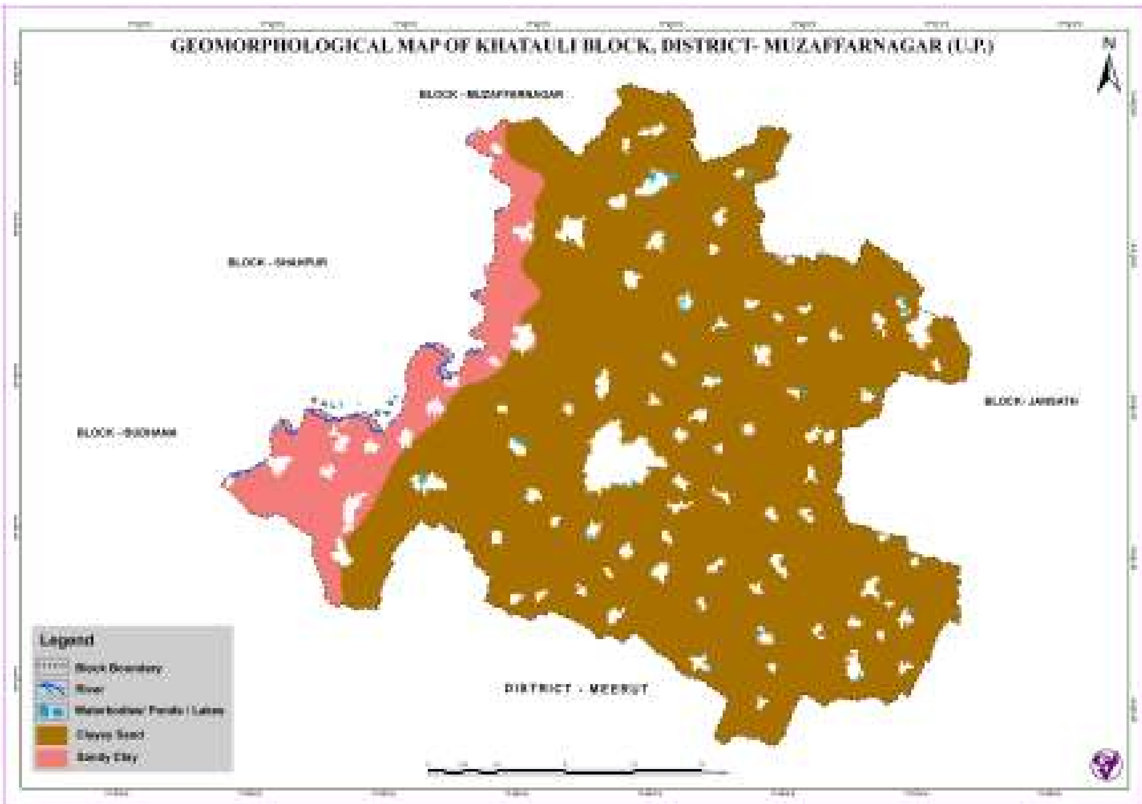


Fig-5



The soils of the block are formed by the transport of silt carried by the two rivers, Ganga and Yamuna. The soils are composed of Pleistocene and sub-recent alluvial sediments transported and deposited by river action from the Himalayan region. Soils are predominantly coarse loamy calcareous, coarse loamy & fine silty (Fig-3).

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 and show quick alteration from finer to coarser at places. 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 (Fig-4).

Geomorphologically the block virtually forms a flat terrain forming a part of Ganga Plains. There are patches of saline and alkaline lands called "Bhur" areas mostly along the bank of Yamuna and the bank of upper Ganges canal. The stretches of low land along the rivers are called "khadars". The khadar of Ganges differs from that of Yamuna, in not having wide stretches of settled countries and in having a better clay deposit (Fig-5).

(Figures in Ha.)

Table-1: Agricultural Statistics

	Sown area			**Season-wise Crop Area**			**Irrigated Area**			
Block	*Net Area Sown*	*Area sown more than once*	*Total*	*Rabi*	*Kharif*	*Jayad*	*Net Irrigated*	*Gross Irrigated*	Cropping Intensity	Irrigation intensity
Khatauli	26420	9437	35857	11920	20680	2715	26521	37512	136	141

Table-2: Area Under Principal Crops

Rice (Kharif)		**Rice (Jayad)**		**Total Rice**		**Wheat**		**Sugarcane**	
Total	Irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigated
870	870	0	0	870	870	8562	8214	21437	21437

Table-3: Dynamic Ground Water Resource of Muzaffarnagar District, UP (as on 31.3.2013) (Ham)

Net Annual GW Availability	Gross Ground Water Draft for Irrigation	Existing Gross GW Draft for All Uses	Stage of Ground Water Development (%)
13307.86	4701.56	5469.10	41.10

Fig-6: Depth to Water Map

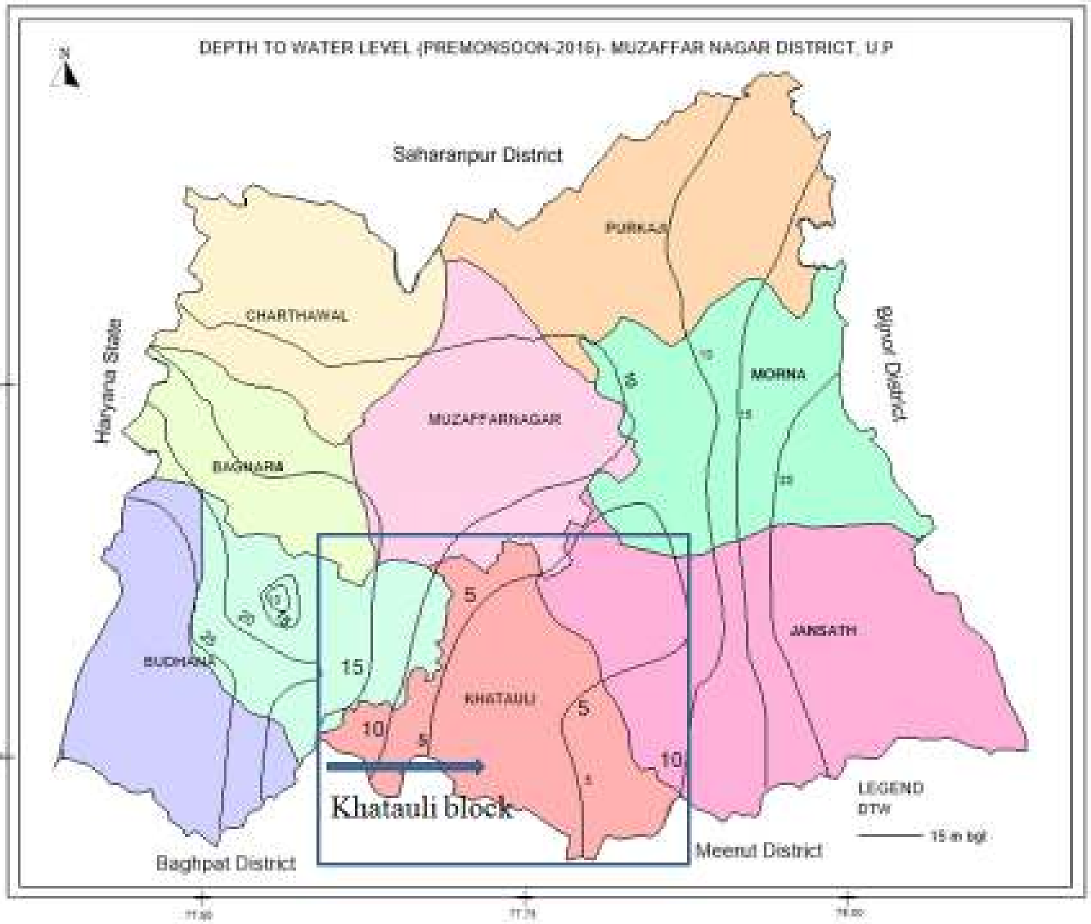
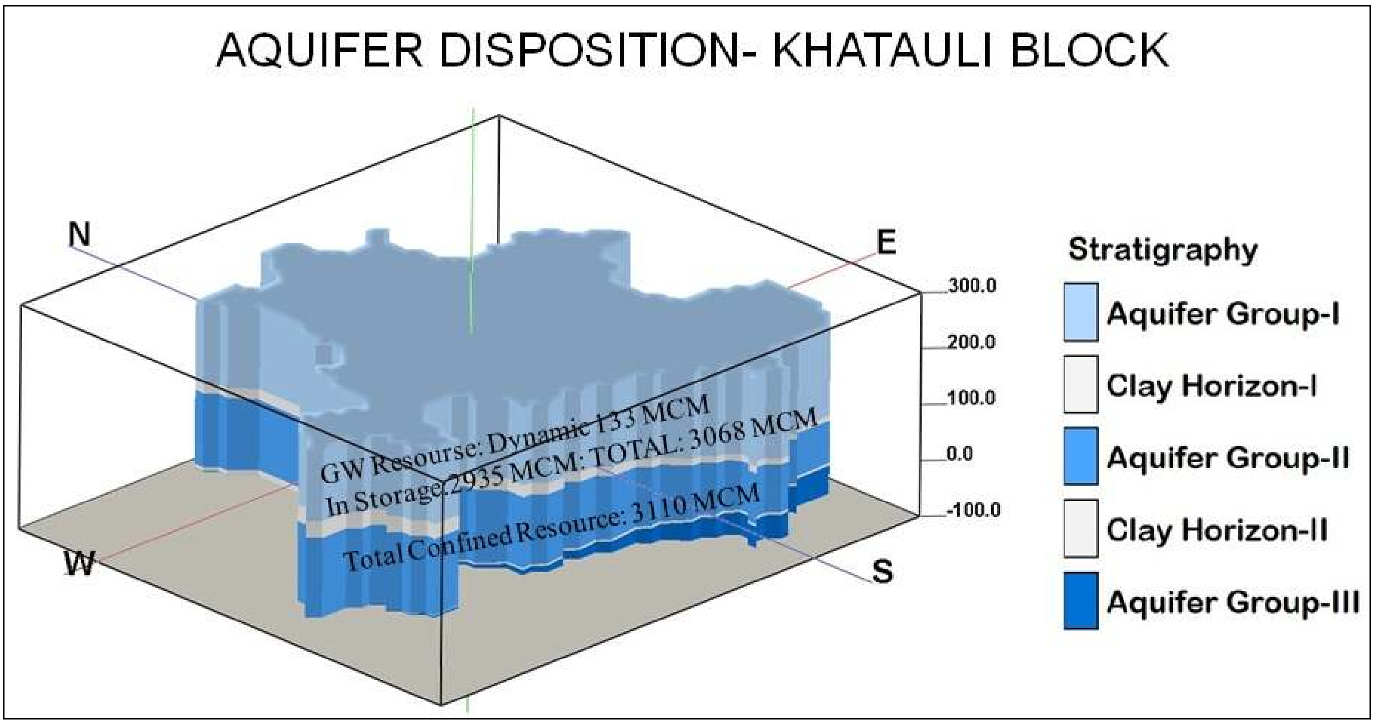


Fig- 7: 3-Dimensional Aquifer Disposition in Khatauli Block

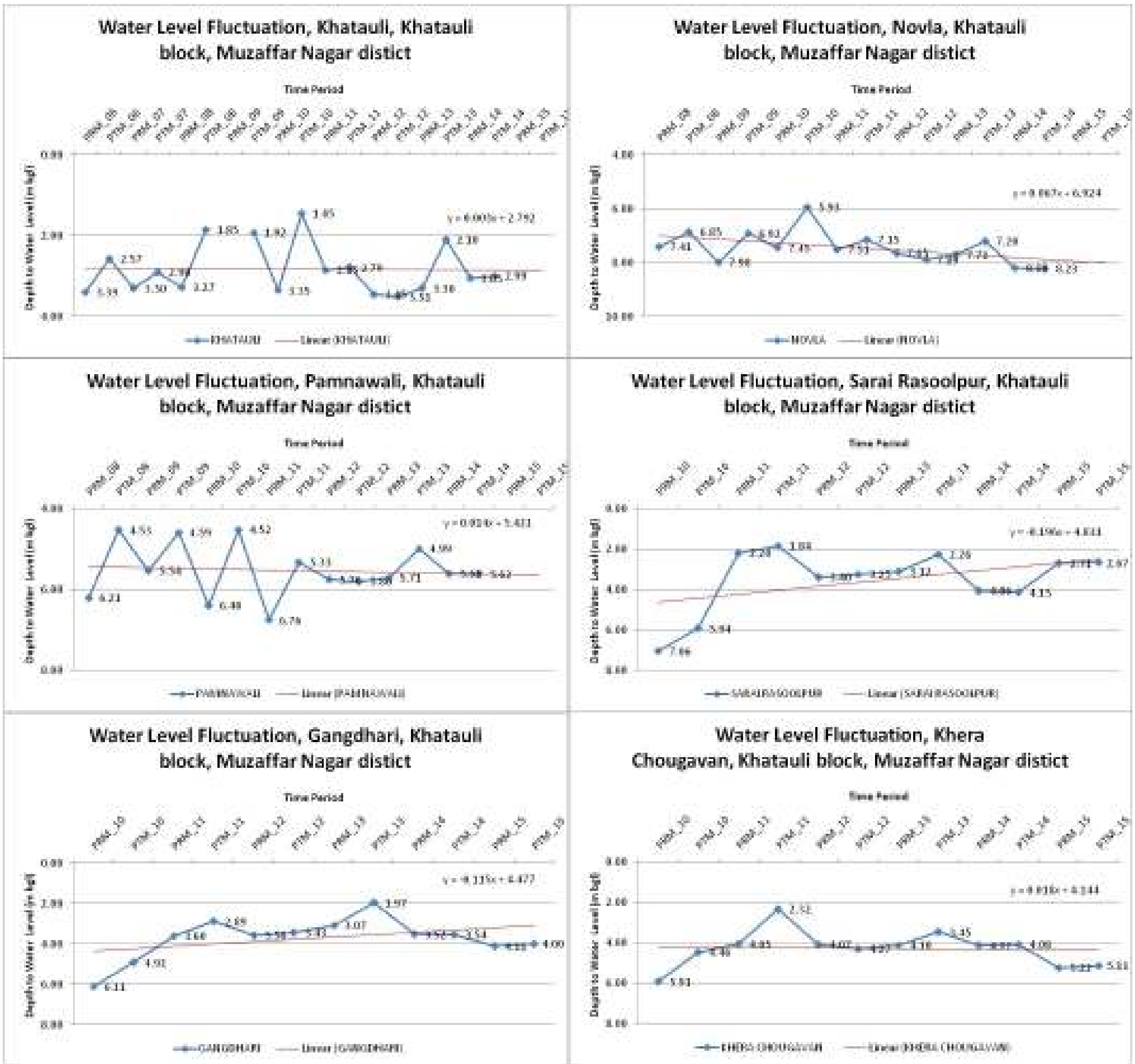


The Figures 6 & 7 give an overview of depth to water and 3-dimensional aquifer disposition in Khatauli block down to 300 m depth with dynamic & confined ground water resource.

12.3.0 GROUND WATER ISSUES:

The development of ground water is relatively low in Khatauli block and has been categorised as safe. The trend analysis of historical ground water level data of State GWD wells indicates long term feebly rising to feebly falling in most of the wells in the block.

Fig-8 Long term ground water level trend/fluctuation



Although there is good scope of ground water development in the area as the current category of the block is 'Safe' but the dominance of sugarcane cultivation in the area calls for simultaneous adoption of measures to increase recharge and reducing the draft.

12.4.0 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 following measures:

Demand Side Management

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

12.4.1 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.

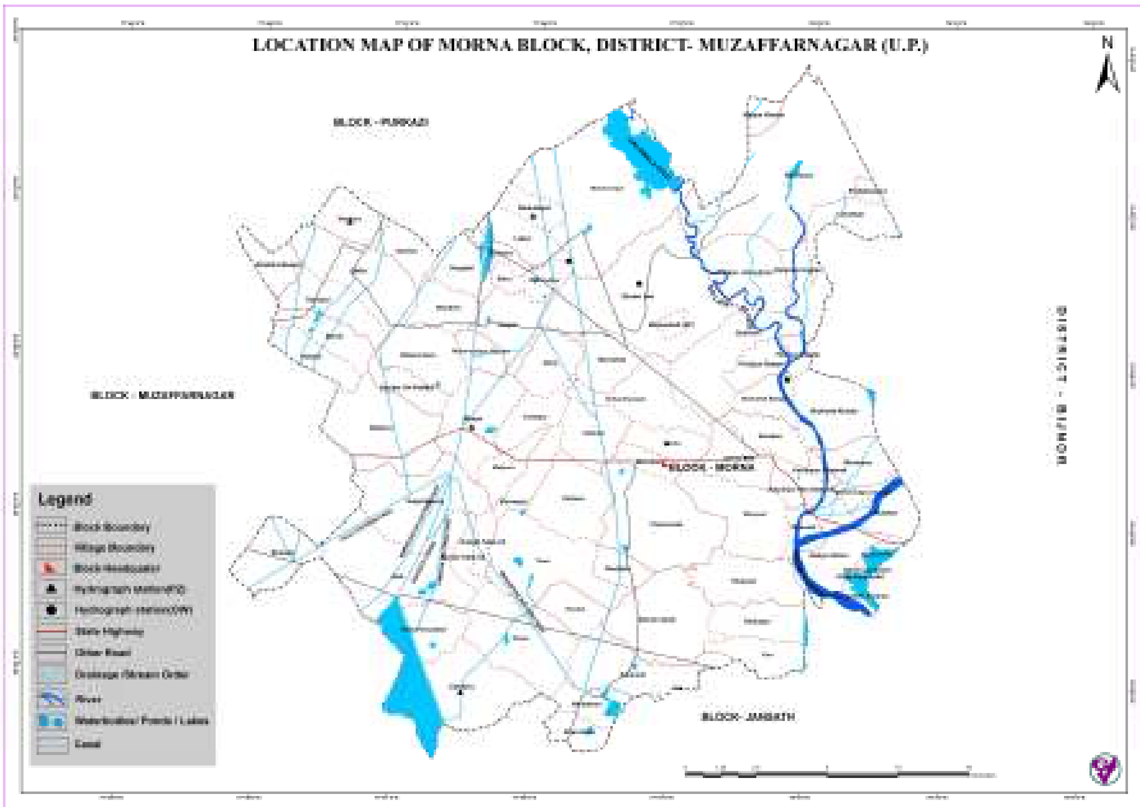
- Summer paddy and maize need to be avoided which are grown over substantial area in the block.
- Large scale adoption of rice-wheat rotation system & sugarcane cultivation is the main reason of over exploitation of groundwater. Late sown wheat/peas are replaced by spring maize which consumes more water. 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

13.0 GROUND WATER MANAGEMENT IN SAFE MORNA BLOCK

13.1.0 INTRODUCTION:

Morna block lies in the eastern part of the Muzaffarnagar district encompassing an area of 354.98 Sq Km. It is flanked by Muzaffarnagar (Kukra Sadar) & Purqazi blocks in the West and North respectively and Bijnor district in the east separated by Ganga River (Fig-1).

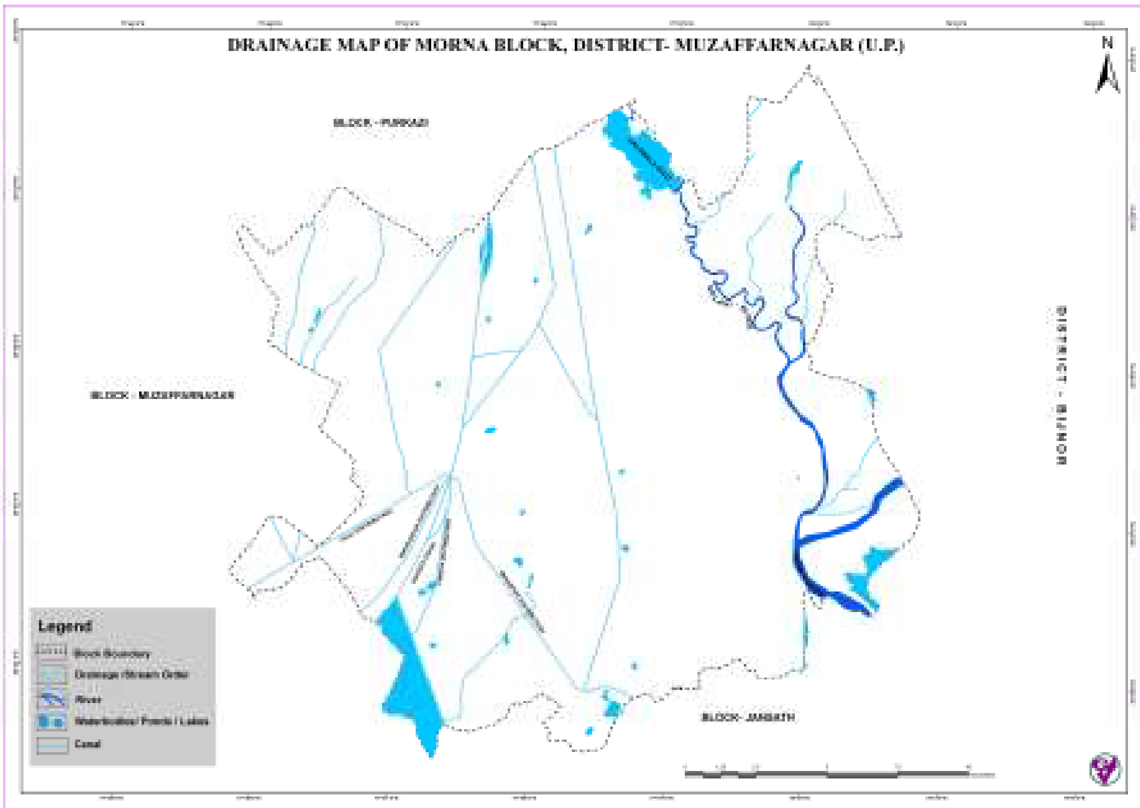
Fig-1



13.1.1 Drainage:

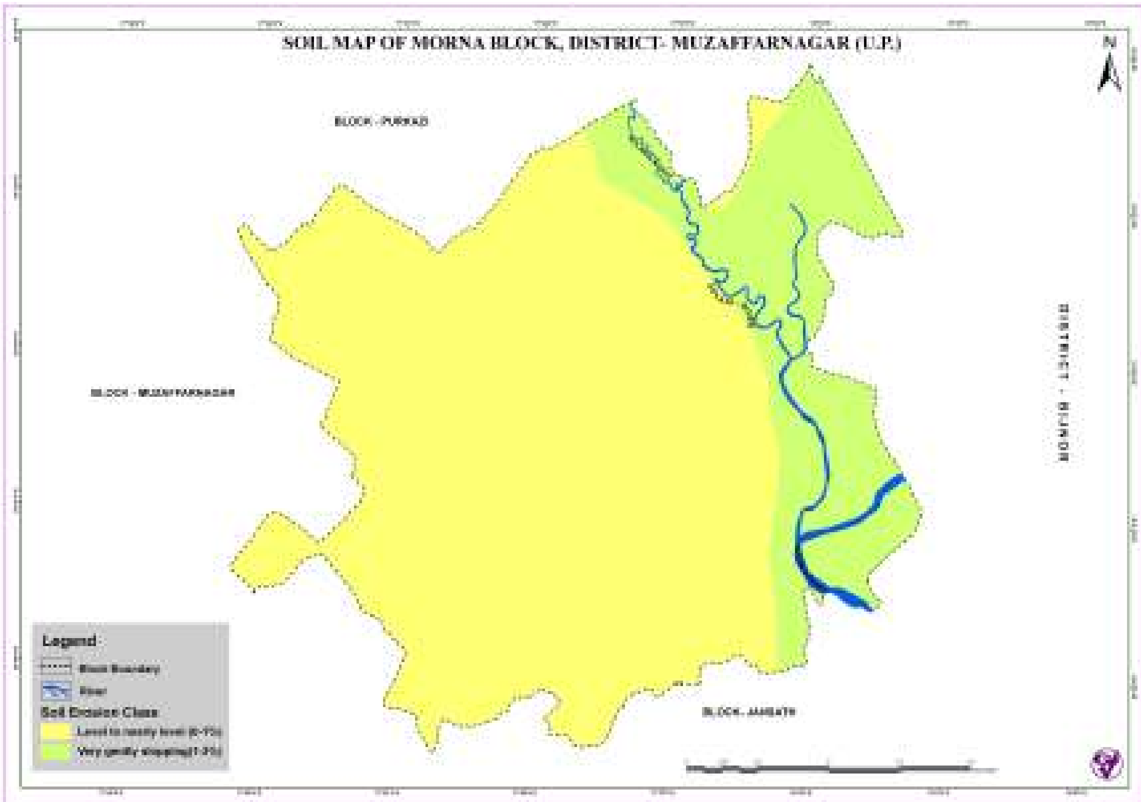
The bock is drained by Ganga River that follows the eastern boundary of the block.Saloni River is tributary of Ganga in the north easter part. The block has well developed canal network (Fig-2).

Fig-2



13.1.2 Soil:

Fig-3



13.2.0 GEOLOGY:

Fig-4

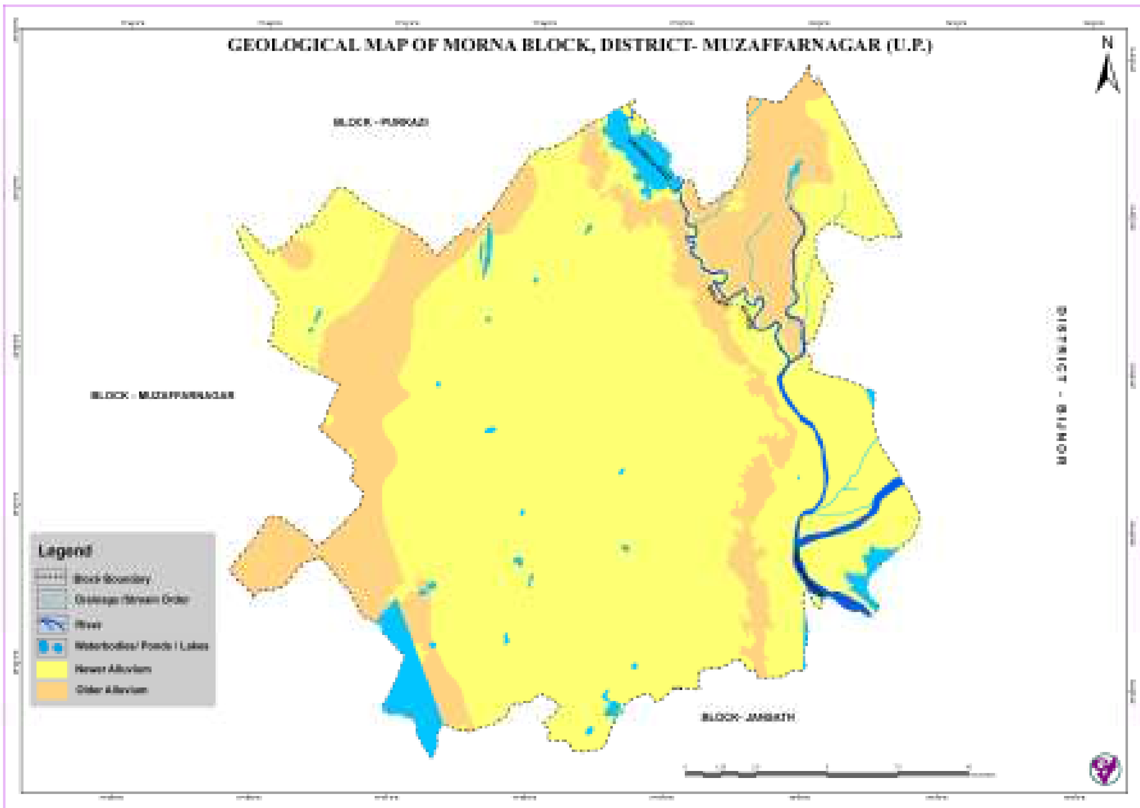
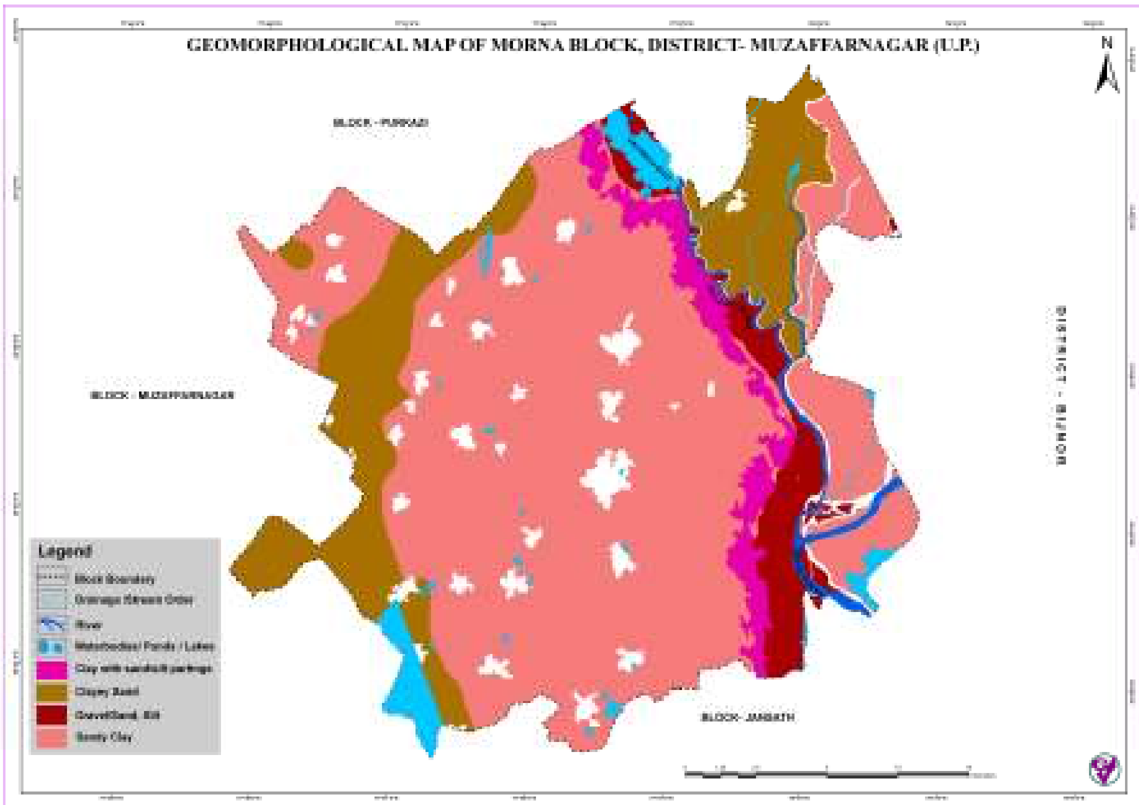


Fig-5



The soils of the block are formed by the transport of silt carried by the two rivers, Ganga and Yamuna. The soils are composed of Pleistocene and sub-recent alluvial sediments transported and deposited by river action from the Himalayan region. Soils are predominantly coarse loamy calcareous, coarse loamy, sandy coarse loamy & fine silty (Fig-3).

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 and show quick alteration from finer to coarser at places. 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 (Fig-4).

Geomorphologically the block virtually forms a flat terrain forming a part of Ganga Plains. There are patches of saline and alkaline lands called "Bhur" areas mostly along the bank of Yamuna, Ganga and the bank of upper Ganges canal. The stretches of low land along these rivers are called "khadars". The khadar of Ganges differs from that of Yamuna, in not having wide stretches of settled countries and in having a better clay deposit (Fig-5).

(Figures in Ha.)

Table-1: Agricultural Statistics

	Sown area			**Season-wise Crop Area**			**Irrigated Area**			
Block	*Net Area Sown*	*Area sown more than once*	*Total*	*Rabi*	*Kharif*	*Jayad*	*Net Irrigated*	*Gross Irrigated*	Cropping Intensity	Irrigation intensity
Morna	25300	9109	34409	8840	24267	1361	26567	33478	136	126

Table-2: Area Under Principal Crops

Rice (Kharif)		**Rice (Jayad)**		**Total Rice**		**Wheat**		**Sugarcane**	
Total	Irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigated
1055	1055	0	0	1055	1055	8840	8625	21258	21170

Table-3: Dynamic Ground Water Resource of Muzaffarnagar District, UP (as on 31.3.2013) (Ham)

Net Annual GW Availability	Gross Ground Water Draft for Irrigation	Existing Gross GW Draft for All Uses	Stage of Ground Water Development (%)
14660.08	5168.98	5545.05	37.82

Fig-6: Depth to Water Map

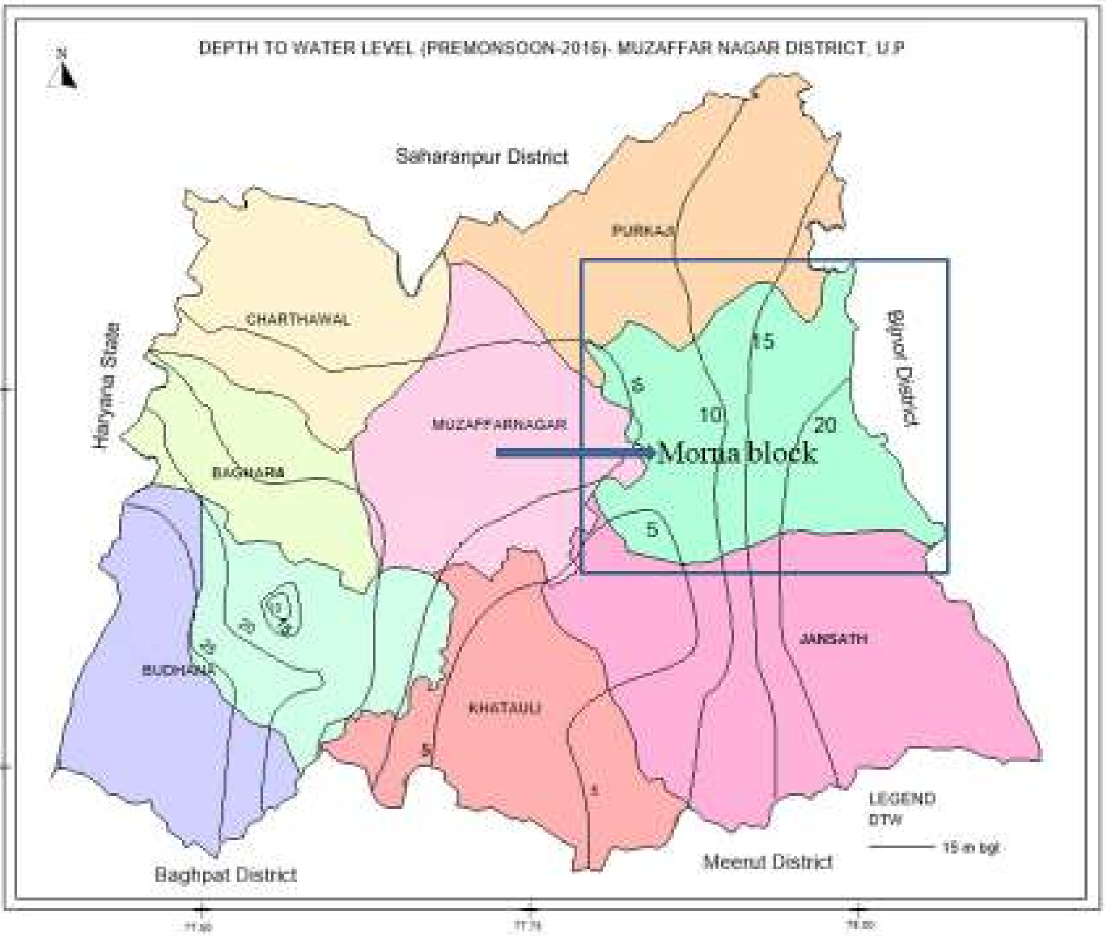
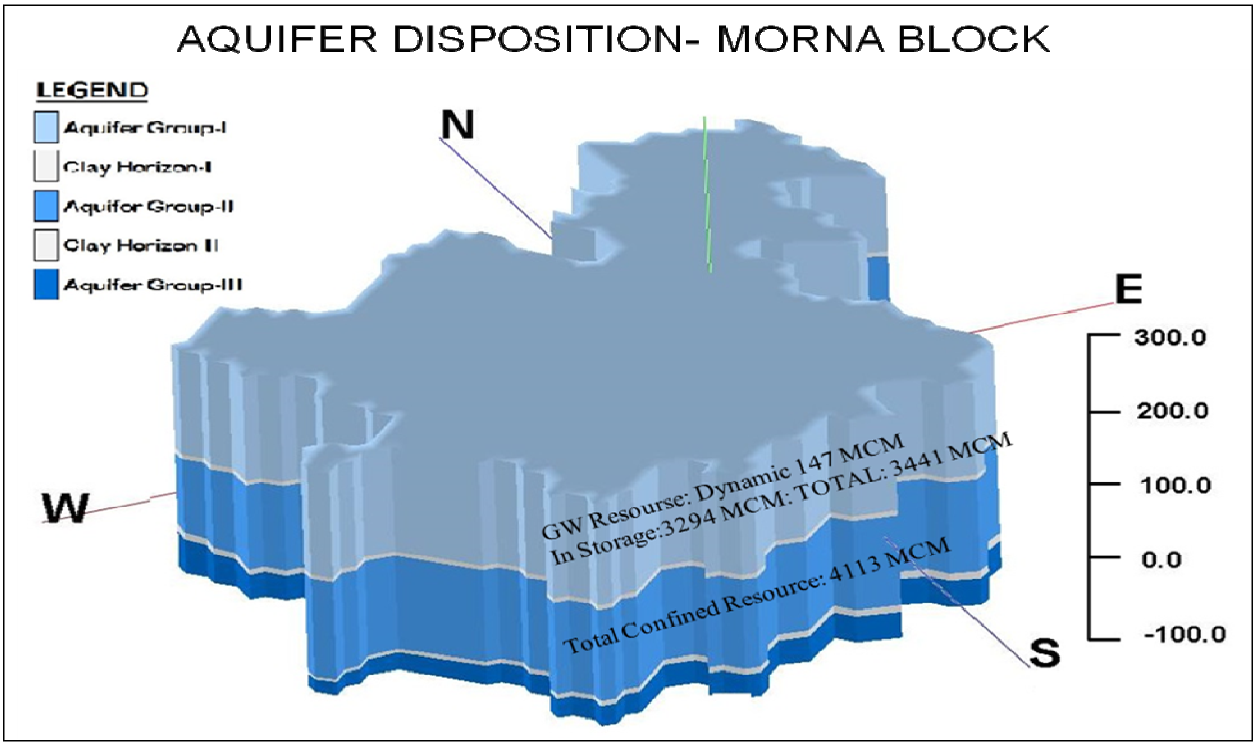


Fig- 7: 3-Dimensional Aquifer Disposition in Morna Block

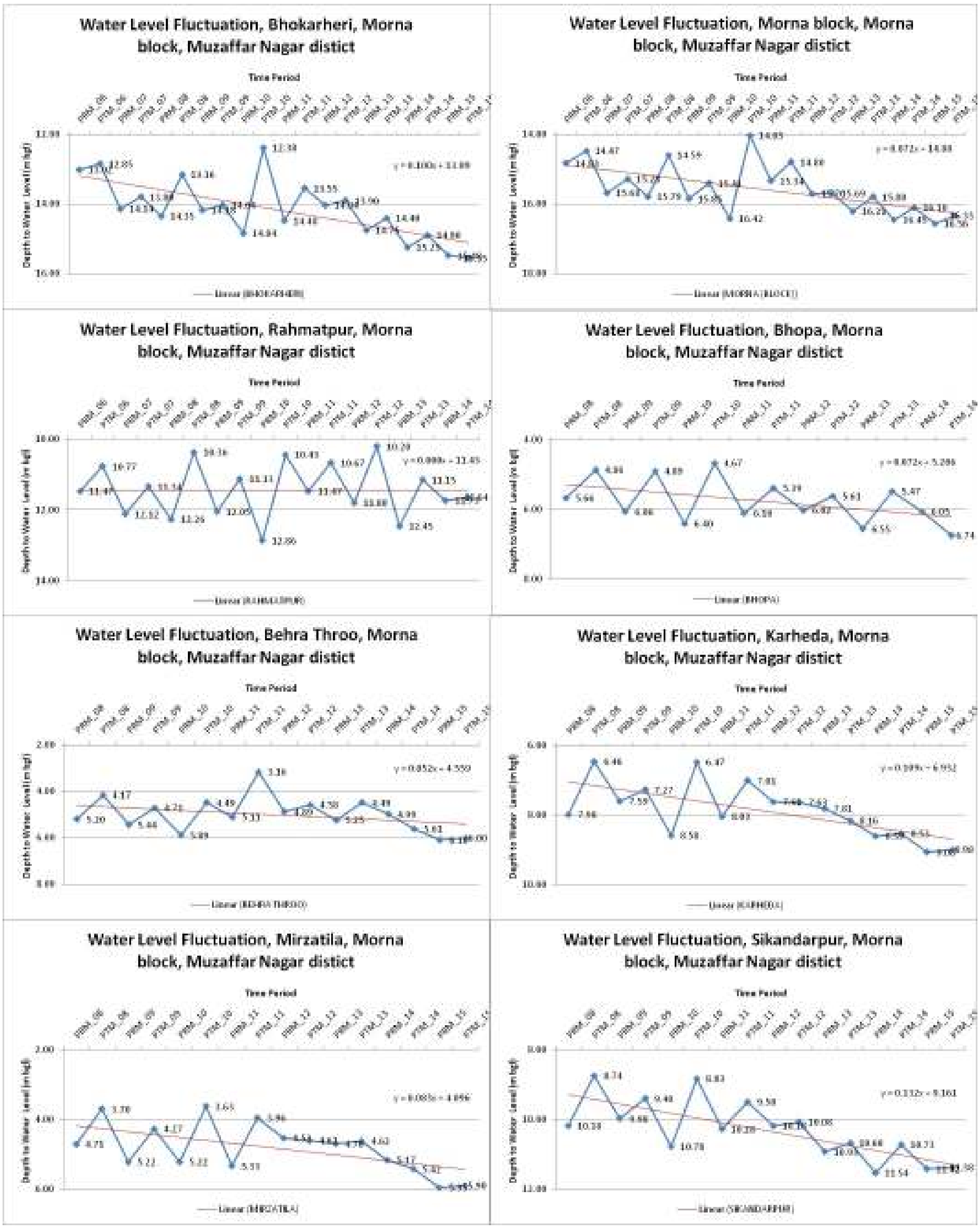


The Figures 6 & 7 give an overview of depth to water and 3-dimensional aquifer disposition in Morna block down to 300 m depth with dynamic & confined ground water resource.

13.3.0 GROUND WATER ISSUES:

The development of ground water is relatively low in Morna block and has been categorised as safe. The trend analysis of historical ground water level data of State GWD wells indicates long term feebly rising to feebly falling in most of the wells in the block.

Fig-8 Long term ground water level trend/fluctuation



Although there is good scope of ground water development in the area as the current category of the block is 'Safe' but the dominance of sugarcane cultivation in the area calls for simultaneous adoption of measures to increase recharge and reducing the draft.

13.4.0 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 following measures:

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

13.4.1 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.

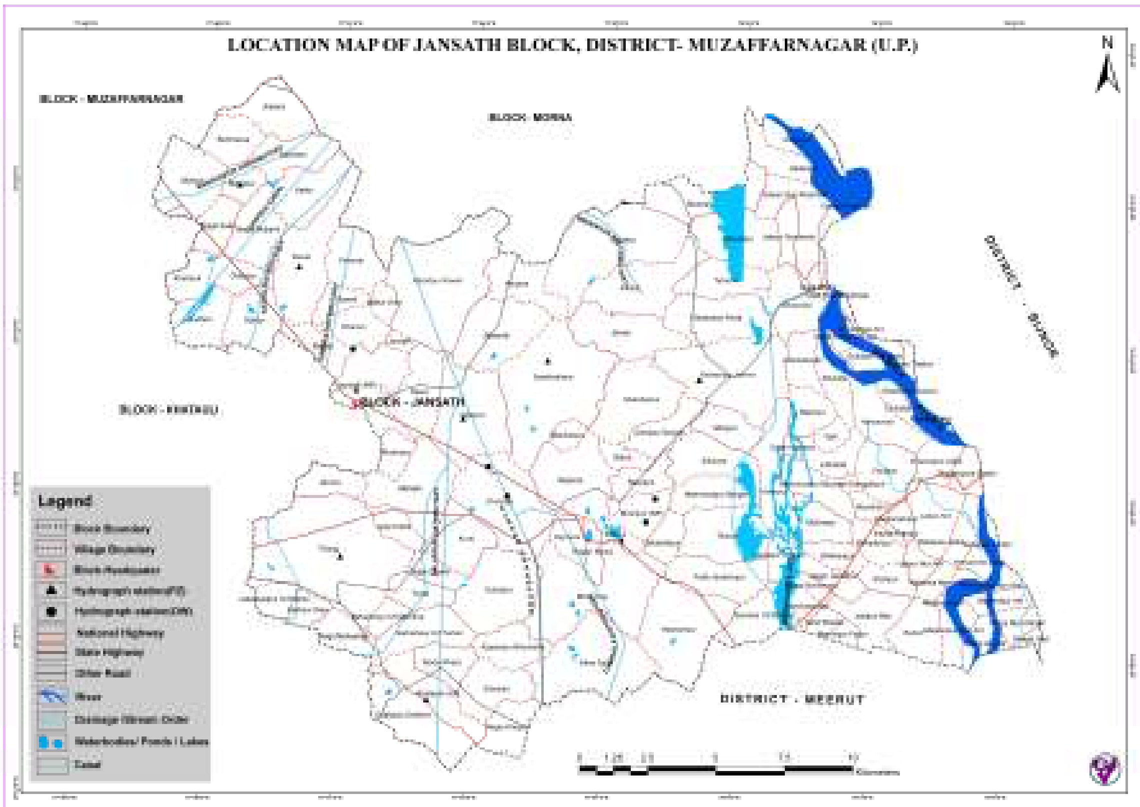
- Summer paddy and maize need to be avoided which are grown over substantial area in the block.
- Large scale adoption of rice-wheat rotation system & sugarcane cultivation is the main reason of over exploitation of groundwater. Late sown wheat/peas are replaced by spring maize which consumes more water. 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

14.0 GROUND WATER MANAGEMENT IN SAFE JANSATH BLOCK

14.1.0 INTRODUCTION:

Jansath block lies in the southeastern part of the Muzaffarnagar district encompassing an area of 481.04 Sq Km. It is flanked by Khatauli & Morna blocks in the West and North respectively and Bijnor district in the east separated by Ganga River (Fig-1).

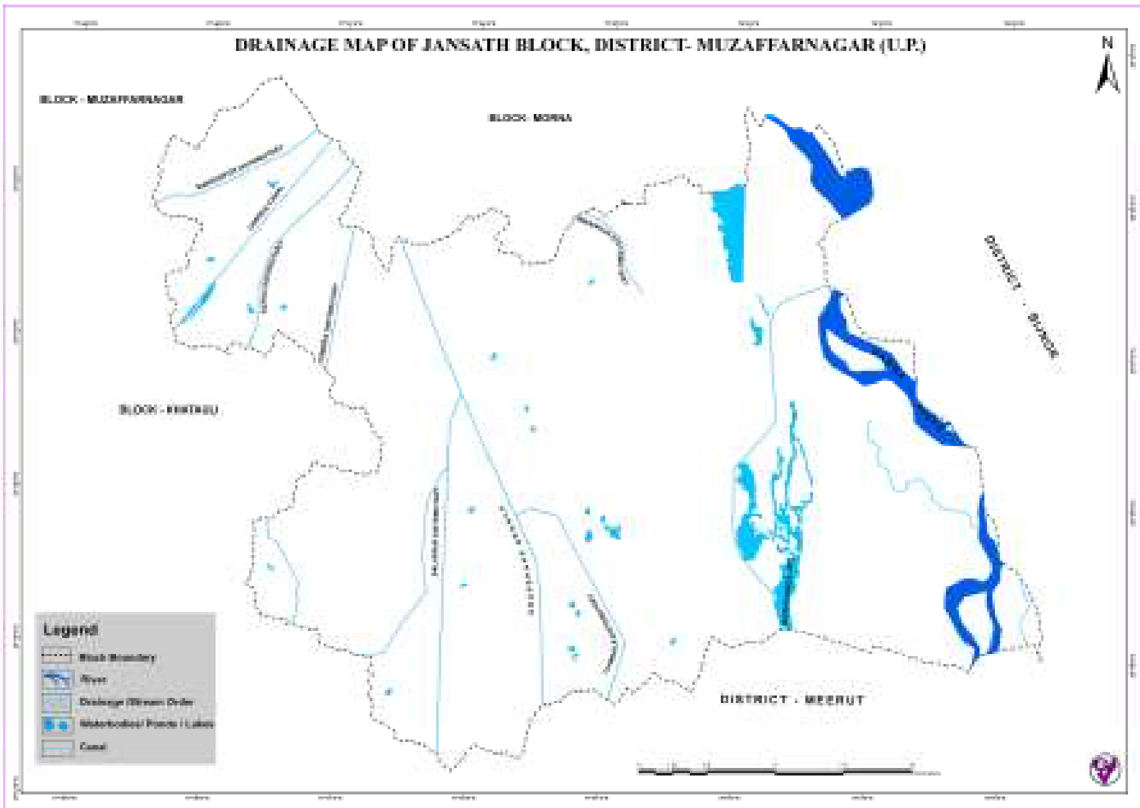
Fig-1



14.1.1 Drainage:

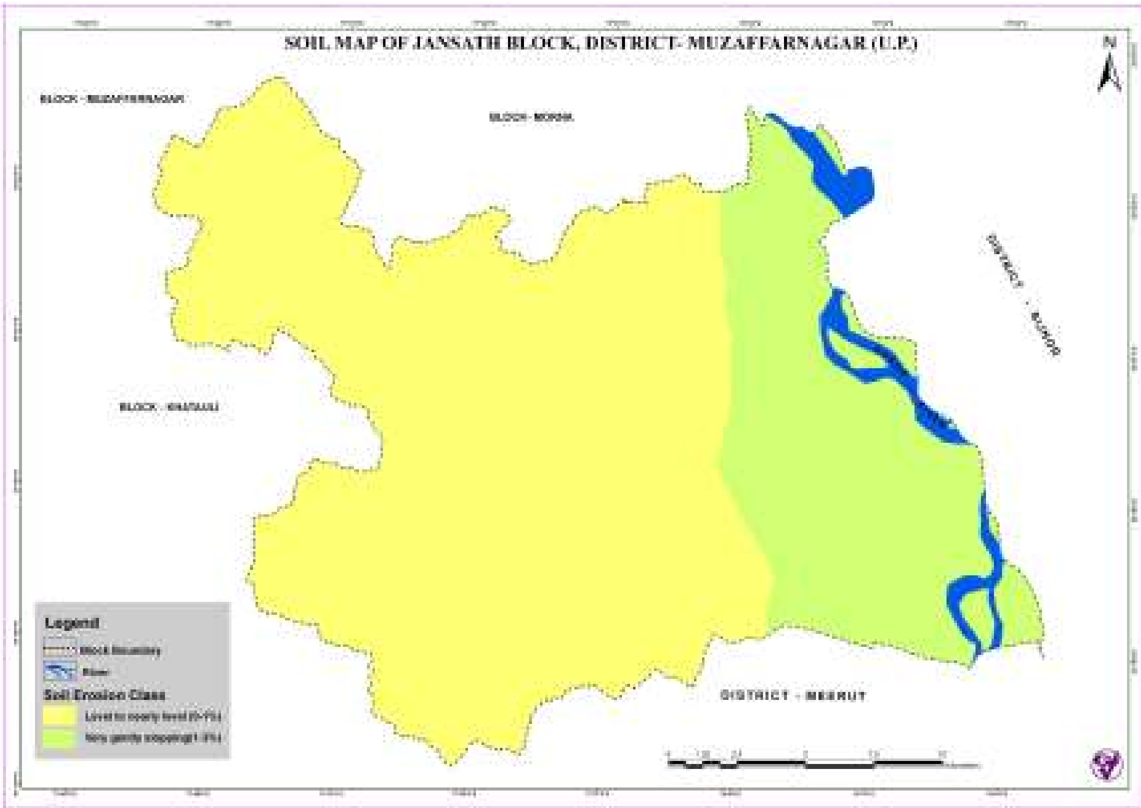
The bock is drained by Ganga River that follows the eastern boundary of the block. The block has well developed canal network (Fig-2).

Fig-2



14.1.2 Soil:

Fig-3



14.2.0 GEOLOGY:

Fig-4

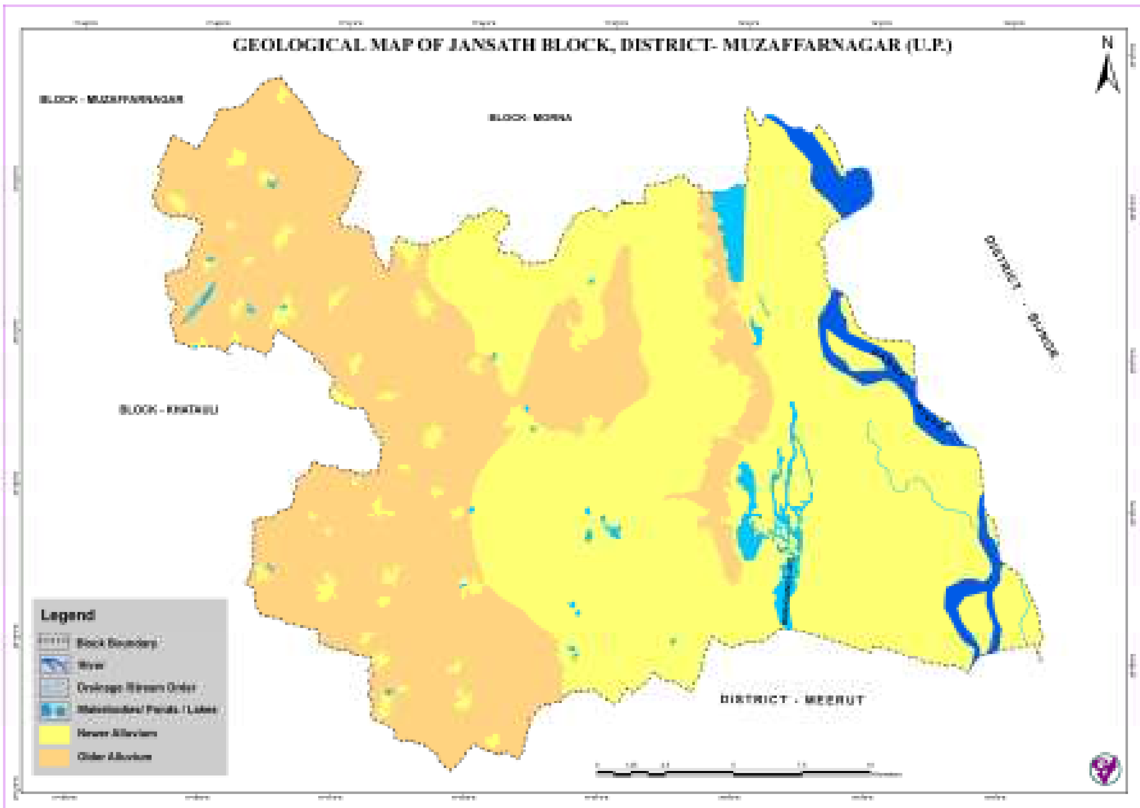
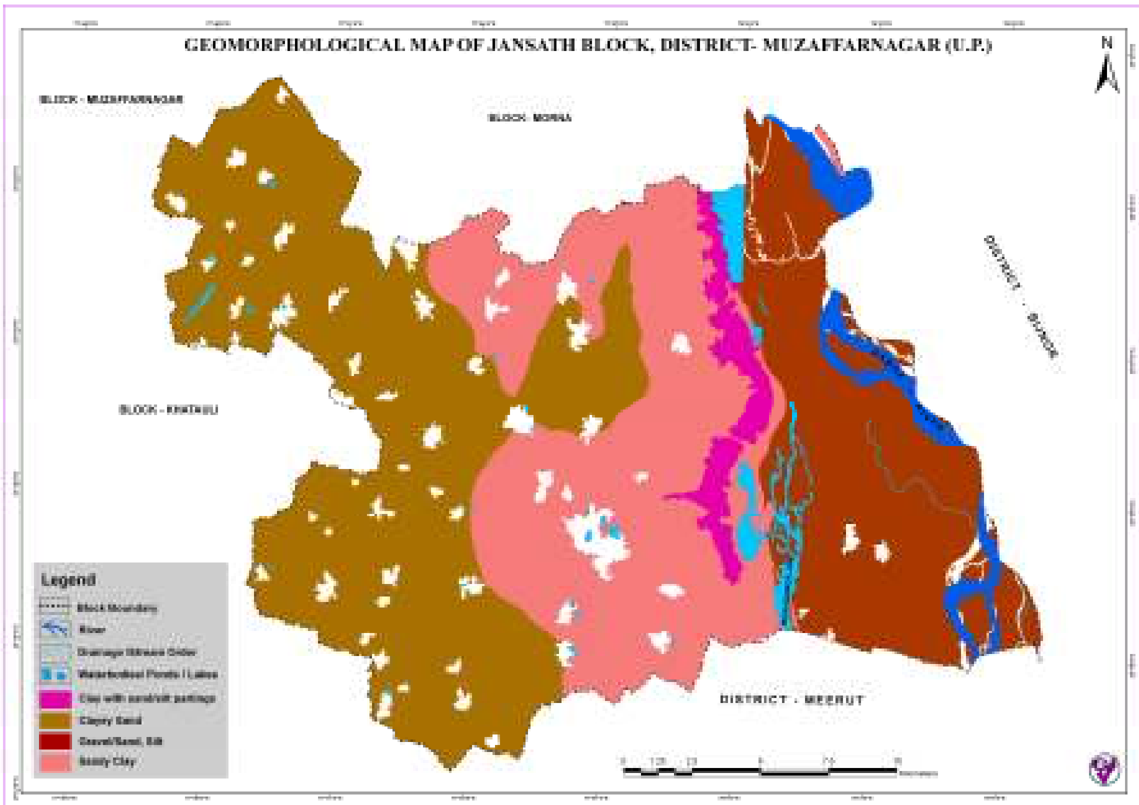


Fig-5



The soils of the block are formed by the transport of silt carried by the two rivers, Ganga and Yamuna. The soils are composed of Pleistocene and sub-recent alluvial sediments transported and deposited by river action from the Himalayan region. Soils are predominantly coarse loamy calcareous, coarse loamy & sandy coarse loamy (Fig-3).

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 and show quick alteration from finer to coarser at places. 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 (Fig-4).

Geomorphologically the block virtually forms a flat terrain forming a part of Ganga Plains. There are patches of saline and alkaline lands called “Bhur” areas mostly along the bank of Yamuna, Ganga and the bank of upper Ganges canal. The stretches of low land along these rivers are called “khadars”. The khadar of Ganges differs from that of Yamuna, in not having wide stretches of settled countries and in having a better clay deposit (Fig-5).

(Figures in Ha.)

Table-1: Agricultural Statistics

Block	**Sown area**			**Season-wise Crop Area**			**Irrigated Area**			
	Net Area Sown	*Area sown more than once*	*Total*	*Rabi*	*Kharif*	*Jayad*	*Net Irrigated*	*Gross Irrigated*	Cropping Intensity	Irrigation intensity
Jansath	32353	10272	42625	10896	29484	2077	27169	45552	132	168

Table-2: Area Under Principal Crops

Rice (Kharif)		**Rice (Jayad)**		**Total Rice**		**Wheat**		**Sugarcane**	
Total	Irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigated
1720	1720	56	56	1776	1776	8935	8906	23867	23726

Table-3: Dynamic Ground Water Resource of Muzaffarnagar District, UP (as on 31.3.2013)

(Ham)

Net Annual GW Availability	Gross Ground Water Draft for Irrigation	Existing Gross GW Draft for All Uses	Stage of Ground Water Development (%)
21683.25	9365.25	9907.02	45.69

Fig-6: Depth to Water Map

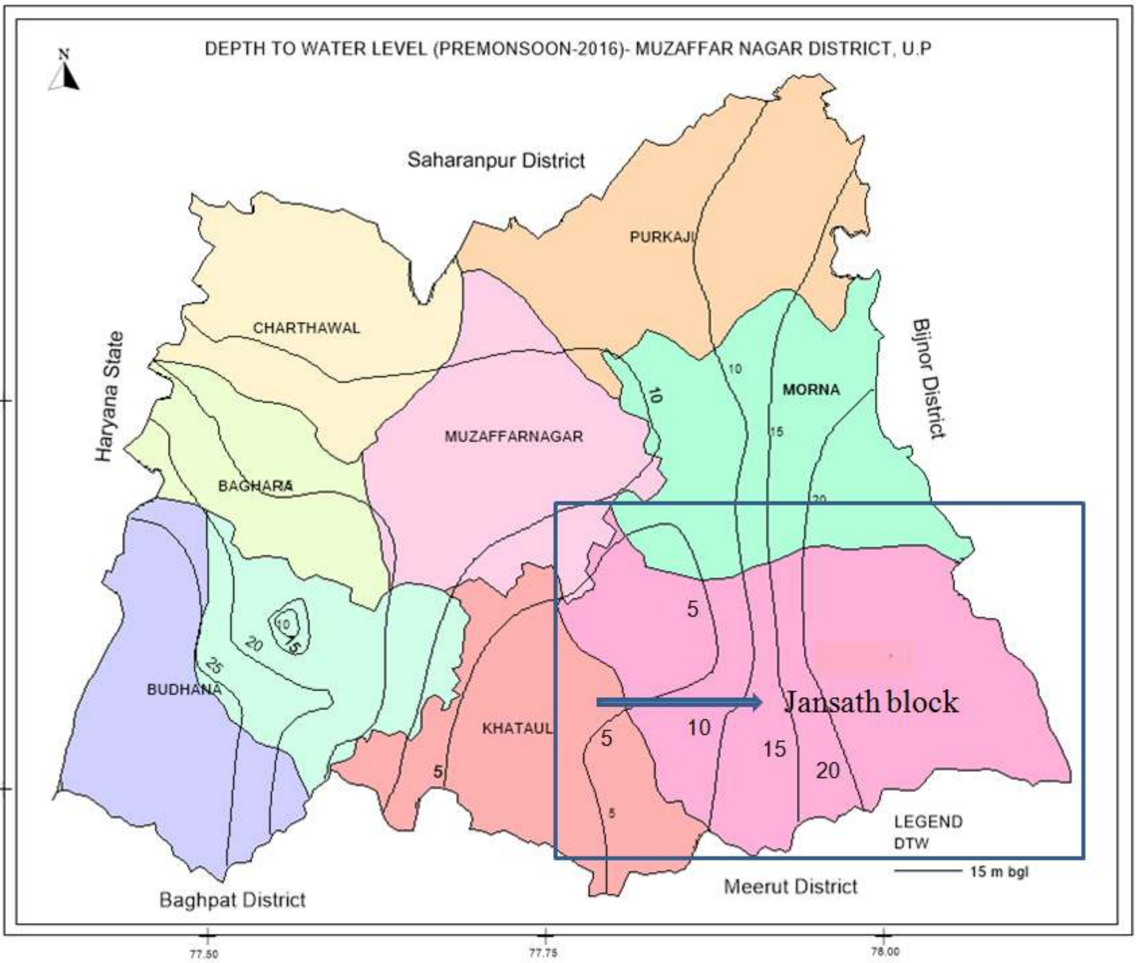
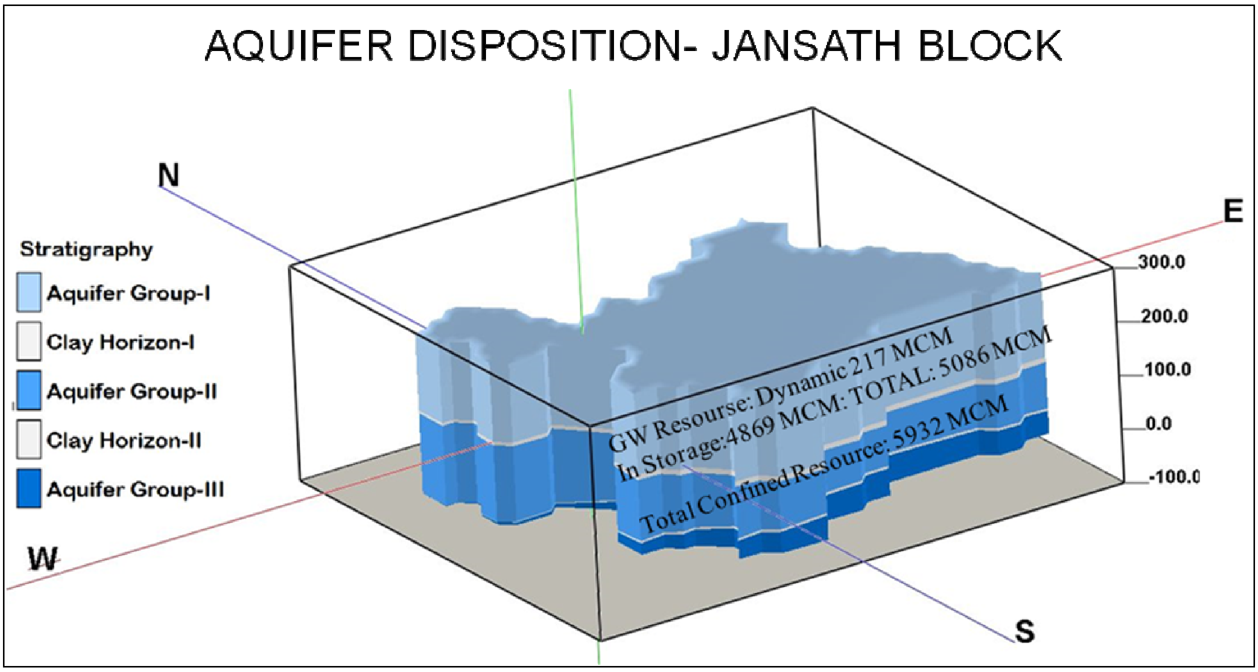


Fig- 7: 3-Dimensional Aquifer Disposition in Jansath Block

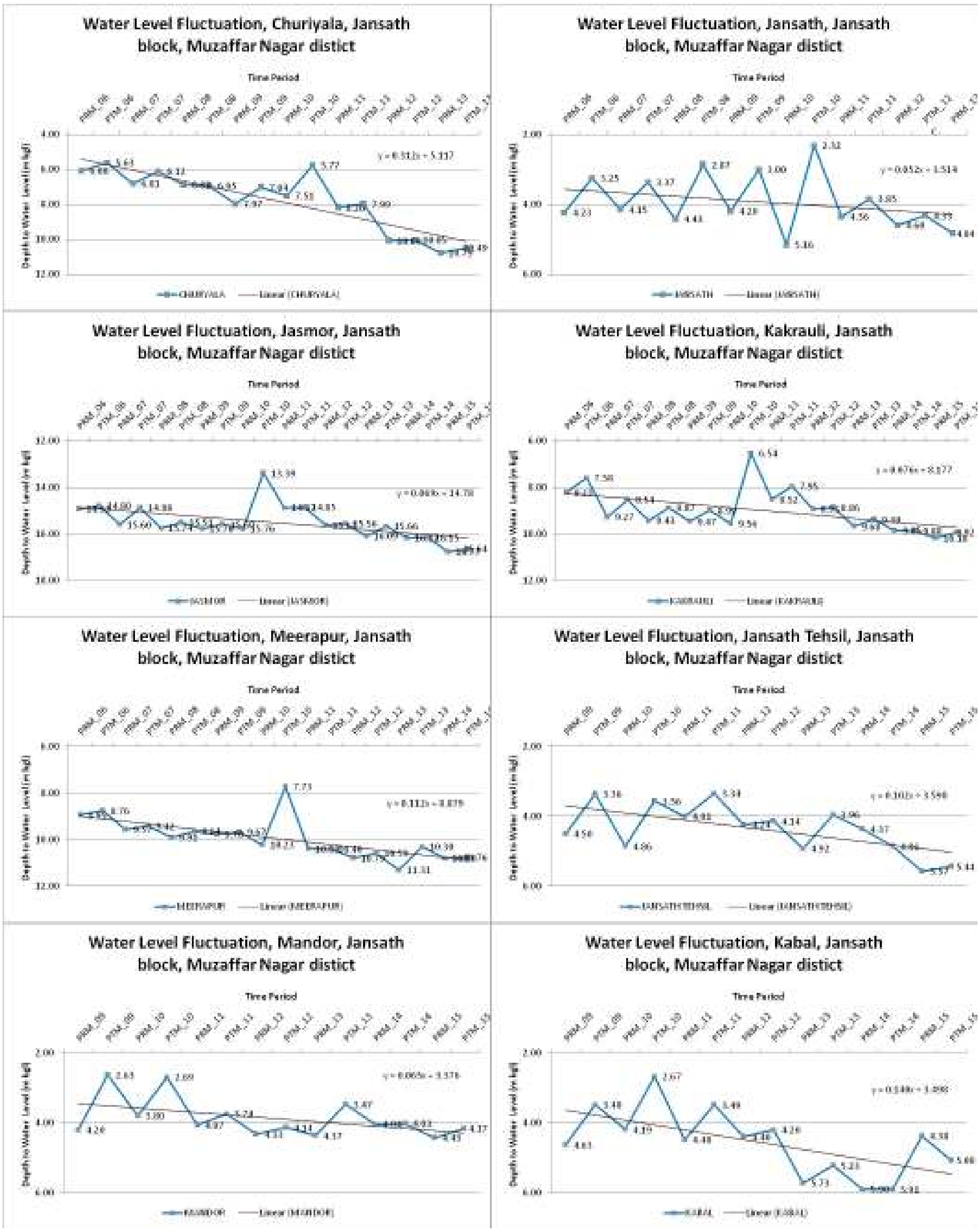


The Figures 6 & 7 give an overview of depth to water and 3-dimensional aquifer disposition in Jansath block down to 300 m depth with dynamic & confined ground water resource.

14.3.0 GROUND WATER ISSUES:

The development of ground water is relatively low in Jansath block and has been categorised as safe. The trend analysis of historical ground water level data of State GWD wells indicates long term feebly rising to feebly falling in most of the wells in the block.

Fig-8 Long term ground water level trend/fluctuation



Although there is good scope of ground water development in the area as the current category of the block is 'Safe' but the dominance of sugarcane cultivation in the area calls for simultaneous adoption of measures to increase recharge and reducing the draft.

14.4.0 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 following measures:

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

14.4.1 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.

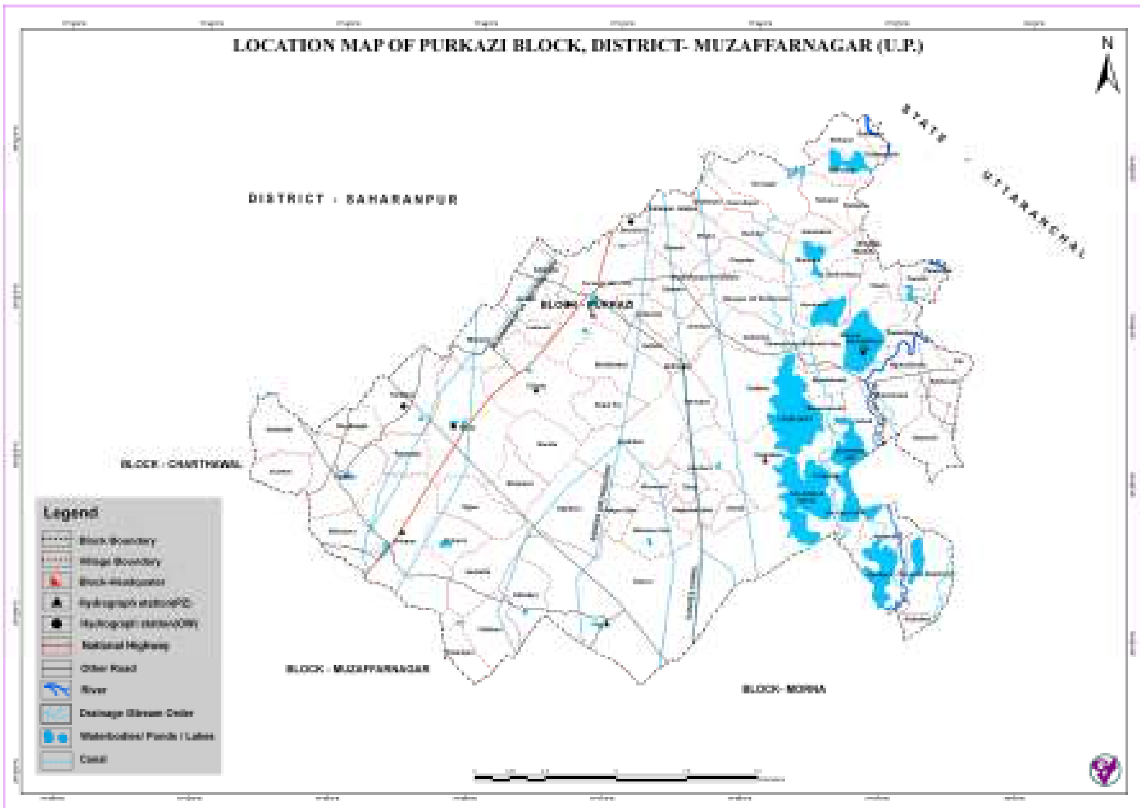
- Summer paddy and maize need to be avoided which are grown over substantial area in the block.
- Large scale adoption of rice-wheat rotation system & sugarcane cultivation is the main reason of over exploitation of groundwater. Late sown wheat/peas are replaced by spring maize which consumes more water. 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

15.0 GROUND WATER MANAGEMENT IN SAFE PURQAZI BLOCK

15.1.0 INTRODUCTION:

Purqazi block lies in the Northeastern part of the Muzaffarnagar district encompassing an area of 288.80 Sq Km. It is flanked by Muzaffarnagar (Kukra Sadar) & Morna blocks in the southest and south respectively and Bijnor district in the east separated by Ganga River (Fig-1).

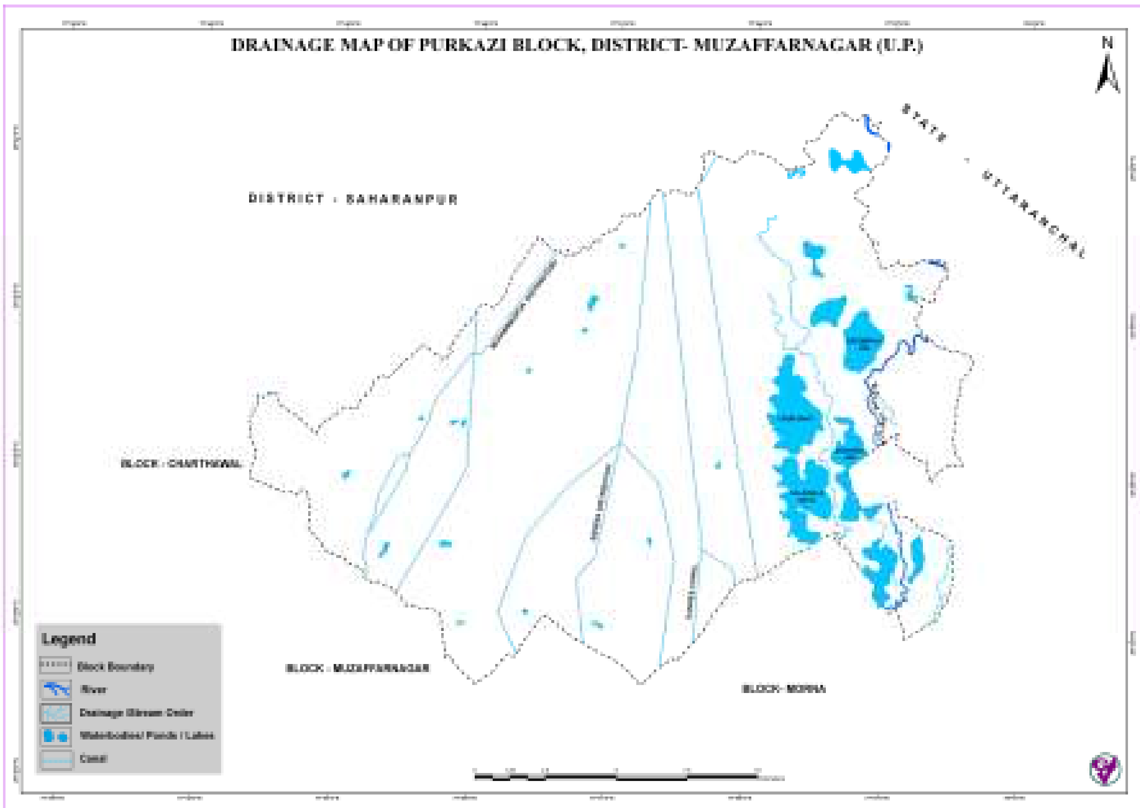
Fig-1



15.1.1 Drainage:

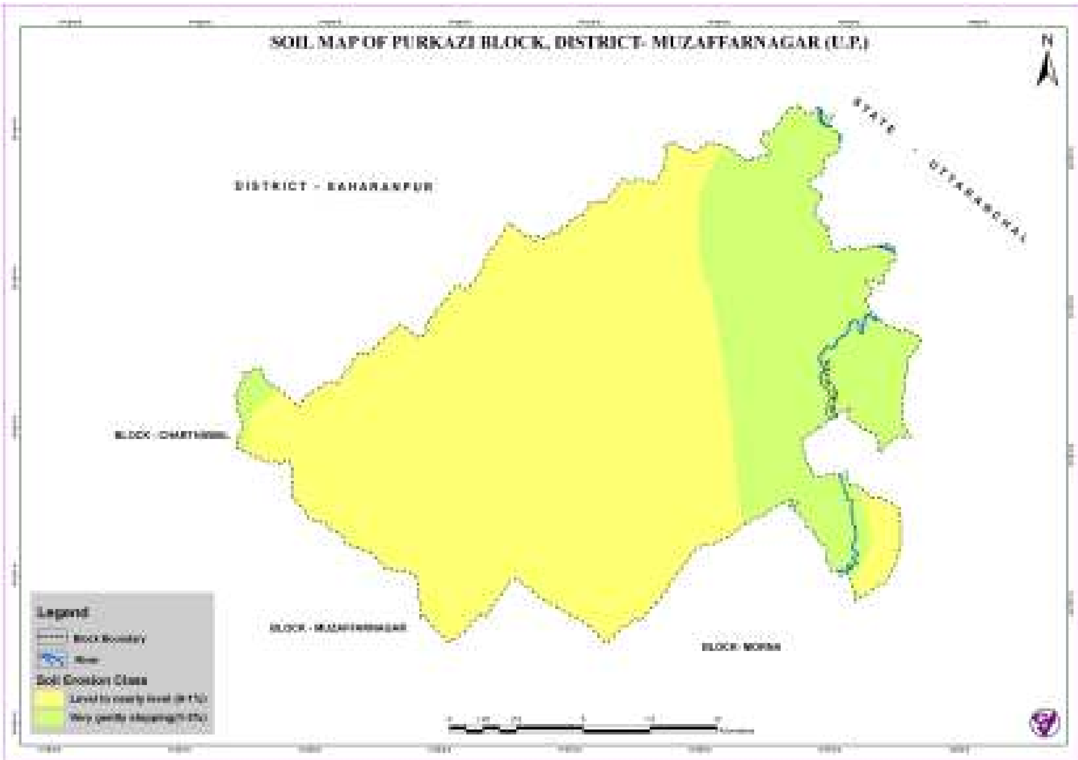
The bock is drained by Ganga River that follows the eastern boundary of the block.Salon River is tributary of Ganga in the north easter part. The block has well developed canal network (Fig-2).

Fig-2



15.1.2 Soil:

Fig-3



15.2.0 GEOLOGY:

Fig-4

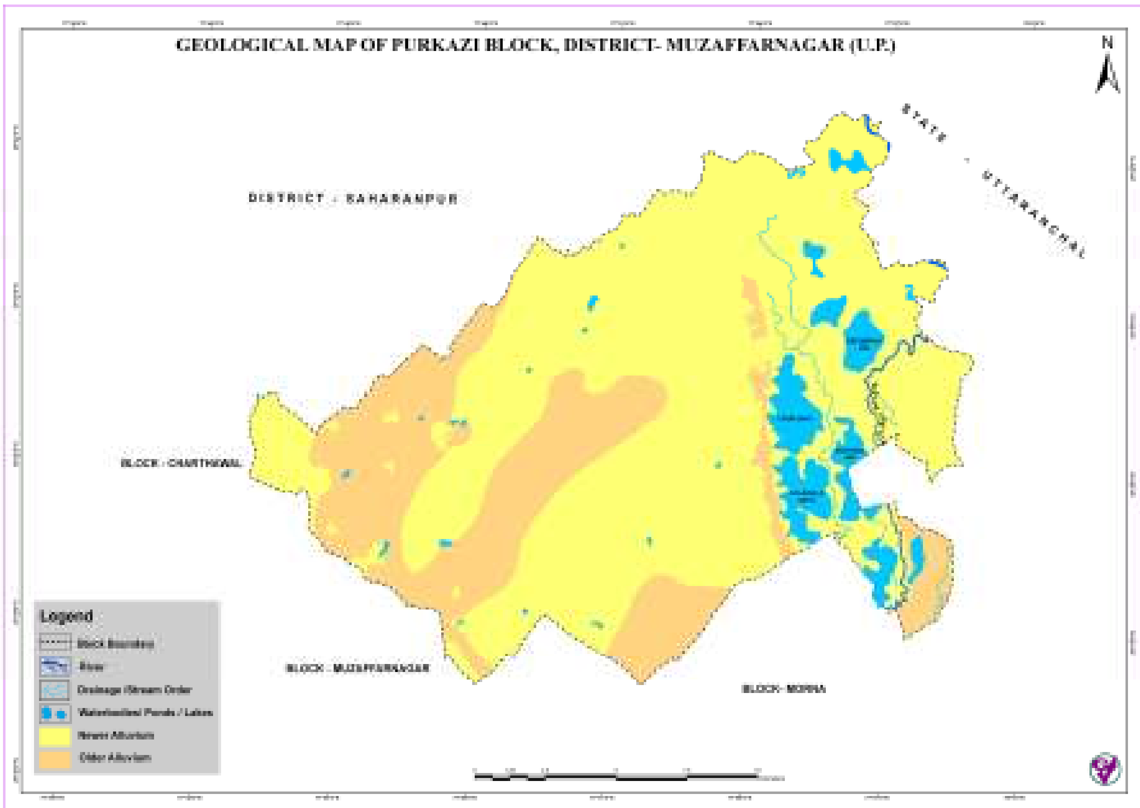
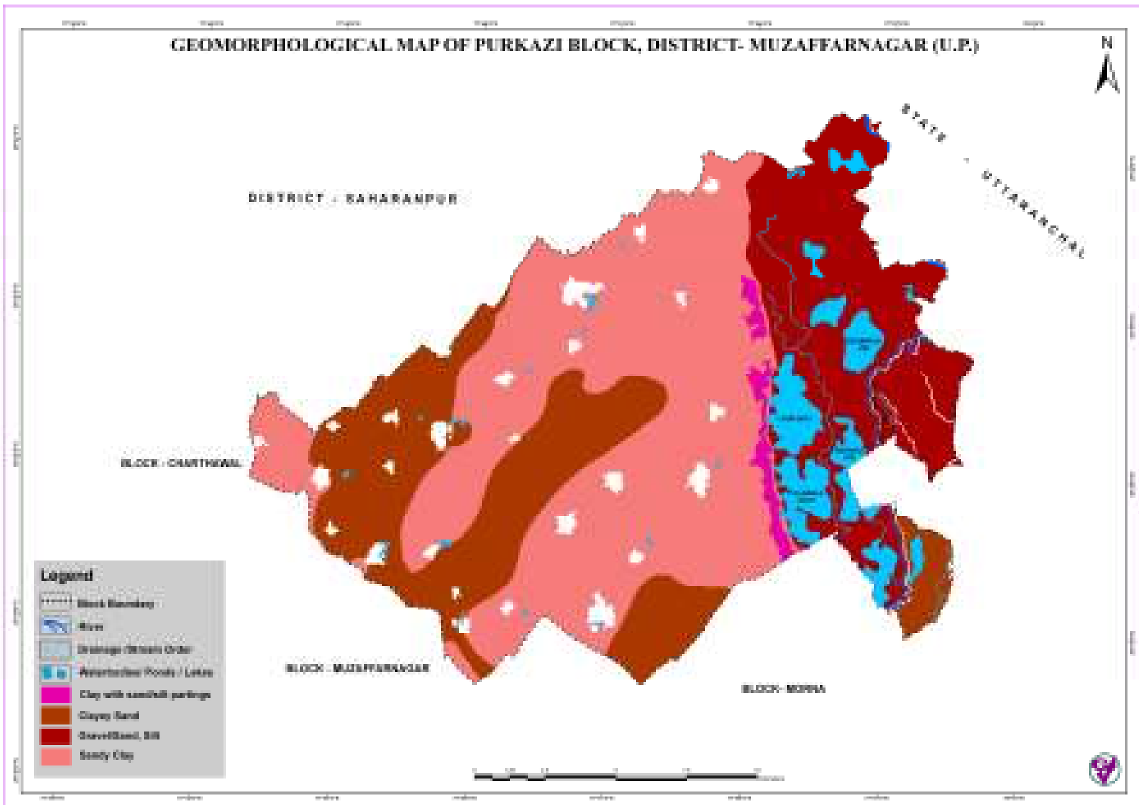


Fig-5



The soils of the block are formed by the transport of silt carried by the two rivers, Ganga and Yamuna. The soils are composed of Pleistocene and sub-recent alluvial sediments transported and deposited by river action from the Himalayan region. Soils are predominantly coarse loamy & fine silty (Fig-3).

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 and show quick alteration from finer to coarser at places. 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 (Fig-4).

Geomorphologically the block virtually forms a flat terrain forming a part of Ganga Plains. There are patches of saline and alkaline lands called “Bhur” areas mostly along the bank of Yamuna, Ganga and the bank of upper Ganges canal. The stretches of low land along these rivers are called “khadars”. The khadar of Ganges differs from that of Yamuna, in not having wide stretches of settled countries and in having a better clay deposit (Fig-5).

(Figures in Ha.)

Table-1: Agricultural Statistics										
	Sown area			**Season-wise Crop Area**			**Irrigated Area**			
Block	*Net Area Sown*	*Area sown more than once*	*Total*	*Rabi*	*Kharif*	*Jayad*	*Net Irrigated*	*Gross Irrigated*	Cropping Intensity	Irrigation intensity
Purqazi	22885	11470	34355	7637	25265	1420	21636	29172	150	135

Table-2: Area Under Principal Crops									
Rice (Kharif)		**Rice (Jayad)**		**Total Rice**		**Wheat**		**Sugarcane**	
Total	Irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigated	Total	Irrigated
1620	1620	40	40	1660	1660	8352	8352	15925	15652

Table-3: Dynamic Ground Water Resource of Muzaffarnagar District, UP (as on 31.3.2013) (Ham)			
Net Annual GW Availability	Gross Ground Water Draft for Irrigation	Existing Gross GW Draft for All Uses	Stage of Ground Water Development (%)
8990.39	5220.36	5722.89	63.66

Fig-6: Depth to Water Map

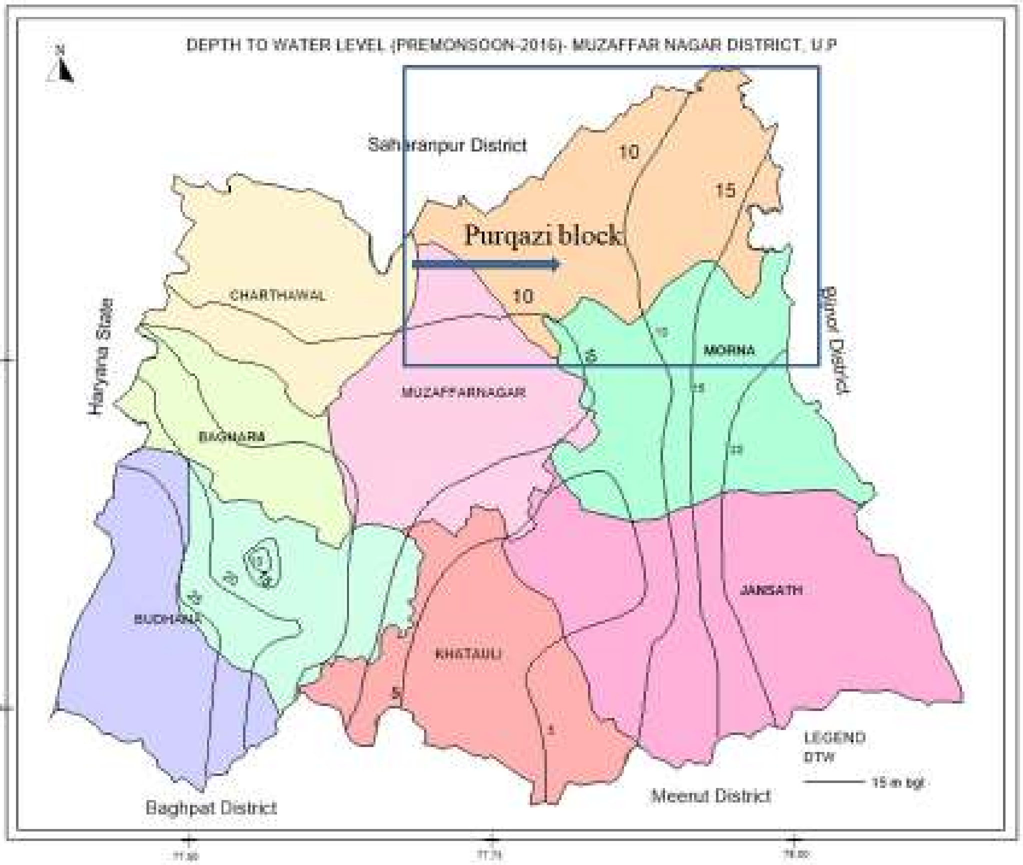
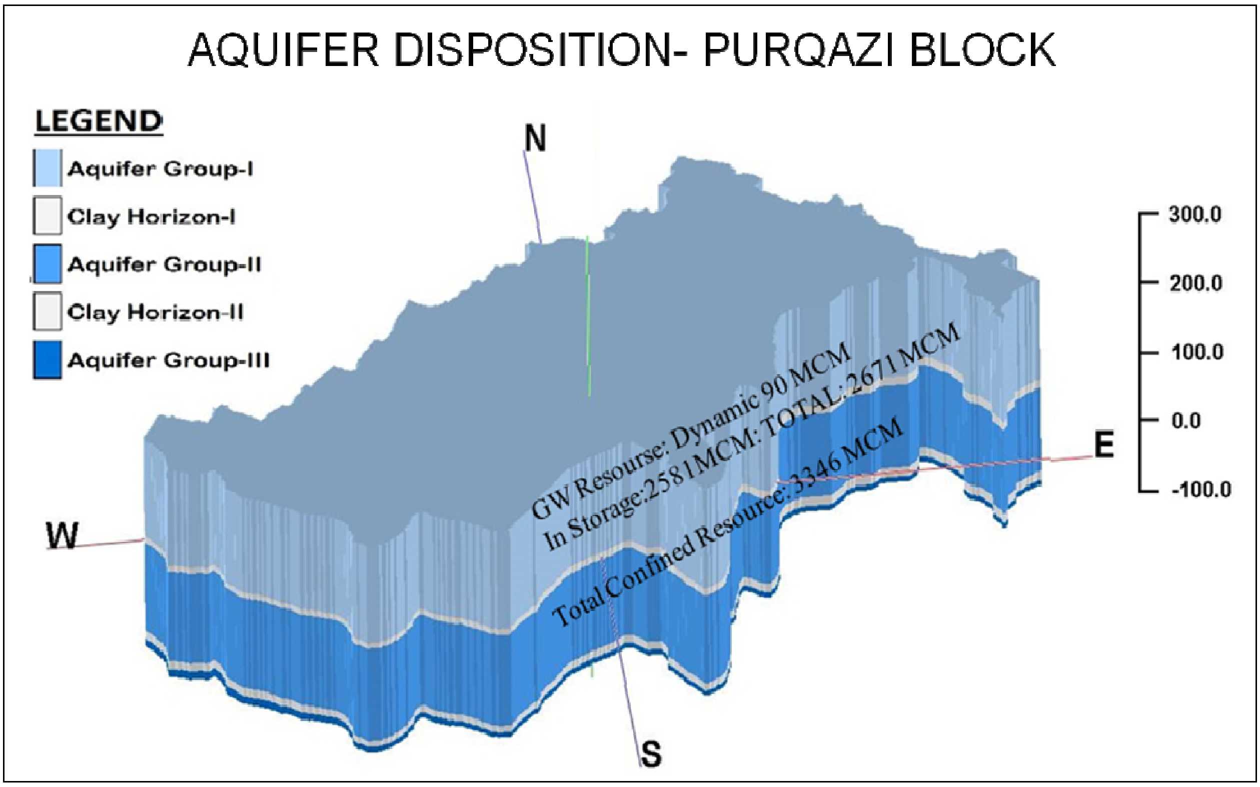


Fig-7: 3-Dimensional Aquifer Disposition in Purqazi Block

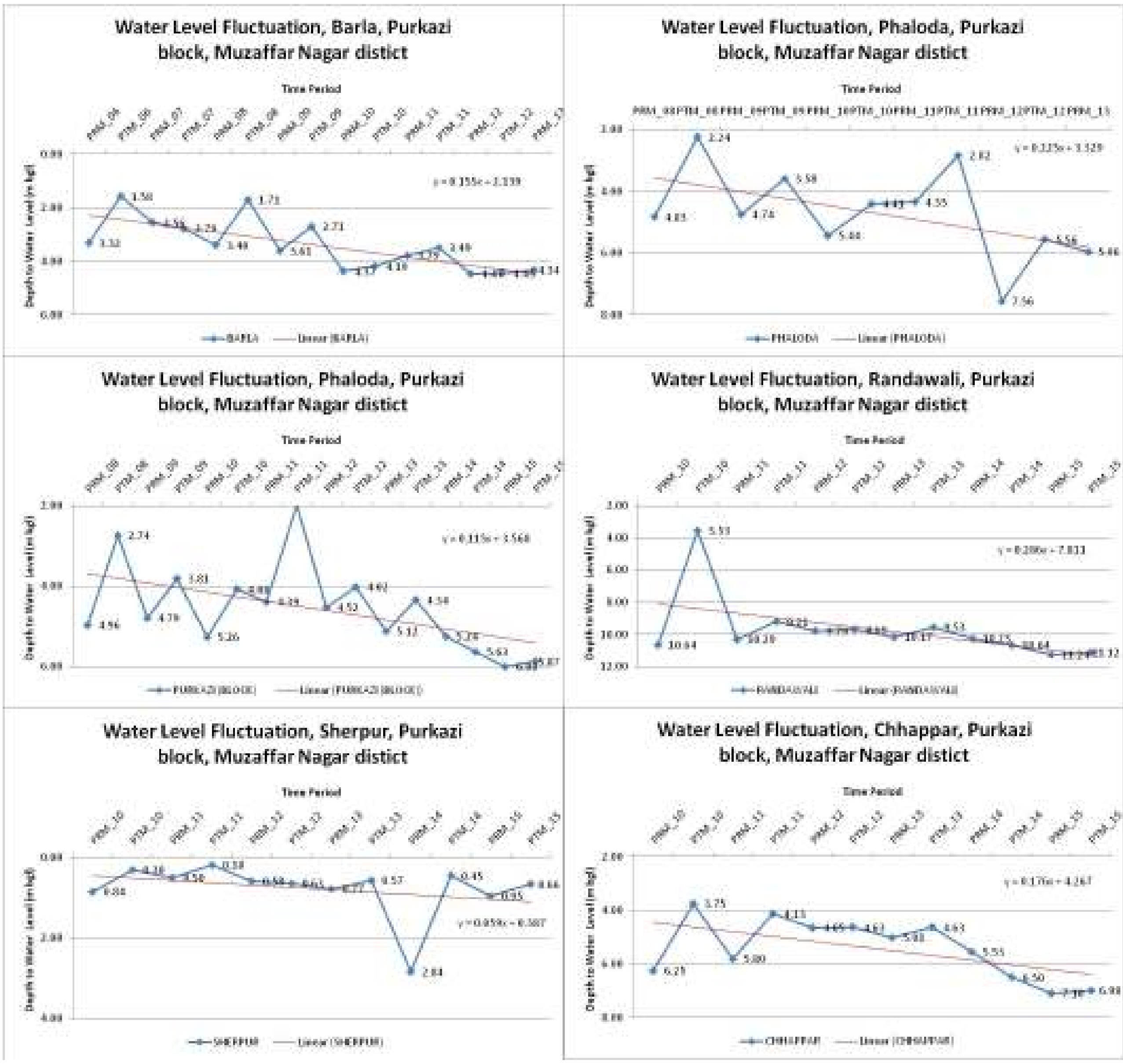


The Figures 6 & 7 give an overview of depth to water and 3-dimensional aquifer disposition in Purqazi block down to 300 m depth with dynamic & confined ground water resource.

15.3.0 GROUND WATER ISSUES:

The development of ground water is relatively low in Purqazi block and has been categorised as safe. The trend analysis of historical ground water level data State GWD wells indicates long term feebly rising to feebly falling in most of the wells in the block.

Fig-8: Long term ground water level trend/fluctuation



Although there is good scope of ground water development in the area as the current category of the block is ‘Safe’ but the dominance of sugarcane cultivation in the area calls for simultaneous adoption of measures to increase recharge and reducing the draft.

15.4.0 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 following measures:

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

15.4.1 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

16.0 CONCLUSION

1. Muzaffarnagar district, covering an area of 2958.08 sq. km lies in the northwest of Uttar Pradesh. For administrative purposes, the district has been sub-divided into 3-tehsils and 9- developmental blocks.
2. The district falls between Ganga in the east and Hindon Rivers in the west. The western half of the district occupies part of Yamuna basin and eastern part of the district occupies part of the Ganga basin.
3. The drainage pattern of the district is strictly governed by the two major rivers Ganga and Yamuna, which forms western boundary of the Shamli district. Both the rivers in their respective course flow more or less north to south. Major tributary of Ganga is Solani river and that of Yamuna is Hindon and Kali Nadi.
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 219517 ha, Net irrigated area is 216865 and Gross irrigated area is 314180 ha. Tubewell irrigation accounts for about 70% in the area.
6. The maximum canal irrigation is in the Khatauli block followed by Purkaji block whereas it is minimum in Budhana block.
7. The normal annual rainfall in the district is 869 mm. About 737 mm, 80% of rainfall takes places from June to September.
8. The entire Muzaffarnagar district is a flat terrain falling in middle Ganga plain. The highest point in the district is 222.00 m (amsl) in the north and the lowest 201.00 m (amsl) in the south, giving rise to an average slope of about 0.40 m/ km towards south.
9. Muzaffarnagar district is underlain by Quaternary alluvium deposited by Ganga and Yamuna river system. Lithologically the alluvial sediments comprise of sand, silt, clay and kankars in varying proportions.
10. Pre-monsoon Depth to water level varies from 3.43 to 16.84 mbgl and Post-monsoon Depth to water level varies from 2.60 to 17.10 mbgl. Long term water level trend in the past 10 years shows a fall of 5-54 cm/yr during pre monsoon and a fall of 14-66 cm/yr during post monsoon period.

11. Relatively deeper water are observed in the eastern as well as western part of the district whereas relatively shallower water levels are present in the central part of the district.

12. Groundwater flow direction is broadly North- Southwest in western part of the district whereas it is Northwest- Southeast in the eastern part of the district towards Ganga river. It shows that major river system in the district is perennial in nature.

13. Broadly Aquifer Group I extends down to around 160m, Aquifer Group II extends down to around 150-327m and Aquifer Group III extends down to 300-460m. At places, the layer separating different aquifer groups pinches out, making the two groups as one continuous aquifer system.

14. Transmissivity of aquifer varies from 857 – 2204 m2/day and Storativity 3.16×10-3. Discharge varies from 33 – 37 lps.

15. Sand percentage in the first aquifer system is on the higher side towards Ganga River in the eastern part of the district ranging between 75 and 85 % whereas sand percentage decreases progressively towards Yamuna river in the western part of the district ranging between 65 and 75%.

16. As in the case of first aquifer, the sand percentage in the second aquifer system also is on the higher side towards Ganga River in the eastern part of the district ranging between 75% and 85% whereas sand percentage decreases progressively towards Yamuna river in the western part of the district ranging between 50 and 70 %.

17. Isopachs of first aquifer system shows that thickness of the aquifer increases towards eastern part of the district towards Ganga river and decreases in western part of the district towards Hindon/Yamuna river.

18. Isopachs of Second aquifer system shows that thickness of the aquifer increases towards western part of the district towards Hindon/Yamuna river and decreases in eastern part of the district towards Ganga river.

19. The total ground water draft is 62,053.10 ham, which is being used in present for domestic, irrigation & industrial purposes against the ground water availability of 94377.07ham. Out of 9 blocks, three blocks falls under over exploited category which are Baghara, Budhna, Chathawal, and one block Shahpur under Critical and rest five blocks fall under Safe category. Overall stage of ground water development in the district is about 65%.

20. 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.

17.0 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. On farm activities are proposed in an area of 9600 hectare.
4. It is proposed to construct 11 Check dams of 10,000 cubic m. capacity and 120 nala bunds of 7,500 cubic meter capacity, to revive and renovate 430 ponds and development of 26 Km. stream channel.
5. 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 Muzaffarnagar district will substantially bring down stage of ground water development.
6. 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 about 61000 Ha. area of sugarcane cultivation in over-exploited and 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.

7. Although there is good scope of ground water development in 5-'Safe' blocks in the district but 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.
8. 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.
9. Agriculture department should promote to conserve the soil moisture by reducing ET losses through cultivation of 'Green Manure'.
10. Alternate cropping system having lower requirement of water should be encouraged in accordance to the irrigation water availability.
11. Furrow irrigation with raised bed planting in wide row crops should be practised.
12. Irrigation in checks in close row crops should be practised.
13. Drip irrigation (fertigation) in sugarcane and other wide row crops should be practised with mulch in the area.
14. Multiuse of water through integrated farming system.
15. Conjunctive use of surface and groundwater should be encouraged in the district.
16. 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.
17. 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.
18. 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.

18.0 ACKNOWLEDGEMENTS

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