

Groundwater Sustainability versus Urbanization: A Case Study from Haryana

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Abstract : The depletion of ground water table in Gurgaon and it's a neighboring district is going down in unsustainable manner, that leads water scarcity conditions in the district for various sectors. The average annual rainfall in the district is about 550 mm and not able to recharge the depleted ground water level which is occurring with high pace due to population increase and rapid urbanization pressure. Moreover the land contributing for groundwater recharge is also reducing due to increase in urban built-up areas. The total annual ground water availability of the district is 2.02×10^4 hms and existing overall stage of ground water development in the block is of the order of 209% which has exceeded the available recharge. This is the reason the district has been categorized as over exploited region as per the availability of the groundwater is concern. Sustainable utilization of ground water holds the key to counter the problem of declining water table. An attempt has been made in this paper to highlight the prevailing ground water scenario and the need for scientific management of this vital resource. Optimal utilization of ground water through properly designed abstraction structures constructed at suitable location can mitigate the problems of water scarcity faced during summer season in various part of the districe. Rainwater harvesting, proper run off management measures and optimal ground water conservation practices will be helpful for eradicating the problem of declining water table in the district.

Keywords: Sustainability, Ground Water Depletion, Urbanization, Fluctuation of Groundwater table, Ground Water Balance, GIS and RS technologies, Optimizations

INTRODUCTION

Gurgaon, one of the southern districts of Haryana has been declared a 'dark zone' for its gradually decreasing level of ground water. Since the surface water potential is not promising in the district, there is increased dependence on ground water for meeting the agricultural, domestic and industrial requirements resulting in depletion of ground water resources in the district. The district has seen a sharp decline in ground water table by four to six feet per year (2006 – 2008). Located between the East longitudes of $74^{\circ}27'00''$ and $77^{\circ}35'00''$ and North latitudes of $21^{\circ}39'00''$ and $30^{\circ}55'00''$, the district is having a geographical area of 1254 Sq. Km. The share of rural population is 64.42% of the total population and agriculture is the predominant occupation of the majority of the people in Gurgaon district. 92.4% of the net sown area is irrigated in the district. The main

source of the irrigation is tube-well, which irrigates about 96.8% of the total irrigated area. Indiscriminate use of underground water has depleted the ground water to the level of over exploited category. The ground water balance as on 2004 shows that there is no scope of further development in the district. Optimal utilization of ground water resources will be able to mitigate the depleted water level in the district.

HYDROGEOLOGY

The major part of Gurgaon district is underlain by Quaternary alluvium consisting of sand, clay and silt. The quartzite ridge trending NNE-SSW is located about 7 Km east of town in which ground water occurs in fractures, joints and crevices. Sandy layers at various depths from major water bearing horizons above the crystalline basement. Ground water in the block occurs in unconfined and semi-confined condition. The upper zone of

saturation consists of fine sand with silt varying from place to place. In Udyog Vihar and city area the depth of first aquifer varies from 34 to 43m below ground level. However in industrial area of Manesar top most aquifer can be encountered at 20 m. The thickness of sandy layer is very limited. The drawdown is generally high indicating absence of highly potential ground water bearing aquifers. Tube-wells in the depth range of 45 to 90 m below ground level have been installed by different agencies in the block. The yield of these tube-wells varies in different areas ranging within 129 to 606 lpm. Some of the tube-wells and

agencies are given below.

The water table generally follows the topography of the area. Geothermal springs exist in and around Sohna. The alluvium sediments consist of fine to medium sand, clay and kankar. The clay and sand belts are mostly mixed up with kankar. These sediments rest upon the basement of the block of Delhi system. The thickness of alluvium is different depth range of 0-30, 31-60, 61-90, 91-120 m for all the blocks of the district is given in the Table No.1 below and Figure No.1 below shows the area under study.

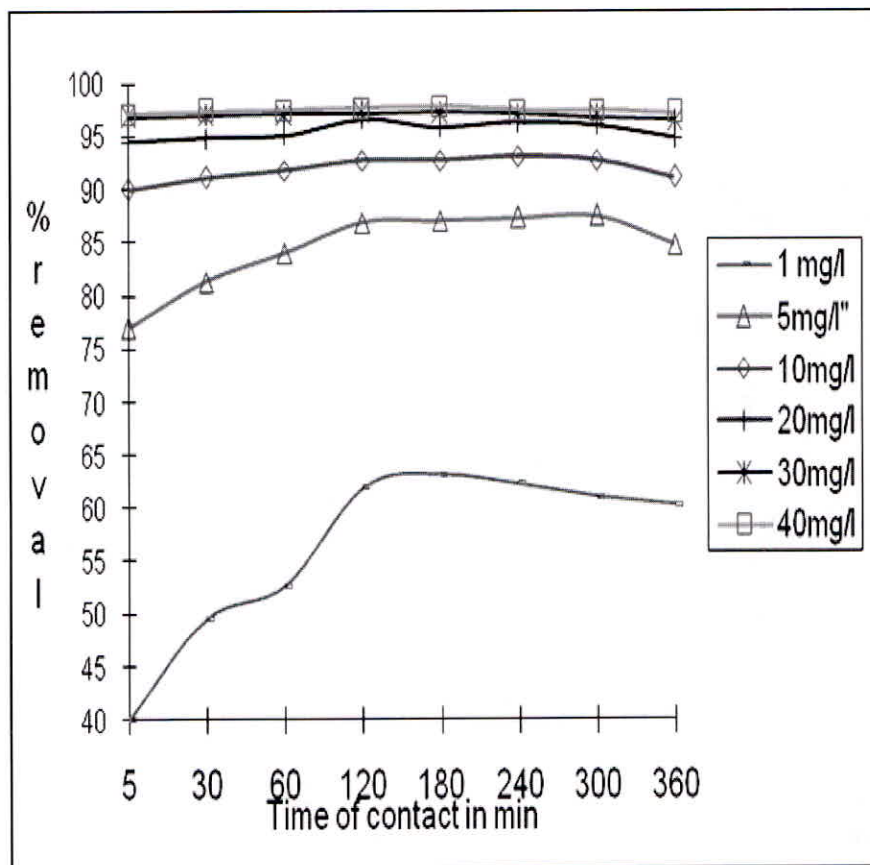


Fig. 1. Map of the area under study

Table.1. Block wise & zone wise Area of Depth of Water as on October 2008 of District Gurgaon

SNo.	Name of Block	Area in Sq. Km.				Depth Zones (m) (Area in Sq. Km)													
		Geographical	Out Crop	Net	%	0-1.5	%	1.5-3	%	3-10	%	10-20	%	20-30	%	30-40	%	Ab. 40	%
1	Gurgaon	354.62	12.88	314.74	96	2.18	1	6.55	2	29.25	8	99.63	28	110.30	31	53.75	15	40.08	11
2	Farukh Nagar	280.09	0.31	279.78	100	-	-	-	-	26.15	9	161.70	58	91.93	33	-	-	-	-
3	Pataudi	275.61	0.45	275.16	100	-	-	-	-	-	-	-	-	216.36	79	58.75	21	-	-
4	Sohna	339.01	24.25	314.76	93	-	-	-	-	32.68	10	127.85	38	145.81	43	8.42	2	-	-
	Total	1249.33	37.89	1211.44	97	2.18	-	6.55	1	88.08	7	389.18	31	564.40	45	120.92	10	40.08	3

WATER TABLE FLUCTUATIONS

The fluctuation in the water table is of two types – the long term due to the development in ground water and short term (seasonal fluctuation) due to rainfall. At present the water level is monitored on 4 key observation wells and 4 piezometric tubes monthly and twice a year (pre and post monsoon period) on 59 grid wells. The long term fluctuation in water level from June 1974 to June 2008 and October 1974 to October 2008 has been calculated and is shown in tables given below. It is observed from the statements that there is a decline in water level in all the blocks of the district. The highest decline during June 1974 to June 2008 is reported

in Pataudi block (20.53 mts.). The reason behind is that the density of M.I. Units is higher in Pataudi block (20 M.I. Units Per Sq. Km.). The average annual decline in the district for the above said period is 0.41 mtr. The water level fluctuation during June 1974 to June 2008 and October 1974 to October 2008 is also shown in the map tables. The short term (seasonal) fluctuation in water level of Gurgaon district have been studied for the period June and October 2008 and is given in the table below. It is clear from the table that there is a rise in water table in Sohna and Pataudi blocks & there is decline in water table in post monsoon in Gurgaon & Farukh Nagar blocks.

Table 2. Geological formation of Aquifers

% Distribution of Sand, Clay, Kankar at various depth in district Gurgaon													
S. No.	Name of Block	Depth											
		0-30 m			31-60 m			61-90 m			91-120 m		
		Sand	Dry	Kankar	Sand	Dry	Kankar	Sand	Dry	Kankar	Sand	Dry	Kankar
1	Gurgaon & Farukh Nagar	44.0	44.7	11.3	42.9	37.9	19.2	16.7	50.7	52.6	-	-	-
2	Pataudi	21.2	70.8	8.0	35.3	54.9	9.8	20.4	52.2	27.4	-	-	-
3	Sohna	27.8	47.2	25.0	16.0	60.1	23.9	0.0	79.3	20.7	-	-	-

DECLINE OF GROUND WATER LEVEL

DEPTH TO WATER TABLE

On the basis of grid well selected in the district (each well represents 20 Sq. Km) about 6% of the area lies in depth to water zone within 10 m below ground level during June 2008. This area includes northern part of Farukh Nagar and eastern part of Sohna block. About 36% area falls under 10 to 20 m water table range. About 50% area falls under the water table above 20 m below ground water

table during June 2008. The table showing block wise name of village falling under different water table during pre and post-monsoon period of the year 2008 is given below. The average water level of the district for June 2008 and October 2008 is 22.62 m and 22.67 m respectively.

GROUND WATER FLOW

In general, the water table contour follows the surface topography. The altitude of water table ranges between 176.78 to 274.85 m at msl. In north

Table 3. Statement Showing the Blockwise & Zone Wise Area of Depth to Water During June 2008 of Distt. Gurgaon

S. No.	Name of Block	Area in Sq. Km.				Depth Zones (m) (Area in Sq. Km)											
		Geographical	Out Crop	Net	%	1.5-3	%	3-10	%	10-20	%	20-30	%	30-40	%	40-50	%
1	Gurgaon	354.62	12.88	314.74	96	2.11	-	18.99	5	94.93	27	151.88	43	40.08	11	33.75	10
2	Farakh Nagar	280.09	0.31	279.78	100	-	-	19.08	7	155.04	55	150.14	38	-	-	-	-
3	Pataudi	275.61	0.45	275.16	100	-	-	-	-	-	-	216.20	78	58.96	22	-	-
4	Sohma	339.01	24.25	314.76	93	-	-	31.48	9	125.90	37	152.84	45	4.54	2	-	-
	Total	1249.33	37.89	1211.44	97	2.11	-	70.07	6	375.87	30	626.06	50	103.58	8	33.75	3

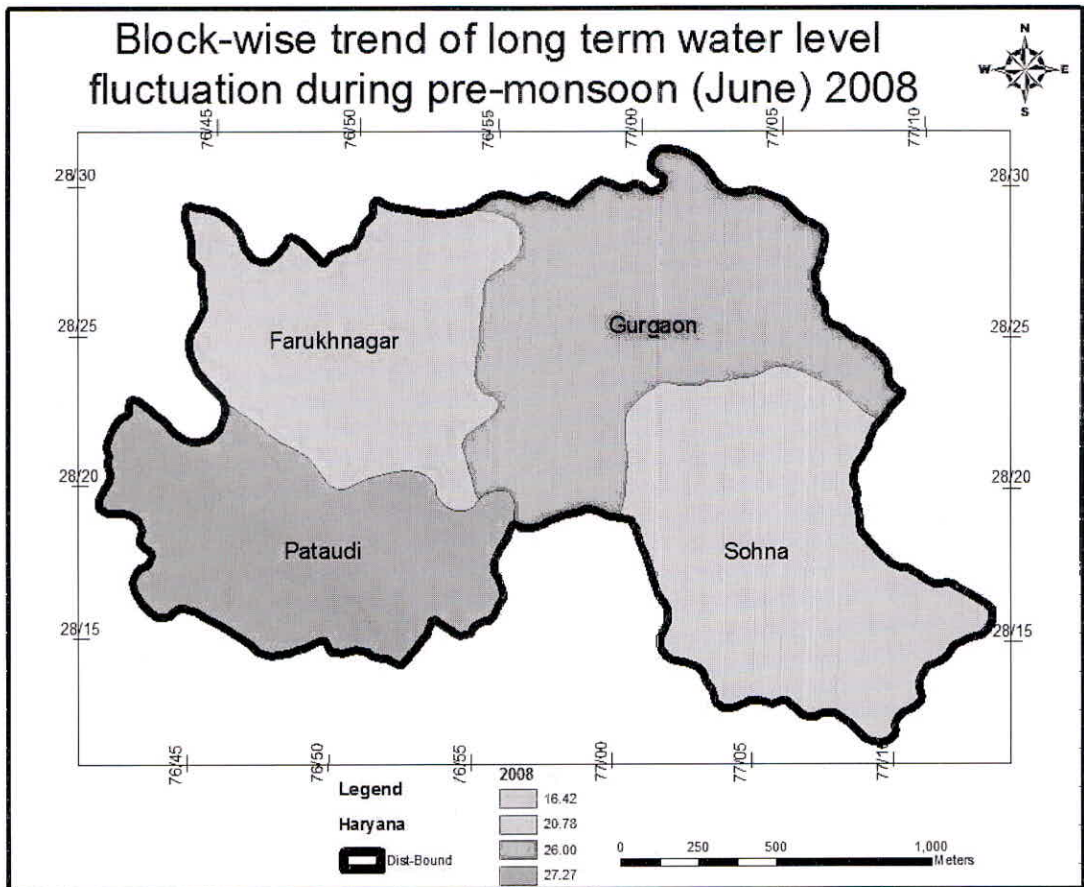


Fig. 2. Depiction of long term water level fluctuation during post-monsoon (June) 2008

and western parts of the district, the water table slopes north and north-west of the area whereas in southern part water table slopes towards southern direction with an average hydraulic gradient of 1.5 m/km.

GROUND WATER BALANCE

The ground water balance scenario shows that on March 2004, the net ground water available in the district was lesser than the total draft. The development of water was highest (311%) in Gurgaon block followed by Pataudi (222%) Sohna (155%) and Farukh Nagar (148%) and all blocks of the district are categorized as over exploited zones.

BLOCK WISE SCOPE OF DEVELOPMENT

The block wise position is as under:

Gurgaon Block

The total geographical area of the block is 354.62 Sq. Km. out of which during June 2008, 85% falls under fresh 9% under sub-marginal, 6% saline and rest is hilly region. In general depth to water varies from 2.93 m. (Dharampur) to 49.05 (Dundahera P.T.) below ground level and the average comes to be 26.00 m during June 2008. In 6% of the area depth to water is up to 10 m depth, 28% of the area water table is 10 to 20 m depth below ground level and

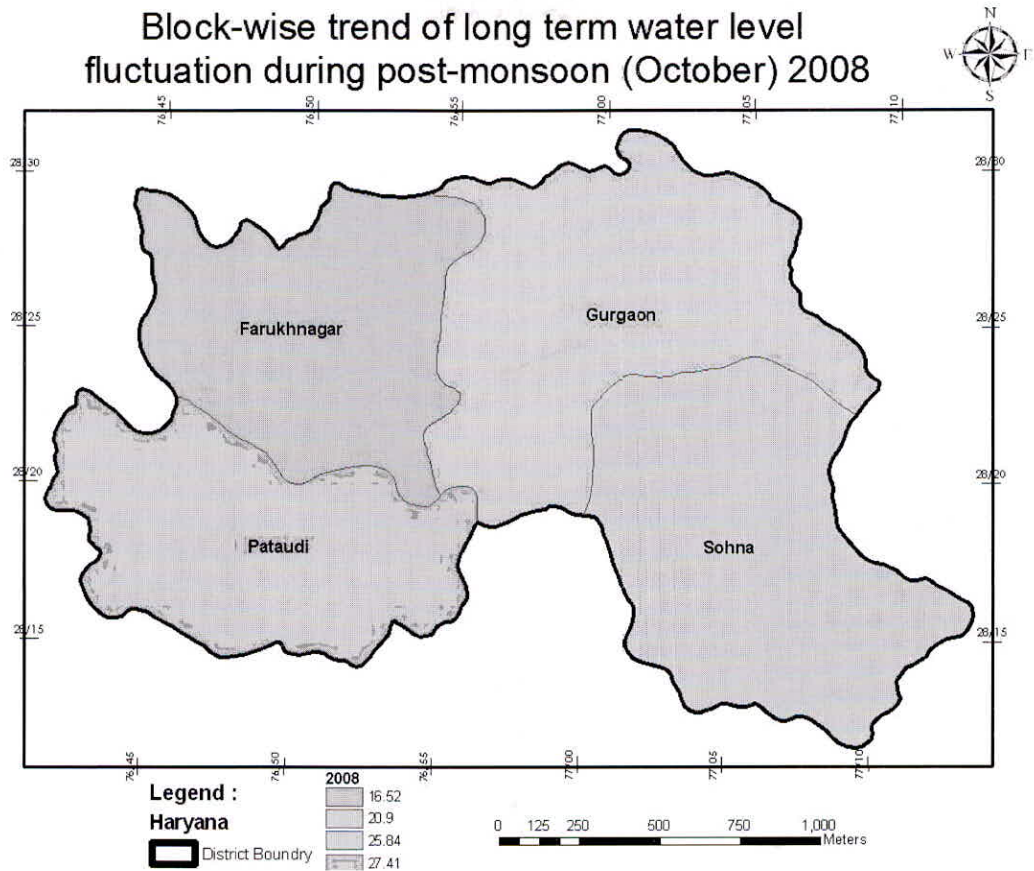


Fig. 3. Depiction of long term water level fluctuation during post-monsoon (October) 2008

66% of the area is beyond 20 m depth below ground level. The net recharge as on 31/03/2004 is 59.85 mcm and draft 84.42 mcm and the overall percentage of development is 311%. The block falls in over exploited category and there is no further scope of development.

Pataudi Block

The total geographical area is 275.61 Sq. Km. during June 2008, 94% of the area falls in fresh category and 6% as such under marginal category. The depth to water varies from 24.10 m (Kuffarpur) to 31.50 m (Nanukhurd P.T.) below ground level and the average comes to be 27.41 m during June

2008. In 79% of the area water table is 20 to 30 m depth while in rest of the area it lies above 20 m below ground level. The net recharge as on 31/03/2004 is 49.18 mcm and draft 107.24 mcm. The overall percentage development is 222% and the block falls under over exploited category. So there is no further scope of development in the block.

Farukh Nagar Block

The total geographical area is 280.09 sq. km. out of which during June 2008, 96% of the area falls under fresh, 2% sub-marginal to marginal category. The depth to water in the area varies from 9.10 m (Kherla – Jhanjrola) to 16.42 m (Dhana) below

Table 4. Ground Water Balance in District Gurgaon as on 31/03/2009

SN	Name of Block	Net Ground Water available (mcm)	Net Draft (mcm)	Future allocation of industrial & domestic draft (mcm)	Ground Water Balance	Percent Development	Category
1	Gurgaon	59.85	84.42	10.51	-35.08	311	Over Exploited
2	Farukh Nagar	39.90	58.09	8.21	-26.40	148	Over Exploited
3	Pataudi	53.23	80.80	4.34	-31.91	155	Over Exploited
4	Sohna	49.18	107.24	3.25	-61.31	222	Over Exploited
	District Total	202.16	234.03	26.31	-58.18	209	Over Exploited

ground level and the average comes to be 16.52 m during June 2008. The 7% of the total area is within 10 m depth, 55% area 10 to 20 m and in rest of the area water table lies between 20 to 30 m below ground level the net recharge as on 31/03/2004 is 39.90 mcm. And draft 58.09 mcm. The percentage of the development in the block is 148% and falls under over exploited category, so there is no further scope of development in the block.

Sohna Block

The total geographical area is 339.01 Sq. Km. out of which during June 2008, 80% area falls under fresh, 13% under sub-marginal to marginal and rest in hill and saline. The depth to water varies from 7.30 m (Ghangola) to 31.00 m (Kherla) below ground level and the average comes to be 20.90 during June 2008 10% of the area falls within 10 m depth and in 82% area water table lies between 0 to 30 m below ground level The net recharge as on 31/03/2004 is 53.23 mcm and draft 80.80 mcm. The percentage development is 155% and this block fall in grey category. Hence, there is no scope of development.

GROUND WATER EXPLORATION

The detailed exploration of ground water has been carried out by Central Ground Water Board (Northern Region), Chandigarh. Under the

exploratory programme of Central Ground Water Board, 20 test bore has been drilled out of which 10 boreholes were declared abandoned due to inadequate thickness of granular zones and poor quality of water. In addition 14 boreholes have been put in by HSMITC out of these 7 bore successful and remaining have been abandoned.

GROUND WATER RESOURCES

Ground water Resources estimation of the district was done in 2004 for Gurgaon district. Perusal of the estimates reveals overall stage of ground water development in the block is of the order of 209% which has exceeded the available recharge and thus the district has been categorized as over exploited. Net annual ground water availability of the district is 20215.12 ham and existing gross water draft for all users is 33055.33 ham.

Gurgaon district is mainly underlain by alluvium of Quaternary age, which forms the principal ground water reservoir. Some amount of ground water also occurs in fractures, joints and cervices of hard rocks found as strike ridges in the district. Granular zones of sand, which occurs inter bedded with clay in alluvial formation form the main aquifer system. The upper surface zone of the saturation is represented by water levels in dig wells. The ground water in the upper zone, the thickness of

which varies from place to place is known to exist down to 70 mm below ground level, hold water under phreatic condition. The aquifers that occur at deeper levels are normally inter-bedded by sub-regionally to regionally extending alternating impervious to previous layers of clays. Therefore, ground water in these aquifers occurs under confined to semi-confined conditions. Ground water in shallow aquifers is exploited through shallow tube-wells whereas deep aquifers are exploited by medium tube-wells.

CONCLUSIONS

Ground water decline and salinity is the major problem in the district. Ground water is declining at a rate with the range of 0.77 m/yr. (Bilaspur) to 1.2 m/yr. (Haily Mandi). The stage of ground water development for the district is 209% that means that net annual withdrawal is more than the net annual recharge. During the last 20 years, the ground water level has declined in whole of the area of the district. All the four blocks fall in over exploited categories. There is no scope for further ground water development. So there is a need to take measures to arrest the decline of ground water level.

REMEDIAL MEASURES RECOMMENDED

1. In order to arrest the declining trend of water level in the district, the roof top rain water harvesting technology should be adopted and recharge structures may also be constructed in depression areas where water gets accumulated during rainy season. This will help in enhancing the recharge to ground water reservoir.
2. Measures should be made to increase the canal water supply for irrigation to reduce the dependency on groundwater.
3. The construction of roof top rain water harvesting structures should be made mandatory in building bye-laws in all the blocks which will help in checking the falling water trend in.
4. The crops consuming less quantity of water may be grown in place of crops requiring more water in the over exploited blocks.
5. The abandoned dug wells may be cleaned and should be used for recharging the ground water by utilizing the surface monsoon run off.
6. There should be necessity to take up study for revision of tube well draft as well as seepage factor of canal.
7. More emphasis should be given in the design and quality control of tube wells for getting optimum discharge and to save lot of energy wasted by running inefficient ground water structures in the area.
8. The area is complex in nature both in regards to existence of aquifer zones and quality of ground water. So detailed village wise micro level survey is required to be taken up in the area.

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