Dwindling Ground Water Table: An Ecological Study of Southern Haryana

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Abstract. The dwindling ground water level is one of the critical issues that plague India in the present times. This research study primarily has its basis in the secondary data, gathered from the Ministry of Water Resources. The main aim of the present research study is to highlight the issues related to ground water in various parts of India with the main focus on southern part of Haryana state. The spatial pattern of the ground water depth is studied using the secondary data from various sources. The water table depth and fluctuation maps in Arch GIS 9.3 are analysed by making use of geological analysis extension. The water elevation is examined by employing the Kriging estimator. Also, the different ways of prevention that can help in checking the quick dwindling of ground water table are discussed so that the sustainable use of ground water can be encouraged and achieved. It is observed that the menace of ground water depletion has posed alarming threat to the states of Punjab, Haryana, Uttar Pradesh and some south Indian states. This is attributed mainly to the agricultural, industrial and human needs amidst the ever-rising rate of population in India. In the southern Haryana, the Mahendergarh district and Firozpur block of Mewat area have been identified as most critical zones in relation to water depletion. The study suggests judicious and sustainable use of water resources so as to check the alarming dwindling of the ground water table.

Keywords: ground water; alarming situation; population growth, suggestions; judicious use of ground water.

1. Introduction

Ground water is one of significant sources of fresh water, primary source of irrigation, industrial and drinking water requirements in many parts of the world (Singh et al., 2010). At a world level, the ground water provides about 50 per cent of the present share of water supply and over 20 per cent meets the demand for agricultural purposes It has been observed that the ground water is often relatively benefitted than that of surface water with point of view per unit volume. It is because of readily local availability, drought reliability and good quality requiring minimal treatment (Shah et al., 2000; Villholth, 2006). It is renewable source and has the remarkable distinction of being almost solo dependable and safe source of water supply (Moench, 1992; Singh & Singh, 2002).

The share of ground water in the agricultural irrigation for agricultural practices is the maximum and plays a significant role by supplying the source of irrigation and ensure the food security and livelihood for the millions of people across the world, particularly the agrarian economy in most of the developing countries of the world, depend upon the ground water (Gleick, 2003; Mukherjee & Shah, 2005). India, Pakistan, Bangladesh and China accounts for the lion's share of making use of ground water as agricultural irrigation (Kaur & Rosin, 2011). It is estimated that there is from 55 to 60 per cent of the rural population of India directly depends upon the ground water for their livelihood. The significance of the ground water in India, two fifth of the agriculture depend on irrigation from the ground water resources (Govt. of India, 2016) and 60 per cent of food-crops depend upon the underground water as source of irrigation (Dhawan, 1995). It is also estimated that there is 57 per cent of the house-holds; receive the water from the hand pumps and wells are connected with ground water (Shankar et al., 2011).

It is because of excessive use of groundwater, various regions of the country which have been over exploited of ground water resources. However, the consistent efforts for sustainable development of various crops, particularly the rice cultivation has led to depletion of water at rapid rate, particularly in interior and southern Haryana (Bhalla, 2007). As a result, the rural population pressure on ground water resources has aggravated the situation in a multiple way. The large-scale mining of ground water has given rise to depletion of ground water resources at the fast rate; as a result, about 50 per cent blocks in this region fall under over exploited category (Govt. of India, 2016).

Objectives of the study. The study is aimed at the following objectives which are as follows:

1. To highlight the overall ground water depletion scenario in the most affected states of India;
2. To highlight the declining trend of ground water table of Southwestern part of Haryana;
3. To recommend some of preventive and curative measure for depletion of the ground water.

2. Materials and Methods

In order to examine the overall ground water depletion scenario, different reports on ground water depletion have been consulted. Among these reports on water depletion, which have been published by the Ministry of Water resources, in last December 2017, has been consulted and closely examined to know the factual information about the changing ground water scenario. In case of Haryana, the data base of secondary data from ground water cell, Haryana and other sources of data such as statistical abstract of Haryana has been used to get the desired results.

The data relating to ground water depth, area under water logging, block wise statistics and information on status of blocks in relating to depth of water table (over exploited, critical and semi critical, and safe) and rainfall have been collected from Central Ground Water Board (Northern region), Chandigarh and Ground water cell has been consulted.

2.1. Data base and methodology

In order to get the desired objectives of the study, the secondary sources of information have been used to assess the changing scenario of agronomic practices in the southern Haryana. In this context, the requisite information has been collected from Statistical Abstract of Haryana, Planning department of Haryana. Similarly, the data related to ground water depth, area under water logging, block wise statistical figures on depth of water table (over exploited, critical, semi-critical and Safe) and rainfall have been collected from Central Ground Water Board (Northern region), Chandigarh and Ground Water Cell (GWC), Department of Agriculture, Haryana, Panchkula has been consulted. The proportion of area under varied water depth in the various districts of Southwestern Haryana for the years 1977 to 1987 and 1977 to 2017 has been tabulated in accordance with the factual figures.

In order to reveal the spatial pattern of the ground water depths, it was found that there were over 706 tube wells and boring wells (660 tube wells, for observation, 32 pezometers and 14 key observation wells) from the Ground Water Cell, Panchkula. With the help of all these, water table depth and fluctuation maps in Arch GIS 9.3 by making use of geological analysis extension are analysed. The geological analysis primarily focuses on the age and origin. In order to examine the water table elevation, an ordinary Kriging estimator has been used to get the desired results. In terms of the statistics, Kriging is a phenomenon of interpolation that has its basis in the gaussian process of regression. The Kriging estimator can be effectively employed to generate unbiased linear predictions, given the assumptions are appropriate.

2.2. Study area

The study area is entire India in general and southwestern Haryana in particular; where the areal differentiation in problematic areas has been examined in accordance with prevailing local conditions. South-western region of Haryana which is almost characterized with scanty rainfall and lack of assured irrigation system (Tejpal & Jaglan, 2012). In this study, there were seven districts which have been included as Rohtak, Jhajjar, Bhiwani, Gurgaon, Rewari, Mahendergarh and Nuh (Mewat). The geographical is located from 27°30’35” to 29°0’5’’ North latitude and from 76°45’30” to 78°30’50” East longitude. According to census 2011, there are 39 development blocks, and 2357 villages with their total area 14,564 km^2. The population of the selected seven districts is approximately 8 millions with an average density of population is 554 persons per km^2. In the South-eastern Haryana, dry-land agronomic practices with scant sources of irrigation are used by the farmers.

The topography of the entire region is characterized with inland seasonal streams, sandy plains, shifting of sand dunes along with Rajasthan bordering areas, lack of vegetation, dissected topography, denuded rocky hill ranges are some of salient features of this area of Haryana. The annual temperature of the study area is 25°C. The temperature is not a limiting factor for agricultural production. High range annual range of temperature has paved the way for taking three crops in a season. The Kharif crops are sown in the Monsoon season; whereas Rabi crops are sown during winter rainfall, starting from Oct to November months. The Zaid crop season extent from April to May during dry season and an annual precipitation is nearly 459 mm which is unevenly distributed. The rainfall during summer brings over 75 per cent and only 25 per cent of the rainfall comes during winter season. The Rabi season is almost dry and soil moisture becomes difficult to maintain. In the Rabi season the crops are cultivated by different modes of irrigation. In the study area, the agriculture growth has been sluggish till 1980s. Subsequently, rapid growth in number of tube wells and boring of fields for the irrigation purposes with different modes of irrigation, has given rise to fast growth of depletion of ground water in the study area.

The study area is having a considerable regional disparity in the levels of development. In this context, the district like Rohtak, Gurugram, Faridabad and Bahadurgarh Tehsil of Jhajjar district is characterized with better level of urban, Industrial development and other infrastructural development as compared with Mahendergarh, Rewari, Bhiwani and Mewat areas, where the space of urbanization and industrialization have been relatively lower than that of rest of Haryana.

3. Results and discussion

The ground water table is dwindling every year at an alarming rate, particularly in northern India. The latest inputs from central ground water board indicate crucial position of ground water dwindling. This research study explores the decreasing course of ground water in almost all the provinces situated along the Indo-Gangetic plains of northern India. It is mainly because of agronomic practices of resorting to the flood irrigation by the means of tube wells. This research study primarily has its basis in the secondary data, gathered from the Indian Ministry of Water Resources. It is observed that the menace of ground water depletion has posed threat to the states of Punjab, Haryana, Uttar Pradesh and some southern Indian states. This is attributed mainly to the agricultural, industrial and human needs amidst the ever-rising rate of population in India. Keeping in view the gravity of problem, it requires a judicious water resource management in accordance with prevailing local problems, so that the sustainable utilization of ground water resources can be encouraged and adopted throughout the country.

All these states are Punjab, Rajasthan and Haryana in the northern India where the 90 per cent, 76 per cent and 56 per cent of blocks have experienced severe ground water depletion in northern India. In case of South India, it is obvious from the tabulated figures that the worst affected states in the south India are Andhra Pradesh, Telangana, Tamil Nadu, and Kerala where; over 40 to 80 per cent of the blocks have been over exploited the ground water and due to chronic water depletion, it has given rise to fight with drought like conditions. On the other hand, the states like Delhi have experienced over 70 per cent blocks with deletion of ground water.

In this context, there are some of states like Uttar Pradesh and *Uttarakhand* shows that there are two extreme positions in relation to ground water depletion which reveal that there is 20 per cent and there are only two blocks which have experienced a severely depletion of ground water. In the central India, the states like Madhya Pradesh and Chhattisgarh show that there are 25 per cent of the blocks which have experienced ground water depletion. In case of Maharashtra state, only 5 per cent of blocks which have experienced the problem of ground depletion of water. Lastly, in the western part of India, covering the state like Gujarat, where the 25 per cent of the blocks have experienced chronic ground water depletion in the whole region of *Saurashtra*. In case of Haryana, whole Haryana is suffering with chronic depletion of ground water, and particularly where there is a relatively low rainfall area; as a result, a rapid growth of ground water depletion has been experienced during different successive periods.

In case of Haryana, where the problem of ground water depletion has increased during different successive years; it is indicated that an aggravated situation has taken place during different successive periods. Keeping in view the tabulated figures (Table 1) of fluctuation of ground water table of Southwestern part of Haryana, as a result the following inferences have been drawn:

- There are two phases which have been chosen for the study, i.e., 1977 to 1987 and 1977 to 2017. In this context, it is to be noted that the rate of change in water table of ground water differs with the depth ranges, taken for the study.
- It is obvious from the tabulated figures that the relatively short span of period shows a considerable variability in change of water levels with varied depths which indicate a regional disparity as tabulated below.

Table 1. Periodic change in percentage of area under different categories of rise and fall of water table in Southern Haryana (1977-1987 and 1977-2017)

DISTRICT	PERIODS	RISE (in meters) <10	RISE (in meters) 10-20	FALL in meters) < 10	FALL (in meters) 10-20
Bhiwani	1977- 1987	+99.25	+1.78	-0.13	-0.00
	1977- 2017	+33.99	+15.24	-35.56	-22.67
Rohtak	1977- 1987	+48.24	+0.00	-34.28	-00.13
	1977- 2017	+77.87	+0.15	-54.32	-00.12
Jhajjar	1977- 1987	+37.26	+0.17	-53.43	-00.11
	1977- 2017	+55.56	+0.19	64.87	-00.27
Mahendergarh	1977- 1987	+8.22	+0.11	-48.77	-58.49
	1977- 2017	+0.55	+0.14	-34.77	-96.42
Rewari	1977- 1987	+5.67	+0.13	-6.89	-0.11
	1977- 2017	+0.57	+0.19	-96.77	-59.56
Gurugram	1977- 1987	+0.01	+0.16	-43.45	-0.11
	1977- 2017	+0.01	+0.19	-49.78	-55.43
Mewat (Nuh)	1977-1987	+0.02	+0.59	-99.00	-0. 00
	1977-2017	+0.05	+0.61	-45.59	-55.41
Southwestern Haryana	1977- 1987	+45.17	+0.59	-49.89	-8.58
	1977- 2017	+25.78	+5.51	-36.67	-38.90

Source: Directorate of Agriculture Haryana & compiled and worked out by the author.

In order to examine the district wise study, shows a considerable regional variability in rise or fall in areas in different districts of the study area. It is obvious from the tabulated figures that there is 72 per cent of area of Southwestern Haryana, has experienced a declining trend of water table. During this period, it has also been observed that during this period about 1/3 area of this region, the water table has been reduced over 10 meters. Meaning thereby, the declining in water table has been reduced relatively at fast rate during last two decades (Since 1987). With reference to the study period from 1977 to 1987 which indicate that the table increased only 45.17 per cent of the entire south western Haryana. It is because of rapid growth in tube well connection within this region. The ground water depletion has been experienced maximum in the southwestern parts of the *Mohendergarh* district. On the other hand, water table has been experienced maximum rise in the northern part of the region of *Bawani Khera* in *Bhiwani* district.

In case of *Gurugram* district, it has been observed from the tabulated figures which show that there is considerable fall in area -43.45 per cent between the years 1977 to 1987, but during the years 1977 to 2017, the depletion within less than 10 meters has been 49.78 per cent. On the other hand, the corresponding figures of the water depletion within the 10 to 20 meters; it has reduced only - 0.11 per cent; during the period of 1977 to 1987, but the quantum of depilation of water during relatively longer period has been declined by -55.43 per cent. In case of *Mewat* district, where the over 70 per cent of the ground water is saline and there is considerable seasonal fluctuation in water table of ground water in the entire reason. In this context, it is obvious from the tabulated figures which shows that during the period 1977 to 1987, within the depth of less than 10 meters; only marginal i.e., + 0.2 per cent has area has been risen marginally, but within the depth of 10 to 20 Meters, the areas have been risen slightly better i.e., + 0.59 per cent. On the other hand, there was a slightly better situation has been observed during the periods 1977 to 2017. In case of fall in area; where there was the depth of ground water is less than 10 Meters, a considerable declining in area i.e., -0.99 per cent was noticed, whereas within the ground water depth ranging from 10 to 20 Meters, has experienced reduction of area declined by - 45.59 per cent. By examine the falling trend of the ground water level up to 10 meters, which indicates that there has been experienced a *zero* per cent declining in area, but in the depth of 10 to 20 meters, as a result; we observe from the tabulated figures which shows that there were declining of -55.41 per cent of area within the Nuh (Mewat) district of Haryana.

In case of examining the periodic fluctuating trends of whole Haryana, there is a considerable varied trend; as indicated by the tabulated statistical figure (Table 1) in whole Haryana. In this context, it has been observed from the Table 1, which shows that during the period 1977 to 1987, within the depth less than 10 meters there is + 45.17 per cent of the underground water coverage area has been noticed. On the other hand, the corresponding figures for the period 1977 to 2017, shows a quite different growth figure i.e., + 25. 78 per cent reduced area, but the corresponding within 10 to 20 meters of water table depth shows a considerable variability in at the depth within the depth of 10 to 20 meters; indicates a relatively higher figure -5.51 per cent of area coverage. In case of periodic assessment of the falling trend of whole Haryana, as a result, it has been observed that there has been very critical situation of falling the area coverage by -49.89 per cent (1977-1987) as compared with 36.67 per cent (1977-2017) with the depth of less than 10 meters ground water level. Lastly, reviewing the area shrinkage within the depth of 10 to 20 meters, the area coverage of Haryana; has been declined from – 08.58 per cent to -38.90 per cent during the period since 1977 to 1987 and 1977 to 2017 respectively. The Figure 1 shows the depleting groundwater scenario in southern Haryana in detail.

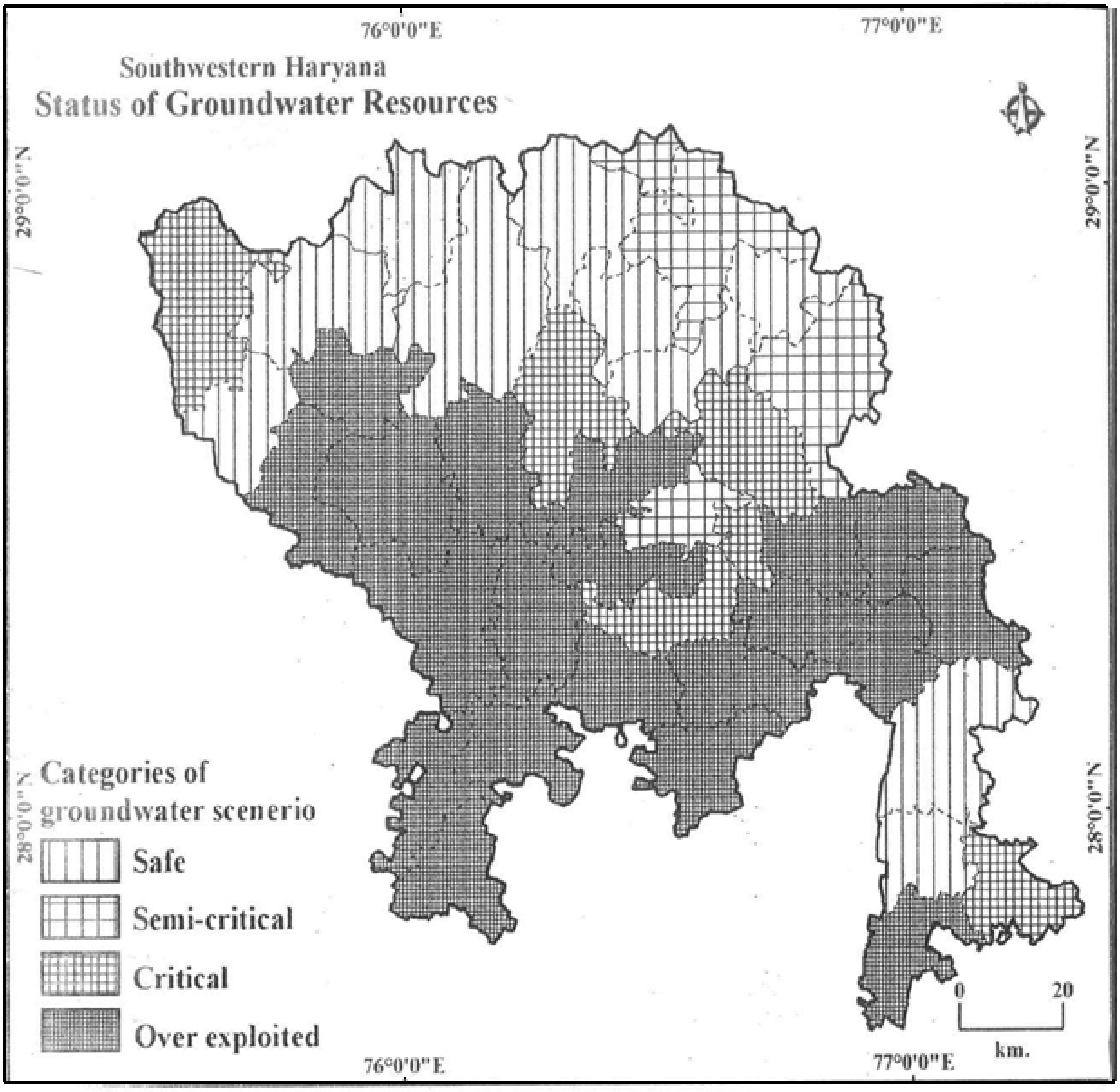

Figure 1. Ground water depletion scenario in Southwestern Haryana. Source: Ground water Cell, Haryana (2016)

In this context, an ambitious Master plan for *Artificial Recharge* has been formulated and executed for recharging the ground water and identified thousands of places, covering the area of 4.5 lakhs square Kilometers in the country. Secondly, the CGWB (Central Ground Water Board) has circulated a manual on techniques of artificial recharging to the states to enable them to formulate an area specific artificial recharge schemes to check the declining trend of ground water levels;

Thirdly, rain water harvesting is being promoted by creating mass-awareness programmes and make available of technical and professional guidance to various government and non-government organizations; Finally, CGWA (Central Ground Water Authority) has notified that there were 20 severely over-exploited areas in the country for regulation of ground water development and management. The CGWA is also regulating development of ground water by the new industries and projects in all over exploited or critical areas of India. Apart from the steps, taken by CGWB and other institutions, there are some of other institutional supports like *Panchayati Raj* institution and the CSR (Corporate Social Responsibility), the corporate social responsibility can be proved conducive to conserve the water resources, particularly the ground water, to a considerable extent in the all the problematic areas of India. The government has also taken curative measures to reduce the chronic rice dominancy areas in rice growing areas. In this context, comprehensive alternative *crop-combination* plans have been suggested to reduce the chronic rice dominancy in some of specific areas of India. Apart from this, a focus has also been given to developing the less water consuming rice varieties in some of chronically ground water depleted areas.

In this context, the main focus is to be given to make the use of ground water more judicious, so that the haphazard growth of ground water depletion may be reduced from the flood *irrigation dominant* areas. More emphasis should be given to drip-irrigation and sprinkler irrigation for other than the rice crops in the ground water depletion areas. Similarly, the practices of *'osra Bandi' or 'Bara Bandi'* is also be more focused rather than irrigation the land altogether. The role of agriculture extension by the agriculture extension officials gains more significance to remove the *fallacious* aspects on irrigation and should inculcate the factual thought in to the minds of the farmers, so that the farmers may make the use of water in a judicious way and save the ground water from steadily depletion from the problematic areas.

Hence, it is obvious that the ground water problem from the problematic areas cannot be overcome, unless active people participation is not taken place by the farmers, the members of the *Gram-Panchayats* and other *voluntary organizations* at a grass-root level. Only then, the chronic depletion of ground water may be prevented from all the problematic areas of India. It is expected to pave the way to find out the effective strategies which suits to the prevailing local conditions to get the desired objective. Only then, all the preventive and curative measures may get the desired results on sustainable basis in all the problematic areas.

4. Conclusions

The ground water table is dwindling every year at an alarming rate, particularly in Northern India. The latest inputs from central ground water board indicate a crucial position of ground water dwindling. On the basis of multifaceted study which indicates a decreasing course of ground water in almost all the states situated along the Indo-Gangetic plains of northern India. The problem has also occurred at gigantic scale in the southern states like Andhra Pradesh, *Telangana* and Tamil Nadu. In case of South western part of Haryana which is one of critical regions of India; where the ground water depletion has been experienced by the farmers; district Mahendergarh and Firozpur block of Mewat area have been identified as most critical zones in relation to water depletion. All these problems require a *judicious planning* for water resources so that every state may receive their due share in accordance with demand and supply of water and its available resources throughout the country. In order to reduce the ground water depletion, it becomes imperative to develop good extension works for the farmers and educate them on various problematic areas of water resources in relation to its use and mis-use, so that a sustainable way may be attained in relation to availability of ground water and its use in present and future periods.

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