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RESEARCH PAPER

Groundwater depletion in Haryana: A challenge

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Abstract : India is the world's largest user of groundwater with over 80% of the rural and urban domestic water consumption met by available groundwater, but every year the water table is depleting in different states of the country. There are total 141 blocks in Haryana, out of which 86 blocks (61% of the state's geographical area) had reached the red zone due to groundwater exploitation. In year 2004, 55 blocks were under the red category zone, which means that 31 more blocks have come under the distressed category in a decade and a half. The depletion in the water table is now a cause of concern in 14 of the 22 districts of Haryana and mainly Ambala, Kurukshetra, Kaithal, Karnal and Panipat are the worst affected. In the absence of adequate surface water quantity, groundwater has become the main sources of irrigation in the state and the total geographical area of Haryana is 44,212 Sq. Km and out of which cultivable area 36,760 Sq. Km (83.15%). The total area under under irrigation is 2974000 ha (81%) i.e. by Canals 11,53000 ha (38.80%) and by tube wells 18,2100 ha (61.20%). Net Area Irrigated is 29,740 Sq. Km. This has resulted into excessive exploitation of groundwater resources. The indiscriminate withdrawal of groundwater has created a declining water table situation in the state. The average rate of decline over the last 48 years has been about 24 cm per year. In addition, fourteen districts out of twenty two have been categorized as over exploited. This paper, therefore, attempts to analyze the problem of declining water table, factors for its depletion and suitable mitigation measures to combat the declining water table problem for sustainable agriculture development in the state.

Key Words : Groundwater depletion, Degradation, Sustainable agriculture

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INTRODUCTION

India is the world's largest user of groundwater with over 80% of the rural and urban domestic water supplies met by available groundwater. But each year the water table keeps falling in different states. The latest data of the Central Ground Water Authority revealed that out of the total 141 blocks in Haryana, 86 blocks (61% of the state's geographical area) had reached the red zone due to groundwater exploitation. Upto year 2004, 55 blocks were under the red category zone, which means that 31 more blocks have come under the distressed category in a decade and a half. The depletion in the water table is now a cause of concern in 14 of the 22 districts of Haryana and districts Ambala, Kurukshetra, Kaithal, Karnal and Panipat are the worst affected. Irrigation is the prime source of depletion and mainly due to paddy crops that require high amount of water for cultivation. A block is included under the red category when the extraction of groundwater is far greater than the recharge, resulting in the continuous depletion of the

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ground water table. According to the data from the Government of Haryana, annual groundwater recharge from rain and canal water is 10.15 billion cubic meters (bcm) out of which 9.13 bcm is extractable (one cubic meter = 1,000 liters). The current annual groundwater extraction in the state is 12.50 bcm, of which 11.53 bcm is alone used for irrigation and the remaining goes for domestic (0.63 bcm) and industrial use (0.34 bcm). Approximately from half of the state's area, groundwater withdrawal is more than recharged water every year, resulting in continuous depletion of groundwater table. The annual groundwater withdrawal in Haryana is 137% of its annual extractable groundwater resources, which is the third-highest in the country. The national average is at 63%.

There are two categories of groundwater - one that is dynamic and the other is static *i.e.* far deep underground. The residents in districts like Kurukshetra, Karnal, Panipat etc. have even started using static groundwater hints at a severe ecological crisis and in districts like Rohtak, Jhajjar etc. having high groundwater level created water logging problems and also the groundwater is saline and cannot be used for irrigation purposes. So, farmers are mostly dependent on canal water for irrigation in these districts. Thus, we have reached at a stage where we need to focus on water use efficiency and use of groundwater through methods like micro-irrigation and crop diversification, increasing recharge points or digging the canals to prevent the groundwater from further depletion.

Basic agriculture statistics of Haryana state :

The total geographical area of Haryana is 44,212 Sq. Km and out of which cultivable area 36,760 Sq. Km (83.15%). Out of which 2974000 ha area is under irrigation (81%) *i.e.* by Canals 11,53000 ha (38.80%) and by tube wells 18,2100 ha (61.20%). Net Area Irrigated is 29,740 Sq. Km. The total nos. of tube wells in 2017-18 were 847750 (297616 Diesel Pump Sets and 550134 Electric Pump Sets). In the state available water potential has depleted due to over exploration by large number of shallow and deep tube wells (14/km^2). This has led to continuous decline in water table in North-Eastern region of the state. The area under paddy in Haryana went up sharply from 8.5 lakh (850,000) hectares in 1996 to 13.87 lakh (1.38 million) hectares in 2018, before coming down to 12 lakh (1.2 million) hectares in 2020-21.

Water depletion in Haryana: A challenge

Estimates of groundwater depth in the state shows that the groundwater level is generally high in the Southern parts of Haryana and low in the North and North-Eastern parts, which is a hilly tract. During the pre-monsoon period, it ranges from 5m to 21m below ground level (bgl). What is often not recognized is that the groundwater problem in Haryana has two dimensions. The first is that of rising groundwater table in the areas with low quality aquifer zones, leading to secondary salinization and water logging. The second is that of declining water tables due to over-pumping of groundwater in fresh and good quality aquifer zones.

Reasons for water table depletion in Haryana:

In all of the above regions, the continuous rice-wheat cropping system and high water requirement crops like sugarcane are mainly responsible for the depleting of ground water. The cultivation of additional rice crop followed by early transplanting of main rice crop in some areas has further aggravated the situation. The inadequate recharge due to erratic rainfall over the years, cultural practices such as continuous puddling in submersed soil for rice crop transplanting and compaction due to pass of heavy machinery, no canal system in these regions and disturbing equilibrium of subsurface hydrological regime, are the other factor contributing the degrading and/or depleting of ground water resources. Numerous studies, for example, Chand (1996), Chand and Haque (1997), Kataki *et al.* (2001), Duxbury (2001), Singh (2017) and Aneja (2017) hold that both in Punjab and Haryana the paddy-wheat rotation is unsustainable and is lowering the water table. The increased popularity of these crops may be attributed in part to the government's price policy. It is important to note here that initially, at least, providing remunerative prices for rice and wheat was important not only for ensuring food security, but they also helped in draining out the excess water brought about due to unlined canals and lack of adequate drainage in the state. But cultivation of these crops over the years has brought about a massive decline in the water level. Therefore, the crops that were earlier encouraged have now become a cause of a depleting resource base. Keeping the above in mind the present study is an attempt to access the impact of area under water hungry crops as well as number of tube-wells and of annual rain fall on depth of ground water level in Haryana. The main objectives of the study are as follow:

– To study the recent trends in ground water level in Haryana.

– To find the impact of area under water hungry crops, number of tubewells and annual rainfall on the ground level water depth in Haryana over the time.

RESULTS AND DISCUSSION

The study is analytical in nature and based on secondary source of information. Major sources of data are ground water year book (2014) published by central ground water board and ground water cell, agriculture department, government of Haryana and statistical abstract of Haryana. The study is carried out for the period of 23 years (1990-91 to 2013-14). The impact of area under water hungry crops, number of tube-wells and annual rain fall on ground water level depth has been analyzed by applying the multiple regression analysis. District-wise average depth of water in Haryana has been shown in Table 1.

The above data reveals that average depth of water among the districts of Haryana is continuously increasing. The situation of groundwater table depth from period 1974 to 2018 is very critical in the districts namely Mahendergarh (32.43 m), followed by kurukshetra (29.84 m), Kaithal (23.05 mt), Gurgaon (20.24 m), Fatehbad (19.30 m), Panipat (16.61 m), Rewari (15.56 m), Karnal (13.41 mt), Panchkula (10.05 mt), Faridabad (12.15 m), Ambala (5.65 m) and Yamuna nagar (6.44 m) and average groundwater table depletion also highest in District Mahendergarh (0.74 m/year) followed by the districts Kurukshetra (0.68 m/year), Kaithal (0.52 m/Year), Gurugram (0.46 m/ year), Fatehbad (0.44 m/ year), Panipat (0.38 m/Year) and Rewari (0.35 m/Year). Interestingly, the water table has declined both in the regions, where the water table was high as well as those where the water table was deep (such as Mahendargarh). In contrast, in the regions of Hissar, Rohtak and Jhajjar, the water table has risen by 2 to 8 meters over the period of time (Table 1).

Table 1 : The periodic (June 1974 to June 2018) fall of average depth (mt) of water table in different district

Sr. No.	Districts	June 1974	June 2018	Water table depletion (in mt.)	Average water table depletion (m/year)
1.	Ambala	5.79	11.44	-5.65	-0.13
2.	Bhiwani	21.24	24.19	-2.95	-0.07
3.	Faridabad	6.42	18.57	-12.15	-0.28
4.	Fatehbad	10.48	29.78	-19.30	-0.44
5.	Gurugram	6.64	26.88	-20.24	-0.46
6.	Hissar	15.47	8.08	7.39	0.17
7.	Jind	11.97	14.33	-2.36	-0.05
8.	Jhajjar	6.32	5.24	1.08	0.02
9.	Kurukshetra	9.27	39.11	-29.84	-0.68
10.	Kaithal	6.28	29.33	-23.05	-0.52
11.	Karnal	5.72	19.13	-13.41	-0.30
12.	Mahendergarh	16.11	48.54	-32.43	-0.74
13.	Mewat	5.50	11.33	-5.83	-0.13
14.	Palwal	5.37	11.09	-5.72	-0.13
15.	Panipat	4.56	21.17	-16.61	-0.38
16.	Panchkula	7.58	17.63	-10.05	-0.23
17.	Rohtak	6.64	4.22	2.42	0.06
18.	Rewari	11.75	27.31	-15.56	-0.35
19.	Sonipat	4.68	10.23	-5.55	-0.13
20.	Sirsa	17.88	20.71	-2.83	-0.06
21.	Yamunanagar	6.26	12.70	-6.44	-0.15
	Average	9.19	19.57	-10.38	-0.24

Source: Ground water cell of Department of agriculture Haryana

Characterization of ground water exploitation of Blocks:

The exploitation of ground water table within blocks is characterized under four major categories by Central Ground water Board, Government of India as follows:

Safe block :

If the rate of groundwater exploitation is below 70 per cent of its utilizable recharge, the block is under safe block category.

Semi-critical block :

If the rate of groundwater exploitation is in the range of 70 per cent to 90 per cent of its utilizable recharge, the block is under Semi-critical block category.

Critical block :

If the rate of groundwater exploitation is in the range of 90 per cent to 100 per cent of its utilizable recharge, the block is under critical category.

Overexploited block :

If the groundwater use is above 100 per cent of its utilizable recharge the block is under overexploited category

The characterization of blocks of Haryana on the basis of groundwater exploitation is shown below as per the report of Central Ground water Board, Government of India year 2020 (Table 2).

Out of all 141 hydro-geological blocks in Haryana, 61 per cent of them are categorized as over exploited blocks. In fact, in few cases the utilization ratio exceeds even 100 per cent of recharge – Kurukshetra (178%), Karnal (132%) and Mahendargarh (130%). The situation is also severe in the districts of Ambala, Panipat and Yamunanagar. 24 blocks out of total 140 blocks are in semi critical and critical category. This leaves only 22 per cent of the area categorized under safe zone. All blocks of Charkhi Dadri, Panipat and Rewari lie under safe category only, otherwise maximum blocks of other districts of Haryana lie under over exploited category.

Table 2 : Categorization of blocks on the basis of groundwater assessment as on April, 2020

Sr. No.	District	Number of blocks			
		Safe<70	Semi-critical 70-90	Critical 90-100	Over exploited>100
1.	Ambala	1	0	2	3
2.	Bhiwani	1	1	0	5
3.	Charkhi Dadri	2	0	0	2
4.	Faridabad	0	0	0	3
5.	Fatehbad	0	0	1	6
6.	Gurugram	0	0	0	4
7.	Hissar	2	3	2	2
8.	Jind	6	1	0	0
9.	Jhajjar	2	1	0	5
10.	Kurukshetra	0	0	0	7
11.	Kaithal	0	1	0	7
12.	Karnal	0	0	0	7
13.	Mahendergarh	3	1	1	3
14.	Mewat	3	1	2	1
15.	Palwal	1	2	1	2
16.	Panipat	2	0	1	0
17.	Panchkula	0	0	0	6
18.	Rohtak	0	0	1	6
19.	Rewari	5	0	0	0
20.	Sonipat	0	1	0	6
21.	Sirsa	3	0	0	5
22.	Yamunanagar	0	0	1	6
	Total	31	12	12	86

Groundwater quality of Haryana:

Groundwater in most of the area of South-Western Haryana is unfit for consumption due to salinity or high concentration of nitrate or fluoride present in water. The worst hit districts are Bhiwani, Fatehabad, Jhajjar, Mewat and Sirsa. Majority of samples drawn from wells and hand pumps in these districts failed the test as chemical parameters were higher than permissible limits (BIS 2012). Groundwater in these districts is not only unsuitable for drinking but also for irrigation. In the North-Western region Ambala, Jind, Kaithal, Karnal, Kurukshetra, Palwal, Panipat, Panchkula, Rohtak, Sonepat and Yamunanagar have more than 50 percent water fit for human use [Central Ground Water Board (CGWB) report]. The samples with low salinity (<750 µS/cm) were found in Ambala, Gurgaon, Panchkula, Panipat, Karnal, Kaithal, Kurukshetra, Sonepat and Yamunanagar districts, intermediate salinity (750-3,000 µS/cm) were found in all districts and high salinity (>3,000 µS/cm) were found scattered in Bhiwani, Faridabad, Gurgaon, Hisar, Jhajjar, Kaithal, Mahendergarh, Mewat, Palwal, Rewari, Rohtak, Sirsa and Sonepat districts. The high ground water salinity may be due to high concentration of salts as evapo-transpiration is more than precipitation (semi-arid climatic conditions) and lack of drainage in these areas. Mewat has been found to be worst affected and at an alarmingly high salinity level (Table 3).

From the above data it is quite clear that there is very high decline in ground water table of the state and this is very alarming situation and there should be quite check in further declining of water table.

Management strategies :

Keeping in view of declining of ground water table and degrading water resources, it is essential to optimize

Table 3 : Ground water quality degradation

Contaminants	Districts affected (in part)
Salinity (EC>3000 µS/cm at 25^0C)	Bhiwani, Faridabad, Gurgaon, Hissar, Jhajjar, Jind, Kaithal, Mahendergarh, Palwal, Rohtak, Sonepat and Sirsa.
Fluoride (>1.5mg L^{-1})	Bhiwani, Faridabad, Gurgaon, Hissar, Jind, Kaithal, Panipat, Rewari, Sirsa and Sonepat.
Arsenic (above 0.05mg L^{-1})	Ambala, Fatehabad, Karnal, Sonepat and Mewat.
Iron (>1.0mg L^{-1})	Ambala, Bhiwani, Faridabad, Fatehabad, Gurgaon, Hissar, Jhajjar, Jind, Sonepat, Sirsa and Yamunanagar.
Nitrate (>45 mg L^{-1})	Bhiwani, Faridabad, Gurgaon, Hissar, Jhajjar, Jind, Kaithal, Mahendergarh, Palwal, Sirsa and Sonepat
Heavy metals:	
Lead (> 0.01 mg L^{-1})	Bhiwani, Faridabad, Fatehabad, Gurgaon, Hissar, Jhajjar, Jind, Kaithal, Karnal, Mahendergarh, Panchkula, Rewari, Rohtak,Sonepat and Sirsa
Cadmium(> 0.003mg L^{-1})	Gurgaon, Jhajjar, Jind and Rohtak.

Table 4 : Crop diversification (Option replace of rice with)

Crop	Area (Km^2)	Irrigated water demand (Rice = 73 cm) with attemative (cm)	Water saved (M m^3)
Maize	2500	60	325
Groundnut	500	50	115
Soybean	500	60	65
Pluses	500	45	150

Source: Aggarwal *et al.* (2009)

Table 5 : Irrigation efficiency of various irrigation techniques (%)

Irrigation efficiency	Methods of irrigation		
	Surface irrigation	Sprinkler system	Drip system
Conveyance efficiency	40-50 (Canal), 60-70 (Well)	100	100
Application efficiency	60-70	70-80	90
Surface water moisture evaporation	30-40	30-40	20-25
Overall efficiency	30-35	50-60	80-90

Source: Narayanmoorthy, 2004

the utilization of ground water resource. The following management strategies should be considered to tackle the problem.

Water conservation practices :

Farm management practices of efficiently use of ground water are very helpful in improving the water use efficiency by strengthening of bunds, land leveling, cleaning of field channels, adopting proper architecture of irrigation plots depending on slope, soil physical conditions, drainage and optimum depth and time of irrigation.

Rain water harvesting and under ground water recharge :

Artificial recharge spreading and rainfall water injected in the bore wells. Accumulation of water in stream, drains and pits should be adopted to replenish the receding ground water resources.

Crop diversification :

The continuous adoption of rice-wheat cropping system in more than three decades in the state has contributed to tremendous decline in water table of the ground water. Thus, now there is requirement for having crop diversification to replace rice-wheat cropping system. Replacing wheat-rice cycle with less water requiring crops like maize, soybean, groundnut, oilseeds, sunflower, and pulses etc. during Kharif and Rabi season in the state of Haryana can save substantial quantities of water. Replacement of rice crop with maize crop in 2500 km^2 will save about 325 M m^3 of water and pulses in 500 Km^2 save about M m^3 of water (Table 4).

During *Rabi* the wheat can be replaced by oil seed crops, winter maize and in *Kharif* season the rice can be replaced by pulses. The Government of Haryana has launched a scheme "Mera Pani Meri Virasat" for crop diversification through paddy to maize and/or horticultural crops in *Kharif* season.

Reclamation and recycling of waste water :

Large amount of industrial effluent, sewage water produced and their disposal is great problem. However these can be used for irrigation after suitable treatment in valuing primary, secondary and tertiary treatment. These treatments considerable decreased the toxicity hazards of water under treatment and making it suitable for irrigation. This water can also be used efficiently for drinking and other uses.

Efficient irrigation system :

More efficient irrigation system like underground pipe lines, drip and sprinkler micro irrigation msystems can be adopted for saving the water and also to utilize the saline/sodic water for cultivation of crops without affect the yields drastically. Micro irrigation systems (sprinkler and drip) have the potential to increase irrigation water use efficiency (Aggarwal *et al.*, 2009). The usages of these systems can increase the irrigated area without constructing any new irrigation projects, reduce energy requirement (electricity), weed problems, soil erosion and cost of cultivation (Narayanmoorthy, 2004). The efficiencies of different micro irrigation systems and clearly suggests that these systems are more efficient than surface irrigation systems (Table 5). The efficacy of water use is substantially higher under micro irrigation techniques in comparison to sirfece irrigation techniques, mainly because of reduction in convenience and distribution losses. Moreover, application of drip irrigation system saved water without reducting yield. To avoid aggravating supply-demand gap in irrigation water in the future, it is essential to bring more cropped area under micro irrigation systems in the state of Haryana.

Conclsion:

The present study has been made an attempt to address the issue of declining ground water level in Haryana and also measured the impact of number of tube-wells and area under water hungry crops on depth of ground water level in the state. In Haryana two types of problem are observed *i.e.* water logging and water depletion. The serious concern over the rapidly declining groundwater levels in various parts of Haryana is noticed and the cultivation of water-intensive crops is increasing in the regions, where the water table is depleting. The declining ground water level is becoming challenge for the sustainability of the state. The study suggests there is very high decline in ground water table of the state and this is very alarming situation and there should be quite check in further declining of water table and require the immediate attention of policy makers in this direction.

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Competing interests:

There are no competing interests involved with this review.

Author's contributions:

Dharam Pal designed the study and wrote the first draft of this review paper. Sunil Kumar managed the draft and aided in information collection process. All the authors played their part in reading, drafting and have approved it for final submission process.

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