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Groundwater Problems in Punjab: A Matter of Concern

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Abstract:

Nature has gifted Punjab with rich sources of water; ground as well as surface. High yielding capacity of the wells and aquifers in the State offered unprecedented supply as well as use (misuse) of groundwater resource. The state water resources have been/are exploited for large –scale supplies of water for irrigation, industrial and urban use. Though Punjab occupies only 1.57 percent geographical area of the country, yet it contributes about 50 percent of the total grain production. More than 83 percent of land of Punjab is under agriculture and agriculture is highly modernized. After green Revolution, modern technology like agriculture machinery, irrigation facilities, HYV seeds, chemical fertilizers, pesticides etc. have been used to increase production of crops which exploited the soil and water resources very badly and affected many segments of agrarian society of Punjab. In the major parts of Punjab, ground water levels ranges from 10 to 20 meters from the ground surface but in central parts it ranges from 20 to 40 meters. In contrast to this situation the south western part of Punjab is facing entirely a different problem that is the rise in water table and those areas are affected by water logging. Thus, in some areas irrigation becomes cause of declining water table and in other areas it becomes cause of water logging. The major concerns related to groundwater quality in this State are high salinity, high levels of fluoride, chloride, nitrate, uranium etc. In this paper effort has been made to find out the spatial extent and causes of groundwater depletion in major parts of Punjab.

Keywords: Groundwater, Depletion, water logging, Management and Punjab.

1. Introduction

The main source of water on earth surface is rain water, some portion of rain water infiltrates and percolates into the earth surface, some part of it evaporates & some part of it runs off into ocean, seas and lakes directly. The average depth of ground water on earth ranges from 1 m to 1000 m (meters) below the earth surface. Ground water forms a major part of the world's fresh water resources. The upper surface of this ground water is called the water table. The water table is higher in the areas with high rainfall and areas nearby other water bodies like rivers and lakes etc. On the other hand, ground water is scarce in mountainous, hard lithology & dry weather areas. India, which receives its maximum amount of rainfall in monsoon season, is rich in surface and groundwater reserves but the regional distribution of this resource is quite uneven due to uneven availability of rainfall, unevenness in topography etc. Some areas receive high rainfall and subsequently have good water resource but others where rainfall amount is low, in that sense, a situation of water scarcity is quite obvious. The groundwater is becoming scarcer in India but demand is rising. According to Central Ground Water Board (1996) the groundwater availability in India has declined from 6008 cu m (cubic meter) in 1947 to 2384 cu m in 2000.

India is a vast country and it is divided into three major regions according to its topography- Himalayan region, Ganga-Brahmaputra Plains region, Peninsular region. The state of Punjab is situated in the Sutlej plain which is a western part of Sindhu-Ganga-Brahmaputra Plains. These alluvial plains of India constitute a vast underground water reservoir, which is very fertile for agricultural activities. Although Punjab, which was called land of five rivers with plenty of water, is highly productive but is becoming scarce in terms of water availability whether it is groundwater or surface water. Underground water is depleting at very fast rate. Underground water is getting depleted in all districts of the state, But in Central and North-Eastern Punjab the condition is worst (NAPCC 2011). The objectives of this paper are to explore the followings:

- The current situation of underground water in Punjab in terms of availability.
- Declining quality and quantity of ground water resources in Punjab.

This study is organized as follows: Section 2 discusses the current situations of water resources in study area, Punjab. Section 3 discusses the major groundwater issues and reasons behind them. Section 4 discusses the governmental policies and ongoing programs regarding groundwater resources in Punjab. Section 5 provides recommendations that can effectively address the major issues of groundwater resources in Punjab. Section 6 deals with concluding remarks.

2. Area of Study

Punjab state has its extent from 29°30'N to 32°32'N latitude and 73°55'E to 76°50'E longitudes. The total geographical area of the state is 50,362 sq. km.¹ The economy of the state is mainly based on agriculture. In 2011 the total net sown was 4.20 m ha (million hectare), total irrigated area was 4.06 m ha (97.4% of total geographical area), canal irrigated area was 1.10 m ha (27.4%), tube well irrigated area was 2.93 m ha (70%), total cropped area was 7.90 m ha.² In the Punjab state 85% of geographical area is under agriculture. It has a cropping intensity of 184%. Traditionally, the farmers were following the Maize-Wheat or Sugarcane-Maize-Wheat cropping pattern but from last four decades, the cropping pattern of the farmers have been shifted Wheat-Rice that enhance the demand of water for irrigation. There were only 1.92 lakhs shallow tube wells in the State in 1970 which has increased to 6.00 lakhs in 1980, and presently there are more than 10 lakhs tube wells in the state.

2.1 Water resources in Punjab-The major rivers of Punjab are Sutlej, Ravi, Beas and Ghaggar. Sutlej River enters Punjab near Nangal & moves down to plain area at Ropar, passes through Ludhiana and joins Beas River at Harki. The lower Sutlej basin is irrigated by Bist-Doab and Sirhind irrigation system. The North and Central part of the Sutlej basin is an area of increased ground water over-exploitation. The South-Western part of the state is water logged and affected by salinity. Besides this, problems of high levels of fluoride, selenium and arsenic in the ground water have been reported in the lower Sutlej basin. Major part of the basin experiences over exploitation of ground water, thereby indicating a negative balance when withdrawal exceeds the groundwater recharge (NAPCC 2011). The annual amount of rainfall in the state varies from 250mm to 1000mm. Eastern Punjab receives much amount of rainfall as compare to the western part.

Punjab is rich in water resources due to rich aquifers and rivers. But in recent decades the water is going down under the surface and getting contaminated due to excessive use of chemicals in agriculture sector. Major water issues in Punjab-Some of the major issues of water resources in Punjab that need to be addressed are outlined by Sushil Gupta (2010); Ground Water Depletion due to overexploitation. Rising water table and water logging, Saline/ Brackish water and declining ground water quality.

3. Current Situations of Groundwater in Punjab

In the state of Punjab, there are several problems that are associated with ground water. Whereas a greater part of the state is facing declining ground water levels due to over-exploitation of the water resources, some part is facing the problem of water logging. There are cases of pollution of groundwater due to human activities. Disposal of untreated heavy metal contaminated effluents from manufactures has contaminated groundwater in industrial areas of the state. Industries and factories release untreated effluents directly to ground and to other water sources like rivers etc. That effected water is used in agricultural sector for irrigation; in that way contaminated water goes to fields and degraded the quality of water and soil.

Annual Ground water availability	21.44 BCM
Groundwater Extraction	31.16 BCM
Average level of Ground water development	145%
Very high level of groundwater extraction in districts of Fatehgarh Sahib, Amritsar, Jalandhar, Kapurthala, Ludhiana, Mansa, Moga, Nawanshahar, Patiala and Sangrur	144% to 254%
Ground water over-exploited blocks	103 out of 137
Critical blocks	5
Ground water over-exploited blocks in 1984	64
Ground water over- exploited blocks in 2006-07	103
Decline in level of ground water in the basin by CGWB	4.5 to 13.5
Area identified for recharging groundwater basin by CGWB	16450 Km ²
Waterlogged Area	200,000ha
Salinity Affected Area	1,000,000ha

Table 1. Current Situation of Groundwater in Punjab

Source: NAPCC 2011

Table 1 indicates that the annual groundwater availability is 21.44 BCM (Billion Cubic Meter) but the groundwater extraction is 31.16 BCM. Groundwater extraction is higher so groundwater level is depleting. Out of 137 blocks in the state there are 103 blocks which are under over exploiting category of groundwater extraction and out of these 5 blocks of central Punjab have critical situation. Whereas there were only 64 blocks in 1984, which were under the category of over-exploited groundwater but in

¹ http://www.global.ucsb.edu/punjab/journal_11_1/3_gosal.pdf.

² <http://agricoop.nic.in/kharif12.htm>. (national conference on agriculture for kharif campaign- 2012)

2006-07 the numbers has increased up to 103. The growing and developing agricultural activities is causing groundwater depletion because much more water is required in agriculture for irrigation crops especially like paddy. The depth of groundwater varies from 4.5 m to 13.5 m from the surface level in Punjab. There is some area facing the problems like water logging and salinity also. Total area under water logging conditions is 200,000 hectare on the one hand and total area under salinity is 1,000,000 hectare on the other hand. (NAPCC 2011).

3.1. Groundwater Depletion and water logging

The depth to ground water in a major part of the state ranges between 10 to 20 mbgl (meters below ground level) except in the south-western part where it is less than 5 mbgl. Depth to water level is more than 20 mbgl around major cities like Jalandhar, Ludhiana, Amritsar, Patiala, Fatehgarh Sahib, Nawashahar and Sangrur. Water levels are deeper than 50 m in the region of Garshamkar Block of Hoshiarpur district. Thus out of 50,362 sq. Km area of state, 39000 sq. Km area (78%) shows a decline in water levels. The decadal fluctuations in water level show that there is a fall in water levels lies between less than 2 meters to more than 4 meters (Gupta 2010).

3.1.1. Ground Water depletion trend

In the North-Central parts, the ground water levels range between 10 to 15 m. The north-eastern part of the state has groundwater depth ranges between 5 to 10 m. So, the critical situation is found mainly in North-central parts of the state. Depth of groundwater is lowest (1.12m) in Muksar and highest in (33.50m) in Ludhiana (NAPCC 2011).

Trend of declining water tables casts its shadow in North-Western region of the Country India. The bread basket states of the country mainly Punjab and Haryana, Which historically have had very rich aquifers and are considered as role models for green revolution, now suffering from the problem of declining ground water tables (Shekhri 2012).

Zones	District	Trend (decline) (in m/yr)
Zone I North Eastern Area	Hoshiarpur,	0.68-0.07
	Nawashahar	--
	Ropar	--
	Fatehgarh Sahib	0.025-0.58
	Patiala	0.5
Zone II North Central Area	Jalandhar	--
	Ludhiana	0.11-1.34
	Kapurthala	0.20-1.00
	Moga	0.20-1.00
	Mansa	--
	Sangrur	0.65
Zone III South Western Area	Faridkot	--
	Ferozpur	--
	Muksar	--
	Bathinda	--

Table 2: Groundwater depletion trend in Punjab
Source: NAPCC 2011

Table 2 Indicates that among the three major zones, North-Eastern zone, North-Central zone and South-Western zone, the trend of decline in groundwater level is higher in North-Central zone. The districts like Jalandhar, Ludhiana, Kapurthala, Moga, Mansa and Sangrur are experiencing more declines in groundwater per year. In the central Punjab, the decline in meters per year ranges between 0.11 to 1.34 m/year (NAPCC 2011). The much critical condition is found in the district Ludhiana, which has maximum depth of groundwater among the other districts of the state. The depth of groundwater is 33.50 m in Ludhiana District. In Ludhiana District water extraction is higher because, in this area water is used in agricultural sector as well as in Industrial sector. Ludhiana is highly industrialized district among other districts of Punjab. Ludhiana is famous for its Hosiery Industry which requires more water. The shallow groundwater level less than 5 m below ground level is seen in the south-western parts of the state. In these parts the problem of water-logging can be observed.

3.1.2. Reasons behind groundwater depletion and water logging

During 1960's, Punjab became the bread basket of the country as a result of adoption of new technology during the period of Green Revolution. In the beginning of Green Revolution, the strategy was to increase the production of food grains with the help of new technology, use of HYV seeds, use of Chemical Fertilizers, use of pesticides etc. without estimating the consequences of it. The extraction of groundwater through wells and tube wells have caused steep decline in level of groundwater in Punjab but Central & North Punjab affected badly. Punjab agriculture is primarily based on intensive irrigation using surface as well as groundwater resources, and rainfall hardly provides one-fifth of the irrigation requirements. The total surface water availability in Punjab is not sufficient to fulfill the irrigational needs of the state. In that sense, ground water is extracted through wells and tube

wells increased the use of ground water in many areas of the state. Consequently, the deficit in groundwater is mainly caused by over-exploitation of the groundwater reserves through tube wells for irrigation (Jeevandas et al. 2008).

After green revolution, the irrigated area in the state more than doubled between 1965 and 1995. Consequently, the area under major crops, which include rice, wheat, cotton, was irrigated by ground water sources mainly. The number of tube wells in the region has increased during last three decades for the requirements of agriculture. Groundwater extraction has resulted in over-exploitation of water and groundwater table declines up to 2 m in last 20 decades (Singh 2001).

As studied by B.D Dhawan in 1993, the four factors contributing to the declining tendency in the ground water table and increasing depletion of groundwater resource in Punjab, These are: Displacement of maize by paddy in farmers crop mix, increase in intensity of land use via reduction in seasonal following, a bad run of below-normal rainfall, increased lining of canal network at the territory level. While the first two factors lead to extra demand for groundwater, the last two factors decrease groundwater availability as such. The shallow groundwater level less than 5 m below ground level is seen in the south-western parts of the state. In these parts the problem of water-logging can be observed (Table 2).

The main factor of water depletion mainly in the central Punjab and problem of water logging in the South-Western Punjab is the difference in nature of aquifers and soil structure also. However, in south western parts, the thickness of fresh water aquifer is much less than other parts of the state because area is underlain by brackish/saline water. The thickness of fresh water sediments barring south western part is more than 350m (explored depth). In north eastern part of the State the thickness of fresh water sediments is greater than 450m (explored depth). In south western part the thickness of fresh water sediments varies from 10 to 200m, it decreases towards extreme south western corner of the State where it is less than 10m (Gupta 2010)

The other main reasons behind the water logging condition in southern Punjab is over irrigation, seepage of canal water in low-laying areas, less extraction of underground water. In the southern Punjab, there are mainly two crop combinations, Wheat-Rice and wheat-Cotton, these crops needs much water, so for that purpose surface water is much used as compare to groundwater. The nature of soils is sandy- clay and sandy-silt that they do not allow water to penetrate into depth under the earth surface and the condition of water logging has been created.

3.2 Declining water quality: Status and Causes

About 75-80 % of human requirements for water are fulfilled by groundwater. In recent studies it is observed that the use of inorganic fertilizers has resulted in increasing nitrate and related pollution in ground water (Singh 2001). The most common ground water quality as well as surface water quality problem is observed in the South-Western Punjab. These problems are mainly caused by natural constituents but mainly by human activities. These are high salinity, high levels of fluoride, and high levels of chloride and nitrate in ground water. The salinity levels increases from north-east to south-western districts of the state. The central part of the state have moderate to high salinity levels in the water. The block wise presence of high levels of fluoride, iron, total dissolved solid chloride and nitrate in the unconfined aquifers as observed by CGWB are given in the following tables: Table 3 indicates the presence of fluoride and nitrate in various blocks in Punjab. Among all the districts of Punjab, there are 7 districts which have high amount of fluoride content in water and those are Ferozepur, Fatehgarh Sahib, Mansa, Moga, Muktsar, Patiala and Sangrur. The maximum amount of fluoride, more than 11 mg/l, has been observed in the every blocks of district Sangrur. It can be well estimated that the presence of fluoride can be seen in the Malwa region of the state, because all these districts fall in the Malwa region. Table 4 indicates the presence of Nitrate in the various districts of Punjab. The presence of Nitrate is much more in the Malwa region as compared to fluoride. The highly affected districts are Bathinda, Faridkot, Ferozpur, Ludhiana, Mansa, Muktsar, Patiala, and Sangrur. In Sangrur district the contamination is very high.

District	Fluoride range (mg/l)
Ferozepur	1.63-3.4
Fatehgarh Sahib	1.54
Mansa	1.58-8.3
Moga	1.965.36
Muktsar	--
Patiala	2.05-2.80
Sangrur	1.71-11.30

Table 3: High levels of fluoride in various parts of Punjab
Source: NAPCC 2011

District	Nitrate Level mg/l
Bathinda	61-401
Faridkot	60-287
Ferozpur	69-241
Ludhiana	57-105
Mansa	70-206
Muksar	83-940
Patiala	47-52
Sangrur	107-1180

Table 4: High levels of Nitrate in Ground Water of Punjab
Source: NAPCC 2011

While fluoride and nitrate are also present in the groundwater of other districts in Punjab, but in above mentioned districts the conditions are much critical. Besides fluoride and nitrate, other chemical substances are present in the ground water which create contamination like chromium, uranium, cadmium and many other heavy metals.

Punjab is one of the most agriculturally productive regions of the world. Increased production and productivity that characterized the green revolution of the 1970s came about due to a combination of factors including expansion of irrigated areas by the development of surface and ground water resources and increased use of inputs, such as pesticides, herbicides and fertilizers. Since then, water supply has been threatened due to degradation of water quality, uncontrolled disposal of urban waste into open water bodies, poorly managed landfills and open dumps cause ground water contamination (Singh 1999).

In the industrial and urban fringe zones of cities, the subsoil water has already been polluted by industrial effluents. The wells near residential areas are contaminated with nitrate and detergents that comes out from households. The high fluoride content of groundwater has negative effects and is suspected to cause health hazard in the surrounding region (Singh 2001).

The CGWB reports that the concentrations of heavy metals, such as cadmium, lead, cyanide and chromium, exceed the permissible limits in the shallow aquifers of ground water, but arsenic concentrations were within the permissible limit in shallow water. But on the other hand, small quantities of such heavy metals were also traced in the deeper aquifers also. In the absence of proper modes of disposal, indiscriminate discharge of toxic effluents has caused serious pollution of ground water. The indiscriminate discharge of mercury along with industrial pollutants may result in significant accumulation of the metal in the aquatic environments.

4. Government Policies

State governments have introduced some policies with the objective to reverse the trends of falling ground water. One of the first policies that have been introduced across many states is mandated rainwater harvesting (Sekhri 2012). On 10 December 1996, India's Supreme Court directed the Union Ministry of Environment and Forests to empower the CGWB under the Environment Protection Act, 1986, against overexploitation of groundwater.

Punjab and Haryana are experiencing very rapid decline in their ground water tables. This can threaten future food security in the country also. One of the key initiatives undertaken in Punjab to slow down water table decline is delay of paddy transplanting up to 10 June of every year (Sekhri 2012). In 2006, the state government influenced the date of paddy transplanting by changing the date on which free electricity is supplied to the farm sector for operating mechanized tube wells for groundwater extraction. The date was extended to June 10, thereby reducing the amount of intensive watering that the crop can receive during its production cycle. The delayed date was mandated in 2008 via an ordinance by government. This was later turned into a law -The Punjab Preservation of Sub Soil Water Act, 2009. The main purpose of the law is to preserve groundwater by prohibiting sowing paddy before May 10 and transplanting paddy before June 10. According to this law government has authority to destroy, at the farmer's expense, paddy sowed or transplanted early, and the law assesses a penalty of 10,000 rupees per month, per hectare of land in violation of the law (Government of Punjab 2009).

Haryana passed its preservation of Sub-Soil Water Act in March 2009, and it is very similar to Punjab act. Its main provisions prohibit paddy before May 15 and transplanting paddy before June 15 (Sekhri 2012). The law includes destruction of paddy sowed or transplanted early a penalty of 10000 rupees per month per hectare of land in violation of the law (Government of Haryana, 2009). Such initiatives were taken by the State Government as well as by the Indian Government so that the water resources can be protected and the problem of groundwater resourced can be solved.

4.1. Ongoing Programs- Some water resources management programs which are in progress includes

- Irrigation, flood control and command Area development program;
- Farmers participatory action research program through institutions;
- Pilot schemes on artificial recharge to ground water;
- Watershed development program;
- Reclamation of the water logged areas;
- CGWA ground water management and regulation by CGWA;
- Water conservation component under NREGS.

5. Recommendations

Some of the following policy recommendations are made for sustainable groundwater use in Punjab:

- The water supply in areas with groundwater decline needs to be improved through artificial ground water discharge. The rain water may be an appropriate source for the additional recharge.
- Farm irrigation water management should be given first priority to enable maximum productivity per unit of water and avoid to development of water logging and soil salinity
- Such HYV seeds are used which need less amount of water and less amount of chemical fertilizers.
- Proper prices of crops should be given to farmers and proper information about new policies should be given.
- Many policies in context of ground water depletion exist in the state but the policies regarding water contamination are very few. So, the government should take all possible actions to control water contamination through various policy measures.

6. Conclusion

In Punjab, the water resources were abundant but after green revolution as the irrigation developed in the state the ground water is becoming scarce. Even the surface water by canals, rivers and rainwater could not meet the increasing demand of water in agriculture sector. Due to increasing use of chemical fertilizers, pesticides, herbicides and other chemical substances etc. the quality of ground water is degrading in the state. In some areas, due to over irrigation and the type of soil & aquifers are not favourable, so the conditions of water logging emerged. The whole state Punjab is suffering from many types of water related problems as studied. There is need to took some strict policies to resolve that problems. While the problems could not vanished totally but can be removed to some extent by Government and by the people. Awareness among people and Government response to any problem is must to resolve these problems.

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