Water Crisis: Issues and Challenges in Punjab

Ravishankar Kumar, Upma Vaid and Sunil Mittal

Abstract Punjab, an agricultural state of India, is facing a severe water crisis due to lesser annual rainfall than normal (700 mm) since 1998. Further, Punjab is not getting adequate amount of river water due to political reasons like Indus treaty, damming and diversion of river water, water conflict with Haryana, Rajasthan, and central government. However, the irrigation water demand (4.45 m ham) is significantly more than total irrigation water availability (3.04 m ham). Hence, in most parts of the Punjab state, groundwater is being overexploited for irrigational purpose. Apart from this water scarcity or depletion problem, water quality is also being deteriorated and not suitable for drinking purpose. Basic groundwater parameters such as salinity, electrical conductivity (EC), chloride (Cl^-), and nitrate (NO_3^-) have surpassed the maximum permissible limit in most of the parts of this state. Even toxic heavy metals [like selenium, uranium, arsenic, and lead] and pesticides have also been reported in groundwater samples of several regions of Punjab. Intake of this heavy metals and pesticides contaminated water is affecting the health of native people. The condition of groundwater depletion and quality deterioration is most severe in Malwa region of Punjab. The poor water quality and presence of toxic heavy metal may be linked with the prevailing health issues in this region. Government is taking several initiatives regarding this issue and passed the Punjab Preservation of Sub-Soil Water Act (2009). Government is also providing subsidy to individual farmer to lay down underground pipeline, drip and sprinklers systems for irrigation. Additionally, government is promoting and appreciating preventive measures like watershed management and rainwater harvesting.

Keywords Groundwater · Punjab · Heavy metals · Malwa region

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Introduction

Water is one of the fundamental resources and indispensable element of life on the earth. Out of total available water on earth, 97.2% water is saline and only 2.8% is fresh water. Even out of this 2.8% fresh water, 2.1% is found in the form of ice/glaciers, while only 0.37% is available in the form groundwater, and 0.02% as surface water. In surface water, 87% is in lakes, 11% is in swamps, and only remaining 2% is in rivers (Fig. 1).

In the last few decades, overpopulation, industrialization and vast agricultural practices are making situation more critical and it is becoming difficult to meet the water demand for drinking and other purposes. Worldwide, around one billion people are devoid of safe drinking water. Half of the world's wetlands have been lost since 1900. It can be predicted on the basis of increasing water demand and declining freshwater availability that future conflicts over water will may result into water wars.

India has 16% of the world's population but only 4% of the world's renewable water sources. Hence, it is a big challenge to meet the demand of safe drinking water of such a huge population with inadequate water resources. Therefore, in our country, unsafe water and lack of basic sanitation is causing several types of diseases and killing many people every year. Even almost 30,000 children under 5 years of age die every week due to consumption of unsafe water and unhygienic living conditions.

Punjab is called as breadbasket of nation. It is a cocktail of heavy agricultural practices and industrialization activities. Now, this Indian state is coming under threats of deficit of water recourses. The water table is falling rapidly and it is a serious matter of concern not only from state point of view also from national. Additionally, the water quality of the state is also deteriorating rapidly. The interesting similitude is found between the states of Punjab and California (USA) (The Tribune 2015). Both are world's leading food producing states; providing annually 30–50% of rice and 40–75% of wheat to the central food pool. But currently, both are facing identical problems related to the water required to irrigate cropland.

The state of emergency has been declared consecutively fourth year in California regarding water scarcity. Punjab is also facing water crisis situation, but not like California. However, if current condition continues then Punjab will also attain similar condition as California. The NASA (National Aeronautics and Space

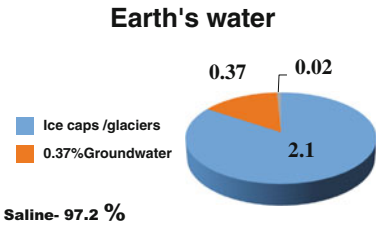

Fig. 1 Distribution of water on earth

Administration) have reported that beneath the earth surface level, water is disappearing in the Northern part of India (The Tribune 2015), especially in the states like Punjab and Haryana and if the same continues then there are chances to collapse agriculture system of that region. The aim of this paper is to assess the current situation of water crisis in Punjab and their challenges. So, the water crisis issues and their challenges of Punjab state are described in detail in this current assessment. Further, preventive measures adopted against the current situation and the initiatives taken by the Punjab government and other agencies have also been discussed.

Sources of Water and Their Status in Punjab

Groundwater

Agricultural activities of Punjab have heavy requirement of water for irrigation purpose. Rivers, groundwater, canal water and rainfall are the major sources of water in Punjab. Canal and tube wells are the main sources of irrigation. The dominancy of rice and wheat cropping system has overexploited groundwater resources, resulting in rapid decline of groundwater table of the entire state (approximately). Tube wells are the major source of over exploitation of underground water reserves. The number of tube wells in the state has been increased from 1.92 Lakhs in 1970 to 13.8 Lakh in 2011 (ENVISb 2015). Approximately, one tube well is there for every 2 ha in this state. The irrigation water demand (4.45 m ham) is significantly more than total irrigation water availability (3.04 m ham) (Table 1). The estimated net available groundwater is around 20.35 Billion Cubic Meter (BCM), which is less than annual demand 34.66 BCM (Fig. 2). The annual deficit of groundwater is determined as 14.31 BCM (CGWB 2016; ENVISb 2015; SOE Punjab 2007).

Eighty percent of the total geographical area of the state (110 blocks) is categorized as overexploited, 3% area (5 blocks) as critical and semi-critical, whereas only 17% area (23 Blocks) is under safe category for groundwater development (CGWB 2009) (Fig. 3). During 2008–2012, the water table all across the state has receded at average annual rate of 0.70 m (Fig. 4) and range of water table decline varies from 0.10 to 4.0 m (Jain 2013). Sangrur and Patiala are the most affected districts in concern of water table. However, the water table is rising in some southwestern parts of the state. The reason behind that in those regions,

Table 1 Status of water in Punjab (*Source* CGWB 2009 ; ENVISb 2015; ENVIS Newsletter 2014–2015; SOE Punjab 2007)

Irrigation water demand	4.45 m ham
Surface water availability	1.43 m ham
Annual replenishable recharge	1.61 m ham
Total irrigation water availability	3.04 m ham
Irrigation water deficit	1.41 m ham

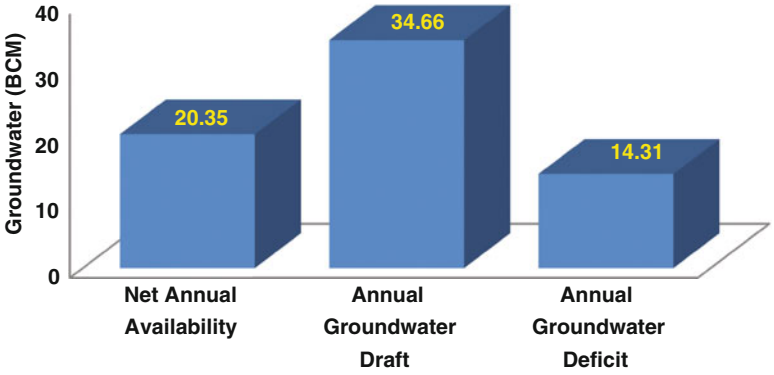

Fig. 2 Status of ground water resources of Punjab. *Source* Central Groundwater Board, Chandigarh (2009)

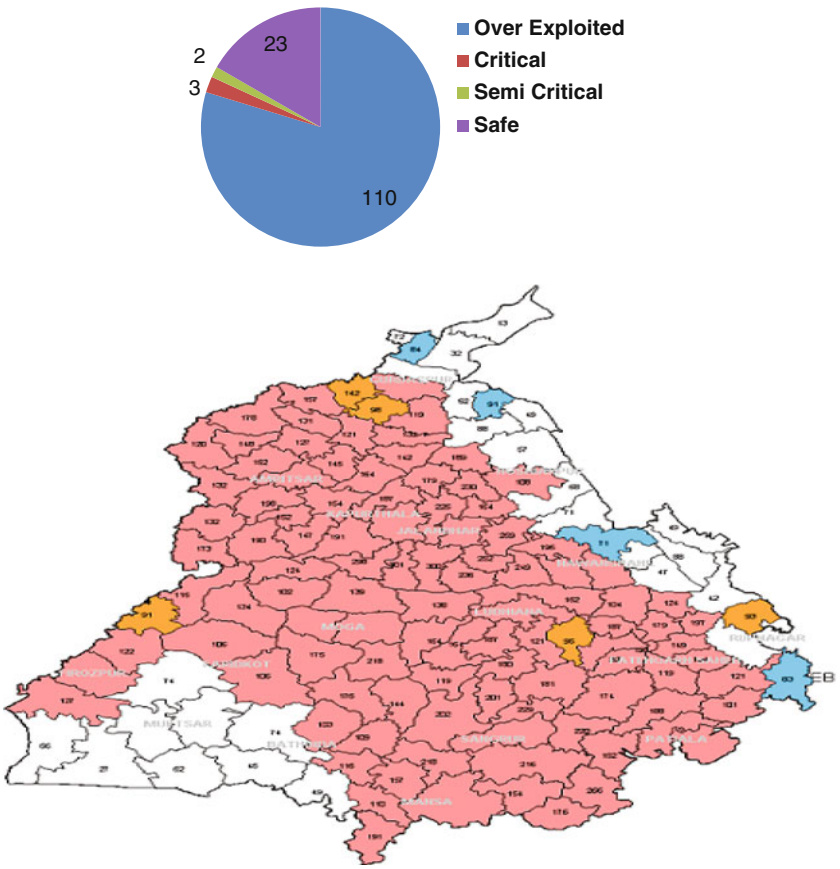

Fig. 3 Categorization of blocks in Punjab based on ground water development. *Source* Central Ground Water Board (2009)

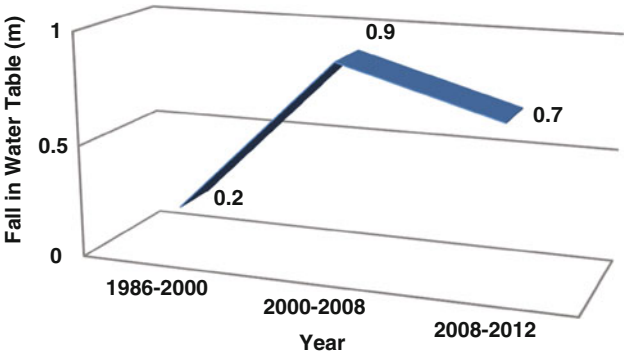

Fig. 4 Decline in water table (in meters) in Punjab. *Source* Jain (2013)

Table 2 Deficit monsoon rainfall year Punjab (2005–2014)

Monsoon year	Actual (mm)	Normal (mm)	Deficit %
2005	445.1	501.8	−11.3
2006	436.5	501.8	−13.0
2007	340.4	501.8	−32.2
2008	603.7	501.8	+20.3
2009	323.6	501.8	−35.5
2010	458.2	496.4	−7.5
2011	459.2	496.4	−7.5
2012	266.0	496.3	−46.4
2013	477.9	491.5	−2.8
2014	243.9	491.5	−50.4

Source Indian Metrological Department, Ministry of Earth Sciences, Session Report (2014)

groundwater extraction is limited for irrigation purposes due to brackish and saline quality of water.

Rainfall

The status of rainfall is less than normal (700 mm) since 1998. The state faced a severe drought due to low rainfall in this region. After 2005, the state is facing continuous low rainfall problems (Indian Metrological Department 2014). Except 2008, the rainfall was always below average in the state since 2004 (Table 2).

Table 3 Canal networks of Punjab (*Source* Department of Irrigation, Punjab)

S. No.	Name of canal system	Length of main canal (in km)
1	Sirhind Canal	59.44
2	Bist Doab Canal	43.00
3	Upper Bari Doab Canal	42.35
4	Sirhind Feeder	136.53
5	Eastern Canal	8.02
6	Bhakra Main line	161.36
7	Shahnehar Canal	24.23

Rivers and Canal

Beas, Chenab, Jhelum, Ravi, and Sutlej are the main rivers of Punjab state. All rivers are tributaries of river Indus. These five rivers are divided between India and Pakistan. However out of five, three rivers Sutluj, Beas, and Ravi flow through the Indian state of Punjab. Area of Punjab between rivers of Beas and Sutluj is called Doaba, which includes Jalandhar, Hoshiarpur, and Nawanshahr. The area of Majha lies between Beas and Chenab and also at both the sides of Ravi. The Majha part is called heart of Punjab and includes Amritsar, Gurdaspur, Faridkot, and Ferozepur cities. Malwa region is located in southern Punjab at range of Sutluj River and the major cities include Ludhiana, Patiala, Sangrur, Malerkotla, Shahabad, and Abohar. Although, Punjab has one of the largest canal systems of the country, but this state is not getting adequate amount of river water due to political reasons, i.e., Indus treaty, damming and diversion of river water, water conflict with Haryana, Rajasthan, and central government. Almost 30.88 lakh hectare of the cultivated area comes under canal networks. The estimation of river water is approximately 14.22 MAF, distributed into 7th main canal system of this state (Department of Irrigation, Punjab) (Table 3).

Further, an inadequate amount of rainfall is the major reason for the deficiency of required amount of water in the rivers as well as canals. The insufficient amount of canal water for irrigation purpose leads to overexploitation of groundwater.

Water Quality and Health Issues

Apart from depletion of water, quality of groundwater is also not suitable for drinking purposes. Rapid increases in population, urbanization, industrialization, and extensive agricultural practices have deteriorated water quality of this region. The intense agricultural activities of Punjab help to achieve national food security. But, large quantity of fertilizers and pesticides being used for better and enhanced crop yield, are also contaminating both groundwater as well as surface water bodies (Aulakh et al. 2009). Pesticides adversely affect human health and linked to certain

Table 4 Status of physicochemical parameters of districts of Punjab (*Source* ENVISa 2015a)

Contaminants	Districts affected (in part)
Salinity (EC > 3000 µS/cm at 25 °C)	Firozepur, Faridkot, Bhathinda, Mansa, Muktsar, Sangrur
Fluoride (>1.5 mg/l)	Amritsar, Bhatinda, Faridkot, Patiala, Fatehgarh Sahib, Firozepur, Sangrur, Gurdaspur, Mansa, Moga, Muktsar,
Chloride (>1000 mg/l)	Firozepur, Muktsar
Iron (>1.0 mg/l)	Bhathinda, Faridkot, Fatehgarh Sahib, Firozepur, Gurdaspur, Mansa, Hoshiarpur, Rupnagar, Sangrur
Nitrate (>45 mg/l)	Bhathinda, Faridkot, Fatehgarh Sahib, Firozepur, Gurdaspur, Patiala, Hoshiarpur, Jalandhar, Kapurthala, Ludhiana, Mansa, Moga, Muktsar, NawanShaher, Rupnagar, Sangrur

Table 5 Health effect of polluted water in Punjab (*Source* Bajwa et al. 2015; CGWB 2012 & 2016; Hundal et al. 2007, 2009; Hundal and Khurana 2013; Kochhar et al. 2007; Kumar 2005; Sharma 2012; Singh et al. 2003; Singh et al. 2013; Swarup et al. 1992)

Metals	Health effects	Reported areas of Punjab
Mercury	Abdominal pain, headache, diarrhea, haemolysis, chest problems	Presence in Budhanala water sample
Lead	Anemia, vomiting, loss of appetite, convulsions, damage of brain, liver and kidney	Highly reported in Bathinda and Ropar area
Arsenic	Lung cancer, disturbed peripheral circulation, metal problems, liver cirrhosis, hyper kurtosis, gastrointestinal tract ulcers, kidney damage	Bathinda and Mansa
Cadmium	Growth retardation, diarrhea, bone deformality, kidney damage, testicular atrophy, anemia, injury of central nervous system and liver, hypertension	In Canal water of Aboher and Bathinda area
Selenium	Damage of liver, kidney and spleen, fever, nervousness, vomiting, blood pressure, blindness, and even death	Ferojpur, Bathinda, Mukatsar District
Chromium (hexavalent)	Diseases in central nervous system, cancer, diarrhea, nephritis gastrointestinal ulceration	Scarce amount detection in some places of Malwa region
Uranium	Cancer, Infertility, diseases in central nervous system, mental abnormalities	Mostly in Villages of Bathinda, Firojpur, Mansa, and Sangrur District

types of abnormalities (Mittal et al. 2014). The enhanced level of basic physico-chemical characteristics is detected in several districts of Punjab (Table 4). Contaminated water causes serious health hazards and people of this region are affected by various water-borne diseases (Table 5).

As per reports of Central Groundwater Water Board, water quality of rivers is being degraded at several locations. Ghaggar River flows during monsoon rains and the water quality of this river is generally observed worst at all locations. After that, deterioration in water quality of Sutluj and Beas rivers by discharge of industrial effluents and municipal waste has also been reported. Water-borne diseases have been reported in Moga, Jalandhar, and Barnala locations due to the presence of microorganisms in water (CGWB, Ministry of Water Resources Report 2014).

The groundwater pollution has crossed all the limits established by various national and international agencies. Several reports have already described the presence of high content of nitrate, fluoride, total dissolve solids, electric conductivity, chloride, and sulfate in the groundwater of this region. The presence of toxic heavy metals like arsenic (As), uranium (U), lead (Pb), cadmium (Cd) and selenium (Se) has also been reported in groundwater (Bajwa et al. 2015; CGWB 2007, 2011; Hundal et al. 2007, 2009; Hundal and Khurana 2013; Sharma 2012; Singh et al. 2013).

Heavy metals like As and Pb are classified as the carcinogenic chemical by WHO. Further, in case of U, reports suggested that its radiological risks may be linked with cancer. Due to the extensive deterioration of groundwater, the Malwa region of Punjab is facing serious health issues. The presence of U and As like carcinogenic chemicals of this region indicates their probable link with health issues (Bajwa et al. 2015; Blaurock-Busch et al. 2014; Sharma et al. 2013; Singh et al. 2013). The presence of U concentration in the hair samples of breast cancer patients was reported in this region (Blaurock-Busch et al. 2014). Not only anthropogenic activities, the natural geomorphologic structure of this region is also responsible for deterioration of water quality (Kochhar et al. 2007; Bajwa et al. 2015).

The water quality of canal system is considered better and more suitable for human consumption than groundwater of this region. So, Punjab government has decided to give more emphasis on use of canal water as portable water. Moga and Barnala districts have been chosen under 300-crore pilot project, to set up conventional water treatment plant for supplying potable water to residents of the villages affected by toxic heavy metals problems like arsenic and uranium.

Government Initiatives

The Central Ground Water Board, Punjab Irrigation Department and Agriculture Department have been monitoring the rapidly declining water table as well as water quality for the past many years. Further, various other central and state departments as well as R&D institutions are actively engaged in water quality assessment and monitoring. In 2012, the Central Ground Water Authority has notified 45 blocks in this state for restricting and banning the construction of new structures for extraction of groundwater for any use other than drinking. The government of Punjab took several initiatives regarding this issue and passed the Punjab Preservation of

Sub-Soil Water Act (2009) for saving water resources. According to this act, nursery of paddy should not be sown by the farmers before the 10th day of May and transplantation should not be done before the 16th day of June. The government of Punjab has taken initiatives to provide subsidy to the individual farmer to lay down underground pipelines, drip, and sprinkler systems. Additionally, government is promoting and appreciating preventive measures like watershed management and rainwater harvesting. Department of soil and water conservation of Punjab has successfully established Sahoran Kandi watershed (village Sahoran) and Fatehpur Kangar sub-watershed (Mohilpur block) in Hoshiarpur district under National Watershed Development Project for rainfed areas of integrated development. In other parts of Punjab like Kandi region, watershed development process is progress. The drainage project has been successfully established in village Mehatpur Oladini in Nawanshahar district and water table is rising after implementation. Four rainwater harvesting dams are built and the resultant of that 180 ha area is benefited (http://dswcpunjab.gov.in/contents/successstories.htm). In most of the drought-affected parts of Patiala, Sangrur, and Ropar, groundwater recharging projects are started by central groundwater board. Especially in Patiala district, a massive project for groundwater recharge is in progress.

Future Prospects

The preventive measures taken by the concerned authorities to meet the challanges regarding water related issues are insufficient. Now, time demands to take effective preventive measures massively to regulate the water usage and to introduce the water-saving measures like sprinkling system, rainwater harvesting, and underground piping system for irrigation on a large scale. The canal system requires to be revamped. The regulation or check on the farm and industrial sector on pumping out water should be imposed because almost more than 3 crore gallons of water is pumped out by industries in Ludhiana alone. The state government should constitute Water Regulatory Authority and also promote less water-consuming crops such as maize and sunflower. Role of public investment in water sector should be examined. The penalty or punisment should be strictly imposed on the person or industries, involved in contamination and wastage of water. The political reasons should be removed and the implementation of government policies should be done effectively with zero tolerance.

Conclusions

Rivers, canals, rainfall, and groundwater are main sources of irrigation in agricultural state of Punjab. The insufficient amount of rainfall is responsible for inadequate amount of water in rivers and canals. As a result, groundwater is

being overexploited. This overexploitation of groundwater resources is a serious matter of concern. Almost all the drinking water parameter values exceed the acceptable limits in case of groundwater. The higher concentration of U, As and Pb like carcinogenic chemicals in groundwater may pose health risk to the local population of this region. Though efforts are being made by the concerned authorities to combat these issues and challenges, but there is an urgent need to take effective measures massively to regulate usage of water. Water-saving measures such as drip irrigation, sprinkling system, rainwater harvesting and underground piping system should be preferred for irrigation on a large scale. The canal system requires to be revamped. The state government should constitute Water Regulatory Authority and also promote less water-consuming crops such as maize and sunflower. Role of public investment in water should be examined. Hence, there must be strong regulations or check on pumping out groundwater by farming at farm and industrial sector. There must be some penalties to the persons or industries involved, in contaminating and wastage of water. The government policies should be implemented effectively with zero tolerance.

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