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Water Resources Problems and Management in Perspective of Punjab (India)

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Abstract: The state of Punjab is a major consumer of water for agricultural purposes, primarily on account of rice-wheat cropping pattern. The problem of declining water table, especially in central Punjab; deterioration in quality of groundwater on account of its excessive extraction, heavy use of chemical fertilizers and pesticides are spreading fast. High residues of pesticides found in food, fodder, water, milk, fruit and vegetables has led to many health problems. The paper discusses the problems of declining groundwater table and quality related problems of Punjab. It suggests the various techniques of rainwater harvesting and groundwater recharge to maintain the production level and water reserve of Punjab. A model of rainwater harvesting for potable water is also outlined to tackle the water quality problems. Though some of the technique described in this paper were developed for arid region of Rajasthan but are equally effective for state of Punjab as well.

Keywords: Water quality; Rainwater harvesting; Groundwater recharge; Micro-catchment; Punjab

INTRODUCTION

Water is one of the unique resources available on our planet. Water is essential for sustaining all forms of life on the earth. All human activities including food production, economic development and others are dependent on the availability of water. Good quality potable water is a global necessity. The principal source of water for all the water resources is precipitation. Water resources consists of both surface water and ground water resources. More than 70% of available water resources are used for the agriculture. With rapid growth in population and improving living standards, the pressure on available water resources is increasing and per capita availability of water resources is decreasing day by day. The per capita availability of water in India has dropped from 5300 m^3 in the year 1955 to 2200 m^3 in the year 2000 compared to 7420 m^3 world and 3250 m^3 Asian average for the same. The overall national availability of water may not pose a serious problem in near future, but there would be a severe shortage of water in many regions. In India 60.5% area is under rainfed agriculture and remaining 39.5% area is irrigated. The state of Punjab leads with its 97% area under irrigation and contributed nearly 60% of wheat and 40% of rice to the central pool for the past four decades (Hira, 2009).

In Punjab total estimated water availability from canal and groundwater is 1.45 M-ha-m and 1.68 M ha-m respectively which makes the total availability of water to be 3.13 M-ha-m (Prihar *et al.*, 1993). The crop-water demand has been estimated to be 4.40 M ha-m, thus leaving an annual deficit of about 1.27 M-ha-m. The deficit of water demand is being met by groundwater extraction leading to rapid declination of groundwater. The number of tube wells has increased from 0.192 to 1.165 million in the last 35 years (Aggarwal *et al.*, 2009). Groundwater is declining at a very fast rate in the central plain region of Punjab, comprising about 80% area of the state. Water table in the central districts of Punjab is falling at an average rate of 55 cm yr^{-1}. (Kaushal, 2009). The stage of ground water development for the State as a whole is 145% and the State falls under "over- exploited" category.

Beside depletion of groundwater, quality of water is another important issue. As per Punjab Remote Sensing Centre (Punjab Agriculture University, Ludhiana) and National Bureau of Soil Survey and use planning survey, very high concentration of sodium carbonate and salinity in tube well water were reported. About 7.7% ground water in Punjab is totally unfit, 5.3% has high salt contents and 42.1% contains sodium bicarbonate and and 57% of ground water is unfit for irrigation. Another reason for poor quality of groundwater is excessive use of chemical fertilizers and pesticides. Punjab is highest is india for use of Chemical fertilizer (10%) and Pesticides (18%). High residues of pesticides found in food, fodder, water, milk, fruit and vegetables is leading to many health problems.

THE PROBLEMS

Water resource problems of Punjab can be broadly classified in two categories i.e. quantity and quality. Punjab agriculture is today facing the problem of deteriorating water quality and depleting underground water resources. The state of the World report, 1998 by the World Watch Institute in USA estimates that the gap between water use and sustainable yield of the aquifer is so high that the aquifer under Punjab could be depleted by the year 2025. The shortage of water and consequently more withdrawal of groundwater further worsening quality. In Punjab about 3058 km^2 area is underlain by saline groundwater with EC >$4dSm^{-1}$. Beside this, excessive use of chemical fertilizers and pesticides is further adding to environmental pollution. The problem is most critical in central Punjab. Farmers are having a hard time finding ground water to grow their crops. Beside these problems water logging due to excessive irrigation and salinity due to use of poor quality groundwater is also reported from many areas. These issue needs to be address immediately.

MANAGEMENT STRATEGIES

The root cause of water resources problems of Punjab is scarcity of water to maintain the present level of crop production. Scarcity of water leads to further exploitation of groundwater resources. The overexploitation of groundwater resources further deteriorates the quality of water, increased energy requirement for lifting water, salinity due irrigation with poor quality water and consequently reduction in yields. The water resource problems of Punjab can be address by two approaches namely by increasing the availability of water through rainwater harvesting and subsequently augmenting the recharge of groundwater aquifers and by increasing the water use efficiency.

Rainwater harvesting

Rainwater harvesting, its conservation and efficient utilization can solve the problem of water scarcity to the greater extend. Punjab covers a geographical area of 5.036 m ha, currently comprising of 17 districts and 137 blocks. The average annual rainfall in the state varies from 1000 mm in the northeast to 250 mm in the southwest with over all average of 649 mm. About seventy per cent of rainfall is received during the monsoon period (i.e. July– September). Punjab has a huge potential for rainwater harvesting. About 10% of the total geographical area of the state comprising of Shivalik foothills known as Kandi area. The average rainfall in this area varies from 1000 mm to 1200 mm; the irrigated area (20%) is far below than the rest of the state where more than 97% of the area is under assured irrigation. Therefore, the management of rainwater in this region is a key to environmental, economical & social sustainability. Rainwater harvesting include rooftop rainwater harvesting and surface runoff harvesting through check-dams, anicuts etc. Khepar (2001) has reported that by land-leveling, bench terracing and installing rainwater harvesting structures, the water balance of Kandi area has increased from (–) 97867 ha-m to (+) 52075 ha-m, thereby raising the water table at a rate of 5.9 cm per year during the period 1979–98. Therefore intensive rainwater harvesting on extensive basis can substantially improve the water reserve on sustainable basis.

Groundwater recharge

Groundwater can be broadly partitioned into two parts i.e. static and dynamic water reserve. Static groundwater is nature's inherent reserve and is accumulated over centuries during wetter period. Static water reserve depends on type and nature of the aquifer while dynamic reserve is average long term recharge by the precipitation. The recharge process in nature is very slow. Ideally only dynamic groundwater reserve should be used for irrigation or other purposes. Dynamic groundwater reserve are replenishable by the rainfall however when extraction exceeds this limit then groundwater table declines permanently. During last ten years a decline in groundwater table was reported from most parts of Punjab. According to Water Resources and Environment Directorate, Punjab Irrigation Department out of a total of 137 blocks, only 25 have been found safe with 103 of them being overexploited, five being critical and four in a semi-critical state. With increasing demand for water, more and more blocks are likely to be in the category of over exploited and needs immediate attention for recharge of ground water.

The decline in water table can be arrested by either restricting the groundwater draft or increasing the groundwater recharge. Percolation tanks, pondage in stock tanks with infiltration galleries, sand filled dam, anicuts across the stream, sub-surface barriers etc. are very effective measures for groundwater recharge (Ojasvi *et al.* 1996; Goyal, 1999). Bhati *et al.,* (1997) has reported a rise in groundwater table @ 0.33m to 0.75m year^{-1} due to adoption of conservation measures like anicuts, loose stone check dams, brush wood check dam etc. in a watershed area located in hot arid zone of Rajasthan. In an another watershed, conservation measures like loose stone check dams; vegetative barriers and anicuts resulted rise in water table by 1.1 m indicating the effectiveness of conservation measures for the recharge of ground water (Gupta *et al.*, 2000). Sub-surface barrier constructed across ephemeral streams traps sub-surface flow to recharge groundwater aquifer (Khan, 1998). Construction of two sub-surface barrier of 10 m length each within 300 m from water supply well was found enough to store runoff water required for a village having a population of 500 people (Anon., 1974). Singh *et al.*, (1989) reported that soil conservation practices have increased recharge to an extent of 14.02 to 19.52 % of rainfall in Udaipur region. An integrated approach of reduced groundwater draft by adoption of improved agronomic practices and increased groundwater potential by artificial recharge can be very effective in controlling the decline of groundwater table (Khepar *et al.*, 1996). Artificial recharge can be achieved by constructing various types of checking structures across the existing drainage network, the renovation of village ponds to increase their recharging capacity (Chawla *et al.*, 2002), harvesting rooftop rainwater in urban areas by injection/percolation wells/ trenches and using surplus canal water at the escapes for artificial recharge during periods of lean water requirement. By adoption of appropriate measures groundwater recharge can be augmented and the process of groundwater depletion can be halted. Groundwater recharge not only adds to dynamic groundwater reserve but will also improve the quality of water.

Reducing losses

Evaporation accounts for over two third of water losses from surface water bodies in hot climate. Reducing surface area by increasing storage depth can appreciably reduce water losses. The surface area can also be reduced by storing the water in a compartmented reservoir, and pumping the water from one compartment to another as the water is used, so that there are some full compartments and some empty, instead of a single shallow sheet when the reservoir is partly used. Covering the field with any kind of mulch also helps in reduction of evaporation losses from the surface. Evaporation loss can also be minimized by reducing wind velocity through shelter-belts of suitable tree species around water bodies or by artificially shading of water surfaces. Studies on artificial shading of water surface have shown encouraging results in controlling evaporation losses. Shading of water surface with polyethylene sheet successfully reduced evaporation by 91%. Evaporation reduction with floating materials ranged from 37% for *Saccharum munja* to 82% for polystyrene sheet. Foamed rubber sheet, polyethylene sheet and bamboo reduced evaporation by 74%, 66% and 53%, respectively. The floating polystyrene sheet and polyethylene covers were the most economical (Khan and Issac, 1990). The micro-irrigation systems like drip and sprinkler economize both water and fertilizers. These systems could be popularized to increase the productivity of limited rainwater.

Tree collars

Tree improves the surrounding environment. The main problem associated with tree establishment is the initial survival. Once tree attains an age of 2-3 years it generally doesn't require special care. The main cause for the failure of tree in the initial stage is scarcity of water. However planting tree with micro-catchment significantly improves the survival and growth. Saucer shaped circular micro-catchment of 3-5 m^2 area with inward slope and tree in the centre proves to be excellent for the survival and growth (Gupta, 1984, Sharma *et al.,* 1986; Gupta *et al.,* 1997). V-shaped micro-catchment with plantation of tree in the center of notch followed by mulching by trash may also helps in harvesting and conservation of runoff water.

Water-harvesting system of circular and elliptical catchments (7.07 m^2) for establishment of *ber* trees lined with sand-filled used polythene carry bags, stone pieces, waste marble pieces and newspapers to induce runoff show improvement in plant height by 33.3%, 25%, 25% and 8.3% in comparison to unlined catchments. The soil moisture in the 90 cm profile at the end of season was highest in stone lined (78.6 mm) followed by marble (75.6 mm) and least in the control catchment (Ojasvi *et al.,* 1999) thus 40-60% higher survival over control with different lining materials. Similarly, micro-catchments produced 13 to 32% of rainfall as runoff at 0.5% slope; and 36 to 45% higher runoff at 5% inward slope of micro-catchment and proved useful (Sharma, 1986; Sharma *et al.,* 1986). Compaction of micro-catchment and lining with polythene sheet can further help in establishment of trees.

FLOOD MANAGEMENT

As per Rashtriya Barh Ayog (constituted by the Government of India in 1976) report (1980) out of total geographical area of 5.036 m ha of Punjab, 3.7 m ha is flood prone making it most flood affected state of the India. Flash floods are common in the south-eastern parts of the state. Though annual average rainfall in Punjab has decreased from 739.1 mm in 1980 to 565.9 mm in 2005. However, declining trend has affected the use of seasonal drains. Seasonal flow through these drains has either completely stopped or reduced drastically. Taking advantage of the situation, inhabitants began encroaching on these drains and ultimately most of them have completely disappeared (Vashisht, 2009). In event of good rainfall these drains overflows and causes flood like situations.

Several districts of Punjab and Haryana faced the flood following heavy rains in the year 2010. Canals have breached, national highways are flooded and rivers are flowing over the danger mark. Although floods are considered a natural calamity, however, if the excess flood water or its part can be managed and utilized for rejuvenating the depleted aquifers as well as improving surface water resources the problem of water scarcity during droughts can be solved. Harvesting and conservation of floodwater to rejuvenate the depleted aquifers by adopting artificial recharge techniques will remarkably improve the water availability for growing population.

POTABLE WATER

While the water for drinking is the first priority for sustenance and survival, its quality is very important for sustained health. In developing world 80% of the diseases are caused due to the poor quality of drinking water. The quality of ground water has become vulnerable in the number of villages of Punjab due to intensive use of agricultural chemicals and fertilizers, increased urbanization and industrialization. Rainwater is the purest form of water. Appropriate harvesting of rainwater from roof top and open and its utilization can sustainable resource for drinking water. Studies conducted at Central Arid Zone Research Institute- Jodhpur (CAZRI) have revealed that roof made of different materials can generate 50- 80% runoff that can be stored in underground cistern (*tanka*) which could provide excellent drinking water round the year. Rainwater can also be harvested in *tanka* using artificially prepared catchment.

CAZRI has designed improved *tankas* for individual family to community with capacities of 5,000 to 600,000 litres. Vangani *et al.,* (1988) have observed that an individual family tanka is better managed than a community *tanka*. The improved *tankas* include silt traps at the inlets to prevent pollutants from entering the *tanka*. The improved designs have a lifespan of more than 20 years. Planting of suitable tree species around the periphery of the catchment area of a *tanka* is recommended to improve the local environment (Bhati *et al.,* 1997). The improved *tanka* design developed by CAZRI has been widely replicated under Rajeev Gandhi National Drinking Water Mission. *Tanka* is economical compared to the expenditure incurred on various disease caused by drinking polluted water.

CONCLUSIONS

The issue of decline in water table and deterioration in water quality is required to be given proper attention and priority. There is an urgent need for proper water management. The adoption of technologies like rainwater harvesting through rooftops, surface runoff harvesting through *tanka*, village ponds, artificial groundwater recharge through anicuts, check-dams, injectionwell/inverted well etc., are expected to imrove the water base of the state. The other strategies should include crop diversification and enhanced water use efficiency and improved agronomic practices for long term sustainable production.

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