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Irrigation and India Agriculture: Difficulties and Options

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ABSTRACT: The rapidly increasing population of India needs increase in food production and water consumption however land is limited. Agriculture links to food security, development and growth in rural areas, nutrition and health security, however it is the largest water user sector in a developing country like India. The availability of water for irrigation purpose, domestic and industrial uses are decreasing with an alarming rate. However, irrigation is a major factor contributing to poverty alleviation in the country because yield is higher in the irrigated areas of country. Realizing this, the adoption of advance irrigation techniques like drip irrigation, treated waste water utilization, control over ground water exploitation, growing of water efficient crops, rain water harvesting, rehabilitation and modernization of existing canal projects, generating awareness about the water in the country and ultimately maximize yield per unit of water and saving water for our future generation are major issues. This paper highlights challenges of irrigation water in India and its management.

Keywords: Agriculture, Irrigation water, irrigation techniques, water conservation.

INTRODUCTION

Water is accepted as a natural wealth of a country and a basic human need (Ministry of water resources, GOI, 2002). Although the water content on earth is abundant but its 97 percent is salty, which can be made accessible after desalination (still we don't have any efficient way of desalinization) and the remaining 2.5 percent is freshwater that is frozen as glaciers or stored as groundwater, and only less than 1% of all water is for human consumption (Oki and Kanae, 2006). Thus, most portion of water is unsuitable for use. In Indian situations water is characterized by its highly uneven spatial distribution, so crisis of water resources arises and its efficient management becomes a major challenge for a country like India (Nautiyal, 2017). Accordingly, the importance of water must be recognized and emphasis needed to be given on its economic use and better management. India has about 17% of the world's population whereas fresh water assets are only 4 % (Dhawan, 2017). Population of India is rapidly increasing that continuously increasing pressure on the food supply and the environment. Climate crisis also become a major threat that going to affects water supply in the near future (Bates *et al.*, 2008; Vorosmarty *et al.*, 2000). The high alerts and sensitivity of semiarid and arid regions of the world to climate emergency, along with the already existing water crisis driven by development in agricultural and industrial sector and urbanization (Intergovernmental Panel on Climate Change, 2007). Struggle for water is increasing and environmental degradation concerned with water usage is serious. The increasing demands of water by industrial and agricultural sector along with its diminishing quality because of pollution and over extraction have led to a condition where the consumption of water is rapidly increasing however its supply is continuously decreasing (Darshna *et al,.* 2015. In most parts of the India, water table is declining with an alarming rate 1-2 m/year (Singh and Singh, 2002). However, with development in agriculture and irrigation, according to the reports of Composite Water Management Index 2.0 report, released by NITI Aayog of India in August 2019, the total irrigated command area was increased from 55.38 million hectares in 2015-16 to 63.94 million hectares in 2017-18. According to Hazell, 2010 and Bhattarai *et al,.* 2002 the success of green revolution in Asia was credited to the availability of irrigation water that became major factor for the significant productivity gains during green revolution. Because of all the efforts in development of canal systems, dams and underground water pumping, according data of World Fact book of the Central Intelligence Agency, 2012, India was among top three irrigated countries in the world.

Table 1: Top three irrigators of world.

S. No.	Country/Region	Irrigated land (km^2)
1	China	690,070
2	India	667,000
3	United States	264,000

(Source: World Fact book of the Central Intelligence Agency, 2012)

However, the groundwater reduction (the quantity of water removed from aquifers exceeds the amount that is replenish naturally) was increased by 23 percent between 2000 and 2010 (Dalin *et al.*, 2017). India is among the four largest water consumers for agriculture along with China, USA and Pakistan that together account for 58 % of the total water consumption related to crop production worldwide (Mekonnan and Hoekstra, 2011). Agriculture is a significant user of water resources in India (Fig 1), so if water scarcity will occur, it will definitely affect agriculture and it will be difficult to feed such a large population of a country like India. Additionally, overuse of water will cause future water crisis and harms the environment in many ways such as nutrient

pollution, increased salinity, destruction of part of the floodplains and wetlands. As per reports of OECD 2012, India may face severe water crisis by 2050. According to reports Ministry of water resource, GOI, 2017, less than 1700 cubic meters annual per-capita water accessibility referred as water-scarce situation, while annual per- capita water availability of India in the years 2001 was 1820 cubic meter which in 2011 become 1545 cubic meters and that may decline in the years 2025 and 2050 to 1341 and 1140, respectively.

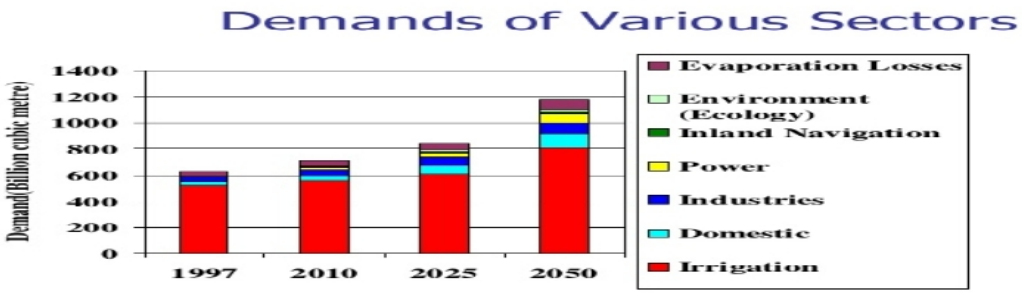

Fig. 1. Demand of water by various sectors in India (Jeyaseelan, 2014).

The irrigation system in India is well developed but it is characterized by high levels of inefficient water use (OECD/FAO, 2014). The poorly maintained canals of India draw four times more water from the rivers than what they actually delivered to agriculture lands and situation of water utilization efficiency of canals is less than 30% in the idle cases and half of that quantity in poorest (Sen, 2018). Despite some promising initiatives and efforts the present irrigation situation is far from satisfactory; these are characterized by less than optimum irrigation efficiency, low popularity of advanced micro irrigation in canal command area, poor water use efficiency systems, overexploitation of groundwater resources and extensive use of water-intensive crops and poor management of freshwater resources. As much as 8 percent of agricultural crops grown are using groundwater heavily than its replenishment, and most of the rivers are diverted so heavily for canals that most of the year they don't reach the sea and with high rate of urbanization as the urban population may reach to five billion by 2025, farmers will face more competition for water resources with cities and industries (West, 2006). There is urgent need of proper strategies for efficient management highly scarce water resources. This paper reviews the present status of irrigation water in agriculture and how India can attempt to move towards water conservation and its efficient management.

IMPROVEMENT IN IRRIGATION TECHNIQUES AND ITS IMPACT

The basic principle behind crop water management is to find out the actual water requirement as accurately as possible. In this contest, the farmer's organization needs to encourage scientific technological means for improving water use efficiency in farm lands, for this there is need of funding for development in better efficient irrigation systems and transfer of advance improved scientific technologies (e.g. soil moisture and canopy sensors) to farmers field, so that irrigation system should match with crop water demands, along with adoption of advance agricultural practices like minimum tillage, soil fertility improvement, building water retention or conservation capacity and irrigation scheduling during night that may reduce evaporation loses (COPA-COGECA, 2007).

With the use of advance irrigation methods such as micro irrigation techniques (sprinkler and drip that having water efficiencies as high as 70-75% and above 90% respectively) (Howell, 2003), the overall water productivity can easily be increased to significant level, but yet poor uniformity and application efficiency has resulted because of various causes such as improper maintenance of drip and sprinkle system, issues related to inlet pressure or pressure fluctuations, clogging in pipes and emitter and improper system design etc. (Hsiao *et al.,* 2007). In arid regions, farmers also facing issue of problematic water/saline/sodic/brackish irrigation water and usually they have no option for irrigation other than applying available saline brackish water in agriculture fields during its severe demand of water in crop, that exacerbating the problem for agriculture. The problem encountered by drip systems as it is very precise and efficient, without the need to flush the entire soil volume water remain in root zone only but in saline/sodic irrigation water, salts accumulate in root zone along with drip water and not flushed out of soil crating further problems for plants to survive. Even, world's best drip irrigation systems manufacture, usually claims that their water efficiency is 95% that means the irrigation water is delivered highly efficiently to localized are of root zone from where it can be easily used by plants and that is important for efficient water management, but it is also responsible for salts accumulation around the plants or in the root zone that itself do not get removed out from the field and start creating salinity problem. Else than it, polluted irrigation water is also a serious issue for soils, fields and peoples near cities. The uncontrolled wastewater of cities and industries is reusable water that creates serious health and environmental problems. However, these issues can be resolve to some extend by subsurface irrigation systems by different micro irrigation systems, especially for systems utilizing treated effluents; however more technological improvement is necessary for their upgradation and popularity. In the underground system, soil serves and works as a bio-filter to decrease the contamination. Simultaneously, the underground water irrigation system also enhances an additional level of protection from toxins and preventing direct contact of workers with wastewater. Application of irrigation water (and salts) in subsurface systems dramatically reduce evaporation losses of water from the agricultural fields, it also reduces weeds and helps in minimizing soil salinity resulted in frequent improvement in yields. Thus the subsurface irrigation needs more attention and development for its widespread popularity. There is urgent need of making some good plans at national and state level for every city of the country for better utilisation of treated waste water that can be a reliable source of irrigation if treated properly can be used in non-edible crops. The water treatment to the marked

desired level is needed so that it does not adversely affect the soil, environment or wherever it come in contact that can be ensured by vigilance, good monitoring and should have control from Pollution Control Authority.
In canal command areas the water table is increasing very rapidly and even starts causing problem for agriculture fields like water logging etc. Simultaneously, the over exploitation of groundwater starts threatening the groundwater quantity as well as quality that urgently needs legislation or incentives/disincentives. In addition, there is need to aware peoples about alarming situation of groundwater to control over its exploitation.
According to the report of India Today Web Desk, 2019, wheat and rice that is the most important staple crop of India has highest water-guzzling and we are producing it intensively. Rice is the most water-inefficient grain crop and wheat has been recognized as the driver in increasing water stress. Replacing these crops with other locally available crops such as maize, barley, millets, sorghum with their good varieties could minimise water demand by one-third" and simultaneously their consumption in diet chart is good for health too. The selection of crop for any area should be according to its ecology and water availability in the area.
The production of one kg wheat needs average 1,654 litres of water; simultaneously average 2,800 litres of water is needed for production of one kg rice. According to report by India Today Web Desk, 2019, India exported 37.2 lakh tonnes of basmati rice in 2014-15 and for exporting that much quantity of basmati rice around 10 trillion litres of water is used; that means India 10 trillion litres of water was indirectly exported. As rice and wheat is an important crop of India, there is urgent need of proper irrigation management for their production and how much production we needed in India under water scarcity environment is an important issue. The adoption of 'wet/dry' growing method in which paddy is flooded for certain durations rather than permanently submerged can improve water efficiency; however more research strategies needed in this direction.

WATER CONSERVATION

Water conservation practices are practiced since ages in India such as Bawaries, Khadins, Johads and with so many local names and forms for storing of the valuable water used for drinking and agricultural purposes, but lack of their care and maintenance mostly of them are not in working condition today and require maintenance. The higher rate of exploitation of ground water emerges the need of recharging groundwater by improved recharge systems, technology needed according to local hydrogeological situation of area; some prevalent recharge structure in country are as under (Central Ground Water Board, GOI, 2013):

A. Percolation tanks
The percolation tanks are used to harvest water and store surface water to ground water. They are most frequently available structures in India that helps to recharge groundwater reservoir.

B. Gabion structure
They are built across small stream and help to restore stream flows of water. The boulders are kept inside the steel wire and placed across the stream for making small dam like structure, height of these structures are about 0.5 m and used for 10 to 15 m width streams.

C. Check dams/Nala bund
They build across small streams in gentle slope. The location of Check dam construction should be such that it has sufficient thickness of permeable bed for easy infiltration, percolation and recharge of stored water. Nala bunds are mini percolation tanks whose water storage limited to stream course, the width of nala bed is from 5 meters to15 meters and its depth should be at least 1 meter.

D. Dug well recharge
India has many wells which have gone dry; these dug wells may be used to recharge ground water. The rain water should be diverted to these dried wells to recharge the dried aquifer.

E. Recharge shafts
These structures penetrate the above impermeable surface horizon and ease the infiltration of water from surface to recharge the ground water. A trench dug to 3 m depth and filled with boulders and gravels and has injection well for effective recharge of the ground water.

F. Injection well
In many areas of country the surface layers has low permeability so aquifer cannot get naturally replenished and along with this the over exploited of ground water by tube well pumpage, needs direct injection through recharge wells these also called injection well.

G. Conversion of village tanks into water harvesting structure
Already available tanks of villages whose functioning affected by siltation or damaged should be modified to harvest surface runoff water by desilting combined with waste weir and "Cut Off Trench" (COT) construction on upstream.

H. Ground Water Dams/ Sub Surface Dykes/ Under Ground Bandharas (UGB)
These structures are formed below surface act as barriers across stream that stop the surface flow of water and stores water in sub surface that helps to fulfil the demand of water whenever needed.

I. Rain water harvesting in roof top
India urgently need rain water harvesting in roof top that need to be a part of every roof of every building so that recharge of ground water and problem of water scarcity can be solve out. Rain water harvesting needs outlet pipes from roof to some storage system like some specially designed wells. However, more improved and advance designs are needed for its complete success and popularity.

The rehabilitation and modernisation of existing projects should have improved and efficient hydraulic flow conditions that reduce water losses. The regular maintenance of canal is required for improving water efficiency in minimum investment. The active involvement of beneficiary farmers is also good for maintenance and success of canal. For the proper planning of irrigation projects, following points should be taken into consideration at the beginning of the reservoir operation, (1) the initial storage capacity of reservoir, (2) the expected inflow of water into the reservoir during each intra-seasonal period, (3) water carrying capacity of channels, (4) crop calendar (5) reduction in yield with water deficit in critical growth stages of crop is important for determining water requirement for each crop (Singh *et al.*, 2001; Sethi *et al*., 2002).

The watershed management should include tree plantation and soil conservation measures in basins so that siltation of dams and flow peaks should be reduced. In agriculture sector, improved technologies should develop for improving yields per unit of water. The deficit irrigation concept includes predetermined use of less amount of irrigation water than overall need of the particular crop in a season should be included in the water strategic plan. This concept need further studies and research for getting more crop production in per drop of water.

Our diets also affect overall water requirement, like according to report of Viegas, 2007, production of pound of corn require about 100 to 250 gallons of water, variation according to soil, climate and irrigation method of the area grown. However, on other side production of grain to produce a pound of beef may need 2,000 to 8,500 gallons of water. So, becoming vegetarian is good for caring our nature and water saving.

In water conservation contest, Israel becomes a learning lesson, water scarce nation Israel, having extreme dry weather are today under water surplus condition. Israel is well known for drip irrigation but now one step ahead it initiates using treated sewage effluents and this treated water became important source of irrigation water in agriculture (Tal, 2002). Slowly but steadily, Israel followed strategy of maximum effluent utilization. In 2015, the Israel recycled 86% (400 million m^3) of the sewage water and used it. This means that every drop of water in Israel is used twice. The waste water recycled for use in agricultural farms and simultaneously contamination of the fresh water due to waste water stops. Israel modifies their open canals to closed piped systems; that also help in saving water by reducing its evaporation, seepage and other loses occurring in open canals (Tal, 2007).

CONCLUSION

Water sector is facing very acute and serious problems. There is urgent need of implementation of the required action plan that will enable to fight the challenges and attain effective and economic management of the scarce water resources of the country and efficient utilization of water through water conservation measures and use of water saving devices and practices that lead to effecient irrigation management.

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