Irrigation in India: Status, challenges and options

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Irrigation in India: Status, challenges and options

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ABSTRACT

In India, spatial and temporal variation of precipitation has been boundless varying from 11000 mm to 90 mm. The average annual per capita water availability has declined from 5000 cubic meter in year 1950 to 1545 cubic meter in year 2011 and estimated to reduce further to 1341 and 1140 cubic meter in year 2025 and 2050, respectively. Agriculture sector, which provide 54.6% of total employment to growing population, alone consumes more than 90% of total groundwater draft in irrigation. Over the years, groundwater has become dominant source of irrigation due to its independent access and timely availability of water. This outrageous dependency on groundwater has led to depletion of water table in 64% district of the country between TE2002 and TE2016. With collective efforts of government at various levels, utilized irrigated potential including both surface and ground water has increased to 87 Mha while ultimate irrigation potential touched 140 Mha. In context of rapid depletion of water resources, there is need to increase water use efficiency. Efficient method, like microirrigation, can play pivotal role in management of irrigation water demand. Properly designed and managed drip and sprinkler irrigation system have irrigation efficiency about 90% and 70%, respectively contrast to surface irrigation method which have just about 40%. Recognizing the gravity of water scarcity in many part of the country, government has started formulating its water policy pivotal to micro irrigation. In year 2015, government has bundled all ongoing irrigation schemes into *Pradhan Mantri Krishi Sinchayee Yojna* (PMKSY) in which micro irrigation as an integral component. The successful adoption of water efficient technologies has two preconditions namely technical know-how and its accessibility through institutional support systems. Government has taken many initiatives to intensify outreach of efficient irrigation technology to farm.

Key words: Water resources, Micro-irrigation, Schemes, Optimum crop plan, India

INTRODUCTION

Efficient utilization of available water resources is crucial for a country like, India, which shares 17% of the global population with only 2.4% of land and 4% of the water resources. Further, per capita availability in terms of average utilizable water resources, which was 5247 m^3 in 1951 (presently 1453 m^3) is expected to dwindle down to 1170 m^3 by 2050 (CWC, 2015). Agricultural sector alone consumes 80% of the ground water (Harsha, 2017). The declining trend of groundwater level in all parts of the country also indicates that the assured supply of good quality water will become a concern for country's development (Manivannan *et al.*, 2017).The overall efficiency of the flood irrigation system range between 25-40% (Amarasinghe, 2007). Overall, micro irrigation shows superiority over other traditional irrigation methods in term of water use efficiency, energy saving, yield increase and net return per unit volume of groundwater (Kumar and Palanisami, 2010; Chandrakanth *et al*., 2013). To meet the food security, income and nutritional needs of the projected population in 2050, the food production in India will have to be almost doubled. The groundwater table can be improved with construction of various artificial conservation practices and improve crop productivity (Paul and Panigarhi, 2016). All these emphasize the need for water conservation and improvement in water-use efficiency to achieve More Crops per Drop. The paper is organized as follows. Firstly, the paper presents status of irrigation in India followed by challenges of irrigation systems in India. The paper also highlights various schemes of irrigation and availability of surface and ground water. Lastly, we discuss various options to overcome these challenges, government initiations for efficient water management in agriculture followed by conclusion. This paper represents the personal opinion of the authors and does not represent the position or opinions of ICAR or its institute.

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STATUS OF IRRIGATION IN INDIA

Irrigation is main consumer of fresh water and more than 90 per cent of groundwater draft in India. Growing population coupled with food security has put extra pressure on water resources. Country has reached a situation where the demand of water from various sector of economy is rapidly increasing while the supply of fresh water is constant. Additionally, water overuse harms the environment by increased salinity, nutrient pollution, and the degradation and loss of flood plains and wetlands. Owing to poor water resource management system and climate change India faces a persistent water shortage.

Spatial and temporal variation of precipitation has been boundless varying maximum in Cherrapunji (>11000mm) to lowest in western Rajasthan (<100 mm). In India, annual precipitation is nearly 4000 BCM and average flow of rivers is estimated to be 1869 BCM. But nearly 75% of rainfall occurs during monsoon season (June-Sept), which restricted utilizable quantum of surface water to 690 BCM. Total annual replenishable groundwater potential in the country estimated to be 433 BCM in which rainfall contribute 74% in groundwater recharge and the rest is contributed by canal, pond and other water conservation practices. With an annual groundwater draft of 253 BCM, irrigation alone consumes nearly 91% of total draft irrigating 62% of total irrigated area of the country (CGWB, 2017). But groundwater development is not uniform across the country.

Net irrigated area (%) of India has increased from nearly 18 to 48% in recent times due to government interventions at various levels (Fig. 1). Although government has given much emphasis on improving canal system in various five year plans but it has declined over years (Fig. 1). People have identified groundwater irrigation as much reliable and independent source of irrigation. Groundwater irrigation has taken quantum jump since 1965.

Irrigation schemes and sources

Planning commission has classified the irrigation in India in 3 types namely major (cultivable command area (CCA) >10000 ha), medium (CCA from 2000-10000 ha) and minor (CCA <2000 ha) irrigation schemes. Created irrigation potential increased from 22.8 Million ha (Mha) to 107.2 Mha while utilized irrigated potential (both surface and ground water) increased to 87 Mha (Table 1).

Since 1950-51, the government had given considerable importance to the development of command area under canals. As a result presently, India has gross irrigated area of 96.46 Mha, net irrigated area 68.38 Mha and food grain production of 275.11 million tonnes in 2016-17. In 1950-51, the canal irrigated area was 8.3 million hectares and it currently (2014-15) stands at 16.18 million hectares. On the other hand, the well and tube well accounted for 29% total irrigated area in 1950-51 and now they share 63% of the total irrigated area. Despite that, the relative importance of canals has come down

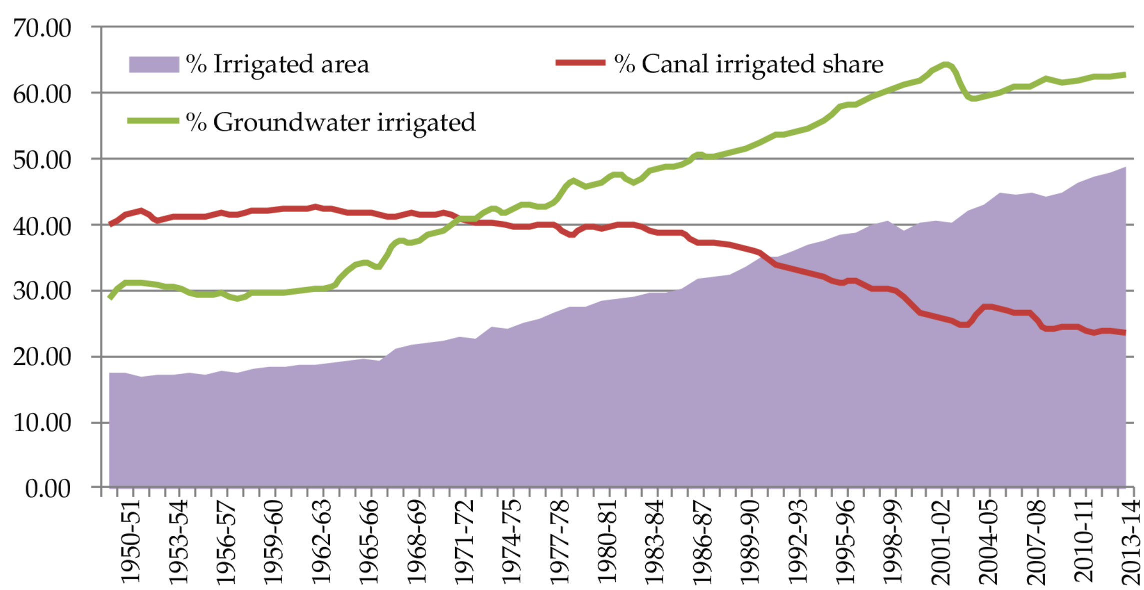

Fig. 1. Irrigation trends since 1950-51 (*Source*: based on data from DES, 2017-18); % Irrigated area : Net Irrigated area to net sown area, % Groundwater irrigated: Groundwater irrigated area share in net irrigated area, % Canal irrigated : Canal irrigated area share in net irrigated area

Table 1. Source wise created utilized and ultimate irrigation potential

Source	Irrigation potential (million hectares)			
	At the time of independence	Up to 2007-12		Ultimate
	Created & Utilized	Created	Utilized	
Major & medium (Surface water)	9.7	47.97	34.95	58.5
Minor (Surface water)	6.4	NA	NA	17.3
Minor (Surface & ground water)	12.9	65.56	52.5	81.4
Total (Major, medium and minor)	22.6	113.53	87.86	139.9

Source: CWC (2015); DES, GoI (2017)

Table 2. Net Irrigated area from various sources and their relative contribution

Source	2009-10		2014-15	
	NIA (Mha)	Contribution (%)	NIA (Mha)	Contribution (%)
Canal	16.697	26.40	16.18	23.66
Tank	1.638	2.59	1.72	2.52
Wells	39.042	61.72	42.96	62.82
Others	5.880	9.30	7.52	11.00
Total	63.257	100	68.38	100

Source: DES, MoA&FW, GoI (2018)

from 40% in 1951 to 24% in 2014-15. Table 2 highlights that irrigated area under canals and tank has been declining since 2009-10 but area under groundwater sources are on rise, which is a matter of concern.

There has been a lot of spatial variation among different sources of irrigation. Well Irrigation is common in alluvial plains of the country except the deserts of Rajasthan. Plains of UP, Bihar, Gujarat, Karnataka and Tamil Nadu are the states which are more prominently under the well irrigation. Canals are second most important source of irrigation in India after wells and tube wells. The canals are irrigating those lands, which have large plains, fertile soils and perennial rivers. The plains of North India are mostly canal irrigated. Other parts are coastal low lands and some parts of Peninsular India. The states are: Andhra Pradesh, Assam, Haryana, Jammu & Kashmir, West Bengal, Punjab Rajasthan, Bihar, Karnataka, Tamil Nadu and Uttar Pradesh. The Tank irrigation is more in the rocky plateau area of the county, where the rainfall is uneven and highly seasonal. The Eastern Madhya Pradesh, Chhattisgarh, Orissa, interiors of Tamil Nadu and some parts of Andhra Pradesh have more land under tank irrigation.

CHALLENGES FOR IRRIGATION IN INDIA

Depletion of water table

India invested nearly 4,000 million US dollars in public canal systems during 1991-2007 (Dhawan, 2017). Yet the canal-irrigated area decreased by 38 lakh hectares during that period, as infrastructure is old, water supply is unreliable, further there are no incentives. This implies that "despite of heavy public expenditure on canals, our governments have not been able to reduce the groundwater depletion". The key reason is widening gap between irrigation potential created and actually utilized.

States with the highest dependency on ground water for irrigation include Punjab (79% of the area irrigated is by tube-wells and wells), Uttar Pradesh (80%) and Uttarakhand (67%). As per the assessment carried out by the Central Ground Water Board (CGWB) in 2013, India's total annual replenishable groundwater resource is around 433 billion cubic meters (BCM) and net annual ground water availability is 398 BCM of which India withdraws 253 BCM (62%) annually. According to the CGWB, around 39% of the wells are showing a decline in groundwater level. Out of 6,584 assessment units in the country, 1,034 units (in 15 states and 2 union territories) have been categorized as "over exploited" based on the stage of groundwater withdrawal as well as long term decline in groundwater level (CGWB, 2017).

The deterioration of groundwater resources is the outcome of technology and policy led shift in cropping pattern (towards paddy), irrigation source (towards groundwater) and energy source (towards electricity) in Punjab (Srivastava *et al.*, 2015).

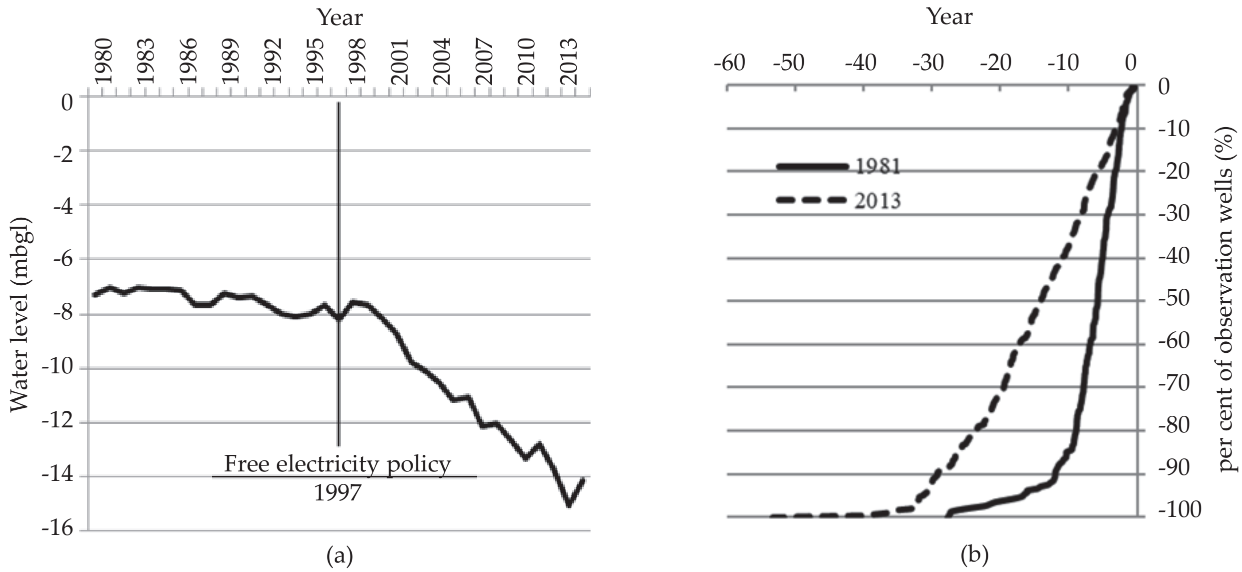

Fig. 2. Trend in average groundwater level (panel a) and cumulative distribution curve of observation wells (panel b) in Punjab

Agricultural advancement in Punjab was achieved at cost of over-exploitation of groundwater (Singh, 2012; Kulkarni and Shah, 2013). Total annual groundwater draft in Punjab is 14.56 BCM higher than the sustainable limit leading to drastic decline in groundwater level from 8 meter in 1999 to 15 meter in 2014 (Srivastava *et al*., 2015; Srivastava *et al*., 2017). Unsustainable use of groundwater in Punjab (with 16 districts out of its 22 districts having more than 100% ground water development) has led to continuous depletion of ground water table in Punjab (Fig. 2). It seems introduction of free electricity policy for irrigation in 1997 has been one major cause for depleting ground water table in Punjab.

Uneven rainfall distribution

In India, nearly half of the net sown area comes under rainfed lands. Even after achieving ultimate irrigation potential, 31% of cultivable area will remain under rainfed cultivation. There has been substantial disparity in rainfall, both in time and space with strong risks of dry spells at critical stages of crop even during good rainfall years (Fig. 3).

There has been considerable spatial and temporal variation in rainfall in India. Most of the rainfall occurs with onset of southwest monsoon during June to October month. It varies from less than 100 mm in western Rajasthan to more than 2500mm in northeast region of country (CWC, 2017). Flood considered to be devastating natural calamities, led damaged of crops worth of Rs. 3214.99 crore grown on 31.58 million hectare in year 2013. This has affected 21.13 million peoples and caused total loss for economy worth Rs. 11095.14 crore in same year (CWC, 2015).

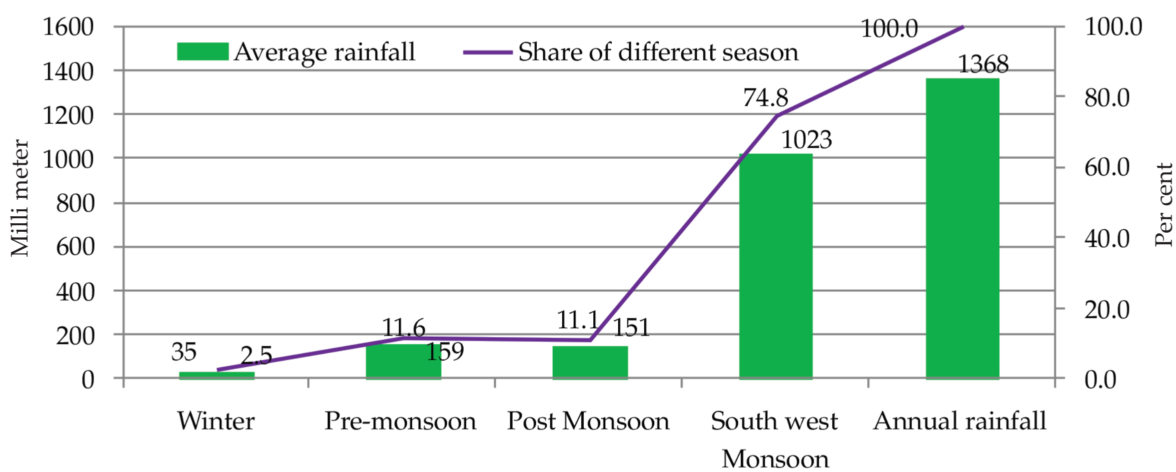

Fig. 3. Seasonal variation of rainfall in India

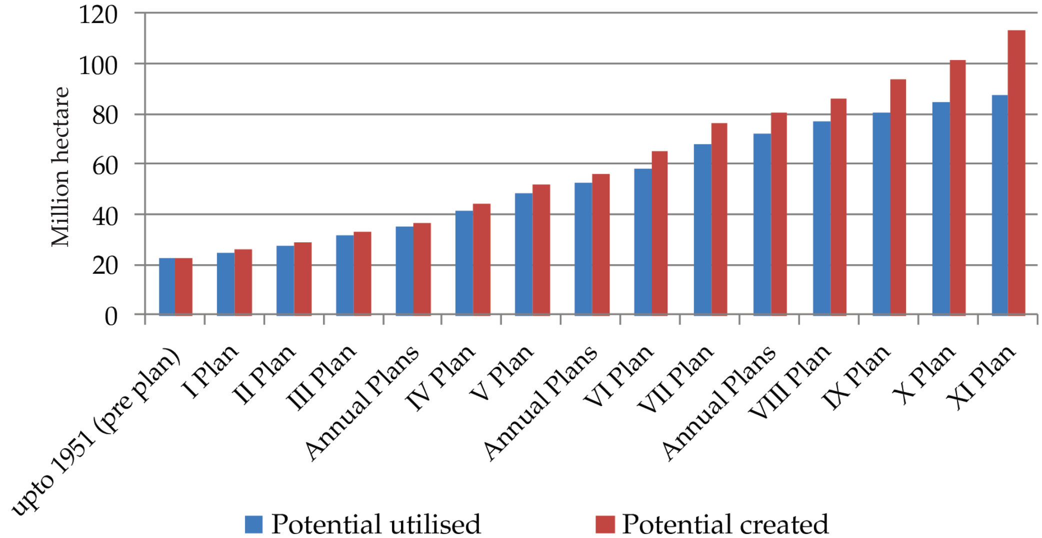

Fig. 4. Increasing gap between created and utilized irrigation potential (CWC, 2015)

Poor irrigation efficiency

Inadequate off-farm and on-farm infrastructures and poor maintenance leads to poor irrigation efficiency e.g. unlined canal and farm channels. Overall, average irrigation efficiency is observed as 38 per cent, which is much below desired efficiency. Average conveyance efficiency is 70 per cent. Thus, there is scope to reduce losses occurring due to poor irrigation infrastructure like unlined canal and channels. Similarly on farm application efficiency is also only 50 per cent. It was estimated (Arshad *et al*., 2009) that lining of watercourses reduced water loss by 22.5 per cent. The probable causes of water leakage are cracks, eroded mortar and structural failure of lined walls. Also due to absence of non-availability of control structures and regulation gates, there is inadequate and irregular canal water supply in many command area. Further, many times canals have breaches, which cause displacement of thousands of people, destruction of properties, land, and damage to costly crops worth millions rupees. In addition to that, breach failures also can cause water shortages when the failure occurs during the peak demand period. There are various causes of embankment failures, which include overtopping, internal erosion, structural defects and piping.

Huge and increasing gap between created and utilized irrigation potential

There has been a large gap in utilization of created potential. At the end of Eleventh plan, total utilization of irrigation potential was to the extent of 87.86 million hectares as against the total created potential of 113.53 million hectares showing a gap of 25.67 million hectares (CWC, 2015). The main reasons behind this non-utilization of created potential are delay involved in the development of on-farm works like construction of field channels, land leveling or shaping and adoption of the warabandi system and finally the time taken by farmers in switching over the new cropping patterns, i.e., from dry farming to irrigated farming (Fig. 4).

Frequent droughts and ground water overuse

The frequency of occurrence of drought years has significantly increased in India. The period between 1950 and 1989 had 10 drought years, while there have been five droughts in the last 16 years (since 2000). According to meteorologists, the frequency is set to increase between 2020 and 2049. In India, the lack of monsoons result in water shortages, resulting in below-average crop yields. This particularly occurs in major drought-prone regions (more than 60% area of the country) such as Southern and Eastern Maharashtra (Western India), Northern Karnataka (South-Western India), Andhra Pradesh (Southeastern coast of India), Odisha (Eastern coast of India), Telangana (Southeastern coast of India) and Rajasthan (Western India). Increased groundwater use during droughts can help overcome such critical periods. However, the resulting groundwater overuse and quality deterioration mean there is also less groundwater available for agriculture than there was before, thus causing even more pressure on agricultural production. In Gujarat, (Western India) semiarid northern region, one of the most intensively irrigated regions in India; water availability is a concern because groundwater irrigation contributes more than 90% of the overall livelihoods of the farms. It is worth mentioning that in some tehsils of Latur, there is no water even 304 meters below the ground. Just in one year (2015-16) the water table in Latur has gone down by 3.5 to 4.0 meters.

WATER MANAGEMENT OPTIONS

As the agriculture sector alone consumes about 80% of the total withdrawal of water, so its management become pivotal for food security. Supply-side management practices include watershed development and water resource development through major, medium and minor irrigation projects; and development of drainage system to avoid salinity and water logging problems. Demand management practices include enhancement of water use efficiency, optimal crop plans and balancing virtual water trade. This section presents some water management practices below.

Infrastructural development for adequate and regular water supply

There is inadequate and irregular canal water supply in many commands. To tackle this conjunctive water use needs to be facilitated. Further, creation of appropriate infrastructures is required to supplement canal water and ground water.

Drainage for water logging and salinity in major irrigation commands

The problem of water logging and salinity requires conjunctive water use with emphasis on ground water pumping to dewater the aquifer. Further, drainage system should be put in place using suitable horizontal pipe drainage, vertical pipe drainage and optimally designed multiple well point drainage system.

Improving irrigation efficiency

The traditional methods of irrigation have low irrigation efficiency due to excessive seepage loss, inequitable and untimely supplies. Micro-irrigation can play vital role in improvement in water use efficiency. Application of sprinkler and drip irrigation wherever applicable improves irrigation efficiency. Further canal automation and volumetric measurement of supply, bench marking of irrigation systems, water audit/ budgeting and appropriate pricing of water can increase irrigation efficiency. The method of irrigation followed in the country is flood irrigation, which results in a lot of water loss. Greater efficiency in irrigation was achieved through proper designing of irrigation system for reducing water conveyance loss. Adoptions of water saving technologies such as sprinkler and drip irrigation systems have proven extremely effective in not just water conservation but also leading to higher yields. Comparison of various methods of irrigation suggests that drip irrigation achieves highest application efficiency of 90 per cent with overall efficiency ranging between 80-90 per cent (Table 3). New agronomic practices like raised bed planting, ridge-furrow method of sowing, subsurface irrigation and precision farming are also helpful in improving water efficiency.

Water pricing is also helpful in improving irrigation efficiency. In case of Punjab, India where ground water is over exploited due to free electricity for irrigation, de-subsidizing will help in reducing irrigation and saving of ground water (Table 4).

Table 3. Irrigation efficiencies under different methods of irrigation

Irrigation efficiencies	Method of irrigation		
	Surface	Sprinkler	Drip
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: Sivanappan (1998); Dhawan (2002); Saleth (2009); Narayanmoorthy (2006); Kumar and Palanisami (2010)

Table 4. Effect of withdrawal of subsidy on use of ground water for irrigation of important crops in case of Punjab, India

S. No.	Particulars	Paddy	Wheat	Sugarcane	Maize	Cotton
1	Effect on groundwater use (cum/ha)	-3533	-1200	-2749	-1217	-1478
2	Present level of groundwater use (cum/ha)	12151	2520	6735	1485	3920
3	Change in groundwater use (%)	-29	-48	-41	-82	-38

Source: Adapted from Srivastava *et al*. (2017)

Table 5. Optimum crop model for ground water use restricted to replenishable limit in Punjab: Ground water sustainability scenario

Crops	Existing area ('000 ha)	Optimum area ('000 ha)	Direction of change required
Kharif crops			
Paddy (including Basmati)	2760	1143	-
Maize	136	218	+
Vegetables	57	29	-
Others (including fodder)	28	36	-
Rabi Crops			
Wheat	3520	3945	+
Vegetables	65	104	+
Potato	69	35	_
Oilseeds (Rapeseed+Sunflower)	51	48	_
Others (including fodder)	39.1	28	_
Sugarcane (annual crop)	70	35	_

Source: Adapted from Jain *et al*. (2016)

Optimum crop plans

Due to varying water requirement of each crop, ground water exploitation may be reduced by shifting water intensive crops to the regions having ground water abundance (Jain *et al*., 2016; Table 5). In their case study on Punjab, they used optimization approach to restrict the ground water use to replenishable level of ground water (22 BCM) against existing level of ground water use (34 BCM). As per the recommendations, to restrict ground water use to replenishable limit, area under paddy, kharif vegetables, potato, oilseeds, sugarcane and other crops including fodder has to be reduced and shifted towards maize in kharif season and wheat in rabi season. However, it requires giving incentives to farmers adopting optimum crop plans to compensate for losses in farm income due to adoption of optimum cropping pattern which provides lesser income at current level of technology and market price (Jain *et al*., 2016). Table 5 highlights the need to review the cropping pattern and to shift cultivation of water intensive crops towards water abundant areas. Jain *et al*. (2019) presents detailed methodology for developing optimum plans using case study of Punjab.

Virtual water trade

Indian farmers use 2-4 times more water to produce a unit of grain as compared to China and Brazil. Virtual water flow from states like Punjab (facing depletion of ground water) needs attention. India is a net importer of one per cent of available water every year in the form of virtual water (Dhawan, 2017). Ratio of virtual water export to import is 4 and 0.1 for India and China respectively. Thus, china is a net importer of water. India exports water intensive commodities like rice, cotton, sugarcane, soybean while China exports vegetables, fruits and processed food items. It requires 3000-3500 Litres of water to produce 1 kg of rice. Thus, there is a need to revisit trade policies to reduce virtual water flow from India.

Improving water productivity

Water productivity denotes the amount or value of product over volume of water depleted or diverted. Various options for improving water productivity of crops are : (i) water should be priced at a level enough to motivate farmers to save water (Bakia *et al*., 2018), (ii) New revenue from water pricing should be offset with tax exemption or other subsidies, (iii) subsidies for energy for water pumping should be abandoned for ground water irrigation,(iv) biological water-saving measures, engineering solutions, agronomic and soil manipulation should be collectively explored.

GOVERNMENT INITIATIVES ON IRRIGATION MANAGEMENT

Water management organizations

Water Management organizations like Central Water Commission (CWC) for promoting integrated and sustainable development for management of water resources and Central Ground Water Board (CGWB) for management of ground water resources were established. CWC and CGWB have formulated "General Guidelines for Water Audit and Water Conservation". These guidelines have been circulated to all the state governments, concerned central ministries, and other utilities for framing their own specific guidelines. Following these guidelines, some of the state governments such as Punjab, Gujarat and Maharashtra are offering subsidy on irrigation related aspects.

Subsidy to improve efficiency of irrigation system

To mitigate water scarcity and reduce irrigation water demand, government has focused on increasing irrigation efficiency. To enhance water use efficiency, government at centre as well as at state is providing huge subsidies to increase adoption rate of efficient irrigation method like micro irrigation.These include districts of South and North Interior Karnataka (Southern India); Rayalseema in Andhra Pradesh (Southeastern coast of India); Vidarbha and Marathwada in Maharashtra (Western India); Western Rajasthan and Bundelkhand region of Uttar Pradesh (Northern India) and Madhya Pradesh (Central India).

Various schemes launched by central government led emergence of micro irrigation

Recognizing the importance of micro irrigation, Central Government emphasized on micro irrigation in 1992, 2006 (Centrally Sponsored Scheme on Micro Irrigation), 2010 (Nation Mission on Micro Irrigation) and 2014 (National Mission for Sustainable Agriculture). Subsuming all the schemes of irrigation, *Pradhan Mantri Krishi Sinchayee Yojana* (PMKSY) was launched in 2015, integrating micro irrigation as an integral component. This programme includes creating infrastructure to bring water to farms and watershed development. All these programmes and schemes have been initiated by the government with specific objectives to improve the water use efficiency and water productivity by raising more crops per drop of water.

Despite these efforts, still a specialized solution is required in chronically water stressed areas where measures implemented until now were ineffective. Understanding best practices from other countries and India's own community based interventions models will help present policy thinkers and planners to enhance governance structures and understand key indicators that can assist in data-driven decision-making.

IMPACT OF GOVERNMENT INITIATIVES ON MICRO-IRRIGATION

Status of micro-irrigation in India

In-spite of many initiatives and schemes by Government of India, the status of Micro- Irrigation (MI) is not encouraging. Total area covered under MI is 10.3 million ha while there is potential of 69.5 million ha under MI. Thus, the country achieved target of 14.8% of potential area under MI (Table 6). Share of total area under MI is highest in Rajasthan (17.9%), Andhra Pradesh (15.5%) and Maharashtra (15.1%). Andhra Pradesh is leader in adopting drip irrigation with its share of 24.1%

Table 6. Distribution of micro irrigation area among states and penetration to gross sown area

State	Drip (%)	Sprinkler (%)	Total (%)	Penetration## (%)
Andhra Pradesh	24.1	7.9	15.5	20.6
Gujarat	13.3	11.8	12.5	10.0
Haryana	0.6	10.3	5.8	9.1
Karnataka	12.2	12.9	12.5	10.5
Madhya Pradesh	6.1	4.2	5.1	2.2
Maharashtra	22.8	8.3	15.1	6.6
Rajasthan	4.8	29.4	17.9	7.6
Tamil Nadu	8.6	1.7	4.9	8.4
Telangana	3.4	1.1	2.2	4.2
Others	4.0	12.5	8.6	1.2
Total area (mha)#	100 (4.7)	100 (5.6)	100 (10.3)	198.4
Potential area (mha)*	27.0	42.5	69.5	
% achievement to Potential estimated	17.4	13.2	14.8	

Source: Ministry of Agriculture (2017); '#': figures in parenthesis refer to country area in million hectares; '*':estimated by Task force on Micro Irrigation, 2004; '##': per cent micro irrigation area to its gross sown area.

Table 7. Impact of drip irrigation in banana, coconut and grapes

Particulars	Banana		Coconut		Grapes	
	Drip	Control	Drip	Control	Drip	Control
Quantity of water applied (m^3)	8979*	12669	3096*	10855	5195*	6757
Quantity of energy consumed (kWh)	2219*	8294	917*	7423	550*	3124
Cost of labour (Rs.)	9761*	31487	3733*	12024	17324*	29433
Capital (Rs.)	80369*	104351	27510*	32560	50690*	60124
Yield ('00 nuts &tones)	60.34*	57.79	227*	201	22.84*	19.45
Gross income (Rs.)	280602*	267400	105443*	86419	246668*	233454
Gross margin (Rs.)	200232*	163048	77933*	53859	195978*	173330
Yield per water Unit (kg/m^3)	7.4*	4.9	7.3*	1.9	4.7*	3.1
yield per unit of energy (kg/kWh)	28.6*	7.2	28.6*	2.6	43.7*	6.2
Return per unit of water (Rs./m^3)	23.8*	13.3	25*	5	41*	27
Return per unit of energy (Rs./kWh)	92.3*	19.8	98*	7	378*	55

Source: Kumar and Palanisami (2010); '*' refers to values are significantly different at 1 per cent level from its control

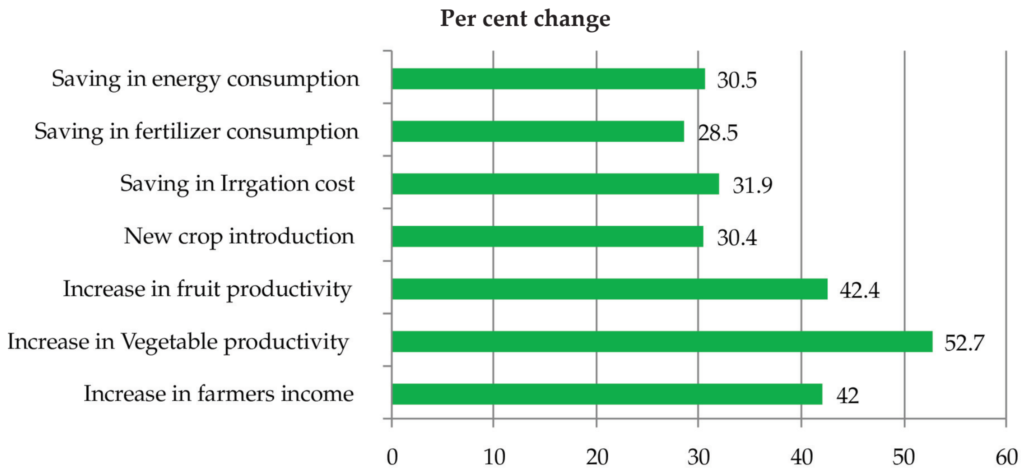

Fig. 5. Impact of Micro-Irrigation on beneficiaries (*Source*: National Mission on Micro Irrigation Impact study prepared for the GoI, 2014); the percent change figures are according to a survey of 5,892 beneficiaries of NMMI across 13 states.

while Rajasthan is leading in sprinklers with its share of 29.4 per cent. Punjab which is most affected by depletion of water table covers less than one per cent of total area under drip irrigation and sprinkler irrigation each. Andhra Pradesh have covered its nearly 21% of gross cropped area under micro irrigation which is highest among all states.

Case studies of micro-irrigation

To assess the impact, the economics of drip irrigation were worked out for banana, coconut and grapes in Tamil Nadu (Kumar and Palanisami, 2010). The adoption of drip irrigation has significant positive impact on the cost of cultivation and returns to the farmers (Table 7). The economics of banana cultivation revealed that the cost of labour was significantly lower under the drip method (Rs 9761/ha), which was 69% less than in the control villages (Rs 31487/ha). The drip method saved nearly 71% of weeding labour when compared to flood method of irrigation. Since grape cultivation is sensitive to water stress and involves huge labour for irrigation, weeding, training and pruning, the drip could result in significant savings in water and labour, leading to reduction in cost of cultivation. The analysis of economics of crop cultivation under drip and flood methods of irrigation has revealed that the former has a significant impact on resources saving, cost of cultivation, yield of crops and farm profitability. The physical water and energy productivity was significantly high in drip than flood method of irrigation.

National Mission on micro-irrigation (NMMI) conducted an impact study based on survey of 5892 beneficiaries. The study was done for government of India in 2014. The results shows that there is 42 per cent increase in farmers income and savings in irrigation cost, fertilizer cost and energy consumption. Further fruits and vegetables productivity also increased by 40-50 per cent (Fig. 5).

CONCLUSION

In India, groundwater has become dominant source of Irrigation. On the other hand, there is large gap between the ultimate and utilized surface water potential. With continual diminishing per capita water availability coupled with groundwater exploitation, it has become imperative to switch to efficient water saving technologies and alternative source of irrigation like canal and rain water, rainwater harvesting. Rapid depletion of water table, low irrigation efficiency, and frequent droughts indicate towards water crisis in near future if existing water use pattern is not rectified. Irrigation infrastructure needs to be further improved to harvest rainwater and increase storage capacity in order to utilize runoff water. Micro irrigation has scope for improving irrigation efficiency up to 90 per cent. Further, micro irrigation and optimum crop plan will play decisive role in conservation of water resources and food security of the nation. Virtual water trade should be balanced instead of orienting it towards export. Farmers should be made aware of the various government schemes to utilize their utmost potential which is lacking in some states.

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