IMPROVING WATER PRODUCTIVITY IN IRRIGATED COMMANDS

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ABSTRACT

Availability of food is prime requisite for achieving food security. Irrigated agriculture reportedly increases yield of most of the crops by 100 to 400% (FAO). However, perpetual increase in water demand coupled with spatial and temporal variation in water resources endowments is resulting in mismatch between utilizable water resources and demand in many regions of the country and the gap is widening. Over and above, stiff competition from other sectors especially industrial sector which is able to pay more for water has reduced water availability for agriculture sector but this may have serious repercussions on food availability unless addressed. The water use efficiency in existing irrigation systems in India at present is quite low and estimated to be in the range of 35% to 40%. Though bringing more area under irrigated agriculture is crucial to improve food security, the present increase in water productivity of irrigated areas is not sufficient to fully meet the projected demand of food grains. Challenge is therefore to achieve higher food grain production with reduced availability of water.

The paper discusses about the present projected availability of water and its demand; present status of water use efficiency (WUE) in existing projects; evaluation of the reason for low WUE; adoption of appropriate water management practices, measures for improving performance of irrigation systems with the objective to enhance the overall water productivity to ensure food security of the nation. Specific strategies for improving WUE of old irrigation systems by 30% or so and overall increase in WUE by 7% by 2017 have been discussed in the paper. Some success stories of Farmers Participatory Action Research Programme (FPARP) initiated by Ministry of Water Resources, Govt. of India are also highlighted in the paper.

INTRODUCTION

India is an agrarian country with majority of population engaged and dependent on agriculture. Adequate water resources are instrumental in ensuring food security and affordability for whole of the society. India has made significant progress in development of its water resources over the past 60 years. The expansion of irrigation system alongwith modern agronomic practices have increased the production of food grains from a meager 51 million tonne in 1951 to more than 235 million tonne at present. While irrigation projects have helped in making the country self sufficient in food and fibre, at the same time development of irrigation has brought into focus certain problems like availability of utilizable water resources, under utilization of created potential, water logging, salinity/alkalinity, inequitable distribution of water amongst the beneficiaries, lack of reliability of supply of water both in terms of its quantum and time, low operational efficiencies, lack of maintenance, low yields from irrigated agriculture compared to possible potential. All these issues are to be addressed in a holistic manner.

WATER PRODUCTIVITY: Concept and Definition

Initially, irrigation efficiency or water use efficiency was used to describe the performance of irrigation systems. In agronomic terms, '*water use efficiency*' is defined as the amount of organic matter produced by a plant divided by the amount of water used by the plant in producing it (De Wit, 1958). However, the used terminology '*water use efficiency*' does not follow the classical concept of '*efficiency*', which uses the same units for input and output. Therefore, International Water Management Institute (IWMI) has proposed a change of the nomenclature from '*water use efficiency*' to '*water productivity*'. The water productivity per unit of gross inflow (WPG) is the crop production divided by the rain plus irrigation flow. The discussion in the paper however is limited to improving water use efficiency and thus water productivity through various water management practices, adoption of modern technologies in water application in irrigated commands etc.

DEMAND OF WATER FOR VARIOUS SECTORS

Worldwide, agriculture uses about 70% of all water. Developing countries require more water for agriculture and it is estimated that in India, irrigated agriculture consumes about 80% of total developed fresh water resources. With increase in population and better standard of living, the water demands for various uses are on rise and will continue to do so. Water requirement for various sectors as assessed by the National Commission on Irrigation and Water Resources Development (NCIWRD) is as under.

Sector	**Water demand by NCIWRD (in BCM)**		
Year	2010	2025	2050
Irrigation	557	611	807
Drinking Water	43	62	111
Industry	37	67	81
Energy	19	33	70
Other	54	70	111
Total	**710**	**843**	**1180**

Irrigation requirement estimated by NCIWRD is with the premise that the irrigation efficiency will increase to 60% from the present level of 35 to 40%.

PRESENT STATUS OF IRRIGATED AGRICULTURE

Irrigation Potential Created and Utilised

The ultimate irrigation potential of the country has been assessed as 139.9 Mha. At the beginning of Plan era, the total irrigation potential created was of the order of 22.6 Mha. Irrigated agriculture reportedly increases yield of most of the crops by 100 to 400% (FAO). A large number of irrigation projects were therefore taken up with the objective to increase agricultural production in the country. To achieve food security for the growing population, focus is on to bring more and more area under irrigation; reducing gap between potential created and utilized and efficient water management.

Water Use Efficiency

The water use efficiency in most irrigation systems is low and estimated to be in the range of 35 percent to 40 percent. Efficiency what we are talking about is the system efficiency i.e. ratio of actual water consumed by the crops (evapotranspiration) for its growth to the total water supplied from the main source. The main cause of low efficiencies is observed and as also identified by Indian Institutes of Management (IIMs) who carried out studies are: deficiencies in water delivery system, inequitable delivery of water to the fields and inefficient management. The reasons of present low efficiencies include, long period of development of large projects resulting in shift towards high water consuming crops as well as wasteful use of water by head reach farmers, excessive losses in conveyance due to seepage and evaporation, inequity and indiscipline resulting from faulty design and operation, low water charges resulting in shortage of funds with State Govt. for maintenance resulting in dilapidated conditions of canal systems, inability of the systems to quickly adjust to variations in demand, non- completion of On-Farm development works, lack of involvement of beneficiaries, lack of drainage facilities, use of old age methods of water application etc. Besides, absence of any meaningful co-ordination of multidisciplinary departments at various levels also results in wasteful use of water resulting in low efficiencies & productivity levels.

CHALLENGES

Availability of water is limited and almost fixed but perpetual increase in its demand coupled with spatial and temporal variation in water resources endowments is resulting in mismatch between utilizable water resources and demand in many regions of the country and the gap is widening. Stiff competition from other sectors especially industrial sector which is able to pay more for water has reduced water availability for agriculture sector but this may have serious repercussions on food availability unless addressed. Though bringing more area under irrigated agriculture is crucial to improve food security, the present increase in yield of irrigated areas is not sufficient to fully meet the projected demand of about 450 million tones food grains by 2050. Challenge is therefore to achieve higher food grain production with reduced availability of water.

Against the backdrop of a situation of scarce resources and inter-sectoral competition, the development and management of water resources has to undergo a paradigm shift and deep introspection. Thus the need of the hour in water resources development & management is to maximize agricultural production per unit of area as

well as to maximize the production per unit of water in sustainable manner for ensuring food & fibre needs of the nation.

MEASURES FOR IMPROVING WATER PRODUCTIVITY

Completion of Ongoing Projects

Delay in project completion, beside cost over-run results in excessive and wasteful use of available water in the part commands. For expeditious completion of the projects which were in advanced stage of completion, the Accelerated Irrigation Benefit Programme (AIBP) was conceived by the Government of India and financial assistance provided to the States to complete such ongoing projects in the country so that envisaged irrigation potential of the project could be created and desired benefits achieved. More area has been brought under irrigation with the available water thus preventing its wasteful application and in the process achieve increased productivity.

Operation and Maintenance (O&M)

- It is estimated that about 70 to 80% of the O&M cost comprises of the wages and salaries of the staff. It is recommended that this be limited to about 30% so that reasonable funds are available for physical improvement of the system. Water charges needs review and revised so as to meet the O & M expenses. However this has to be with simultaneous improvement in the quality of services provided. This will encourage the farmers to pay water charges, avoid over irrigation and wasteful use of water, thereby increasing water use efficiencies.
- Loss of water in the conveyance system is mainly on account of seepage. Water loss in an unlined canal is almost 4 times that of lined canals. In areas of poor quality ground water and in drought prone areas, to maximize the use of surface water, lining of canal network is recommended.
- The involvement of stakeholders is essential to achieve the objective of improvement in efficiency and maximization of productivity. State Governments need to concentrate on maintenance of main water distribution system, leaving sub-distribution system to water users association in order to reduce cost on staff and for equitable distribution of water.

On Farm Management

- For completion of on farm activities so as to bridge the gap between irrigation potential created and utilized and efficient use of water, Command Area Development and Management Programme (CAD&WM) has been taken up by Govt. of India.
- The application efficiencies gets substantially improved in furrow as water application area reduces. Besides, precision land leveling on the fields reportedly results in water savings upto 25% and yield increase by 10-20%.
- Lack of operational plan for irrigation water distribution inevitably put the areas in the head reaches of the distribution system in a relatively advantageous position with the degree of reliability, falling as one move towards the tail end. Though the head reaches are in advantageous position, but any overuse of water do not necessarily increase the yield, rather it may reduce. In recent years efforts have been made to draw attention towards introduction of rotational water supply system in surface irrigation.

Technology Upgradation / Micro Irrigation System

- Several practices such as SRI method of rice cultivation, alternate wet and dry irrigation in rice fields are experimented to reduce water use in rice cultivation. It has been documented that many of these practices increase yields with use of less water.
- Considerable savings in water can be achieved by adoption of sprinkler, drip/micro-sprinkler irrigation systems in water scarcity areas. Actual field studies indicated water saving of 25 to 33 per cent and increased yield upto 35 percent with sprinkler system. Drip irrigation is considered to be most efficient as water is released directly into the root zone of crop. 25 to 60 percent water is saved in drip method and increased yield upto 60 percent is obtained compared with conventional surface irrigation methods. Drip systems are becoming popular with each passing day with the Govt. of India taking initiatives and providing incentives. As per the report of the National Task Force on Micro Irrigation in India, 27 Mha can be brought under drip irrigation and 42.5 Mha areas can be covered by Sprinklers.

State Govts. are advised to make provision of drip irrigation in atleast 10% of the command of the proposed projects.

Conjunctive Use of surface and ground water

Though surface water & ground water are integral part of available water resources, planning for their use in conjunction is for from satisfactory. Though private well come up in irrigated command, it is difficult to manage the resource efficiently in absence of proper planning. In some of the projects like Sarda Sahayak Project, while carrying out the appraisal, it was observed that command area will be waterlogged in case additional surface water application is made. Studies were carried out in consultation with the CGWB and the analysis indicated that more than 20000 tube wells are required to be put in operation in the command to maintain water balance. It was also recommended that the well shall be drilled before the intensity of surface irrigation is increased. For efficient management of water resources, similar action is desirable in all projects.

Deficit Irrigation

Experiments conducted by Indian Agricultural Research Institute (IARI), New Delhi with wheat (Sonar-64) show that with three watering at the most appropriate stages, the yield was 3.8 times, with four watering 4.5 times and with five watering 5.1 times. Studies indicate that with deficit irrigation i.e. supplying water in critical stages only but less than the full quantity improves water productivity.

Multiple uses of water

Multifunctional farm ponds that store water for crop irrigation and for domestic purposes are considered suitable for rearing fish and aquaculture to improve household nutrition and provide a ready source of income. Integrated agriculture-aquaculture provides a means of recycling water and nutrients and obtaining more value and income from farm enterprises.

Automation

Decision support system (DSS) and establishment of Management Information System (MIS) for reservoir and canal operation helps in improved irrigation management by quickly responding to sudden change in demand. Partial automation on irrigation systems has been experimented in various canal systems such as Tungabhadra, Majalgaon, Khadakwasla and Chambal with limited success. To ensure sustainability, more efforts are required in the area of adequate infrastructure such as power supply and communication network, adequate training of staff, implementation of available technology etc.

Water Audit

Water Audit is considered to be one of the effective tools towards water conservation and preventing wasteful use of water as it gives fair idea of total water drawn from the source, its actual use and the water lost in the system. Some of the water loss in any system is inevitable. Any excessive loss of water noticed will warrant carrying out the remedial measures. Water audit serves the purpose of a correct diagnosis of the problems, faced in order to arrive at optimum solutions. It may also prove an effective tool for realistic understanding and assessment of the present performance level of the service for future expansion.

Performance Evaluation Studies / Benchmarking of Irrigation Systems

Studies to assess the actual performance of the system vis a vis the assumed objectives helps to identify deficiencies if any and find a viable and economical solution of various problems. Benchmarking is a continuous process of measuring one's own performance and practices against the best competitors. Analysis of the Performance Evaluation and Benchmarking indicators helps to take timely and appropriate remedial measures not only for enhancing present system performance but also to plan a proper strategy for future improvements in management and operation.

IMPROVING WATER USE EFFICIENCIES BY 20% - STRATEGIES

National Water Mission (NWM)

The National Action Plan on Climate Change (NAPCC) has identified the approach to be adopted to meet the challenges of impact of climate change through eight National Missions. The National Water Mission (NWM) is

one of them. One of the most important identified goals of the National Water Mission is to improve the efficiency of water use by 20%. The key identified strategies for achieving the goal of increasing water use efficiency by 20% are: research in area of increasing water use efficiency and maintaining its quality in agriculture, industry and domestic sector; incentivize recycling of water including wastewater; promotion of water efficient techniques and technologies; promote Water Regulatory Authorities for ensuring equitable water distribution and rational charges for water facilities; promote mandatory water audit including those for drinking water purposes; adequate provision for operation & maintenance of water resources projects; incentive through award for water conservation & efficient use of water and incentivize use of efficient irrigation practices.

Action Plan

- Studies have been undertaken in respect of evaluation of water use efficiencies for 43 major and medium projects. More studies are envisaged.
- Pilot projects for improvement in water use efficiency in collaboration with States are proposed.
- Establishment of Water Regulatory Authority in the States is promoted. Water Management Fund for repair and maintenance of system is also envisaged.
- It is estimated that about 25 Mha of irrigated area from major and medium projects from pre-independence period and those completed 25 years ago have become less efficient. Renovation / upgradation for restoration of the areas which have gone out of irrigation, either partly or fully, due to deterioration in performance of the systems is recommended. It is estimated that by taking up activities like improvement in conveyance efficiency through ERM of Major & Medium irrigation projects, water use efficiency through CAD&WM and adoption of micro irrigation alone will increase the water use efficiency of such projects by as much as about 30% as detailed in the table below.

Sl. No.	Identified strategies	Increase in the level of water use efficiency		Physical Target	Overall increase in water use efficiency as a whole
		In respect of specific activity	Improvement in project efficiency		
1	Improvement in conveyance efficiency through ERM of Major & Medium Irrigation Projects	15 to20%	8 to 11% (say 9.5%)	Coverage of 25.3 Mha of command	2.46%
2	Improvement in irrigation water use efficiency through on farm development (Command Area Development activities)	15%	11%	Coverage of 13.7Mha	1.95%
3	Improvement in water application efficiency through adoption of micro irrigation systems (Sprinkler and Drip Irrigation Systems)	50%	10%	Coverage of 12.5Mha(as projected in NMSA)	1.15%
4	Improvement in water use efficiency through RRR of water bodies and minor irrigation issues.	50%	-	Coverage of about 1 Mha of command	0.20%

In addition to above, it is felt that improvement in management through better operation & maintenance, improved system of distribution and encouragement to participatory approach in water management; mass awareness etc. will improve the overall water use efficiency by about 0.5%. With taking up activities as above for improvement of WUE in other sectors also, it is estimated that overall water use efficiency in the country can be improved by 20% i.e. from about 35% to about 42% by end of 2017.

SUCCESS STORIES OF FARMERS PARTICIPATORY ACTION RESEARCH PROGRAMME (FPARP)

Ministry of Water Resources is implementing Farmers' Participatory Action Research Programme (FPARP) throughout the country for conducting demonstrations at farmers' fields. FPARP involves field demonstration of water saving technologies developed by various institutes for increased productivity per drop of water. As per the details received from the institutes, in general, the demonstrations show that the saving of water ranges between 10 to 30 % (wheat from 5 to 33%, vegetables from 23 to 40% and paddy from 25 to 54%) and yield improvement of the crops ranges between 10 to 40% (wheat ranging from 16 to 43%, vegetables from 10 to 23%, paddy from 10 to 62%). Farmers have also shown their interest to support the programme and have positive view in respect of water saving and increase in yield by such demonstrations.

Some of the success stories are as under.

- **Department of Agronomy, Faculty of Agriculture, Birsa Agricultural University, Ranchi**

  Participatory as well as adjoining farmers realized about the water saving and enhancement in yield by adopting improved irrigation methods i.e. adoption of micro irrigation systems (MIS). Results of the demonstration on Sprinkler as well as Drip irrigation systems are summarized in Tables 1 and 2.

Table 1: Response of different crops to sprinkler irrigation systems

Crops	Water Saving (%)	Yield Increase (%)
Bhindi	37	25
Chilli	40	26
Onion	41	25
Cauliflower	41	24
Wheat	42	27

Other benefits:

- Elimination of the channels of conveyance, thereby reducing conveyance loss.
- Saves land as no bunds are required.

Table 2: Response of different crops to Drip Irrigation Systems

Crops	Yield Increase (%)	Water Saving (%)
Cauliflower	30 – 40	50 – 60
Cabbage	25 – 35	60 – 70
Potato	25 – 35	55 – 65
Tomato	30 – 50	55 – 75
Bhindi	30 – 45	40 – 50
Brinjal	25 – 35	50 – 70

Other benefits:

- Irrigates only the root zone of the crop rather than the entire line surface.
- Reduces weeds in the crop field.

- **Sher-e- Kashmir University of Agricultural Sciences & Technology of Kashmir, Shalimar, Srinagar (J&K)**

  New technology of water application like drip irrigation system which consists of main line, submain line, laterals, valves, drippers or emitters, riser valves, pressure gauges, filters, flush valves and pressure regulators have been successfully demonstrated in the farmers fields. The performance of these systems evaluated for horticultural crops, row crops and floricultural crops are given in Table 3.

Table 3: Water saving and increase in yield through drip irrigation system

Sl. No.	Name of the Crop	Water saving (%)	Increase in yield (%)
Drip Irrigation with fertigation			
1.	Apple	40-65	60 - 85
2.	Grapes	48-52	67
3.	Pear	45	30 - 48
4.	Cherry	32-50	40 - 65
5.	Apricot	35-67	67- 80
6.	Tomato	30-40	32
7.	Cauliflower	35-50	45
8.	Cabbage	35 - 60	45-67
9.	Ridge Gourd	60	10-30
10	Chilly	40-62	25-30
11.	Radish	50-77	45-70

12	Onion	17-30	30-55
13.	Lady finger	45 - 65	45-55
14	Strawberry	68	55-87
15	Tulip	40-45	-
16.	Almond	40-52	60-75
Rice Wheat Rotation*			
1.	Rice	30-40	105-145
2.	Wheat	20-25	88-110

* The wheat crop is mostly grown under rainfed conditions in Kashmir valley but during the project an additional three irrigations have been given to the crop which has shown a good effect on the yield of the wheat crop.

The effect of technologies demonstrated on **wheat** is given in Table 4.

Table 4 Effect of technology demonstrated for Wheat in Kashmir Valley

Particulars	**Demonstrated Technology**	**Farmers practice**
Grain Yield (kg./ha.)	2450	1100
Straw yield (kg/ha)	3062	1725
No. of irrigations provided	3	Rainfed
Depth of irrigation (cm)	4	-
WUE (kg/ha/mm)	3.18	1.69
Fertilizer applicable (N;P;K,Kg/m)	120 : 90: 40	150: 80: 40
Water use for irrigation (cu.m)	7300	6500
Seed rate (kg/ha.)	95	110
Net returns (Rs./ha)	48996	24800

- **Division of Water Management, Indian Council of Agricultural Research, ICAR Complex for NEH Region, Umroi Road, Umiam, Meghalaya**

  Technology demonstrated was construction of Low cost micro rain water harvesting structure (Jalkund) for Hill top and in-situ residue management for carry over soil moisture for second crop under terrace situation. The impact of demonstrations on increase in yield of the crops is given in Table 5 and 6 respectively.

Table 5: Technology - Construction of (Jalkund)

Crops	**Production before Jalkund (q/ha)**	**Production after Jalkund (q/ha)**	**Increase in Yield (%)**
Tomato	2720	3500	27
Brinjal	110	165	50
Strawberry	80	110	38
Broccoli	119	175	47
Cabbage	162	220	35
Leafy Mustard	128	172	34

Table 6: Technology – In-situ soil moisture conservation for second crop

Districts	**Crops**	**Production before demonstartion (t/ha)**	**Production after demonstration (t/ha)**
Ri-Bhoi	Maize & Mustard / lipatta (leafy vegetables)	2-6	3.2-10
East Khasi Hills	- do -	5-7.5	8-15
Jaintia Hills	- do -	5-8	7.4-13
West Khasi Hills	- do -	5.4-9.3	16.8-18

- **Soil and Water Management Research Unit, Navasari Agricultural University, Navasri, Gujarat**

  Technology like Low cost polyhouse (LCPH) with low energy drip systems and installation of drainage were demonstrated. The outcomes are given in Table 7.

Table 7: Water saving and increase in yield

Sl. No.	**Name of the Crop**	**Water saving (%)**	**Increase in yield (%)**

Low cost polyhouse (LCPH) with low energy drip systems			
1.	Brinjal seedlings	44	231
2.	Tomato seedlings	63	31.7
3.	Chillies seedlings	37	22.8
4.	Coriander	70	184
5.	Spinach	50	258
6.	Broccoli	67	48
7.	Lettuce	71	44
8.	Green garlic	50	33
Installation of drainage			
1.	Sugarcane (ratoon)	-	46.3
2.	Sugarcane	-	9.4

CONCLUSION

There is scope for improving water efficiency by as much as 20% of existing about 35% by the year 2017 and in the process water productivity by taking measures for improving performance of irrigation systems and adoption of appropriate water application practices,. Many promising pathways for raising water productivity are available to fully irrigated farming systems. There is scope for reducing water applied to fields and to increase water productivity either by increased yields or by serving more commands with same water availability made available through improvement in irrigation systems. The scope for improvement is not limited to irrigated commands but also in rainfed commands. The economic productivity of water through its multiple uses notably by integrating fisheries and aquaculture with irrigation in many regions will get further improved.

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