Technical Bulletin No. 88

Recommendations of Brainstorming Workshop on

Enhancing Agricultural Water Productivity in Canal Commands: A Dialogue

R.K. Panda, K.K. Bandyopadhyay & Arjamadutta Sarangi

भाकृअनुप-भारतीय जल प्रबंधन संस्थान, भुवनेश्वर
ICAR- Indian Institute of Water Management, Bhubaneswar

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Bhubaneswar, Odisha-751023
2024

CORRECT CITATION
Panda, R.K., Bandyopadhyay, K.K. and Sarangi, A. (2024) Recommendations of Brainstorming Workshop on Enhancing Agricultural Water Productivity in Canal Commands: A Dialogue, Technical Bulletin No. 88, ICAR-Indian Institute of Water Management, Bhubaneswar, Odisha, India, 1-20 p.

Technical Bulletin No. 88

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LAYOUT & PRINTED AT
Print-Tech Offset Pvt. Ltd.
Bhubaneswar

MESSAGE

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भारतीय कृषि अनुसंधान परिषद
कृषि एवं किसान कल्याण मंत्रालय, कृषि भवन, नई दिल्ली–110 001

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As we navigate the complex challenges posed by population growth and climate change, the efficient management of water resources assumes paramount importance. The canal irrigation system in India, a cornerstone of our agricultural landscape, faces significant inefficiencies, with irrigation efficiency hovering at a modest range of 30-40%. Recognizing the urgency of the situation, the ICAR-Indian Institute of Water Management, Bhubaneswar, Odisha convened a brainstorming workshop to devise comprehensive strategies to address this pressing issue.

In this technical bulletin, the outcome of collective efforts crafted through rigorous analysis, informed discussions and innovative ideas are presented. It underscores the importance of judicious management and proactive governance in optimizing the invaluable water resources. Strategic interventions and meticulous planning would offer promising avenues for enhancing the water use efficiency in canal commands as the development of new irrigation infrastructure may not be feasible.

I commend the dedication and expertise of all participants who contributed to this endeavour. I hope the publication serve as a guiding beacon for policymakers, practitioners, and stakeholders alike in their efforts to enhance the resilience and sustainability of canal commands of the Country.

(Himanshu Pathak)

Dated the 2nd May, 2024
New Delhi

MESSAGE

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01.05.2024

Water, the elixir of life, stands at the forefront of our collective challenges in present time. As India grapples with burgeoning population growth and the far-reaching impacts of climate change, it becomes necessary to give prime emphasis on efficient and sustainable water resources management. At the heart of this endeavour lies the canal irrigation system—a lifeline for agriculture and a cornerstone of rural livelihoods.

The realization that our current canal irrigation system operates at a sub-optimal efficiency that require an urgent and focused action. In response to this pressing need, the ICAR-Indian Institute of Water Management, Bhubaneswar, Odisha convened a brainstorming workshop by uniting experts, scholars, and practitioners from across the Nation to deliberate on transformative solutions.

This Technical Bulletin embodies the collective wisdom and innovative spirit that permeated discussions on the pivotal role of judicious management and strategic governance of irrigation water in canal commands for sustainable livelihoods. In a landscape, where the development of new irrigation infrastructure remains a distant possibility, the path forward lies in harnessing the full potential of existing resources through innovation, collaboration and suitable comprehensive policy.

I extend my heartfelt gratitude to all contributors who have lent their expertise and passion to this endeavour. May this publication serve as a guiding light for policymakers, researchers, and stakeholders as we are committed to safeguard our water resources and build a sustainable canal command and climate resilient agricultural ecosystem.

(S.K. Chaudhari)

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PREFACE

Most of India's major irrigation command areas face issues with insufficient and unreliable water supply, resulting in potential lag, which is the gap between irrigation potential created and utilized. Command area development and renovation of canal conveyance and distribution systems constitute a significant thrust in bridging this potential gap. The major constraints of canal irrigation system include *viz.*, non-availability of reliable minor canals and field channels for supply of water to farmers' field; Dilapidated infrastructure in canal command; Non availability of water measuring systems or devices; Fixed canal rostering in the command based on *Warabandi, Osrabandi and Sejpali* systems; Inadequate co-ordination among line Departments. Given the importance of water and food security, an accurate assessment of the performance of India's canal irrigation systems is essential. Under this backdrop, a brainstorming workshop was organized at ICAR-IIWM, Bhubaneswar on February 13, 2024 on "**Enhancing agricultural water productivity in canal commands: A Dialogue"** with experts from different research organizations like International Water Management Institute, Indian Space Research Organization, Indian Agricultural Research Institute, National Institute for Agricultural Policy, Odisha University of Agriculture and Technology, Officials and Engineers of the line Departments like Department of Water Resources, Govt. of Odisha to chalk out the present status of water management in canal commands, improving the water productivity using modern tools and techniques, development of specific governance framework and policies. Nearly 38 delegates including 16 panellists participated in this brainstorming workshop. The brain storming was targeted towards discussing these issues under specific four themes, such as: (i) Status and scope for enhancing agricultural water productivity in canal commands of the country; (ii) Geo-spatial tools, models, sensors and ICT in enhancing agricultural water productivity from canal commands: present status and future scope; (iii) Climate smart agricultural water management technologies in canal commands and (iv) Policy and institutional governance framework for enhancing agricultural water productivity in canal commands. The salient recommendations of this brainstorming session are being compiled and published for its future use by researchers, stakeholders, administrators and policy makers for enhancing water productivity in canal commands.

(Authors)

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Background

India has a total geographical area of 328.7 million hectares (Mha), of which 141 Mha is net cultivable and 197.3 Mha is gross cultivable area. The net irrigated area in India is approximately 71.6 Mha, with surface irrigation accounting for about 88% of the irrigated area (GOI, 2022). The irrigation sector is the prime user of water resources and it needs special attention in terms of its judicious use to enhance agricultural water productivity. In India, irrigation from well systems is the largest source accounting for nearly 63% (45 Mha), followed by canal irrigation accounting for about 26% (16.7 Mha) of the total net irrigated area with the remaining area irrigated by tank sources (GOI, 2022). Considering the rapid decline of groundwater level due to over-exploitation, canal irrigation plays a major role in enhancing agricultural production in the command area. Most of India's major irrigation command areas face issues with insufficient and unreliable water supply, resulting in potential lag, which is the gaps between irrigation potential created and utilized.

This emphasis corresponds to the increasing competition for water from different sectors, and increasing financial burden on operational and maintenance (O&M) of water delivery system (WDS), particularly in the irrigation sector. Since 1970, the Government of India has invested over 22863 billion INR in the major, medium, and minor irrigation sectors to improve water delivery, water-use efficiency and agricultural water productivity. In spite of the significant investments in the water sector, net canal or tank irrigated area have declined since 1990's. In India, low water-use efficiency (WUE) and productivity besides the widening gap between the irrigation potential created (IPC) and irrigation potential utilized (IPU) generally known as the potential lag and the low consumed fraction (CF) ranging from 25 to 45% is the major concerns in canal irrigation performance. Thus, need of accurate estimation of IPU is critical, which is associated with other performance indicators *viz.*, Actual Evapotranspiration (AET), Water Use efficiency (WUE), irrigation method, land and water productivity and cost benefit analysis.

Water delivery systems for irrigation include major, medium and minor irrigation systems, tanks, ponds, groundwater, run-of-river diversions and lift irrigation systems. Moreover, as on 2020-21, canal irrigation (major, medium, and minor WDS), tanks, tube wells, open wells and other sources irrigate about 18.6Mha, 2.1Mha, 37.2Mha, 10.1 Mha and 9.6 Mha, respectively. In India, the potential lag is a major concern relating to food security. The ratio of IPU to IPC has declined from 86% in 1997 to 80% in 2007 and 77% in 2012. A study commissioned by the Ministry of Water Resources that included several experts from the Indian Institutes of Management (IIMs) revealed that both supply and demand side drivers, such as overestimated IPC or underestimated IPU trigger the potential lag. Case study on increasing WUE in an irrigation system in Maharashtra during 2016 identified rainfall variability, leakages in canal structures and dysfunctional distribution networks and non-availability of water measuring systems as the bottlenecks leading to lower water use efficiency. Without targeting the core issues, many policy interventions target increasing canal irrigation performance. Command area development and renovation of canal conveyance and distribution systems constitute a significant thrust in bridging the potential lag. The Twelfth Five-Year Plan of India (GOI, 2013) allocated 15% of the water sector investments to command area development to bridge the gap between IPC and IPU and proposed a 20% increase in WUE during the plan period (2012–17). More recently, the PMKSY proposed *'Per Drop More Crop'* (increasing water productivity) and *'Har Khet ko Paani'* (irrigation for all) under PMKSY (*Prime Minister's Krishi Sinchayee Yojana*)

as its guiding principles. However, imprecise land and water use information relating to canal irrigation systems often inhibits proper investment decisions and their implementation.

Given the importance of water and food security, an accurate assessment of the performance of India's canal irrigation systems is essential. The focus of performance assessment of canal irrigation systems at present is only on the culturable command area (CCA). For most irrigation managers, the designed CCA is the water influence zone (WIZ) of the water source, be it a reservoir, a run-of-the-river diversion or a lift irrigation project. The prime goal is to increase the irrigation WUE and WP in the CCA and perhaps, the only goal. However, in many instances canal irrigation supplies generate return flows for groundwater irrigation in areas inside and outside the CCA. Thus, it becomes imperative to re-estimate the performance indicators pertaining to the water budgeting aspects of the canal commands for informed decision-making. Waterlogging, salinity and soil degradation all spell trouble for canal irrigation. To ensure the continued success of canal irrigation, replenishing groundwater supplies in the canal command area has become an urgent need. Climate change is another dimension that needs to be considered while discussing improvements in canal irrigation performance. In India, the monsoon season between June and September contributes 75% of the total annual rainfall and is the key to the Indian economy. Any significant changes in precipitation that affect water resources would impact growth and output of not only agriculture but also non-agricultural sectors, which at present contribute 85% of the country's gross domestic product. Thus, increasing climate change impacts, especially flood, high intense and short duration rainfall, moisture stress and droughts affect the irrigation systems to deviate from business-as-usual water management decisions and practices. In the absence, frequent stoppage of canal irrigation supplies and disrupted livelihood systems will significantly challenge policymakers and managers of canal irrigation system. The policy and management decisions should consider alternative solutions to increase productivity and enhance climate resilience in the canal commands. The governance mechanisms should recognize the changes that are already taking place in irrigation commands to address the future challenges.

Studies undertaken by IWMI (International Water Management Institute) and ICAR-IIWM (Indian Institute of Water Management) in the *Sina* and *Kukadi* irrigation systems in Maharashtra demonstrated the deviations of the actual estimates from data reported by different organizations working in canal commands. While the system management focuses mainly on canal water management in the designed canal command area, farmers use groundwater extensively to support agriculture within and beyond the designed command area. The groundwater recharged from the return flows of canal irrigation is a major source of water for agriculture within and outside the canal command area. Depending on the topography, the water influence zone could extend beyond the command area. The gap between irrigation potential created and utilized and the water use efficiency may not be as low as previously thought when we consider conjunctive use of canal and groundwater at the system level. However, there is substantial potential to increase the irrigation water use efficiency (IWUE), which can increase the system and farmers' resilience under extreme climatic conditions, especially in water deficit regions.

A few farmers have adopted diversified cropping patterns from low-value seasonal crops to high-value seasonal or annual crops. These farmers are risk takers and some are

entrepreneurs to support their farm operations. Some have self-sustainable farm operations. So, the pertinent issue lies in the subsequent upscaling of these practices within and across irrigation systems of our Country. Inadequate information pertaining to canal commands is a major deficiency in decision making at present. The resource-strapped irrigation managers use old data collection techniques for assessing land use and cropping patterns. These statistics result in over or under-allocation of water resources across the irrigation systems and investments that inhibit the practices of progressive farmers. Improved information-gathering techniques including satellite data, sensor-based observations, etc. in geospatial format and provision of canal automation and use of advanced Information and Communication Technology (ICT) protocols are necessary for modernizing irrigation systems. Besides this, the protocol needs to be standardized for conjunctive water use planning in the canal command in addition to water harvesting structures. The other deficiency in upscaling advanced practices is the governance mechanism including involvement of WUAs and local institutions. The governance mechanisms that support irrigation systems are no longer adequate to modernize irrigation systems. Modernization requires close cooperation of water, agriculture, markets, the private sector, service providers, communities, etc.

Under this backdrop, it is pertinent to ponder over this important water sector focusing on the canal commands of the Country for enhancing canal water use efficiency and sustainable livelihood. An attempt was made to brainstorm with experts from different research organizations like International Water Management Institute, Indian Space Research Organization, Indian Agricultural Research Institute, National Institute for Agricultural Policy, Indian Agricultural Research Institute, Odisha University of Agriculture and Technology, Officials and Engineers of the Line Departments like Department of Water Resources, Govt. of Odisha to chalk out the present status of water management in canal commands and improving the water productivity using modern tools and techniques and development of specific governance framework and policies. So the brain storming was targeted towards discussing on these specific themes, such as: (i) Status and scope for enhancing agricultural water productivity in canal command of the country; (ii) Geo-spatial tools, models, sensors and ICT in enhancing agricultural water productivity from canal commands: present status and future scope; (iii) Climate smart agricultural water management technologies in canal commands and (iv) Policy and institutional governance framework for enhancing agricultural water productivity in canal commands.

Dr. Arjamadutta Sarangi, Director of the Institute set the stage of the brainstorming workshop by a brief presentation covering the present scenarios of water management in canal commands and emphasized the enhancement of water use efficiency by 20% from present level. Dr. Sarangi also expressed that if we store all utilizable water, we will still fall short of water to satisfy the demand in future. Therefore, there is need of enhancing water use efficiency in the canal command area. He said that there are about 36 canals in India commanding 29.5 Mha area in our country. In 2022-23, out of the 141 million hectares of gross sown area in the country, nearly 52% (73 million hectares) had access to irrigation compared to 41% in 2016. According to the updated data from *Niti Aayog*, GoI, 60% of irrigation is met by groundwater and 40% by canal. The major constraints of canal irrigation system were highlighted *viz*., Non-availability of reliable minor canals and field channels for supply of water to farmers field; Dilapidated infrastructure in canal commands; Non availability of water measuring systems or devices; Fixed canal rostering in the command based on *Warabandi*,

Osrabandi and *Sejpali* systems; inadequate co-ordination among various line departments. Dr Sarangi also pointed out the need for the use of modern tools in canal commands for enhancing agricultural water productivity.

Fig.1. Major Canals of India

SWOT Analysis

A Strength-Weakness-Opportunity-Threat (SWOT) analysis was presented for improving the water productivity in the canal commands

STRENGTH

- **Large-scale coverage:** providing water to millions of farmers
- **Reliability:** reducing dependence on erratic rainfall
- **Infrastructure development:** leading to improved transportation networks and socio-economic development
- **Cost-effective:** providing a low energy requiring cost-effective means of irrigation compared to other methods like tube wells or micro irrigation systems

WEAKNESS

- **Maintenance challenges:** costly and resource-intensive proposition.
- **Water loss:** reducing the efficiency of water distribution.
- **Dependency on weather:** affecting effectiveness during droughts.
- **Limited reach:** leading to disparities in water distribution.

OPPORTUNITY

- **Modernization:** improving the efficiency of water distribution and reduce losses.
- **Interlinking of rivers:** enhancing the efficiency of canal systems.
- **Public-private partnerships:** attracting investment for infrastructure development and maintenance.
- **Crop diversification:** contributing to increased agricultural productivity and income.

THREAT

- **Climate change:** affecting water availability, potentially disrupting canal irrigation systems.
- **Water conflicts:** impacting the stability of this irrigation systems.
- **Land degradation:** leading to soil erosion and degradation.
- **Public challenges:** hindering the effective management and development.

Fig.2. SWOT Analysis of canal commands

Status and Scope for Enhancing Agricultural Water Productivity in Canal Commands of the Country

- There is a need for benchmarking of the canals of India and the difference in water diverted to canal and water availability in field should be reduced. There is need for assessment of water productivity under conjunctive use of canal water and groundwater, and irrigation efficiency in system level and below outlets. Proper measurement and monitoring of water are needed for increasing water use efficiency in command areas.
- There exists a gap between the understanding of the problems and finding solutions for low water use efficiency in canal commands. Water budgeting, improving irrigation conveyance system and testing the feasibility of tools and methodologies developed to solve the problems of water scarcity in canal commands in present and future scenarios is required.
- Increase of water productivity in canal command is possible through demand and supply side management of water. Water saving techniques like partial root zone drying (PRD) and regulated deficit irrigation (RDI) can play a major role in water saving in canal commands. No-till farming or conservation agriculture prevents soil moisture evaporation leading to reduced irrigation water requirement. Modern technology *viz.* Piano Key Weir, which could increase the spillways capacity and create in-channel storage can be implemented.
- In the context of climate phenomena like El Nino and Indian Ocean Dipole (IOD), Madden Julian Oscillation (MJO) which are increasingly impacting the Indian subcontinent, relevance of Regulated Deficit Irrigation (RDI) regimes and Conservation Agriculture have gained urgency for sustenance and growth of canal irrigated agriculture through optimal water use.
- Considering the raging global warming, it is imperative to undertake pilot studies on regulated deficit irrigation (RDI) and Conservation Agriculture practices through well-conceived action program for accomplishing transformation in the canal command.
- The critical headworks infrastructure in India, which are catering to canal irrigation command, should be critically reviewed for required upgradation through retrofitting using recent technology.
- Canal automation in conveyance system along with automated irrigation in canal commands based on downstream demand-oriented irrigation will enhance water productivity in canal commands.
- There exists a minimal difference in application efficiency of groundwater (57-62%) and canal water (53-55%). But the low irrigation water use efficiency in canal system is basically on account of low conveyance efficiency due to unlined conveyance channel. Lining of the conveyance channel or use of piped irrigation with a water measuring system would enhance the irrigation water use efficiency.
- It was highlighted that the water use efficiency is reported within 35-40% in the canal commands. Presently there is a single outlet for 40 ha area and irrigation is mostly given by surface irrigation method. In order to reduce the irrigation water loss by evaporation,

seepage and infiltration, the underground pipe line (UGPL) system with one outlet per ha of land would enhance the irrigation water use efficiency.

- In order to enhance water productivity, pisciculture activity in the water harvesting farm ponds besides vegetable cultivation in the canal commands can be taken up.
- There is a need for strengthening and capacity building of *pani panchayat* or WUA for achieving higher water productivity in canal commands.

Geo-spatial Tools, Models, Sensors and ICT in Enhancing Agricultural Water Productivity from Canal Commands: Present Status and Future Scope

- Modernization of canal network, flow control, regulation & automation, volumetric water measurement & pricing of irrigation; allocation of water quota entitlement and its enforcement; regulating proliferation of wells in the canal commands; transforming WUAs as business entity; grooming 21st century irrigation managers; creating a strong agricultural water management extension service etc. will rezuvenates the canal irrigation system.
- Geo-spatial tools are used for preparation of the digital data base of the canal command network besides mapping the spatial and temporal variability of soil, water and land use parameters. Such data bases need to be integrated with mobile applications for generation of a decision support system for irrigation scheduling in the canal command.
- Models and IoT enabled sensing systems are being used for real time irrigation scheduling for enhancing water productivity. Success of canal automation projects and IoT enabled irrigation scheduling systems need to be replicated to other locations.
- Earth Observation Satellite (EOS-04 and EOS-06) data are used for delineation of *kharif* rice cropped area and *kharif* sown area progress monitoring. Further, the process for identification and classification of rice cropped area using these satellite data are also practised. These remote sensing products can be successfully used for assessing regional water productivity of different crops and cropping systems in canal commands.

Climate Smart Agricultural Water Management Technologies in Canal Commands

- Climate change due to accelerated GHGs emissions is one of the greatest challenges for present day agriculture. Climate smart agricultural practices *viz*., SRI method of rice cultivation, alternate wetting and drying method of irrigation, no-till production system, automated irrigation system, groundwater recharge should be promoted to ensure climate resilient agriculture. Advanced research on use of remote sensing on crop monitoring, water resources inventory, digital soil mapping and use of drones should be promoted to mitigate impact of changing climate on water resources availability and crop production.
- The success stories of 39000 *Pani panchayat* in Odisha can be replicated in other parts of the Country for the equitable distribution of water resources. There is a need to enhance the capacity of the stakeholders on use of scientific methods of water management,

measuring the irrigation water, climate smart water management and develop appropriate guidelines and policy framework to encourage and reward stakeholders for adoption of good agricultural water management practices.

- Site specific climate resilient cropping system for the vulnerable regions and benefits of this should be disseminated among the farming community. The climate smart water management techniques on canal commands *viz.*, water measurement and monitoring, water harvesting and storage, early warning system and agro-diversity, integrated water resources management, water allocation policies, Govt. support and incentives etc. will assist in improving the water productivity in the canal commands under changing climate.
- Success of climate smart agricultural water management techniques for drought management in Dhar (MP) and Mewat (Haryana) *viz.*, deepening of open wells, renovation of water harvesting structures with the involvement of farming communities, integrated water resources management, laser levelling, under-ground pipe based irrigation, micro irrigation, portable sprinkler and rain gun-based irrigation etc. should be replicated in other parts of the country.
- There is need for gradually shifting from canal distribution network to underground pipe irrigation network and formation of Water Users' Association for underground pipe irrigation network.
- There should be policy decision for large scale adoption of climate smart agriculture practices like conservation agriculture for improving water productivity. The success stories of water resources augmentation and management system should be highlighted and disseminated to stakeholders.
- Climate smart water management practices *viz.*, (i) Upgrading canal systems with efficient water delivery mechanisms such as piped networks to minimize water losses through seepage and evaporation, (ii) Installation of flow measurement devices and real-time monitoring systems to improve the efficiency of canal irrigation system; (iii) Precision irrigation Technology to implement variable rate irrigation, demand based water supply to different areas within the command area, (iv) Cultivation of drought-resistant or climate-resilient crop varieties within the canal command to reduce water demand while maintaining productivity; (v) Construction of small on-farm storage structures (ponds and reservoirs) within the canal command to capture and store excess water during periods of abundance for use during dry spells; (vi) Implement an integrated approach for water resource management by considering upstream-downstream linkages and adopting measures to protect and enhance the health of the command will help in improving the water productivity of canal commands.
- Community engagement *viz.*, (a) conduction of training programs and workshops to educate farmers on climate- smart water management practices, efficient irrigation techniques, and water conservation (b) Formation of farmers' associations to promote collective water management efforts, resource sharing, and adoption of sustainable practices will help in implementation of climate smart water management technologies.

Policy and Institutional Governance Framework for Enhancing Agricultural Water Productivity in Canal Commands

- There is a need for analysis of water foot print, recycle and reuse of water including return flows, incentivizing economic and efficient use of water, adoption of water saving technologies, performance monitoring, reclamation of waterlogged and saline area, regulation of water prices, database and information based capacity building, improving conveyance efficiency through lining of canal system, on-farm application efficiency through micro irrigation and bridging the gap between IPC and IPU.
- Dilapidated structures in the canal command, siltation of canal systems, poor maintenance, seepage loss, changing cropping pattern, untrained farmers, low responsive farmers, poor functioning of WUAs are the prime reasons for low water productivity in canal commands. Therefore, strategies such as realignment of cropping pattern, regulation and measurement of water flow, strengthening of WUAs, training and capacity building of farmers, working out mechanisms for regular maintenance of structures should be worked out.
- There is need for prioritizing use of water, proper valuation of water, incentivizing economic use of water, irrigation asset management, and proper supply and demand management of canal water, promoting PIM for effective and efficient use of canal water.
- The main target domains for interventions are strengthening the performance of Water Resource Department (WRD), Participatory Irrigation Management, rehabilitation and upgradation of medium and minor projects and agricultural support. The core strategy of Chhattisgarh Irrigation Development Plan (CIDP) model was to manage *'kharif for rabi'* by shortening the *kharif* crop to maximize the use of rain, harvesting of *kharif* crop (*i.e.* paddy) early and latest by mid-November, and cultivating rabi cash crops using saved water in the reservoir to enhance the water productivity. This lession needs to be replicated in other locations.
- Long-term data analysis during the period 1960-61 and 2019-20 revealed overdependence on groundwater irrigation progressively led to significant decline in groundwater level in Punjab and Haryana. Similarly, the period also witnessed substantial increase in energy use in agriculture and electricity use per hectare. Thus, in order to arrest the decline of groundwater level, strategies such as crop diversification with less water intensive crops by enacting suitable laws, tweaking price policies, regulating electricity uses etc. needs to be addressed. One such law was the Punjab/Haryana Preservation of Subsurface Water Act 2009 that prohibits farmers sowing paddy nursery before May 10 and transplanting before June 10 or any other dates as notified by the Government. The act also contained provisions of penalty for farmers in case of contravention of the law. However, the study clearly showed that the Act, instead of changing the behaviour of farmers towards rational use of groundwater resources, increased groundwater extraction rate through use of higher capacity pumps. That led not only to increase in paddy area but also increase in cropped area during *rabi* season. Therefore, managing groundwater resources in canal commands require comprehensive irrigation strategy encompassing technologies, policies and understanding the responses of farmers.
- By using indirect instruments like date of transplanting instead of directly regulating groundwater extraction led to perverse responses especially when supplementary polices such as zero cost of electricity, support prices and procurement, input subsidies

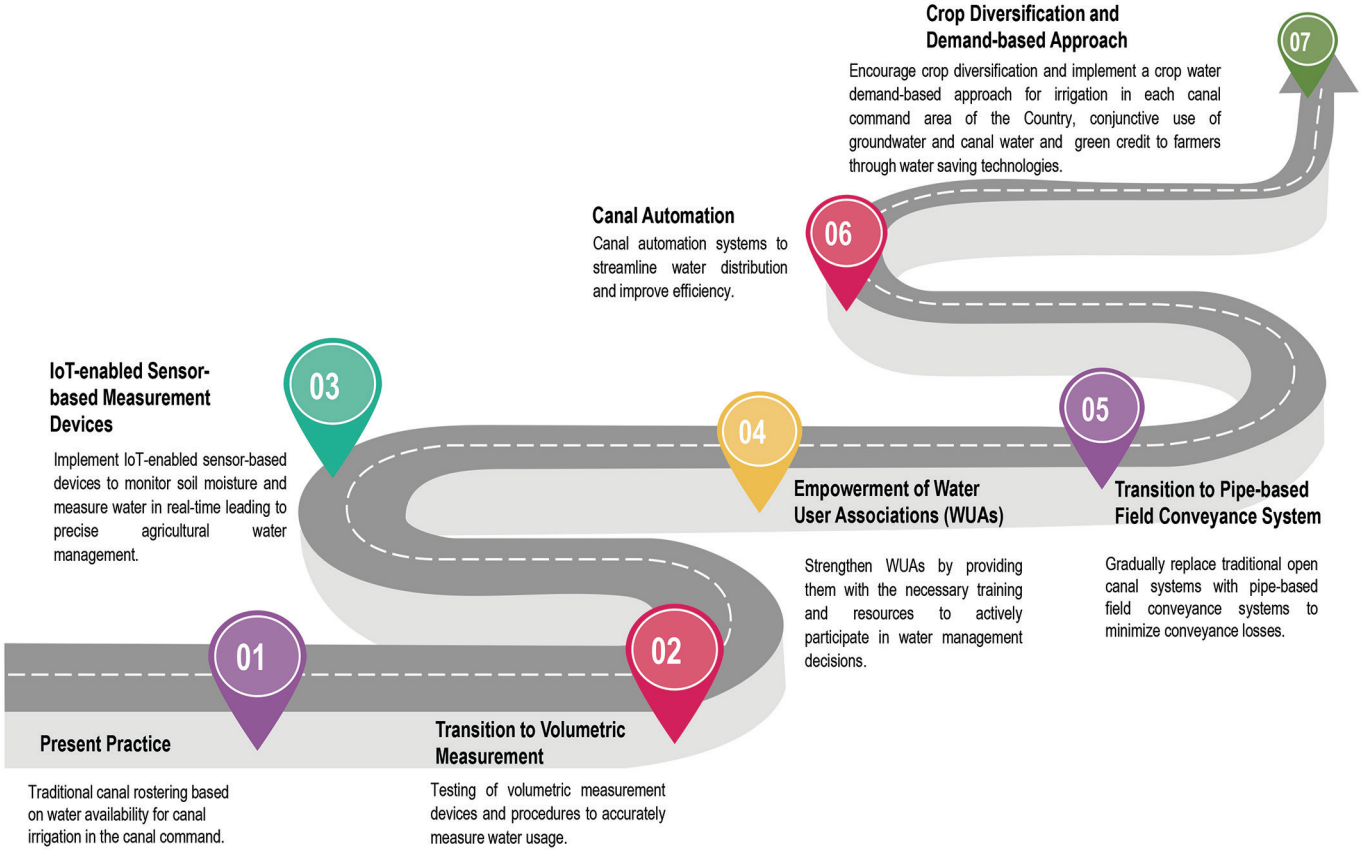
etc. persisted as before. Thus, lack of coherence between water, energy and food policies on one hand besides lack of compliance on part of the farmers on the other were the main reasons for unsustainable use of groundwater in states like Punjab and Haryana.

- There is a great importance of canal command areas in context of sustainable water management, seasonal variability in irrigation, flood control management, crop diversification and yield enhancement. Components of this framework were policy formulation, institutional capacity building, stakeholder engagement, monitoring and evaluation.
- There is a need for robust policies pertaining to water allocation, water pricing, crop selection, land use regulation, implementation of water saving technologies, incentivizing efficient irrigation practices and promoting crop diversification. The other important dimensions are active involvement of stakeholder such as farmers, NGOs, private and govt. agencies, and regular interaction meetings and participatory decision-making process with feedback acquisition and awareness campaigns.
- Odisha *Pani Panchayat* Act 2002 was enacted for equitable distribution of water. Under this Act, more than 38000 *Pani Panchayats* were created to manage 22.6 lakh ha of land. But despite good progress in formation of WUAs, poor performance of such associations in terms of their involvement in carrying out maintenance work in canal system and field channels and in changing cropping patterns in canal commands, efficient sharing mechanism are observed.
- Therefore, detailed studies on functioning of WUAs, their capacity and constraints in managing canal systems for sustainable and equitable distribution of canal water; and characterization of different canal commands and assessment of the potential of such commands would provide insights for realigning policies and strengthening institutions for efficient management of canal water.
- Strengthening institutions is vital for effective implementation of policies and fostering collaboration among stakeholders. Capacity building measures *viz.*, training programs for farmers and water managers, establishment of water user associations, and enhancing technical expertise is essential for improving water productivity in canal commands.
- Active involvement of stakeholders fosters ownership and ensures the sustainability of interventions. Stakeholder groups include: farmers, water users, government agencies, NGOs, and private sector stakeholders. Engagement strategies like consultative meetings, participatory decision-making processes, and awareness campaigns should be developed.
- Regular monitoring and evaluation are essential for assessing the effectiveness of policies and institutional reforms. Indicators of monitoring should include water productivity metrics, crop yields, water use efficiency, and socio-economic impacts. Evaluation methods like impact assessments, performance reviews, and feedback mechanisms should be followed.
- The policy framework for canal commands should include policy interventions and institutional reforms *viz.*, water allocation, pricing mechanism, crop selection and land use regulations aiming at enhancing agricultural water productivity. The benefits of this framework include: (i) water management improvement; (ii) increased agricultural productivity; (iii) socio-economic development; (iv) enhanced food security; (v) sustainable water use; (vi) income generation opportunities and (vii) environmental conservation.

Salient Recommendations

- Benchmarking of India's Canal Systems is necessary to minimize disparities between water diverted to canals and water accessible in the fields. Evaluating water productivity with a combined use of canal and groundwater at both system and outlets is essential. Enhanced measurement and monitoring of water are impressive for improving Water Use Efficiency (WUE).
- Relevance of Regulated Deficit Irrigation (RDI) regimes and Conservation Agriculture (CA) have gained urgency for sustenance and growth of canal irrigated agriculture through optimal water use.
- Modernization of canal network, flow control, regulation and automation, volumetric water measurement and pricing of water; allocation of water quota entitlement and its enforcement; regulating proliferation of wells; transforming WUAs as business entity; grooming 21st century irrigation managers; Creating a strong agricultural water management extension service etc. should be taken up on priority.
- Climate change due to accelerated GHGs emissions is one of the greatest challenges for present day agriculture. Climate smart agricultural practices *viz*., SRI method of rice cultivation, alternate wetting and drying method of irrigation, no-till production system, automated irrigation system, groundwater recharge should be promoted to ensure climate resilient agriculture.
- Use of remote sensing on crop monitoring, water resources inventory, regional estimaton of actual evaporation, digital soil mapping and use of drones should be promoted to assess water resources demand and availability besides crop yield and water productivity.
- There should be policy decision for large scale adoption of climate smart agriculture practices like conservation agriculture for improving water productivity. The success stories of water resources augmentation and management system should be highlighted and disseminated to stakeholders.
- The reasons for low water use efficiency in canal command are *viz*., dilapidated structures in the canal command, siltation of canal systems, poor maintenance, seepage loss, changing cropping pattern, untrained farmers, low responsive farmers, poor functioning of WUAs. Therefore, strategies such as realignment of cropping pattern, regulation and measurement of water flow, strengthening Water User Associations (WUAs), training and capacity building of farmers, working out mechanisms and systems for regular maintenance of structures should be worked out.
- Water users' association (WUA) led collective action in managing water in most of the minor systems, control and management of sluice gate in medium irrigation systems, construction of field channels, and adoption of scientific package of practices are essential for improving water productivity in the canal command project.
- Encouraging participatory canal water management involves enhancing crop and water management at the system level by encouraging WUAs. The goal is to cultivate multi-functional WUAs through consistance and tailored technical support, fostering collaboration with relevant departments, and bolstering the capacity of their personnel through training initiatives.
- Pilot studies on crop water demand-based irrigation scheduling using mobile App based IoT enabled soil moisture sensor, water measuring devices and canal automation projects should be taken up to study its impact and possible upscaling.
- The water budgeting and water footprint estimation for the canal commands should be taken up to decide the optimal cropping pattern and the canal rostering to enhance the water productivity.
- Protocol for carbon credit estimation due to adoption of water saving technologies in the canal command need to be standardized. Besides this, the ecosystem service component based on the water saving interventions adopted by the stake holders need to be quantified.

Roadmap of canal water management: 2024-2047



ICAR-Indian Institute of Water Management
Bhubaneswar, Odisha

Enhancing Agricultural Water Productivity in Canal Commands: A Dialogue

13th February 2024 09:00-17:30Hrs ICAR-IIWM,Bhubaneswar

AGENDA

Time	Agenda	Chairman/Speaker/Rapporteurs
09:00-09:30	Registration	
09:30-09:45	Welcome of Participants and Context Setting	**Dr. A. Sarangi**, Director, ICAR-IIWM
09:45-10:30	Session-1: Status and Scope for Enhancing Agricultural Water Productivity in Canal Commands of the Country	*Chairman:* **Dr. A. K. Sikka**, Country Representative-India at IWMI, New Delhi, India *Co-Chairman:* **Dr. T. B. S. Rajput**, Former Project Director, WTC, ICAR-IARI, New Delhi *Rapporteurs:* Dr. P. Panigrahi and Dr. S. Pradhan *Keynote Address:* **Dr. Nayan Sharma**, Former Professor, IIT, Roorkee *Lead Speaker:* **Dr. D. K. Singh**, Former Professor, Div. of Agricultural Engineering, ICAR-IARI, NewDelhi
10:30-10:45	Tea Break	
10:45-11:30	Session-2: Geospatial Tools, Models, Sensors and ICT in Enhancing Agricultural Water Productivity from Canal Commands: Present Status and Future Scope	*Chairman*: **Dr. U. Amarasinghe**, Senior Researcher, IWMI, Colombo, Sri Lanka *Co-Chairman:* **Dr. S. Kulkarni**, Former Secretary, MWRRA and Executive Secretary, ICID *Rapporteurs*: Dr. Ashok K. Nayak and Er. Ajit K. Nayak *Keynote Address:* **Dr. S. D. Gorantiwar**, Director of Research, MPKV, Maharashtra *Lead Speaker:* **Dr. V. M. Chowdary**, Group Director (Agri Sci. Appl Group), NRSC, Hyderabad
11:30-12:15	Session-3: Climate Smart Agricultural Water Management Technologies in Canal Commands	*Chairman:* **Dr. S. Pazhanivelan**, Director, CWGS (formerly WTC), TNAU, Coimbatore *Co-Chairman:* **Sh. R. R. Nayak**, Director, OIIPCRA, Govt. of Odisha *Rapporteurs:* Dr. K. K. Bandyopadhyay and Dr. A. K. Thakur *Keynote Address:* **Dr. R. K. Panda**, Director, Centre for Climate Smart Agriculture, Siksha 'O' Anusandhan University,Bhubaneswar *Lead Speaker:* **Dr. Manoj Khana**, Principal Scientist, WTC (ICAR-IARI), New Delhi
12:15-13:00	Session-4: Policy and Institutional Governance Framework for Enhancing Agricultural Water Productivity in Canal Commands	*Chairman:* **Dr. K. Palanisami**, Emeritus Scientist, IWMI, New Delhi *Co-Chairman:* **Er. Harish Verma**, Executive Director, ICAD, New Delhi *Rapporteurs:* Dr. H. K. Dash and Dr. D. Sethi *Keynote Address:* **Dr. Pratap Singh Birthal**, Director, ICAR-NIAP, New Delhi *Lead Speaker:* **Er. Lingaraj Gouda**, EIC (Design & Planning), Govt. of Odisha
13:00-13:30	Open Discussion	
13:30-14:00	Concluding Remarks	**Dr. A. Sarangi**, Director, ICAR-IIWM
	Vote of Thanks	**Dr. R. K. Panda**, Principal Scientist & Programme Leader
	Lunch	

Annexture-1

List of attended participants:

Sl. No.	Name	Designation
		Joined Physically
1.	Dr. T.B.S. Rajput	Former Project Director, WTC, ICAR-IARI, New Delhi
2.	Dr. Nayan Sharma	Former Professor, IIT, Roorkee
3.	Dr. S. Kulkarni	Former Secretary, MWRRA and Executive Secretary, ICID
4.	Dr. Arjamadutta Sarangi	Director, ICAR-IIWM, Bhubaneswar, Odisha
5.	Sh. R. R. Nayak	Director, OIIPCRA, Govt of Odisha
6.	Er Lingaraj Gouda	Engineer in Chief (EIC) (Design and Planning), Govt of Odisha
7.	Dr. R.K. Panda	Director, Centre for Climate Smart Agriculture, Siksha 'O' Anusandhan University, Bhubaneswar
8.	Dr. R. K. Panda	Principal Scientist, Program Leader, CWM, ICAR-IIWM, Bhubaneswar
9.	Dr. S. K. Rautaray	Principal Scientist, Program Leader, ICAR-IIWM, Bhubaneswar
10.	Dr. S. K. Jena	Principal Scientist, Program Leader, ICAR-IIWM, Bhubaneswar
11.	Dr. M. Raychaudhuri	Principal Scientist, Program Leader, ICAR-IIWM, Bhubaneswar
12.	Kishore Chandra Pale	Department of Water Resources
13.	Prafulla Kumar Das	AEE, Water Resource Department, Odisha
14.	Dr. Sheelabhadra Mohanty	Principal Scientist, ICAR-IIWM, Bhubaneswar
15.	Dr. A. K. Nayak	Principal Scientist, ICAR-IIWM, Bhubaneswar
16.	Dr. A. K. Thakur	Principal Scientist, ICAR-IIWM, Bhubaneswar
17.	Dr. P. Nanda	Principal Scientist, ICAR-IIWM, Bhubaneswar
18.	Dr. Pravukalyan Panigrahi	Principal Scientist, ICAR-IIWM, Bhubaneswar
19.	Dr. Sanatan Pradhan	Senior Scientist, ICAR-IIWM, Bhubaneswar
20.	Dr. K. K. Bandyopadhyay	Principal Scientist, ICAR-IIWM, Bhubaneswar
21.	Mr. Ajit Kumar Nayak	Scientist, ICAR-IIWM, Bhubaneswar
22.	Dr. Hemanta Kumar Dash	Principal Scientist, ICAR-IIWM, Bhubaneswar
23.	Dr. Debabrata Sethi	Scientist-SS, ICAR-IIWM, Bhubaneswar
24.	Dr. Ranu Rani Sethi	Principal Scientist, ICAR-IIWM, Bhubaneswar
25.	Er. Dwiti Krishna Panigrahi	AEE, DOWR (CAD), Bhubaneswar
26.	Er. Tarini Chandra Sethi	Chief Engineer, CAD, Bhubaneswar
27.	Er. Susmita Swain	Junior Engineer (Agril.), CAD, Bhubaneswar
28.	Er. Purna Chandra Rath	Chief Engineer, Minor Irrigation, Bhubaneswar
		Joined Virtually
29.	Dr. A. K. Sikka	Head-Country Representative - India at IWMI, New Delhi, India
30.	Dr. D.K. Singh	Principal Scientist & Former Professor, Div. of Agricultural Engineering, ICAR-IARI, New Delhi
31.	Dr. U. Amarasinghe	Senior Researcher, IWMI, Colombo, Sri Lanka
32.	Dr. S. D. Gorantiwar,	Director of Research, MPKV, Rahuri, Maharashtra
33.	Dr. V. M. Chowdary	Group Director (Agri Sci. Appl Group), NRSC, Hyderabad
34.	Dr. S. Pazhanivelan	Director, CWGS (formerly WTC), TNAU, Coimbatore
35.	Dr. Manoj Khanna	Principal Scientist, WTC (ICAR-IARI), New Delhi
36.	Dr. K. Yella Reddy	Officer on Special Duty, Water Resource Department, Govt. of Andhra Pradesh
37.	Er. Harish Verma	Executive Director, ICID, New Delhi
38.	Dr. Prabhat Kishore	Scientist, ICAR-NIAP, New Delhi

भाकृअनुप-भारतीय जल प्रबंधन संस्थान, भुवनेश्वर

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