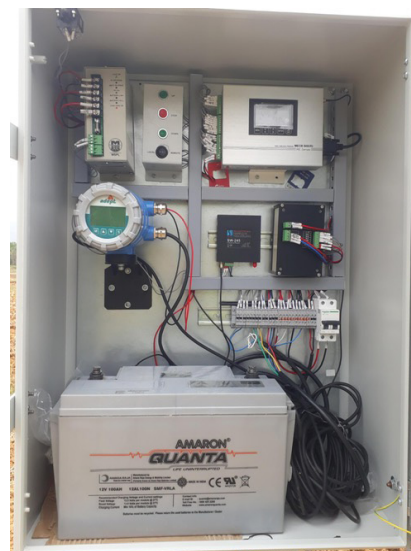


Technical Brochure

Transforming Conventional Canal Irrigation into a Smart Irrigation Network- A case study of the Darpanarayanpur Minor Irrigation Project (MIP), Nayagarh, Odisha



By

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1. Background of the project

Canal irrigation systems in India, particularly minor irrigation projects, often face structural constraints, poor maintenance, inequitable water distribution and supply-based irrigation scheduling resulting in low water productivity, mono-cropping (mainly paddy), and extensive rice fallows after *kharif* in the command.

The *Darpanarayanpur* Minor Irrigation Project (MIP) in Nayagarh, Odisha, with 577 beneficiaries of Darpanarayanpur, Kendudhipi, and Bapujipali villages with a command of 285 ha and paddy-fallow system was identified for the canal automation (Fig.1). The project was undertaken by ICAR-IIWM, Bhubaneswar in collaboration with Department of Water Resources, Govt. of Odisha, *Sukra Behera* WUA, and M/s Mechatronics Pvt. Limited, Pune. The prime objective of the project was to ensure smart water management based on crop water demand and uniform distribution of water in the entire command to enhance the irrigation water use efficiency and agricultural water productivity. Delineated map of the catchment besides the reservoir and the command area is shown in Fig.1.

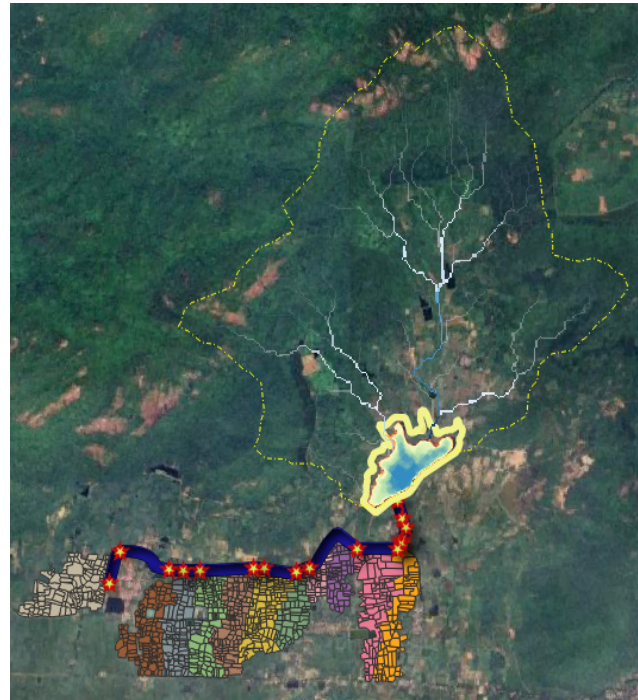


Fig.1. Delineated map of the catchment, the MI reservoir and the command area

1.1 Project overview

The project overview has been presented in Table 1.

Table 1. Overview of the implemented canal automation project

Parameters	Details
Project location	Darpanarayanpur MIP, Nayagarh District, Odisha
Command area	285 ha
Catchment of the MI reservoir	650 ha
Length of the Canal	3.0 km
Field outlets (Solar-operated)	11 Nos.
Automated cross regulators	4 Nos.
Head regulator	1 No
Automatic weatherstation (AWS)	1 Unit
Technology platform	SCADA integrated with IoT with sensors and operated by solar power

2. Baseline information of the canal command before canal automation

2.1 Cropping, water use pattern and baseline socio-economic assessment

Cropping system of the study region is predominantly rice during *kharif* followed by fallow in *rabi* season. There was inequitable water supply in the head and tail reaches of the command and the rostering was based on the available water without any real time monitoring of the water delivered to fields through each outlet. There was low cropping intensity with limited crop diversification. Prior to the operation of the canal automation, a baseline survey was undertaken using the data acquired from 54 farmers across 12 field outlets (head, middle, and tail reaches) of the command. The study significant variation in the indices as shown in Table 2. This indicates disparity in the head, middle and tail reach farmers due to inequitable distribution of water.

Table 2. Different indices of the baseline survey of canal command before operation of canal automation

Name of the index	Index value and mean	Remarks
Cultivable Land Utilization Index (CLUI)	0.243-0.369 (Mean: 0.283 ± 0.037)	CLUI reflects the impact of watershed interventions on cultivable area and cropping duration in pre- and post-project periods; higher CLUI values (up to 1.0) indicate greater land use under crops for longer periods.
Crop Productivity Index (CPI)	0.193-1.000 (Mean: 0.488 ± 0.188)	CPI measures average crop productivity relative to potential yield and is computed as the ratio of observed yield to recommended or highest yield; higher CPI values indicate yields closer to attainable maximum.
Rice cropping intensity (CI)	100-200% (Mean: 149.2 ± 42.4)	Cropping Intensity Index (CII) measures land-use intensity as (Gross Cropped Area / Net Sown Area) × 100; higher values indicate multiple cropping and greater production from the same land.
Crop Fertilization Index (CFI)	0.271-2.350 (Mean: 1.074 ± 0.426)	Crop Fertilization Index (CFI) assesses changes in fertilizer use by comparing actual NPK consumption with recommended doses; values range from 0 to 1, with higher values indicating closer adherence to recommended levels.
Irrigation water productivity	0.62	It is the ratio of crop yield to the irrigation water applied
Partial Factor Productivity of Fertilizer (PFPF)	3.7-65.2 (Mean: 25.7 ± 13.9)	Partial Factor Productivity (PFP) measures nutrient use efficiency as the ratio of crop yield to applied fertilizer (N, P, or K); higher values indicate more efficient fertilizer use.
Gross Benefit-Cost Ratio (B:C)	1.01-5.02 (Mean: 2.54 ± 0.93)	Benefit-Cost Ratio (BCR) is the ratio of the present value of additional benefits to additional costs; BCR > 1 indicates economic viability, with higher values reflecting greater project soundness.

The SWAT model was calibrated (2015–2021) and validated (2022–2024) for the Darpanarayanpur



catchment. Simulation result using the data of 2024 revealed surface runoff of 492.82 mm ($\approx 35\%$ of rainfall depth of 1401mm) and sediment yield of 16.56 t/ha. Soil water storage of 281.23 mm indicated moderate but seasonally variable root-zone moisture, while a water yield of 932.08 mm ($\approx 67\%$ of rainfall depth). Significant gap between PET (1466.95mm) and AET (586.77 mm) indicated significant climatic water stress, which necessitated canal automation-enabled, demand-based irrigation to ensure water availability in *rabi* season to enhance agricultural water productivity and improve system resilience under changing climate.

2.2 Canal automation infrastructure

The Darpanarayanpur MI Project was modernized with the following components:

- 11 solar-operated automated field outlets for energy-efficient control
- 4 automated cross regulators for real-time discharge regulation
- Motorized head regulator with SCADA integration
- Automatic weather station (AWS) for weather and ET_0 data
- Renovation of water course and field channels

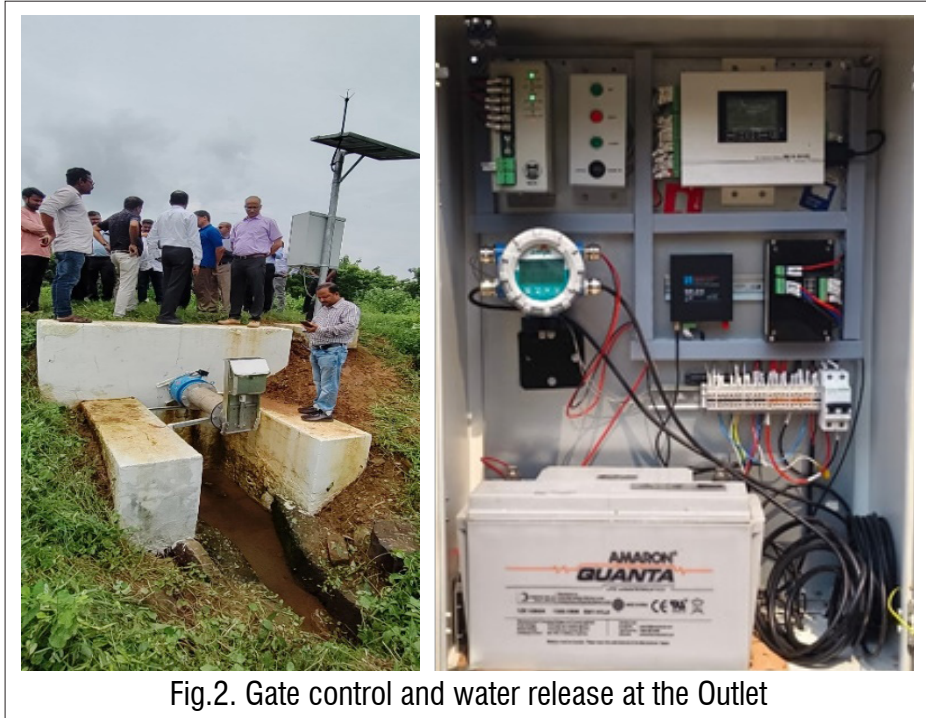


Fig.2. Gate control and water release at the Outlet

The remote control Unit (RTU) and IoT enabled solar operated gate on of the outlet is shown in Fig. 2.

3. Impact evaluation of the canal automation project

Irrigation water supplied to the field through manual and automated release was recorded and a comparative analysis was undertaken by considering the water use efficiency (WUE) and other parameters evaluated in the base line survey.

3.1 Increase in water productivity and climate resilience

Operation of the canal automation project (Fig.3) in the MI led to significant improvements in the canal command with about 28% saving of irrigation water compared to previous supply-based system,

enhanced conveyance efficiency (62% to 81%), and increased cropping intensity through pulse cultivation using saved water and residual moisture in rice fallows. Analysis of *kharif* 2024-2025 data showed an increase in rice water productivity from 0.47 to 0.63 kg/m³. Despite multiple dry spells during these seasons, assured water availability through automation enabled timely nursery raising at the tail end and enhancing resilience to climatic variability.



Fig.3 The detailed layout with automated outlets, head regulator and cross regulators in the entire stretch of the MI command.

3.2 Crop diversification, yield and productivity gains

Assured irrigation by the stored water in the reservoir converted rice fallow land into productive *rabi* cropping and increased land productivity besides increase in the *kharif* rice yield by 9.4% after operation of canal automation (Table 3).

Table 3. Observed short term changes in crop yield due to the canal automation project in the MI

Crop	Pre-automation yield (q/ha)	Post-automation yield (q/ha)	Change	Remarks
Rice (<i>kharif</i>)	35.2	38.5	+9.4%	Optimal, timely and uniform water application
Green gram (<i>rabi</i>)	Rice fallow and no <i>rabi</i> crop	8.2	crop introduced in rice fallow	Increase in the cropping intensity



Pea, Mustard (<i>rabi</i>)	-	Introduced	Crop Diversification	To enhance system water productivity & livelihood
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The assured irrigation enabled conversion of rice fallow land into productive *rabi* cropping through introduction of green gram, black gram, chick pea and mustard crops, thus, increasing the overall land productivity. During *rabi* 2025-26, area expansion under *rabi* crops and crop diversification with water efficient crops like continuation of pulses and oilseeds besides introduction of short duration low water requiring crops like sesame, groundnut and vegetables in the command.

Table 4. Observed short term changes in cropping intensity and income of the stakeholders due to the canal automation

	Pre-automation)	Post-automation	Change	Reasons of the change
Cropping intensity	100%	145%	+45%	Optimal, timely and uniform water application
Water productivity	0.47 kg/m ³	0.63 kg/m ³	+34%	Optimal irrigation supply
Income of the stakeholders	₹64,000/ha/year	₹1,02,000/ ha/year	+59%	Higher yield of the crops and lower use of inputs

Post automation benefits resulted from assured timely irrigation, enabling *rabi* cultivation in rice fallows along with 9.4% rise in *kharif* rice yield, adoption of pulses and oilseeds, and reduced energy and labour costs (Table 4).

3.3 Community participation and institutional strengthening

The water user association (WUA) of Darpanarayanpur MIP (Sukra Behera memorial WUA) played a key role in participatory irrigation management and canal automation. It coordinated with officials and ICAR-IIWM for demand-based water scheduling, equitable distribution, and timely maintenance, while promoting *rabi* crop diversification and improved practices. This enhanced water use efficiency, crop productivity, farmers' income, and strengthened local ownership and sustainability.

3.4 Canal reach wise impact of the automation in the MI command

Canal automation ensured uniform water availability and efficiency across all reaches. Upper and middle reaches exhibited improved productivity and cropping intensity due to better hydraulic control and reduced losses. In the lower reach, there was increase in water reliability from 55-60% to ~90%, rice productivity from 0.32 to 0.58 kg/m³, and irrigated area from 65% to 95%, enabling crop diversification and convergence in overall command performance (Table 5).

Table 5. Water productivity and crop diversification before and after the canal automation project

Canal reach	Indicator	Before automation	After automation	Change (%)
Upper and middle reach	Water delivery reliability (%)	70	95	+ 35.7%
	Irrigated area coverage (%)	100	145	+ 45%
	Rice water productivity(kg/m ³)	0.47	0.63	+ 34.0%
	Crop diversification	1 (Paddy)	3 (Green gram, Peas, Mustard)	
Lower reach	Water delivery reliability(%)	55	90	+ 63.6%
	Irrigated area coverage (%)	65	95	+ 46.2%
	Rice water productivity (kg/m ³)	0.32	0.58	+ 81.2%
	Crop diversification	0-1 (Paddy)	3 (Green gram, Peas, Mustard)	

3.5 Eco-restoration and sustainability aspects of the canal command

The bunds in both side of the water course conveying water from the head regulator is stabilised and planted with lemon (Citrus lime) and papaya along its length. During 2025, about 450 seedlings were planted and assisted in additional livelihood opportunity of the stakeholders.

3.6 Development of Decision support system (DSS) and its integration with SCADA

The DSS under development has three modules-Irrigation (daily crop water requirement and optimal outlet discharge), Hydraulic (canal flow simulation for equitable distribution), and Reservoir (storage, inflow-outflow, and evaporation tracking)-all integrated with SCADA for near real-time, adaptive, and smart water management.



3.7 Replicability of the canal automation system

The Darpanarayanpur MIP, a first-of-its-kind in India, aligns with PMKSY-PDMC, Digital Agriculture Mission, NAPCC, NICRA, and RKVY crop diversification. Its canal automation prototype is suitable for both MI reservoir commands and minor irrigation distributaries.

Summary

Short term impact evaluation of the implemented canal automation project indicated that the conveyance efficiency and water productivity increased by 30 and 34%, respectively (Table 6). Moreover, there was an increase in the cropping intensity and farmer's income by 45 and 59%, respectively.

Table 6. Impact of canal automation on the conveyance efficiency, water productivity, cropping intensity and farmer income

Indicator	Before automation	After automation	Improvement
Conveyance efficiency (%)	62	81	+30%
Water productivity (kg/m ³)	0.47	0.63	+34%
Cropping intensity (%)	100	145	+45%
Farmer income (₹)	64,000/ha	1,02,000/ha	+59%

Conclusion

The Darpanarayanpur MIP demonstrated gated outlet automation, solar energy use, and data-driven irrigation, transforming a minor canal into a resilient, equitable, and productive system. By ensuring tail-end water availability, enabling crop diversification, and improving water productivity, it serves as a national model aligned with India's canal modernization efforts. Enhanced water-use efficiency supports climate-resilient farming, higher farmer incomes, and stronger water user associations for sustainable governance.