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Enhancing water productivity and farm income through location-specific technologies: An FFP success story from tribal Odisha

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The ICAR-Indian Institute of Water Management implemented the Farmer FIRST Programme in the tribal-dominated cluster of Haridamada, Jamujhari, and Barapita villages in Khordha district, Odisha, to enhance water productivity and farm income in rice-based cropping systems under a canal command. Location-specific, multi-thematic interventions such as cove crop, natural resource, horticulture, livestock, and enterprise-based modules improved yield, resource-use efficiency, and livelihood resilience. Demonstrations of high-yielding, ecology-specific rice varieties, balanced nutrient management, need-based pest control, and efficient water management raised grain yield by 10–20% and increased benefit-cost ratios. Diversification into vegetables, fishery, dairy, and mushroom cultivation generated additional income and employment. Model farmers like Shri Manas Kumar Das successfully integrated multiple enterprises, achieving annual incomes above ₹5 lakh. The project's participatory approach and science-led interventions demonstrated a replicable model for transforming smallholder subsistence farming into sustainable, profitable, and climate-resilient agriculture.

Keywords: Climate resilience, Crop diversification, Integrated farming system, Participatory approach, Rice-based cropping system, Sustainable agriculture

THE Farmer FIRST Programme (FFP) implemented by ICAR–Indian Institute of Water Management (IIWM), Bhubaneswar, aimed to enhance water productivity, farm income, and livelihood security in the tribal cluster of Khordha district, Odisha. Through location-specific technologies and integrated farming interventions, the project transformed traditional rice-based systems into sustainable, diversified, and profitable enterprises.

Profile of the study area

The study was conducted in Haridamada, Jamujhari, and Barapita villages of Khordha district in Odisha, which lie within the east and south-eastern coastal plain agro-climatic region. These villages represent a peri-urban rainfed agro-ecosystem, where agriculture is the primary livelihood activity. The region experiences a tropical monsoon climate, with average annual rainfall of 1,100–1,200 mm, predominantly occurring during the southwest monsoon (June-September). Seasonal temperatures range from 16–22°C in winter to 32–40°C in summer, providing a warm and humid environment suitable for paddy cultivation and diversified cropping systems. The soils are mainly loamy sand to clay loam, derived from lateritic parent material, with moderate fertility and variable organic carbon content. These soils are moderately drained, with medium water-holding capacity, making them suitable for upland and medium-land rice cultivation, as well as pulses, vegetables, and horticultural crops. The gently undulating terrain and mixed soil textures require careful water management strategies, particularly during the dry season, to ensure sustainable crop production and improved water productivity.

Haridamada village has a combination of rainfed and canal-irrigated lands (74.14 ha), Jamujhari depends largely on minor irrigation sources (village tanks, ponds, dug wells, bore wells, totalling about 10.0 ha irrigated land), and Barapita village receives partial irrigation from the Deras Dam canal (a part of the Deras Minor Irrigation Project), irrigating nearly 15.09 ha, while the remainder of the cultivated land, i.e. 520.74 ha (out of a total of 620.0 ha cultivated land in the cluster) is rainfed, resulting in seasonal and limited irrigation coverage. The cropping system is dominated by *kharif* paddy, followed by partial fallow or *rabi* crops such as pulses and vegetables, depending on residual soil moisture or minor irrigation. Farmers also practice mixed farming, integrating livestock, backyard poultry, and small-scale horticulture. These three villages are inhabited largely by socio-economically backward marginal and smallholder farmers or sharecroppers, with about 450 households and 3,000 population, including as many as 45% from scheduled tribe communities, and having an average landholding sizes below 1.0 ha. Livelihoods are primarily dependent on agriculture, agricultural labour, and small-scale animal husbandry. The literacy rate is relatively high due to proximity to Bhubaneswar, but migration for non-farm employment is common during lean periods. Women actively participate in agricultural operations and village self-help group (SHG) activities.

FFP interventions: Beginning of the successful agro-changes

The ICAR–IIWM Farmer FIRST Programme (FFP) has been implemented in this newly adopted cluster of villages since December 2022, with location-specific technological interventions to enhance water productivity, livelihood diversification, and efficient resource use. The interventions were delivered through five thematic modules — (i) Crop-based, (ii) Horticulture-based, (iii) Livestock-based, (iv) Natural Resource Management (NRM)-based, and (v) Enterprise-based and included training, on-farm demonstrations, and participatory capacity-building programmes for farmers. The overall objective was to improve the resilience and profitability of the rainfed, partially irrigated agro-ecosystem through scientific and sustainable management of water, soil, and crops.

Crop-based module: Demonstrations on high-yielding paddy varieties (HYVs) and quality seed production for local sale to fellow farmers were conducted during both the summer and *kharif* seasons across 75 acres. Improved agronomic practices such as line transplanting using young seedlings, seed and seedling root dip treatments with *Azotobacter chroococcum* (a nitrogen-fixing biofertilizer) and *Trichoderma viride*, along with the introduction of green gram in rice-fallow systems using *Rhizobium* inoculation, supplemented with inputs for pest and disease management, led to significant improvements in grain yield (10–20%), benefit–cost ratio, and both physical and economic water productivity over local check varieties.

Horticulture-based module: Hybrid vegetable seeds for both seasons and IIHR-developed nutri-garden kits were distributed to farm families, contributing to household-level nutritional security.

Livestock-based module: Improved dual-purpose backyard poultry breeds such as *Vejaguda, Vanaraja*, RIR, and *Kaveri* were introduced, along with supplementary feed, feeders, drinkers, vaccines, and mineral mixtures for dairy animals. These interventions resulted in higher body weight gain and increased egg production (average annual egg yield: RIR, 205; *Kaveri*, 146; *Vanaraja*, 137; and *Vejaguda* 60) compared to local breeds (30–40 per year). Fish farming was also promoted through the supply of quality fingerlings of Indian major carps (*Catla, rohu*, and *mrigal*), further diversifying livelihood options and improving protein availability.

NRM-based module: Technologies were introduced to enhance sustainability and climate resilience. These included optimized dyke height structures to reduce runoff and improve in-field water retention, dug-out sunken ponds for rainwater harvesting and multiple water uses, and mini Integrated Farming System (IFS) models combining aquaculture, horticulture, and irrigation. Polythene mulching, pump sets, and irrigation pipes were promoted to increase water conveyance efficiency and conserve soil moisture.

Enterprise-based module: This module focused on enhancing farmers' income through mushroom cultivation (paddy straw and oyster varieties) and vermicomposting for organic manure production. These interventions provided alternative livelihood opportunities and supported organic farming practices.

Overall, the project successfully introduced and scaled up scientifically validated practices across multiple sectors ie agriculture, water management, horticulture, livestock, and farm-based enterprises i.e.

Rice field day and crop cutting experiments organized by scientists in the presence of farmers in the cluster

Table 1. Performance of recommended high yielding rice varieties over popular local check

Varieties	Crop Duration (Days)	Average Demo Yield (t/ha)	Gross Return (₹/ha)	Cost of Cultivation (₹/ha)	Grain Yield Advantage (% age)	B:C Ratio	Physical Water Productivity (kg/m³)	Economic Water Productivity (₹/m³)
Kharif (Rainfed shallow lowland)								
MTU 1061	155	6.03	1,38,690	56,600	14.42	2.45	0.58	13.27
Mrunalini	145	5.72	1,31,560	56,600	8.53	2.33	0.55	12.59
Swarna sub 1	145	5.53	1,27,190	56,600	4.93	2.25	0.53	12.17
MTU 7029	145	5.52	1,26,960	56,600	4.74	2.24	0.53	12.15
Pooja (Check)	150	5.27	1,12,210	56,600	0	1.98	0.50	10.73
Kharif (Rainfed, medium lowland)								
MTU 1001	135	5.32	1,17,040	55,200	24.29	2.12	0.55	12.10
CR Dhan 310	125	4.92	1,08,240	55,200	14.95	1.96	0.59	11.18
Binadhan 11	120	4.88	1,07,360	55,200	14.01	1.94	0.50	11.10
Lalat (Check)	130	4.28	94,160	55,200	0	1.70	0.44	9.70
Summer (Irrigated)								
CR Dhan 314	130	6.14	1,28,940	45,300	32.32	2.85	0.60	12.64
CR Dhan 206	120	5.89	1,23,690	45,300	26.93	2.73	0.58	12.12
Binadhan 11	125	5.78	1,21,380	45,300	24.56	2.68	0.57	11.90
CR Dhan 310	125	5.61	1,17,810	45,300	20.90	2.60	0.55	11.55
Naveen	125	5.30	1,11,300	45,300	14.22	2.46	0.52	10.91
Mamata (Check)	125	4.64	97,440	45,300	0	2.15	0.45	9.55

Table 2. Special varietal characters of the demonstrated and validated rice varieties

Varieties	Special varietal characters
MTU 1061	Suitable for shallow low land to semi deep water, non-lodging
Mrunalini	Suitable for shallow low land, non-lodging
Swarna sub 1	Suitable for shallow low land, tolerance to flood, resistance to diseases like False smut, Bakanae and Seedling blight
MTU 7029	Suitable for medium land, irrigated as well as rainfed
Pooja	Suitable for shallow lowland, non-lodging, susceptible to false smut
MTU 1001	Suitable for shallow low land, non-lodging
CR *Dhan* 310	Suitable for medium irrigated land; high protein rice (10.5% grain protein content), straw suitable for mushroom production
Binadhan 11	Suitable for medium land, tolerance to drought as well as flash flood (climate smart), suitable for late planting, high water use efficiency, non-lodging
CR *Dhan* 314	Suitable for both *kharif* and *rabi* seasons, aerobic rice, high water use efficiency
CR *Dhan* 206	Suitable for both *kharif* and *rabi* seasons, non-lodging, drought tolerant, moderately resistant to leaf blight, brown spot, sheath rot, sheath blight, and leaf folder
Naveen	Suitable for both *kharif* and *rabi* seasons, resistance to blast

leading to significant improvements in crop and water productivity, farm income, and resource-use efficiency in the tribal-dominated village cluster of Khordha district.

Validated protocols of the successful technological model

Rice-based cropping and farming system was the main source of livelihood of majority of the farm families. The productivity and income was low due to non-availability of quality seeds of ecology specific rice varieties, unbalanced fertiliser use, poor management of weeds and insect pests, and injudicious water management. Interventions were made with the introduction of certified seeds of ecology and season specific varieties followed by appropriate agronomic and plant protection measures and post-harvest care significantly improved the resource use efficiency, system yield and farmers income which influenced the livelihood of farmers and also maintains the soil health.

Selection of appropriate varieties and use of quality seeds: The details of recommended high yielding rice varieties validated based on successful demonstrations, farmers feedback and widespread adoption, and suitable for similar coastal rice ecosystem of Odisha are given in Table 1.

Seed treatment: Wet or dry seed treatment with *Trichoderma* dust formulation at 10g/kg of paddy seed for dry and wet nursery respectively registered grain yield at par with the seed treatment with conventional

Table 3. Recommended fertiliser application schedules for rice-rice cropping system

Season	Basal dose			1st Top dressing (20–30 DAT)	2nd Top dressing (45–60 DAT)	
	FYM (t/ha)	DAP (kg/ha)	MOP (kg/ha)	Urea (Kg/ha)	Urea (kg/ha)	MOP (kg/ha)
Kharif	5	66	25	54	54	25
Summer	5	88	33	70	70	33

Demonstration on nutri-gradens in the cluster being visited by the Nodal Scientist from ICAR-ATARI, Kolkata

Skill-based capacity building programme for farmers being organized in the cluster

fungicide Carbendazim at 2 g/kg of seed in both *kharif* and summer season.

Nursery management and transplanting in main field: Raising of community nursery just before 20–30 days of transplanting in main field, line transplanting (20 cm × 15 cm) of young seedlings (20–30 days) improved the crop establishment and reflected in grain yield.

Weed control: Weeds compete with rice crop in both *kharif* and summer rice crop and cause considerable yield loss. Farmer's practice of manual weed control is labour intensive and cause delay in weeding during peak period of labour demand. Application of ready mix granular pre-emergence herbicide 'Bensulfuron Methyl 60g a.i. + Pretilachlor 600g a.i.' at 10kg/ha mixed with dry sand (1:1) at 3–8 days of rice transplanting as an alternate to manual weeding resulted in broad spectrum weed control and an increase in grain yield of 5–12% in both *kharif* and summer season as compared to farmers practice of manual weeding. Application of early post-emergence herbicide 'Bispyribac Sodium' at 30g a.i./ha (15 ml of commercial product in 16 L tank sprayer) at 2–3 leaf stage of weeds (around 10–15 days after rice transplanting) found promising in controlling weeds in transplanted rice.

Nutrient management: Normally farmers use unbalanced fertilisers as per the availability on local market and inputs in their hand. Application of balanced fertilisers at appropriate time resulted an increase in grain yield, water use efficiency and reduced use of chemical fertilisers, particularly Urea and DAP, significantly in demonstrated clusters by 10–25%.

Insect pest and disease management: Under rice-rice cropping system, stem borer is the most dominant insect pest, which affects rice yield in both *kharif* and summer crop. Application of granular insecticide Clorantrinpole 0.4 G at 10 kg/ha at 1–3 DAT (days after transplanting) significantly reduced the incidence of stem borer and leaf folder at early stage of rice growth. Need-based spraying of Clorantrinpole 18.5 SL at 150 ml/ha in 500 L of water controlled the pest and reduced the percentage of dead heart or white year of rice crop. It was experimented and validated to rotate use of insecticide in rice field. Spraying of Imidacloripid 17.8 SL at 125 ml/ha in 500 L of water found promising as an alternate insecticide.

Water management: Raising the height of field bunds, maintaining optimum dyke height to ensure maximum 20 cm of standing water along with provision for drainage, construction of dug-out sunken ponds along the field slopes, cleaning and mud plastering of bunds and gully plugging significantly improved the rain water conservation during dry spells. Application of live saving irrigation at flowering stage enhanced the grain yield of *kharif* rice by 10–20% as compared to no irrigation. During summer season, irrigation at 2–3 DAD (days after disappearance) of ponded water reduced the irrigation water requirement by 20–25% as compared to continuous flooding.

Harvesting and processing: Harvesting at physiological maturity when 90% grains turn yellow in colour, saved the crop loss from shattering of grains during harvesting. Sun drying for 2–3 days and storage at 14% grain soil moisture minimized the loss due to storage insect pest and fetched better price at market.

With the adoption of location specific varieties, agronomical practices and need-based plant protection measures and timely harvesting, processing and disposal of rice enhanced the resource use efficiency and resulted an increase in grain yield of 10–12 t/ha with reduced cost of cultivation and higher net returns and farmers' profit under rice-rice cropping system.

Crop diversification: A game changer in *Atmanibhar Krishi*

Before the implementation of the FFP interventions, farmers in these villages primarily cultivated rice during the *kharif* season and grew a few vegetables in their kitchen gardens for household consumption only. After the introduction of the FFP initiatives, farmers were motivated to take up commercial vegetable cultivation by utilizing the previously unused upland fallow areas during the *rabi* season. Through this initiative, nearly 20 acres of fallow suitable uplands were brought under productive use for commercial vegetable cultivation, marking a significant shift from subsistence to market-oriented farming benefiting over 130 farmers across the three adopted villages of Khordha district. Crop diversification was promoted through the introduction of hybrid seeds of vegetable crops, such as tomato, okra, brinjal, bitter gourd, pumpkin, cauliflower, cabbage, cowpea, beans, radish, and leafy vegetables like amaranthus, coriander, *palak,* etc., and supported by assured irrigation facilities developed through dugout-cum-sunken ponds and piped irrigation systems enabling timely and efficient water use during the critical growth stages of crops. These interventions ensured that farmers could undertake vegetable cultivation even under limited rainfall conditions, thereby improving water productivity in the rainfed to partially irrigated agro-ecosystem. Proper pest and disease management practices, balanced fertilizer application, and the use of organic manures for maintaining soil health were also adopted.

As a result of these comprehensive technological interventions, supported with regular technical backstopping, farmers achieved higher yields and produced superior-quality, marketable vegetables, leading to enhanced profitability. The demonstrated vegetable crops recorded yields ranging from 14.25–28.5 t/ha, varying with crop type and season. Following the interventions, farmers who previously earned negligible income from vegetable cultivation are now realizing annual returns ranging from ₹1,32,500–₹6,65,000/ha. The shift from traditional mono-cropping of rice to diversified cropping systems involving commercial vegetable cultivation not only increased farm income but also strengthened livelihood security, generated additional employment opportunities and improved resilience to climatic variability in the tribal-dominated rainfed agro-ecosystem.

Shri Das honoured as an “Innovative Farmer 2024” by the Nodal Scientist from ICAR-ATARI, Kolkata in his farm

From rainfed challenges to profitable farming: Successful journey of an adopted farmer

Shri Manas Kumar Das, a progressive farmer from Haridamada village, has shown remarkable dedication to adopting and promoting improved agricultural technologies introduced through the ICAR–Indian Institute of Water Management (IIWM), Bhubaneswar under the Farmer FIRST Programme (FFP). He owns 3.5 acres of agricultural land and has leased an additional 0.6 acre village pond. Of his total landholding, 2.0 acres are irrigated, supported by canal irrigation, rainwater harvesting, and piped irrigation from the pond. In addition to crop cultivation, Shri Das also engages in dairy farming with three milking cows and three calves, and fish rearing of indigenous species in the leased pond. For efficient farm management, he utilizes a 5 HP water pump set with pipes and a manual sprayer, effectively integrating multiple enterprises for enhanced productivity and income.

Adoption of IIWM technologies

Shri Das became associated with ICAR-IIWM, Bhubaneswar, during a Farmers-Scientists Interaction Programme in March, 2023 under the FFP initiative. Guided by IIWM scientists and project staff, he systematically planned his 3.5 acre farm, integrating multiple technologies and best practices. He received key inputs such as trellis nets for vegetable cultivation, green gram seeds with *Rhizobium* culture, hybrid vegetable seeds, high-yielding paddy varieties, and *Trichoderma viride* for seed treatment. He was also trained and supported in implementing Integrated Farming System (IFS) practices that combine crop cultivation, fishery, and dairy farming, along with eco-friendly pest management techniques such as pheromone traps, yellow sticky traps, liquid bio-fertilizers, and bio-pesticides. Following the recommendations of IIWM experts, Shri Das adopted several water management and productivity-enhancing technologies, including:

- Crop diversification with suitable high-value crops.

Vegetable fields of Shri Manas Kumar Das

Stocking of fish fingerlings in the pond of Shri Manas Kumar Das

Table 4. Achievements and impact of interventions by Shri Manas Kumar Das (2024–25)

Field crops	Area (acres)	Variety/ Breed/ No./Technologies adopted	Annual income (₹)
Paddy (Summer)	1	Adopted high yielding varieties namely, CR Dhan 314, CR Dhan 310. Adopted complete package of practices along with line transplanting of 25 days old seedlings, seed treatment, recommended dose of fertilizers, need-based application of pesticides and regular field surveillance, etc. (Total production 22.5 q, Sale at ₹1,800/q)	40,500.00
Paddy (*Kharif*)	2	Adopted high yielding varieties namely, MTU 7029, Pooja. Adopted complete package of practices along with line transplanting of 25 days old seedlings, seed treatment, recommended dose of fertilizers, need-based application of pesticides and regular field surveillance, etc. (Total production 35 q, Sale 25 quintal at ₹1,940/q and 10 q at ₹3,000/q)	78,500.00
Pulses (*Rabi*)	0.4	Cultivation of Green gram (variety : Sikha) after *Kharif* paddy	5,000.00
Vegetables	1	Round the year production of all types of locally demanded commercial and hybrid vegetables with 2-3 crops in sequence, majority being bitter gourd, cucumber, pumpkin, okra, cowpea, cauliflower and potato seasonal greens like amaranths, etc.	140,750.00
Fishery (Own)	0.6	Initiating a fish farming enterprise in my village pond, rearing Indian Major Carps by stocking 2500 fingerlings (Catla-650, Rohu-1,200, and Mrigal-650) using a composite culture system. The goal was to generate sustainable income through scientific aquaculture practices. Production: 3.5 q, Sold: at ₹180/kg	63,000.00
Dairy	Cowshed	Improved desi milking cow 2 nos., Calf-3 nos., Daily milk production 4-6 L, sold at 40/L,	29,000.00
		Sub-total (A)	3,56,750.00
Raj Mistri	Earnings towards working as a Raj Mistri (Mason)		1,80,000
		Sub-total (B)	1,80,000
		Total annual income (A+B)	5,46,750

- Ridge and furrow system for effective rainwater management.
- Piped irrigation conveyance to supply pond water efficiently to his own and neighbouring fields.
- Appropriate irrigation scheduling based on crop needs.
- Scientific pond water management to sustain both aquaculture and irrigation.
- Linkage with urban markets in urban and capital region for getting remunerative price

Through the adoption of ICAR-IIWM recommended technologies and integrated farming practices, Shri Manas Kumar Das has significantly enhanced his farm productivity, water use efficiency, and overall income. His total annual income has now reached ₹5.46 lakhs, including ₹3.66 lakhs from farming and ₹1.80 lakhs from non-farming sources. His farm stands as a model of sustainable and integrated agriculture, showcasing the benefits of scientific water management and diversified farming systems in a rainfed ecosystem.

Shri Manas Kumar Das honoured with "Progressive Farmer Award 2025" at ICAR–NAARM, Hyderabad

Shri Das exemplifies the spirit of innovation and scientific farming. His enthusiasm for adopting improved practices, willingness to share knowledge with fellow farmers, and commitment to sustainable agriculture make him a deserving candidate for recognition as an 'Innovative Farmer' in the IIWM-Farmer FIRST Programme adopted cluster. On 1 September 2025, Shri Das was honoured with "Progressive Farmer Award 2025" by ICAR-NAARM at Hyderabad during its 50th Foundation Day celebration. The recognition highlights the efforts and commitments of ICAR-IIWM, Bhubaneswar under the Farmer FIRST Programme in empowering farmers through improved technologies and livelihood development.

SUMMARY

Appropriate agro-technological demonstrations, introduction of new enterprises through crop diversification and sustained efforts of both farmers and mentors through the Farmer FIRST Programme have proved to be a game changer in a tribal dominated village cluster practicing subsistence agriculture. The farmers have been educated and motivated to undertake profit-making farming and agro-enterprises in order to earn more profit to support livelihood. Few young educated youths and agri-preneurs like Shri Manas Kumar Das have become torch-bearers in the region to achieve the mission and vision of Hon'ble Prime Minister of India like, Doubling Farmers' Income (DFI), Atma Nirbhar Bharat and Viksit Bharat by 2047.

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