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भाकृअनुप ICAR

Indian Farming

बेटी बचाओ बेटी पढ़ाओ

Special Issue on Milestones of ICAR's Farmer FIRST Programme

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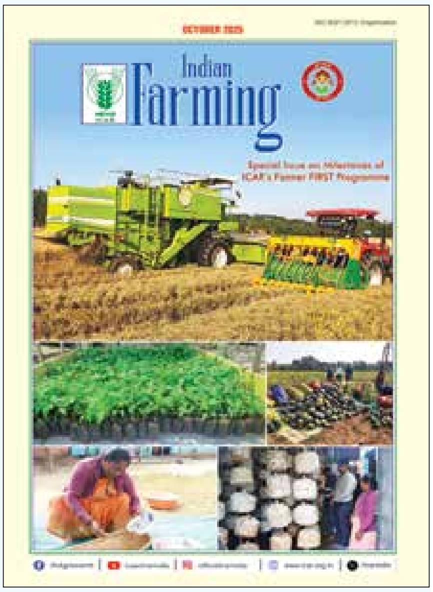

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In This Issue

Empowering Rural India through

Farmer FIRST Programme

THE Farmer FIRST Programme (FFP), launched by ICAR and implemented through Central and State Agricultural Universities and Research Centres, has emerged as a transformative initiative for rural India. By bridging the longstanding gap between agricultural research and field-level practices, FFP promotes need-based, location-specific, and sustainable farming solutions. It fosters collaboration among farmers, scientists, and extension agencies while valuing local knowledge alongside modern scientific innovations. Through participatory approaches, the programme ensures that farmers actively identify challenges, set priorities, and test innovations directly on their farms, enabling practical solutions that address real-world agricultural needs.

The special issue of October 2025 highlights FFP's profound impact on livelihoods across India, particularly in rural regions. Beyond economic gains, FFP has delivered significant social and environmental benefits, demonstrating that rural development extends beyond increased agricultural productivity, it strengthens socio-economic resilience and empowers communities. Farms once limited by traditional practices and mono-cropping have been transformed into diversified, year-round enterprises. By integrating technology, skill development, and market linkages, FFP promotes sustainable rural enterprises that advance food security, financial independence, and gender equity.

During October and November month, vast stretches of north-west India witness the burning of paddy residue, an annual environmental crisis that clouds the air and depletes the soil. Backed by government support and extensive outreach through ICAR, farmers are increasingly adopting *in situ* residue management practices. These efforts have drastically reduced field-burning incidents while improving soil fertility and farm profitability.

By encouraging sustainable practices, efficient resource use, and eco-friendly agriculture, the programme strengthens community resilience against climatic and seasonal uncertainties. Hands-on training, exposure visits, and farmer-to-farmer extension have fostered knowledge-sharing networks, enabling innovations to scale across villages. Digital tools and market linkages further expand farmers' reach, facilitating branding, marketing, and profitable enterprise development.

We congratulate all FFP participating institutes for their remarkable contributions. The cumulative impact of FFP extends far beyond agricultural productivity. It nurtures empowered, self-reliant farmers who adopt innovative technologies, diversify income streams, and make informed decisions to improve household welfare. By integrating scientific knowledge, skill development, and entrepreneurship, the Farmer FIRST Programme stands as a replicable model for sustainable rural transformation. As India continues to face evolving agricultural challenges, initiatives like FFP underscore the power of participatory research, innovation, and empowerment in building resilient and prosperous rural communities.

(Dr Rajbir Singh)
DDG, Agricultural Extension

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Introduction of hybrid rice cultivation: A boost on rice productivity and livelihood security of farmers

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The Farmer FIRST Programme (FFP) of ICAR-Directorate of Weed Research, Jabalpur, was initiated in 2017 in Barauda and Umariya Choubey villages of Panagar block, Jabalpur district, Madhya Pradesh, to enhance rice productivity and farmers' livelihoods through the introduction of hybrid rice cultivation and improved weed management practices. Initially, the entire rice area in these villages was under the traditional, long-duration variety 'Kranti', *which limited productivity and delayed wheat sowing. Through participatory interventions, high-yielding hybrid rice varieties i.e. 'Arize Gold 6444' and* 'Ganga *Hybrid' were introduced, coupled with the use of broad-spectrum, high potency, low dose ready-mix herbicides in rotation and robust capacity-building efforts. As a result, hybrid rice adoption expanded to over 99% of the rice area in both villages by 2023–24. Over seven years, grain yield increased by 33–34%, and net returns improved by 62–65% compared to traditional farmers' practices. The sustained adoption of these technologies, even after the project transitioned to a new site, highlights the long-term positive impact of the programme on productivity and profitability in rice cultivation.*

Keywords: Capicity building, Economic impact, Farmer First Programme, Input support, Participatory technology dissemination, Weeds management

RICE (*Oryza sativa* L.) is a vital staple food crop for more than half of the world's population. In India, it plays a pivotal role in national food security, cultivated on approximately 51.42 million hectares, with an annual production of 149.07 million tonnes (MoAFW 2024, USDA 2024). Hybrid rice, introduced to exploit heterosis, offers a 15–30% yield advantage over conventional varieties and is currently cultivated on 3.5 million hectares, constituting around 8% of the total rice area in India (ICAR-NRRI 2021). In Madhya Pradesh, rice is predominantly grown during the *kharif* season under upland irrigated and rainfed conditions. However, productivity remains suboptimal due to the prevalence of long-duration, low-yielding traditional varieties such as *'Kranti'*. Additionally, late harvesting of such varieties delays wheat sowing, ultimately reducing wheat yields. To address these issues, the Farmer FIRST Programme (FFP) of ICAR-DWR, Jabalpur, introduced hybrid rice cultivation combined with improved weed management practices in Barauda and Umariya Choubey villages of Panagar block, Jabalpur district of Madhya Pradesh.

Interventions

Before the adoption of the Farmer FIRST Programme (FFP), farmers in these villages primarily depended on the traditional long-duration rice variety *'Kranti'*, which resulted in low yields and inefficient use of resources. The baseline appraisal of the adopted villages after the inception of FFP led to the introduction of hybrid rice varieties 'Arize Gold 6444' and *'Ganga* Hybrid', which significantly improved rice productivity. One of the key components of the intervention was enhancing the managerial skills of the farmers in modern integrated weed management practices, particularly for hybrid rice cultivation. Hands-on training sessions were organized to equip farmers with technical know-how and practical skills on advanced weed management strategies developed by ICAR-Directorate of Weed Research (ICAR-DWR), Jabalpur. Regular trainings, farmer-scientist interface meetings, and exposure visits to ICAR-DWR research farms enriched farmers' understanding of improved weed control techniques, spraying methodology, use of seed treatments, and cultivation of high-yielding rice varieties. The introduction of high-yielding hybrid rice varieties like 'Arize Gold 6444' and '*Ganga* Hybrid', along with broad-spectrum weed management using new-generation, high potency, low dose ready-mix herbicides like cyhalofop-butyl 5.1% w/w + penoxsulam 1.02% w/w OD and triafamone 20% w/w + ethoxysulfuron 10% w/w WG in rotation to minimise the problem of weed flora shift, provided a substantial boost to rice productivity. The continuous adoption of hybrid rice cultivation combined with advanced weed management practices delivered through FFP interventions led to a 33–34% increase in grain yield and a 62–65% increase in net returns over the last seven years of the project. Beginning in 2018, the FFP team introduced the following key interventions:

- ***Hybrid rice varieties:*** 'Arize Gold 6444' and '*Ganga* Hybrid' were introduced based on their high yield potential and suitability for upland irrigated conditions.
- ***Weed management*:** Broad-spectrum, new-generation, high potency, low dose ready-mix herbicides like cyhalofop-butyl 5.1% w/w + penoxsulam 1.02% w/w OD and triafamone 20% w/w + ethoxysulfuron 10% w/w WG, using in rotation to minimise the problem of weed flora shift, were promoted for effective and timely weed control.
- ***Capacity building*:** Hands-on training, field demonstrations, and farmer-scientist interface meetings focused on hybrid rice cultivation, herbicides and herbicide application techniques, and good agronomic practices.
- ***Input support:*** High-quality seeds of hybrid rice and herbicides were provided as critical inputs to ensure successful adoption.

Adoption of hybrid rice

Before the intervention, 100% of the rice area in both villages was under the traditional long-duration variety '*Kranti*'. Following sustained awareness, training, and demonstration activities, hybrid rice adoption increased significantly.

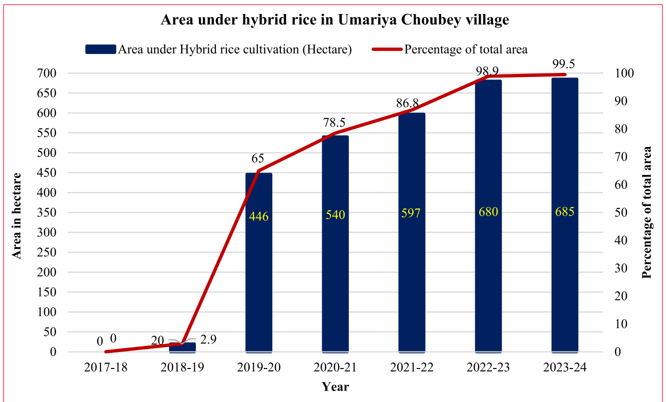
Table 1. Area under hybrid rice before and after FFP intervention

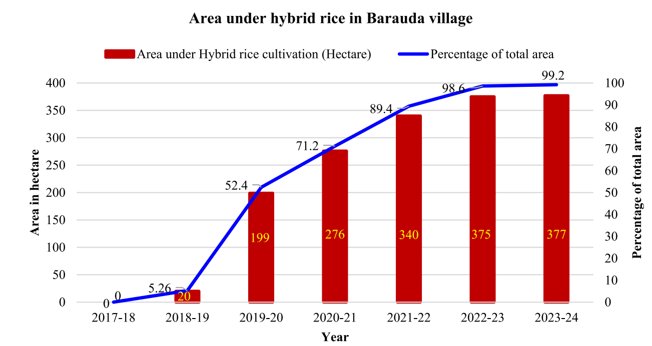
Intervention	Area 2017–18	Area 2023–24	Area 2017–18	Area 2023–24
	Umariya Choubey		Baraude	
Introduction of hybrid rice cultivation technology (Variety Arize Gold 6444 and *Ganga* hybrid) and weed management practices	688 ha area under *Kranti* (100%)	685 ha area under Hybrid rice (99.5%)	380 ha area under *Kranti* (100 %)	377 ha area under Hybrid rice (99.2%)

Note: (Umariya Choubey total area-688 ha and Baraude total area-380 ha)

Table 2. Increasing area of hybrid rice cultivation from 2017–18 to 2023–24

Introduction of hybrid rice cultivation technology (Variety Arize Gold 6444 and Ganga hybrid) and weed management practices	Umariya Choubey (ha)		Baraude (ha)	
2017–18	100% area under *Kranti* (Long duration traditional variety)	688	100% area under *Kranti* (Long duration traditional variety)	380
2018–19 (Inception of FFP)	2.9% area under Hybrid rice	20	5.26% area under Hybrid rice	20
2019–20	65% area under hybrid rice	446	52.4% area under Hybrid rice	199
2020–21	78.5% area under Hybrid rice	540	71.2% area under Hybrid rice	276
2021–22	86.8% area under Hybrid rice	597	89.4% area under Hybrid rice	340
2022–23	98.9% area under Hybrid rice	680	98.6% area under Hybrid rice	375
2023–24	99.5% area under Hybrid rice	685	99.2% area under Hybrid rice	377





Yield and economics

The continuous adoption of integrated crop management technologies-including the cultivation of high-yielding hybrid rice, application of balanced fertilizers at recommended doses, and improved weed management practices resulted in significant yield and economic gains under the Farmer FIRST Programme. In Umariya Choubey village, the intervention led to an additional grain yield of 7.5 q/ha (16%)–11.09 q/ha (19.3%) compared to the farmers' practice. The corresponding increase in net profit ranged from ₹10,379/ha (20%)–31,309/ha (39%).

Similarly, in Barauda village, an additional grain yield of 5.0 q/ha (11%)–10.98 q/ha (19%) and an increase in net returns of ₹8,873/ha (19%)–₹28,886/ha (36%) were recorded over the farmers' practice (Table 4). The cumulative impact of hybrid rice cultivation over seven years under FFP, thus demonstrated consistent and substantial improvements in both grain yield and profitability, validating the effectiveness of the integrated technological package introduced.

Table 3. Economics of hybrid rice cultivation in Umariya Choubey village from 2017–18 to 2023-24

Year	Yield (q/ha)		Net returns (₹/ha)		BC ratio	
	Farmers' practice	Inter-vention	Farmers practice	Inter-vention	Farmers' practice	Inter-vention
2017-18	47.5	55	51907	62286	3.39	4.12
2018-19	35	46.48	35167	55160	2.64	3.87
2019-20	50.52	59.28	58402	75156	2.72	3.26
2020-21	46.6	66.1	50501	89519	2.46	3.64
2021-22	43.7	62.95	39053	74998	1.85	2.59
2022-23	46	77.47	48115	116885	2.05	3.84
2023-24	57.6	68.69	80016	111325	2.75	3.73

Table 4. Economics of hybrid rice cultivation in Barauda village from 2017–18 to 2023–24

Year	Yield (q/ha)		Net returns (₹/ha)		BC ratio	
	Farmers' practice	Inter-vention	Farmers practice	Inter-vention	Farmers' practice	Inter-vention
2017-18	45	50	45698	54571	2.90	3.38
2018-19	36.9	46.58	37076	55278	2.73	3.87
2019-20	51.87	62.49	60872	81032	2.79	3.43
2020-21	45.1	66.20	47417	87557	2.29	3.43
2021-22	45.94	64.95	48048	82753	2.17	2.91
2022-23	46.4	77.25	48931	116437	2.07	3.83
2023-24	57.3	68.28	79361	108247	2.74	3.65

Training Programme conducted on "Weed Management in Field Crops" among the adopted farmers under FFP and distribution of seeds of Hybrid rice (*Ganga* Hybrid) to the farmers

Popularization of Arize Gold 6444 and *Ganga* hybrid rice among the farmers of adopted villages under FFP

SUMMARY

The Farmer FIRST Programme (FFP) was initiated on 1 February 2017 in the villages of Barauda and Umariya Choubey under the Panagar block of Jabalpur district, Madhya Pradesh. Participatory Rural Appraisal (PRA) revealed that nearly 100% of the cultivable land in both the villages was under the traditional long-duration rice variety *'Kranti'* during the *kharif* season, which not only limited rice productivity but also delayed wheat sowing, leading to significant yield reduction of wheat. Farmers largely relied on conventional agricultural practices, resulting in low productivity and inefficient resource use. To address these challenges, FFP interventions included farmer trainings, interface meetings, and exposure visits to ICAR-DWR research farms, enhancing farmers' knowledge of hybrid rice cultivation and advance weed management technology were introduced. High-yielding hybrid rice varieties like 'Arize Gold 6444' and *'Ganga* Hybrid' were introduced alongside broad-spectrum, high potency, low dose ready-mix herbicides in rotation resulted in significant improvement on crop performance. Continuous adoption of these technologies, with technical support from the FFP team, led to expansion of hybrid rice cultivation to 99.5% in Umariya Choubey and 99.2% in Barauda, resulting in an average yield increase of 33–34% and net profit enhancement of 62–65% over farmers' practice during the seven-year period. Even after the project was shifted to a new site, farmers in both villages have continued growing hybrid rice during the kharif season, sustaining the impact of the programme.

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Harvesting change: Tech-driven solutions for paddy residue management

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The management of paddy residue in northwest India, particularly Punjab, Haryana, and Uttar Pradesh, constitutes a critical environmental and agricultural challenge owing to large-scale residue burning, which causes severe air pollution, soil degradation, and health risks. To address this, a range of farm machineries, such as the Super SMS attachment, Happy Seeder, Smart Seeder, Surface Seeder and Super Seeder, have revolutionized in in situ *rice residue management practices. Supported by robust government schemes and extensive Information, Education, and Communication (IEC) initiatives led by Krishi Vigyan Kendras, these mechanized solutions have resulted in an impressive reduction of residue burning incidents between 2020 and 2024. A detailed economic evaluation highlights the cost-effectiveness and ecological sustainability of these methods compared to conventional burning. Short-duration rice varieties and crop diversification serve as pivotal strategic interventions to effectively reduce residue generation. The integration of technological innovation, robust policy frameworks, and heightened farmer awareness collectively paves a transformative pathway towards sustainable conservation agriculture, promoting enhanced productivity, environmental stewardship, and the long-term resilience of the rice-wheat cropping system in this crucial agrarian region.*

Keywords: Conservation agriculture, IEC activities, *In situ*, Paddy residue management

THE states of Punjab, Haryana, and western Uttar Pradesh are crucial for India's food security, playing a major role in the production of paddy and wheat. However, these areas are now facing a serious environmental and agricultural issue of managing paddy residue. With about 4.2 million hectares of paddy fields in Punjab and Haryana, the amount of paddy residue produced is huge. Due to the very short time between harvesting paddy and sowing wheat, many farmers feel they have no choice but to burn the leftover straw in their fields. The burning occurs mainly within a span of 15–20 days, releasing large amounts of pollutants into the air, which leads to serious environmental pollution, loss of nutrients, and damage to soil and human health. Scientific studies show that burning one tonne of paddy straw produces around 3 kg of particulate matter (PM), 60 kg of carbon monoxide (CO), 1,460 kg of carbon dioxide (CO_2), 199 kg of ash, and 2 kg of sulphur dioxide (SO_2). These emissions significantly worsen air quality, creating serious health risks for both humans and animals by worsening respiratory, heart, and other chronic diseases. Considering the vital role of this agricultural region and the urgency of the problem, it is essential to adopt innovative, sustainable, and farmer-friendly methods for managing crop residue.

Recognizing the gravity of the issue concerning crop residue burning, the Ministry of Agriculture and Farmers' Welfare of the Government of India initiated the central sector scheme titled "Promotion of Agricultural Mechanization for *in situ* Management of Crop Residue in the States of Punjab, Haryana, Uttar Pradesh, and the NCT of Delhi" in the fiscal year 2018–19. The scheme's primary aim is to comprehensively promote agricultural mechanization to facilitate the *in situ* management of crop residue by fostering awareness and building capacity among farmers. As part of this initiative, individual farmers are provided with 50% financial support for acquiring agricultural machinery, while Farm Machinery Banks or custom hiring centres for crop residue management (CRM) are established with an 80% subsidy on the overall project cost. The Indian Council of Agricultural Research (ICAR), through its network of 60 Krishi Vigyan Kendras (KVKs) across Punjab (22), Haryana (14), Delhi

(1), and Uttar Pradesh (23), has been assigned the task of executing Information, Education, and Communication (IEC) activities under the CRM project.

Table 1. Details of major Information, Education and Communication (IEC) activities under CRM Project from 2018–19 to 2024–25

IEC Activities	Conducted	Beneficiary
Awareness programmes (District/ Block/ Village Level)	4,487	3,55,347
Training programmes	1,417	49,012
Kisan Melas on CRM	380	8,20,390
Mobilization of school and college students	1,841	2,28,383
Demonstrations on CRM machinery (1 ha each)	78,054	1,36,308
Exposure visits	996	41,966
Field/ Harvest days	1,146	59,452

Since its inception in 2018, ICAR through its network of KVKs, a total of 4,487 awareness programmes, 454 Kisan Melas, 996 exposure visits, and 1,146 field and harvest days have been conducted, encouraging over 1.95 million farmers and stakeholders to adopt *in situ* CRM technologies. In an effort to broaden their outreach, 1,841 educational institutions have been engaged, mobilizing more than 2.25 lakh students to ensure that the message against crop residue burning permeates households and local communities. Various social media platforms, including WhatsApp, Facebook, and YouTube, alongside traditional media such as posters, banners, wall writings, news articles, and television and radio broadcasts, have been effectively utilized to raise awareness among 1.8 million farmers. Acknowledging the necessity for skilled personnel, ICAR-KVKs have conducted 1,417 capacity-building programmes, each spanning five days, training approximately 49,012 farmers, tractor operators, and machine bank operators. These trained individuals are anticipated to operate CRM machinery and provide assistance to fellow farmers in their communities. Additionally, the KVKs have carried out over 78,000 demonstrations of CRM machinery on more than 136,000 farmers' fields, offering practical experience on how to cultivate crops without burning paddy residue.

Tools of transition: Managing residues with mechanisation

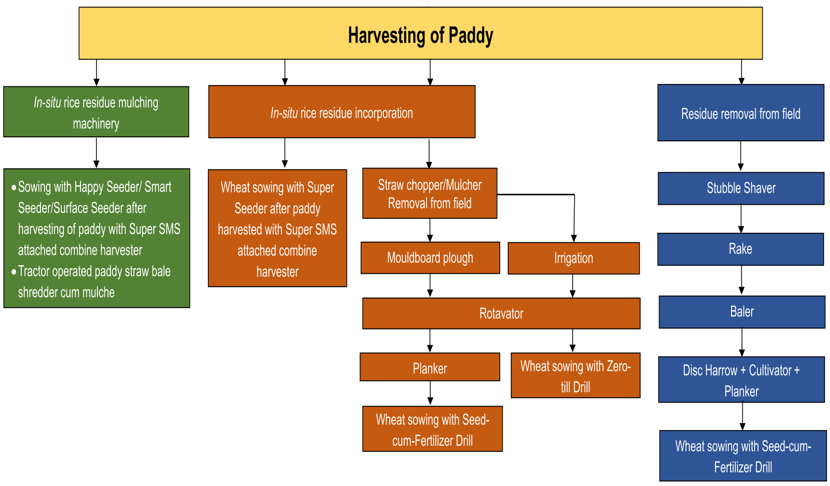
Punjab Agricultural University (PAU), Ludhiana has developed and recommended different farm machineries for the efficient management of paddy straw, applicable both in-field and for off-field utilization. Paddy straw can be managed within the field either by using it as surface mulch or by incorporating it into the soil. This in situ management approach retains essential nutrients such as N, P, K, S and organic carbon, thereby improving soil fertility and health. Also, continuous adoption of these *in situ* straw management practices not only prevents residue burning but also leads to a significant increase in the productivity of the rice-wheat cropping system, promoting sustainable and environmentally friendly agriculture in the region.

Machinery for *in situ* rice residue mulching

Super straw management system: To ensure the effective operation of *in situ* mulching machines such as the Surface Seeder, Smart Seeder or Happy Seeder in combine-harvested paddy fields, PAU, Ludhiana developed the Super Straw Management System (SMS) attachment which is fitted behind the straw walkers of the combine harvester and mounted at its rear end. The straw coming out of the walkers is directed into the unit, where it is chopped by flail blades mounted on a rotating shaft. For smooth operation, it is important that all rotating parts such as blades, bushes, plates and bolts are of the same dimensions to ensure proper fitting. Any mismatch can cause vibrations in the unit. Dynamic balancing of the rotor is also necessary to minimize vibration at high speeds. The Super SMS attachment should be firmly supported by the chassis of the combine harvester to reduce overhang and mechanical stress. In addition, the V-belt and pulley system should be chosen carefully so that belt slippage remains within acceptable limits.

Happy seeder: The Happy seeder is a machine designed to sow wheat directly into combine-harvested paddy fields. It is a tractor PTO driven machine which can be operated by 45 hp or above tractor and can cover 0.33–0.38 ha/h. In a single operation, the Happy seeder cuts the standing straw in front of its furrow openers and places it over the sown wheat crop. This layer of straw serves as mulch, helping to conserve soil moisture and improve soil health. For best results, the loose residue should be spread evenly in the field before operating the Happy seeder.

Smart seeder: Smart Seeder manages the rice residue by shallow incorporation and surface mulching. The machine sows wheat seeds in a narrow, well-tilled



Smart paddy straw management and direct wheat seeding solutions strip of soil and then covers the seed rows using furrow-closing rollers. The furrow closing roller also acts as depth control mechanism for sowing wheat. It is a PTO driven machine operated by 45 hp or above tractor and it covers about 2.8–3.2 ha/day.

Surface seeder: Surface Seeder comprises of a straw cutter-cum spreader fitted with seed and fertilizer box attachment. This machine can be easily operated by the 40 hp tractor or above. It is an economical machine designed to cut and spread paddy straw while sowing wheat seed and applying fertilizer in a single operation. It is followed by light irrigation for initiating the germination of wheat. Operate the machine with 4–5 inches above the soil at proper speed to spread seed and fertilizer evenly, ensuring seeds are covered with paddy mulch.

Tractor operated paddy straw bale shredder-cum-mulcher: Tractor operated paddy straw bale shredder cum-mulcher can be used for reducing straw size of a straw bale and spreading it uniformly in the field for mulching in widely spaced crops. This machine will reduce dependence on labour for mulching and reduce straw size thereby effective in controlling weeds. This machine can be easily operated by the 35 hp tractor or above with average field capacity of 0.25 ha/h.

Machinery for *in situ* rice residue incorporation

Super seeder: Tractor operated Super Seeder is a machine used for direct sowing of wheat in combine harvested paddy field. The machine is a combination of roto seed drill and disc type seeding attachment. The machine is equipped with a straw management rotor, fitted with flanges carrying six blades each, which chop and mix the straw into the soil. Machine is operated by a 55 hp or above tractor.

Paddy straw chopper-cum-spreader: This machine chops and spreads straw left after combine harvesting in a single pass, using a 45 hp or above tractor with capacity of 0.32–0.35 ha/h. If sufficient moisture is present after paddy harvesting, incorporate the chopped straw into the soil with mouldboard plough and prepare the field with a rotavator. If 2–3 weeks are available before wheat sowing depending upon soil type, apply shallow irrigation and mix the straw using disc harrow or rotavator.

Machinery for collection of rice residues

Straw baler: The straw baler collects loose paddy straw and compresses it into rectangular or round bales for easy handling. Before baling, standing stubbles are reaped with stubble shaver to facilitate smooth baler

Farm machinery involved in paddy residue maangement; (i) PAU Super SMS attached combine harvester; (ii) Happy Seeder; (iii) PAU Smart Seeder; (iv) Paddy Straw Bale Shredder-cum-Mulcher; (v) PAU Surface Seeder; (vi) Super Seeder; (vii) Mouldboard plough; (viii) Paddy straw chopper; (ix) Baler operation. Square balers produce bales 40–110 cm long, weighing 15–25 kg depending on moisture content, with a field capacity of 0.7–0.72 ha/h. Large round balers make heavier bales of 300–500 kg, with a standard width of 120 cm and bale diameter varies from 90–180 cm. These bales are useful for power generation, compressed biogas, bio-ethanol, composting and mulching. They can also be used in making cardboard and packaging materials.

Rake: The rake is used to collect loose stubbles and form windrows with rotary spikes powered by the tractor PTO. It is operated after the stubble shaver to collect loose straw in the field efficiently. This reduces the number of baler turns in the field and increases field capacity.

Paddy straw bales have become a vital resource for energy and industrial applications, effectively transforming agricultural residue into economic assets. These bales are extensively utilized in biomass power plants, paper manufacturing units, and industrial boilers and alternative to conventional fuels. Furthermore, the production of paddy straw pellets for brick kilns is gaining traction, reducing the reliance on coal and mitigating pollution. The bio-CNG and ethanol plants have also started using these paddy bales.

Table 2. Economic analysis of different methods of wheat sowing

Method	Machines	Operational cost (₹ /ha)
Conventional method (Burning of paddy residue)	Stubble Shaver + Disc Harrow × 2 + Cultivator × 2 + Planker + Seed Drill	8,875
In situ paddy residue management	Super SMS + Happy Seeder	4,400
	Super SMS + Smart Seeder	4,550
		6,075
	Super SMS + Super Seeder	13,600
	Chopper/ Mulcher + MB Plough + Rotavator + Planker + Seed Drill	8,350
	Chopper/ Mulcher + Light Irrigation + C type blade Rotavator + Zero till drill	1,750–2,250
Ex situ paddy residue management	Surface Seeder	10,225
	Stubble Shaver + Rake + Baler + Disc Harrow + Cultivator + Planker + Seed Drill	

Comparative cost analysis of different wheat sowing methods

The comparative analysis of various paddy residue management methods reveals a clear shift from the traditional practice of residue burning towards more sustainable, cost-efficient, and environmentally responsible approaches. Conventional burning, though convenient, incurs higher operational costs (₹ 8,875/ha) and leads to severe ecological damage. In contrast, *in situ* residue management techniques such as the use of Super SMS with Happy Seeder or Smart Seeder not only reduce costs significantly (₹ 4,400–6,075/ha) but also enhance soil health and moisture retention. Among these, surface seeding stands out as the most economical option (₹ 1,750–2,250/ha), offering a simple yet effective solution for farmers. Meanwhile, *ex situ* management through straw collection and baling (₹ 10,225/ha) provides a pathway for utilizing residues as biofuel or compost.

Role of short-duration rice varieties in sustainable paddy residue management

Several short-duration rice cultivars have been developed and promoted to ensure the timely vacating of fields for proper rice residue management that also have low biomass which again helps in easy *in situ* or *ex situ* management of rice residue. Among these paddy varieties, PR 126, which matures in about 93 days after transplanting, and PR 130, maturing in around 105 days after transplanting, generate only 36.1 q/acre of straw, thereby substantially reducing residue load in the fields. Similarly, other improved short-duration varieties such as PR 114 (matures in about 115 days, 36.7 q/acre straw load), PR 121 (about 119 days, 36.3 q/acre), PR 128 (about 111 days, 36.9 q/acre), and PR 131 (about 110 days, 36.7 q/acre) also provide a balanced grain yield while producing less straw.

Role of crop diversification

Crop diversification plays a transformative role in paddy residue management by reducing the extensive mono-cropping of paddy, which contributes significantly to residue accumulation and stubble burning. By shifting portions of paddy cultivation to alternative crops such as pulses, maize, cotton, and oilseeds, crop diversification not only lowers the volume of paddy straw residue but also breaks the cycle of ecological degradation caused by excessive water use. This strategy enhances farmers' income opportunities and strengthens environmental sustainability by decreasing the urgency for open-field burning, facilitating better residue utilization practices, and improving soil health. Government incentives and mechanization support further promote this shift, enabling farmers to adopt diversified cropping patterns that mitigate air pollution and contribute to climate resilience in Punjab's agrarian landscape.

Managing crop residues at farm level

With collective efforts from all quarters in effectively engaging, educating and empowering farmers through "Push, Pull and Enforcement" mechanism with due consideration of incentives to adopting *in situ* CRM practices, there has been a notable decline in crop-burning incidents, with reductions of 10% in 2021, 38% in 2022, 53% in 2023, and 80% in 2024 compared to the baseline year of 2020 (from September 15 to November 30). Specifically, the northwest region experienced an overall decrease of 65% in residue burning events

Combo technology of super SMS fitted combine and sowing of wheat with Happy Seeder

compared to 2023. In Punjab, a consistent downward trend has been observed, with reductions of 14% in 2021, 40% in 2022, 56% in 2023, and 87% in 2024 relative to the 2020 burning events (83,002 events). The impact of these initiatives is further illustrated by the adoption of *in situ* residue management practices in Punjab, which resulted in cost savings of ₹538 crores by lowering cultivation expenses, conserving farm nutrients valued at ₹495 crores through residue retention, and saving at least one irrigation cycle, thereby preventing the extraction of 571 million cubic meters (MCM) of groundwater. Most significantly, over the past seven years, more than 1,350 villages have been supported by ICAR-KVKs, with over 350 villages successfully transformed into "Burning Free Villages."

Way forward

The sustainable management of paddy residue presents both a crucial challenge and a pivotal opportunity to enhance agricultural productivity while safeguarding environmental health. Moving forward, the focus must be on scaling up farmer education and expanding access to affordable, cutting-edge mechanization that facilitates efficient *in situ* residue management, especially for smallholder farmers. Promoting crop diversification and short-duration rice varieties will reduce residue accumulation and enable timely sowing of subsequent crops. Additionally, leveraging innovative residue utilization avenues such as bioenergy, organic compost, and industrial raw materials can transform waste into value-added products, providing economic incentives for farmers. Strengthening policy support, fostering multi-stakeholder collaboration among government, research institutions, and communities, and employing robust monitoring systems for adaptive management are essential to sustain and accelerate progress. Together, these integrated strategies will drive the evolution of a resilient, eco-friendly, and economically viable agrarian system in north-western India, ensuring long-term environmental sustainability and farmer prosperity.

SUMMARY

The management of paddy residue stands as a pivotal environmental and agricultural challenge in north-west India, particularly in the states of Punjab, Haryana, and Uttar Pradesh, which are crucial for India's food security. The traditional practice of open-field burning of paddy straw, while convenient for farmers, results in severe air pollution, soil degradation, and significant health hazards. The integration of advanced farm machinery, combined with robust government schemes and intensive Information, Education, and Communication (IEC) campaigns led by Krishi Vigyan Kendras, has revolutionized *in situ* crop residue management. These innovations have achieved impressive reductions in residue burning incidents, demonstrating both economic viability and ecological sustainability. The successful adoption of these paddy residue management farm machineries, along with strategic crop diversification and promotion of short-duration rice varieties, offer transformative pathways towards conservation agriculture. This multi-faceted approach not only curtails pollution but also improves soil health and boosts productivity of the rice-wheat cropping system. Continued policy support, farmer awareness, and technological advancements remain essential to sustain this positive trend, ultimately securing a cleaner environment and resilient agrarian economy for the region.

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Spring-summer mungbean for sustainable intensification: A pathway to higher yields and incomes

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Mungbean (Vigna radiata L.) *is a nutritionally rich pulse crop, valued for its protein, dietary fiber, vitamins, minerals, and bioactive compounds, making it a functional food for human health. Beyond its nutritional importance, mungbean serves as a short-duration crop that fits well into the cropping calendar, enabling sustainable intensification and diversification of Indian agriculture. This study reports the adoption and impact of high-yielding, disease-resistant mungbean varieties (IPM 410-3* Shikha *and IPM 205-7* Virat*) in spring-summer cultivation under the Farmer FIRST Programme and Model Pulse Village programmes in Kanpur Dehat and Hamirpur districts of Uttar Pradesh. Demonstrations with improved agronomic practices, including line sowing, seed treatment, and integrated insect-pest management, showed significantly higher yields (12.20–16.72 q/ha) compared to traditional practices (9.75–11.14 q/ha), resulting in additional farmer income of ₹1,02,354–1,06,869. The integration of short-duration mungbean into fallow or traditional cropping systems enhanced land use efficiency, crop intensification, soil health through nitrogen fixation, and profitability. These interventions highlight the potential of improved mungbean technologies to strengthen farmer livelihoods, promote sustainable intensification, and serve as a model for scaling up in similar agro-climatic zones.*

Keywords: Crop diversification, Disease-resistant variety, Farmer FIRST Programme, High-yielding varieties, Income enhancement, Model Pulse Village

MUNGBEAN *(Vigna radiata* L.*)* is a versatile pulse crop widely cultivated across India due to its high nutritional value, short duration, and adaptability to multiple cropping systems. It is a valuable source of protein, dietary fiber, vitamins, minerals, and bioactive compounds, which contribute to human health and nutrition. Beyond its dietary importance, mungbean plays a crucial role in crop diversification, sustainable intensification, and soil fertility improvement through nitrogen fixation. Spring and summer mungbean cultivation provides a strategic opportunity to utilize fallow land after *rabi* harvest, enhancing income and productivity for farmers while maintaining ecological balance. Recent advancements in breeding and crop management by ICAR-Indian Institute of Pulses Research (ICAR-IIPR), Kanpur, have led to the development of high-yielding, disease-resistant varieties such as IPM 410-3 *(Shikha)* and IPM 205-7 *(Virat)*, specifically suited for north and central India. The dissemination of these varieties, combined with improved agronomic practices and integrated pest management, offers farmers an effective pathway to achieve higher yields, income, and sustainable intensification in traditional cropping systems.

Nutritional and agricultural significance of mungbean

Mungbean is an important pulse consumed all over India. It has been known to be a good source of quality protein, dietary fiber, minerals, vitamins, and significant amounts of bioactive compounds, including polyphenols, polysaccharides, and peptides, therefore, becoming a popular functional food in promoting good health. Apart from the nutritional aspect, mungbean plays a unique role in diversifying and intensification of Indian agriculture. The crop is versatile and fits well across the seasons which have led to significant area expansion under mungbean cultivation in the recent years. Spring/summer mungbean is an important crop cultivated by the farmers for additional income. Being a short-duration crop, it fits well within the cropping

Mungbean demonstrations in Hamirpur district

Mungbean demonstrations in Kanpur Dehat district

window between the *rabi* (winter) harvest and the *kharif* (monsoon) sowing. Besides generating additional yield and income, it plays an important role in improving soil health through nitrogen fixation.

Development of improved mungbean varieties

Advancements in pulse research have led to the development of short-duration, disease-resistant mungbean varieties suitable for different agro-climatic zones of India. These efforts have promoted the cultivation of mungbean during the summer/spring season in north and central India. ICAR-Indian Institute of Pulses Research (ICAR-IIPR), Kanpur has made a substantial contribution to the development of several high-yielding, disease-resistant mungbean varieties for different production niches across the country. The mungbean varieties developed by the institute accounted for more than 60% of the total breeder seed indent for mungbean varieties in the country during *kharif* 2024. IPM 410-3 (*Shikha*) and IPM 205-7 (*Virat*) are two very popular high-yielding, disease-resistant varieties developed by ICAR-IIPR, Kanpur in 2016 for cultivation in the North West Plain Zone and Central Zones of India during the summer/spring season. The variety IPM 205-7 *(Virat)* matures in 52–56 days and has a potential yield of 10–11 q/ha, while IPM 410-3 *(Shikha)* matures in 65–70 days with a potential yield of 11–12 q/ha.

Dissemination of improved technology through Farmer FIRST

The ICAR-IIPR, Kanpur institute is continuously making efforts to disseminate improved pulse production technologies, including mungbean, to reach farmers through on-farm interventions under ongoing projects such as the Farmer FIRST Programme and Model Pulse Village, among others, in the adopted villages. Some success cases of short-duration mungbean varieties (IPM 410-3 and IPM 205-7) in project villages are shared in this article.

Introduction of high-yielding varieties in project villages

Prevalence of non-descript mungbean varieties and limited uptake of plant protection technologies were the major challenges, restricting farmers from realizing the full yield potential of spring mungbean cultivation in the project villages of Kanpur Dehat and Hamirpur districts.

To address these challenges, high-yielding and disease-resistant mungbean variety *(Shikha)* was successfully introduced for the first time in Kanauta Danda and Gimuha Danda project villages of Kurara block, Hamirpur district of Uttar Pradesh during 2022–23 under the Farmer FIRST Programee (FFP). A total of 3.2 ha was brought under summer mungbean cultivation in partnership with nine farmers. The mungbean was introduced to intensify cropping systems such as sorghum–chickpea–fallow, sesamum–chickpea–fallow, fallow–wheat–fallow, fallow–mustard/rapeseed–mungbean, and fallow–field pea–mungbean. Besides improved varieties, farmers were trained on improved mungbean cultivation practices, including line sowing, seed treatment, and timely use of recommended insecticides. Sowing of mungbean was carried out by the farmers during the second fortnight of March to the first fortnight of April 2023, following pre-sowing irrigation. The first irrigation was applied 20–25 days after sowing, followed by irrigation at 10–15 day intervals as per crop requirement. Farmers recorded an average yield of 16.72 q/ha from demonstration plots compared to 10.53 q/ha from control plots, earning additional income of ₹1,02,354/ha from summer mungbean cultivation.

Continued demonstrations and expansion

In continuation to the attempts made, demonstrations on summer mungbean (var. *Shikha)* were organized on 12.8 ha in partnership of 18 farmers of Hamirpur district of Uttar Pradesh during 2023–24 under FFP. Sowing was done during second fortnight of March to first fortnight of April 2024. The previously mentioned package and practices was followed by the partner farmers. The partner farmers received 12.12 q/ha yield from demonstrations plots compared to control plots (that translated the gross income of ₹103,748/ha. In the same year i.e. spring 2024, mungbean viz. IPM 207-5 *(Virat)* and IPM 410-3 *(Shikha)* were successfully introduced on 75 ha in partnership of 148 farmers of Kandhi, Kandhi Ki Madaiya, Ingwara and Korawa project villages under Model Pulse Village project. Besides improved varieties, insect-pest management is

Mungbean demonstrations in Kanpur Dehat district

a crucial component of spring mungbean cultivation, however limited availability of spraying machines deterred farmers from following the recommended spray schedule. To address this challenge, partner farmers were also supported by providing spraying machines (100 nos.) under SCSP project. These efforts led to proper insect-pest management in mungbean crop. The enthusiasm of partner farmers and the technology backup under Model Pulse village project led to higher productivity levels of the spring mungbean crop in the project villages. The farmers fetched average yield of 12.20 q/ha from demonstrations plots against 9.75 q/ha from control plots, leading to higher income from demonstrations plots (₹104,864.60 q/ha) as compared to control plots (₹ 83,440.5 q/ha). In this line, during the year 2025, attempt made to increase the income of partner farmers from summer mungbean (var. *Shikha* and *Virat)* cultivation in project villages of Kanpur Dehat district, demonstrations on summer mungbean were organized on 12 ha in partnership of 15 farmers of project villages of Kanpur dehat under Model Pulse Village project. The partner farmers received 14.84 q/ha yield from the demonstration's plots in compare to control plots (11.14 q/ha) of the region and earned ₹106,869/ha as a gross income.

Impact of improved mungbean cultivation practices

The efforts made in the project villages of Kanpur Dehat and Hamirpur districts showed that adopting improved varieties, timely sowing, seed treatment, and insect-pest control measures led to higher yields and returns from mungbean cultivation compared to traditional methods. These demonstrations also highlighted the potential of short-duration summer mungbean in income enhancement by intensifying traditional cropping systems. The outcomes serve as a strong motivation for farmers in nearby villages to adopt improved spring/summer mungbean production technologies for additional income and higher yields.

SUMMARY

Spring-summer mungbean is a short-duration, high-protein pulse that supports both nutrition and agricultural intensification in India. ICAR-IIPR, Kanpur, has developed high-yielding, disease-resistant varieties such as IPM 410-3 *(Shikha)* and IPM 205-7 *(Virat)*, suitable for diverse agro-climatic zones. Through Farmer FIRST and Model Pulse Village projects, these varieties were successfully introduced in Kanpur Dehat and Hamirpur districts, along with training on line sowing, seed treatment, irrigation, and pest management. Demonstration plots consistently outperformed control plots, yielding 12–16.7 q/ha and generating additional income of ₹1–1.06 lakh/ha. Adoption of improved varieties and practices enhances cropping system intensification, income, and farmer motivation for sustainable mungbean cultivation.

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Model Pulse Village

THE **Model Pulse Village (MPV)** project, sanctioned by the Department of Agriculture and Farmers' Welfare, Ministry of Agriculture and Farmers' Welfare, Government of India, is designed to develop villages capable of sustaining and enhancing pulse production through a holistic approach integrating social, economic, technological, institutional, and skill development components.

Each MPV functions as a **community-oriented, self-sustaining model** that demonstrates best practices in pulse cultivation, seed production, and technology dissemination. Implemented in clusters of villages, these projects involve **collaboration among government agencies, research institutions, and farmers,** focusing on major pulse crops such as **chickpea, pigeon pea, mungbean, urdbean, lentil, and field pea.**

Key Objectives

- ***Enhance productivity:*** Double pulse yields by overcoming constraints like low productivity, pests, and diseases.
- ***Promote sustainability:*** Encourage climate-smart, resource-efficient, and region-specific pulse cultivation practices.
- ***Improve livelihoods:*** Boost farmers' income through access to quality seeds, improved technologies, and better markets.
- ***Strengthen self-reliance:*** Reduce pulse imports by increasing domestic production and ensuring national self-sufficiency.

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Commercialization of summer radish

cultivation for higher income generation

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Under the ICAR's Farmers FIRST Programme (2016–2024) in Dharer Panchayat, Baijnath Block, Kangra district, Himachal Pradesh, summer radish cultivation was promoted to enhance farmers' income through diversification. Improved hybrids and scientific practices such as line sowing and seed treatment replaced traditional broadcast methods, resulting in higher yields (170.7 q/ha vs. 115.9 q/ha) and improved B:C ratios (4.9 vs. 2.8). Farmers adopted commercial-scale cultivation, supported by improved road access and market linkages. The intervention increased total farm income by about 79%, with nearly 45% of farmers doubling their income, demonstrating the profitability and scalability of summer radish in hill farming systems.

Keywords: Diversification, Farm income enhancement, Hill agriculture, Off-season vegetables, Technology adoption

HIMACHAL Pradesh, a north-western hill state of India lies between 30°22′40″ and 33°12′40″ N latitude and 75°47′55″ and 79°04′20″ E longitude with altitudes varying from 350–6,975 m amsl. According to NARP concept of classification, Himachal Pradesh has been divided into four zones viz. sub-mountain and low hill sub-tropical, mid hill sub-humid zone, high hill temperate wet zone and high hill temperate dry zone. Among the four agro-climatic zones, mid-hill sub-humid zone has been characterized as the grainery of the State for production and productivity of field crops and milch animals. This zone comprises of about one sixth of total area and contribute for about one fourth of total food grain production. District Kangra is one of the most important districts of the State with respect to agriculture, wherein major areas fall in the mid hill zone. Wheat, paddy, maize, pulses and vegetables apart from horticulture are the main crops of the district and source of livelihood to rural masses.

To ensure food and nutritional security to fast growing Indian population, making agriculture a remunerative occupation and enhance farmer's income, the Government of India initiated a mission for doubling the farmers' income and to achieve it, the agriculture sector needs to grow at 15% per annum. Therefore, there is a need for reorienting the conventional cropping system with a more productive alternative integrated farming systems, combining on and off-farm enterprises with latest technological support. Keeping this objective in mind, the farmers' FIRST [Farm, Innovation, Resources, Science and Technology] Programme of the Indian Council of Agricultural Research (ICAR) was implemented by the Directorate of Extension Education of the university in a cluster of villages of Dharer Panchayat, Baijnath Block, District Kangra, Himachal Pradesh, from 2016–17 to 2023–24.

The selected project operational area represents different micro-farming situations prevalent in mid-hill sub humid zone and over and above the existence of agro-ecosystems and their production systems identified for technology assessment and dissemination. About 80% of the area of district is rainfed and maize-wheat is the most dominating cropping system. Concerted efforts in the past has resulted in diversification of this system and many areas have adopted vegetable cultivation for better returns. Different set of farm families were identified. The project interventions hence, were conceptualized in view of the facts that it will cover all farm families in the cluster for different modules based on their existing production systems potential and interest.

Based on results of benchmark survey using participatory rural appraisal (PRA) technique and extensive discussions with farmers regarding their skills and managerial capabilities, 16 interventions of various farming modules of doubling farmers' income model were implemented in 500 farm holdings in a systematic

Women farmers transporting radish from their fields

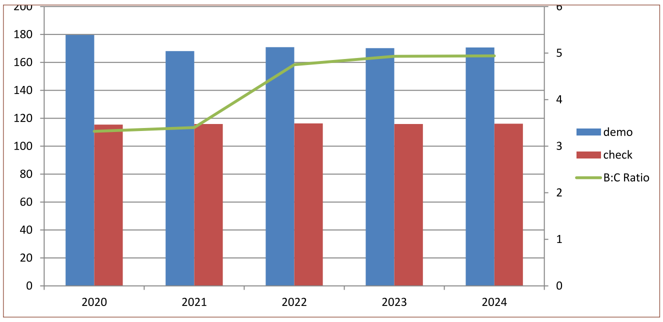
manner. In selected households, the average family size was 3.80 and most of the (75.21%) population had agriculture as the main occupation, while nearly 25% families had employment as an additional income source. The average size of holdings was 0.35 ha. The selected farmers were continuously provided technological and partial input support in terms of training, skill up-gradation, supply of seeds, fertilisers and other production linked inputs. The outputs in terms of production/productivity, revenue generation and profitability of the model were regularly recorded to quantify the contribution of interventions over the traditional farmers' practices.

Visualizing the agroecological conditions prevailing in the study area, the operational area has the potential to grow various high value cash vegetable crops. The cultivation of off-season vegetable production had high potential for supplementing farm income. During summer season, the possibilities of cultivation of French bean, peas and radish existed and amongst these crops, the radish crop appeared to be less input demanding and high profit making when it is available during summer rainy season (June-August). Initially, the farmers of the area were broadcasting radish seeds and the varieties in cultivation bolt (flower) early without forming appropriate marketable sized roots during summer season (April-May). As a result, the farmers were not getting premium prices of their produce.

The farmers of the area were educated about line sowing of the crop and improved radish varieties and hybrids suitable for growing especially during summer season (April-May sowing time) and these produced good quality marketable sized roots and did not bolt (flower) during summer season. As such, the quality produce fetched premium prices in the market during off-season. Since, 2020–21, the summer crop of radish is continuously producing higher root yield and a substantial improvement over B:C ratio has been recorded. The farmers of the area are highly impressed with the successful and higher income generating activity in the area. Earlier, the farmers used to transport the produce to the markets manually or the use of animal power for transport especially the horses. With the concerted efforts of the farmers and Gram Panchayat representatives, the local road has been constructed which is now facilitating the transport of fresh produce from the production sites in the villages to the markets. The farmers of the area are now cultivating summer crop of radish on commercial scale and the entire two village clusters namely, Kandkosari-I, Kandkosari-II are completely saturated with this crop. The farmers are earning lucrative returns through the sale of their produce and are sustaining their livelihoods.

Table 1. Yearly wise demonstrations, yield increase and B:C ratio of summer radish cultivation in the area

Year	Seed (Kg)	Area (ha)	No. of Farmers	Yield of Demo (q/ha)	Yield of Check (q/ha)	% Increase	B:C ratio of Demo	B:C ratio of Check
2020-21	5	1.0	120	179.60	115.45	55.49	3.32	2.08
2021-22	10	2.0	30	168.09	115.88	45.75	3.40	2.22
2022-23	18	3.5	84	170.90	116.3	46.90	4.75	2.96
2023-24	18	3.6	88	170.20	115.9	46.85	4.93	2.80
2024-25	20	4.0	79	170.70	116.1	47.02	4.94	2.81
Average	14.2	2.8	80	171.89	115.92	48.4	4.3	2.6



Year wise yield increase and B:C ratio over local check of radish cultivation

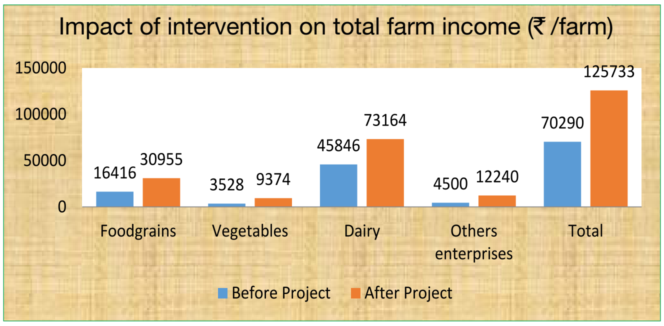
Impact on farmers' income

The impact assessment studies of various interventions executed from 2016–17 to 2023–24 revealed that due to high productivity, the income from foodgrain crops increased by about 88.57% from ₹16,416 before the interversion of the project to ₹30,955 the income significantly by ₹14,539. In case of vegetables, due to the increase in productivity of the existing vegetables and introduction of new crops by replacing pulses and oilseeds, the income of the vegetables increased by 165% (from ₹3,528 to ₹9,374/farm/annum) compared to the before project. The major increase in the farm income was noticed in dairy component as increased significantly by ₹27,318 i.e. from ₹45,846 to ₹73,164 thereby showing an increase of 59.59% The income from ancillary enterprises (mainly mushroom and backyard poultry) was more than double showing an increase of about 172%. Overall, the total farm income that was estimated ₹70,290/farm before project increased to ₹125,733/farm after the project interventions. This clearly shows a significant addition to the income worth of ₹55,443 farm. Therefore, the total income in the project area got increased by about 78.88% as a result of various technological interventions.

As far as distribution of total income among the different farm components is concerned, the data revealed that before the project, major portion of total farm income was derived from dairy component (65.22%) followed by foodgrains (23.35%) and ancillary farm enterprises. However after the project interventions, productivity foodgrains and ancillary increased by 25, 7 and 9%, respectively. Income of the 40% of the farmers got doubled or more than doubled while the income of 10% of the farmers increased by more than 75%. The income of 9.33% farmers increased in the range of 50-75% while income of about 11% of the farmers increased to the extent of 25–50%. The income of 12% of the farmers recorded a meagre increase and there was no change in the farm income of 18% of the beneficiary farmers. In this way, the income increased was recorded on about 82% of the farm households that clearly embarks the appreciable impact of the project activities in the study area.

Table 2. Impact of intervention on total farm income (₹/farm)

Crops	Before Project	After Project	% increase
Food grains	16,416 (23.35)	30,955 (24.62)	88.57
Vegetables	3,528 (5.02)	9,374 (7.46)	165.7
Dairy	45,846 (65.22)	73,164 (58.19)	59.59
Others enterprises	4,500 (6.41)	12,240 (9.73)	172
Total	70,290 (100.00)	125,733 (100.00)	78.88



Extent of increase in farm income

The extent of increase in the farm income at the beneficiary farms has also been analysed. It was inferred that that the proportion of the farmers at which the farm income increased by more than 100% was quit high i.e. 44.67% of the total farmers. The proportion of the farmers who were able to increase their income by 75–100 and 50–75% was found to be about 14 and 15%, respectively. The table clearly indicated that majority of the beneficiary farmers (about 73%) has increased their income by more than 50%. However, there has been no change in the income on 6.67% of the beneficiary farmers.

Table 3. Distribution of beneficiary households according to income enhancement

Extent of increase in income	No. of farmers	Farmers (%)
>100 (more than doubled)	67	44.67
75–100	21	14.00
50–75	22	14.67
25–50	16	10.67
Less than 25	14	9.33
No change	10	6.67
Total	150	100.01




Demonstrations of summer radish in FFP area



Demonstrations of summer radish in FFP area

SUMMARY

The Farmers FIRST Programme implemented from 2016–2024 in Kangra district, Himachal Pradesh, introduced summer radish cultivation as a profitable diversification option for smallholders. Through demonstrations, training, and supply of improved varieties, farmers shifted from traditional broadcast sowing to scientific practices, achieving about 48% higher yields and doubling profitability. The adoption of improved varieties and better market access enabled commercial-scale production across village clusters. Overall, farm income in the project area rose by nearly 79%, with 45% of farmers doubling their earnings. The initiative proved that off-season vegetable cultivation can significantly enhance livelihoods and sustainability in hill farming systems.

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Empowering farmers with improved finger millet production technologies for higher productivity

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Finger millet is a highly nutritious and climate-resilient crop, primarily cultivated for both food and fodder. It thrives in sub-tropical climates at high altitudes and is notable for its high calcium, dietary fiber and high quality protein, making it a highly nutritious grain. India produces 1.8 million tonnes annually, with Karnataka contributing about 60%. The crop adapts well to kharif season rainfed conditions and prefers loamy to sandy soils with good drainage. Various improved and nutrient-rich varieties were developed with resistance to major diseases and pests. Improved practices such as proper land preparation, seed treatment, spacing, timely irrigation and weed control enhance productivity. Intercropping with legumes and crop rotation with pulses improve soil fertility and yield sustainability, making finger millet an ideal crop for climate-resilient and nutrition-sensitive agriculture. Improved finger millet production interventions led to notable increases in yield and profitability, achieving up to a 21% gain compared to existing traditional techniques.

Keywords: Disease resistance, Economic impact, High nutrition, Improved production interventions, Intercropping system, Sub-tropical, Sustanable cultivation

FINGER millet *(Eleusine coracana* L.*)* is third most important millet next to pearl millet and sorghum, grown for food and fodder, commonly known as Ragi, *Mandika, Marwah* (Hindi), *Nagli, Nachni* (Marathi), Ragi (Kannada), *Ragulu, Chodi* (Telugu), *Keppai, Kelvaragu* (Tamil), *Marwa* (Bengali), *Nagli, Bavto* (Gujrati), *Mandia* (Oriya), *Mandhuka, Mandhal* (Panjabi). Grains of finger millet are rich in calcium (250–350 mg/kg) and known for dietary fiber and quality protein. In India, finger millet is cultivated in an area of 1.18 million ha with productivity of 1,600 kg/ha and production of 1.8 million tonnes. Karnataka occupies about 60% of the area in cultivating finger millet, followed by Tamil Nadu, Maharashtra and Uttarakhand. Finger millet grows well in subtropical climate and can be cultivated up to an altitude of 2,100 m. The minimum temperature required is 8–10^{o}C. A mean temperature range of 26–30^{o}C during the growth is the best for proper development and good crop yield. Finger millet contains 7.2% protein, 66.8% carbohydrates, 11.2% dietary fiber and 2.5–3.5% minerals. It has the highest calcium content among all cereals and millets (344 mg/100 g). The major phenolics found in finger millet are ferulic acid and p-coumaric acid and the bound phenolic fraction accounts for 64–96% and 50–99% of total ferulic acid and p-coumaric acid contents of millet grains, respectively. High calcium content of finger millet is useful for growing children, elderly people and lactating women. Building strong bones in childhood was found to be associated with maintaining bone strength, in elders especially after menopause. Regular consumption of high calcium reduces the chance of kidney stone formation from dietary oxalates. Calcium binds with oxalic acid in intestines and prevents absorption of oxalates by the body.

Improved varieties

Several high yielding and nutri-rich varieties were developed and released for cultivation in different states. The list of latest and popular varieties recommended for different states and nutri-rich varieties were given in the tables.

Soil and climate

Finger millet is grown in all cropping seasons except winter, however 90% of the area is under *kharif* rainfed conditions. The crop is widely adaptable to a range of environmental conditions and is grown in

Table 1. Recommended improved varieties of finger millet in different states

Varieties	Adaptation	Crop duration (days)	Yield (q/ha)
CFMV-1*(Indravathi)*	Andhra Pradesh, Karnataka, Tamil Nadu, Puducherry and Odisha	110–115	30–32
CFMV–2	Andhra Pradesh, Chhattisgarh, Gujarat, Maharashtra and Odisha	119–121	29–31
VL–378	Rainfed organic conditions of the Uttarakhand hills	110–114	22–24
VL–382	Rainfed organic conditions of the Uttarakhand hills	106–108	11–13
Chhattisgarh Ragi–3 (FMV–1102) (BR–14-3)	Northern Zone (Assam, Bihar, Chhattisgarh, Jharkhand, Uttarakhand and MP)	110–115	33
ATL–1 (TNEc-1285)	Tamil Nadu	105–110	30
Dapoli 3 (DPLN–2)	Konkan region of Maharashtra	125–130	20–22
Birsa Marua–3	Jharkhand	110–112	26.9
Gossaigaon Marua Dhan (AAU-GSG-Marua *Dhan*–1) (FMV1156)	Assam	125–130	30.51
Phule Kasari (KOPN 942)	Maharashtra	100–110	22.44
CFMV–4 (FMV1166)	Andhra Pradesh, Maharashtra, Tamil Nadu	113	GY: 28.66 FY: 60.29
VL *Mandua* 400 (CFMV5) (FMV1162)	Madhya Pradesh, Karnataka, Chhattisgarh, Bihar, Jharkhand, Gujarat and Andhra Pradesh	102	GY: 34.77 FY: 84.80
Gosthani (VR 1099)	Andhra Pradesh	110–115	GY: 38–39
Siri (KMR–316)	Zone 5,6 of Karnataka	105–110	30–35
Shreeratna (OUAT Kalinga finger millet–1) (OEB 601)	Odisha	117	23.5

GY= Grain yield, FY= Fodder yield

Table 2. Recommended nutri-rich varieties of finger millet in different states

Name	Adaptation	Special features
CFMV-2	Andhra Pradesh, Chhattisgarh, Gujarat, Maharashtra, Odisha	Resistant to leaf blast, foot rot, brown spot, grain mold and moderately resistant to neck blast, finger blast and banded blight
CFMV-1 *(Indravathi)*	Andhra Pradesh, Karnataka, Tamil Nadu, Puducherry, Odisha	Resistant to finger blast, neck blast, banded blight and foot rot, shoot aphids, stem borer and grass hoppers; rich in calcium (428.3 mg/100 g), iron (58.3 mg/kg), zinc (44.5 mg/kg)

altitudes ranging from mean sea level to the foothills of the Himalayas. The crop can tolerate a certain degree of alkalinity. The best soil is alluvial, loamy and sandy soil with good drainage. The minimum temperature for germination is 8–10°C and mean temperature of 28–32°C is ideal for good crop development.

Land preparation

In the month of April or May, one deep ploughing with a mould-board plough helps in retaining more soil moisture followed by, harrowing twice is necessary. Before sowing, secondary tillage with a cultivator using multiple-tooth hoe to prepare smooth seedbed is necessary. Minor land smoothening before sowing helps in better *in situ* moisture conservation. Seeds are very small and take 5–7 days to germinate. Hence, good seeds, land preparation helps in better germination, minimize weeds problems and effective soil moisture conservation. In Uttarakhand, where frequent ploughing operations are difficult to carry out, effective digging and turning of soil, removing perennial weeds, land smoothening and providing an inward slope with a shallow drain help in taking out excess rainwater.

Soil and moisture conservation practice

To increase soil quality, summer ploughing or ploughing after the harvest of previous crop can be done across the slope. Preparation of small section bunds at an interval of 10–12 m, depending on the slope and levelling, helps in better management for operations. Opening a dead furrow at 3.3–4.0 m intervals is beneficial.

Seed rate

Use 8–10 kg/ha (3–4 kg/acre) for line sowing is advised and 4-5 kg/ha (1.5–2.0 kg/acre) for transplanting. A seed rate of 10 kg/ha is found to be optimum for drill sowing and 5 kg/ha for raising transplanted seedlings.

Seed treatment

Seed should be treated with Thiram or bavistin @2.5 g/kg of seed to prevent diseases. Treating seeds with *Azospirillum brasilense* (N-fixing bacterium) and *Aspergillus awamori* (P-solubilizing fungus) @25 g/kg seed is beneficial. In case seeds are to be treated with seed dressing chemicals, treat the seeds first with seed dressing chemicals and then with bio-fertilizers at the time of sowing.

Bio-fertilizer culture is specific to the crop to be used at 25 g/kg of seed. A sticker solution is necessary for effective seed inoculation. This can be prepared by dissolving 25 g jaggery or sugar in 250 ml water and boiling for 5 min. The solution thus prepared is cooled. Smear the seeds well using the required quantity of sticker solution. Then add culture to the seeds and mix thoroughly to achieve a fine coating of culture on the seed. The culture-coated seed is to be dried well in shade to avoid clumping of seeds. Use of the inoculated seeds for sowing can be done.

Sowing time

Suitable time for sowing for *kharif* is in June to July, and for *rabi*- September to October. In certain regions, it is grown in summer under irrigated land conditions.

Method of sowing

Line sowing is beneficial, helps in inter cultivation and control weeds effectively. Maintenance of optimum plant population of 4–5 lakh plants/ha and this is attained by line sowing using seed drill with spacing of 22.5–30.0 cm between rows and 7.5–10.0 cm between plants. Transplanting is also done in irrigated conditions.

Nursery preparation

An area of 150–200 m^2 is required to raise seedlings to cover 1.0 ha of main land. Apply 2–3 baskets of well decomposed farmyard manure (FYM) along with 1.0 kg super phosphate, half kg muriate of potash and half kg ammonium phosphate and 750 g zinc sulphate per bed. Sow the seeds by opening rows at every 3 inch uniformly. Cover the seed with well decomposed FYM and soil/sand/water in every bed. Top dressing with urea 500 g/bed when the seedlings are 12–14 days old is necessary. Seedlings of 21–25 days old are ideal for transplanting in rows of 22.5–25 cm with 2 seedlings/hill with 10 cm between hills.

Spacing and fertilizers

In direct sowing, spacing between rows should be 22.5–30 cm, plant-to-plant 7.5 cm and depth 3-4 cm. Application of additional quantities of organic matter in soil is considered beneficial, since it helps to improve the physical condition of soil, which helps soil to retain moisture for a longer period. Apply 5–10 t/ha FYM about a month before sowing. The crop responds well to fertilizer application. The general recommendation for finger millet is 60 kg nitrogen, 30 kg P and 30 kg K/ha under irrigation and 40 kg nitrogen, 20 kg P and 20 kg K/ha is for rainfed conditions. Entire P and K fertilizers are to be applied at sowing, whereas nitrogen is to be applied in two or three split doses, depending upon moisture availability.

In areas of good rainfall and moisture availability, 50% of recommended nitrogen is to be applied at sowing and the remaining 50% in two equal splits at 25–30 and 40–45 days after sowing.

In areas of uncertain rainfall, 50% N at sowing and the remaining 50% around 35 days after sowing is recommended.

Irrigation management

Finger millet is generally grown during *kharif* under rain-fed conditions. If there is any longer dry spell, then irrigation would be required. Depending on soil type, weather conditions and duration of variety, for light soils irrigate the crop once in 6–8 days, and for heavy soils once in 12–15 days under limited irrigation. The crop may be irrigated at critical growth stages like tillering, flowering and grain filling.

Important weeds

Grassy weeds: *Echinochloa colonum, Echinochloa crusgulli* (sawan), *Dactyloctenium aegypticum* (makra), *Elusine indica* (kodo), *Setaria glauca* (banra), *Cynodon dactylon* (doob), *Phragmites karka* (narkul), *Cyperus rotundus* (motha), *Sorghum halepanse* (banchari) are common weeds.

Broad-leaved weeds: *Celosia argentia* (chilimil), *Commelina benghalensis* (kankoua), *Phylanthus niruri* (hulhul), *Solanum nigrum* (makoi) and *Amaranthus viridis* (chaulai) are common weeds.

Weed control

The field should be kept weed-free up to 25–30 days after sowing. It is essential to control weeds in the initial stage of plant growth and development. The inter-cultivation and weeding should be done with a hand hoe at 25 days after sowing (DAS). Weed problems in finger millet crop can be effectively managed by cultural and mechanical operations. In line sowing, 2–3 intercultivations and one hand weeding is suggested. For the broadcast crop, 2 hand weedings will minimize weeds. In assured rainfall and irrigated areas, pre-emergence weedicide spray with Isoproturon at 0.5 kg a.i./ha needs to be done. In rainfed areas, spray of Oxyfluorfen at 0.1 L a.i./ha (irrigated areas) can be done. For post-emergence spray, 2, 4–D sodium salt at 0.75 kg a.i./ha should be done at around 20–25 days after sowing to control these weeds.

Intercropping

Intercropping in finger millet improves resource use efficiency, reduces pest and disease incidence and enhances overall crop productivity. Finger millet is a resilient and nutritious cereal, is widely intercropped with legumes and oilseeds across India to improve soil fertility and increase farmers' income. The intercropping ratios and companion crops vary based on regional agro-climatic conditions.

Table 3. Intercropping systems of finger millet in different states of India

State	Crop system
Karnataka, Tamil Nadu and Andra pradesh	Finger millet + Pigeon pea; 8-10:2
	Finger millet + Field bean; 8:1
	Finger millet + Soybean; 4:1
Bihar	Finger millet + Pigeon pea; 6:2
Uttarakhand	Finger millet and soybean mixed in 90:10% proportion by weight basis
North hilly areas	Finger millet + Soybean in *kharif* and oats in *rabi* is an ideal
Maharashtra (Kolhapur)	Finger millet + Black gram/moong bean 6-8: 1

Crop rotation year-wise

Northern states: Rotation with legumes like green gram/black gram/rice bean/soybean.

Southern states: In southern states, horse gram, pigeon pea, field bean or groundnut are good for crop rotation. This practice will minimize inorganic fertilizer application and sustain higher yields. Finger millet-finger millet rotation must be discouraged as it affects the sustainability of soil as well as crop yield.

Crop sequence

Northern Bihar: Potato-paddy-finger millet cropping sequence is highly remunerative than other cropping sequences.

Table 4. Insect-pests and diseases identification symptoms and their management

Insect pest	Key identification	Control measures
Army worms and cut worms	Caterpillars cut seedlings at the base during early stage, which appears as it was grazed by domestic animal. They are active during night. In later stages, these insects act as defoliators.	Apply poison baits, comprising 10 kg rice bran + 1 kg jaggery + 1 L quinolphos (25% EC). Prepare small balls and broadcast in the fields, preferably in the evening time. Spraying Chloroantraniliprole 18.5 SC at 0.4 ml/litre water control armyworms/cutworms.
Leaf aphid	It occurs throughout the crop growing period. The nymphs and adults suck the sap from tender leaves and stem. They can cause serious damage at the seedling stage up to 30 days.	Spraying of Quinolphos (0.05%) or Imidacloprid 17.8 SL at 0.25 ml/L give effective control.
Pink stem borer	The larva bores into the stem, resulting in dead heart.	Spraying the crop with Chloroantraniliprole 18.5 EC at 0.4 ml/litre helps in control of borer.
Ear head caterpillars	Ear head caterpillars appear at dough stage on ears and persist till harvest. The caterpillars bite the maturing seeds and make a fine web out of their casting and half eaten grains. This further attracts saprophytic fungi.	Dust Chloroantraniliprole 18.5 EC at 0.4 ml/litre or Quinolphos 1.5% at 24 kg/ha.
Diseases		
Blast *(Piricularia fungi /Pyricularia grisea)*	Diamond-shaped lesions with gray center and dark margin appear on the leaf. Any part of plant including leaves, peduncle, and fingers can be infected. Infected fingers become brown to black in colour with poor or no seed setting in the infected parts. Grains on blast affected fingers become shriveled, discoloured and light in weight.	Treating seeds with fungicides like Carbendazim at 2g/kg a day before sowing. Spraying the nursery with Kitazin or Tricyclazole at 0.1% a.i 10-12 days after sowing is recommended depending on disease incidence. Spray the fungicide at 50% flowering stage and repeat 10 days later for controlling neck and finger blast.
Brown spot	Many small to medium-sized brown to dark brown spots appear on the leaf, leaf sheath, and other plant parts. Damage could be severe if the crop is subjected to drought or nutritional deficiency.	Proper nutrition and water management can effectively manage the disease. Need-based spraying of Mancozeb (0.2%) can be taken up.

Southern Karnataka or Deccan plateau: Finger millet-potato-maize or finger millet-onion- finger millet is highly remunerative cropping sequence.

Assured rainfall areas: Raising crop of cowpea or green gram or sesamum, followed by sowing/transplanting of early duration finger millet can be practiced.

Insect-pests and disease management

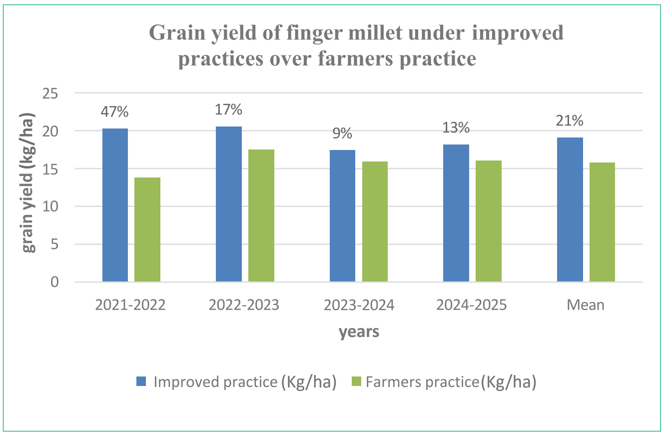
Finger millet though known for its resilience and adaptability to diverse agro-climatic conditions, is susceptible to a range of insect pests and diseases that can significantly influence its growth, productivity and grain quality. Timely identification and integrated pest and disease management practices are crucial for ensuring sustainable yield and profitability.

Harvesting and yield

The crop matures in about 95–110 days for early varieties and 115–125 days for medium to late duration varieties depending on the crop season. The panicles are harvested with ordinary sickles and straw is cut close to ground. At some places under rain-fed condition, the whole plant with panicles are cut, heaped, sun dry and then threshed. Average grain yield of 2.0–3.0 t/ha and 3.0–4.0 t/ha under well managed conditions and 6.0–9.0 t/ha fodder. The straw of finger millet makes nutritious fodder and it is preferred over paddy straw. It can be conserved by putting up in well-built stakes.

Performance of improved technologies in farmers' fields under Farmers FIRST Programme

The analysis of yield and economic data of the technology evaluation trials organized in Sangareddy district of Telangana state during 2021 to 2025 showed that improved agricultural practices consistently outperformed traditional farmers' practices in terms of productivity and net returns. The average yield obtained under improved practices was 19.08 kg/ha, which was 21% higher than farmers' practices (15.80 kg/ha), reflecting potential to bridge yield gap



substantially. The most significant yield advantage was observed during 2021–2022, with a 47% increase, while the lowest was recorded (9%) in 2023–2024. Although the magnitude of improvement varied across years, likely due to environmental factors, resource availability, or levels of adoption, the overall trend indicates that improved agricultural practices contribute positively to enhancing the productivity and income to the farmers. These findings underscore the importance of promoting and supporting the adoption of improved technologies to achieve sustained finger millet productivity.

A mature finger millet earhead in the field

Grains of finger millet

SUMMARY

The adoption of improved finger millet production technologies led to significantly higher yields and profitability, achieving yield gains of up to 21% compared to conventional methods. These results show potential for finger millet farmers to enhance productivity through the implementation of these improved production interventions. To facilitate wider dissemination, conducting field demonstrations, farmer field schools. Strengthening the farmers through regular training, expert guidance and access to extension support will further accelerate the adoption of improved practices. A coordinated approach involving research institutions, extension systems and local stakeholders is essential for scaling these innovations and ensuring sustainable intensification of finger millet cultivation.

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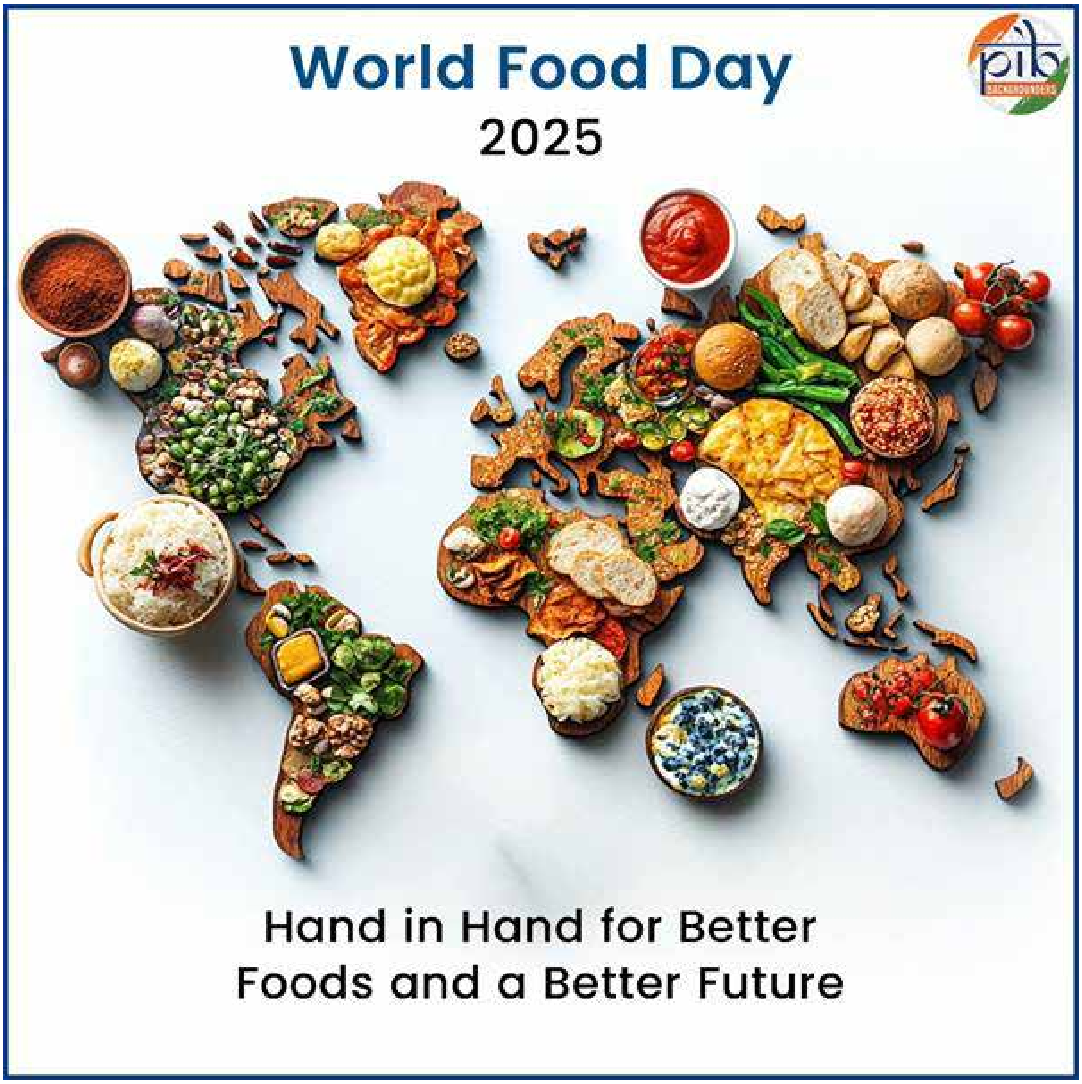

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Innovative processing approaches for producing chemical-free jaggery from sugarcane

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Jaggery production from sugarcane is vital for rural employment and value addition, yet conventional methods rely on chemical clarificants that compromise quality and safety. Under the ICAR-CIPHET's Farmer FIRST Programme, an improved, chemical-free, and energy-efficient jaggery-making system was introduced at Uppal Farm, Rahon (SBS Nagar). Using plant-based clarificants like okra mucilage and a multi-pan furnace burning sugarcane waste, the process enhances energy efficiency and product purity. The improved system enables production of both solid and granular jaggery, offering a sustainable, health-safe, and income-generating alternative for farmers.

Keywords: Energy-efficient processing, Farmer empowerment, Okra mucilage, Organic clarificants, Three-pan furnance, Value-addition

INDIA is the largest producer of jaggery, generating over 300 MMT of sugarcane annually, of which approximately 79.71%, 11.29%, and 8.80% are processed to produce white sugar, jaggery, and cane juice, respectively. The recovery and quality of jaggery primarily depend on sugarcane variety, fertilizer type and dose, irrigation, and crushing methods.

Jaggery or *gur*, is a traditional sweetener widely consumed in South Asia, Africa, and Latin America. It is known by various regional names, such as 'Gur' in India, 'Panela' in South America, and 'Jaggery' in South Asia. It is an unrefined, nutritional, non-centrifugal whole cane sugar consumed globally, and in Ayurveda, it is considered a therapeutic sugar for the treatment of lung and throat infections, possessing antioxidative and anticarcinogenic properties. Jaggery is generally prepared from sugarcane juice *(Saccharum officinarum)*, though it can also be made from palm and sweet sorghum. It contains 60–85% sucrose, 5–15% glucose and fructose, and various minerals. It is considered a healthy sugar due to its richness in minerals such as iron, magnesium, sodium, phosphorus, zinc, potassium, and vitamins.

The colour of jaggery typically ranges from brown to dark brown, while golden yellow jaggery is preferred in the market. Jaggery is available in three main forms: liquid, solid, and granular. Solid jaggery is produced by heating the concentrated juice to 116–128°C, followed by cooling and molding into rectangles or cubes using stainless steel or wooden molds. Liquid jaggery is a semi-solid product obtained by boiling sugarcane juice to 105–108°C. Granular jaggery is prepared by heating to 120–122°C, cooling, and scraping to form crystals. Traditional jaggery production often involves the use of chemicals, such as lime and hydros, to clarify the juice. While these chemicals improve shelf life and appearance, their residues in the final product can pose potential health risks to consumers. Growing awareness of chemical effects on health has increased the demand for organic and chemical-free jaggery that preserves nutritional value and health benefits.

ICAR-CIPHET has played a significant role in promoting chemical-free jaggery production by developing improved processing techniques, hygienic handling, and energy-efficient methods to maintain shelf life and purity. Adoption of these methods enables farmers to produce high-quality jaggery, ensuring that chemical-free jaggery reaches the market in good condition, thereby enhancing farmers' income and promoting employment-generating agricultural practices.

Processing stages in jaggery production

Jaggery production involves a series of operations to convert sugarcane juice to solid, granular jaggery. Each step plays an important role in maintaining the yield, colour and overall acceptability of the final product. The detailed process is given below:

Harvesting of sugarcane: Harvesting of mature sugarcane is crucial for achieving high sugar content, maximum yield, and high-quality jaggery.

Juice extraction: Sugarcane juice is extracted using power operated vertical or horizontal crusher. Horizontal multi roller crusher is preferable due to its high juice extraction capacity (60–65%). The fibrous material remained after juice extraction is bagasse, dried and utilized as a biofuel to heat the juice during boiling stages.

Filtration and settling: After extraction, the juice is passed through a wire mesh or thick cloth to remove suspended impurities like bagasse and other plant debris. The filtered juice is collected into a stainless steel or aluminum tank through underground PVC pipes. The juice is allowed to left undisturbed for 10–15 min in covered tank to allow settling of heavy impurities at the bottom. The clear juice is then transferred to the furnaces pans for further concentration.

Boiling and clarification: The filtered juice is boiled in large iron vessels or open pans, heated by burning bagasse as biofuel. To clarify juice from the impurities like soil, wax, protein, gums, tannins, and colouring particles, clarifying agents (Sodium hydrosulphide, lime, sodium bicarbonate, or organic calrificants like deola or okra mucilage) are added to the heated juice at an optimum temperature of 70–80°C. The effectiveness of juice clarification greatly affects the quality of the jaggery. The efficiency of clarifying agents directly affect the colour, taste, texture, overall quality and acceptability of the jaggery.

Striking point: After clarification, the juice is continuously boiled to remove excess moisture and to concentrate the juice. The boiling process continues for 2–2.5 h until the temperature reaches to 116–118°C, knows as striking point. The end point can be determined by using an infrared thermometer or drop test, by dropping syrup in cold water, if it holds its shape, it is ready to remove from furnace. Adding a small amount of oil (groundnut, mustard, or coconut) can help to prevent excessive frothing, and pouring. The quality of jaggery largely depends on the composition of the sugarcane juice, the type of clarifying agents used, and the temperature at which the juice is concentrated.

Cooling and moulding: The hot concentrate is transferred into a wooden or aluminium troughs for settling and cooling. Once partially solidified, it is poured into moulds of desired shape and size like rectangular, round balls or cubes. For uniform packaging, cubes or rectangular shapes are popular due to convenience in packaging and distribution.

Packaging: Jaggery is traditionally packed in plastic bags, containers, wooden boxes, or cardboard boxes. To ensure hygienic conditions and better shelf life, it is recommended to pack jaggery in PET or polythene bags. Vacuum packaging can extend the shelf life of jaggery upto one year and reduce weight loss. Liquid jaggery can be packaged in PET bottles, while granular jaggery can be packaged in polyethylene pouches, PET jars or bottles. Information like the composition, net weight, manufacturing season, grade, manufacturer, manufacturing date, packaging date, and health benefits of jaggery can be printed on the packaging to promote its sales

Storage: Proper storage conditions are important to maintain the shelf life and quality of jaggery. Jaggery is most susceptible to spoilage due to high humid conditions during the rainy season. To prevent deterioration, the moisture content of jaggery should be between 5–7%. A relative humidity of 50–60% is ideal for storage. Sun drying or solar drying can reduce excess moisture in jaggery, though shade drying is preferred to prevent cracking and maintain a uniform texture.

The method of storing jaggery vary across regions and depends upon the local practices and infrastructure. Traditionally, it is stored in earthen pots, wooden boxes, metal drums, or simply covered with cane trash, bagasse, wheat straw, cotton seed, or rice husk to protect it from moisture. However, many small scale producers and farmers store jaggery in poorly maintained godowns, and kitchens, which can encourage the growth of harmful microorganisms and lead to spoilage.

Traditional method of jaggery production

Jaggery processing techniques vary widely, with traditional methods often relying on inefficient, single-pan furnaces that required higher mechanical and thermal energy to prepare jaggery. In conventional method, sugarcane juice is extracted by crushing the sugarcane using mechanical crusher followed by heating to prepare jaggery. The open pan heating system consists of three stages.

I Stage is raising the temperature of sugar cane juice to initiate boiling.

II Stage is supplying heat to boiling temperature to evaporate water from the sugarcane juice.

III stage is increasing heat to raise temperature from boiling point to striking point, the point when sugarcane juice converted to semi solid state and cooled as jaggery.

However, in traditional process, uncontrolled heat often leads to maillard reaction and sugar caramelization, resulting in dark coloured jaggery and quality deterioration of product. Chemical clarificants like lime, hydros and phosphoric acid are used to clarify the sugarcane juice, while the traces of clarificants remained in the end product which could pose harmful effect on human health.

Unit operation of jaggery manufacturing process

Improved modern chemical free jaggery processing method

Modern furnaces, designed for optimal heat utilization and operational efficiency through the use multiple pans and recover the waste heat to preheat incoming sugarcane juice. This design significantly improves energy efficiency and reduces processing time. ICAR-CIPHET has demonstrated improved three-pan furnaces that enhance thermal efficiency while saving fuel and processing time. The triple-pan furnace,

Traditional vertical crusher

Traditional method of jaggery concentration using single pan

Jaggery round blocks

Traditional (one pan) method

in particular, utilizes the waste heat from the lower pans to preheat juice in the upper pans.

The jaggery making process in a three-pan system is continuous, and typically required 3-4 skilled workers. Sugarcane juice is filled into all three pans, with fuel combustion occurs beneath the bottom pan. The temperature is highest at the bottom pan and gradually decreases upward, facilitating effective heat transfer through convection and radiation. During processing, scum is removed continuously from the first two pans. As the juice in the bottom pan thickens and solidify into jaggery, the preheated juice from the middle pan moves downward, and the fresh juice enters to the top pan. This continuous process ensures controlled process, uniform evaporation, thermal efficiency and high-quality jaggery.

In addition to it, Jaggery is traditionally sold in large quantity and bulk packing is done in wooden boxes or cardboard boxes, which increase the risk of quality deterioration of jaggery due to moisture variation that lead to microbial attack. To address this issue, ICAR-CIPHET, recommended a packaging of jaggery in polythene bags or PET jars to ensure the longer shelf life of product which significantly preserve colour, texture and taste of the jaggery.

Modern (Three pan) method

The moulding of jaggery by silicon mould enables the farmers to prepare uniform sized jaggery cubes or candy shapes rather than irregular or round shapes. The uniformity in shape of the final jaggery cubes enhances the marketability, ease of handling, packaging convenience and consumer appeal, which improves the farmers income by 30%.

Establishment and impact of the chemical free jaggery processing plant by ICAR-CIPHET

Several key activities were undertaken during the establishment of the chemical-free jaggery production unit under ICAR-CIPHET.

Equipment installation: Equipment such as sugarcane crusher, collection tank, jaggery moulding frame, mould frame tray, and an open pan heating set were procured.

Table 1. Equipments for the establishment of the jaggery processing unit

Equipment	Application
Sugarcane crusher	Extract juice from harvested sugarcane
An open pan heating set up	Provide controlled heating for boiling of juice to concentrate
Collection tank	Collect and store juice temporarily before further processing
Jaggery mould frame	Shapes concentrated jaggery syrup into uniform blocks or cubes
Mould frame tray	Support moulds and ensure proper shaping and cooling of jaggery
Refractometer	Measure total soluble solids

Technology dissemination and farmer training: The unit was handed over to farmers in Rahon, Nawanshahr. A sugarcane crusher and a three-pan heating system was installed. The participating farmers in the jaggery production plant were registered with FSSAI under the guidance of Farmer FIRST Programme team of ICAR-CIPHET.

Processing: The efficient crushing and concentration process enabled the plant to produce high-quality value added jaggery, both granular and solid. The organic clarificants, that is, okra mucilage, was used to clarify the juice.

***Moulding and packaging*:** Silicon moulds were provided to the farmers for production of cubical/candy shaped jaggery, which enhance marketability and consumer appeal of jaggery.

Profits and market value: The farmers sold their jaggery at attractive prices and earned profits. The solid and granular jaggery were sold at ₹ 100/kg and ₹ 120 /kg, respectively. In 2019, the farmers processed 300 quintals of solid jaggery and 100 quintals of granular jaggery, earning a profit of ₹5.5 lakh from the unit. Selling jaggery in addition to sugarcane helped the farmers increase their income by 30%.

Employment opportunities: This project created employment opportunities for local farmers and inspired other sugarcane farmers. Many farmers visited the unit and showed strong interest in establishment of their own chemical free jaggery production unit.

FSSAI registration certificate issued for the farmer of Farm Nation, Uppal Farm, Rahon, Nawanshahr

Installation of sugarcane crusher at Rahon, Nawanshahr

Installation of 3 pan heating system for sugarcane juice heating

Moulding of jaggery (candy/cubes) using silicon mould

Success Story: FFP intervention

Intervention: Establishment of modern chemical free jaggery production unit at Uppal Farm, Bharta Khurd, Rahon, SBS Nagar

Name : Shri Sohan Singh Uppal
Age : 50 years
Education : Graduate
Address : Uppal Farm, Rohan, SBS Nagar

Rationale of the intervention: Shri Sohan Singh Uppal, a farmer from Bharta Khurd, Rahon, SBS Nagar, Punjab, cultivates about 200 acres of land with crops mainly paddy, wheat, sugarcane, maize, and potato, in which sugarcane is cultivated on 60–70 acres of lands. Earlier, he sold sugarcane to nearby sugarcane mills and also produced jaggery for household use, by employing traditional method. The sugarcane growing farmers in the region were facing significant challenges due to delayed payment and inappropriate price of produce, from the mills. The price given by the mills could not cover cultivation cost. During field visit of FFP staff, the issues faced by the farmers were observed and FFP team advised the sugarcane growing farmers to start sugarcane processing at farm level instead of direct selling of sugarcane to the mills. Sri Uppal was motivated and guided to start his own jaggery processing plant using modern, energy efficient and chemical free technology. Under the guidance of ICAR-CIPHET, the training and practical exposure was provided to group of farmers to process sugarcane for the production of solid and granular jaggery. With the guidance of ICAR-CIPHET, Ludhiana, a chemical free jaggery unit was successfully established at Uppal Farm, Rahon, SBS Nagar under the Farmers FIRST Programme.

This jaggery processing unit is a semi-automatic plant, uses three-pan system to concentrate the juice. The unit setup includes a sugarcane crusher with a capacity of 1tonne/h), juice collection tank of capacity of 750 L, three open juice concentration pans, jaggery moulding frames, trays, etc. Using these frames, the concentrated jaggery can be moulded into unifrom cubical shapes (1″ × 1″ × 1″), which enhanced its market value. The higher crushing capacity of crusher and three pan setup ensures the higher processing and production efficiency of jaggery.

Outcome: The intervention helped the group of farmers to produce large quantity of solid and granular jaggery under hygienic conditions, at farm level. The uniform shape of jaggery improved selling price and consumer acceptance of jaggery in the market and thus, helped to earn good profits. This initiative also created a lot of employment opportunities. Processing and marketing of the jaggery in addition to sugarcane sale, increase the income of the farmers by nearly 30%. Successful operation of the setup also attracted 40–50 sugarcane farmers. They visited the plant and showed keen interest in the jaggery unit setup. Currently, Sri Uppal is producing solid and granular jaggery with a brand name "Farm Nation" and selling it in retail wholesale market. According to Shri Sohan Singh Uppal, if more farmers adopt this modern chemical free jaggery production method then they can significantly enhance their profitability in sugarcane farming.

Table 1. Economic analysis of jaggery processing unit

Capacity	55 q/day
Principal component cost (crusher, moulding frame, sieves, boiling pans, etc) (in lakhs)	9.75 L
Monetary benefits per annum (5-6 months) (₹in lakhs)	36.71 L
Saving over sugar cane selling (in lakhs)	17.96 L
Profit per ha (in lakhs)	3.06 L
Value addition (%)	204
Employment (Mandays)	15
Benefits-Cost ratio	1.6

SUMMARY

The traditional method uses one-pan system and chemical clarificants that affect the quality of product and human health. On the other hand, the modern method, chemical-free jaggery production process/developed by ICAR-CIPHET, Ludhiana under the Farmer FIRST Programme has significantly improved the quality, safety and market value of jaggery. The key features of chemical free Jaggery processing units are as follow:

- Adoption of three-pan system, is energy-efficient, ensure uniform heating and processing of jaggery, and it has optimal utilization of energy.
- Horizontal crusher increased the efficiency of juice extraction by 4–5% more juice than vertical crusher, which ultimately increases the finished product recovery. The reduced moisture content of bagasse inhances its improved burning efficiency thereby minimizing environment at pollution.
- Introduction of silicon mould to the farmer, enabled them to produce jaggery with uniform size and shape (Cube/ Candy), which improves the appearance, packaging convenience and market value (25–30% higher) of jaggery than the traditional round blocks. Diverse mould design are available to prepare jaggery cubes of different sizes (5–25 g) and shapes that helps to create market value.
- Adaptability of hygienic packaging material such a polythene pouches or PET jars, protected the jaggery from insect and moisture exchange, that could extend the shelf life of the jaggery upto one year.

Overall, the scientific intervention of ICAR-CIPHET empowered farmers through trainings and technical guidance, leading to an improvement in the value-addition of sugarcane to jaggery by 200%, contributing to high market demand, employment opportunities, and reduction in post-harvest losses for sugarcane farmers.

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Effective utilization of harvested water:

Natural resource management initiatives under Farmer FIRST Programme

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Efficient management of water resources is critical for sustainable agriculture, especially in semi-arid and rainfed regions. Under the Farmer FIRST Programme, several interventions were implemented to enhance water harvesting and its optimal utilization. These interventions included construction of farm ponds, installation of drip irrigation systems and rain guns, renovation of existing check dams, and demonstration of conservation furrows. This article highlights the effectiveness of these interventions in improving water availability, enhancing crop productivity, and reducing input costs for farmers.

Keywords: Check dam, Conservation furrow, Drip irrigation, Farm pond, Sustainable agriculture, Water harvesting

WATER scarcity and inefficient utilization of available water resources are major challenge in agriculture. With unpredictable rainfall pattern and depleting groundwater, efficient water management has become crucial for sustaining agriculture. Harvesting rainwater and ensuring its optimal use can significantly improve crop yields and reduce dependency on erratic rainfall. Under the Farmer FIRST Programme (FFP) of ICAR-CRIDA, a series of interventions were implemented like development of farm ponds, installation of drip irrigation and rain guns, community check dam renovation, and conservation furrows under the soil and water conservation module to help farmers make the most of harvested water in adopted villages. These interventions helped farmers in the adopted villages to harvest and utilize water effectively, boosting productivity and income.

Interventions under FFP for effective water utilization

Farm ponds for harvesting rain water: Farm pond is a small water storage structure that collects and stores rainwater or surface runoff for irrigation during dry period. Under the FFP, two farm ponds were constructed in Devinoniguda and Rakamcharla villages. Each pond has a storage capacity of about 38.52 m^3, providing protective irrigation for nearly one acre of farmland. Before these ponds were built, farmers often faced moisture stress, leading to poor yields. Now, they are able to grow vegetable crops like cabbage, cauliflower, and okra even when rainfall is insufficient. The ponds ensured water availability at critical crop stages, reducing crop loss and improving productivity.

The results have been remarkable, farmers recorded around 25% higher yields compared to earlier seasons. The technology has also brought visible improvements in livelihoods through higher income and better resource use efficiency.

Farm pond in Devinoniguda village

Table 1. Cropping pattern, yields, and income before and after pond intervention

Season	Crop	Area (acre)	Yield (q/ acre)	COC/ acre	Price (₹/q)	Gross returns (₹)	Net returns (₹)
Cropping pattern and returns before pond							
Kharif	Maize	4	16	21,500	2,180	34,880	13,380
Kharif	Redgram	3	4	1,8500	7,300	29,200	11,000
Rabi	Maize	4	18	24,000	2,240	40,320	16,320
Cropping pattern and returns after farm pond							
Kharif	Redgram	4	5	19,800	8,400	42,000	22,200
Kharif	Cotton	3	7	23,600	6,900	48,300	24,700
Rabi	Bhendi	0.5	60	40,000	2,000	120,000	80,000
Rabi	Peas	0.5	30	37,000	3,000	90,000	53,000

Table 2. Economic returns on farm ponds

Adopted Villages	Number of Ponds	Storage Capacity (m^3)	Area Benefited (acre)	Yield Increase (%)	Average Net Returns (₹/pond)	Benefit–Cost Ratio
Devinoniguda, Rakamcharla	2	38.52	1 per pond	25	25-000–30,000	2.38

Efficient utilization of water using drip irrigation and rain guns: Under project, efficient irrigation practices were promoted through the installation of micro-irrigation systems such as drip irrigation and rain guns. These systems were aimed at improving water-use efficiency, ensuring uniform irrigation, and enhancing productivity in high-value crops like cabbage, chilli and tomato.

A total of 21 drip and rain gun systems were installed in Gangupally, Devinoniguda, Pudugurthy, Medikonda, and Rakamcherla villages, covering an area of about 21 acres. These interventions significantly improved water-use efficiency by nearly 30% along with reduced labour and resulted in an average yield increase of 30–40%. Farmers observed that they could easily manage irrigation during prolonged dry spells, leading to healthier crops, reduced stress, and improved fruit quality.

The economic analysis revealed a net return of ₹75,000/acre, with a benefit-cost ratio of 2.5:1, highlighting the profitability of adopting such technologies. Farmers also reported reduced labour and time in irrigation activities, ensuring timely water supply and sustainable resource utilization.

Tomato cultivation with drip irrigation

Brinjal cultivation under drip + Mulching

Table 3. Economic returns from micro irrigation systems

Villages Covered	No. of Systems installed	Area Covered (acres)	Crops Covered	Avg. Water-use Efficiency (%)	Avg. Yield Increase (%)	Avg. Net Returns (₹)	Benefit–Cost Ratio
Gangupally, Devinoniguda Rakamcharla, Medikonda	21 (Drip and Rain Guns)	21	Chilli, Tomato, Cabbage, Cauliflower	30	30–40	75,000	2.5:1

Renovation of community check dam in adopted village: In one of the adopted villages in Gangupally, the community check dam was renovated to restore its full capacity. The renovation included strengthening the sidewalls, desilting the water storage area, and repairing leakage points. These efforts helped the structure hold more water and improved its durability for long-term use.

After the renovation of the check dam, there was a noticeable increase in groundwater levels by about 1.5–2.5 m in nearby wells. The improved structure now holds enough water to irrigate nearly 30 acres of farmland, directly benefiting around 20 farming families in the village. The stored water seeps into the ground, recharging nearby open wells and borewells. This has ensured a steady water supply throughout the year for farming, livestock, and household needs. With the assured water availability, farmers have started cultivating a second crop during the *rabi* season and shifted towards high-value crops like vegetables, which has improved their income and overall livelihood.

Renovated check dam in Gangupally village

Table 4. Impact of renovation of community check dam

Adopted Village	No. of Bene-ficiary Farmers	Area Irrigated (acres)	Avg. Increase in ground water levels (m)	Key Benefits	Impact on Cropping Pattern
Gangupally	20	30	1.5–2.5	Improved water storage, groundwater recharge, livestock and domestic use	Enabled second crop and vegetable cultivation

In situ *moisture conservation practices in adopted villages:* In the adopted villages of Vikarabad district, demonstrated the simple yet effective technique of conservation furrows as an *in situ* moisture conservation practice. After the usual field preparation and first weeding (around 30 days after sowing), made furrows between two crop rows at 3 m intervals using a traditional bullock-drawn plough. These furrows played a key role during low rainfall, they captured and stored rainwater, and during heavy rains, they drained out excess water. This helped maintain ideal soil moisture conditions and protected the crop during its crucial growth and grain-setting stages.

In situ moisture conservation practices were demonstrated across 315 acres by 250 farmers. The practice increased the average pigeon pea yield from 10 q/ha to 12.75 q/ha, a 27.5% improvement, even in years with below-normal rainfall. Farmers reported that their fields retained more moisture, crops looked healthier during dry periods, and overall productivity improved significantly. This low-cost and farmer-friendly practice has become a widely accepted method to enhance yield, conserve soil moisture, and reduce the risks associated with climate variability.

Conservation furrows in pigeonpea crop

Table 5. Overall benefits accrued to farmers with conservation furrows

District	No. of Farmers	Area Covered (acres)	Crop	Avg. Yield (q/ha)	Avg.Yield Increase (%)	Avg. Net Returns (₹)	Benefit–Cost Ratio
Vikarabad	250	315	Pigeon pea	12.75	27.5	45,175	1:0.85

Overall outcomes

The combined interventions of farm ponds, drip irrigation and rain guns, check dam renovation, and conservation furrows brought significant positive changes for farmers. Farm ponds provided protective irrigation during dry periods, allowing the cultivation of winter and high-value vegetables, improving both yields and income. Drip irrigation and portable rain guns helped farmers use water efficiently, ensuring crops received adequate moisture during dry spells and improving crop quality. The renovation of community check dams restored water storage, enhanced groundwater recharge, and made water available not only for agriculture but also for livestock and domestic purposes. Conservation furrows helped retain rainwater in the fields, protecting crops from intermittent dry periods and maintaining soil moisture for better growth. Together, these interventions increased crop productivity, allowed off-season vegetable cultivation, improved water management, and strengthened community participation. Farmers reported more reliable irrigation, reduced dependence on unpredictable rainfall, healthier crops, and better livelihoods, showing that a combination of simple, cost-effective water harvesting practices can transform farming systems and build climate resilience in rainfed areas

SUMMARY

The Farmer FIRST Programme successfully demonstrated that intervention-specific water management from farm ponds to drip irrigation, check dam renovation, and conservation furrows can transform rainfed drylands into productive, resilient farms. Each intervention complements the other, turning harvested water into a resource that sustains livelihoods, enhances crop production, and restores environmental balance.

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Enhancing farm productivity and profitability

with Farmer FIRST Programme, focus at Khordha district of Odisha

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The Farmer FIRST Programme (FFP) implemented by Odisha University of Agriculture and Technology (OUAT) in six villages of Khordha district has significantly enhanced agricultural productivity, profitability, and socio-economic conditions of farmers. The programme adopted an integrated module approach involving field crops, horticulture, livestock, enterprises, and resource-based activities. Interventions included replacement of traditional paddy varieties with high-yielding ones, off-season vegetable cultivation, improved livestock management, and promotion of mushroom and small-scale enterprises. These efforts led to yield increases of 23–87% in paddy and 33–116% in vegetables, and income gains ranging from 70–467%. Dairy, goatery, and backyard poultry modules recorded substantial improvements in productivity and profitability. The project also empowered women through resource-based enterprises like dal and flour mills, enhancing their income sources. Socio-economic impact analysis revealed marked improvements in farmers' participation, contact with extension agencies, decision-making ability, and social security. Case studies demonstrated income enhancement up to 215%, showcasing the success of FFP interventions in transforming smallholder livelihoods and promoting sustainable, inclusive growth in the region.

Keywords: High-yielding varieties, Livestock management, Mushroom cultivation, Odisha agriculture, Off-season vegetables, Socio-economic impact, Women empowerment

AGRICULTURE in Odisha, particularly in the coastal districts like Khordha, is characterized by small and fragmented holdings, traditional crop management practices, and limited adoption of modern technologies. To bridge the gap between research and field realities, the Farmer FIRST Programme (FFP)—an innovative initiative of the Indian Council of Agricultural Research (ICAR), implemented through Odisha University of Agriculture and Technology (OUAT) aims to strengthen farmer–scientist partnerships and promote need-based, location-specific technologies. The programme emphasizes enhancing farm productivity, profitability, and sustainability by integrating field crops, horticulture, livestock, and small-scale enterprises. In Khordha district, interventions under FFP have successfully transformed the livelihood of rural farmers through technological empowerment, diversification of farming systems, and development of rural enterprises, leading to measurable improvements in income and socio-economic well-being.

The district of Khordha comes under east and south eastern coastal plain agro-climatic zone with several farming situations. The selected villages under the 'Farmer FIRST' programme were Govindapur, Gopalpur, Brahmapura, Brahmapurapatna, Lokipur, and Brahmapura II in Begunia Block of the district.

Modules undertaken and technical interventions

- ***Crop based:*** Replacing old and local paddy varieties with high yielding new varieties and capacity building on INM, IWM and IPM.
- ***Horticulture based:*** Off-season cultivation of hybrid pumpkin and hybrid cucumber with seedlings raised in pro-tray under poly house, capacity building on scientific management practices of cultivation of hybrid papaya and cucumber, introduction of cultivation of pointed gourd in trellis as an intercrop with papaya.
- ***Livestock based:*** Promotion of cross bred cow and goat through scientific practices of rearing and management.
- ***Enterprise based:*** Installation of spawn production unit and training to 6-8 farmers on spawn production in each village, capacity building on production,

processing, value addition and preservation of paddy straw and oyster mushrooms, rearing backyard poultry for egg and meat.

- ***Resource based:*** Providing an option for unemployed mass of village women to earn their own income source through dal mill and flour mill.

Outcomes of the project

FFP was implemented since October 2016 in four villages (Govindapur, Gopalpur, Brahmapura, and Brahmapurapatna) provided better opportunities for farmers to enhance their farm productivity and profitability through farmer-scientist interactions and capacity building on improved methods of crop cultivation and scientific rearing and management of livestock. After successful implementation of the programme in these four villages, the activities were subsequently extended to two more villages (Lokipur and Brahmapura II) from the year 2022–23.

The substitution of traditional paddy varieties with high-yielding varieties (HYVs) such as Swarna Sub-1, Hasant, Sarala, Kalajeera, Kalachampa, and Gitanjali enhanced productivity by 23–87% and increased farmers' net income by 70–207%.

Off-season (September/February) cultivation of hybrid pumpkin (Vimal Tokita) and cucumber (Annapurna Rajmata), with seedlings raised in pro-trays under polyhouses, increased productivity by 33–116% and 40–66%, and profitability by 75–467% and 277–432%, respectively. The introduction of commercial cultivation of hybrid papaya 'Red Lady 782' in place of local papaya in kitchen gardens and nearby homestead lands resulted in a 46–235% improvement in fruit yield and a 61–460% increase in income. Furthermore, when pointed gourd was grown in the inter-row spaces of papaya under a trellis system, productivity and profitability were further enhanced by 82–97% and 186–259%, respectively, over the sole hybrid papaya crop.

Capacity building on the scientific rearing and management of large animals such as cows and small ruminants like goats in the adopted villages, along with regular advice on artificial insemination, vaccination, deworming, and proper nutrition with suitable mineral mixtures, yielded positive results. Support to livestock farmers with medicines, vitamins, and mineral mixtures proved beneficial. Following the interventions, milk yield increased by about 200% (from 2–3 L to 5–6 L/animal), with a corresponding 241% enhancement in income (₹1,490 to ₹5,090 per month). In goatery, the introduction of superior Ganjam breed bucks into existing flocks reduced mortality from 20% to 4%, and meat weight per animal at marketable age (18 months) increased from 5 kg to 7 kg, leading to an 83% rise in income. Encouragement of backyard poultry with suitable breeds such as Vanaraja, Palishree, and Kadaknath enhanced profitability by 175%, with body weight increasing from 1.2 kg to 2–2.5 kg per bird at the 4–6 month stage.

Under the enterprise-based module, capacity building on mushroom spawn production using low-cost technology such as polypropylene (PP) bags and paddy seeds instead of glass bottles and wheat reduced the cost of spawn production by ₹3 bag. Spawn quantity increased by 15% using PP bags. About 14 progressive farmers were trained in this technology, and 20 farmers received training on value addition of oyster mushrooms (drying and powder making).

Under the resource-based module, one self-help group (SHG), Omm Shiva Shankar, was empowered with the supply of a dal mill and a flour mill, ensuring a net income of ₹ 35,000–50,000 and ₹ 23,000–27,000, respectively.

Expansion of technology

Looking at the success of the technological interventions under the project, non-adopted farmers from the same as well as nearby villages showed keen interest in adopting these improved technologies. Considering the growing enthusiasm and demand among farmers, the technologies were continuously upscaled to cover a larger number of households. As a result, a remarkable expansion in the outreach and adoption of all technological interventions was observed during the project period.

Table 1. Up-scaling and out-scaling of the relevant technologies with intervention of the project

Particulars	Up-scaling with intervention of the project (number of households)		Out-scaling with horizontal expansion (number of households)
	2021–22	2024–25	2024–25
Crop (paddy)	250 (60 ha)	350 (140 ha)	420 (168 ha)
Pumpkin	43 (4.5 ha)	100 (9 ha)	215 (22 ha)
Cucumber	46 (4.2 ha)	90 (8 ha)	115 (13 ha)
Dairy	50 (100 ha)	200 (250 animals)	235 (285 animals)
Goatery	10 (12 animals)	55 (486 animals)	65 (639 animals)
Mushroom	20	120	135
Backyard poultry	30 (1,800 birds)	350 (4,800 Birds)	420 (6,150 birds)

Impacts of the project on socio-economic aspects

The detailed socio-economic impact study of the project in the adopted villages clearly indicated significant improvement in farmers' social perception, participation, and sense of security. The timely availability of quality seeds, adoption of new production technologies, irrigation at critical crop stages, and appropriate nutrient and plant protection management, supported by the continuous technical guidance of the OUAT team, made these outcomes possible. The beneficiaries' keen interest, perseverance, and hard work in effectively utilizing their land and labour for improved production practices brought notable changes in their livelihood conditions.

The villagers gained self-confidence in scientific paddy cultivation and livestock rearing, while the better utilization of paddy straw for mushroom cultivation contributed to additional farm income. The project also facilitated horizontal expansion of technologies through the provision of critical inputs and experience sharing among farmers, leading to overall improvement in their socio-economic status. Furthermore, many farmers earned social recognition within their communities and emerged as role models, inspiring others to adopt similar scientific and profitable farming practices.

Table 2. Impacts of the project on socio-economic aspects of the farmers

A) Social impact	
Variables	Percentage change (%)
Participation in different extension activities	34
Contact with extension agents (agriculture/horticulture officers, input dealers, KVK and OUAT scientists)	42
Mass media contact	23
Social participation	30
Contact with financial institution	22
Decision making ability	34
Social security	46
B) Economic impact	
Variables	Change
Annual income	20–25% (increased)
Savings	Increased
Expenditure pattern	Modified (increased)
Debt	25–30% (decreased)
No. of earning members	Average 2 members per family (increased)

Case studies on DFI after interventions of Farmers FIRST Programme

Case study 1: Before the intervention of the FFP, Shri Harihar Pradhan of Gopalpur village earned an average annual profit of only ₹50,800 from the sale of farm produce from his 1.48 ha of land (2016–17). The low crop yield was analyzed in consultation with scientists under the FFP, and several remedial measures were introduced, such as the use of good-quality seeds (HYVs/hybrids), line transplanting, and nutrient management based on soil test-based fertilizer recommendations and leaf colour charts. Off-season cultivation of vegetables and proper grading of harvested fruits helped him fetch better market prices. In addition, capacity-building programmes on scientific crop management, along with demonstrations and exposure visits, were conducted. By the end of 2024–25, his annual net income had increased to ₹2,16,400—an improvement of more than 200% over the baseline income. In recognition of his achievements, Shri Harihar Pradhan was awarded by OUAT and the Department of Agriculture and Farmers' Welfare, Government of Odisha, as a progressive farmer.

Case study 2: Before the intervention of the Farmers FIRST Programme (FFP), Shri Subash Behera of Brahmapura-II village earned an annual profit of ₹40,000 from the sale of produce from his 1.12 ha of land (2022–23). With the introduction of scientific crop and livestock management practices under FFP, along with the inclusion of new crops such as cucumber,

Table 3. Increase in the income of Shri Harihar Pradhan through the FFP interventions

Components	Area (ha)	Production (t)	Gross income (₹)	Net income (₹)	Percent increase due to intervention	
					Production	Income
Paddy	0.80	3.60	79,200	30,000	38	71
Cucumber	0.20	5.00	75,000	45,000	Introduced	
Brinjal	0.04	1.00	20,000	10,000	20	11
Tomato	0.10	2.50	30,000	20,000	25	100
Okra	0.04	0.60	12,000	7,000	20	134
Bitter gourd	0.10	1.60	40,000	25,000	33	21
Pumpkin	0.20	5.00	40,000	20,000	42	67
Papaya	0.10	9.30	1,11,600	59,400	Introduced	
Total	1.58		4,07,800	2,16,400		213

Table 4. Increase in the income of Shri Subash Behera through the FFP interventions

Components	Area (ha)	Production	Gross income (₹)	Net income (₹)	% increase due to intervention	
					Production	Income
Paddy	0.80	3.50 t	77,000	27,800	25	44
Brinjal	0.04	1.00 t	20,000	10,000	25	43
Tomato	0.10	2.50 t	30,000	20,000	36	60
Okra	0.04	0.64 t	12,800	7,800	32	55
Cucumber	0.04	0.88 t	17,600	11,600	Introduced	
Bitter gourd	0.10	1.50 t	37,500	22,500		
Poultry (Kadaknath)	30	3,000 no. eggs	30,000	18,000	200	350
Paddy straw mushroom	500 beds	350 kg	52,500	32,500	Introduced	
Total			2,77,400	1,50,200		218

Crop based module


Horticulture based module


Vegetable based module


Off-season cultivation based module


Horticulture based module


Livestock based module


Goat based module


Poultry based module


Enterprise based module

bitter gourd, and paddy straw mushroom, his farming system became more diversified and profitable. By the end of 2024–25, his annual net income had increased to ₹1,50,200—an impressive rise of about 215% over his previous income.

SUMMARY

The Farmer FIRST Programme (FFP) implemented by Odisha University of Agriculture and Technology (OUAT) in six villages of Khordha district has significantly improved farm productivity, profitability, and livelihoods. Using an integrated approach combining field crops, horticulture, livestock, enterprises, and women-led resource activities, the project introduced high-yielding paddy and hybrid vegetables, improved livestock management, and promoted mushroom cultivation and rural enterprises. Paddy and vegetable yields rose by 23–116%, while incomes increased by 70–467%. Livestock modules recorded up to 200% rise in milk yield and 83% gain in goat meat yield. Women earned additional income through dal and flour mills. Socio-economic analysis revealed higher participation in extension activities, improved decision-making, and greater financial security. Case studies showed over 200% income growth, demonstrating the success of FFP interventions in transforming smallholder farming into a more productive, profitable, and sustainable system, fostering inclusive rural development in Khordha district.

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Transformative grassroot innovations for sustainable hill agriculture

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The Farmer FIRST Programme, implemented in the ICAR Research Complex for NEH Region, Umiam, Meghalaya, has significantly advanced sustainable and inclusive agricultural development in the north eastern hill region of India. Through participatory and location-specific interventions, the programme has promoted both grassroot innovations and transformative technologies that utilize locally available resources to enhance productivity, resilience, and rural livelihoods. Notable grassroots innovations include the use of banana pseudo-stems to protect transplanted seedlings from intense sunlight and rainfall, and the utilization of bamboo for constructing low-cost poultry baskets, feeders, irrigation conduits, and aeration systems for fishponds, demonstrating effective integration of Indigenous Technical Knowledge (ITK) with scientific practices. Complementing these, transformative interventions such as second cropping in rice fallows, rabi *maize cultivation, orchard establishment, backyard poultry and pig farming, oyster mushroom cultivation, scientific beekeeping, rainwater harvesting, integrated farming systems (IFS), composite fish culture, and farm mechanization through custom hiring centres have enhanced farm productivity, income generation, and resource-use efficiency. Collectively, these efforts have transformed traditional hill farming into a diversified, market-oriented, and environmentally sustainable system, underscoring the vital role of the Farmer FIRST Programme in fostering innovation-driven, climate-resilient, and economically viable rural prosperity in Meghalaya and the broader north eastern region.*

Keywords: Farmer FIRST Programme, Hill agriculture, Indigenous technical knowledge, Integrated farming systems

THE north eastern region of India, characterized by hilly terrain, high rainfall, and rich biodiversity, offers unique opportunities for developing sustainable agricultural models suited to fragile ecosystems. However, the region's farmers continue to face multiple constraints such as limited cultivable land, soil erosion, poor mechanization, and low productivity. The rice-based farming system prevalent in Meghalaya often leaves vast stretches of land fallow after harvest, leading to underutilization of resources and reduced farm income.

To address these challenges, the Farmer FIRST Programme (FFP), implemented by the ICAR Research Complex for NEH Region, Umiam, Meghalaya, promotes farmer-centric, participatory, and resource-efficient innovations that combine modern agricultural technologies with Indigenous Technical Knowledge (ITK). The programme focuses on enhancing productivity, diversifying income, and ensuring ecological balance through location-specific interventions. In the Marngar cluster and Mawsiatkhnam villages, farmers adopted a range of grassroot innovations and transformative technologies. The integration of indigenous creativity with scientific technologies under the FFP demonstrates a powerful model for inclusive, climate-resilient, and sustainable hill agriculture, setting a benchmark for rural transformation in the north-eastern region.

Grassroot innovative technologies

Grassroot innovations involve practical, locally developed solutions that address specific challenges in agriculture and rural livelihoods. The north-eastern region of India, with its rich natural resources and diverse agro-ecological conditions, offers ample opportunities to harness indigenous knowledge for sustainable farming. The Farmer FIRST Programme (FFP) encourages farmers to experiment with innovative techniques to enhance productivity, reduce costs, and improve resource efficiency. The documented innovative practices in Marngar cluster villages, Meghalaya, focus on the use of banana pseudo-stems and bamboo for agriculture, poultry, aquaculture, and irrigation.

Banana pseudo-stem for protecting seedlings against sunlight: Under FFP, an innovative practice was introduced in the Marngar cluster villages to enhance the survival and growth of transplanted seedlings. The t echnique involves placing banana pseudo-stems around newly transplanted seedlings to shield them from direct sunlight and heavy rainfall. This simple and eco-friendly method helps minimize heat stress, conserve soil moisture, and protect young plants from harsh weather conditions. As the banana stem decomposes, it enriches the soil with organic matter, thereby improving fertility. The intervention has demonstrated how locally available resources can be effectively utilized for sustainable and climate-resilient crop production, aligning traditional wisdom with modern agricultural initiatives under FFP.

Protection of seedings with banana pseudo-stem

Bamboo for making baskets: In the north eastern region of India, where bamboo is exceptionally abundant, accounting for a significant share of India's bamboo area and production, using bamboo baskets for poultry egg laying and also as low-cost poultry feeders is a prime example. These practices leverage the region's rich bamboo resources to provide affordable, locally crafted solutions for poultry management, supporting rural livelihoods and reducing dependence on external inputs. The widespread availability and adaptability of bamboo empower communities to create stundy, biodegradable nesting baskets and durable feeders that fit local poultry rearing systems, reflecting both environmental sustainability and cultural continuity in the region.

Bamboo based feeder for poutlry

Bamboo basket for nesting

Bamboo-based aeration for fishponds: Shri Gumbir Syiem, an innovative farmer from Margnar village, addressed the challenge of insufficient aeration in his fishponds by developing a low-cost, environment-friendly aeration system using locally available bamboo. Instead of using expensive PVC pipes or motorized aerators, he utilized a rare indigenous bamboo species known locally as 'doluba,' which is long (about 42 feet) and durable. Each bamboo, costing about ₹100, can cover up to three-fourths of a pond, making this method highly cost-effective. The bamboo aerator harnesses water from a nearby stream, ensuring adequate oxygen supply for fish and improving water quality. This solution not only reduces operational costs but also avoids environmental harm associated with plastic and electric alternatives, demonstrating how traditional, sustainable resources can address modern aquaculture needs efficiently.

Bamboo for irrigation of vegetables: Bamboo can be effectively used instead of PVC pipes for irrigating vegetables. In many regions, especially where bamboo is abundant, farmers use hollow bamboo stems to transport water directly to their crops. This method is both cost-effective and environmentally friendly, providing a sustainable alternative to plastic pipes.

Bamboo based aeration system in fish ponds

Using bamboo for irrigation takes advantage of natural resources and helps ensure a steady supply of water to vegetable fields.

Bamboo irrigation channel

Transformative technologies

Hill farmers in the north-eastern region of India often face constraints such as limited cultivable land, low productivity, and inadequate access to modern agricultural technologies. The rice-based farming system prevalent in Meghalaya leaves substantial post-harvest fallow areas that remain underutilized, resulting in reduced farm income and livelihood vulnerability. The Farmer FIRST Programme (FFP), implemented in ICAR-RC NEH Region, Umiam, aims to address these challenges by promoting participatory, location-specific interventions that combine modern agricultural innovations with locally available resources and Indigenous Technical Knowledge (ITK). By leveraging both scientific and traditional practices, the FFP initiative provides a sustainable pathway for improving rural livelihoods, promoting resource-efficient farming, and enabling market-oriented agriculture in the hilly terrains of Meghalaya.

Enhancing productivity through* rabi *vegetable cultivation in rice fallow lands: To utilize fallow land after paddy harvest, trainings-cum-demonstrations on scientific *rabi* vegetable cultivation were conducted in Marngar cluster and Mawsiatkhnam village. Training focused on improved practices like variety selection, sowing time, nursery management, mulching, irrigation, and use of banana pseudostem and bamboo for seedling protection and irrigation. Quality seeds were distributed to 147 farmer. Thirteen growers cultivated vegetables over 31.1-acre, broccoli covered 12.7 acre (yield: 21.1 tonnes), followed by capsicum (5.3 acre) and cabbage (3.6 acre). Net income was highest in broccoli (₹3.8 lakh), capsicum (₹2.3 lakh), and peas (₹0.4 lakh), with benefit-cost ratios of 1.8 and 1.6 in broccoli and peas, respectively.

Intervention of* rabi *maize variety in paddy fallow: To utilize unproductive paddy fallow, *rabi* maize cultivation was introduced for the first time in Lalumpam, Borgang, Borkhatsari, and Purangang villages through demonstrations held on 2 and 12 November, and 10 and 23 December 2021. Quality seeds (120 g/packet) of maize varieties RCM1-76 and RCM1-61 were distributed to 30 farmers (21 with RCM1-76, 9 with RCM1-61). Technical guidance on cultivation and land management was provided. Field monitoring on 09th February 2022 showed slow growth but good vegetative performance, with crops at cob formation stage.

Establishment of orchard of fruit, spices and plantation crops: To enhance long-term farm income, orchards of fruit, spice, and plantation crops were established covering Khasi mandarin (0.60 ha, 250 trees), Guava (0.85 ha, 350 trees), Assam lemon (0.70 ha, 200 plants), Arecanut (3.00 ha, 900 plants), and Black pepper (0.70 ha, 200 plants). Currently, 40 Khasi mandarin trees yield 1.8 kg/plant, 60 guava trees yield 1.4 kg/plant, and Assam lemon plants bear 10–20 fruits each, while arecanut and Black pepper remain in the vegetative stage.

Backyard poultry farming: Improved backyard poultry and pig farming (33 Hampshire crossbred pigs to 33 farmers) were introduced to enhance rural livelihoods. Poultry income from 20 birds sold averaged ₹49,000 with a net profit of ₹21,800 (B:C-1.80). A pig breeding cluster of three farmers sold 38 piglets and 5 adult pigs, earning ₹2,54,300 with a B:C ratio of 1.74, including Shri Mrinal Sohkhwai's net profit of ₹33,700 from 10 piglets and 2 adults (B:C-1.76).

Development of pig breeding cluster in village: A pig breeding cluster using improved Hampshire crossbred pigs was established with three farmers Shri Mrinal Sohkhwai, Shri Dominick Syiem, and Shri Jiten Sohkhwai-who collectively sold 38 piglets and 5 adult pigs, earning ₹2,54,300 with a B:C ratio of 1.74. Individually, Shri Mrinal earned ₹33,700 (B:C-1.76), Jiten ₹48,650 (B:C-1.75), and Dominick ₹26,100 (B:C-1.71) as net profits from their sales. This cluster enhanced organized breeding and improved farmer incomes.

Oyster mushroom cultivation: The demonstrated technology involved the distribution of oyster mushroom spawn to various beneficiaries from adopted villages. A total of 100 spawn packets (weighing 40 kg) were distributed, resulting in a yield of 90 kg of fresh oyster mushrooms. These mushrooms were sold in local markets at a rate of ₹ 200–250/kg, generating a total income of ₹ 15,800. The cost of production was ₹ 6,320.00, leading to a net profit of ₹ 9,840 and a B:C- 2.5.

Scientific beekeeping: The demonstrated technology involved scientific beekeeping practiced by 8 farmers from adopted villages using 15 bee colonies received in previous year. A total of 53 L of honey was harvested, resulting in a net profit of ₹ 31,800.

***Construction of low cost rainwater harvesting structure,* Jalkund:** The demonstrated technology involved the construction of 35 low-cost rainwater harvesting structures *(jalkunds)* measuring 5 m × 4 m × 1.5 m each, built before the onset of the monsoon. The stored water is utilized for irrigating crops, cleaning livestock sheds, and fish rearing.

Establishment of integrated farming systems: In Nalapara village (1.6 ha), Shri Jiten Sohkhwai's IFS generated ₹7,21,500.00 income from fishery (2 ponds, 1000 m^2 each), crops (1 acre paddy, 0.8 acre vegetables), piggery (26 piglets born, 24 sold, 1 adult sold), dairy (8 adult cows sold), duckery (70 ducks received, 50 sold, 510 eggs sold), goatery (2 kids sold), and rabbitery (13 offspring). Expenditure was ₹3,16,850 net profit ₹4,04,650; B:C ratio 2.28.

In Joigang village (1.5 ha), Shri M. Raja's IFS earned ₹3,27,366.00 from fishery (0.75 acre angling), crops (2 acres paddy, 0.7 acre broccoli), poultry (80 birds, 30 sold, 12 trays eggs), piggery (7 adults, 3 sold, 8 piglets), duckery (107 ducks, 30 sold, 17 trays eggs), and goatery (10 goats, 2 males sold). Expenditure was ₹1,59,112.00; net profit ₹1,68,254.00; B:C of 2.06.

Composite fish culture: To address low farm income in the adopted villages, composite fish culture was demonstrated using *Rohu*, *Mrigal*, Grass carp, Common carp, Silver carp, and *catla.* Three beneficiaries achieved a total yield of 480 kg, sold at ₹ 250.00–300.00/kg, generating an income of ₹ 1,14,800.00 with a B:C of 3.1.

Farm mechanization through custom hiring centres: To reduce the cost of cultivation, a farm mechanization module was implemented through the establishment of three custom hiring centres at marngar cluster (2) and Mawsiatkhnam village (1). These Custom Hiring Centres are well equipped with modern farm machineries. Over 389 farmers registered and around 200 farmers utilized the implements, generating total revenue of ₹ 27,780 in 2021–22, which was used for maintenance and repair. Investment in new machinery is also planned.

SUMMARY

The Farmer FIRST Programme (FFP) implemented by ICAR Research Complex for NEH Region, Umiam, Meghalaya, has successfully demonstrated the convergence of grassroots innovations and modern agricultural technologies to enhance hill farmer livelihoods. Innovative, low-cost practices such as using banana pseudo-stems for seedling protection and bamboo-based systems for poultry housing, irrigation, and fishpond aeration effectively integrated indigenous technical knowledge with scientific approaches. Transformative technologies including *rabi* maize and vegetable cultivation, orchard establishment, livestock improvement, mushroom cultivation, beekeeping, integrated farming systems, and mechanization through custom hiring centres significantly improved productivity and income. Farmers like Shri Gumbir Syiem, Shri Jiten Sohkhwai, and others exemplify innovation-led transformation towards sustainable, diversified, and climate-resilient hill agriculture in Meghalaya.

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From fields to futures: Farmer FIRST

Programme transforming rural livelihoods through science and participation

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The Farmer FIRST Programme (FFP) of ICAR-IARI, New Delhi, has transformed farming communities in Palwal district, Haryana, through participatory technology application and multi-stakeholder convergence. Operating across four clusters—Amarpur, Dadhota, Katesra, and Kulena, the project integrates crop, horticulture, livestock, and enterprise-based interventions over 93.2 ha, benefiting more than 760 farm families. Demonstrations of improved wheat, paddy, and mungbean varieties enhanced productivity, profitability, and resource efficiency. Diversification through vegetables, floriculture, and nutrition-oriented kitchen gardens empowered women and improved household nutrition. Livestock health initiatives, protected cultivation, and mushroom enterprises further strengthened income resilience. Capacity-building activities and institutional convergence fostered farmer–scientist collaboration, entrepreneurship, and sustainable livelihoods. The initiative exemplifies how participatory science can drive rural transformation, blending innovation with inclusivity and environmental stewardship.

Keywords: Agripreneurship, Crop diversification, Farmer–scientist interface, Livelihood enhancement, Palwal, Participatory extension, Women empowerment

IN the heartlands of Palwal district, Haryana, a quiet revolution is taking place. Farmers who once depended solely on traditional practices are now turning into innovators, entrepreneurs, and changemakers under the Farmer FIRST Programme (FFP) of the ICAR-Indian Agricultural Research Institute (IARI), New Delhi. The project titled *"Participatory Technology Application and Multi-Stakeholder Convergence for Market-led Agripreneurship and Sustainable Rural Livelihoods"* is redefining how agricultural science reaches and resonates with farming communities. Anchored in the philosophy of *"Farmer FIRST–Farmer Innovation, Resourcefulness, Science and Technology,"* the programme ensures that farmers are not just recipients of technology but active partners in innovation and decision-making. The programme operates in four clusters of Palwal district, Haryana–Amarpur, Dadhota, Katesra, and Kulena. The interventions span 93.2 ha and benefit more than 760 farm families, integrating crops, horticulture, livestock, natural resource management, and rural enterprises. The project has been implementing various interventions module-wise over the period since 2016.

MODULE I

Crop-based interventions: Strengthening the production backbone

Wheat- Sustaining food and income security: Wheat continues to be the backbone of north Indian agriculture, and the introduction of ICAR-IARI varieties i.e. HD 3226, HD 3086, HDCSW 18, HD 3271, and HD 3298 has created a new benchmark for productivity and profitability. These varieties were demonstrated on 40.4 ha involving 101 farmers. The results were encouraging showcaseing an average yield of 53.25 q/ha compared to 49.30 q/ha from local varieties, reflecting a yield gain of about 8%. Farmers realized net returns of ₹ 98,929/ha and benefit–cost (B:C) ratios of 3.10, compared to 2.94 for local checks. Farmers appreciated the improved disease resistance, higher straw yield, and better chapati-making quality of IARI varieties. Several farmers have begun multiplying these seeds for local exchange, ensuring continuity and local ownership of technology.

Paddy- Early-maturing basmati for smarter water use: To address the challenge of delayed wheat sowing due to late Basmati harvests, the project introduced short-duration, disease-resistant varieties — PB 1509, PB 1692, PB 1718, and PB 1885 across 7.2 ha (18 farmers). The interventions resulted in 8–12% higher yields over PB 1121 and reduced irrigation needs by 15 days. Farmers gained net returns up to ₹ 1.15 lakh/ha, with B:C ratios of 3.07, fully consistent with district-level economics. Notably, PB 1885 emerged as a farmer favorite for its early maturity and blast resistance. Integrated management practices, particularly Integrated Nutrient Management (INM) and Integrated Pest Management (IPM) modules, enhanced yields by 5–7%, reduced pesticide use by one-fourth, and improved profitability. Farmers in Palwal were made aware of INM during a one-day farmer workshop organized under ICAR/IARI's 'Farmer FIRST Programme'.

Mungbean- Greening the summer fallow: The rice-wheat system often leaves land fallow in summer, reducing soil fertility. Introducing summer mungbean varieties Pusa Vishal and Pusa 1641 on 17.6 ha (44 farmers) turned these bare fields into green, nitrogen-fixing assets. Average yields reached 10.75 q/ha compared to 9.30 q/ha from local varieties, a 15.6% gain that aligns with ICAR benchmarks. The net returns of ₹47,162/ha and B:C ratio of 2.94 reflected both economic and environmental benefits. By adding a third crop without additional irrigation infrastructure, farmers not only improved their annual income by ₹20,000–₹25,000 but also enhanced soil organic content. Mungbean has, thus, become a gateway crop for sustainable intensification in the FFP villages.

MODULE II

Horticulture for diversification and nutrition

Vegetable varieties for profit and health: To diversify incomes and diets, the project demonstrated IARI's improved vegetable varieties over 4.2 ha involving 84 farmers. Among the crops introduced, Pusa Sneha (sponge gourd) yielded an impressive 114.5 q/ha, providing farmers a net return of ₹84,389 with a benefit–cost ratio (B:C) of 2.44, reflecting consistent performance under field conditions. The bottle gourd variety Pusa Santushti emerged as a top performer, producing 176.2 q/ha and earning ₹ 1,16,788/ha with a B:C ratio of 3.03, signifying its strong market acceptance and profitability. Similarly, Pusa Sag-1 (leaf mustard) recorded a yield of 164.6 q/ha with ₹ 64,616 net returns and a B:C ratio of 2.81, indicating its potential as a short-duration, high-value crop. Root vegetables also performed well — Pusa Rudhira (carrot) achieved 197 q/ha yield with ₹1,15,490 net return and B:C ratio of 2.93, while Pusa Riddhi (onion) produced 191 q/ha, generating ₹1,17,399 net return and a B:C ratio of 2.89. Each crop demonstrated a clear profitability edge.

Marigold- Blooming livelihoods of farmess: Marigold, particularly Pusa Narangi Gainda, has blossomed into a profitable venture for small farmers. Demonstrated across 2.4 ha (12 farmers), it recorded 125 q/ha yield against 112 q/ha (local), giving net returns of ₹1.25 lakh/ha and B:C ratio 3.2, perfectly reasonable and consistent with floriculture economics in peri-urban Haryana. With local access to Delhi's flower markets, farmers now see floriculture as a viable short-duration enterprise, particularly appealing to women and youth.

Fruit orchards- Planting the seeds of future security: Long-term orchard plantations were initiated on 0.45 ha, featuring IARI varieties of mango (Pusa Surya, Pusa Arunima), guava (Pusa Pratiksha), and lemon (Pusa Lemon-1). Although yield data will take time to accrue, the intervention aligns with climate-smart diversification goals, providing shade, soil health improvement, and steady income prospects within 3–4 years.

Nutrition at the doorstep- Kitchen gardens for women empowerment: A flagship component has been the Nutritional Kitchen Garden initiative, covering 4.1 ha and empowering 410 women farmers. Using ICAR/IARI varieties such as Pusa A-5 (okra), Pusa Shyamla (brinjal), Pusa Sukomal (cowpea) and All Green (palak), women ensured year-round vegetable supply for their families. Each 100 m² plot yielded 90–280 kg of mixed vegetables with B:C ratios of 2.2–2.9. A *Kisan Goshthi* on "Nutrition Security for Women Empowerment" in Dadhota, trained 65 women on seed saving, pest control, and compost preparation. Post-training, adoption rates exceeded 85%, reflecting immediate practical impact.

MODULE III

Livestock: A catalyst for household income stability

Recognizing livestock's role in smallholder resilience, the project collaborated with the Department of Animal Husbandry, Haryana, and KVK Gurugram to conduct Animal Health Camps and field demonstrations on balanced feeding. Over 40 dairy farmers benefitted from mineral mixture distribution, deworming campaigns, and awareness sessions on diseases like FMD, LSD, and mastitis. The reported 10–15% rise in milk yield post-intervention is consistent with established extension findings. Farmers were also oriented on schemes like Pashu Kisan Credit Card and Mini Dairy, linking animal health with financial access — a key step towards integrated livelihood enhancement.

MODULE IV

Rural enterprises: From farmers to agripreneurs

Protected cultivation for off-season advantage: Two insect-proof net houses (100 m² each) demonstrated the viability of protected vegetable cultivation. In the insect-proof net house, cucumber cultivation recorded an impressive yield of 648 kg/100 m², generating a net profit of ₹9,119 and achieving a benefit–cost (B:C) ratio of 3.19. Similarly, capsicum grown under the same structure yielded 565 kg/100 m², with a net profit of ₹7,670 and a B:C ratio of 3.11. The consistent profitability and efficient use of resources highlight the potential of protected farming as a viable agripreneurial model for land-constrained and youth farmers seeking steady income through off-season production.

Button mushroom- A growing enterprise: A set of 8 demonstration units in Katesra and Dadhota produced 4,530 kg of button mushrooms, with total expenditure ₹1.80 lakh and gross income ₹4.98 lakh. The net profit of ₹3.18 lakh. For a single cropping cycle of button mushroom, each unit produced 566 kg, incurred an

Glimpses of the interventions conducted under Farmer FIRST Programme

expenditure of ₹22,470, realized a gross income of ₹62,288, earned a net income of ₹39,818, and achieved a B:C ratio of 2.77. The enterprise has sparked local interest due to low space needs, quick turnover, and year-round market demand.

Farmer-led seed production: Linking farmers to markets: Under ICAR-IARI's buy-back arrangement, a progressive farmer from Dadhota produced seeds of HD 3226 (wheat) and PB 1718 (paddy) over 4 acres.

Table 1. Econimcs of wheat and paddy sead prodcution

Crop	Gross Income (₹)	Net Return (₹)	B:C Ratio
Wheat (HD 3226)	1,30,131	89,611	3.21
Paddy (PB 1718)	1,58,440	1,09,930	3.27

Seed cultivation generally fetches a higher market value due to stringent quality standards and demand from certified seed programs. With the B:C ratio of 3.2, seed production remains very economically viable under favorable agro-climatic conditions. Seed buy-back by ICAR-IARI ensured assured markets and quality maintenance, inspiring others to replicate the model.

Natural farming cultivating sustainability: A diversified natural farming model demonstrated the cultivation of 30 crops across seasons, achieving gross income of ₹4.16 lakh/acre and net income of ₹1.82 lakh.

MODULE V

Capacity building and convergence: Strengthening knowledge networks

Throughout the year, the project organized 16 Farmer–Scientist Interface meetings, bringing together farmers, scientists, and institutional partners. Experts from divisions such as Agronomy, Plant Pathology, Seed Science, and Horticulture worked hand in hand with farmers to diagnose problems and fine-tune solutions. Partnerships with NABARD, ICAR–NDRI Karnal, and local NGOs (Thora Vikas Samiti, Gramin Shiksha Mitraon) enhanced resource convergence. Farmers also participated in Pusa Krishi Vigyan Mela 2025, connecting them directly to national innovations. The participatory approach has led to trust, empowerment, and continuous learning—the true pillars of sustainable agricultural extension.

SUMMARY

The Farmer FIRST Programme at ICAR–IARI stands as a living model of participatory extension where science meets soil, and farmers co-create solutions. By integrating advanced technologies, entrepreneurship, and gender-inclusive approaches, the project has generated tangible improvements in crop yield, income stability, and community empowerment. From high-yielding wheat and paddy to vibrant kitchen gardens and profitable mushroom units, every initiative carries the imprint of partnership and purpose. The results narrate stories of resilience, innovation, and transformation. As farmers and scientists continue to learn from each other, Farmer FIRST Programme reaffirms that sustainable agricultural growth is born from collaboration of scientific knowledge, and grassroots innovation.

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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.

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.

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

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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Pindi Balochan: Exhibiting pathway of climate resilience

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In India, green revolution has brought food security through improved varieties and technologies, however, overexploitation has led to soil pollution, environmental degradation, high use of synthetic fertilizers, etc. Pindi Balochan, is one of those villages in Punjab facing these challenges besides climatic variability. To address these challenges, interventions of KVK, Faridkot under National Innovations on Climate Resilient Agriculture (NIRCA) has helped in adoption of climate resilient agriculture through crop residue management, agroforestry, and improved livestock practices. The story of Pindi Balochan reaffirmed that with the right integration of technologies, innovations, traditional knowledge, empowered communities, and supportive policies, even the most vulnerable rural landscapes could transition towards resilient livelihoods, sustainable ecosystems, and long-term climate stewardship.

Keywords: Climate resilient agriculture, Crop residue management, NIRCA, Sustainable ecosystems

PINDI Balochan, a prominent agricultural village situated in Faridkot district, Punjab is a part of India's north-western agrarian belt with paddy-wheat cropping system. Like many parts of Punjab's Malwa region, the village forms a microcosm of both the strengths and vulnerabilities of Punjab's Green Revolution landscape, with high productivity, but also high input dependency, soil degradation, water scarcity and environment pollution. Despite its high productivity, agriculture in Pindi Balochan had increasingly come under stress due to climatic variability and resource depletion. Erratic rainfall, heat waves, declining groundwater levels, and soil nutrient depletion have adversely affected the long-term sustainability of farming systems.

Climatic vulnerabilities

Pindi Balochan village was confronted with a complex set of climatic and environmental challenges that had significantly affected its agricultural sustainability and livelihoods. The region experienced wide temperature fluctuations (4.6–43.8°C). These extremes disrupted crop growth cycles, causing heat stress in wheat during grain filling and increasing the risk of lodging in paddy. Rainfall was both scanty and erratic (averaging only 433 mm) against a potential evapotranspiration of nearly 3,000 mm, which created a severe water deficit to rely heavily on groundwater extraction, leading to further aquifer depletion. Furthermore, practice of crop residue burning contributes to air pollution by releasing large amounts of particulate matter, carbon monoxide, and greenhouse gases.

The soils, predominantly loamy sand, were inherently fragile, prone to leaching, and poor in organic carbon. Continuous paddy-wheat cultivation, coupled with residue burning, has worsened soil health, depleted organic matter, and contributed to greenhouse gas emissions. Seasonal heat waves and prolonged dry spells further compounded the problem, drying soils, lowering fodder availability, and reducing milk productivity in livestock. At the livelihood level, farmers' dependence on rice and wheat, both highly input-intensive crops, left incomes vulnerable to climatic variability, rising production costs, and fluctuating market prices. Taken together, these interlinked stresses underscored the urgent need for climate-resilient agricultural interventions in Pindi Balochan.

KVK interventions

Under the National Innovations in Climate Resilient Agriculture (NICRA) initiative, KVK Faridkot implemented a comprehensive set of technological, ecological, and institutional interventions in Pindi Balochan to address the village's vulnerabilities and transform its agricultural landscape. These interventions were not limited to tackling immediate issues but were strategically designed to improve long-term

Table 1. Agro-climatic profile of Pindi Balochan

Parameter	Description/Value
Location	30.68°N, 74.50°E (Faridkot District, Punjab)
Total cultivated land	1,060 ha
Soil type	Loamy sand
Annual average temperature	24.2°C
Temperature range	4.6°C (winter)–43.8°C (summer)
Average annual rainfall	433 mm
Potential evapotranspiration	≈ 3,000 mm
Cropping System	Paddy-wheat (dominant)
Average holding size	2–5 ha
Livestock	Buffaloes and cows (dairy-linked income)

Table 2. Major climate vulnerabilities before NICRA

Challenge	Impact on agriculture
Erratic rainfall and high temperature	Crop yield variability, heat stress in wheat
Groundwater depletion	Crop yield variability, heat stress in wheat
Residue burning	Air pollution, loss of soil organic carbon
Soil nutrient depletion	Air pollution, loss of soil organic carbon
Livestock heat stress	Decline in milk yield, low fertility
Pest attacks	Crop losses in maize, vegetables, and fruits

sustainability by reducing greenhouse gas emissions and enhancing carbon sequestration.

A breakthrough was achieved through Crop Residue Management (CRM), where the introduction of the Happy Seeder and Zero till Drill enabled wheat to be sown directly into rice residues. This eliminated residue burning on nearly 900 ha, saving around 50 L of diesel/ha and reducing land preparation costs by ₹ 1,650/ha. Alongside this, farmers adopted improved, climate-resilient crop varieties such as PR-126, PR-131, and PR-132 in paddy, and PBW-766 (Sunehri) and PBW-826 in wheat. These varieties stabilized yields at approximately 70–72 q/ha for paddy and 58–60 q/ha for wheat, even under varying weather conditions. To restore soil fertility, balanced fertilization and site-specific nutrient management were introduced, while residue incorporation enhanced soil organic carbon levels.

In livestock management, the use of Urea Molasses Mineral Blocks (UMMB) and balanced rationing improved digestibility, cut methane emissions, and increased milk productivity by 8–12%. Stall feeding reduced open grazing pressure and nutrient wastage, contributing to better fodder efficiency. Efforts in grassland development further secured fodder resources, with rehabilitated pastures and improved fodder varieties increasing dry matter availability by nearly 40 q/ha and reducing dependence on external purchases. Simultaneously, forestry and agroforestry initiatives (4.52 ha) brought significant ecological benefits. Trees planted along farm bunds and common

Table 3. Key NICRA interventions in Pindi Balochan

Intervention type	Practice/Technology	Outcome
Crop residue management	Happy Seeder and Zero Till Drill wheat sowing directly into rice residue; residue burning eliminated on ~900 ha	~85% adoption; ~₹1,650/ha savings; diesel savings (~50 L/ha); major drop in air pollution
Climate resilient varieties	Climate resilient paddy (PR 126, PR 131) and wheat (PBW 766, PBW 826) varieties	Yield stability even under weather stress: ~71 q/ha for paddy; 58 60 q/ha for wheat
Soil fertility enhancement	Balanced fertilization, nutrient management, residue incorporation	Increased soil organic carbon; minimized overuse of N; better soil health
Water conservation	Direct Seeded Rice (DSR), short duration varieties, alternate irrigation practices	Saved 25 30% water (~1,000 1,200 m^3/ha); lower labour & irrigation costs
Livestock and fodder	Urea Molasses Mineral Blocks (UMMB), balanced rations, area specific mineral mixture, stall feeding, silage	Milk yield up by 8 12%; reduced open grazing; lower methane emissions per unit output
Forestry and agroforestry	Trees planted along bunds and community land	Enhanced green cover; carbon sequestration; income diversity for farmers
Institutional innovations	Custom Hiring Centre (CHC) for shared access to machines; scientific advisories (e.g. for heat stress)	Small farmers can afford CRM tools; damage in heat waves mitigated; overall resilience of systems improved

lands enhanced green cover, while agroforestry systems boosted carbon sequestration and provided farmers with diversified sources of income.

During the extreme heat wave of March 2022, timely advisories on potassium nitrate sprays, light irrigations, and livestock management minimized losses across farming systems. While regional wheat yields declined by 4–6 quintals, farmers in Pindi Balochan faced only a marginal reduction of around 2 quintals, indicating enhanced adaptive capacity. Integrated measures, such as zero-till wheat, KNO_3 sprays, silage preparation, and use of foggers and bypass fat, helped sustain crop and livestock productivity despite climatic stress. Even under erratic rainfall, pest attacks, and temperature extremes, these practices reduced vulnerability, stabilized incomes, and safeguarded food and fodder availability. The experience underlines that informed advisories, adaptive technologies, and local capacity-building can significantly strengthen resilience to heat, drought, and biotic stresses, ensuring sustainable production in climate-affected regions.

A major institutional innovation was the establishment of a Custom Hiring Centre (CHC) in the village. The CHC made climate-resilient machinery such as the Happy Seeder, Zero till Drill, and Rotavator available to farmers on a rental basis, ensuring that even small and marginal farmers could access advanced

Smart seeder sown wheat in rice residues

Direct Seeded Rice

Happy seeder sown wheat in rice residues

technologies. This significantly expanded the adoption of CRM practices, reduced residue burning, and supported transitions to Direct Seeded Rice (DSR) and zero-till wheat. By lowering operational costs and promoting collective use of machinery, the CHC strengthened community cooperation and made climate-smart agriculture more inclusive. The CHC earned an income of ₹ 8,24,190/- by providing farm machinery services that promote mechanized and eco-friendly farming practices.

Together, these interventions transformed Pindi Balochan into a model of climate-smart agriculture, where resource conservation, productivity gains, and environmental stewardship went hand in hand.

Impact and resilience

The combined effect of the interventions in Pindi Balochan fundamentally reshaped both agricultural performance and the carbon profile of the village. Crop

Table 4. Machinery available at custom hiring centre, Pindi Balochan

Name of machine/Implements	Hiring rate (₹/h)	Hiring rate (₹/acre)
Happy Seeder	800	1500–1800
Super Seeder	900	1600–2000
Rotavator	700	1200
Zero Till Drill	600	1000
Mulcher	800	1400
Laser Land Leveler	1000	1500
MB Plough (Reversible)	700	1200
Paddy Straw Chopper	900	1500
Seed Drill (Conventional)	500	900
Disc Harrow	600	1000

Area specific mineral mixture

Preventive vaccination

yields improved significantly, with wheat production rising from an average of 58 q/ha to 62–65 q/ha, while paddy yields stabilized at 70–72 q/ha. Farmers reported that yields became more reliable and consistent even under erratic rainfall, a sign of strengthened resilience. Residue management practices also marked a major shift, with nearly 85% of farmers adopting CRM technologies. This not only prevented residue burning but also helped conserve soil nutrients valued at nearly ₹ 4,000 per hectare, while simultaneously cutting down on air pollution. The shift to reduced tillage and direct seeding resulted in substantial energy and cost savings, lowering diesel use by 50 L/ha. These savings, along with reduced field operations and labour, translated into additional profitability of ₹ 7,000–10,000 per hectare annually.

Livestock and fodder management further enhanced village livelihoods. Grassland development met household fodder requirements, reducing dependence on external purchases and ensuring steady dairy income. Improved feed and rationing techniques boosted milk yields, which in turn improved the daily cash flow of smallholder families. Beyond productivity, the interventions had a measurable impact on the village's carbon balance. Avoiding stubble burning alone reduced carbon dioxide emissions by several hundred tonnes each year. Combined with agroforestry plantations and residue incorporation, these practices added to carbon sequestration, ultimately shifting the village's carbon profile from deficit to surplus. Pindi Balochan emerged as one of the rare examples of a village-level carbon sink.

The impact in Pindi Balochan was multi-dimensional. By avoiding residue burning and saving fuel, along with better soil, tree, and livestock management, the village achieved near carbon-neutral and even carbon-positive status in some models. Farmers gained economically through input savings, higher yields, and better milk production, improving profits by 15–20% over the baseline. Socially, collective adoption of clean and smart technologies built stronger community cooperation and reduced air pollution, leading to better health and a cleaner environment.

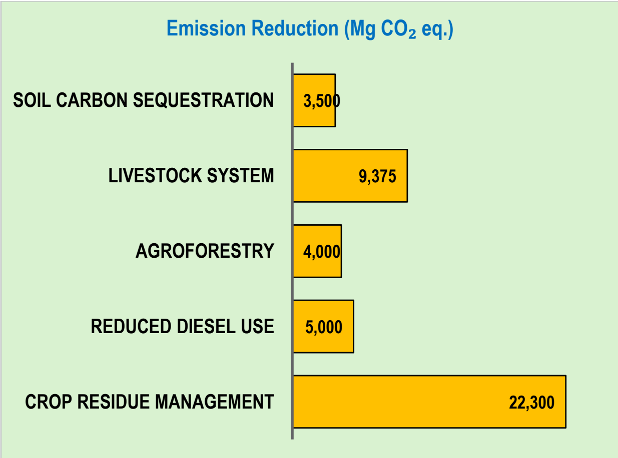
Promotion of Direct Seeded Rice (DSR) and short-duration paddy varieties in Faridkot showed remarkable results under NICRA interventions. DSR reduced irrigation requirements by about 25–30%, saving nearly 1,000–1,200 m^3 of water per hectare, and cut cultivation costs by ₹ 4,000–₹ 5,000/ha compared to puddled transplanting. Adoption of short-duration varieties like PR-126 further enabled early sowing of wheat, helping farmers escape terminal heat stress. Extrapolating these outcomes district-wide, with around 60,000 ha under paddy, potential water savings exceed 60 million m^3 annually, while improving input-use efficiency, reducing methane emissions, and enhancing climate resilience across Faridkot's rice–wheat system.

The study indicated that Pindi Balochan village was found to have significant climate-resilient transformation driven by the adoption of improved agricultural and livestock management practices under the NICRA framework. The village recorded the highest carbon sink potential among all study sites, particularly through interventions in irrigated rice systems where emissions dropped from 59,392 Mg CO_2 eq. to 37,119 Mg CO_2 eq., marking a reduction of nearly 37% due to the adoption of crop residue management practices like the Happy Seeder and alternate wetting and drying. While there was no perennial cultivation intervention, the annual cropping system showed a 42% increase in carbon sequestration, mainly through diversification into sugarcane, berseem, wheat, and vegetables. Interestingly, livestock numbers declined from 845 to 410, creating a net carbon sink (- 9,375 Mg CO_2 eq.) from this sector. The lowest nitrogen fertilizer application rate (120 kg N/ha) was also recorded in this village due to awareness and green manuring, contributing to reduced N_2O emissions. Overall, Pindi Balochan demonstrated how integrated climate-resilient practices, especially crop residue and nutrient management, can substantially mitigate emissions, enhance soil carbon, and lower emission intensity, with the lowest recorded farm-gate emission intensity of 0.43 kg CO_2 eq./kg of rice and 0.44 kg CO_2 eq./kg of milk among all villages studied Another study observed that the farmers in the village showed a high level of conviction toward the adoption of climate-resilient practices. As a result of these interventions, NICRA village Pindi Balochan enhanced its adaptive capacity, improved incomes, and functioned as a model "knowledge hub" for scaling the technologies to broader areas.

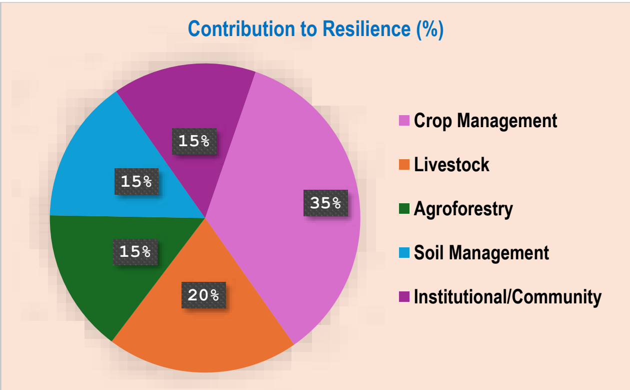
The findings from Pindi Balochan village, highlighted in the Hindustan Times feature "Farmers of Punjab's Climate-Smart Villages Geared Up to Protect Wheat from Heat Stress" (12 March 2023), underscore the village's success as a model under the NICRA initiative.

Farmes there effectively mitigated the adverse impact of rising temperatures on wheat yield by adopting climate-smart practices such as timely sowing, use of short-duration and heat-tolerant wheat and paddy varieties, eco-friendly residue management, and direct-seeded rice (DSR). Progressive farmers like Jaspal Singh reported spraying potassium nitrate as advised by experts to counter sudden heat surges, which significantly reduced yield loss during the 2022 heatwave. While neighbouring areas experienced wheat yield reductions of 4–6 q/acre, Pindi Balochan farmers saw only a marginal loss of about 2 q, demonstrating the effectiveness of these interventions. Our experience shows that the village exemplifies how scientific advisories, timely actions, and farmer capacity-building can enhance resilience to climate-induced heat stress and protect productivity in Punjab's climate-vulnerable regions.

Ultimately, these transformations established resilience in multiple dimensions. Agricultural resilience was achieved through stable yields, while ecological resilience came from improved soil carbon, reduced erosion, and better nutrient cycling. Livelihood



Component-wise carbon emission reduction



Sector-wise contribution to climate resilience

resilience followed with income diversification via forestry and dairy improvements, along with cost reductions. Community resilience strengthened through collective action in machinery sharing, particularly via CHC, and residue management. Another important milestone is that the village has achieved nutritional security, as every household maintains a nutritional garden cultivating indigenous varieties of vegetables organically using vegetable kits. Most importantly, climate resilience was achieved as Pindi Balochan transitioned to a carbon-positive profile, reducing local vulnerabilities while contributing to broader goals of global climate change mitigation.

Way forward

The success of Pindi Balochan charted a clear way forward for scaling and sustaining climate-resilient agriculture across Punjab and beyond. The interventions demonstrated in the village provided practical models for replication, particularly in neighbouring villages of Faridkot and the wider Malwa region, where similar climatic vulnerabilities exist. Scaling up crop residue management, agroforestry, and improved livestock practices could help expand both productivity and environmental gains.

Equally important is building stronger policy linkages, aligning village-level actions with national and state schemes such as the Crop Residue Management (CRM) Scheme, PM-KUSUM for solar-based irrigation, MGNREGA for land and water resource development, and the soil health card programme for balanced nutrient use. Future progress also lies in connecting farmers to carbon credit markets, creating a framework where sequestration services are monetized, and farmers are rewarded for maintaining a carbon-positive profile. Strengthening institutional mechanisms, particularly Farmer Producer Organizations (FPOs), will be vital for collective residue management, bulk input procurement, and better marketing of produce. Most importantly, Pindi Balochan holds the potential to be showcased as a climate-smart village model under NICRA, where integrated interventions not only ensure resilience but also highlight the synergies between sustainability, profitability, and community welfare.

SUMMARY

The journey of Pindi Balochan from a climate-vulnerable settlement to a climate-resilient, carbon-positive village stood as a testament to the transformative power of science-based interventions, farmer participation, and institutional convergence. What began as a response to recurring heat waves, erratic rainfall, and soil degradation gradually evolved into a comprehensive model of sustainable agriculture and rural resilience. By raising crop yields, lowering production costs, securing fodder supplies, and achieving a favourable carbon balance, the village demonstrated that climate-smart agriculture was both an environmental imperative and an economic opportunity. The story of Pindi Balochan reaffirmed that with the right mix of technologies, empowered communities, and supportive policies, even the most vulnerable rural landscapes could transition towards resilient livelihoods, sustainable ecosystems, and long-term climate stewardship.

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Women empowerment initiatives under the

Farmer FIRST programme for the livelihood development of tribal farm women in Chhattisgarh

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The Farmer FIRST Programme (FFP), implemented by ICAR-NIBSM, Raipur, aimed to enhance the livelihoods and empowerment of tribal farm women in Chhattisgarh through diversified agricultural enterprises. The project was undertaken in five tribal villages, namely Bakla, Kharaha, Bamhani, Kurraha, and Kharri of Kasdol block in Baloda Bazar district. Five key interventions were introduced: mushroom production, nutritional home gardens, agro-processing centres, goat farming, and Kadaknath poultry farming. These initiatives provided farm women with training, resources, and technology for skill development and income generation. Mushroom production benefitted three SHGs and 30 farm families, generating an annual income of ₹1,44,000; nutritional home gardens improved family nutrition and saved over ₹2,400 per household annually; agro-processing centres supported 152 farm families with an annual income of ₹4,78,200; goat farming engaged 83 women and generated a net income of ₹3,95,270; and Kadaknath poultry farming benefitted 20 women with an income of ₹2,10,000. Overall, more than 485 farm women were empowered, collectively earning over ₹12,29,870 annually. The FFP interventions effectively promoted economic independence, entrepreneurship, and sustainable livelihood opportunities among tribal farm women, contributing to their social and economic empowerment.

Keywords: Capacity building, Income generation, Rural entrepreneurship, Self-help groups, Skill development, Sustainable agriculture

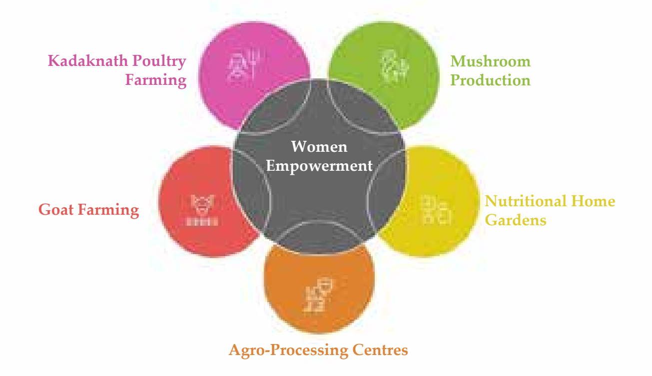
RURAL women are essential drivers of social, economic, and environmental transformation in 'New India.' With approximately 80% of rural women engaged in agriculture, empowering them is crucial for fostering inclusive economic growth. Integrating rural women into the agricultural workforce can significantly enhance food security and effectively combat poverty. This strategy is imperative for achieving the Sustainable Development Goals (SDGs) by 2030.

The Farmer FIRST initiative was launched at ICAR-NIBSM in 2016 to enhance the livelihoods of tribal farmers by integrating agricultural enterprises into fallow rice fields. The programme was centred on a cluster of five tribal villages—Bakla, Kharaha, Bamhani, Kurraha, and Kharri—situated in the Kasdol block of Baloda Bazar district, Chhattisgarh. A total of five modules were identified and implemented under this project i.e. crop-based, livestock-based, enterprise-based, horticulture-based, and natural resource management (NRM)-based modules.

Since 2016, several interventions have been initiated to improve the status of rural women in society by creating livelihood opportunities, and FFP initiatives have attracted the participation of about 34% of farm women. Farm women in tribal areas face significant drudgery due to the manual handling of agricultural and animal husbandry tasks, largely because of limited farm mechanization.

To address these challenges, various livelihood-support options were explored in the adopted villages, leading to the identification of suitable interventions aimed at enhancing the income and standard of living of selected farm families. The following five interventions were implemented under the Farmer FIRST Programme

- Mushroom production
- Nutritional home gardens
- Agro processing centers
- Goat farming
- Kadaknath poultry farming



Mushroom production

Farmwomen face several challenges, including mono-cropping, limited investment capacity, lack of alternative livelihood options, resource scarcity, inadequate marketing networks, and low awareness. Mushroom farming has emerged as a profitable enterprise that can support rural development by enhancing income and promoting self-employment. Under the FFP, economic empowerment of farmwomen was facilitated through skill-oriented training and the establishment of small enterprises. Oyster and paddy straw mushroom production units were set up, and farmwomen were trained to generate additional income and improve nutritional security using waste paddy straw. Demonstrations of paddy straw mushroom *(Volvariella volvacea)* and oyster mushroom *(Pleurotus florida)* production were conducted in all adopted villages, resulting in the establishment of four mushroom production units. A total of three Self-Help Groups (SHGs) and 30 farm families directly benefited, generating an aggregate annual income of ₹1,44,000 through this enterprise.

Table 1. Economic analysis of mushroom production

No. of Bags	Weight per Bag (kg)	Total Weight (kg)	Rate per kg (₹)	Total Income for one Group (₹)	No. of SHG Groups	Total Income for 3 SHGs (₹)
20	1	20	200	48,000	3	1,44,000

Nutritional home gardening

A kitchen garden or home garden is primarily intended to provide a continuous supply of fresh vegetables for family use. Several vegetables are grown on available land, offering a variety of produce rich in nutritional bioactive compounds. They are also important sources of protective nutrients such as vitamins, minerals, antioxidants, folic acid, and dietary fibres. Farmwomen were previously fully dependent on the market to procure vegetables for day-to-day consumption. Considering this, improved vegetable seeds from ICAR-IIHR (Arka Mega Seed Kit) were introduced, along with other inputs, modern equipment, and tools for vegetable cultivation. Training and demonstrations were conducted on nursery-raising techniques, crop management, and plant protection. Farmers now have access to fresh vegetables at their homes. This technology is highly effective, requiring minimal water, nutrients, labour, time, and cost, and


Mushroom production unit


Distribution of improved vegetable seeds


Harvesting of mushroom


Distribution of Arka Mega seed kit

can be easily managed by women alongside household activities. More than 200 farmwomen were covered and achieved very good yields. Each household saved over ₹2,400 annually in vegetable purchases from the market.

Agro-processing centres

Agro-processing centres are enterprises that process agricultural commodities post-harvest to enhance their storability and marketability. Women in this sector significantly improve agricultural output, making it more marketable and profitable, thereby contributing to the sustainability of agricultural systems. The initiative involves participatory resource sharing, technology development, value addition of cereals and spices, supply chain management, entrepreneurship development, increased family income, and alternative livelihood options for farmwomen. Four small-scale agro-processing centres (APCs) were established in the adopted villages, equipped with machines such as PKV dal mills, mini flour mills, mini rice mills, rice-cum-flour mills, pulverizers, and mini oil expellers. Farmwomen operate these machines easily, generating additional income and livelihood options at the village level. Marketing networks were also provided to support these centres. The establishment of APCs under the Farmer FIRST Programme benefitted a total of 152 farm families, resulting in an aggregate annual income of ₹4,78,200 through value addition and processing-based interventions.

APC of flour mill

APC of pulse milling

Table 2. Economic analysis of Agro-processing centres

Material Processed	Quantity Processed (kg)	Processing Charge per kg (₹)	Total Processing Cost (₹)
Flour	9,800	5	49,000
Pulses	300	5	1,500
Oilseeds	1,500	10	15,000
Rice Milling	78,300	5	3,91,500
Spice Grinding	1,060	20	21,200
Total			4,78,200

Goat farming

Due to the various challenges faced by villagers in remote areas, goat farming was suggested as an alternative livelihood option. Groups of 15–20 farmwomen were formed, with a total of five groups established across the five villages. They were provided with improved breeds of goats—*Sirohi, Jamunapari,* and *Barbari*—from Itarsi (Madhya Pradesh). A total of 83 goats (5 males and 78 females) were distributed among the farmwomen. Vaccination, healthcare activities, and other capacity-building programmes were organized in collaboration with the local veterinary department. All 83 farmwomen were covered under this intervention, generating additional income through livestock-based enterprises. The total cost of rearing was ₹1,72,330, while the gross return amounted to ₹5,67,600, resulting in a net income of ₹3,95,270 through goat rearing.

Goat rearing by farmwomen

Kadaknath poultry farming

Kadaknath chickens are a nutritious and easy-to-raise option for women, providing both financial and social empowerment. Supporting women's roles as livestock owners and enhancing their decision-making power is crucial for promoting economic and social empowerment. *Kadaknath*, a high-value chicken with medicinal properties, offers a viable livelihood option for tribal farmwomen, improving their financial condition and supporting resource-poor and landless farmers. The women maintain the poultry, generating cash revenue while providing eggs and meat for their families. The Farmer FIRST Programme has significantly enhanced the financial stability of tribal village farmers by providing timely assistance in inputs and capacity-building programmes. Under the *Kadaknath* poultry

Kadaknath poultry farming

Table 3. Comparison between before and after interventions

Interventions	Before	After
Mushroom production	• Limited technical knowledge • Non-availability of quality spawn • Low confidence in commercial production	• Skill enhancement through training • Mushroom production at the village level • Improved nutrition and household income • Collective enterprise through SHGs
Nutritional home gardens	• Lack of awareness about a balanced diet • Dependence on the market for vegetables • Small landholdings and input scarcity	• Year-round access to vegetables • Improved family nutrition • Surplus produce for sale
Agro processing centres (APCs)	• Unorganized home-based processing • No access to modern equipment • Limited market linkages • Low bargaining power	• Establishment of women-led APCs • Value addition (Flour, pulses, oilseed, spice grinding, etc.) • Rural women employment generation • Branding and collective marketing • Increased income and decision-making power
Goat farming	• Lack of improved breeds • High mortality due to diseases • Low productivity from traditional practices	• Improved breeds and vaccination • Reduced mortality and higher herd size • Women organized in SHGs/goat producer groups
Kadaknath poultry farming	• Limited availability of chicks • Lack of scientific rearing knowledge • High chick mortality	• Training in scientific rearing and vaccination • Access to Kadaknath chicks via low-cost hatchery units • Higher income from premium market demand • Direct marketing by women groups

farming intervention, a total of 500 chicks were distributed among 20 farmwomen, generating an annual income of ₹2,10,000 from the enterprise.

SUMMARY

The Farmer FIRST Programme in Chhattisgarh has played a pivotal role in promoting economic empowerment, self-confidence, and self-reliance among tribal farmwomen in Kharaha, Kharri, Bakla, Bamhani, and Kurraha villages. By providing targeted livelihood opportunities through mushroom production, nutritional home gardens, Agro-Processing Centres (APCs), goat farming, and *Kadaknath* poultry farming, the project enabled women to actively contribute to their household income while strengthening their role in community development.

The diversified interventions under the Farmer FIRST Programme (FFP) significantly enhanced the technical skills, knowledge, and entrepreneurial capacity of farmwomen. Mushroom production benefitted three Self-Help Groups (SHGs) and 30 farm families, generating an aggregate annual income of ₹1,44,000. Nutritional home gardens covered over 200 farmwomen, resulting in improved household nutrition and annual savings of more than ₹2,400/family on vegetable purchases. The establishment of Agro-Processing Centres supported 152 farm families, contributing to a total annual income of ₹4,78,200 through value-added processing activities. Goat farming interventions engaged 83 farmwomen, achieving a net income of ₹2,95,270, while *Kadaknath* poultry farming benefitted 20 farmwomen with the distribution of 500 chicks, collectively generating ₹2,10,000 annually.

In total, more than 485 farmwomen directly benefited from these initiatives, collectively earning an annual income exceeding ₹12,29,870. Beyond the financial gains, these interventions fostered entrepreneurship, strengthened women's decision-making capacity, reduced household vulnerability, and promoted sustainable livelihood practices. The FFP model demonstrates that with appropriate technological, capacity-building, and institutional support, tribal women can become active drivers of rural economic development, thereby contributing to both social and economic resilience in resource-constrained communities.

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Transforming rural livelihoods: Tribal women-led agripreneurship under the Farmer FIRST Programme

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The Farmer FIRST Programme (FFP) has significantly enhanced rural livelihoods in the plateau region through resource based interventions and focusing farmer participation and integrating indigenous knowledge with scientific advancements. This participatory approach bridges the gap between researchers, extension workers, and farmers, fostering collaborative problem-solving to overcome the limitations of traditional top-down models. This study highlights the transformative journeys of Smt. Albina Ekka and Smt. Sukarmani Kharkhusa, who adopted integrated farming system and enterprise-based module respectively to diversify income sources and create a roadmap to self-reliance.

Keywords: Enterprise-based module, Farmer participation, Integrated farming system, Interventions

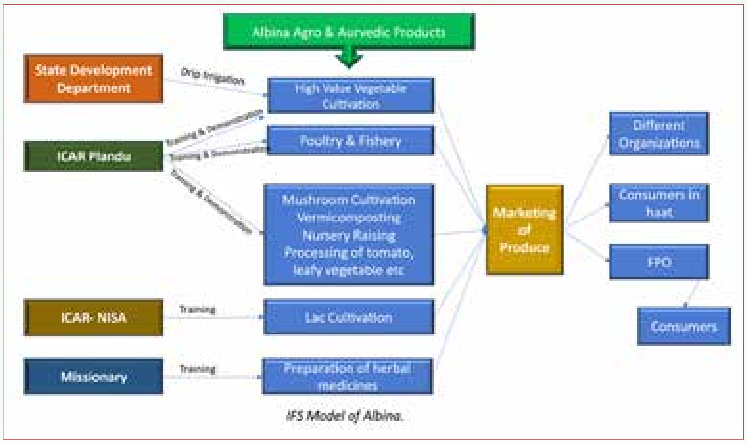
THE Farmer FIRST (Farm, Innovations, Resources, Science, and Technology) programme, launched by the Indian Council of Agricultural Research (ICAR), aims to establish a strong partnership between farmers and researchers. It was initiated to address the long-standing gap between scientific research and its practical application in agriculture. The programme emphasizes farmers' active participation in identifying problems, setting priorities, and testing innovations directly on their farms using local resources. By valuing farmers' experiential knowledge alongside scientific expertise, Farmer FIRST promote need-based, location-specific, and sustainable agricultural solutions. Farmers work along with scientists to conduct research. The village as a whole or a chosen group of farmers participates in monitoring experiments with scientists to determine the research questions. Ultimately, it seeks to enhance the relevance, adoption, and long-term impact of agricultural technologies across rural India.

Among beneficiaries of Farmer FIRST Programme (FFP), two tribal women were resource-constrained; one small and the other landless farmer. Recognizing their distinct conditions, the FFP team recommended differentiated modules, such as the Integrated Farming System (IFS) and enterprise-based modules, to effectively enhance their livelihoods and ensure sustainable empowerment.

Interventions under the Farmer FIRST Programme

IFS-Based Module

Smt. Albina Ekka, a tribal woman farmer from Kharsidag village in Ranchi district, Jharkhand, who owns five acres of land but faced low productivity, irregular income, and limited livelihood options due to traditional farming practices, weak market linkages, and less technical knowledge. Her family often depended on informal loans and wage labour to sustain basic needs. The Farmer FIRST Programme team of ICAR-RCER, FSRCHPR, Plandu identified her farm through Participatory Rural Appraisal (PRA) and found suitable for an integrated farming system module that



Integrated farming system module

would integrate high-value, short-cycle activities with medium-term enterprises and value addition to enhance income and sustainability. In 2018, the Farmer FIRST team carried out a farm diagnostic and co-designed a farmer participatory plan centred on an integrated farming system module to ensure year-round income and improved resource use.

Key elements of the intervention :

- **Participatory farm diagnostic and planning:** It was to identify available resources, fallow patches, labour capacity and market windows.
- **Promotion of integrated enterprises:** High value vegetables cultivation, oyster mushroom cultivation (short-cycle, high-value), composite fish culture in pond, backyard poultry, lac cultivation, vermicomposting, nursery raising for vegetables and timber plants and cultivation of medicinal herbs for processing.
- **Provision of critical inputs:** Mushroom spawn, polypropylene (PP) bags, formalin, bavistin, fish fingerlings, poultry chicks, brood lac, vermibed, quality seed/ planting materials for vegetables, timbre, and medicinal herbs.
- **Capacity building:** Hands-on training on mushroom cultivation, composite fish culture, poultry husbandry and basic animal health, vermicomposting, simple processing (mushroom *badi*, pickles, tomato ketchup, etc.); packaging, and basic bookkeeping and marketing.
- **Institutional linkages:** Facilitation of contact with Jharkhand State Livelihood Promotion Society (JSLPS), ICAR-NISA, ICAR-IIAB, KVK and support for the formation and functioning of a Farmer Producer Organisation (FPO) for collective input purchase and marketing.

The strategy focused on combining rapid-return activities (high-value vegetables, oyster mushrooms, etc.) that provide quick cash flow with medium-term enterprises (fish, poultry, lac cultivation, herbal processing, etc.) that stabilizes income across seasons. Value-addition training was facilitated so that Albina could capture more value rather than relying purely on raw commodity sales.

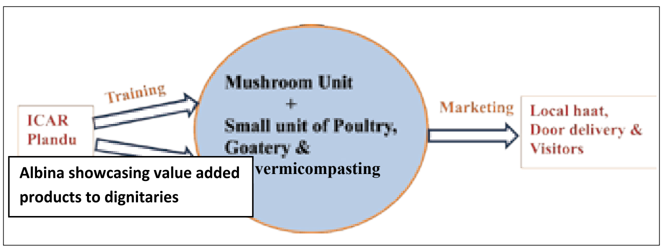
Production practices and resource use: Albina's integrated farming system module emphasizes resource efficiency and recycling:

- **High-value vegetable cultivation:** Grafted tomato, beans, strawberry, watermelon, cucumber, and other crops were successfully cultivated; dried vegetable leaves were used for vermicomposting, while poultry aided in natural pest management by feeding on field insects.
- **Mushroom cultivation:** Oyster mushrooms were cultivated in a dedicated room using straw-filled PP bags, yielding the best results from October to March. The spent substrate was utilized for vermicompost production, which was later applied to vegetable fields. Observing market demand for button mushrooms, she began procuring them from local producers at lower prices and selling them in local markets for profit.
- **Fish culture:** Small earthen pond(s) were constructed/ renovated on marginal low-lying areas and stocked with composite fish culture (Rohu, Catla, Mirgala and Common Carp). Fish Pond based on affordable local feeds and farm-made supplements.
- **Poultry:** Backyard poultry of a small flock (20–30 birds) provides eggs and occasional birds for sale; poultry manure is composted and applied in vegetable fields.
- **Lac cultivation:** She received training on lac cultivation in ICAR-NISA and initiated cultivation on 37 ber plants (30 small and 7 big trees). A big tree yielded 20 kg and small tree 3 kg scrap lac per plant which was sold in the local haat.
- **Herbal cultivation and processing:** Selected medicinal/herbal plants are cultivated in small beds. Processing includes drying, preparation of medicines and packaging under hygienic conditions as taught by Missionaries.
- **Value-addition:** When fresh sales are constrained, Albina processes mushrooms into badi and pickles, and prepares tomato ketchup, packages herbal products in small, labelled packs for local markets. She also collects underutilized leafy vegetables, dry it, process and sell in the market.Enterprise-based Module

Value added procducts by Smt. Albina Ekka

Enterprise based module

Smt. Sukarmani Kharkhusa, a landless tribal woman farmer from Plandu village in Ranchi district, was the sole earner for her six-member family. Before joining the Farmer FIRST Programme in 2019, she worked as a maid and labourer, earning just ₹6,000 per month,



Enterprises based module of Smt. Sukarmani

Table 1. Year-wise production and income from the IFS module

Output of Albina Ekka IFS Module during 2024—2025						
Intervention	Production (kg/acre/ population/ plant)	Market Price (₹)	Gross income (₹)	Expenditure (₹)	Net income (₹)	BC ratio
High Value Vegetable Cultivation (French bean)	3200 kg/acre	70	2,24,000	25,000	1,99,000	8.96
Poultry (Desi)	500 kg	500	2,50,000	30,000	2,20,000	8.33
Fishery	150 kg	200	30,000	4,000	26,000	7.5
Mushroom (Trading)	5,475 kg	200	10,95,000	8,21,250	2,73,750	1.33
Lac Cultivation	375 kg	1,000	3,75,000	1,07,500	2,67,500	3.49
Nursery	1,500 plants	50	75,000	10,000	65,000	7.5
Herbal Product	2,000 bottles/packets	200	4,00,000	1,80,000	2,20,000	2.22
Paddy	1,520 kg/acre	19	28,880	15,000	13,880	1.93
	Net annual income				12,85,130	

which was insufficient to meet her family's needs, forcing her children to drop out of school. She had also taken a ₹50,000 loan from a women self-help group to cover basic expenses.

During a home visit in 2019, the FFP team introduced her to the programme's interventions, particularly the enterprise-based module, which emphasized the establishment of small-scale, income-generating oyster mushroom unit that aligned with available resources. This module, coupled with a one-day training on mushroom cultivation in 2019 and a three-day advanced training in 2022 at ICAR RCER, FSRCHPR, Plandu, that motivated her to dedicate a room in her home to mushroom production. Under the enterprise-based approach, she received essential inputs including mushroom spawn, polypropylene (PP) bags, formalin and bavistin and regular monitoring by the FFP team to ensure success. This structured, enterprise-focused support enabled Smt. Sukarmani to establish a profitable, home-based mushroom enterprise, laying the foundation for sustainable income and household self-reliance. In addition to mushroom unit, she also maintains a small unit of poultry birds and goatery for supporting income sources specially during off season of oyster mushroom.

Cultivation of oyster mushrooms under the Farmer FIRST Programme

Output

Smt. Sukarmani successfully sold 133 kg of fresh oyster mushrooms in 2020–21 at ₹150/kg in the local markets of Rampur and Namkum. Encouraged by initial success, she decided to pursue year-round mushroom cultivation. However, her business faced a slowdown during the lockdown period due to reduced demand. To overcome this challenge, she diversified her business by producing mushroom-based products like badi and pickles. By 2022, her business regained momentum and she also started cultivating milky mushrooms along with consistent cultivation of oyster mushrooms. To ensure zero waste in her operations, she efficiently recycles the spent mushroom substrate for vermicomposting, thereby promoting sustainable resource utilization.

Preparation of mushroom badi by Smt. Sukramani

Table 2. Economics of mushroom cultivation by Smt. Sukramani Kharkhusa

Year	No. of bags (1kg dry substrate per bag)	Yield (kg)	Average selling price (₹/kg)	Cost of cultivation (₹/bag of 1 kg dry substrate)	Gross Income (lakh rupees)	Net Income (lakh rupees)	BC ratio
2020–21	150	133	150	30	0.19	0.15	4.43
2021–22	1,500	1,335	160	35	2.1	1.6	4.07
2022–23	2,100	1,869	180	40	3.3	2.4	4.01
2023–24	3,000	2,670	180	40	4.8	3.6	4.01
2024–25	3,100	2,950	180	40	5.3	4.0	4.28

Journey to self-reliance of tribal women farmers

Through the Farmer FIRST Programme, both Smt. Albina Ekka and Smt. Sukarmani Kharkhusa exemplify the transformative power of self-reliance and innovation in rural livelihoods. Albina, supported by FFP, built strong institutional linkages with JSLPS, ICAR-NISA, and the State Development Department, leading to the formation of a women's group, a FPO, and a mini cold storage facility in her village. As a board member of the Namkum Farmer Producer Company, she plays a pivotal role in collective marketing and resource management, while also mentoring other women farmers. Trained in herbal medicine preparation, she now manages "Albina Agro and Ayurvedic Products," which provides year-round employment to over ten women, and supports micro-enterprises such as LED bulb production. Her efforts have significantly enhanced her family's income, nutrition, and social standing, positioning her as a role model for women-led rural entrepreneurship.

Similarly, Smt. Sukarmani Kharkhusa, once a landless labourer, achieved economic independence through FFP's training and input support in mushroom cultivation. By establishing a home-based unit, diversifying into poultry and goat rearing, and adopting efficient marketing practices such as flexible pricing and local distribution, she ensured steady income, repaid her self-help group loan, and secured her children's education.

Impact

Smt. Albina and Smt. Sukarmani's success stories triggered a wider wave of rural transformation and women's empowerment. Albina's leadership in forming a women-led FPO through the IFS module, promoting market linkages, and conducting on-farm demonstrations encouraged replication across neighbouring villages. While the enterprise-based model of Sukarmani encouraged 83 farmers, many of them were women who adopted mushroom cultivation, including milky mushrooms, collectively generating an additional ₹4.46 lakh in net income in project villages. Her farm now serves as a training and demonstration hub for NGOs and government agencies. Both Albina and Sukarmani stand as living examples of self-reliant, tribal women-led agricultural entrepreneurship, showcasing how integrated, participatory models can drive inclusive and sustainable rural development.

Way forward

Scaling up the FFP module across similar agro-ecological regions can further strengthen women's participation in agriculture and rural entrepreneurship. Focused interventions should continue to integrate short-cycle, high-value enterprises with medium-term and value-added activities to stabilize income and optimize land use. Strengthening FPOs, promoting market linkages, and providing targeted capacity-building and technical support will enhance adoption and profitability. Additionally, documentation of best practices and establishment of demonstration hubs can facilitate knowledge transfer, inspire neighbouring farmers, and ensure the sustainability of women-led, resilient, and inclusive agricultural enterprises.

SUMMARY

The Farmer FIRST Programme has demonstrated a transformative impact on tribal women-led rural livelihoods through the adoption of integrated farming systems and diversified enterprises. Smt. Albina Ekka, by integrating vegetables, mushrooms, poultry, fish, nursery production, lac cultivation, herbal medicines, and value-added products, achieved substantial income growth, improved nutrition, and year-round employment. Strong institutional linkages and continuous technical support from the FFP facilitated access to quality inputs, effective marketing, and minimized demonstration failures. Similarly, Smt. Sukarmani Kharkhusa leveraged FFP training and support to establish a profitable mushroom enterprise, achieved financial self-sufficiency, and secured her family's well-being. Both cases illustrate how participatory, resource-appropriate interventions can empower tribal women, enhance household resilience, and catalyze the replication of sustainable farming practices in the plateau region.

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Goat farming as a profitable alternative for tribal farmers: An experience from FFP at Chhattisgarh

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Goat farming has proven to be a profitable and sustainable livelihood option for small, marginal, and landless farmers in the tribal-dominated regions of Chhattisgarh under the Farmer FIRST Programme. The initiative, implemented by the ICAR-National Institute of Biotic Stress Management (NIBSM), Raipur, was carried out in five villages of Kasdol block, Balodabazar district, where a total of 83 improved breed of goats (Sirohi, Jamunapari, and Barbari) were distributed among farmer groups comprising 15–20 members each. Capacity-building programmes, along with vaccination and healthcare support, were provided in collaboration with the local veterinary department to ensure scientific management and enhance productivity. The economic analysis revealed that the total annual cost of rearing amounted to ₹1,72,330, while the gross income from the sale of live goats was ₹5,67,600, resulting in a net income of ₹3,95,270 and a benefit: cost ratio (B:C) of 3.29. These results clearly demonstrated that goat farming is a highly remunerative enterprise requiring low investment and minimal resources. The initiative not only enhanced income and livelihood security among tribal farmers but also reduced seasonal migration, promoted rural entrepreneurship, and strengthened women's participation in livestock-based enterprises, thereby contributing significantly to economic resilience and sustainability in rural communities.

Keywords: Chhattisgarh, Farmer FIRST Programme, Goat farming, Livelihood improvement, Rural entrepreneurship, Tribal farmers

GOAT, also known as the poor man's cow in India, plays a vital role in the rural economy. Goats are versatile animals that produce milk, meat, fibre, and manure. India, with a population of over 148.88 million goats, is the world's fifth-largest goat producer, accounting for 13.39% of the global population. The country also ranks second in goat meat production, contributing 8% to the GDP and employing 4% of the rural population.

Goat rearing is a profitable venture for small and marginal farmers on undulating lands, as it requires very low investment and can serve as an alternative to cow or buffalo rearing. Goats play a crucial role in the economy and nutrition of landless, small, and marginal farmers as they can survive in harsh environments with low-fertility lands. Goat milk is consumed more globally than cow milk, and goat meat is consumed more than beef. It provides nutritious and easily digestible milk to children and serves as a regular source of additional income for the poor and marginal farmers.

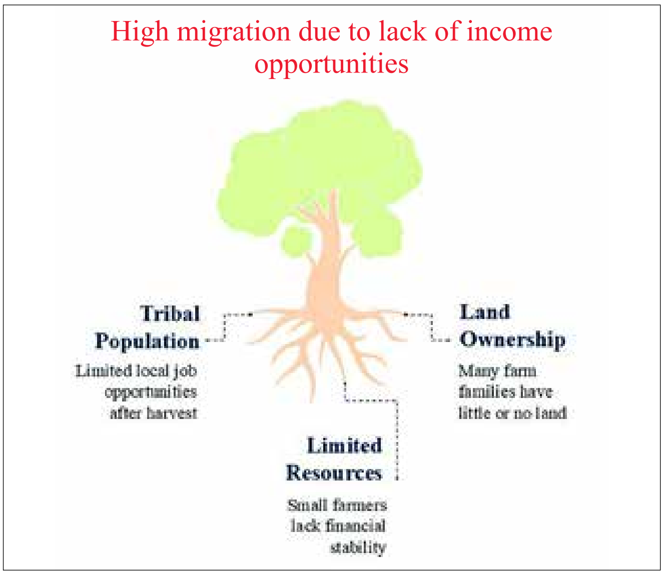
The Farmer FIRST Programme (FFP) has been playing a pioneering role in technology transfer, refinement, and imparting need-based training to farmers and rural youth. This particular success story highlights the achievement of tribal farm women, entrepreneurs, and technologists working together for the sustainable development of goat farming in a cluster of five villages (Bakla, Kharaha, Bamhani, Kurraha, and Kharri) in Balodabazar district, Chhattisgarh.

Challenges before goat farming

Before the introduction of scientific goat farming practices, several socio-economic and infrastructural challenges restricted the adoption and productivity of this enterprise among tribal and rural farmers. In the Kasdol block of Balodabazar district, where most households are small, marginal, or landless, goat rearing was largely traditional and unorganised.

The primary challenge was seasonal unemployment and migration, as nearly 40–60% of the tribal population migrated to other states in search of livelihood after paddy harvesting due to a lack of year-round income sources. Limited access to quality breeds and dependence on low-yielding local goats further reduced productivity and profitability. Another major constraint was inadequate knowledge and technical skills in scientific feeding, breeding, and health management. Farmers were unaware of vaccination schedules, disease prevention, and balanced nutrition, leading to high mortality rates.

Scarcity of fodder and grazing land, particularly during the dry season, made it difficult to maintain animal health. In addition, poor access to veterinary services, medicines, and market linkages prevented farmers from obtaining better prices for their animals. The absence of proper housing, capital investment, and institutional support also discouraged the adoption of improved practices. Collectively, these challenges made goat farming less organized and less profitable until targeted interventions under the FFP addressed them through training, technology transfer, and input support.



Farmer FIRST interventions

At the ICAR-National Institute of Biotic Stress Management (NIBSM), Raipur, the Farmer FIRST Programme (FFP) has been implemented since 2016 with a focus on livelihood diversification, resource-use efficiency, and farmer empowerment through innovative and sustainable agricultural practices. Under this programme, goat farming was identified as a viable livelihood option in the Kasdol block of Balodabazar district, where small, marginal, and landless farmers faced livelihood insecurity, seasonal migration, and underemployment.

The farmers' dependence on rainfed paddy cultivation provided limited income opportunities beyond the harvest season, and the lack of productive livestock further restricted household earnings. To address these challenges, improved goat breeds such as *Sirohi, Jamunapari,* and *Barbari*—known for their higher growth rate, adaptability, and market demand—were introduced.

A cluster-based approach was adopted wherein five farmer groups, each comprising 15–20 members, were formed across five adopted villages. Comprehensive capacity-building programmes were provided, including training on scientific goat rearing, feeding management, healthcare, disease control, and breeding practices. Farmers were also sensitized to aspects such as housing, hygiene, record-keeping, and the importance of timely vaccination and deworming.

In collaboration with the local veterinary department, regular health camps were organized, and the supply of essential veterinary medicines was ensured. The programme also focused on market linkage development by connecting farmers with nearby livestock markets, improving price realization. Beyond technical interventions, women and youth were encouraged to actively participate in goat farming groups. Many tribal women emerged as successful livestock entrepreneurs, contributing significantly to household income and decision-making.

In essence, goat farming was transformed from a subsistence activity into a profitable, scientific, and community-driven enterprise, empowering rural and tribal farmers both economically and socially. The model stands as a successful example of participatory technology dissemination combining innovation, inclusion, and impact for sustainable rural development.

Benefits of goat farming

Low investment and high returns:

- Requires minimal initial investment compared to other livestock enterprises.
- Goats need simple housing, a small space and low-cost feed resources.
- Four goats can be maintained as economically as one indigenous cow, reducing financial stress on poor households.

Efficient feed utilization:

- Can thrive on locally available shrubs, tree leaves, kitchen waste and crop residues.
- Suited for resource-scarce areas due to efficient feed conversion and minimal maintenance needs.

Adaptability to harsh conditions:

- Highly adaptable to varied climatic conditions including semi-arid, hilly and drought-prone areas.
- Can survive on limited fodder and irregular water supply, making them ideal for rainfed regions.

Quick reproduction and income generation:

- Early sexual maturity (10–12 months) and short generation interval.
- Can produce offspring twice a year, ensuring rapid herd growth and regular income.

Nutritional benefits:

- Goat milk is easily digestible and rich in essential nutrients.
- Preferred over cow milk for its superior digestibility and lower allergenic potential.
- Goat meat is lean, low in cholesterol and highly nutritious, fetching premium market prices.

Employment and livelihood security:

- Generates regular income through the sale of milk, meat, manure and live animals.
- Enhances livelihood diversification and financial stability of rural households.

Empowerment of women and marginal farmers:

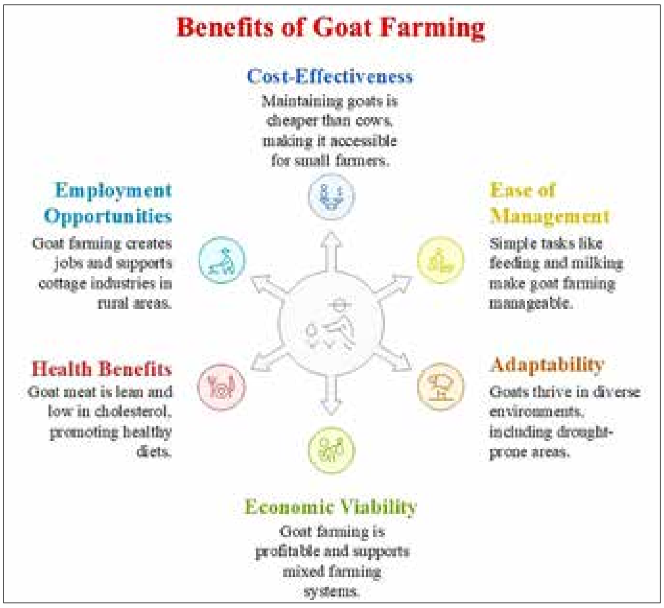
- Goats' small size and docile nature make them easy to manage by women and elderly farmers.
- Encourages women's participation in livestock-based livelihoods, fostering empowerment and self-reliance.

Support for integrated and sustainable farming:

- Goat manure serves as a valuable organic fertilizer, improving soil fertility.
- Promotes integrated farming systems and sustainable agriculture.

Promotion of rural entrepreneurship:

- Supports development of cottage industries such as meat processing, leather production and composting.
- Strengthens rural economies and reduces migration in tribal and backward regions.
- Goat farming acts as a resilient livelihood option for small and marginal farmers.
- Overall, it contributes to food and nutritional security, women's empowerment and rural development.



Performance indicators

The performance indicators provided a comprehensive assessment of the economic viability and profitability of the goat-rearing enterprise. The analysis was based on a total of 83 goats, including *Sirohi, Jamunapari,* and *Barbari* breeds, reared over one year. The total cost of rearing comprised expenses on labour, medicine, and shed construction or maintenance. The expenditure on labour amounted to ₹4,980 for 12 months at a rate of ₹415 per month, while the cost of medicines for all 83 goats was ₹37,350, covering routine vaccination, deworming, and healthcare needs. The cost incurred for constructing or maintaining a goat shed was ₹1,30,000 for one unit, bringing the total annual cost of rearing to ₹1,72,330.

On the output side, the major source of income was from the sale of live goats based on body weight gain. The goats collectively gained 1,320 kg of live weight, which, at the market rate of approximately ₹430/kg, generated a total income of ₹5,67,600. After deducting the total cost of rearing from the gross returns, the net income amounted to ₹3,95,270/year. The calculated benefit–cost (B:C) ratio was 3.29, indicating that for every rupee invested, the return was ₹3.29.

This high B:C ratio demonstrates that goat rearing, under the given management conditions and breed combination, is a profitable and economically sustainable enterprise. The results suggested that while the initial investment in infrastructure such as the goat shed constitutes a major portion of the total cost, the recurring expenses are relatively low compared to the high returns obtained from live goat sales, making it a financially attractive livelihood option for rural farmers.

Table 1. Economic analysis of goat farming

A total of 83 goats, including *Sirohi*, *Jamunapari* and *Barbari* breeds							
Input (Per Year)				Output (Per Year)			
Items	Rate (₹/Unit)	Total requirement	Total amount of recurring cost (₹)	Items	Rate (₹/Unit)	Qty (Kg)	Total amount (₹)
Labour (per month)	415	12 Months	4,980	Live body weight gain	430	1,320	5,67,600
Medicine	450	83 Goats	37,350				
Shed (No.)	1,30,000	1 Unit	1,30,000				
Total cost of rearing			1,72,330	Total benefit of rearing			5,67,600
Net income				3,95,270			
B:C ratio				3.29			

Farmers practicing goat farming in the adopted villages of FFP

Recommendations from FFP experience

Based on the successful outcomes of the goat farming initiative implemented under FFP in Balodabazar district, several measures are recommended to ensure the long-term sustainability and scalability of similar livelihood interventions:

Strengthen breeding and health infrastructure: Establish local breeding units and community-level health service centres to ensure the timely availability of quality breeds, vaccines and veterinary support.

Promote fodder and feed resource development: Encourage the cultivation of fodder crops and the use of crop residues and tree leaves to overcome feed scarcity, especially during lean seasons.

Enhance capacity building and farmer-to-farmer learning: Regular training, exposure visits and demonstrations should be organised to sustain technical knowledge and promote peer learning among goat farmers.

Develop market linkages and value addition: Establish cooperative marketing networks and support small-scale processing units for goat meat and manure products to enhance farmers' income and bargaining power.

Integrate women and youth in entrepreneurship: Special focus should be given to empowering rural women and youth through access to credit, training and enterprise management opportunities in goat-based livelihoods.

Institutional and policy support: Facilitate convergence among line departments, financial institutions and research organizations to create an enabling policy environment for scaling up goat farming as a profitable rural enterprise.

SUMMARY

The experience of promoting goat farming under the Farmer FIRST Programme (FFP) in the tribal villages of Balodabazar district, Chhattisgarh, clearly demonstrated its potential as a sustainable and profitable livelihood option for small, marginal, and landless farmers. The introduction of improved goat breeds such as *Sirohi*, *Jamunapari*, and *Barbari*, along with the provision of scientific training, healthcare support, and market linkages, significantly enhanced the productivity and income levels of participating farmers. The economic analysis revealed a benefit–cost ratio of 3.29, indicating that goat farming generates substantial returns even with modest investments.

Beyond financial gains, the intervention contributed to social and economic empowerment by engaging tribal farm women and youth in income-generating activities, thereby reducing migration and ensuring year-round livelihood opportunities. The participatory approach adopted under FFP strengthened the research–extension–farmer interface and encouraged collective action through farmer groups. The initiative not only enhanced household income and nutritional security but also demonstrated how location-specific livestock interventions can promote inclusive rural development and resilience in resource-constrained regions. In conclusion, the success of goat farming under FFP reaffirms that, with appropriate technological, institutional, and capacity-building support, small livestock-based enterprises can serve as effective drivers of farmer empowerment, livelihood diversification, and rural prosperity.

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Economic performance of smallholder goat farmers under the Farmer FIRST Programme

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Goat farming serves as an important livelihood source for small and marginal farmers in Madhya Pradesh, ensuring income generation and nutritional security. The present study evaluated the economic performance of smallholder goat farmers under the ICAR Farmer FIRST Programme (FFP) implemented in Jabalpur district. Data from 140 respondents comprising FFP beneficiaries, non-beneficiaries within project villages, and farmers from non-FFP villages were analyzed for key economic indicators including fixed cost, variable cost, total cost, gross return, net return, gross income, and benefit–cost (B:C) ratio using one-way ANOVA and post-hoc tests. Results indicated no significant difference in fixed costs; however, FFP beneficiaries reported significantly lower variable costs and higher gross returns (₹2842), net returns (₹2268), and B:C ratio (4.14) than control groups. The study highlighted that FFP interventions improved profitability through efficient feeding, breeding, and health management. These findings validate participatory extension as a sustainable model for strengthening smallholder goat-based livelihoods.

Keywords: Economics, Farmer FIRST Programme, Goat farming, Madhya Pradesh, Smallholder farmers

GOAT rearing is an important livelihood strategy among marginal and smallholder farmers in India, contributing to income, nutritional security, and enhanced resilience to agricultural risks. Because of their relatively low input requirements, adaptability to diverse environments, and steady market demand, goats are often referred to as the "poor man's cow." In states such as Madhya Pradesh, goat husbandry has the potential to augment farm incomes, particularly for resource-poor farmers in rainfed and marginal zones.

Yet, profitability of goat farming under smallholder conditions is constrained by inefficiencies in feeding, health care, and management practices, as well as limited extension support. Few empirical studies have systematically quantified the economic impact of participatory interventions or extension projects on small ruminant enterprises.

The Farmer FIRST Programme (FFP), an initiative under ICAR, seeks to integrate farmers into the innovation process through on-farm trials, capacity building, and location-specific recommendations. This study aims to evaluate whether FFP interventions bring economic gains in goat farming for smallholder farmers in Madhya Pradesh. Specifically, we compare cost structure (fixed, variable, and total costs), returns (gross, net), benefit–cost ratio (B:C), and net income among three groups: (1) beneficiaries under FFP, (2) non-beneficiaries in the same villages, and (3) farmers in non-FFP villages.

By applying one-way ANOVA and robust post-hoc analyses, this research provides evidence on the effectiveness of extension interventions in small ruminant farming. The results can guide scaling of such models and refinement of extension strategies in goat production systems.

Study area and project background

The present investigation was conducted under the aegis of the Farmer FIRST (Farm, Innovation, Resources, Science and Technology) project, implemented by Nanaji Deshmukh Veterinary Science University (NDVSU), Jabalpur, Madhya Pradesh since 2017. The project encompasses six villages namely Ghana, Kailwas, Chattarpur, Deori, Silua and Padriya, located in the Jabalpur district, characterized by agro-climatic conditions favourable for integrated farming systems. The project's core objective was to disseminate location-specific technologies to smallholder farmers through integrated farming system (IFS) modules comprising crop production, horticulture, livestock rearing, and value-added enterprises, aimed at enhancing economic sustainability and livelihood security.

Sampling design and selection of respondents

A three-tier stratified sampling framework was adopted to evaluate the economic impact of goat enterprise under the Farmer FIRST project during the agricultural year 2024–25. The study employed a quasi-experimental design with propensity score matching (PSM) to ensure comparability across groups and minimize selection bias.

Experimental group (Treatment group)

From a total of 320 registered project beneficiaries across six villages, 120 actively participating farmers were purposively selected for comprehensive impact assessment. Among these, 67 farmers engaged in goat rearing constituted the experimental group for the present study. These farmers were given improved Sirohi, Barbari and black Bengal goats by the project team along with various capacity building programmes.

Control groups

Two distinct control groups were established to isolate the project impact:

***Internal control group (ICG)*:** Comprised 35 non-beneficiary goat farmers residing within the six project-implementation villages who were engaged in goat rearing but did not participate in the Farmer FIRST programme. This group controlled for village-level factors such as infrastructure, market access, and local governance.

External control group (ECG): Consisted of 37 goat farmers from non-project villages within the same agro-ecological zone and district, matched for similar socio-economic and farming system characteristics. This group served to account for broader regional influences.

Propensity score matching

To ensure comparability and reduce confounding effects, PSM technique was employed using logistic regression. Matching was conducted based on critical covariates including:

- Farming experience (years)
- Educational attainment (years of formal schooling)
- Operational landholding (hectares)

A caliper width of 0.05 standard deviations was maintained to ensure quality matches. Common support condition was verified, and balance diagnostics (standardized bias and t-tests) were conducted post-matching to confirm covariate balance across groups. A final matched sample of 60 farmers per group was retained for analysis, yielding a total analytical sample of 140 goat-rearing households (67 experimental + 35 ICG + 37 ECG).

Data collection instruments and procedure

Primary data were collected through a pre-tested, structured interview schedule administered through personal interviews during the period (October 2024 to January 2025). The instrument was developed based on extensive literature review and pilot-tested on 15 non-sample farmers to ensure clarity, relevance, and reliability. Trained field enumerators with agricultural extension background conducted the interviews under close supervision of the research team. The questionnaire captured comprehensive information on:

Economic variables:

- **Fixed cost of goat enterprise (FCG):** Annualized depreciation on goat sheds/housing structures, equipment (feeders, waterers, weighing scales), veterinary instruments, and other capital assets. Depreciation was calculated using the straight-line method as per prevailing norms.
- **Variable cost of goat enterprise (VCG):** Recurrent expenditure including:
    - o Feed and fodder (concentrates, dry fodder, green fodder, mineral supplements)
    - o Veterinary services and medicines (vaccination, deworming, treatment costs)
    - o Labour costs (both hired and imputed value of family labour at prevailing wage rates)
    - o Breeding expenses (natural service charges or artificial insemination fees)
    - o Miscellaneous inputs (utilities, transportation, marketing costs)
- **Total cost of goat enterprise (TCG):** Computed as the sum of fixed and variable costs.

$$TCG = FCG + VCG$$

- **Gross return from goat enterprise (GRG):** Total income accrued from:
    - o Sale of live goats (adults, kids, culls)
    - o Goat milk and milk products
    - o Manure/farm yard manure
    - o Other by-products (skin, wool where applicable)
- **Net return from goat enterprise (NRG):**

$$NRG = GRG - TCG$$

- **Benefit-Cost Ratio (B:C):**

$$B:C = GRG \div TCG$$

- **Gross Income (GI) and Net Income (NI):** Representing return per unit of investment.

Socio-demographic variables: Age, education level, family size, herd size, farming experience, social category, and access to institutional credit and extension services were also recorded for descriptive characterization, though not included in the present comparative analysis.

Data processing and statistical analysis

Data were coded, entered into IBM SPSS Statistics (Version 25.0), and subjected to rigorous validation and cleaning procedures including range checks, logical consistency tests, and outlier detection using box plots and z-scores.

Descriptive statistics: Means and standard deviations were computed for all economic indicators disaggregated by farmer groups.

Inferential statistics

Assumption testing: Prior to parametric analysis, normality of distribution was assessed using the Shapiro-Wilk test and graphical methods (Q-Q plots, histograms). Homogeneity of variances across groups was evaluated using Levene's test of equality of error variances.

Analysis of variance: One-way ANOVA was conducted to test the null hypothesis of no significant difference in economic indicators among the three farmer groups (Experimental, ICG, ECG). In cases where Levene's test indicated heterogeneity of variances ($p < 0.05$), Welch's robust test of equality of means was employed as an alternative.

Post-hoc comparisons: To identify specific pairwise group differences, Games-Howell post-hoc test was applied (appropriate for unequal variances and unequal sample sizes). Where variances were homogeneous, Tukey's HSD test was used. Results were interpreted at $\alpha = 0.05$ significance level.

Socio-economic characteristics of respondents

Age distribution: The majority of respondents (66.91%) belonged to the middle age category (30–45 years), followed by young farmers below 30 years (17.99%) and older farmers above 45 years (15.11%). This age distribution was relatively uniform across all three groups, indicating that goat rearing attracted predominantly middle-aged farmers who are typically in their most productive phase of life with accumulated farming experience and family responsibilities. The predominance of middle-aged farmers aligns with earlier findings that suggest this age group possesses optimal combination of physical capability, experience, and risk-taking capacity for livestock enterprise management.

Educational status: The educational profile revealed that 22.30% of respondents were illiterate, while 39.57% had middle school education (5–7 years), representing the largest educational category. Only 2.88% had education beyond intermediate level. The limited formal education among goat farmers is consistent with the general demographic pattern of smallholder livestock keepers in rural India, where animal husbandry often serves as a livelihood option for less educated farmers. The similar educational distribution across groups ensured comparability in terms of knowledge acquisition and technology adoption potential.

Social composition: All respondents were Hindu by religion. Caste-wise distribution showed that Other Backward Classes (OBC) constituted 51.08% of the sample, followed by Scheduled Castes (19.42%), Scheduled Tribes (15.11%), and General category (14.39%). The predominance of socially disadvantaged groups in goat rearing underscores its role as a livelihood

Table 1. Socio economic profiles of the rice respondent farmers

Characteristic	Category	G0 (n=35)	G1 (n=67)	G2 (n=37)	Total (n=139)
Age	Young (<30 yrs.)	07	12	06	25
	Middle (30–45 yrs.)	23	45	25	93
	Old (>45 yrs.)	05	10	06	21
	Illiterate (0 years)	8	15	8	31
Education	Primary (1–4 years)	8	12	9	29
	Middle school (5–7 yrs)	14	24	17	55
	High school (8–10 yrs)	4	14	2	20
	Intermediate (11–12 yrs)	1	1	1	3
	Above Intermediate (>12 yrs)	0	1	0	1
Religion	Hindu	35	67	37	139
Caste	General	5	9	6	20
	OBC	19	31	21	71
	SC	5	16	6	27
	ST	6	11	4	21
Primary Occupation	Agriculture	12	17	14	43
	Animal Husbandry	16	23	19	58
	Wage labour	7	19	4	30
	Government services	0	2	0	2
	Private services	0	6	0	6
Land Holding (Acre)	Large (4–6)	0	2	1	3
	Medium (2–4)	4	7	3	14
	Small (0–2)	31	58	33	122

Table 2. Mean of cost and return parameters across respondents on per goat basis of groups

Indicator	FFP beneficiaries (N=67)	Non-beneficiaries (FFP village) (n=35)	Non-FFP villages (n=37)
Fixed Cost	74.34 ± 9.32	78.57 ± 9.44	78.25 ± 12.00
Variable Cost	499.60 ± 85.04	559.43 ± 87.89	584.50 ± 91.14
Total Cost	573.94 ± 87.82	637.99 ± 84.98	662.75 ± 90.35
Gross returns	2,841.91 ± 1,009.40	1,996.23 ± 427.57	1,963.50 ± 287.34
Gross income	2,342.31 ± 1,031.52	1,436.80 ± 448.33	1,379.00 ± 285.78
Benefit cost Ratio	4.14 ± 2.28	2.19 ± 0.89	2.01 ± 0.55
Net returns	2,267.97 ± 1,031.77	1,358.23 ± 445.26	1,300.75 ± 284.36

strategy for marginalized communities, often referred to as the "poor man's cow" in rural India.

Occupational pattern: Animal husbandry emerged as the primary occupation for 41.73% of respondents, followed by agriculture (30.94%) and wage labour (21.58%). Notably, only 5.76% were engaged in government or private services. The high proportion of farmers primarily dependent on animal husbandry highlights the critical importance of goat enterprise for household income and livelihood security in the study region.

Land holding: An overwhelming majority (87.77%) of respondents were small farmers with landholding less than 2 acres, while 10.07% were medium farmers (2–4 acres) and only 2.16% possessed large holdings (4–6 acres). This landholding pattern is characteristic of the fragmented agrarian structure in central India and explains why goat rearing, which requires minimal land and capital investment, serves as an important subsidiary enterprise for small and marginal farmers.

The propensity score matching process successfully ensured homogeneity across groups in key matching variables (age, education, and landholding), thereby isolating the treatment effect of the Farmer FIRST intervention from confounding socio-economic factors.

Economic performance of goat enterprise

The comparative economic analysis of goat enterprise across the three farmer groups was conducted on a per goat unit basis to enable standardized comparison across different herd sizes.

Fixed cost components: The mean fixed cost per goat was marginally lower among FFP beneficiaries (₹74.34 ± 9.32) compared to non-beneficiaries from FFP villages (₹78.57 ± 9.44) and farmers from non-FFP villages (₹78.25 ± 12.00). However, ANOVA results indicated that these differences were not statistically significant. The relatively low fixed costs across all groups reflect the low-input nature of goat husbandry in the study area, with minimal investment in housing and equipment infrastructure. The non-significant difference suggests that the Farmer FIRST intervention did not substantially alter the capital investment pattern in goat sheds and equipment, possibly because beneficiaries utilized locally available low-cost materials for housing construction.

Variable cost components: Substantial and statistically significant differences were observed in variable costs across groups. FFP beneficiaries incurred significantly lower variable costs (₹499.60 ± 85.04) compared to non-beneficiaries from FFP villages (₹559.43 ± 87.89) and non-FFP villages (₹584.50 ± 91.14). The reduction of approximately 10.69% and 14.52% in variable costs relative to the two control groups, respectively, can be attributed to several project interventions including training on feed formulation using locally available resources, improved fodder cultivation through azolla and improved grass varieties, strategic health management, and timely veterinary services provided under the Farmer FIRST Programme. Lower variable costs directly enhance profitability and economic viability of the enterprise.

Total cost of production: The total cost per goat followed a similar pattern, with FFP beneficiaries incurring significantly lower costs (₹573.94 ± 87.82) compared to internal control group (₹637.99 ± 84.98) and external control group (₹662.75 ± 90.35). The cost advantage of 10.04% and 15.47% for FFP beneficiaries demonstrates the effectiveness of integrated resource management strategies promoted through the project. Efficient cost management is crucial for smallholder farmers operating under resource constraints and price uncertainties.

Gross returns: The most striking difference emerged in gross returns, where FFP beneficiaries achieved substantially higher income (₹2841.91 ± 1009.40) compared to non-beneficiaries from FFP villages (₹1996.23 ± 427.57) and non-FFP villages (₹1963.50 ± 287.34), representing an increase of 42.37% and 44.74%, respectively. The enhanced returns can be attributed to multiple factors including improved breeding through buck exchange programmes and artificial insemination, better growth rates resulting from balanced nutrition, reduced mortality through systematic vaccination and deworming protocols, and improved market linkages facilitated by the project. The higher standard deviation among FFP beneficiaries (₹1009.40) compared to control groups suggests greater variability in performance, possibly reflecting differential adoption intensity and management skills among beneficiaries.

Net returns and gross income: Net returns exhibited a similar pattern, with FFP beneficiaries earning

₹2267.97 ± 1031.77 per goat compared to ₹1358.23 ± 445.26 and ₹1300.75 ± 284.36 for the two control groups, respectively. Gross income followed an identical trend ($F = 26.210$, $p < 0.001$), with FFP beneficiaries earning 63.01% and 69.89% higher income than the respective control groups. These substantial differences in profitability indicators underscore the transformative economic impact of the Farmer FIRST intervention on household income and livelihood sustainability.

Benefit-cost ratio: The benefit-cost ratio, a critical indicator of economic efficiency, was significantly higher for FFP beneficiaries (4.14 ± 2.28) compared to non-beneficiaries from FFP villages (2.19 ± 0.89) and non-FFP villages (2.01 ± 0.55). A B:C ratio exceeding 4.0 among FFP beneficiaries indicates that for every rupee invested in goat enterprise, beneficiaries earned ₹4.14, demonstrating exceptional economic viability. While all three groups achieved B:C ratios above 2.0, suggesting inherent profitability of goat rearing, the substantially higher ratio among FFP beneficiaries highlights the economic advantage conferred by project interventions. The nearly two-fold improvement in economic efficiency emphasizes the potential of technology-backed extension support in enhancing the profitability of smallholder livestock systems. Studies done by Khadda *et al.* 2018 reported a benefit cost ratio in the range of 2.23–2.37 for tribal farmers of Uttarakhand highlighting goat farming will have a marginal profit if no capacity building and input distribution efforts were not conducted whereas Pawar et al reported even lower out put to input ratio of 1.40 per farm household indicating the meagre profits from Goat farms.

Statistical inference

The one-way ANOVA results revealed statistically significant differences among groups for all economic parameters except fixed costs. The F-statistics and associated p-values demonstrated that the Farmer FIRST intervention had a profound and statistically significant impact on reducing production costs and enhancing returns from goat enterprise.

For variable costs, total costs, gross returns, net returns, benefit-cost ratio, and gross income, the p-values were consistently less than 0.001, indicating that the probability of observing such differences by chance alone was less than 0.1%. The F-values ranging from 12.886 to 26.466 suggested moderate to large effect sizes, confirming the substantial magnitude of project impact.

The non-significant difference in fixed costs aligns with the project's focus on optimizing operational efficiency through improved feeding, breeding, and health management rather than promoting capital-intensive infrastructure development. This approach is particularly appropriate for resource-constrained smallholder farmers who cannot afford substantial capital investments.

The large variance in gross returns and net returns, particularly among FFP beneficiaries, suggests heterogeneity in performance outcomes. This variation may stem from differences in adoption intensity, management skills, initial herd quality, and household resource endowments. Future research employing regression-based impact evaluation could identify the determinants of this performance heterogeneity and help target interventions more effectively.

Post-hoc pairwise comparisons conducted using Games-Howell test revealed that FFP beneficiaries significantly o utperformed both control groups across all economic parameters, while the two control groups did not differ significantly from each other. This pattern confirms that the observed economic advantages were attributable to the Farmer FIRST intervention rather than location-specific factors or general developmental trends in the region.

SUMMARY

The findings demonstrate that integrated extension interventions combining technological inputs, capacity building, and institutional support can substantially enhance the economic performance of goat enterprises among smallholder farmers. The 66–74% increase in net returns and doubling of benefit-cost ratio achieved by FFP beneficiaries highlight the transformative potential of well-designed farmer-centric programmes.

For policy makers and development agencies, these results underscore the importance of investing in location-specific, participatory extension models that go beyond one-time technology transfer to provide sustained handholding support. The cost reduction achieved through locally available feed resources and preventive health management offers a scalable and sustainable pathway for improving livestock productivity without requiring prohibitive capital investments. The study also reinforces the critical role of goat enterprise as a livelihood strategy for socially disadvantaged and land-poor rural households, warranting targeted policy attention and resource allocation to strengthen small ruminant production systems in India.

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Success stories from north-eastern India:

Empowering rural livelihoods through scientific pig rearing and mushroom cultivation

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The Farmer FIRST Programme (FFP), implemented in Central Agricultural University, Imphal, and ICAR Research Complex for NEH Region, Umiam, has significantly contributed to empowering rural livelihoods in north-eastern India through scientific interventions in pig rearing and mushroom cultivation. Through hands-on training, technical guidance, and input support, smallholder farmers and rural youth have adopted improved practices, transforming traditional piggery and mushroom production into profitable and sustainable enterprises. Integration of piggery, mushroom cultivation, fish farming, and vermicomposting demonstrates resource-efficient and diversified farming systems. These participatory, science-led, and locally adaptive interventions enhance income, food security, and employment, while fostering community-based knowledge sharing. The experiences underline the transformative potential of such initiatives to empower rural communities, build resilience, and promote sustainable livelihoods in smallholder farming landscapes of north-eastern India.

Keywords: Farmer FIRST Programme, Integrated farming, Rural livelihoods, Rural entrepreneurship, Smallholder farmers

LIVESTOCK-BASED and allied agricultural interventions are essential for improving income, nutrition, and resilience among smallholder farmers in north-eastern India. Recognizing this, the Farmer FIRST Programme (FFP) has promoted scientific pig rearing and mushroom cultivation through training, technical guidance, and input support. By bridging the gap between research and practice, the programme empowers farmers and rural youth to adopt improved husbandry and entrepreneurial practices. The experiences of Shri Songaning from Ukhrul district, Shri S Lawrance from Senapati district, Manipur and Shri Raymond B Marwein from Ri-Bhoi district of Meghalaya demonstrate how locally adaptive technologies, capacity building, and integrated farming systems can transform livelihoods, strengthen food security, and promote sustainable rural development.

Pig rearing

Livestock-based livelihood interventions play a pivotal role in enhancing income and nutritional security among small and marginal farmers in North Eastern India. Recognizing this, the Farmer FIRST Programme (FFP) implemented by Central Agricultural University (CAU), Imphal, has introduced scientific pig rearing practices to improve productivity and sustainability in rural communities. Through training, input support, and continuous technical backstopping, the programme has successfully transformed traditional piggery units into profitable and resilient enterprises. The following two success stories from Ukhrul and Senapati districts of Manipur, illustrate how knowledge empowerment and locally adaptive technologies can significantly uplift rural livelihoods and promote community-based dissemination of improved livestock management practices.

Shri Songaning's success in pig rearing from Shangshak village: Shri Songaning, a resident of Shangshak Khullen village, Ukhrul district, Manipur, is one of the progressive farmers benefitting from the Farmer FIRST Programme (FFP) implemented by Central Agricultural University (CAU), Imphal. Under the livestock-based livelihood intervention, he initially received four piglets. Although one piglet succumbed early, he continued rearing the remaining three using locally available and low-cost feed resources such as kitchen waste, colocasia, banana stem, pumpkin, maize, and rice brew residue. He also invested around ₹3,000 annually in basic veterinary care and limited use of commercial feed.

Before the intervention, Shri Songaning had an interest in pig rearing but lacked adequate scientific knowledge and technical skills. The FFP bridged this gap by providing hands-on training, scientific guidance, and continuous technical support. Consequently, he adopted improved husbandry practices, maintained better hygiene and disease control, and enhanced pig health and productivity.

Through these improved practices, he achieved a net annual income of ₹56,500 from his piggery unit. He sells adult pigs at ₹16,000 each and piglets at ₹6,500 each. By incorporating local pig breeds to meet household consumption and market demand, he has strengthened food security and income stability. This case exemplifies the impact of technical support and resource optimization in transforming rural livelihoods through scientific pig farming under the FFP. It also demonstrates potential for replication in other remote areas with similar agro-ecological conditions.

Story of Shri S Lawrance, Maopungdong Village: Shri. S Lawrance, a progressive farmer from Maopungdong village, Senapati district, Manipur, is another successful beneficiary of the Farmer FIRST Programme (CAU, Imphal). Prior to the intervention, he had limited knowledge of scientific pig rearing practices. After attending training and capacity-building sessions under the project, he began implementing improved husbandry techniques. Under the FFP initiative, he received three piglets, two males and one female. One male pig was reared to maturity and sold for ₹15,000, while the female pig attained reproductive maturity within the first year and farrowed eight piglets. Despite losing two piglets at birth, a common case of pre-weaning mortality, the remaining six were successfully raised under improved management.

In the same year, he sold three piglets at ₹6,500 each, generating an income of ₹19,500, while retaining others to sustain his piggery. Showing community spirit, he also donated one healthy female piglet to his elder brother, Shri S. Puijon, thus promoting horizontal dissemination of improved technologies within his village.

The success of farmers like Shri Songaning and Shri Lawrance highlights the tangible benefits of scientific interventions in livestock-based livelihood programmes. The Farmer FIRST Programme has played a crucial role in empowering rural households by building capacity, improving animal health and management practices, and fostering local innovation and knowledge sharing. These outcomes demonstrate the potential of science-led, farmer-participatory approaches to enhance income, food security, and resilience among smallholder farmers in north-eastern India.

Mushroom cultivation

Mushroom cultivation has emerged as an attractive avenue for self-employment among rural and educated youth in the north-eastern region. Owing to its low investment, minimal space requirement, and quick returns, it has become a popular enterprise in rural, suburban, and urban settings. Among the different species, oyster mushrooms are particularly preferred for their ease of cultivation, high yield potential, and nutritional value. However, the availability of quality spawn, a critical input for successful cultivation, continues to be a limiting factor.

To address this challenge, the ICAR Research Complex for NEH Region, Umiam, Meghalaya, under the Farmer FIRST Programme (FFP), has been promoting scientific training and low-cost technologies for spawn production and mushroom entrepreneurship. The success story of Shri Raymond B Marwein, an educated youth from Umsmu village, Ri-Bhoi district, exemplifies how knowledge empowerment, innovation, and scientific intervention can transform rural livelihoods and inspire youth toward agri-entrepreneurship.

Shri Raymond B Marwein, a postgraduate in Pharmacy (M. Pharm) with distinction, was an unemployed youth seeking livelihood opportunities when he first visited ICAR Research Complex for NEH Region, Umiam. During his visit, he was introduced to the scope of mushroom cultivation and the growing

  

Mushroom unit of Shri Raymond

demand for quality spawn in the region. Recognizing this opportunity, he decided to pursue mushroom entrepreneurship and enrolled in a seven-day intensive training programme on "Mushroom Spawn Production and Entrepreneurship Development" organized under the FFP.

The training covered both theoretical and practical aspects, tissue culture preparation, substrate development, production of mother and commercial spawn, and quality control. Special emphasis was given to low-cost methods developed by the institute to support small-scale entrepreneurs.

Establishing a low-cost spawn production unit: With the knowledge and skills acquired, Shri Raymond established a low-cost mushroom spawn production laboratory in his village. He converted two small rooms into functional workspaces with a 5×4 sq. ft. inoculation room and a 4×4 sq. ft. incubation room equipped with wooden racks. To minimize initial investment, he used conventional equipment, a pressure cooker for sterilization, an inoculation hood in place of a laminar airflow cabinet, and a well-maintained room for incubation instead of a BOD incubator.

Starting small, he prepared 500 ml of culture media in two flasks. Although half of the initial media was contaminated, his perseverance led to successful isolation of pure cultures from the samples provided by ICAR. From these, he produced 23 mother spawn packets (250 g each) with a success rate of 91.3%, and later expanded to 230 commercial spawn packets (500 g each) in his first production batch.

Sustaining and scaling the enterprise: At present, Shri Raymond produces around 500 packets of commercial spawn per week, with consistent demand from neighboring villages for 350–400 packets. He sells the spawn at ₹100/kg and also cultivates fresh mushrooms for use in tissue culture and as a source of mother spawn. His homestay business also benefits, as fresh mushrooms are served to guests, adding value to his integrated enterprise.

The initial investment of ₹90,000 covered basic infrastructure renovation and 120 mandays of labour. His current gross monthly income from spawn and fresh mushroom sales is approximately ₹40,000. His long-term goal is to upgrade his laboratory with advanced facilities and transform Umsmu village into a hub of mushroom production, creating local employment opportunities for rural youth.

Towards an integrated farming system

Building on his success, Shri Raymond has expanded his activities to establish a small-scale integrated farming system on his family land. The system includes piggery, fish culture in two ponds, vermicomposting using spent mushroom substrates, and vegetable cultivation. This holistic approach ensures resource recycling, environmental sustainability, and diversified income generation. His journey serves as an inspiration for other educated youth in Meghalaya to engage in scientific agriculture and allied sectors.

SUMMARY

The Farmer FIRST Programme (FFP), implemented by Central Agricultural University, Imphal, and ICAR Research Complex for NEH Region, Umiam, has significantly empowered rural livelihoods in north eastern India through scientific interventions in pig rearing and mushroom cultivation. Success stories of Shri Songaning from Ukhrul district and Shri S. Lawrance from Senapati district demonstrate how hands-on training, technical guidance, and input support transformed traditional piggery units into profitable, resilient enterprises, improving income, nutrition, and food security. Meanwhile, Shri Raymond B Marwein from Ri-Bhoi district established a low-cost mushroom spawn production unit after undergoing FFP training, generating regular income, employment opportunities, and promoting youth entrepreneurship. By integrating piggery, mushroom cultivation, fish farming, and vermicomposting, these interventions exemplify sustainable, resource-efficient farming systems. Collectively, these cases highlight the transformative impact of participatory, science-led, and locally adaptive technologies in enhancing livelihoods, promoting community-based knowledge dissemination, and inspiring rural youth toward agri-entrepreneurship and integrated farming practices across north eastern India.

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Trace mineral supplementation in cattle
reduces somatic cell count: Evidence from Farmer FIRST Programme

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The intervention to prevent mastitis through nutritional interventions was undertaken under the ICAR's flagship extension programme entitled Farmer FIRST Programme. It was found in earlier surveys that there was prevalence of mastitis in the adopted villages. To address this, trace mineral feeding was chosen as a strategic technological input along with advisories on ration balancing, and prevention of mastitis. The somatic cell count was chosen as an indicator of assessment, which is widely used for assessing the milk quality and diagnosing sub-clinical mastitis. Among the adopted villages in District Barnala, two villages namely Hamidi and Dhaner were selected for the intervention, from which a total of 90 cattle farms, 45 from each village with less than 10 dairy animals were selected for methodological coherence and prescriptive standards of biological research. Commercially available trace mineral supplement (comprising Zn, Cu, Mn and Fe) was distributed to the beneficiary farms and advised to feed the same to cattle at the rate of 20g/animal/day for 30 days. The data for somatic cell counts (SCC) were collected before and after the intervention from 90 farms. The results revealed drop in somatic cell count in milk from average 196.99 x 103 cells/ml of milk to 159.22 x 103 cells/ml which was found significant. However, it may be a small decrease in SCC as far as mastitis was concerned but provided evidence, which aligns with the established pattern of science, proved concerted role of trace mineral supplementation in prevention of mastitis.

Keywords: Cattle, Mastitis, Ration, Somatic cell count, Trace minerals

THE strategic position of India in livestock production has constantly been improving over time. From net importer of dairy products, the journey, which traverse over a quarter century, has positioned India at higher stakes in dairy production. As per latest BAHS (2024), India stands at zenith and owns a global share of 24% in milk production. This is because of the overarching efforts of Indian farmers and scientists backed by policy framework from the government. The technology-driven extension has been playing an unequivocal role in uplifting the socio-economic status of the farmers by guiding through better nutrition, management, healthcare, marketing, etc. All the actors in dairy production from universities to research institutions, associations to non-governmental organizations, outreach centres to line departments, both union and state ministries, etc. play a crucial role in overall development of the dairy sector in India.

Mastitis in general and subclinical mastitis (SCM) in particular, is often termed as the "invisible thief" of the dairy industry, and its economic impact on the resource-constrained Indian dairy sector is devastating. Multiple studies and meta-analyses estimate the average prevalence of SCM in India to be between 30–50% at the cow level and can be as high as 70–80% in some organized farms. Furthermore, mastitis is the most common and expensive disease of dairy animals, with SCM being 15–40 times more prevalent than clinical mastitis. The economic loss from this disease breaks the spine of dairy industry and is not from a single factor, but a combination of direct and indirect losses. The total annual economic loss due to mastitis in India is estimated to be a staggering ₹7,000 crores to over ₹11,500 crores (approx. USD 840 million to 1.4 billion). A significant portion of this around 70 percent is attributed to subclinical mastitis. Another economic factor due to

SCM is 'price penalty' which is largely implicit, due to increased Somatic Cell Count (SCC). Increase SCC leads to reduced shelf life, poor taste, and problems in processing (e.g. lower cheese yield). Losses can also be attributed to discarded milk and increased culling of the animals (NDRI 2019).

However, there is an intricate network of technologies for detection, prevention and management of mastitis. In this article, we have discussed the outcomes of trace mineral supplementation in dairy cattle for prevention of mastitis after pursuing purposive research in the adopted villages under the Farmer FIRST Programme (FFP).

Context of trace mineral supplementation

Trace minerals are critical for a robust immune system. Deficiencies in key minerals like Zinc (Zn), Copper (Cu), Cobalt (Co), Manganese (Mn), etc. directly impair the cow's ability to prevent and fight off the intramammary infections that cause mastitis. In India, where soil deficiencies are common and conventional feed often lacks adequate minerals, strategic supplementation is not just beneficial, it is essential for udder health and profitability. Mastitis is an inflammation of the udder, primarily caused by bacteria. The cow's defense system, specifically the white blood cells (leukocytes), must move from the blood into the milk to engulf and destroy these pathogens. This process is called leukocyte migration. Trace minerals are co-factors for enzymes and proteins that make this defense effective.

In the current intervention, a commercially available high-potency trace mineral supplement was used which per kg contained zinc (96 g), copper (20 g), cobalt (2500 mg), manganese (20 g), chromium (2000 mg), iodine (6000 mg) and iron (40 g). Zinc strengthens the keratin plug in the teat canal, the first physical barrier against bacteria. It also forms the part of the enzyme Superoxide Dismutase (SOD), which neutralizes free radicals produced during inflammation. Copper has antioxidant and anti-inflammatory properties whereby it acts as cofactor for Cu-Zn SOD. It helps control the inflammatory response in the udder. It is essential for "respiratory burst," the process neutrophils use to kill engulfed bacteria. Cobalt is used by rumen microbes to synthesize Vitamin B12, which is crucial for energy metabolism and immune cell function. A deficiency can lead to a sluggish immune response. Manganese along with being cofactor for SOD, is essential for glycosyltransferases, the enzymes important for cellular integrity and function. Particularly during transition period and heat stress, chromium can improve insulin sensitivity and potentially reduce the immunosuppressive effects of cortisol. A less stressed cow has a more competent immune system. High levels of iodine in teat dips are directly bactericidal. Dietary iodine helps maintain healthy, pliable teat skin, which is more resistant to chapping and bacterial entry.

Interventions under FFP

A quasi-experimental, pre-post intervention study was designed to evaluate the efficacy of a strategic technological package in improving udder health in dairy cattle. The intervention was premised on the critical role of trace minerals in immune function and the high prevalence of subclinical mastitis in the region, which incurs significant economic losses. Somatic Cell Count (SCC) was selected as the primary outcome measure due to its well-established correlation with intramammary infection and its status as a key international indicator of raw milk quality. The study was conducted in District Barnala, Punjab. The intervention was carried out over a defined period, with pre-intervention data collection followed by a 30-day intervention phase and subsequent post-intervention data collection. From the adopted villages under Farmer FIRST Project in District Barnala, two villages namely Hamidi and Dhaner were purposively selected for the intervention based on high incidences of mastitis and sub-clinical mastitis.

Within each selected village, a total of 90 cattle farms were selected, with 45 farms from each village (N=90). The farms having less than 10 dairy animals were selected and large farms were excluded to ensure methodological coherence and adhered to prescriptive standards for biological research. The core intervention was a commercially available trace mineral supplement (Teamin®), which was distributed to all 90 beneficiary farms. Farmers were instructed to feed the supplement at a standardized dosage of 20 g/animal/day. Alongside the supplement, farmers were provided with advisories on ration balancing and mastitis prevention through online and offline media. The intervention period was 30 days for each farm to ensure uniformity in assessing the short-term impact.

Data for the primary outcome variable, i.e. Somatic Cell Count (SCC), were collected twice for each farm. Milk samples were collected from all 90 farms (45 from Hamidi and 45 from Dhaner) immediately prior to the commencement of trace mineral feeding. This established the pre-interventional baseline SCC level. Following the 30-day intervention period, milk samples were collected again from the same 90 farms using identical sampling protocols, which constituted post-interventional SCC level. The composite milk samples (as per the defined protocol) were collected aseptically, preserved appropriately, and analyzed using a standardized method for SCC, using calibrated portable somatic cell counter at the Department of Veterinary Medicine, Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana, to ensure accuracy and reliability. The collected data was analyzed to determine the intervention's effect. The pre- and post-intervention SCC data was compared using a paired t-test to ascertain if the observed reduction in SCC was statistically significant. The unit of analysis was the farm-level average SCC.

Impact

The effect of the trace mineral supplementation protocol for 30 days on udder health was assessed by comparing the average Somatic Cell Count (SCC) before and after the intervention. The results demonstrated a statistically significant reduction in SCC following the supplementation period. The mean SCC across all 90 farms decreased from 196.99 × 10^3 cells/mL pre-intervention to 159.22 × 10^3 cells/mL post-intervention. This represents an absolute reduction of 37.77 × 10^3 cells/mL, equivalent to a 19.2% decrease from the baseline level. Statistical analysis confirmed that this reduction was significant at $p< 0.05$, indicating that the observed effect is unlikely to be due to random chance.

While the post-intervention SCC of 159.22 × 10^3 cells/mL still lies above the ideal threshold for uninfected quarters (<100 × 10^3 cells/mL), the statistically significant ($p<0.05$) reduction is biologically and economically meaningful. This decline indicated a substantial decrease in the inflammation level within the mammary gland. The initial SCC of 196.99 × 10^3 cells/mL is indicative of a significant subclinical mastitis burden in the study population, a common challenge in Indian dairy herds as reported by Sharma *et al.* (2020). The observed 19.2% reduction aligns with the established role of trace minerals in immune potentiation. Minerals like zinc, selenium, and copper are co-factors for critical enzymes in the antioxidant defense system (e.g. Glutathione Peroxidase, Superoxide Dismutase), which protects leukocytes from oxidative damage during phagocytosis, thereby enhancing their ability to eliminate pathogens.

The magnitude of the SCC drop observed in this study is consistent with findings from other controlled trials. A meta-analysis by Salman *et al.* (2023) on the role of micronutrients in bovine mastitis concluded that supplementation with organic trace minerals, particularly Zinc and Selenium, consistently led to SCC reductions ranging from 15–30% percent. Furthermore, a specific study by Kumar *et al.* (2018) on crossbred cows in India found that a 60-day supplementation of a balanced trace mineral mixture resulted in a significant SCC decrease from 218 × 10^3 cells/mL to 178 × 10^3 cells/mL, a pattern strikingly similar to our findings. This consistency across studies reinforces the reliability of the present results.

It is crucial to interpret this "small decrease" in the context of mastitis dynamics. Subclinical mastitis is a chronic condition, and reversing established intramammary infections is challenging. The primary role of trace minerals is 'prophylactic rather than therapeutic'; they strengthen innate immunity to prevent new infections and help the immune system better control existing ones. The significant reduction achieved here suggests the intervention successfully enhanced the cows' immune resilience. As Weiss (2005) noted, correcting a trace mineral deficiency to manifest as an improved SCC can take 60–90 days due to the time required for immune cell turnover. The significant improvement seen in just 30 days in this trial is therefore highly promising, and a longer supplementation period would likely yield further gains.

From an economic perspective, even a modest reduction in SCC has substantial implications. A decrease in SCC is directly correlated with increased milk yield and improved milk quality (higher fat and protein content). Research by Hagnestam-Nielsen *et al.* (2009) demonstrated that for every 100,000 cells/mL reduction in SCC, milk yield can increase by up to 0.5 kg/day in the subsequent lactation. Therefore, the observed reduction of ~38,000 cells/mL in this study translates to tangible, albeit modest, production gains. When scaled across a herd and over time, this leads to significant economic benefits for smallholder farmers by reducing hidden losses, which are the hallmark of subclinical mastitis. The findings of this study provide compelling evidence that targeted trace mineral supplementation, integrated with management advisories, is an effective strategy for improving udder health and controlling subclinical mastitis in smallholder dairy systems.

Limitations and future directions

A limitation of this study is the relatively short 30-day intervention period. Future research should investigate the long-term effects of supplementation over an entire lactation, monitoring not only SCC but also the incidence of new clinical mastitis cases. Additionally, correlating the SCC data with specific bacteriological findings would provide a more granular understanding of the intervention's impact on different mastitis-causing pathogens.

SUMMARY

In conclusion, the strategic feeding of a trace mineral supplement at 20 g/animal/day for 30 days resulted in a statistically significant and biologically relevant reduction in somatic cell count. This finding provides robust, evidence-based validation for integrating targeted micronutrient supplementation into standard dairy management practices in India. By scientifically bolstering the innate immunity of dairy cattle, this approach offers a sustainable and proactive strategy to combat the pervasive economic losses inflicted by subclinical mastitis, thereby strengthening the resilience and profitability of the smallholder dairy sector.

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Livelihood transformation through pig farming

among tribal communities of Jharkhand under the Farmer FIRST Programme

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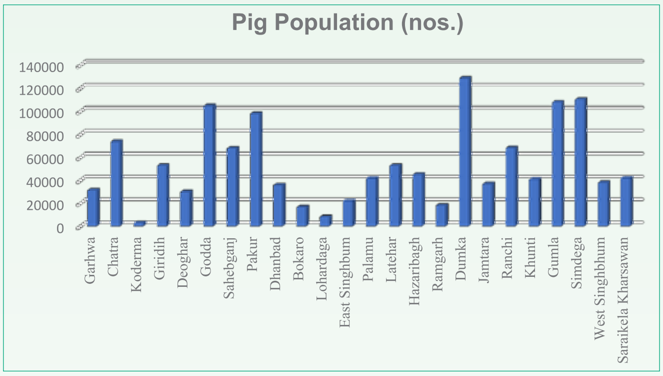
Pig farming is an important livelihood activity for tribal and marginal farmers of Jharkhand, providing a sustainable source of income, employment, and nutrition. Among the livestock systems, pig is more efficient converter of low-quality feed to high quality animal protein and also needs less feed per kg of body weight. In Jharkhand, Farmer FIRST Programme carried out in tribal villages of Ranchi district shown a remarkable growth in pig-based production system towards the sustainable livelihood of the tribes. Scientifically managed pig production system along with crossbreed namely 'Jharsuk' can play an important role in mitigating hunger, providing nutritional security and counteracting environmental degradation in the tribal area.

Keywords: Farmer FIRST Programme, Jharsuk breed, Pig farming, Tribal livelihood

PIG farming stands as a cornerstone livelihood for marginalized rural communities, serving as a financial cushion for economically weaker sections. Pigs are generally known for their superior feed conversion efficiency, rapid growth, short reproductive cycle, and high carcass yield, offer a low-maintenance yet highly rewarding enterprise. Their ability to convert agricultural waste into high-quality protein further enhances their value in sustainable food systems. In return, pigs provide highly nutritious animal protein and fat in the form of pork, a valuable addition to the human diet. With minimal investment in housing, equipment, and labour, pig farming remains an economically viable venture, yielding swift and substantial returns. This makes it a crucial source of livelihood and financial upliftment for rural communities.

Challenges in pig farming in Jharkhand

As per the Livestock Census of 2019, Jharkhand is home to a total of 12,76,973 pigs, out of which 10,08,966 pigs are indigenous, while only 2,68,010 are crossbred or exotic varieties. In the Ranchi district alone, the pig population stands at 68,396, the vast majority of which, 56,347, are indigenous pigs, and just 12,049 are of crossbred or exotic lineage.



Districtwise pig population of Jharkhand as per Livestock Census (2019)

In the state, pig rearing forms an integral part of the livelihood system of tribal and marginal farmers. These farmers predominantly rear desi pigs—non-descript varieties lacking distinct breed characteristics. Over generations, these indigenous pigs have adapted well to local conditions, thriving in environments where scientific breeding practices are largely absent. Traditionally, pig rearing has been practiced under backyard systems using indigenous breeds, with husbandry practices often relying on unscientific breeding methods and suboptimal hygiene standards, resulting in low productivity. Consequently, poor genetics combined with inadequate management have led to significantly lower returns, limiting the economic potential of pig farming in these communities.

While such traditional systems align with the resource-conserving practices of rural households, they also expose animals to health risks and restrict productivity. The prevalence of unscientific breeding, poor hygiene, and rudimentary management practices has kept the sector stagnant, preventing it from evolving into a more organized and commercially viable enterprise.

Additionally, most tribal farmers cultivate crops such as paddy, maize, and mustard, along with vegetables and small ruminants like goats. However, delayed monsoons and mid-season droughts often lead to reduced productivity, further constraining their livelihood opportunities.

Interventions under Farmer FIRST Programme

Recognizing the potential of pig farming as a means of socio-economic upliftment, the government has actively encouraged rural communities to adopt more scientific and organized approaches to pig rearing. Addressing these challenges, the Farmer FIRST Programme (FFP) of the Indian Council of Agricultural Research (ICAR), through its project centres at Birsa Agricultural University (BAU), Ranchi, and ICAR-RCER, FSRCHPR, Ranchi, has been instrumental in transforming subsistence-driven pig farming into a sustainable and economically rewarding enterprise among tribal communities.

Under the Farmer FIRST Programme, scientific pig farming interventions were introduced in the operational areas by BAU, Ranchi, and ICAR-RCER, FSRCHPR to enhance farmers' income, employment, and nutritional security. For this purpose, an improved pig breed '*Jharsuk*' meaning "pigs of Jharkhand"developed under the AICRP on Pig by BAU, Ranchi, was propagated through the project. This breed exhibits superior economic traits compared to local pigs. '*Jharsuk*' pigs can attain a body weight of around 80 kg at 8–10 months of age and produce 8–12 piglets per farrowing, with two farrowings per year. The breed demonstrates faster growth, lower maintenance costs, better feed conversion efficiency, and improved reproductive performance compared to other indigenous pig breeds.

Sensitization of farmers under the project

The intervention was primarily implemented in tribal villages of Ranchi district, namely Chipra, Jhabutoli, Panchdiha, Kutiyatu, Malti, and Tetri, which are predominantly vegetable-growing areas where farmers also rear small livestock such as pigs, poultry, and goats for domestic use. A survey using the Participatory Rural Appraisal (PRA) approach was conducted to assess the prevailing situation in the operational area. Beneficiary farmers were selected based on a baseline survey, prioritizing those with prior experience in pig rearing and ownership of a few animals.

The selected farmers were initially sensitized to the importance of scientific pig farming and its role in improving livelihood and income security through group discussions and awareness programmes. Subsequently, interested farmer groups received specialized training on scientific piggery, covering aspects such as housing, feeding, breeding, and health management, including vaccination, deworming, and disease prevention. Demonstrations on balanced feed formulation using locally available resources were conducted, and one-month-old piglets, along with essential inputs such as pig mineral mixtures and medicines, were distributed to the beneficiaries.

In addition, farmers were advised to diversify their cropping systems by introducing high-value crops and improved technologies during the *kharif* and *rabi* seasons. This integration of livestock and crop interventions resulted in higher yields and substantial increases in income.

Impact

Economic impact: Since the inception of the Farmer FIRST Programme, pig farming in the project areas has made a substantial contribution to enhancing the overall household income of tribal farmers. The introduction of the Jharsuk breed, coupled with scientific management practices, has resulted in remarkable income improvements. In most cases, annual household

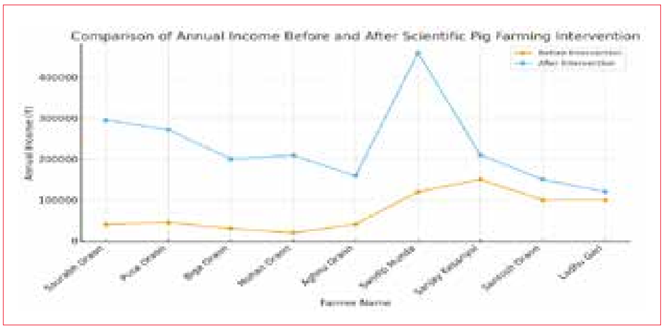
Traditional way of free-range rearing of pigs

Intensive pig production system

income increased from ₹27,000–55,000 to ₹55,000–85,000, representing a 200–900% rise in some instances. A few progressive farmers, who expanded their piggery from 1–2 pigs to 10 pigs, are now earning net incomes of ₹3–4 lakh annually. The sale of piglets and pork has ensured a steady cash flow, while improved feeding and healthcare practices have reduced mortality rates.

Table 1. Impact of intervention on different enterprises

Enterprise	Name of Crop/ Livestock	Area (acre)	Before Net Income (₹)	After Net Income (₹)
Field Crop	Rice/Maize/ Wheat/Mustard	1.0-4	20,000–25,000	25,000–35,000
Horticultural Crop	Elephant foot yam/ Bitter gourd/ Cucumber/Pea/ Okra/Tomato Cauliflower	0.5–1.0	10,000–20,000	15,000–25,000
Livestock	Desi Pig/Goat/ Poultry	2–10	7,000–10,000	15,000–25,000
Total Annual Net Income (₹)		0.5–4	27,000–55,000	55,000–85,0000



Moreover, diversification of livelihood activities through pig farming has reduced dependence on rainfed agriculture, providing resilience against climatic and seasonal uncertainties. This integration of piggery with other farming practices has strengthened financial stability and enhanced overall livelihood security for the tribal households.

Social and environmental impact: Pig farming has also generated notable social and environmental benefits. The regular availability of pork has improved household nutritional security and dietary diversity. Employment opportunities within families, particularly for women, have increased as pig rearing developed into a household-level enterprise. Additionally, the effective utilization of pig manure as organic fertilizer has contributed to soil health and promoted eco-friendly farming practices.

The graphical representation of annual income before and after the adoption of scientific pig farming interventions clearly demonstrates substantial income increases among nearly all progressive farmers, highlighting the positive impact of improved piggery management practices on livelihoods. Farmer-to-farmer extension, led by progressive farmers trained under the programme, has emerged as a local resource network, guiding and motivating other community members to adopt pig farming as a sustainable livelihood option. The success stories of farmers such as Shri Saurabh Oraon, Shri Pusa Oraon, and Shri Biga Oraon underscore the potential of livestock-based diversification for promoting sustainable rural development.

SUMMARY

The adoption of scientific pig farming practices under the Farmer FIRST Programme has transformed traditional subsistence systems into profitable enterprises, ensuring livelihood security, increasing income levels, and strengthening the rural economy of Jharkhand.

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From dairy farming to dairy processing:

A story of rural entrepreneurship

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Dairy farming plays a vital role in strengthening the rural economy by providing farmers with a steady and reliable source of additional income. Along with crop cultivation, dairy has become an important livelihood activity that ensures daily cash flow and financial stability for farming families. By taking a step further into dairy processing, farmers can transform raw milk into value-added products such as curd, paneer and ghee for much higher returns compared to selling liquid milk alone. Processing not only helps in extending shelf-life and reducing spoilage but also enables farmers to build their own brands in local markets. With proper training, technical support, and entrepreneurship development, farmers can acquire skills in processing, packaging, and marketing, becoming self-reliant entrepreneurs. Thus, dairy farming and processing together create a sustainable model that enhances income, employment opportunities, and rural prosperity, making it a powerful tool for empowering the farming community. S. Jasveer Singh, from village Hamidi, district Barnala, is such an examplary to illustrate how scientific guidance, training, and entrepreneurship can transform rural livelihoods.

Keywords: Digital marketing, Family enterprise, Farmer FIRST Programme, Milk products, Value-addition

DAIRY farming is a cornerstone of rural livelihoods, providing farmers with a reliable source of income, nutritional security, and daily cash flow. Beyond traditional milk production, value addition through dairy processing enables farmers to transform raw milk into products such as curd, paneer, ghee, and sweets, significantly increasing profitability. By integrating modern processing techniques, packaging, and marketing strategies, farmers can establish sustainable enterprises that generate employment and strengthen household economies. The ICAR–Farmer FIRST Programme, implemented by Guru Angad Dev Veterinary and Animal Sciences University (GADVASU), Ludhiana, has been instrumental in promoting such entrepreneurial initiatives. The journey of S. Jasveer Singh from Hamidi village exemplifies how training, technical guidance, and entrepreneurial support can convert conventional dairy farming into a thriving value-added business, empowering rural households both economically and socially.

Success story of Shri Jasveer Singh: Beneficiary farmer under Farmer FIRST Programme

The story outlines the initial adoption of Shri Jasveer Singh's village, Hamidi, under the ICAR–Farmer FIRST Project, implemented by Guru Angad Dev Veterinary and Animal Sciences University (GADVASU), Ludhiana. During the early camps and demonstrations organized by the Farmer FIRST team at Hamidi, Shri Jasveer Singh came into close contact with GADVASU scientists and developed an interest in modern dairy processing and value addition techniques. A former army man, he used to run a small dairy shop in his village and owned a small farm of buffaloes. His interest deepened with time, his curiosity turned into passion, and he finally voiced his ideas to become an entrepreneur.

Motivated by these exposure visits from the Farmer FIRST Project team, he decided to upgrade from traditional liquid milk selling to value-added dairy entrepreneurship. In January 2025, Shri Jasveer Singh attended a five-day value addition training programme at the College of Dairy and Food Science Technology, GADVASU, where he received hands-on training in milk processing, product diversification, packaging, hygiene, and marketing.

Inspired by the training, he established his own dairy processing unit in his village after numerous consultations offered by the Department of Dairy

Shri Jasveer Singh working at his milk plant

Family of Shri Jasveer Singh packing milk-based sweets together

Shri Jasveer Singh receiving 'Progressive Entrepreneur' award at Pashu Palan Mela 2025 at GADVASU

Engineering for commissioning of the plant. At his plant, Shri Jasveer Singh now produces and markets Dahi (curd) in 5 kg and 15 kg packs, and desi ghee. His focus on maintaining quality, cleanliness, and consistency has earned him a strong local customer base. As a result, his profit margins have multiplied. From selling cow milk for ₹45/L and buffalo milk for ₹60/L, he now sells ghee for ₹900/kg, curd for ₹66/kg, paneer for ₹350/kg, and butter for ₹600/kg, which truly shows the importance of value addition of milk in doubling his income. Due to the surge in demand, he now also prepares sweets like khoya barfi, milk cake, khoya pinni, kalakand, etc. Furthermore, several dealers regularly visit his plant to procure his products owing to their purity and quality.

Recognizing the importance of modern marketing, Shri Jasveer Singh has also stepped into the digital space. He is active on social media and has started advertising his products on Instagram, expanding his reach to urban consumers and nearby towns. His use of digital platforms for branding and sales reflects his progressive mindset and entrepreneurial spirit.

The establishment of Shri Jasveer Singh's dairy processing unit has not only augmented his income but also created meaningful employment opportunities for his entire family. Every family member now contributes actively to different stages of milk processing, packaging, and marketing. Both men and women work together with equal dedication from handling milk and preparing dahi to managing sales and customer relations. The involvement of women in the enterprise has boosted their confidence, decision-making ability, and financial independence. Shri Jasveer Singh's mother proudly shares that both brothers and their families now work hand in hand, turning the unit into a true family-based entrepreneurship model. This collective effort has strengthened family bonds, enhanced profitability, and set a shining example of how value addition in dairy can empower rural households both economically and socially.

SUMMARY

Shri Jasveer Singh's journey truly represents the spirit of "Farm to Market" entrepreneurship. With the support of the ICAR–Farmer FIRST Programme and training from GADVASU, he has transformed himself from a visionary dairy farmer into a successful dairy processor and marketer. His story highlights how entrepreneurship development, training in value addition, and digital promotion can empower rural youth to create sustainable and profitable enterprises in the dairy sector. Shri Jasveer continues to work closely with GADVASU experts, motivating other farmers in his village to adopt value addition and scientific dairy management for better income and livelihood security.

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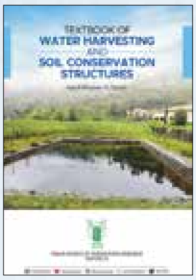

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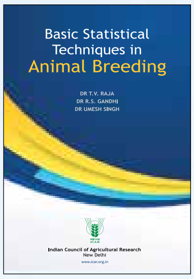

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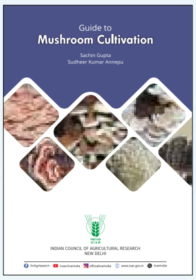

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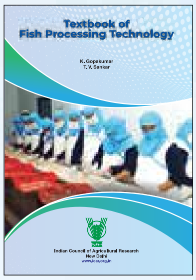

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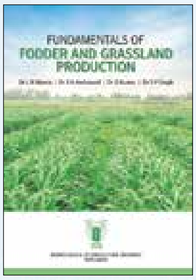

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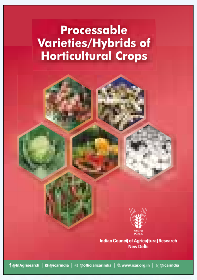

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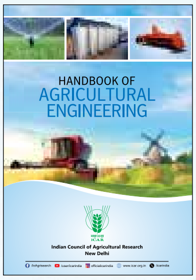

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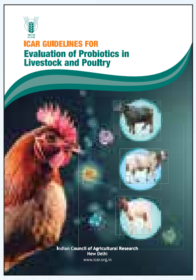

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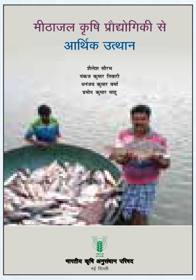

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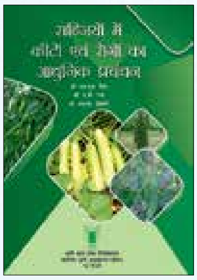

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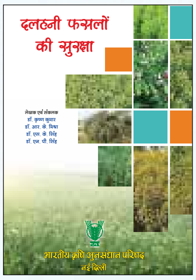

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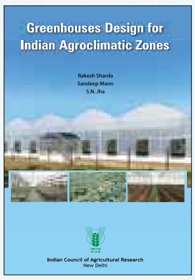

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