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ECONOMIC EVALUATION OF RICE PRODUCTION UNDER THE FARMER FIRST PROGRAMME: EVIDENCE FROM SMALLHOLDER FARMERS OF JABALPUR, MADHYA PRADESH, INDIA

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ABSTRACT

This study assessed the economic impact of the Farmer FIRST Programme (FFP) on rice cultivation among smallholder farmers in Jabalpur district, Madhya Pradesh, during the kharif season (January 2023–December 2024). A comparative analytical framework examined three distinct cohorts: FFP beneficiaries (G1, n=71), non-beneficiaries from adopted villages (G0, n=51), and non-beneficiaries from different villages (G2, n=52). Economic indicators revealed significant advantages for FFP participants, with G1 farmers achieving substantially higher gross revenue (Rs. 100,228) compared to G0 (Rs. 91,152) and G2 (Rs. 90,272), and greater net income (Rs. 54,992) relative to G0 (Rs. 46,124) and G2 (Rs. 45,979). FFP beneficiaries also demonstrated a more favourable B:C ratio (2.21) versus non-beneficiary groups (approximately 2.02). Statistical analysis through correlation and univariate generalized linear modelling revealed that while control groups exhibited significant negative associations between demographic factors (age, gender, caste) and economic outcomes, these socioeconomic disparities were effectively neutralized in the intervention group. Educational attainment emerged as the sole consistent predictor of economic performance across all groups, irrespective of intervention status. These findings substantiate FFP's dual impact in enhancing overall agricultural productivity while simultaneously promoting socioeconomic equity among smallholder rice producers.
***Keywords*:** Farmer First Programme, Rice farming, Smallholder farmers, Economic impact.

Introduction

Rice (*Oryza sativa* L), serves as an essential dietary staple and a principal source of livelihood for majority of small-scale farmers (Wassmann and Dobermann, 2007; Saha *et al.,* 2021). On a global scale, farms classified as smallholdings, encompassing less than 2 ha, account for 83% of the approximately 537 million agricultural operations, with Asia accommodating 87% of these, including India, which possesses 117 million such farms, representing 23% of the world's smallholdings (Fanzo, 2017). According to the Agriculture Census 2015–16, 86.1% of agricultural practitioners in India are categorized as small and marginal with less than 2 ha land. These smallholder farms, are particularly vulnerable to systemic challenges, and fluctuations in climate (Gathala *et al.*, 2011; Venkatesan *et al*., 2016).

In Madhya Pradesh, rice farming during the kharif season represents a significant segment of rural agricultural endeavors (Jambhulkar *et al.,* 2024) where the cropping framework is predominantly characterized by monsoon-dependent cultivation. The state of Madhya Pradesh has experienced variations in rice output, achieving a production level of 7,020,000 tone in 2023 an appreciable increase from 4,810,000 t in 2022. At the national level, India's total rice production for the 2023–24 period is projected to reach a historic high of 137.825 mt. The strategic significance of rice cultivation in the Jabalpur region is emphasized not only by its socio-economic relevance and implications for food security but also by its prospective role in fostering climate-resilient agricultural practices, particularly in the context of escalating climate uncertainties (Aggarwal, 2008).

Rice productivity levels among smallholders frequently remain suboptimal due to variables such as restricted access to contemporary agricultural technologies, insufficient extension services, and susceptibility to climatic fluctuations (Feder *et al*., 1985). These impediments have necessitated the development and execution of innovative, farmer-centric models aimed at enhancing productivity and income stability. One such initiative is the Farmer FIRST Programme (FFP), launched by the Indian Council of Agricultural Research (ICAR), which endeavors to amalgamate scientific research with farmers' experiential knowledge to enhance agricultural productivity and ecological sustainability (Singh *et al*., 2016). The FFP promotes on-farm research, collaborative technology development, and ongoing skill enhancement through grassroots within practical farming contexts.

Profitability of rice farming is influenced by the availability of institutional support, improved agronomic practices, and financial incentives (Bravo-Ureta and Evenson, 1994). A multitude of empirical investigations (Kharel *et al*., 2021) have utilized economic metrics such as gross returns, gross margins, and benefit-cost ratios (BCR), to assess the profitability inherent within rice farming systems along with input–output dynamics and financial sustainability associated (Akite *et al*, 2022). Nevertheless, there exists a paucity of empirical research that has critically analyzed the differential impact of structured agricultural initiatives, on the economic parameters across analogous socio-ecological contexts.

This research on beneficiary's vs non beneficiaries of FFP endeavours to fill this void by conducting an economic analysis targeting the smallholder demographic a group that is both economically vulnerable and pivotal to India's food production framework (Pingali and Rosegrant, 1995). The adoption of novel agricultural methodologies among smallholders is further influenced by social networks, risk perceptions, and diffusion processes, all of which are susceptible to the effects of institutional interventions like the FFP (Feder *et al*., 1985). By investigating the extent to which participation in the FFP affected the economic outputs of rice farming, this study augmented the understanding of the role those participatory institutional innovations played in bolstering smallholder resilience. Additionally, by incorporating non-beneficiaries from both inside and outside the village, the research also examined the pathways of knowledge dissemination and the dynamics of informal technology transfer, aligning with broader paradigms in development economics that highlighted the implications for peripheral stakeholders (Krishna, 2004; Fanzo, 2017).

Materials and Methods

About Farmer First project and study site

Farmer FIRST project implemented by Nanaji Deshmukh Veterinary Science University; Jabalpur entitled" Improved Integrated practices through IFS farming" project aims to improve the livelihood of small holder farmers of Madhya Pradesh through IFS module. The project was implemented in 6 villages in Jabalpur Block namely Padariya, Silua, Chattarpur, Deori, Kailwas and Ghana.

The research design incorporated a comparative framework comprising three groups: (1) FFP beneficiaries (Intervention Group-$G_{1)}$), (2) non-beneficiaries within the same village (internal control group-G_0), and (3) non-beneficiaries from outside villages (external control group-G_2). This design allowed for a nuanced analysis of both the direct and indirect impacts of the FFP intervention on the economic performance of rice cultivation. Moreover, such an approach also enables the exploration of potential spillover effects, where informal knowledge exchange and community-level learning can influence neighbouring non-participants (Krishna, 2004). For improving sampling accuracy, a multi stage stratified sampling framework was employed. To increase the robustness of comparison propensity score matching (nearest neighbour matching) was employed where respondents in the control groups were matched with intervention group on key baseline characteristics like years of schooling. Farming experience and land holding. Thus, the study selected 240 IFS farmers -120 from intervention group, 60 each from internal and external control group. But of the total farmers, only 174 farmers were involved in rice farming which includes, 71 farmers from FFP intervention Group (G_1), 51 farmers from the Internal control group and 52 farmers from external control group. This study adopted a quantitative analytical framework to rigorously assess the economic viability of rice production systems in Jabalpur, Madhya Pradesh conducted over a period of 6 months (June 2024-November 2024) so as to capture the full spectrum of production activities from land preparation through harvest. This temporal coverage enabled thorough documentation of all input applications, management practices, labor allocations, and yield outcomes essential for robust economic analysis of rice production systems under varied intervention conditions in Jabalpur, Madhya Pradesh.

Methods of data Collection

This study employed action research to assess the economic outcomes of rice farming among smallholder farmers in Jabalpur, comparing beneficiaries and non-beneficiaries of the Farmer FIRST Programme (FFP). Face to face interviews were collected from farmers during different stages using structured schedule to estimate the economics of rice farming.

Cost and Revenue Estimation

Economic performance was evaluated based on several key variables, operationally defined and measured as detailed. The economic evaluation was anchored on a suite of financial metrics designed to capture the multi-dimensional nature of rice production economics. Cost structures were disaggregated into non-recurring and recurring expenditures. Non-recurring costs included capital investments such as land development, irrigation infrastructure, farm machinery, and durable storage facilities. These were annualized using the capital recovery factor method to reflect their contribution over the asset's useful life. Recurring costs, which comprised operational expenditures, were captured ha^{-1} and encompassed pre-planting inputs (seeds, land preparation), crop establishment (transplanting or direct seeding), crop management (fertilizer, pesticide, herbicide, fungicide applications), resource inputs (irrigation volume and energy costs), harvest and post-harvest activities (labor, threshing, drying, packaging, transport), marketing costs (market fees, commissions), and financial costs (interest on working capital, insurance premiums). The total recurring cost (TRC) was calculated by aggregating the product of quantity and unit price for each input item.

Revenue estimation accounted for both the main output (milled rice) and by-products (straw, husk, bran), with the gross revenue (GR) calculated as the sum of the product of output quantities and their respective market prices. Gross income (GI) and net income (NI) were derived by subtracting variable and total production costs, respectively, from the gross revenue. The benefit-cost ratio (BCR), a key indicator of economic efficiency, was computed as the ratio of gross revenue to total production cost for a single-season analysis, and as the ratio of present value of benefits to present value of costs for multi-period investment scenarios.

Primary data were meticulously collected from the rice producers, capturing detailed input-output records for each farm. These were complemented by direct field measurements, including yield assessments via crop cutting experiments, and triangulated with available farm records and receipts. Secondary data were obtained from governmental agricultural databases, market monitoring systems, research institution archives, and meteorological sources, ensuring contextual alignment and data robustness.

Statistical Analysis

Data analysis employed a range of statistical and econometric techniques. Descriptive statistics provided foundational insights into the central tendencies and dispersion of key economic indicators. To analyze the differences in economic outcomes among the three farmer groups (G_1, G_0, and G_2), Welch Analysis of Variance (Welch ANOVA) was employed. This robust method was chosen due to the violation of the homogeneity of variance assumption, as indicated by Levene's test ($p \leq 0.05$). Welch ANOVA accommodated unequal group variances and sample sizes, providing more reliable comparisons than standard ANOVA under such conditions.

Following a significant result in the Welch ANOVA, pairwise comparisons between the groups were conducted using the Games-Howell post hoc test. The Games-Howell test was suitable for situations with unequal variances and sample sizes, offering a more accurate assessment of which specific group means differ significantly while controlling for Type I error. All statistical analyses, including Welch ANOVA and the Games-Howell post hoc test, were conducted using the R statistical software (version 4.2.2). This comprehensive statistical approach ensured a rigorous examination of the economic impacts of the FFP on rice farming among smallholder farmers in the study area.

While the methodological rigor of this study was high, certain limitations were acknowledged. Reliance on farmer recall for some input variables might introduce recall bias, although this was mitigated through validation against farm records and input receipts. Regional price data were used, which might limit generalizability to other markets. Environmental externalities, such as impacts on soil and water quality, were not monetized. Family labor was valued at local prevailing wage rates, which might under represent true opportunity costs. The long-term sustainability implications, including effects on soil fertility and pest resistance, were beyond the scope of this economic analysis.

To ensure data reliability and validity, multiple verification procedures were employed. Triangulation with secondary sources strengthened the credibility of primary data. A subsample (15%) of surveyed farms underwent field verification to cross-check reported figures with observed practices. Preliminary findings were reviewed by an expert panel comprising agronomists, economists, and extension specialists. Finally, the study benchmarked its outcomes against existing literature and prior studies conducted in comparable agro-ecological settings, thus situating its findings within the broader discourse on rice production economics in India

Results and Discussion

The socio-economic profile and economic parameters of the respondents are given in table 1 and 2.

Table 1: The Socio-economic Profiles of the Respondents (Rice farmers)

Characteristic	Category	G0 (n=51)	G1 (n=71)	G2 (n=52)	Total (n=174)
Age	Young (<30 yrs.)	08	02	00	10
	Middle (30–45 yrs.)	35	41	39	115
	Old (>45 yrs.)	08	28	14	50
Education	Illiterate (0 years)	10	20	07	37
	Primary (1–4 years)	04	10	13	27
	Middle school (5–7 yrs)	03	04	04	11
	High school (8–10 yrs)	09	15	13	37
	Intermediate (11–12 yrs)	18	14	12	44
	Above Intermediate (>12 yrs)	07	08	04	19
Religion	Hindu	51	71	52	174
Caste	General	20	11	18	49
	OBC	14	21	19	54
	SC	10	21	10	41
	ST	07	18	06	33
Primary Occupation	Agriculture	45	63	49	
	Animal Husbandry	0	01	0	01
	Wage labour	04	04	03	11
	Government services	0	01	0	01
	Private services	02	02	0	04
Land Holding (Acre)	Large (4–6)	00	01	01	02
	Medium (2–4)	24	32	21	77
	Small (0–2)	27	38	31	96

Table 2: Mean values of economic indicators of rice farming (in rupees ha^{-1})

Economic Indicator	G0	G1	G2
Rental value+ land tax	10528±828.75	10669±851.59	10498±826.91
Depreciation (at 10%)	743.47±41.39	744.10±37.94	743.73±41.81
Interest on fixed capital	1127.11±82.91	1141.38±85.16	1124.16±82.82
Non-recurring cost	12398.5 ± 912.03	12555 ± 936	12365 ± 908
Hired value of labour	4458.64±202.90	4430.13±174.29	4459.38±203.17
Hired value of machinery	4755.98±197.88	4750.10±183.31	4759±195.89
Imputed value of family labour	4874.36±167.60	4909.70±171.78	4870.82±166.08
Cost of seeds	6331.42±522.90	6350.87±571.79	6317.80±521.67
Cost of pesticide & insecticide	1505.55±183.47	1542.96±164.08	1505.86±181.72
Cost of manure +fertiliser	4720±122.55	4694.39±133.40	4722.85±123.85
Cost of irrigation	3848.98±363.29	3864.60±361.22	3856.57±359.38
Interest on working capital	2134.66±48.78	2137.96±57.98	2134.48±48.82
Recurring cost	32629.82 ± 745	32680.38 ± 886	32627.15 ± 746
Total cost	45028±1165	45235+1467	44993+1171
Mean production	39.63^{a}±2.72	43.58^{b}±3.09	39.55^{a}±2.73
Gross revenue	91152^{a} ± 6252	100228^{b} ± 7103	90272^{a} ± 6278
Gross margin	58522^{a} ± 6321	67547^{b} ± 7257	58345^{a} ± 6360
Net income	46124^{a} ± 6242	54992^{b} ± 7487	45979^{a} ± 6237
B:C ratio	2.025^{a}	2.21^{b}	2.022^{a}

Means bearing different superscript differ significantly

The comparative economic analysis revealed that farmers who participated in the Farmer FIRST Programme (FFP) demonstrated higher profitability in rice cultivation than their non-beneficiary counterparts. Beneficiaries exhibited increased gross returns, gross margins, and benefit-cost ratios (BCR), indicating improved input-output efficiency. This was consistent with recent findings that participatory extension models significantly enhanced the adoption of sustainable technologies and improve economic outcomes for smallholders (Babu and Joshi, 2020). Additionally, evidence suggested that integrating local knowledge with scientific innovations contributed to better agronomic decisions and resource management among beneficiaries (Limpo *et al.,* 2023).

Non-beneficiaries residing in the same locality also recorded better economic performance than those outside the intervention zone even though the difference was not statistically significant. This outcome hints at potential spillover effects, wherein the diffusion of knowledge and practices occurred informally through farmer-to-farmer interaction. Such spillover dynamics have been increasingly recognized in recent research, which emphasized the importance of social networks and geographic proximity in amplifying the reach of institutional programs (Gao *et al.,* 2023).

The cost of cultivation ha^{-1} was significantly lower for FFP participants, primarily due to the adoption of input-efficient practices such as improved seed varieties, line sowing, and timely pest and nutrient management. These results aligned with studies demonstrating that conservation agriculture often introduced through structured programs, reduced input dependency while maintaining or enhancing yields (Bell *et al.,* 2019).

Comparative analysis of Association of Socio-economic variables with economic parameters

Table 3: Correlation of socio-economic variables with Economic parameters

Variables	Total cost	Mean production	Gross revenue	Gross margin	Net income	B:C ration
Group 0 (Internal Control Group)						
Age	-0.064	-.562**	-.564**	-0.574**	-0.542**	0.505**
Sex	-0.034	-0.464**	-0.468**	-0.490**	-0.453**	-0.423**
Education	-0.170	0.270	0.272	0.312*	0.298*	0.317*
Land holding	0.034	-0.410**	-0.412**	-0.383**	-0.396**	-0.371**
Group 1 (Intervention Group)						
Age	-0.147	-0.140	-0.145	-0.117	-0.104	-.061
Sex	-0.140	-0.014	-.031	-0.029	-0.026	-.020
Education	0.005	0.607**	0.609**	0.597**	0.575**	0.515**
Land holding	0.094	0.0067	-0.068	-0.058	-0.082	-0.097
Group 2 (External control Group)						
Age	0.015	-0.474**	-0.472**	-0.490**	-0.494**	-0.497**
Sex	-0.099	-0.471**	-0.469**	-0.450**	-0.470**	-0.450**
Education	0.081	0.751**	0.749**	0.763**	0.762**	0.749**
Land holding	-0.096	-0.270	-0.265	-0.279**	-0.262	-0.248

**-correlation is significant at 0.01% level, *-Correlation is significant at 0.05% level

A significant negative association was observed between age, gender and landholding in both internal (G_0) and external (G_2) control group with economic performance indicators (gross margins, net income, and B:C ratio). Conversely, Educational attainment indicated a strong positive correlation with economic parameters across all the cohorts, including intervention group. Finding elucidated that socio demographic variables and Resources (land holding) exerted strong negative effect on production efficiency and economic viability of small holder rice farmers, however these impediments were substantially mitigated in the intervention group, which might be due to its successful developmental initiatives like training and input distribution through the programme. The counterintuitive negative correlation between landholding size and profitability metrics suggests possible diseconomies of scale in larger operations, contrasted with enhanced managerial efficiency characteristic of smaller agricultural enterprises, which predominantly leverage family labor resources for operational optimization. Studies done in various developing countries (Mwalyagile *et al*., 2024**;** Ojo and Baiyegunhi, 2023) around the world have reported a gender difference in rice production and economic parameters among small holder farmers.

To quantify the association between demographic variables and net income, the primary indicator of profitability, linear regression analyses were conducted separately for both the internal (G0) and external (G2) control groups.

Table 4: Regression coefficient of socio-economic variables with Net income for Group 0 (Internal control group)

Model	Unstandardized Coefficients		Standardized Coefficients		
	B	**Std. Error**	**Beta**	**B**	**Std. Error**
(Constant)	71798.886	6253.761		11.481	.000
Gender	-4822.400	1881.838	-.356	-2.563	.014
Age	-394.600	142.558	-.372	-2.768	.008
Edu	-100.472	177.300	-.081	-.567	.574
Land holding	-1670.930	982.751	-.210	-1.700	.096

Dependent Variable: Net income, R^2=42.2

Table 5: Regression coefficient of socio-economic variables with Net income for Group 2 (External control group

Model	Unstandardized Coefficients		Standardized Coefficients	t value	Sig
	B	**Std. Error**	**Beta**	**B**	**Std. Error**
(Constant)	45828.361	4224.186		10.849	.000
Gender	-134.661	77.373	-.177	-1.740	.088
Age	-335.157	1510.461	-.024	-.222	.825
Edu	851.166	148.056	.666	5.749	.000
Land holding	45828.361	4224.186		10.849	.000

Dependent Variable: Net income, R^2=52.1

Linear regression analyses, conducted to quantify the association between socio-economic variables and net income in the control groups, yielded distinct insights for the internal (G0) and external (G2) cohorts. For the internal control group (Table 4), gender (β = -.356, p = .014) and age (β = -.372, p = .008) exhibited statistically significant negative associations with net income. While landholding showed a negative coefficient, its association with net income was not statistically significant at the conventional p < .05 level (β=-.210, p=.096). Interestingly, educational attainment also displayed a negative coefficient, though it was not statistically significant (β = -.081, p = .574).

In contrast, the external control group (Table 5) revealed a different pattern. Here, educational attainment demonstrated a strong and statistically significant positive association with net income (β = .666, p < .001). While gender displayed a negative coefficient, its association was not statistically significant (β = -.177, p = .088). Similarly, age exhibited a negative but non-significant association (β = -.024, p = .825). Notably, landholding showed a positive and highly significant association with net income in the external control group (B = 45828.361, p < .001), a finding that contrasts with the negative coefficient observed in the internal control group.

Analysis of effects of Gender and intervention on net income

A two-way ANOVA was conducted to analyse the effect of Gender and intervention and its interaction of net income. Results are as shown in table: 6 revealed significant main effects of group and gender on net income, as well as a significant interaction. Post-hoc analysis showed that both male and female farmers in the intervention group (training and inputs) had significantly higher net income than those in the control groups. Importantly, simple effects analysis indicated a significant gender gap in net income favouring men within both control groups; however, this gender-based disparity was not statistically significant in the intervention group, suggesting that the provided training and inputs may have mitigated pre-existing gender inequalities in agricultural income.

Overall, the results confirmed that targeted institutional support under the FFP framework significantly improved the economic viability of rice cultivation for smallholders, while also generating knowledge spillovers that benefited the broader farming community.

Table 6: Means values of Net income of men and women in each group

Variables	Group 0	Group 1	Group 2	F value
Men	$48028^{a,A}$	$55,161^{b,A}$	$47626^{a,A}$	F=48.060, P=0.000
Women	$41,893^{a,B}$	$54,762^{b,A}$	$41,194^{a,B}$	
Difference	6135	399	6432	
F value of interaction (gender and group)	F=3.940, p=0.021			

Means within a row (Men or Women) with different lowercase superscripts (a, b) are significantly different across groups (p < 0.05, Bonferroni post-hoc test). Means within a column (for each group) with different uppercase superscripts (A, B) are significantly different between genders (p < 0.05)

Caste specific effect on economic parameters: Comparative analysis between intervention and control group

Table 7: Effect of caste on variables-gross returns, gross margin, B:C ratio and net income in group 0 (internal control Group)

Variables	General (n=20)	OBC (n=14)	SC (n=10)	ST (n=7)	F value
Gross returns	92345^{a}±6431	92492^{a}±6196	86020^{b}±4085	90357^{b}±6466	2.950*
Gross margins	59833^{a}±6670	60084^{a}±6370	57452^{b}±6674	58341^{b}±6490	2.837*
BC Ratio	2.04±0.17	2.07±0.13	1.93±0.092	2.00±0.151	1.926
Net income	47183±6979	47823±6088	41532±4010	45983±6460	2.418

Means bearing different superscript differ significantly

One-way ANOVA revealed significant differences across caste groups for Gross Returns (F=2.950, p=0.039) and Gross Margins (F=2.837, p=0.046), but not for BC Ratio (F=1.926, p=0.136) or Net Income (F=2.418, p=0.078). Tukey's HSD post-hoc analysis indicated that General and OBC farmers had significantly higher Gross Returns and Gross Margins compared to Scheduled Caste farmers, while no significant differences were observed between the caste groups for BC Ratio and Net Income.

Table 8: Effect of caste on variables-gross returns, gross margin, B:C ratio and net income in group 2 (external Control Group)

Variables	General (n=18)	OBC (n=18)	SC (n=10)	ST (n=6)	F value
Gross returns	$90977^{a,b}$±6222	94905^{a}±4525	86020^{b}±3385	91001^{b}±6307	7.202**
Gross margins	$58266^{a,b}$±6278	62302^{a}±4455	52835^{b}±6005	54838^{b}±2826	7.918**
BC Ratio	2.03^{a}±0.14	2.09^{a}±.087	1.88^{b}±0.065	$1.99^{a,b}$±0.064	7.853**
Net income	46146±6173	49619±4148	40417±5877	42757±2842	7.782**

Means bearing different superscript differ significantly

One-way ANOVA revealed a significant effect of caste on Gross Returns ($F(3, 49) = 7.202$, $p < .001$), Net Returns ($F(3, 49) = 7.782$, $p < .001$), BC ($F(3, 49) = 7.853$, $p < .001$), and Gross Income ($F(3, 49) = 7.918$, $p < .001$). Post-hoc analyses using Tukey HSD and Bonferroni tests (appropriate given the generally met assumption of homogeneity of variances) identified consistent patterns of significant differences. Specifically, for Gross Returns, Net Returns, BC, and Gross Income, Other Backward Caste (Caste 2) farmers had significantly higher values compared to Scheduled Caste (Caste 3) farmers ($p < 0.01$ in all cases). Additionally, for Net Returns and Gross Income, Other Backward Caste (Caste 2) farmers also had significantly higher values compared to Scheduled Tribe (Caste 4) farmers ($p < 0.05$). No other pairwise comparisons reached statistical significance at the $p < 0.05$ level."

Table 9: Effect of caste on variables-gross returns, gross margin, B:C ratio and net income in group 1 (Intervention Group)

Variables	General (n=11)	OBC (n=21)	SC (n=21)	ST (n=18)	F value
Gross returns	101200±6666	99228±8042	99885±6877	101200+6877	0.321
Gross margins	68636±6858	66509±8135	67102±7222	68613±7308	0.408
BC Ratio	2.26±0.18	2.19±0.23	2.20±0.18	2.24±0.17	0.498
Net income	56408±7272	53926±8407	54435±7407	56021±7147	0.366

The analysis reveals no statistically significant differences in gross returns, gross margins, B:C ratio, or net income among caste groups (General, OBC, SC, ST) within the intervention group (Group 1), as indicated by the F-values (all $p > 0.05$). This suggests that the provision of training and input support under the intervention may help neutralize caste-based disparities in economic outcomes, enabling more equitable benefits across social categories.

Analysis the combined interactions effect of caste sex and intervention on net income

A generalised liner model was employed to analyse the combined interactions effect of caste sex and intervention on net income, results of which are given in table:10

Table 10: Univariate Generalised Linear Model Results – Effects of Caste, Sex, and FFP Beneficiary Status on Net Income

Source	df	F	Sig.	Partial Eta Squared
Main Effects				
Caste	3	0.93	0.429	0.018
Sex	1	0.28	0.601	0.002
FFP Beneficiary	2	42.97	0.000	0.367
Two-Way Interactions				
Caste × Sex	3	1.24	0.298	0.024
Caste × FFP Beneficiary	6	1.02	0.412	0.040
Sex × FFP Beneficiary	2	0.03	0.967	0.000
Three-Way Interaction				
Caste × Sex × FFP Beneficiary	6	1.01	0.421	0.039
Covariates				
Age	1	0.25	0.618	0.002
Education	1	34.97	0.000	0.191
LAH	1	2.91	0.090	0.019

$R^2 = 0.580$, Adjusted $R^2 = 0.506$

Table 11: Estimated Marginal Means of Net Income by Caste and Sex (Covariates Adjusted)

Caste	Sex	Adjusted Mean (NR)	95% CI
Gen (1)	Male (1)	Rs. 49,106	[Rs. 46,888, Rs.51,324]
Gen (1)	Female (2)	Rs. 49,038	[Rs.45,872, Rs.52,204]
OBC (2)	Male (1)	Rs. 50,183	[Rs.48,483, Rs.51,884]
OBC (2)	Female (2)	Rs. 45,714	[Rs.40,827, Rs.50,601]
SC (3)	Male (1)	Rs. 46,702	[Rs.42,304, Rs.51,100]
SC (3)	Female (2)	Rs. 46,290	[Rs.43,924, Rs.48,656]
ST (4)	Male (1)	Rs. 47,459	[Rs.44,629, Rs.50,289]
ST (4)	Female (2)	Rs. 49,789	[Rs.45,753, Rs.53,826]

A univariate General Linear Model was conducted to examine the effect of caste, sex, and FFP beneficiary group on net income (NR), controlling for age, education, and landholding (LAH). The model explained a substantial proportion of variance in net income ($R^2 = 0.580$, Adjusted $R^2 = 0.506$).

Among the predictors, FFP beneficiary status had a highly significant effect on net income ($F = 42.97$, $p < 0.001$, $\eta^2 = 0.367$), indicating that intervention and control group differences significantly influenced income levels. Additionally, education was a significant covariate ($F = 34.97$, $p < 0.001$), suggesting that higher educational attainment positively influenced net income.

In contrast, neither caste ($F = 0.93$, $p = 0.429$) nor sex ($F = 0.28$, $p = 0.601$) had significant main effects. Similarly, no significant interactions were found among caste, sex, and FFP beneficiary groups, indicating that the effect of the intervention was consistent across social categories.

Adjusted means show relatively minor differences in net income between men and women within each caste group, further confirming the non-significant effect of sex or caste on income when access to interventions is ensured.

These findings suggest that targeted programmatic support (training, input provision) can effectively reduce income disparities across caste and gender lines, reinforcing the potential of inclusive agricultural interventions in promoting economic equity.

The empirical findings demonstrate that FFP intervention effectively ameliorates socioeconomic disparities in rice cultivation profitability. While control groups exhibited significant income variations based on gender and caste, with negative correlations between age, gender, landholding size and economic performance, these disparities were notably absent in the intervention group. The univariate GLM analysis confirms that FFP beneficiary status, rather than demographic factors, becomes the predominant determinant of economic outcomes when targeted support is provided. Educational attainment emerged as the sole consistent predictor of income across all groups, underscoring its fundamental role in agricultural productivity regardless of intervention status.

Conclusion

The Farmer FIRST Programme successfully enhances economic outcomes while simultaneously mitigating gender and caste-based disparities in agricultural profitability. This dual impact improving overall productivity while promoting socioeconomic equity highlights the transformative potential of well-designed agricultural extension services that combine capacity building with strategic input provision for smallholder farmers.

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