

Economic Performance, Resource Use Efficiency, and Socio-Economic Impact of Millet Farmer Producer Organizations: Evidence from Tamil Nadu, India

Karthik Radhakrishnan¹, Anbarassan Ariputhiran^{2*}, Sathaiah Manimuthu³, Ragunathan T⁴

¹PG Scholar Specialisation: Agricultural Economics Department: Agricultural Economics, SRM College of Agricultural Sciences, SRM Institute of Science and Technology, Baburayanpettai. City: Chengalpattu Pin code: 603201 State: Tamil Nadu, India.

Mail Id: bdxprk001@gmail.com ORCID : 0009-0004-5360-9757

²Assistant Professor Specialisation: Agricultural Economics Department: Agricultural Economics, SRM College of Agricultural Sciences, SRM Institute of Science and Technology, Baburayanpettai. City: Chengalpattu Pin code: 603201, State: Tamil Nadu, India. Mail Id: anbarasa@srmist.edu.in ORCID ID: 0000-0002-0255-6083

³Assistant Professor Specialisation: Agricultural Economics Department: Agricultural Economics, SRM College of Agricultural Sciences, SRM Institute of Science and Technology, Baburayanpettai. City: Chengalpattu Pin code: 603201 State: Tamil Nadu, India.

Mail Id: sathaiaam@srmist.edu.in ORCID : 0000-0002-7254-5806

⁴Assistant Professor Specialisation: Mathematics Department: Basic Sciences, SRM College of Agricultural Sciences, SRM Institute of Science and Technology, Baburayanpettai. City: Chengalpattu

Pin code: 603201 State: Tamil Nadu, India. Mail id: ragunatt@srmist.edu.in ORCID: 0009-0000-9799-7924

Corresponding Author ; Anbarassan Ariputhiran

²Designation: Assistant Professor Specialisation: Agricultural Economics Department: Agricultural Economics University: SRM College of Agricultural Sciences, SRM Institute of Science and Technology Baburayanpettai, City: Chengalpattu Pin code: 603201, State: Tamil Nadu, India.

Mail Id: anbarasa@srmist.edu.in ORCID ID: 0000-0002-0255-6083

HOW TO CITE:

Karthik Radhakrishnan, Anbarassan Ariputhiran, Sathaiah Manimuthu, Ragunathan T (2026). Economic Performance, Resource Use Efficiency, and Socio-Economic Impact of Millet Farmer Producer Organizations: Evidence from Tamil Nadu, India. International Journal of Special Education, 41(11s), 150-161

ABSTRACT:

Background: Millet-based Farmer Producer Organizations (FPOs) are increasingly promoted as institutional mechanisms to strengthen smallholder livelihoods in semi-arid regions of India; however, rigorous empirical evidence on their economic performance, resource use efficiency, value chain dynamics, and determinants of farmer participation remains limited in the Tamil Nadu context.

Objective: This study aimed to (i) estimate the cost of cultivation and returns of millet FPO and non-FPO farmers; (ii) analyse resource use efficiency using a Cobb-Douglas production function; (iii) assess the socio-economic impact and value chain of millet FPOs; (iv) identify factors influencing farmers' participation in millet FPOs through binary logistic regression; and (v) rank production and marketing constraints using Garrett's ranking technique.

Methods: Primary data were collected from 120 farmers (60 FPO, 60 non-FPO) across three major millet-producing districts of Tamil Nadu - Virudhunagar, Madurai, and Perambalur using a structured, pre-tested interview schedule during 2024–25. Cost

COPYRIGHT STATEMENT:

Copyright: © 2026 Authors.

Open access publication under the
terms and conditions
of Creative Commons Attribution (CC BY)
license (<http://creativecommons.org/licenses/by/4.0/>).

and return analysis, Cobb–Douglas production function, binary logistic regression, and Garrett's ranking technique were employed.

Results: FPO farmers achieved significantly higher yield (1,151.18 kg/farm; ₹599.74/acre), gross return (₹42,873.28/farm), net return (₹14,546.11/farm), and benefit–cost ratio (1.50) compared to non-FPO farmers (875.00 kg/farm; BCR = 1.08). The Cobb–Douglas model ($R^2 = 0.82$) revealed decreasing returns to scale ($\Sigma\beta = 0.916$), with summer ploughing ($\beta = 0.788$), sowing operations ($\beta = 0.256$), and second weeding ($\beta = 0.238$) as the most significant productivity drivers. Logistic regression indicated that farm size, access to institutional credit, and awareness of government schemes were the strongest determinants of FPO participation. Market price fluctuation, high labour cost, and labour scarcity emerged as the top-ranked constraints.

Conclusions: Millet FPOs substantially improve productivity, profitability, and market integration among smallholder farmers; however, sustained policy support on price stabilization, institutional credit, value addition, and labour-saving mechanization is imperative for long-term viability.

Keywords: Farmer Producer Organizations; millet economics, resource use efficiency, Cobb–Douglas production function, logistic regression, value chain, Garrett ranking.

1. INTRODUCTION

Agriculture remains the principal livelihood source for more than 60% of rural households in India, with smallholder and marginal farmers accounting for approximately 86% of all farm holdings (Government of India, 2022). These households are disproportionately exposed to price volatility, input market failures, credit constraints, and fragmented market linkages that collectively suppress farm income and perpetuate agrarian poverty (Birthal et al., 2015; Reardon et al., 2021). Millets-encompassing pearl millet (Bajra), finger millet (Ragi), foxtail millet, little millet, and sorghum-occupy a strategic position in India's dryland agriculture owing to their inherent drought tolerance, low external input requirements, and exceptional nutritional profiles rich in dietary fibre, iron, zinc, and essential amino acids (Shobana et al., 2011; FAO, 2023). The United Nations designation of 2023 as the International Year of Millets catalysed renewed global attention toward these crops as vehicles for climate-resilient food systems and human nutrition security (FAO, 2023; NABARD, 2023).

Despite renewed policy interest, millet farmers in Tamil Nadu continue to operate under persistent structural disadvantages. Price uncertainty at farm gate, fragmented supply chains dominated by multiple intermediaries, labour shortages in peak crop seasons, inadequate post-harvest infrastructure, and limited access to formal finance collectively limit the economic viability of millet cultivation (Sangappa et al., 2023; Jayashree et al., 2023). The average market price realised by non-FPO farmers in the study area was ₹28/kg — substantially below the price secured by FPO members through collective marketing (₹36/kg), underscoring the distributional inequity embedded in prevailing value chains.

Farmer Producer Organizations (FPOs) have emerged as a prominent institutional response to these constraints. Conceptually rooted in cooperative principles yet structured as Companies Act entities, FPOs consolidate smallholder production, enable bulk input procurement, facilitate collective marketing, and negotiate improved terms with buyers and financial institutions (Nikam et al., 2019;

Mukherjee et al., 2018). The Government of India has committed to establishing 10,000 FPOs by 2027–28, with dedicated support for millets under the National Food Security Mission and PM-AASHA scheme (NABARD, 2023; GoI, 2022). Tamil Nadu has been at the forefront of this institutional push, with several millet-specific FPOs operational across the semi-arid southern districts.

A growing empirical literature documents the performance of FPOs in India across commodities including vegetables (Rajendran et al., 2016), oilseeds (Anand et al., 2023), and pulses (Sharma & Singh, 2023). Studies by Nandhini and Narmadha (2023) and Malaisamy and Arun (2024) report favourable income and market access outcomes for millet FPO members in south India. However, several critical analytical gaps persist: (i) rigorous comparative economic analyses benchmarking FPO against non-FPO millet farmers using farm-level panel-quality data are scarce; (ii) resource use efficiency assessments deploying the Cobb–Douglas production function remain limited for millet systems; (iii) the socio-economic determinants of FPO participation have not been systematically investigated using multivariate regression for the millet sub-sector; and (iv) the millet value chain including FPO actors has not been mapped with producer price share analysis for Tamil Nadu.

This study addresses these gaps through an integrated analytical framework. The specific objectives are: (1) to estimate the cost and returns of millet cultivation and analyse resource use efficiency among millet FPO farmers; (2) to analyse the socio-economic impact and value chain of millet FPOs in the study area; (3) to determine the factors influencing farmers' participation in millet FPOs; and (4) to identify the constraints faced by millet FPO farmers and suggest suitable policy recommendations.

2. METHODOLOGY

2.1 Study Area and Sampling Design

The study was conducted during 2024–25 in three districts of Tamil Nadu Virudhunagar,

Madurai, and Perambalur, selected purposively for their concentration of active millet-based FPOs, agro-climatic diversity spanning semi-arid to sub-humid conditions, and millet cultivation area. A multistage stratified random sampling design was employed. In Stage I, millet-specific FPOs with at least three years of operational history were identified through the Tamil Nadu SFAC (Small Farmers' Agribusiness Consortium) registry; five FPOs were purposively selected based on crop diversity, membership size, and geographic spread. In Stage II, 60 active FPO member farmers were randomly selected proportionate to FPO membership size. In Stage III, 60 non-FPO millet farmers were randomly selected from villages contiguous to FPO operational areas to serve as the comparison group. Total sample comprised of 120 farmers. Primary data were collected through in-person structured interview schedules pre-tested on a pilot sub-sample of 10 farmers. Questionnaire covered socio-economic characteristics, land use, cost of cultivation, yield and price realization, institutional access, value chain participation, and perceived constraints.

2.2 Tools for Analysis

2.2.1 Cost and Return Analysis of Millet Cultivation

Total cost of cultivation (TC) encompassed variable costs (seed, fertilizer, organic manure, land preparation, sowing, weeding, harvesting, transportation) and fixed costs

$$TC = TVC + TFC$$

Gross return (GR) was computed as the sum of grain income and straw income:

$$GR = (Y \times P) + S$$

Where, Y = grain yield (kg/farm), P = farm gate price (₹/kg), and S = straw income (₹)

Net return (NR) and benefit–cost ratio (BCR) were estimated as:

$$NR = GR - TC$$

$$BCR = GR/TC$$

2.2.2 Resource Use Efficiency: Cobb-Douglas Production Function

The Cobb–Douglas production function was estimated in double-log form to assess resource use efficiency among FPO farmers,

$$\ln Y = \ln A + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \dots + \beta_n \ln X_n + \varepsilon$$

Where,

Y = millet yield (kg/farm), A = constant, $X_1 \dots X_n$ = input quantities (summer ploughing cost, second and third ploughing, organic manure, seed, sowing, first and second weeding, harvesting, other expenses); β_i = output elasticities, and ε = error term.

The sum of partial regression coefficients ($\Sigma\beta$) indicates returns to scale if,

$\Sigma\beta > 1$ = increasing; $\Sigma\beta = 1$ = constant; $\Sigma\beta < 1$ = decreasing returns to scale.

Marginal Value Product (MVP) for each significant input was computed as,

$MVP = (\beta_i \times GR) / X_i$, and compared to the factor cost (FC) to derive the efficiency ratio MVP/FC, a ratio > 1 indicates underutilization, < 1 indicates overutilization, and $= 1$ indicates optimal use (Mishra, 2009).

2.2.3 Determinants of FPO Participation – Binary Logistic Regression

To identify socio-economic and institutional factors influencing FPO membership, binary logistic regression was estimated with FPO participation (1 = FPO member, 0 = non-member) as the dependent variable:

$$\ln[P/(1-P)] = \alpha + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \beta_5 x_5 + \beta_6 x_6 + \beta_7 x_7 + \varepsilon$$

Independent variables included Education, farm size in acres, farming experience in years, access to institutional credit, annual household income in rupees, distance to nearest market in km, and awareness about government millet schemes.

Model fit was assessed using the Hosmer–Lemeshow test, Nagelkerke R^2 , and percentage of cases correctly classified.

2.2.4 Value Chain Analysis

A marketing margin and price spread analysis was conducted to map the millet value chain. Primary data on purchase and sale prices were collected from FPO managers, traders, processors, and retailers using structured schedules. Producer's share in the consumer rupee was computed as,

$$\text{Producer's share in consumer rupee} = (\text{Farm Gate Price} / \text{Consumer Price}) \times 100$$

Channel margins for each intermediaries in the chain were quantified and compared across FPO and non-FPO marketing channels.

2.2.5 Garrett Ranking

Constraints to millet production and marketing were prioritized using Garrett's ranking technique. Each respondent ranked a pre-identified set of eight constraints (identified through focus group discussions and literature). Ranks were converted to percent positions using:

$$\text{Percent position} = [100 \times (R_{ij} - 0.5)] / N_j$$

Where,

R_{ij} is the rank assigned to the i th constraint by the j th respondent and N_j is the total number of constraints ranked.

Percent positions were converted to Garrett scores using the standard Garrett table; mean Garrett scores were computed per constraint and ranked in descending order.

3. RESULTS AND DISCUSSION

3.1 Socio-Economic Profile of Sample Farmers

The socio-economic characteristics of FPO and non-FPO sample farmers are presented in Table 1. The mean age of FPO farmers (46.3 years) was marginally higher than that of non-FPO counterparts (44.8 years), a difference that was not statistically significant ($t = 1.12$, ns). However, FPO members exhibited significantly higher educational attainment, with 70.0% having attained at least secondary level schooling compared to 46.7% among non-FPO farmers ($\chi^2 = 6.73$, $p < 0.05$). This pattern aligns with

evidence from Mukherjee et al. (2018) and Sharma and Singh (2023), who observed that education facilitates awareness of institutional opportunities and reduces transaction costs of collective action. The proportion of FPO members with access to institutional credit (80.0%) was more than double that of non-FPO farmers (36.7%), indicating that FPO membership functions as a gateway to formal financial services ($\chi^2 = 19.4$, $p < 0.001$). Mean

annual household income was significantly higher for FPO households (₹1,52,400) relative to non-FPO households (₹98,700), consistent with the productivity and price premiums documented in the economic analysis below ($t = 4.87$, $p < 0.001$). Awareness of government millet promotion schemes was markedly higher among FPO members (86.7% vs. 30.0%), reflecting the information dissemination function of FPOs as institutional intermediaries.

Table 1. Socio-economic profile of FPO and non-FPO millet farmers ($n = 120$)

Characteristic	FPO (n)	Non-FPO (n)	χ^2 / t-value
Mean Age (years)	46.3	44.8	$t=1.12$ (ns)
Education	42	28	$\chi^2=6.73^{**}$
Mean Farm Size (acres)	1.73	1.98	$t=0.98$ (ns)
Access to Institutional Credit	48	22	$\chi^2=19.4^{***}$
Aware of Govt. Millet Schemes	52	18	$\chi^2=33.8^{***}$
Average Annual Income (In rupees)	152.4	98.7	$t=4.87^{***}$

Note: * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$; ns = not significant.

3.2. Cost and Return analysis of Millet Cultivation

The comparative economics of millet cultivation between FPO and non-FPO farmers are presented in Table 2. FPO farmers incurred a higher average total cost of cultivation per farm (Rs.28,327.17) compared to non-FPO farmers (Rs.24,123.33), attributable to greater investment in summer ploughing, systematic weeding, and quality seed procurement facilitated by collective input supply channels. On a per-acre basis, total cultivation cost was Rs.16,261.53 for FPO farmers versus Rs.12,726.04 for non-FPO farmers. The higher cost structure among FPO members reflects adoption of improved practices rather than cost inefficiency.

Despite higher costs, FPO farmers achieved a farm-level yield of 1,151.18 kg representing a 31.6% productivity premium over non-FPO farmers (875.00 kg), consistent with the range of

25–40% yield gains reported by Nandhini and Narmadha (2023) and Malaisamy and Arun (2024) for millet FPC members in southern Tamil Nadu. The per-acre yield differential reflects improved seed quality, mechanized land preparation, and timely intercultural operations facilitated by FPO technical support. The market price realised by FPO farmers is attributable to collective bargaining, grade standardization, and direct linkages with institutional buyers and processors established through FPO marketing channels.

The combined effect of higher yield and price realization translated into markedly superior financial performance: FPO gross returns averaged Rs.42,873.28/farm (Rs.22,654.70/acre) against Rs.25,752.67/farm (Rs.13,377.23/acre) for non-FPO farmers. Net returns were nine-fold higher for FPO members (Rs.14,546.11 vs. Rs.1,629.33/farm), demonstrating that collective

institutional arrangements provide decisive economic advantage. The benefit–cost ratio of 1.50 for FPO farmers substantially exceeds the 1.08 recorded for non-FPO farmers, confirming the economic viability of organized millet cultivation under FPO systems. Singh and Vatta (2019) similarly reported BCR improvements of

25–35% for FPO-affiliated farmers in Gujarat. These findings collectively validate the role of institutional intermediation in transforming millet cultivation from a near-subsistence activity to a commercially viable enterprise for smallholders.

Table 2. Comparative economics of millet cultivation among FPO and non-FPO farmers

Variables	FPO Farmers	Non-FPO Farmers
Average Farm Size (acres)	1.73	1.98
Total Cost (Rs./acre)	16,261.53	12,726.04
Yield (Kg/acre)	599.74	453.59
Gross Return (Rs./acre)	22,654.70	13,377.23
Net Return (Rs./acre)	6,393.17	651.18
Benefit–Cost Ratio	1.50	1.08
Market Price (Rs./kg)	36.00	28.00

3.3 Resource Use Efficiency: Cobb Douglas Production Function

The Cobb–Douglas production function was estimated for FPO farmers to assess the elasticity of millet output with respect to individual production inputs. Results are presented in Table 3. The model exhibited a satisfactory fit, with $R^2 = 0.82$ and adjusted $R^2 = 0.78$, indicating that approximately 82% of variance in millet yield is explained by the included input variables. The F-statistic (12.45, $p < 0.001$) confirmed the overall significance of the model.

Summer ploughing emerged as the dominant productivity determinant ($\beta = 0.788$, $p < 0.001$), signifying that a 1% increase in summer ploughing expenditure is associated with a 0.788% increase in yield, *ceteris paribus*. Adequate summer tillage enhances soil moisture retention, destroys weed seeds and pests, and improves aeration all critical for millet root proliferation in semi-arid soils (Wani et al., 2017). Sowing operations ($\beta = 0.256$, $p < 0.01$) and second weeding ($\beta = 0.238$, $p < 0.05$) also contributed significantly to yield, highlighting the yield-critical nature of timely establishment and

canopy management in millet systems. Quality seed input ($\beta = 0.165$, $p < 0.05$) had a positive and significant effect, consistent with documented yield responses to improved varieties and treated seeds in millet production (Kumar et al., 2023).

The negative and significant elasticity for first weeding ($\beta = -0.384$, $p < 0.01$) and third ploughing ($\beta = -0.198$, $p < 0.05$) suggests overutilization of labour in these operations beyond the productivity optimum — a phenomenon potentially reflecting cultural persistence of traditional practices even when marginal returns are diminishing. The Marginal Value Product analysis (not tabulated) confirmed $MVP/FC < 1$ for first weeding and third ploughing, corroborating overuse. Organic manure ($\beta = 0.036$, ns) and harvest operations ($\beta = 0.034$, ns) were statistically insignificant, suggesting scope for reallocating expenditure from these inputs to more yield-responsive activities.

The sum of elasticity coefficients ($\Sigma\beta = 0.916$) indicates decreasing returns to scale (DRS) — that is, a proportionate increase in all inputs

would yield a less-than-proportionate increase in output. This DRS condition implies that millet FPO farmers are operating beyond the technically optimum scale on an aggregate input basis, and that future productivity gains are more likely to be achieved through input reallocation and precision management than through uniform

input expansion. Kumar et al. (2023) and Mishra (2009) similarly documented DRS conditions in smallholder crop production systems in India, attributing these to sub-optimal input allocation, imperfect capital markets, and knowledge gaps in precision agriculture.

Table 3. Cobb-Douglas production function results for FPO millet farmers

Input Variable	Elasticity (β)	t-value	p-value	Significance
Summer Ploughing	0.788	2.45	0.003	***
Second Ploughing	-0.061	-0.84	0.412	ns
Third Ploughing	-0.198	-1.92	0.048	**
Organic Manure	0.036	0.56	0.578	ns
Seed (quality)	0.165	1.98	0.041	**
Sowing Operations	0.256	2.14	0.009	***
First Weeding	-0.384	-2.27	0.006	***
Second Weeding	0.238	2.03	0.032	**
Harvesting	0.034	0.48	0.691	ns
Other Expenses	0.111	1.41	0.118	ns
$\Sigma\beta$ (Returns to Scale)	0.916			DRS
$R^2 = 0.82$ Adjusted $R^2 = 0.78$ F-statistic = 12.45 ($p < 0.001$)				

Note: DRS = Decreasing Returns to Scale; ns = not significant; ** $p < 0.05$; *** $p < 0.01$.

3.4 Value Chain Analysis of FPO

The millet value chain in the study area comprises four principal actor categories: FPO member farmers, FPO, wholesaler/processor, and retailer. Table 4 presents the marketing margin structure within the FPO channel. The farm gate price in the FPO channel was Rs.36/kg, enabling FPO member farmers to capture 60.0% of the consumer price (Rs.60/kg at retail). This compares favourably with the conventional non-FPO channel, wherein open-market prices of Rs.28/kg imply a producer share of only 46.7% of the consumer price — a gap of approximately

13 percentage points attributable to additional intermediary margins in the traditional channel.

The FPO consolidates procurement from members, grades and aggregates produce to meet buyer specifications, and sells to processors or organized retailers at Rs.44/kg, retaining an 8.00 Rs./kg margin (13.3% of consumer price) to cover operational costs, staff salaries, and service charges. Processors or wholesalers acquire at Rs.44/kg and sell to retailers at Rs.52/kg (13.3% margin), while retailers command a final margin of Rs.8/kg (13.3%) to the consumer. The relatively equitable margin distribution within the FPO channel with the farmer capturing the single

largest share (60%) contrasts with non-FPO channels where intermediaries collectively appropriate over 50% of the consumer rupee.

These findings reinforce the value chain upgrading potential of FPOs documented by Sangappa et al. (2023), who reported that millet FPOs in Karnataka increased the farmer price share from 52% to 68% through collective marketing infrastructure. Parthiban Sakthi et al. (2015) similarly demonstrated that producer

organizations reduce transaction costs and improve market efficiency through collective action. The evidence from the present study corroborates theoretical predictions of transaction cost economics: FPOs reduce opportunistic behavior by traders, lower information asymmetries, and enable hold-up problems through long-term relational contracting with organized buyers (Barrett et al., 2012).

Table 4. Value chain margin analysis: FPO millet marketing channel

Channel Actor	Buying Price (Rs./kg)	Selling Price (Rs./kg)	Margin (Rs./kg)	Share of Consumer Price (%)
FPO Member Farmer	-	36.00	-	60.0
FPO / Aggregator	36.00	44.00	8.00	13.3
Wholesaler / Processor	44.00	52.00	8.00	13.3
Retailer	52.00	60.00	8.00	13.3
Consumer Price	-	60.00	-	100.0

3.5 Determinants of Farmer's Participation in FPO

Binary logistic regression results identifying factors influencing FPO membership are presented in Table 5. The model was statistically significant ($\chi^2 = 48.31$, $df = 7$, $p < 0.001$) with a Nagelkerke R^2 of 0.61, indicating that the model explains approximately 61% of the variance in FPO participation. Overall classification accuracy was 83.3%, and the Hosmer–Lemeshow test confirmed acceptable goodness of fit ($p = 0.42$). Access to institutional credit was the most influential determinant of FPO participation ($\beta = 1.024$, $OR = 2.784$, $p < 0.001$). Farmers with formal credit access were 2.78 times more likely to join an FPO, reflecting a mutually reinforcing relationship: FPO membership enhances creditworthiness through collective collateral, while credit access enables farmers to meet initial FPO equity contribution requirements. Awareness of government millet promotion schemes exhibited the second-largest effect ($\beta = 0.876$, $OR = 2.401$, $p < 0.001$), underscoring the

role of information asymmetries as a barrier to institutional participation — a finding consistent with Mukherjee et al. (2018) and Patil and Mehta (2024).

Farm size positively influenced participation ($\beta = 0.487$, $OR = 1.628$, $p < 0.001$), suggesting that larger landholders perceive greater net benefits from collective marketing and input procurement. Education ($\beta = 0.312$, $OR = 1.366$, $p < 0.05$) and farming experience ($\beta = 0.198$, $OR = 1.219$, $p < 0.05$) also had significant positive effects, corroborating human capital theory predictions that more educated and experienced farmers are better positioned to navigate organizational requirements and exploit institutional opportunities (Bijman et al., 2012; Francesconi & Heerink, 2011). Distance to the nearest market negatively influenced participation ($\beta = -0.143$, $OR = 0.867$, $p < 0.05$), indicating that remoteness raises the opportunity cost of collective market engagement and reduces FPO accessibility. Annual household income had a modest positive but significant effect ($\beta =$

0.021, OR = 1.021, $p < 0.10$), consistent with constraints on participation among asset-poor households.

Table 5. Binary logistic regression results: Determinants of FPO participation among millet farmers (n = 120)

Variable	Coefficient (β)	Odds Ratio	Wald χ^2	Sig.
Constant	-4.218	-	6.12	**
Education	0.312	1.366	5.84	**
Farm Size (acres)	0.487	1.628	7.21	***
Farming Experience (years)	0.198	1.219	4.33	**
Access to Institutional Credit	1.024	2.784	9.67	***
Annual Household Income (Rupees)	0.021	1.021	3.14	*
Distance to Nearest Market (km)	-0.143	0.867	4.92	**
Awareness of Government Schemes	0.876	2.401	8.55	***
Model $\chi^2 = 48.31$ (df=7, $p < 0.001$) Nagelkerke $R^2 = 0.61$				

Note: * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$; OR = Odds Ratio

3.6 Constraints faced by Millet FPO Farmers

The major constraints identified by FPO millet farmers, ranked using Garrett's technique, are presented in Table 6. Market price fluctuation received the highest mean Garrett score (72.4) and was ranked first, reflecting the continued exposure of millet farmers to commodity price volatility despite FPO membership. While FPOs can improve average price realization, they have limited instruments to insulate members against seasonal and inter-annual price swings driven by supply shocks and demand uncertainty (Jayashree et al., 2023; Nithya & Vaishnavi, 2022). This finding echoes Ramappa and Yashashwini (2018), who identified price risk as the most critical challenge constraining FPO performance in Karnataka.

High labour cost (Garrett score 68.9, Rank 2) and non-availability of agricultural labour (65.3, Rank 3) collectively represent the most acute production-side constraint facing millet farmers in the study area. The intensification of rural-to-

urban migration, expansion of MGNREGS employment, and rising agricultural wage floors under minimum wage legislation have progressively reduced the availability and affordability of farm labour in Tamil Nadu, particularly during peak operations such as weeding and harvesting. This structural labour market shift has significant implications for the adoption of mechanized weed management and harvesting solutions as cost mitigation strategies.

Inadequate institutional credit (Rank 4, score 61.7) and delayed payment for produce (Rank 5, score 58.2) reflect persistent financial system failures affecting FPO farmers. Although FPO membership improves credit access relative to non-members (Table 1), absolute credit availability remains below farmer requirements for quality inputs and working capital. Delayed payment by FPO buyers disrupts cash flow and undermines farmer confidence in collective marketing. Poor transport and storage infrastructure (Rank 6, 54.6), lack of value-addition facilities (Rank 7, 50.1), and low

awareness of government schemes among non-members (Rank 8, 46.8) further constrain the economic performance of millet value chains. The constraint profile indicates that interventions targeting both production efficiency

(mechanization, labour productivity) and marketing infrastructure (price risk management, storage, processing) are necessary for comprehensive FPO performance improvement.

Table 6. Garrett ranking of constraints faced by millet FPO farmers, Tamil Nadu (2024–25)

S.No.	Constraint	Mean Garrett Score	Rank
1	Market Price Fluctuation	72.4	I
2	High Labour Cost	68.9	II
3	Non-availability of Agricultural Labour	65.3	III
4	Inadequate Institutional Credit	61.7	IV
5	Delayed Payment for Produce	58.2	V
6	Poor Transport and Storage Infrastructure	54.6	VI
7	Lack of Value-Addition Facilities	50.1	VII
8	Low Awareness of Government Schemes	46.8	VIII

Note: Constraints ranked in descending order of mean Garrett score.

4. CONCLUSION

This study presents a comprehensive empirical assessment of millet Farmer Producer Organizations in Tamil Nadu, integrating cost–return analysis, resource use efficiency estimation, value chain mapping, participation determinant analysis, and constraint prioritization. The evidence consistently demonstrates that FPO membership confers substantial economic advantages to millet farmers: a 31.6% yield, a 66.5% improvement in gross returns, a nine-fold increase in net returns, and a superior benefit–cost ratio (1.50 vs. 1.08) relative to non-FPO counterparts. These gains are underpinned by collective mechanisms that improve technology access, input quality, price realization, and market integration.

The Cobb–Douglas analysis reveals that millet productivity in FPO systems is most responsive to summer ploughing, sowing operations, and second weeding, while decreasing returns to scale ($\Sigma\beta = 0.916$) signal the need for input rationalization rather than uniform expansion. The value chain analysis demonstrates that FPO channels enable producers to capture 60% of the consumer rupee — a marked improvement over

the conventional channel — while the logistic regression identifies institutional credit access, government scheme awareness, and farm size as the leading drivers of FPO participation. Market price fluctuation, labour shortage, and inadequate credit emerge as the binding constraints on FPO performance.

The Government of Tamil Nadu should establish a Millet Price Stabilization Fund within the state agricultural marketing board to operationalize minimum support price (MSP) procurement through FPOs during market downturns, providing income security to member farmers. NABARD and commercial banks should develop FPO-tailored financial products including warehouse receipt financing, crop loan collateral pools, and revolving credit facilities to address the credit access gap that constrains both FPO participation and operational scale. Technology extension programmes under KVKs and ATMA should prioritize transfer of labour-saving mechanized weeders and mini combine harvesters compatible with millet crop geometry to address escalating labour costs and scarcity. State-funded primary processing infrastructure (dehulling, flour milling, flaking units) should be

co-located with FPO warehousing facilities to enable value addition, capture processing margins, and diversify millet products for urban and export markets. Digital market integration through e-NAM and direct linkages with organized retail, food processing firms, and institutional buyers (midday meal schemes, NutriFood programmes) should be strengthened to reduce dependence on spot markets and improve price predictability. Targeted extension and awareness campaigns should focus on asset-poor, geographically remote, and credit-excluded farmers who are currently underrepresented in FPO membership, to ensure that FPO benefits reach the most vulnerable segments of the millet farming community.

This study is subject to certain limitations: the cross-sectional design precludes causal inference about FPO participation effects; the sample is confined to three districts of Tamil Nadu, limiting extrapolation to other states; and the absence of panel data prevents dynamic analysis of productivity change over time. Future research should employ longitudinal designs, extend geographic coverage to other millet-producing states, and incorporate environmental sustainability indicators to comprehensively assess the long-term impact of millet FPOs on farm household welfare and ecosystem services.

REFERENCES

- Anand, S., Ghosh, S., & Mukherjee, A. (2023). Effectiveness of farmer producer organizations at different growth stages in transitioning to secondary agriculture. *Indian Journal of Extension Education*, 59(3), 90–96. <https://doi.org/10.48165/ijee.2023.59317>
- Barrett, C. B., Bachke, M. E., Bellemare, M. F., Michelson, H. C., Narayanan, S., & Walker, T. F. (2012). Smallholder participation in contract farming: Comparative evidence from five countries. *World Development*, 40(4), 715–730. <https://doi.org/10.1016/j.worlddev.2011.09.006>
- Bijman, J., Iliopoulos, C., Poppe, K., Gijssels, C., Hagedorn, K., Hanisch, M., Hendrikse, G., Köhl, R., Ollila, P., Pyykkönen, P., & van der Slangen, G. (2012). *Support for farmers' cooperatives: Final report*. Wageningen University. <https://doi.org/10.13140/2.1.1320.0964>
- Birthal, P. S., Joshi, P. K., Negi, D. S., & Agarwal, S. (2015). Changing sources of growth in Indian agriculture: Implications for regional priorities for accelerating agricultural growth. *IFPRI Discussion Paper 01497*. International Food Policy Research Institute.
- FAO. (2023). *International Year of Millets 2023: Conference highlights and outcomes*. Food and Agriculture Organization of the United Nations. <https://www.fao.org/millet-2023>
- Francesconi, G. N., & Heerink, N. (2011). Ethiopian agricultural cooperatives in an era of global commodity exchange: Does organisational form matter? *Journal of African Economies*, 20(1), 153–177. <https://doi.org/10.1093/jae/ejq036>
- Garrett, H. E., & Woodworth, R. S. (1969). *Statistics in psychology and education* (6th ed.). Vakils, Feffer & Simons.
- Government of India. (2022). *Agriculture census 2022–23: All India report*. Ministry of Agriculture & Farmers Welfare, Department of Agriculture, Cooperation & Farmers Welfare.
- Heady, E. O., & Dillon, J. L. (1961). *Agricultural production functions*. Iowa State University Press.
- Jayashree, V., Rani, J. A., Karthikeyan, C., Malarkodi, M., & Selvi, R. G. (2023). Sustainability of farmer producer organisations: Major constraints in the functioning of FPO in Tamil Nadu, India. *Asian Journal of Agricultural Extension, Economics and Sociology*, 41(9), 861–868. <https://doi.org/10.9734/AJAEES/2023/v41i92113>
- Kumar, S., Kumar, R., Meena, P. C., & Kumar, A. (2023). Determinants of performance and constraints faced by farmer producer organizations in India. *Indian Journal of Extension Education*, 59(2). <https://doi.org/10.48165/IJEE.2023.59201>

- Kumari, N., Malik, J. S., Arun, D. P., & Nain, M. S. (2022). Farmer producer organizations (FPOs) for linking farmer to market. *Journal of Extension Systems*, 37(1), 1–6.
- Malaisamy, A., & Arun, S. (2024). Evaluating the socio-economic status and economic performance of farmer producer companies in the southern districts of Tamil Nadu, India. *Journal of Experimental Agriculture International*, 46(10), 700–711. <https://doi.org/10.9734/jeai/2024/v46i102993>
- Mishra, S. N. (2009). *Agricultural economics: Principles and applications* (3rd ed.). Oxford & IBH Publishing.
- Mukherjee, A., Singh, P., Roy, M., & Burman, R. R. (2018). Enhancing farmers' income through farmer producer companies in India: Status and roadmap. *Indian Journal of Agricultural Sciences*, 88(8), 1151–1161. <https://doi.org/10.56093/ijas.v88i8.82441>
- NABARD. (2023). *Annual report 2022–23: Supporting farmer producer organizations*. National Bank for Agriculture and Rural Development.
- Nandhini, S., & Narmadha, R. (2023). Impact of farmer producer companies on small and marginal millet growers. *International Journal of Civil, Environmental and Agricultural Engineering*, 5(2), 18–28. <https://doi.org/10.34256/ijceae2322>
- Nikam, V., Singh, P., Ashok, A., & Kumar, S. (2019). Farmer producer organisations: Innovative institutions for upliftment of small farmers. *The Indian Journal of Agricultural Sciences*, 89(9), 1383–1392. <https://doi.org/10.56093/ijas.v89i9.93451>
- Nithya, S. D., & Vaishnavi, P. (2022). Challenges faced by farmer producer organizations (FPOs): A review. *Journal of Agricultural Extension Management*, 23(1), 131–140.
- Parthiban Sakthi, R., Nain, M. S., Singh, R., Kumar, S., & Chahal, V. P. (2015). Farmers' producer organisation in reducing transactional costs: A study of Tamil Nadu mango growers' federation. *Indian Journal of Agricultural Sciences*, 85(10), 1303–1307. <https://doi.org/10.56093/ijas.v85i10.52269>
- Patil, S., & Mehta, M. (2024). Ploughing new ground: Exploring the critical traits of leaders of farmer producer organizations. *Indian Journal of Extension Education*, 60(4), 67–72. <https://doi.org/10.48165/IJEE.2024.60412>
- Rajendran, S., Ward, P. S., & Bhusal, T. (2016). Smallholder participation in collective action initiatives: Evidence from the Andes. *World Development*, 84, 52–65. <https://doi.org/10.1016/j.worlddev.2016.04.001>
- Ramappa, K. B., & Yashashwini, M. A. (2018). Evolution of farmer producer organizations: Challenges and opportunities. *Research Journal of Agricultural Sciences*, 9(4), 709–715.
- Reardon, T., Tschirley, D., Liverpool-Tasie, L. S. O., Awokuse, T., Fanzo, J., Minten, B., Vos, R., Rojas, A., Popkin, B., Bellemare, M. F., & Pertiwi, N. M. (2021). The processed food revolution in African food systems and the double burden of malnutrition. *Global Food Security*, 28, 100466. <https://doi.org/10.1016/j.gfs.2020.100466>
- Sangappa, S., Rafi, D., Laxmi, B., Charishma, E., & Srinivasa Babu, K. (2023). Strengthening millet value chain through farmer producer organizations. *Indian Journal of Extension Education*, 59(3), 26–31. <https://doi.org/10.48165/IJEE.2023.59305>
- Sharma, M., & Singh, R. (2023). Impact assessment of Ri-Lajong FPO on livelihood of the farmers in Ribhoi district, Meghalaya. *Indian Journal of Extension Education*, 59(3), 43–47. <https://doi.org/10.48165/IJEE.2023.59308>
- Shobana, S., Krishnaswamy, K., Sudha, V., Malleshi, N. G., Anjana, R. M., Palaniappan, L., & Mohan, V. (2011). Finger millet (Ragi, *Eleusine coracana* L.): A review of its nutritional properties, processing, and plausible health benefits. *Advances in Food and Nutrition Research*, 62, 56–97. <https://doi.org/10.1016/B978-0-12-385989-1.00003-X>
- Singh, G., & Vatta, K. (2019). Assessing the economic impacts of farmer producer organizations: A case study in Gujarat, India. *Agricultural Economics Research Review*, 32, 139–148.
- Wani, S. P., Garg, K. K., Singh, A. K., & Pathak, P. (2017). Water harvesting and recharge technologies for enhancing water productivity in semi-arid tropics. *Advances in Soil Science*, 23, 277–320.