



RESEARCH ARTICLE

Sustainable agriculture and farmer welfare: A study of Farmer Producer Organizations (FPOs) and their impact on rural livelihood in Ramanathapuram district

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Abstract

The study assesses the role of 3 Farmer Producer Organisations (FPOs) in enhancing rural livelihood in Ramanathapuram district, Tamil Nadu. One hundred and twenty farmers, including 60 FPO members and 60 non-members, were surveyed to compare socio-economic characteristics and livelihood impact. The research is multi-dimensional as it uses the frequency percentage analysis in the socio-economic profiles of the farmers but also conducts SWOT analysis about FPOs to judge effectiveness and challenges. Besides this, the paper also examines the economic and operational impact of such FPOs on the farmers' livelihood. It uses the Heckman model to correct the selection bias present in the data. The Garrett ranking method is used to identify significant constraints faced by FPOs and suggests possible solutions. The study finds that FPOs positively impact farmers' livelihoods by boosting income, improving market access and promoting modern farming practices. However, challenges like limited credit, poor infrastructure and low technical knowledge hinder their effectiveness. Addressing these through policy support, financial access and training can enhance FPO performance and farmer well-being.

Keywords: farmers income; Farmer Producer Organizations (FPO); garrett ranking; heckman selection model; rural livelihood; SWOT analysis

Introduction

Farmer Producer Organizations (FPOs) are collective groups that empower farmers by improving market access, bargaining power and resource management (1). Despite agriculture being a cornerstone of India's economy, farmers often face low income, poor market linkage and limited access to modern technologies, where agriculture plays a critical role, farmers also struggle with unstable prices and inadequate infrastructure (2 - 4). This study aims to assess the impact of FPOs on farmer incomes and resource access, offering broader insights into their role in improving rural livelihoods across India (5).

1.1 Overview of farmer producer organizations

FPOs are designed to organize marginal and smallholder farmers into collective groups to improve their livelihoods (6). Although agriculture's share in India's GDP has declined to about 13 %, it still employs nearly 55 % of the workforce. According to the 2015 -16 Agricultural Census, over 145 million farm holdings exist in India, with marginal and small holdings (below 2 hectares) comprising more than 86 % of the total (7-9). This disproportionate dependency on agriculture among smallholders underscores the importance of institutional support like FPOs (10).

Several central and state-level initiatives support the formation of FPOs, including schemes such as the Rashtriya Krishi Vikas Yojana (RKVY), Paramparagat Krishi Vikas Yojana (PKVY) and the Vegetable Initiative for Urban Clusters (VIUC). Institutions like the Small Farmers' Agribusiness Consortium (SFAC) and NABARD play leading roles in funding and capacity building for FPOs. These efforts aim to improve access to markets, inputs and knowledge, especially for smallholders (11 -13).

1.2 Impact of FPOs on farmers' livelihoods in Ramanathapuram district

In Ramanathapuram district, the role of FPOs is particularly crucial due to region-specific challenges such as unstable market prices, limited access to modern farming technologies and inadequate infrastructure (14-16). These factors contribute to persistent income instability and low agricultural productivity, making collective action through FPOs a vital strategy for improving farmer livelihoods (17 - 18). In light of the above context, this study seeks to comprehensively examine the role of Farmer Producer Organizations (FPOs) in enhancing the livelihoods of small and marginal farmers in Ramanathapuram district, Tamil Nadu. The specific objectives

of the research are threefold: (i) to assess the current status and operational performance of selected Farmer Producer Companies (FPCs), (ii) to analyze the socio-economic impact of FPC membership on farmers and (iii) to identify the key challenges faced by these organizations and recommend viable strategies for their sustainability. The study is guided by the hypotheses that there exists a significant difference in the income levels of farmers before and after joining FPOs and that various socio-economic and institutional factors, such as gender, education, farm size, access to inputs and training, significantly influence farmer participation in these organizations. Furthermore, it posits that FPO participation leads to reduced transaction costs and improved price realization through collective bargaining and economies of scale. The scope of this research encompasses an in-depth analysis of FPO functioning, governance, member engagement and impact assessment, aiming to generate evidence-based insights for policymakers and development practitioners to enhance the effectiveness and reach of FPOs in rural India (19 - 22).

Research Methodology

The study employed both purposive and random sampling methods to select the sample districts, blocks, villages and respondents for data collection. The Ramanathapuram district was purposefully chosen, with 16 functioning Farmer Producer Companies (FPCs). Three companies were randomly selected and categorized based on their authorized share capital. Specifically, the chosen FPCs included Ramnad Mundu Chilli Producer Company Limited, Parambai Farmers Producer Company Limited and Thiruvadanai Nerkkalanjiyam Farmers Producer Company Limited. In each of the selected FPCs, 20 members were randomly chosen to ensure a representative sample for statistical analysis. To evaluate the impact of FPO membership on various agricultural practices, an additional 20 non-members from the same villages were also surveyed. This approach resulted in a total sample size of 60 FPO members and 60 non-members.

Furthermore, statistical tools such as Heckman's two-step model and Garrett's ranking technique were applied to analyze the data. Heckman's model was used to address potential selection bias, while Garrett's method helped in ranking preferences or challenges faced by the participants before introducing any formulae.

2.1. Sources of data

- ◆ **Primary data:** Well-structured and pre-tested interview schedule for different stakeholders.
- ◆ **Secondary data:** Secondary data were obtained from district handbooks, crop reports and published literature relevant to FPO operations.

2.2. Tools used for analysis

2.2.1. Descriptive analysis

Compound Annual Growth Rate analysis was used to assess the status of FPOs in India and Tamil Nadu in terms of the number of FPOs registered, authorized capital and paid-up capital from 2014 - 2023. Descriptive statistics, including

frequencies, percentages and CAGR, were employed to assess demographic and economic attributes of FPO members. Moreover, the details of the FPO-based information were tabulated and discussed.

2.2.2. Economic performance of FPOs- SWOT analysis

The economic performance of the selected Farmer Producer Organizations (FPOs) was assessed through a SWOT analysis conducted with inputs from Chief Executive Officers and Board members. The data collected was analyzed using simple descriptive statistics, such as frequencies and percentages and the SWOT components were weighted to determine their relative importance. The analysis revealed that key strengths included direct marketing of farm produce, reduced reliance on intermediaries, improved profit margins and enhanced community engagement through Farmer Interest Groups. Opportunities identified were improved access to credit, government schemes, skill development and market linkages. However, weaknesses such as inadequate knowledge of modern practices, lack of processing infrastructure and dependency on external credit sources were prevalent. Threats faced by the FPOs included price volatility, intense market competition and internal coordination challenges. The SWOT analysis helped identify critical areas for strategic improvement to ensure the long-term sustainability and resilience of FPOs.

2.2.3. Factors influencing the participation of members in the FPO -Heckman selection model

The Heckman two-step model is applied to correct for non-random participation in FPOs. Since the decision to join an FPO may depend on specific observable and unobservable factors, there is a risk of selection bias, which could distort the results analysis. Using this model, the study aims to account for this bias and produce more accurate estimates of the effects of FPO participation.

The model consists of the following 2 steps:

1. Probit regression: In the first step, a Probit model estimates the probability of an individual participating in an FPO. This involves identifying factors influencing the participation decision, generating an inverse Mills ratio (λ), which captures the likelihood of selection bias.

2. Ordinary Least Squares (OLS) with λ : In the second step, the λ derived from the Probit model is included as an additional explanatory variable in the OLS regression. This step adjusts for the selection bias identified in the first step, enabling a more accurate estimation of the effects of FPO participation on the outcomes under study.

To assess the factors influencing the participation of members in the FPO program, the Heckman selection two-state model was used (23). Participation in the FPO program was taken as the dependent variable, with the independent variables such as gender, education, age of respondents, dependency ratio, farm size, high-yielding varieties (HYVs), hired labor, credit through KCC, implements and machinery, provision of inputs by FPO. In the second stage of the Heckman selection model with the selection bias and exogenous variables, gender, education, age of respondents, dependency ratio, farm size, high-yielding varieties (HYVs), training by FPOs,

hired labor, credit through KCC, implements and machinery and inverse mill's ratio.

The present study attempted to analyze the factors influencing the income of farmers in FPOs using the Heckman selection two-state model to avoid the selection bias problem of variables (24). In the first stage of the model, the probit model will run with the following equation:

$$P(0,1) = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6 + \beta_7X_7 + \beta_8X_8 + \beta_9X_9 + \beta_{10}X_{10} + \mu_{2i} \quad (\text{Eqn. 1})$$

Where,

$P(0,1)$ = indicating Probit estimates, β_0 = intercept, β_1 to β_{10} = slope coefficients, X_1 = gender, X_2 = education, X_3 = age of respondents, X_4 = dependency ratio, X_5 = farm size, X_6 = high yielding varieties (HYVs), X_7 = hired labour, X_8 = credit through KCC, X_9 = implements and machinery, X_{10} = provision of inputs by FPO and μ_{2i} = Indicates the disturbance terms of model.

$$E_i = \beta_1 + \sum \beta_2 X_{1i} + \mu_{1i} \quad (\text{Eqn. 2})$$

Where,

E_i is a latent variable that indicates dichotomy (denoted by 1, otherwise 0), β_1 = intercept, β_2 = slope coefficient, X_{1i} = exogenous variables that affect the income of farmers and μ_{1i} = indicating disturbance term and $\mu_{1i} \sim N(0, 1)$ means the disturbance term is normally distributed.

In the second stage of the Heckman selection model, the ordinary least squares (OLS) was run by adding the value of Inverse Mill's Ratio (λ_i) as an additional exogenous variable of the model.

$$Y_i = \alpha_0 + \alpha_1X_1 + \alpha_2X_2 + \alpha_3X_3 + \alpha_4X_4 + \alpha_5X_5 + \alpha_6X_6 + \alpha_7X_7 + \alpha_8X_8 + \alpha_9X_9 + \alpha_{10}X_{10} + \alpha_{11}\lambda_i + \mu_{3i} \quad (\text{Eqn. 3})$$

Where,

Y_i = denotes income of respondents, α_0 = intercept, α_1 to α_9 = slope coefficients, X_1 = gender, X_2 = education, X_3 = age of respondents, X_4 = dependency ratio, X_5 = farm size, X_6 = high yielding varieties (HYVs), X_7 = training by FPOs, X_8 = hired labour, X_9 = credit through KCC, X_{10} = implements and machinery, λ_i = Inverse Mill's Ratio and μ_{3i} = disturbance

terms.

2.2.4. Garrett's Ranking Technique

Garrett's Ranking Technique was applied to rank a set of constraints as perceived by the sample respondents based on specific criteria (25). The respondents ranked the problems and then these ranks were converted into percent positions using the formula.

$$\text{Percent Position} = 100 * (R_{ij} - 0.50) / N_j$$

where,

- R_{ij} = Rank given for the i^{th} variable by the j^{th} respondent
- N_j = Number of variables ranked by the j^{th} respondent
- The percent positions established were converted into scores using the Garrett's table. Therefore, each respondent's scores were added for each factor and then the mean value was obtained. The variable with the highest mean value was selected as the most essential factor.

Results and Discussions

3.1. General characteristics of FPO members

Table 1 presents the demographics and socio-economic characteristics of the 120 participants. There seems to be reasonable female participation; the dominance of female participation (77 %) indicates strong gender inclusivity, which may affect decision-making dynamics within FPOs. Age is skewed to be mostly above 50 years (33 %), followed by those between 31 - 40 (30 %), thus skewed to middle-aged and older ones. Regarding education level, 32.5 % have secondary schooling, 22.5 % are graduates, 21 % are higher education graduates and 5 % are illiterate. The majority of the respondents (68 %) belong to family sizes of 4 - 6 members, 37.5 % have a yearly income below ₹1,00,000 and 41.6% fall in between ₹1,00,000 - ₹2,00,000, reflecting a significant majority facing financial restraints. Among the respondents, 30 % have 21 - 30 years of experience and 29.1 % have less than 10 years of experience. Landholding is (39.1 %) with 1 - 2 ha and (27.5 %) have less than 1 hectare, which indicates that most of the

Table 1. General characteristics of FPC members

	Particular	Frequency	Percentage
Gender	Male	27	23
	Female	93	77
	Total	120	100
Age	up to 30 years	16	13.3
	31 - 40	36	30
	41 - 50	28	23.3
	above 50	40	33.4
	Total	120	100
	Illiterate	6	5.1
Educational status	Primary	23	19.1
	Secondary	39	32.5
	Higher	25	20.8
	Graduate	27	22.5
	Total	120	100
Family size (Nos.)	Less 4	25	21
	4 - 6	82	68
	More 6	13	11
	Total	120	100
	Below 100000	45	37.5
Annual income (Rs.)	100000 - 200000	50	41.6
	200000 - 300000	8	6.6
	Above 300000	17	14.3
	Total	120	100

respondents are small-scale farmers. Overall, the data shows that most middle-aged, moderately educated and financially constrained individuals are small-scale farmers, with a strong presence of experienced farmers.

Table 2 reports the farming experience for FPC members in the Ramanathapuram District. Respondents with 11 - 20 years of farming experience dominated with (29.17 %), followed by (26.67 %) who had more than 30 years of experience, implying a huge proportion of highly experienced

Table 2. Farming experience of FPC members in Ramanathapuram district

Sl. No	Particulars	Frequency	Percent (%)
1	Less than 10 years	25	20.83
2	11 - 20 years	35	29.17
3	21 - 30 years	28	23.33
4	More than 30 years	32	26.67
	Total	120	100.00
	Mean farming experience (Years)	18	

farmers. (23.33 %) have 21 - 30 years of experience and (20.83 %) have less than 10 years of experience, indicating relatively new farmers within the group. The mean experience in farming is 18 years, indicating that an average respondent has adequate expertise and know-how in agriculture. Overall, the above data shows a good distribution of mature and relatively fresher farmers by a strong section of farmers owning more than one decade of experience.

Most of the respondents (41.67 %) are marginal farmers with less than 1 hectare of land. Small farmers with 1 - 2 hectares of land accounted for 29.17 %. Semi-medium farmers with 2 - 4 ha of land are (16.67 %). Only 8.33 % constitute medium farmers with 4 -10 ha of land. A meagre 4.17 % are large farmers with landholdings over 10 ha. The mean farm size is 1.8 ha. This means that most FPC members are small or marginal farmers. It shows that the dominant landholding among the respondents is low and that most farmers could face problems with productivity and resource availability in the region.

Table 3. Farm size of the FPC members in Ramanathapuram district

S. No	Particulars	Frequency	Percent (%)
1	Marginal farmers (<1 ha)	50	41.67
2	Small farmers (1 - 2 ha)	35	29.17
3	Semi-medium farmers (2 - 4 ha)	20	16.67
4	Medium farmers (4 - 10 ha)	10	8.33
5	Large farmers (>10 ha)	5	4.17
	Total	120	100.00
	Mean farm size (ha)	1.8	

Table 4 briefly describes 3 FPOs in the Ramanathapuram district: Parambai FPC, Ramnad Mundu Chilli FPO and Thiruvadanai Nerkkanjiam FPC. These FPOs were registered between 2015 and 2019 and are between 6 and 9 years of age. The number of members in each FPOs is a maximum of 1500, mainly small and marginal farmers. The highest proportion of small-scale farmers is found in Parambai FPC, at 40 %, followed by 38 % in both Ramnad Mundu Chilli FPO and Thiruvadanai Nerkkanjiam FPC. Semi-medium and large farmers have the smallest proportion, with large farmers comprising 9 % - 12 % across the FPOs. NABARD and SFAC sponsor the organizations and reach 25 - 30 villages each. They are of financial strength as their authorized capital ranges between ₹10,00,000 and ₹26,00,000, whereas their paid-up capital ranges between ₹10,00,000 and ₹25,00,000. Boards of directors govern, ranging from 5 - 8 members per board and the latest AGMs took place between September 2023 and December 2024. The data shows the high significance of these FPOs in helping small farmers, boosting agricultural growth and being financially stable in the region.

Table 5 depicts that FPCs of Ramanathapuram district are looking to avail themselves of the following sources of grants and loans. In total, 3 FPCs received a total funding of ₹524.00 lakhs, wherein Parambai FPC received ₹205.00 lakhs, Ramnad Mundu Chilli FPO received ₹169.00 lakhs and Thiruvadanai Nerkkanjiam FPC received ₹150.00 lakhs. The primary sources of funding are NABKISHAN, which offered a

Table 4. Profile of Sample Farmer Producer Organization (FPOs) in Ramanathapuram district

Particulars	Parambai farmer producer company limited	Thiruvadanai Nerkkalanjiyam farmer producer company limited	Ramnad Mundu chilli producer company limited
Date of registration	07.12.2018	19.12.2019	24.08.2015
Age of FPC	6 years	5 years	9 years
Number of members	1000	1500	1500
Marginal farmers (<1ha)	610 (61.00)	648 (44.00)	769 (50.00)
Small farmers (1 - 2 ha)	280 (28.00)	582 (39.00)	325 (22.00)
Semi-medium farmers (2 - 4 ha)	-	-	-
Large farmers (>10 ha)	10 (1.00)	115 (7.00)	159 (11.00)
Landless / Agri labourers	100 (10.00)	155 (10.00)	247 (17.00)
Total	2500 (100.00)	1000 (100.00)	1500 (100.00)
Promoted by	NABARD	NABARD	NABARD
Villages covered	30	79	25
Authorized capital (Rs.)	10,00,000	15,00,000	26,04,000
Paid-up capital (Rs.)	10,00,000	15,00,000	25,00,000
No. of BoD including the chairman	5	8	6
The last AGM meeting conducted	25.11.2024	28.09.2023	06.09.2024

Table 5. Sources of grants and loans sought for the FPCs in the Ramanathapuram district

S. No	Type of funding	Source of funds	Parambai farmer producer company Ltd.	Ramnad Mundu chilli farmer producer organisation	Thiruvadanai Nerakkanjiyam farmer producer company Ltd.	Total amount (Rs. Lakhs)
1	Matching grant	NABKISHAN	75.00	70.00	60.00	205.00
2	Start-up grant	Nationalized bank	40.00	30.00	35.00	105.00
3	Equity grant	NABARD and SFAC	20.00	22.00	15.00	57.00
4	Loan	L & T finance	40.00	28.00	20.00	88.00
		Bell star Ffinance	30.00	19.00	20.00	69.00
Total			205.00	169.00	150.00	524.00

total amount of ₹205.00 lakh as a Matching Grant and nationalized banks, which provided ₹105.00 lakh as a Start-up Grant. An Equity Grant of ₹57.00 lakh was received from NABARD and loans were taken from L & T Finance at ₹88.00 lakh and Bell Star Finance at ₹69.00 lakh. Diversified financial support to the FPCs is revealed by the data, financial grants and loans, which have played an essential role in economic sustainability and operational growth.

The FPO distributes seeds, fertilizers and other nutritional products to the sample members at a subsidized rate. The distribution of inputs by the FPO to the sample members is presented in Table 6. The FPO supplies a variety of seeds, including paddy, chilli and cotton, fertilizers like urea and complex and millet cookies to its members. In 2023 - 24, the FPO distributed seeds, fertilizers, cattle feed and health mix pockets at prices below market rates, aiming to benefit farmers. The FPO provided substantial savings on seeds like paddy at Rs. 1500/kg, lower than the market price of Rs. 1550/kg and samba chilli at Rs. 9500/kg, compared to the market price of Rs. 1100/kg and kundu chilli at Rs. 1200/kg compared to the market price of Rs.1250/kg and cotton seed at Rs. 750/kg compared to market price of 800/kg. Similarly, urea is priced at Rs. 6/kg by the FPO, lower than the market rate of Rs. 7/kg and complex fertilizers are also offered at reduced prices compared to the market. Even for millet cookies and laddu, the FPO provided modest to substantial discounts, showing a difference of Rs. 560/kg and Rs. 580/kg, respectively. Overall, this difference in pricing highlights the FPO's role in reducing input costs and enhancing the economic viability of farming operations for its members. Overall, this difference in pricing highlights the FPO's role in reducing input costs and enhancing the economic viability of farming operations for its members. This ultimately leads to improved financial stability and sustainability for farmers.

3.2. SWOT analysis

3.2.1. Strength

The FPOs in Ramanathapuram district demonstrate strong inclusivity, with 77 % female participation, fostering gender-

balanced decision-making. Members have an average of 18 years of farming experience, ensuring a solid technical foundation. Financial stability is supported through ₹498.00 lakhs in grants and loans from NABKISHAN, NABARD and other nationalized banks. Many members are small and marginal farmers, ensuring resources prioritize their needs. The governance structure, with defined leadership and annual meetings, enhances accountability and long-term sustainability.

3.2.2. Weakness

Challenges include small landholdings (under 2 ha), limiting productivity and economies of scale. Large farmers are underrepresented (4.17 %), restricting opportunities for scaling operations. Dependence on external grants and loans raises concerns about future sustainability. Additionally, lower educational levels among some members (5 % illiterate) hinder access to market information, adoption of new technologies and financial literacy.

3.2.3. Opportunities

Expanding market linkages and partnerships with larger agricultural entities can enhance supply chain efficiency. Greater access to funding supports infrastructure growth and operational expansion. Adoption of modern farming technologies and digital tools can improve productivity. Targeted outreach programs can attract medium-to-large farmers, strengthening the FPOs' operational base. Government initiatives provide further resources for rural agricultural development.

3.2.4. Threats

Price volatility in agricultural commodities threatens financial stability. Small and marginal farmers struggle to compete with larger producers, impacting market share. Climate change and unpredictable weather pose risks to agricultural productivity. While members have extensive farming experience, limited access to advanced farming practices and market intelligence may hinder operational efficiency.

3.3. Heckmann analysis:

3.3.1. Testing assumptions of the probit model

The study employed the Heckman two-stage selection model

Table 6. Distribution of inputs by FPO 2023 - 24

S. No	Name of input	Quantity (Kg)	Price (Rs/Kg)	Market price (Rs/Kg)
I. Seeds				
1.	Paddy	15500	1500	1550
2.	Chilly	Kundu	10250	1200
		Samba	9500	900
3.	Cotton	9000	750	800
II. Fertilizers				
1.	Urea	17000	6	7
2.	Complex fertilizer	12000	27	28
3	DAP	20000	80	87
III. Others				
1.	Millet cookies	50	560	580

to analyze the factors influencing farmers' income. In the first stage, a probit model was used, which required the assumption of normally distributed residuals. This was tested using the Jarque-Bera (JB) normality test. The JB statistic was estimated at 9.89, with a p-value greater than 0.05, indicating that the residuals followed a normal distribution.

Another key assumption was the absence of multicollinearity among exogenous variables. This was tested using the Variance Inflation Factor (VIF) and the results in Table 7 showed all VIF values below the critical threshold of 10, confirming no severe multicollinearity existed.

Selection bias was tested using the Inverse Mills Ratio (IMR), which yielded a significant and positive coefficient (0.040, $p < 0.05$), suggesting that unobserved factors influenced income, affirming the need for a two-stage model.

3.3.2. Determination of factors' influence on the income of member farmers (Stage I-Probit Model)

The probit model results (Table 8) revealed that variables such as age, dependency ratio, farm size, high-yielding varieties (HYVs), credit through Kisan Credit Cards (KCC), implements and machinery and input provision by FPOs significantly influenced farmers' income.

Age, credit through KCC and implements and machinery were significant at the 5 % level. Notably, gender, dependency ratio, hired labor, implements and machinery had negative coefficients. In contrast, inputs provided by FPOs had a strong positive effect on the probability of participation.

Farm size was positively associated with income ($\beta = 0.039$, $p = 0.000$), indicating that larger farms generated higher incomes. This aligned with findings by, who emphasized

the income advantage of consolidated farms (26).

Similarly, HYVs had a significant positive impact ($\beta = 0.219$, $p = 0.000$), corroborating, who also observed income increases from HYV adoption (27).

The provision of inputs by FPOs substantially affected income ($\beta = 0.47$, $p = 0.000$). These inputs-seeds, fertilizers, pesticides-were critical for productivity gains. The marginal effect analysis showed a 0.58 unit average increase in income due to input provision, reinforcing the importance of timely and affordable access.

However, implements and machinery negatively impacted income ($\beta = -0.10$, $p = 0.027$). This contradiction was likely due to high maintenance costs, lack of operator training, or underutilization of equipment. Similar inefficiencies in machinery use were discussed by (28).

Dependency ratio negatively affected income ($\beta = -0.6$, $p = 0.002$). Higher numbers of dependents relative to working members strained household resources, limiting productive investment, consistent with observations by (29).

3.3.3. Extent of factors that influence the income of a member (Stage II-OLS Model)

The second stage employed OLS regression to estimate outcome variables while correcting for selection bias. The Inverse Mills Ratio remained significant ($\lambda = 0.323$, $p = 0.040$), confirming non-random sample selection. A high correlation between the error terms ($\rho = 0.955$) validated the two-stage approach.

Training provided by FPOs emerged as the most impactful factor ($p = 0.000$), contributing to a 21 % increase in

Table 7. Variance Inflation Factor (VIF)

Variable	VIF	1/VIF
Farm size	2.21	0.452
High yielding varieties	2.05	0.487
Implements and machinery	1.37	0.729
Education	1.35	0.738
Dependency ratio	1.31	0.760
Provision of inputs	1.19	0.842
Hired labour	1.18	0.846
Gender	1.17	0.852
Age	1.07	0.932
Credit through kisan credit card	1.07	0.938
Mean VIF	1.40	

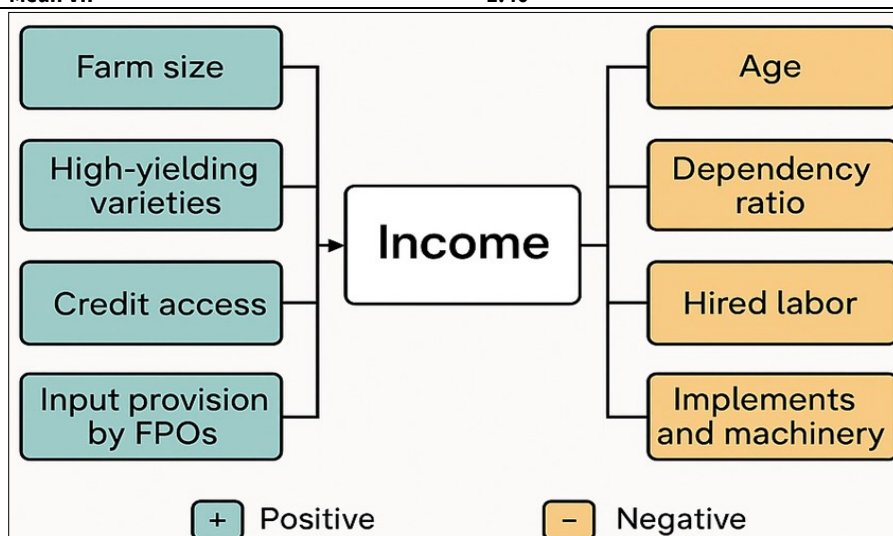


Fig.1. Conceptual diagram of how variables influence income.

Table 8. Probit model estimates of the income influencing factors (n = 120)

Variables	Coefficient	Std. error	p-value	Marginal effect
Constant	0.047	0.275	0.084	1.567
Gender (male = 1, female = 0)	-0.20	0.100	0.841	0.65
Education (Educated = 1, Uneducated = 0)	0.032	0.121	0.788	0.75
Age (Years)	0.08**	0.004	0.049	42.17
Dependency ratio (No. of non-workers/Family size)	-0.06***	0.529	0.002	0.450
Farm size (Ha)	0.039***	0.038	0.000	2.38
HYVs (Yes = 1, No = 0)	0.219***	0.146	0.000	0.48
Hired labour (Yes = 1, No = 0)	-0.03	0.116	0.770	0.75
Credit through KCC (Yes = 1, No = 0)	0.19**	0.094	0.040	0.72
Implements & machinery (Yes = 1, No = 0)	-0.22**	0.105	0.010	0.69
Provision of inputs by FPOs	0.042***	0.113	0.000	0.58
Censored observation		60		
uncensored observation		60		

member income. Training facilitated exposure to innovative farming methods, improved adoption of modern practices and enhanced managerial capabilities. Similar findings were noted by, who linked FPO training to increased income and crop diversification (30).

Hiring labour was associated with a 19 % income reduction. This negative influence was likely due to high wage costs and dependency on external labour, often unskilled. This aligns with, who noted a similar income drop in labour-intensive operations (31).

Gender had a negative but statistically insignificant impact (20 %), implying income disparities possibly driven by limited land access and decision-making power for women, echoing findings by (32).

Education and age, while positively associated, did not significantly impact income in this model. However, more educated farmers pursued off-farm income sources and were better informed about schemes, as noted by (33).

The continued significance of HYVs in the second stage ($p = 0.007$) reinforced the productivity benefits of advanced seed technology, which is crucial for yield improvement.

The findings highlighted several areas for Policy Relevance:

- **Strengthen training programs:** Investment in farmer training should be prioritized to build technical, managerial and financial skills, increasing productivity and income.
- **Promote credit access:** Expanding access to formal credit through tools like KCC helps farmers invest in productive inputs, enhancing income potential.
- **Improve machinery use efficiency:** Establishing shared services or custom hiring centres can address inefficiencies

linked to machinery ownership, reducing costs and boosting returns.

- **Support farm consolidation:** Policies encouraging cooperative farming or land pooling can help smallholders benefit from economies of scale.
- **Targeted input subsidies:** Ensuring affordable access to quality inputs, particularly HYVs, is essential for sustained income growth.
- **Address household demographics:** Programs promoting family planning and creating income opportunities for dependents can alleviate economic strain.

3.4. Constraints faced by the FPO members

Constraints faced by FPOs and their members reveal a complex set of challenges across organizational, economic, technical and marketing dimensions (34).

3.4.1 Organizational constraints

Percentage data on organizational constraints FPOs in Ramanathapuram face serious governance challenges, with poor group formation skills (69.98 %) being the most critical. Weak group cohesion hampers trust, decision-making and effective collaboration, limiting the organization's ability to function optimally. This issue is especially problematic in regions like Ramanathapuram, where farmers rely on collective bargaining to negotiate better prices and secure funding.

Similarly, ineffective teamwork (65.8 %) undermines cooperative efforts, reducing members' willingness to engage in joint decision-making. Disappointing profit shares (56.61 %) discourage participation, leading to lower morale and less commitment from farmers. Members who perceive minimal

Table 9. OLS estimates of factors applied in the Heckman model (n = 120)

Variables	Coefficient	Std. error	p-value
Gender	0.268	0.345	0.439
Education	0.16	0.405	0.131
Age	0.21	0.016	0.199
Dependency ratio	-0.19***	1.147	0.000
Farm size	-0.33***	0.144	0.002
HYVs	0.22***	0.455	0.007
Training by FPOs	0.21***	0.337	0.000
Hired labour	-0.19	0.375	0.131
Credit through KCC	0.09	0.350	0.792
Implements and machinery	-0.10**	0.421	0.027
Inverse Mills Ratio (λ)	0.033**	0.157	0.040
rho		0.955	
sigma		0.338	
lambda		0.033	

Table 10. Organizational constraints

Sl. NO	Organizational constraints	Percentage	Rank
1	Poor group formation skills	69.98	I
2	Group members failing to work together effectively	65.8	II
3	Disappointing profit shares for members	56.61	III
4	Competition in business	43.38	IV
5	Ineffective monitoring	35.85	V
6	Absence of effective decision-making	28.36	VI

economic benefits may disengage, weakening the FPO. External competition (43.38 %) adds further pressure, as larger agricultural businesses overshadow small-scale FPO initiatives.

"Ineffective monitoring" (35.85 %) reflects a lack of accountability, making it harder to track financial and operational performance, while poor decision-making structures (28.36 %), though ranked lowest, still indicate persistent inefficiencies in leadership. Addressing these constraints is crucial to building stronger, more resilient organizations supporting farmers effectively.

3.4.2. Economic constraints

The most pressing challenge, high labour costs (73.46 %), significantly increases the financial burden on farmers, particularly for intercultural farming operations. This issue is worsened by labour shortages (45.08 %), forcing farmers to pay higher wages or struggle with insufficient manpower.

A lack of awareness about credit facilities (65.95 %) prevents farmers from accessing essential financial support, restricting investment in modern technologies and improved infrastructure. This limitation is particularly evident in rural Tamil Nadu, where many smallholder farmers remain disconnected from institutional credit opportunities.

Meanwhile, the high cost of ploughing (64.18 %) reduces profit margins, pushing farmers into unsustainable financial cycles. Climate change further exacerbates the problem, with declining yields (50.9 %) due to unpredictable weather patterns affecting long-term sustainability.

Lastly, inadequate crop insurance (42.91 %) increases farmers' financial vulnerability, exposing them to losses from

extreme weather and market downturns. Addressing these economic barriers is crucial for enhancing financial security and fostering long-term agricultural growth.

3.4.3. Technical constraints

The most severe technical barrier, the unavailability of timely, cost-effective, high-quality inputs (71.27 %), disrupts planting cycles, reducing efficiency and output. Farmers struggle to maintain optimal yield levels without access to essential resources like fertilizers, quality seeds and pesticides at the right time.

Additionally, insufficient awareness of grading, packaging and post-harvest operations (71 %) prevents farmers from maximizing their product value, leading to revenue losses. The lack of understanding of value addition (57.15 %) further limits their ability to enhance product quality, branding and profitability.

Inadequate training and support services (50.23 %) restrict knowledge transfer, preventing farmers from adopting modern farming techniques. Storage shortages (36.32 %) make post-harvest management difficult, while poor drainage systems (33.53 %) contribute to flooding risks, particularly in areas like Ramanathapuram that experience heavy monsoons. Strengthening technical infrastructure and education is essential for improving efficiency and reducing waste.

3.4.4. Marketing constraints

The biggest marketing hurdle, lack of access to current market trends (72.6 %), prevents farmers from making informed decisions on pricing and sales. This issue is particularly severe in rural Tamil Nadu, where digital literacy and market

Table 11. Economic constraints

Sl. NO	Economic constraints	Percentage	Rank
1	Labour costs are significantly higher for intercultural farming operations	73.46	I
2	Lacking knowledge of credit facilities	65.95	II
3	High ploughing costs	64.18	III
4	Declining yields due to climate change	50.9	IV
5	Scarcity of agricultural labour	45.08	V
6	Inadequate crop insurance facilities	42.91	VI

Table 12. Technical constraints

Sl. NO	Technical constraints	Percentage	Rank
1	Unavailability of cost-effective, good-quality inputs on time	71.27	I
2	Insufficient awareness of the importance of grading, packaging and post-harvest operations	71	II
3	People are unaware of the benefits of value addition	57.15	III
4	Lack of adequate training and support services	50.23	IV
5	Lack of adequate storage facilities	36.32	V
6	Inadequate drainage systems	33.53	VI

Table 13. Marketing constraints

Sl. NO	Marketing constraints	Percentage	Rank
1	Insufficient access to current market trends	72.6	I
2	Exploitation of the middleman	64.5	II
3	Significant price fluctuations in the market	54.51	III
4	Delayed payment for goods	48.33	IV
5	Distant marketplace with costly transportation	34.33	V
6	Coordination problem from production to consumption	32.98	VI

information accessibility remain low.

Exploitation by middlemen (64.5 %) continues to be a systemic issue, reducing farmers' earnings while benefiting intermediaries who control distribution networks. Unstable market prices (54.51 %) make income unpredictable, complicating financial planning.

Additionally, delayed payments (48.33 %) create cash flow problems, restricting reinvestment in farming operations. Costly transportation and distant markets (34.33 %) reduce profit margins, while poor supply chain coordination (32.98 %) further slows the movement of goods from farms to consumers. Investing in better market infrastructure and direct farmer-consumer linkages can significantly improve profitability.

4. Policy implications

The study arrives at several policy implications to promote the growth and sustainability of FPOs in Tamil Nadu:

4.1 Promotion of FPOs

- There has been positive growth in the number of FPOs in Tamil Nadu, indicating the need for greater institutional support. This includes promoting more FPOs through policy interventions and institutional support mechanisms (35).

4.2. Training for office bearers

- To increase the sales revenue and profitability of FPOs, training programs for office bearers on managing capital and assets should be prioritized. Focusing on financial management and resource allocation will enhance the operational efficiency of these organizations (36).

4.3. Encouraging FPOs as procurement agencies

- State governments should encourage FPOs to act as procurement agencies, improving market access and facilitating the establishment of forward linkages, including storage facilities, post-harvest processing and value addition. Previous studies have demonstrated that when FPOs manage procurement and post-harvest activities, they create more resilient agricultural value chains (37).

4.4 Enhancing Marketing Activities

- To enhance their marketing activities, FPOs should establish procurement centres at their locations and purchase all crops grown by members. Currently, procurement is conducted at district-level centres, which can limit the reach and efficiency of FPOs. The government should explore the potential of FPOs as local procurement centres, allowing for greater market penetration and improved value capture for farmers (38).

enhancing the socio-economic situation of small and marginal farmers by increasing their access to the market, improving financial support and building capacity opportunities. FPOs have a positive and significant impact on the livelihood of the farmers by providing various support, such as training, scientific methods of farming and input material for farming. The government can facilitate the creation of enabling policies for FPOs to access credit and markets. NABARD can expand funding for capacity-building programs. NGOs should focus on digital literacy and leadership training to strengthen governance structures within FPOs. According to the study, FPO membership has positive results in terms of income level, modern farming technology adoption and negotiating powers in the agricultural market. However, the lack of credit access, poor infrastructure and low technical knowledge remain significant challenges, limiting the FPOs to their full potential. The Heckman model confirms the influence of socio-economic factors like education and farm size on participation in FPOs, thus requiring policy interventions. The Garrett ranking method also points out some key constraints, including high input costs, pests and diseases, low mechanization and requiring support from the government, enhanced access to finances and training programs. Maximizing the impact of FPOs on farmer livelihoods would be critical by strengthening institutional backing, increasing participation among farmers and enhancing financial linkages.

Future Research Directions

- Future studies could explore the long-term impacts of FPO membership through longitudinal data collection to capture dynamic socio-economic changes over time.
- Investigating the role of digital innovations-such as mobile-based extension services, e-marketplaces and digital payment systems-can reveal how technology enhances FPO performance and member outcomes.
- Additionally, assessing how FPOs can be strengthened to improve climate resilience among smallholders, especially in ecologically fragile regions like Ramanathapuram, remains a critical area for further inquiry.

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Authors' contributions

MA conceived the overall research idea and provided guidance. RS participated in designing the study framework and drafted

Conclusion

Farmer Producer Organizations (FPOs) have a crucial role in

the manuscript. RM supervised the study and coordinated the manuscript preparation. All authors read and approved the final manuscript.

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