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Enhancing Livelihoods through Farmer Producer Companies: A Study on Physical and Social Capital in Bihar, India

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Abstract

The study examines the role of Farmer Producer Companies (FPCs) in improving the livelihoods of small and marginal farmers in Bihar, a state in India, with a focus on the interaction between physical and social capital. It aims to explore how FPCs contribute to enhancing agricultural productivity, improving market access, and promoting collective action among farmers, emphasizing the cooperation between infrastructure (physical capital) and networks of trust (social capital) by taking into account the Sustainable Livelihoods Framework (SLF). For primary data, structured questionnaires were sent to 385 respondents, with 300 responding in total; of these, 250 respondents completed the questionnaire accurately. Secondary data is obtained from relevant literature, reports, and studies on FPCs. Regression and variance analyses were used to assess the impact. The study found a significant positive correlation between FPC membership and improvements in key areas such as irrigation systems, storage facilities, and social networks. These enhancements led to increased agricultural resilience, greater market competitiveness, and improved income levels for FPC members. The research is limited to specific districts in Bihar, which may affect the generalizability of the findings to other regions. Additionally, the study focuses on physical and social capital, leaving other factors, such as financial capital, unexamined. The findings offer valuable insights for policymakers, highlighting the need for increased support and development of FPCs. The study provides a comprehensive analysis of how FPCs enhance physical and social capital, contributing to the broader discourse on collective institutions like FPCs in transforming agricultural livelihoods in India.

Keywords: Farmer Producer Companies (FPCs), Livelihoods, Physical Capital, Small and Marginal Farmers, Social Capital.

Introduction

Producer Company (PC) has been viewed as a hybrid of private companies and cooperative societies (1). It is believed that PC reduces the constraints and limitations of cooperatives and blends the efficiency of the private company while keeping the original spirit of the cooperation. PC as a legal entity on the recommendations of a high-powered committee chaired by Y K Alagh was enacted by the government of India in 2003 as per section IX-A of the Indian Companies Act 1956. A PC is a legal entity of the producers of any kind, viz., agricultural produce, forest produce, artisanal products, or any other local produce, where the members are primary producers (2). As per the provisions of law, each member in a PC can have only one vote; he/she can contribute different amounts of share capital to the PC. The shares of the PC members cannot be transferred outside the membership. A PC should have a minimum of 10 members, or two producer entities, or a combination thereof that can form a PC. By virtue of assigning equal voting rights to each member, the issues of management control by small and marginal producers have been resolved in the design of the PC. The primary objective of mobilizing farmers into member-owned producer organizations, or Farmer Producer Company (FPC), was to enhance the production, productivity and profitability of agriculturists, especially small farmers in the country (3). It was for improved transparency and access to the input and output markets with much higher negotiating power, leading towards a sustainable quality of life for small and marginal farmers. An emerging interest in the establishment of Farmer Producer Companies (FPCs) could be viewed as part of critical interventions toward alleviating the problems of tiny and sporadic cultivators. In rural India, agricultural marketing is still in poor condition.

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Farmers who sell their goods at a low price to local traders and middlemen are their only option if there are no reliable purchasing facilities (4). The FPCs are designed to enhance farmers' bargaining power, reach better markets, and improve resource management. Within the Indian agricultural sector, both fragmented land holdings and market inefficiencies meant that FPCs presented an innovative solution to low productivity and income instability. As stated by "the Ministry of Agriculture and Farmers' Welfare," 86% of farmers in India are small and marginal. Hence, cooperative models like FPCs have a huge role to play in making it possible for that farmer to be competitive in the marketplace (5).

The study of FPCs assumes importance as they have the potential to solve several of India's pressing agriculture-related problems. The FPC avails an avenue for collective bargaining over better prices, pooling resources together for buying in bulk and then cutting down on the cost associated with transactions. Furthermore, study has demonstrated that FPCs significantly enhance the economic resilience of smallholder farmers both by offering better market access and better incomes (6). Understanding how FPCs work and the challenges they face thus informs a pathway toward improved efficacy.

The FPCs have the power to alter rural industries' fundamental trajectory. FPCs can reach the markets better, which reduces the input cost and strengthens collective action that would benefit the elimination of rural poverty as well as the improvement of food security (7). FPCs aimed at the establishment of production organizations and the linking of small farmers with conventional contemporary or different markets to increase incomes for farmers (6, 8). The FPCs in India could give new hope for improvement in farmers' incomes and connect them to the modern markets, but an assessment of performance and impact is still needed (6). Producer companies in India enhanced smallholder farmers' competitiveness and advantage in emerging market opportunities, benefiting rural communities and empowering farmers (1). FPOs in India had the potential to improve incomes and reduce transaction costs for small and marginal farmers, but they require sufficient capital to maximize benefits (9).

The impact of farmer-producer organizations in Bihar was positive on the adoption of technology and the adoption of Good Agricultural Practices, while issues like capital accessibility and lack of proper monitoring and evaluation mechanisms remained (10). In Assam, FPCs have been exposed to agro-productivity and profit enhancement opportunities for small and marginal farmers. However, capacity building, market linkages, and technical support turned out to be challenging for FPCs (11). Constraints of credit from banks, registration, fund generation, and market share capturing encumbered the performance enhancement of the same faced by FPCs of Tamil Nadu (12). Over time, the performance of FPCs in India improved, though development was highly variable across states, with both the Small Farmer Agribusiness Consortium (SFAC) and the National Bank for Agriculture and Rural Development (NABARD) as promoters (13). Dairy-based FPCs in India were perceived by farmers as effective tools for maximizing benefits, building capacity, improving access to agricultural services, and reducing transport costs (14).

In the context of Farmer Producer Companies (FPCs), the Sustainable Livelihood Framework (SLF) can be instrumental in evaluating how these entities enhance physical and social capital among farmers. The notion of 'sustainable rural livelihoods' has increasingly become a focal point in discussions on rural development, poverty reduction, and environmental management. The study has adopted the Sustainable Livelihoods Framework as given below in Figure 1 is developed by DFID and is modified (18) for the complete analytical foundation (15). The SLF provides a comprehensive approach to understanding how various forms of capital, viz., physical, human, social, financial, and natural, affect livelihood outcomes (16). FPCs often serve as a conduit for facilitating access to improved farming techniques, infrastructure, and market access, thereby fostering greater agricultural efficiency and long-term sustainability (17).

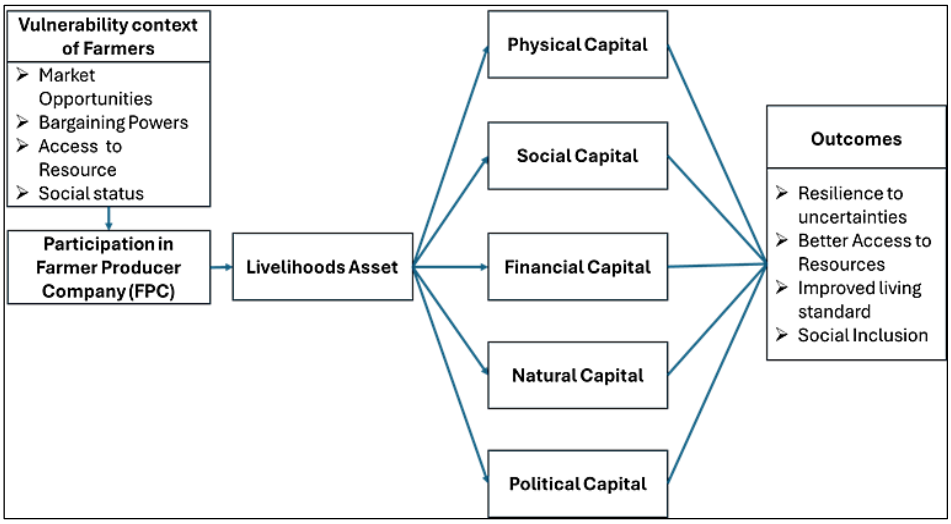

Figure 1: Sustainable Livelihood Framework with Modification

The two key variables analyzed in this study are physical capital and social capital. Physical capital refers to the irrigation system, transportation networks, and storage facilities to improve production (19). Social capital, in contrast, involves the networks, relations and trust among farmers, which enable collective action and resource sharing (20). Different studies have realized that the forms are interlinked and lead to the successful input of FPCs. For instance, FPCs with strong social capital are more likely to have their operations kept running and to yield better economic outcomes for the members (21).

In addition to social and physical capital, other forms of capital, i.e. financial capital, human capital, and natural capital, are relevant in the context of agricultural livelihoods. Financial Capital refers to monetary resources like savings, credit, and remittances that farmers use to enhance their productivity. It is observed that financial capital is important in achieving sustainable rural livelihoods (17). However, this study does not focus on financial capital because its influence on collective actions within Farmer Producer Companies (FPCs) is indirect compared to physical and social capital. Human Capital includes education, skills, and health, which are critical for individual productivity. Human capital has been underscored for its vital role in facilitating collective endeavors (22). Despite its relevance, human capital is not a direct determinant of the infrastructure and trust-based networks integral to FPC success. Natural Capital, which refers to natural resources like land and water, is essential for agriculture. However, it has been noted that natural capital often interacts with physical capital (e.g., irrigation systems) and social capital (e.g., collective water management), which were the focus of this study (23). The study prioritizes social and physical capital because they directly influence the success of FPCs by enhancing infrastructure and fostering networks of trust. Other studies have also highlighted this focus, demonstrating that robust social capital and adequate physical infrastructure serve as key determinants of long-term economic resilience in rural cooperatives (21).

Physical capital is the living assets owned or controlled either by a person or a team, and can be as simple as the body being a part of one's capital (24). This is based on Pierre Bourdieu's concept known as corporeal sociology, in which the body is considered socially produced and becomes an asset in terms of valuation based on physical characteristics and abilities (25). The development of social inequalities involves physical capital for its production since it can also influence a person's standing and opportunities. As a form of physical capital, the body has always had a major role in giving shape to gender and other sorts of social inequalities (26). Social capital entails networks, relationships, and interactions that offer people direct access to resources and support. It is often associated with social cohesion and trust within communities (27). There is great evidence that social capital affects actual health outcomes. For example, high social capital (family support and community cohesion) has been found to relate to better health and increased physical activity levels, especially among youth populations (28). In

adolescents, social capital from family and community is positively associated with the levels of physical activity, indicating its role in promoting healthy behaviors (29).

Most of the earlier studies which had been done on FPCs were regarding economic influence. However, the critical gap lies in understanding the long-run sustainability of such organizations and the specific roles of physical as well as social capital in ensuring their success. The under-researched area of FPC governance structure dependency on external support, including government subsidies and training programs has been observed and highlighted in recent studies (30). Also under investigation was the FPC's capacity to improve rural livelihoods, going about their business by amending core structural imperatives related to agriculture, such as land fragmentation and vulnerability to climate change, among others (31). This gap in the literature highlights the need for further investigation into the most effective approaches to improve FPCs.

This understanding of the role of both physical and social capital toward FPCs' success will greatly give way to some important policy insights that can guide future efforts to strengthen these organizations (32). For example, usually sustainable FPCs depend on sufficient amounts of policy support, such as provision through monetary incentives, capacity building, or infrastructure development (11). Also, social capital positively impacts members' trust in producer companies, with perceived benefits acting as a mediator (8).

Farmer Producer Companies (FPCs) represent a transformative model in addressing the challenges faced by small and marginal farmers. Existing literature extensively explores the economic benefits of FPCs, such as improved income and market access. However, there is a significant research gap in understanding the non-economic dimensions of FPCs, particularly their influence on physical and social capital. Governance structures and financial mechanisms have been emphasized in earlier works, yet limited attention has been given to how FPCs affect infrastructure (physical capital) and networks of trust (social capital) that are pivotal for sustainable agricultural practices (30). Furthermore, the interplay between physical and social capital in enhancing farmer resilience and collective action remains underexplored. Research has yet to systematically evaluate whether FPCs contribute to strengthening irrigation systems, transportation networks, and storage facilities while simultaneously fostering cooperation, trust, and social networks among members. Addressing this gap is critical as these two forms of capital are integral to sustainable livelihoods. This study aims to bridge this gap by investigating the impact of FPCs on the livelihoods of farmer members, first by assessing their contribution to physical capital development and second by evaluating their role in enriching social capital. The study contributes to a holistic understanding of FPCs' potential to transform rural livelihoods by focusing on these objectives.

Hypothesis

The following hypotheses have been framed for this study: -

Null Hypothesis (H_0): Participation in the Farmer Producer Company (FPC) does not significantly influence the physical capital of farmer members.

Alternative Hypothesis (H_1): Participation in the Farmer Producer Company (FPC) significantly influences the physical capital of farmer members.

Null Hypothesis (H_0): Farmer Producer Companies do not have a significant impact on enriching the social capital of farmer members.

Alternative Hypothesis (H_1): Farmer Producer Companies significantly enrich the social capital of farmer members.

Methodology

Study Area

The study was undertaken in the state of Bihar, located in the Eastern part of India. In Bihar, 10 districts were selected where FPCs were functioning. The names of the districts are Bhojpur, Buxar, Jamui, Lakhisarai, Munger, Muzaffarpur, Saran, Siwan, Samastipur, and Vaishali. In Figure 2 maps the ten districts of Bihar where FPC data were collected for this study.

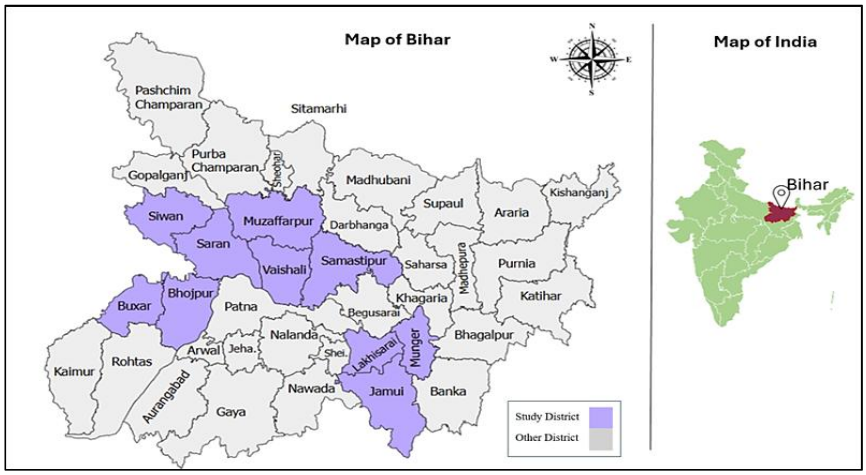

Figure 2: Study Area in the State of Bihar, India

Data Collection and Analysis

The study has used primary and secondary data. Primary data was collected using a structured questionnaire (with printed copies) for the farmers who are members of FPCs to understand their experiences and perceptions directly from the targeted population.

Formation of Questionnaire to Assess the Participation in FPC: The questionnaire included twelve key points to assess the participation in FPC**.** The factors are Opinions and Suggestions, Training and Skill Development, Engagement and Organizational Success, Communication and Information Flow, Transparency in Decision-Making, Networking and Collaboration, Agricultural Knowledge and Market Trends, Farm Productivity, Structure and Participation, Skill-Sharing and Knowledge Transfer, Community and Mutual Support, and Inclusivity and Diversity.

Formation of Questionnaire to Assess the Impact on Physical Capital: The questionnaire included twelve key points to assess the impact on Physical Capital of farmers. The factors are Agricultural Equipment Quality, Modern Farming Technologies, Maintenance of Tools and Machinery, Agricultural Infrastructure Support, Farm Equipment and Adoption of Practices, Physical Infrastructure and Efficiency, Pest Control and Crop Disease Management, Modern Infrastructure and Produce Quality, FPC Support for Physical Capital, Physical Capital and Agricultural Productivity, Agricultural Extension Services, Investment in Physical Capital and Sustainability

Formation of Questionnaire to Assess the Impact on Social Capital: Indicators were identified through existing literature, such as relations and trust among members, networks; collective action and resource sharing were based on validated scales from prior literature (8, 20, 23, 27–29). The operationalization of social capital in this study is based on eight indicators measured through a questionnaire via Likert-scale responses: Social Interactions, Access to Information and Resources, Collaborative Relationships, Community Participation, Trust and Cooperation, Beneficial Partnerships, Information Sharing and Knowledge Transfer, and Social Standing. Cronbach's Alpha ($\alpha = 0.780$) and Bartlett's test confirmed internal consistency and factor analysis validity.

Secondary data were also gathered from existing literature, reports, and studies on FPCs in the context of agricultural productivity and rural development to understand the general background in which this study was situated and assist in planning the primary data collection tools. The study used Cronbach's Alpha formula to determine the sample size. A questionnaire was sent to 385 respondents, as derived from the formula, with 300 responding in total. Of these, 250 respondents completed the questionnaire accurately. A quantitative data collection method was employed, gathering data from 250 respondents in total. The respondents are grouped into sub-groupings known as clusters based on some common characteristics they possess. Finally, from the 10 FPCs, the Multistage Purposive Sampling Technique selected 250 farmers for the study. A purposive sampling method was adopted to include both emerging and established FPCs, based on operational presence, member engagement, and years of registration.

The collected data is analyzed with the aid of Microsoft Excel and IBM SPSS (Statistical Package for Social Science) version 29. Regression analysis is performed to explore the relationships between different variables, assessing how well independent variables predict the dependent variable. Inferential analysis includes making inferences or drawing conclusions about a population using sample data and attempting to generate predictions or generalizations about a broader population based on a smaller selection of data. This approach employs correlation, regression, and variance analysis to demonstrate the links between various variables.

Results

The reliability analysis for FPC members, as given below in table 1, shows that the social and physical capital variables have enough internal consistency. The smallholder farmers' physical capital has a Cronbach's Alpha of 0.709, which reveals a good level of reliability of both capitals. At the same time, the social capital of smallholder farmers has a higher Cronbach's Alpha compared to the previous one, which is 0.780 across the eight items. For both physical capital (0.663) and social capital (0.640), Bartlett's test of sphericity revealed high significance at a level ($p < 0.05$) of sample adequacy, which grants appropriateness for factor analysis in the data. These results, therefore, point to the validity and applicability of the metrics of physical and social capital in further study. Overall, the whole table shows that the constructs are strong and well-defined in such a manner that researchers may rely on the data for further analysis, which tests the effects of social and physical capital on the production and means of subsistence among smallholder farmers. In all practicality, the results undoubtedly point out that both forms of capital potentially pave the way for this community to enhance the efficiency and wellness of this community's agricultural practices.

Table 1: Reliability Statistics Table for FPC Members

Reliability Statistics				
Label	**Cronbach's Alpha**	**No. of Items**	**KMO and Bartlett's value**	**Sig. value**
Physical Capital of Smallholder Farmers	0.709	12	0.663	0.001
Social Capital of Smallholder Farmers	0.780	8	0.640	0.000

Demographic Profile of the Respondents

The demographic profile of 250 FPC members, summarized in Table 2, provides key insights into the inclusivity and composition of Farmer Producer Companies (FPCs). The majority of respondents were women (88.8%), highlighting the significance of targeting women through FPC initiatives. Most participants were actively engaged in farming (78.8%), with a substantial proportion (60.4%) possessing over a decade of experience, suggesting strong potential for adoption of improved agricultural practices. However, inclusivity remains uneven. A significant share of respondents was over 45 years of age (57.6%), while only 4.0% were youth, indicating a generational imbalance and the need for greater youth engagement to ensure long-term sustainability. Literacy levels were relatively high (75.6%), facilitating training and capacity-building efforts, though the presence of 24.4% illiterate members signals the need for tailored communication and education strategies. Economic vulnerability is another critical concern, with 72.4% of respondents reporting low-income levels, pointing to the need for income-enhancing interventions. While 58.0% of members were highly aware of government schemes, 4.4% remained unaware, underscoring the necessity for improved outreach and information dissemination. Overall, while the FPC model reflects inclusive intent, the functioning of these institutions still reflects existing socio-economic disparities, indicating that inclusivity, though evident in certain areas, remains partial and nuanced. The findings stress the importance of addressing gender, youth engagement, literacy, and economic support to improve livelihoods through FPCs.

Table 2: Demographic Characteristics of the Study

Sr. No.	Demographic Characteristics	Particulars	N	%
1	Gender	Female	222	88.8
		Male	28	11.2
2	Age Group	26-35 Years	10	4.0
		36-45 Years	96	38.4
		Above 45 Years	144	57.6
3	Educational Qualification	Literate	189	75.6
		Illiterate	61	24.4
4	Primary Occupation	Farmers	197	78.8
		Agricultural labourer	13	5.2
		Skilled worker	16	6.4
		Unskilled worker	13	5.2
		Other	11	4.4
5	Farming Experience	Less than 5 years	56	22.4
		5-10 years	43	17.2
		Above 10 years	151	60.4
6	Membership in Farmer Producer Company (FPC)	Yes	250	100.0
7	Income Level	Low	181	72.4
		Medium	49	19.6
		High	20	8.0
8	Awareness of Government Schemes	Not aware	11	4.4
		Somewhat aware	94	37.6
		Very aware	145	58.0

The Farmer Producer Company (FPC) Helps Enhance Smallholder Farmers' Physical Capital

The regression analysis was conducted to examine the relationship between participation or involvement in the Farmer Producer Company (FPC) and the physical capital of smallholder farmers. The results presented in table 3 provide insights into the significance and strength of this relationship.

Model Summary

The regression model includes participation or involvement in the FPC as the independent variable and the physical capital of smallholder farmers as the dependent variable. The model demonstrates an R-value of 0.236, indicating a modest but positive correlation between the predictor and the dependent variable. The R-square value of 0.056 suggests that 5.6% of the variance in physical capital can be explained by participation in the FPC.

Analysis of Variance (ANOVA)

The F-statistic of 14.594 is statistically significant at the 0.000 level, indicating that the overall regression model is a good fit and that participation in the FPC significantly contributes to variations in the physical capital of smallholder farmers.

Regression Coefficients

Constant: The constant term has a t-value of 11.45, which is highly significant (p = 0.000). This implies that even without participation in the FPC, a baseline level of physical capital exists among smallholder farmers.

Participation or Involvement in the FPC: The regression coefficient for participation in the FPC has a t-value of 3.82, which is statistically significant (p = 0.000). This finding indicates that involvement in the FPC has a positive and significant impact on the physical capital of smallholder farmers.

Table 3: Model Summary for Regression Analysis

	Model	Sum of Squares	df	Mean Square	F	R	R Square	Adjusted R Square	t	Sig.
1	Regression	247.319	1	247.319	14.594	0.236[a]	0.056	0.052		0.000[b]
	Residual	4202.685	248	16.946						

(Constant)			11.450	0.000
Participation or involvement in the Farmer Producer Company			3.820	0.000
Total	4450.004	249		

a. Dependent Variable: Physical capital of smallholder farmers
b. Predictors: (Constant), Participation or involvement in the Farmer Producer Company

F-Statistic

The F-statistic of 14.594 is statistically significant (p = 0.000), which suggests that the independent variable (participation in the FPC) contributes significantly to explaining variations in the dependent variable (physical capital of smallholder farmers). A high F-value typically indicates that the model fits the data well.

R and R-Square

- **R (0.236):** This indicates a weak but positive correlation between participation in the FPC and the physical capital of smallholder farmers.
- **R-Square (0.056):** This means that only 5.6% of the variability in the physical capital of smallholder farmers can be explained by participation in the FPC. While this suggests that participation plays a role, it also indicates that other factors influence physical capital significantly.

Adjusted R-Square

The adjusted R-square value of 0.052 accounts for the number of predictors in the model. Since it is close to the R-square value, it suggests that the model is relatively stable but not highly explanatory.

t-Statistic

- **Constant (t = 11.45, p = 0.000):** This highly significant result suggests that even without participation in the FPC, a certain level of physical capital exists among smallholder farmers.
- **Participation in FPC (t = 3.82, p = 0.000):** This significant result indicates that participation in the FPC has a strong positive impact on physical capital.

Significance (p-Value)

The p-values for both the constant term and participation in the FPC are 0.000, which is less than the standard significance level of 0.05. This confirms that the predictor variable (involvement in the FPC) has a statistically significant impact on the dependent variable (physical capital).

Actual vs. Predicted/Fitted Analysis

Figure 3 given below compares the actual physical capital (red line) with the predicted physical capital (green line) for smallholders. The x-axis represents farmers, and the y-axis represents physical capital. Actual physical capital exhibits considerable variability, while predicted physical capital is stable and consistent around the standard mean. This indicates that the model predicts physical capital well, and it captures the overall trend regardless of the variability of the actual data. The actual vs fitted graph shows that both closely follow and support the model.

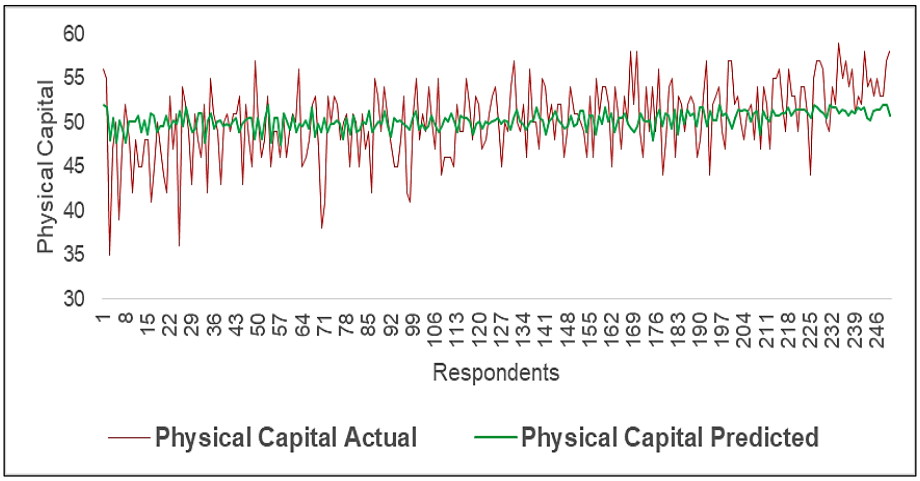

Figure 3: Actual vs. Predicted Physical Capital Graph

Scattered Chart

The scatter plot, as shown in Figure 4, shows a positive correlation between participation in FPC (x-axis) and physical capital (y-axis). Though scattered, data points generally follow a horizontal trend line, indicating that physical capital rises slightly as participation in FPC increases. The red trend line confirms this positive trend, with some variability in the points. The model suggests a consistent link between physical capital and FPC participation, supporting the relationship despite minor fluctuations.

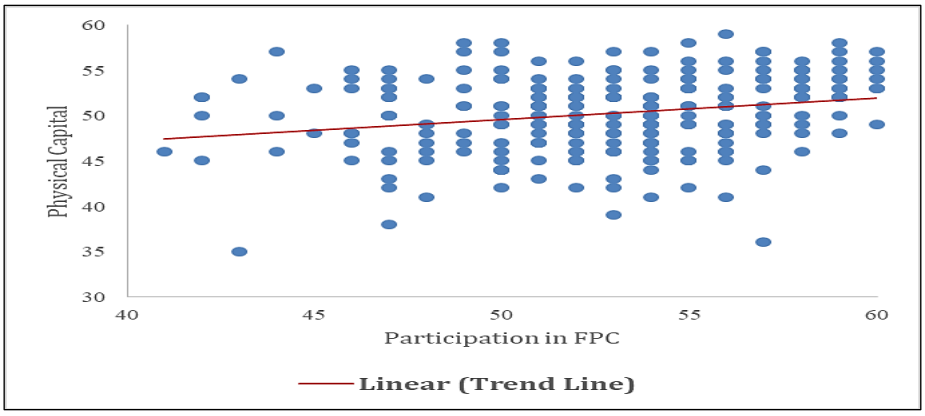

Figure 4: Scattered Chart of Participation in FPC vs. Physical Capital

Overall Interpretation

The regression analysis confirms that participation in the FPC positively impacts the physical capital of smallholder farmers. Mean Absolute Percentage Error (MAPE) was also calculated, which is 6.7%. A MAPE of 6.7% indicates that, on average, the predicted values deviate from the actual values by 6.7%. This suggests a relatively good level of accuracy in the model's predictions, as lower MAPE values indicate better forecasting performance. Generally, a MAPE below 10% is considered highly accurate, between 10-20% is good, 20-50% is acceptable, and above 50% indicates poor predictive ability. It indicates a positive and significant relationship between FPC participation and increases in physical capital. Given the statistical significance of the findings, the null hypothesis (1) is rejected. Future studies should explore other contributing factors to gain a comprehensive understanding of the determinants of physical capital in smallholder farming systems.

The Farmer Producer Company (FPC) Helps Enhance Smallholder Farmers' Social Capital

The regression analysis examines the relationship between participation in the Farmer Producer Company (FPC) and the social capital of smallholder farmers. The analysis assesses how much variation in social capital can be attributed to participation in the FPC and whether this relationship is statistically significant. Table 4, which presents the key statistical indicators, including R, R-square, F-statistic, t-values, and significance levels, provides insights into the model's performance and validity.

Model Summary

The regression model presents an R-value of 0.160, indicating a weak but positive correlation between participation in the FPC and the social capital of smallholder farmers. The R-square value of 0.026 suggests that only 2.6% of the variance in social capital can be explained by participation in the FPC, implying that other factors also contribute significantly to social capital formation.

Analysis of Variance (ANOVA)

The F-statistic is 6.555, with a significance level of 0.011, indicating that the model is statistically significant. This means that participation in the FPC has a measurable effect on social capital, though the explanatory power of the model is low.

Regression Coefficients

Constant Term: The constant term has a t-value of 9.645 with a p-value of 0.000, suggesting that even without participation in the FPC; smallholder farmers possess a baseline level of social capital.

Participation in the Farmer Producer Company

The coefficient for participation in the FPC has a t-value of 2.56 with a p-value of 0.011, indicating that participation positively and significantly influences social capital. This suggests that farmers engaged in the FPC tend to have higher social capital than those who are not involved.

Table 4: Model Summary for Regression Analysis

	Model	Sum of Squares	df	Mean Square	F	R	R Square	Adjusted R Square	t	Sig.
1	Regression	97.441	1	97.441	6.555	.160[a]	.026	.022		.011[b]
	Residual	3686.355	248	14.864						
	(Constant)								9.645	.000
	Participation or involvement in the Farmer Producer Company								2.560	.011
	Total	3783.796	249							

a. Dependent Variable: Social capital of smallholder farmers
b. Predictors: (Constant), Participation or involvement in the Farmer Producer Company

F-Statistic

The F-statistic of 6.555 and its significance level (p = 0.011) indicate that the model is statistically significant; meaning participation in the FPC does have a notable effect on social capital. However, the strength of this effect remains relatively weak, as seen in the low R-square value.

R and R-Square

- **R (0.160):** Represents a weak positive correlation between participation in the FPC and social capital.
- **R-Square (0.026):** Indicates that participation in the FPC explains only 2.6% of the variation in social capital, suggesting that other factors play a more dominant role in influencing social capital among smallholder farmers.

Adjusted R-Square

The adjusted R-square value (0.022) is slightly lower than the R-square value, confirming the model's limited explanatory power. This minor reduction suggests that adding more variables to the model may not significantly improve its predictive strength.

t-Statistic

- **Constant (t = 9.645, p = 0.000):** Indicates that even in the absence of participation in the FPC, smallholder farmers possess a certain level of social capital.
- **Participation in the FPC (t = 2.56, p = 0.011):** Suggests that participation has a statistically significant positive impact on social capital, but the effect size is small.

Actual vs. Predicted/Fitted Analysis

Figure 5, compares the actual social capital (red line) with the predicted social capital (green line) for smallholders. The x-axis represents farmers, and the y-axis represents social capital. Actual social capital exhibits considerable variability, while predicted social capital is stable and consistent around the standard mean. This indicates that the model predicts social capital well, and it captures the overall trend regardless of the variability of the actual data. The actual vs fitted graph shows that both closely follow and support the model.

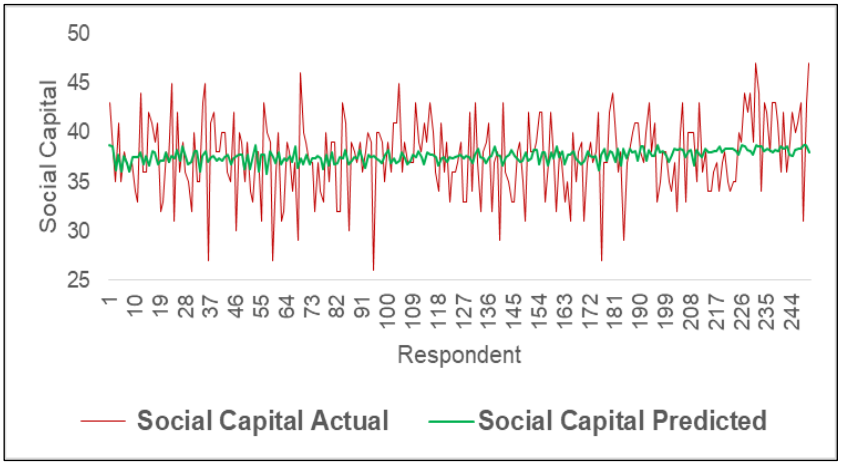

Figure 5: Actual vs. Predicted Social Capital Graph

Scattered Chart

The scatter plot in Figure 6 shows a positive correlation between participation in FPC (x-axis) and social capital (y-axis). The red trend line indicates that as participation in FPC increases, social capital also rises slightly. Although there is some variability in the data, the overall trend aligns with the model, suggesting a consistent relationship between social capital and FPC participation. This positive trend fits the model, indicating that increases in social capital are associated with increased participation in FPC and despite some variability in the data, the slope of the growth path supports the model on an appropriate basis, showing uniformity between social capital and participation in FPC.

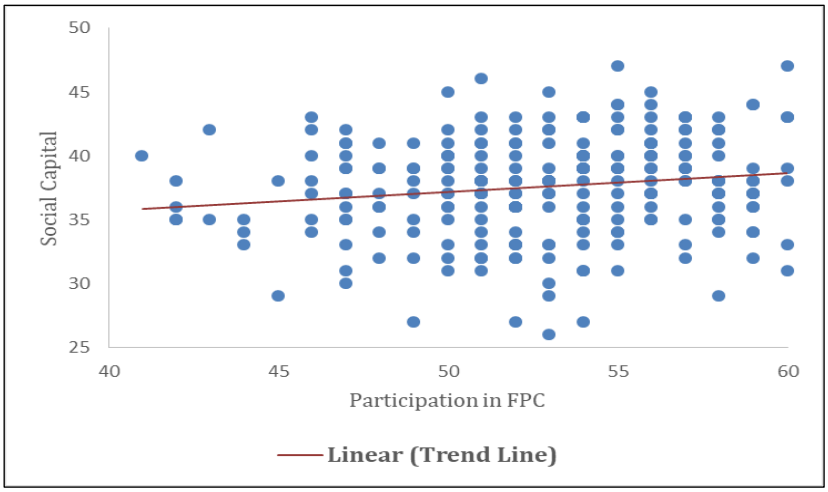

Figure 6: Scattered Chart of Participation in FPC vs. Social Capital

Overall Interpretation

The regression analysis reveals that participation in the FPC has a statistically significant but modest impact on the social capital of smallholder farmers. While the F-statistic confirms the model's validity, the low R-square value suggests that other variables significantly influence social capital formation.

Mean Absolute Percentage Error (MAPE) was also calculated, which is 8.4%. A MAPE of 8.4% indicates that, on average, the predicted values deviate from the actual values by 8.4%. This suggests a relatively good level of accuracy in the model's predictions, as lower MAPE values indicate better forecasting performance. Generally, a MAPE below 10% is considered highly accurate, between 10-20% is good, 20-50% is acceptable, and above 50% indicates poor predictive ability.

It indicates a positive and significant relationship between FPC participation and increases in physical capital. Given the statistical significance of the findings the null hypothesis (2) is rejected. Policymakers and researchers should consider additional factors, such as access to markets, cooperative engagement, and community networks, when assessing social capital. Future research should explore a broader range of determinants to develop a more comprehensive understanding of social capital among smallholder farmers.

Discussion

This study examines FPCs' contribution in enhancing the livelihoods of small and marginal farmers in Bihar; it is specifically linked with the interrelation between physical and social capital. The findings show that, regarding better market opportunities, bargaining powers, and resource sharing, FPCs have significantly contributed to their members' economic conditions. This study supports the existing literature, which identifies that FPCs are catalysts of rural development through enhancing collective action and income. Unlike previous studies on FPCs that were mainly concerned with the economic impacts of these organizations, this study explored the forefront of how physical and social capital play critical roles in defining the success and sustainability of these institutions (33). The current study builds on the understanding that governance is essential for FPCs (30); it pursues this further by describing how the suitability of physical infrastructure, like irrigation systems and storage facilities, combined with the strength of social networking, improves the operational efficiency of FPCs. The results of

these studies are in good agreement with the assertion that FPCs with high levels of social capital perform better economically (34). Compared to states like Tamil Nadu, where FPCs benefit from structured support mechanisms and convergence with government schemes, FPCs in Assam face constraints in institutional backing and market access. While both states have active FPC networks, Tamil Nadu shows higher integration with agri-value chains. In terms of inclusivity, although FPCs are designed to empower all members, field insights reveal that in Assam, marginal farmers, women, and Scheduled Tribes often lack representation in leadership roles. In contrast, Tamil Nadu has seen relatively better participation from women due to targeted state initiatives. These disparities highlight the need for region-specific policies to strengthen managerial capacity, credit accessibility, and social equity (11–13). Enhancing linkages with institutional buyers and capacity-building programs can improve the viability and inclusiveness of FPCs, particularly in Assam.

The previous literature has indicated that the main gap is the lack of attention to long-term sustainability and structural issues that FPCs face. Though FPCs may improve the livelihood of farmers, they do not deal with more fundamental issues like land fragmentation and climate vulnerability (31). This study fills in this gap with a focus on how the interaction of physical and social capital leads to better sustainability outcomes for farmers while taking into consideration the agricultural landscape in Bihar. In addition, by placing much emphasis on social capital in this study, there will be many discoveries regarding the basis of the trust and collaboration that is reflected among the farmers in overcoming challenges in matters of market access and resource management, an aspect that most studies have lacked in previous studies (35). Additionally, the findings of this study resonate with the prior observations that emphasize both capacity building and market linkages as essential factors for the success of FPCs (36). However, the present study extends further by quantitatively measuring these factors against the livelihoods of the FPC members, thus serving to deliver empirical evidence to inform policy frameworks aimed at strengthening FPCs within Bihar and other similar areas.

The demographic study shows the prospect of dominating the women farmers sector, which is rapidly increasing awareness among women about involvement in agricultural activities and decision making. This sub-theme also expands the need to have special kinds of training curricula and gender-sensitive policies, especially for women participants in FPC (37). The present study adds to the knowledge already in existence, based on the identification of gaps within the scope of its study, and hence concludes with practical recommendations for the improvement of FPCs in livelihoods. This study, with a focus on the relationship between physical and social capital, will be very relevant in providing insight into how FPCs could be better structured and supported in the long run and the effective uplifting of smallholder farmers in Bihar.

Conclusion

The study on Farmer Producer Companies (FPCs) in Bihar reveals their significant impact on enhancing the livelihoods of small and marginal farmers. The findings demonstrate that FPC participation positively influences both physical and social capital among farmers, leading to improved economic resilience and income levels. FPCs provide essential infrastructure such as “irrigation systems, transportation networks, and storage facilities, which enhance agricultural productivity and reduce post-harvest losses.” Additionally, FPCs foster strong social networks, trust, and collaboration among farmers, facilitating collective bargaining, resource sharing, and access to better market opportunities. FPCs have many female farmers; hence, the demographic analysis emphasizes the issue of offering gender-specific training and support. The involvement of the younger generations in FPC activities is very important for the sustainability and long-term success of the organizations. The FPC emphasizes the importance of the amalgamation of infrastructure development with strong social networks to ensure operational efficiency and sustainability of FPCs. Such policies further require appropriate funding, building capacity, and infrastructure to be developed for FPCs that should address deeper structural issues regarding land fragmentation and climate change vulnerability. Adequate awareness amongst farmers of the government's schemes and support programmes

is also important. In summary, this study offers insights into how FPCs may be better structured and supported to enhance their impact on rural development and poverty alleviation. FPCs can surely play a positive role in the changing character of rural economies and agricultural development in Bihar, addressing the specific requirements for women and young farmers and providing targeted policy support. There is a pressing need for policies that build managerial capacity among FPC leaders, improve credit access, and ensure social inclusion through targeted interventions for smallholders, youth and women members. Infrastructure support and stronger (preferential) linkages with government schemes and institutional buyers can further improve sustainability.

Limitations of the Study

The research focus was confined to some districts of Bihar, and consequently, the usability of the study is limited to other regions or various agricultural systems and socio-economic conditions. The present nature of the cross-sectional study does not cover the recording of data at one instance of time and thus constrains analysis on long-term effects and changes arising from membership in FPCs. Qualitative information generated from interviews may be skewed with biased conclusions and may influence the insight emanating from them. The scope of the study was also very limited concerning the exploration of physical and social capital, as well as other important dimensions, such as financial and human capital, that may influence FPC success. The external factors, such as government policies, market conditions, and environmental factors, were not discussed in detail and may have a significant influence on the FPCs. This study focuses primarily on bonding social capital (within-group cohesion) with elements of bridging social capital (inter-group collaboration), which are crucial for building internal cohesion and external market linkages in the FPC framework. Linking social capital (institutional connections) is acknowledged but not deeply examined. In future studies, the same limitations should be addressed to better understand the role of FPCs in enhancing the livelihood of small and marginal farmers.

Future Recommendation

The recommendations which can benefit future research concerning the role of FPCs in the livelihood improvement of small and marginal farmers are given as follows. Increasing the sample size by including more diverse districts from Bihar or any other state would allow one to increase the generalizability and validity of the results obtained. Although 10 diverse districts were purposively selected, the sample is not statistically representative of Bihar's entire agrarian structure, a limitation that is acknowledged, with a recommendation for future researchers to consider more robust methods such as random sampling. The effects of long-run membership of the FPC on the livelihood of farmers can be evaluated with the help of longitudinal studies. Further studies can be conducted to explore the impact of different forms of capital, such as physical, social, financial, and human, on the success of FPCs. It is also recommended that external factors, such as government policies, market conditions, and environmental changes, be considered to understand their influence on FPC operations comprehensively.

Abbreviation

None.

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Author Contributions

All authors have contributed equally.

Conflict of Interest

The authors declare that they have no conflict of interest that could have appeared to influence the work reported in this paper.

Ethics Approval

This study was conducted following ethical standards, with approval and consent obtained from all individual participants included in the study.

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