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Climate-Smart Farmer Producer Organizations and Digital Market Integration: A Strategic Framework for Sustainable Agribusiness and Rural Transformation in India

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Abstract

Climate variability, fragmented landholdings, weak bargaining power and limited market access continue to restrict the capacity of smallholder farmers to build stable and sustainable livelihoods. Farmer Producer Organizations (FPOs) have emerged as an important institutional mechanism for aggregation, collective purchasing, value addition and market participation; however, their contribution to rural transformation depends on whether they can simultaneously support climate-smart production and connect members with transparent, diversified and remunerative markets. This exploratory and analytical paper develops a strategic framework linking FPO institutional capacity, climate-smart agriculture adoption, digital market integration, sustainable agribusiness performance and rural transformation. The study follows an integrative review of research on collective action, FPO governance, climate-smart agriculture, digital agriculture, market platforms and sustainable livelihoods, supported by descriptive analysis of recent official programme indicators in India. The policy evidence shows substantial institutional expansion, but uneven depth of market and financial integration. As of the latest available releases, 10,000 FPOs had been registered, 4,642 were linked with e-NAM, 2,583 had obtained credit-guarantee cover, 1,590 had benefited from the Agriculture Infrastructure Fund and 1,175 were registered with entirely women members. The paper argues that registration alone is not an adequate measure of transformation. FPOs create stronger outcomes when governance quality, professional management, climate advisory services, common infrastructure, digital capabilities, buyer relationships and inclusive participation function as a coordinated system. Six hypotheses are proposed for future empirical testing. The framework contributes to sustainable agribusiness literature by positioning the FPO as a rural enterprise platform that can translate collective organization into climate resilience, improved price realization, value-chain participation, women and youth entrepreneurship, and long-term livelihood security.

Keywords: *Climate-Smart Agriculture, Farmer Producer Organizations, Digital Market Integration, Sustainable Agribusiness, Rural Transformation, Smallholder Farmers, e-NAM, Inclusive Value Chains.*

1. Conceptual Background

Indian agriculture operates through a large number of small and marginal holdings that individually face high transaction costs, limited negotiating power and weak access to formal markets. These structural constraints are intensified by climate-related risks such as irregular rainfall, heat stress, water scarcity, soil degradation, pest outbreaks and price volatility. A farm household may improve production in one season and still remain economically vulnerable when the produce is sold through an uncertain channel, storage is unavailable or input costs rise sharply. Sustainable rural transformation therefore requires a combined production, enterprise and market perspective rather than an isolated focus on yield improvement.

Climate-smart agriculture (CSA) provides a useful production-side framework. It seeks to increase productivity and farm income, strengthen resilience and adaptation, and reduce or remove greenhouse-gas emissions where feasible (FAO, 2013; Ma & Rahut, 2024). CSA practices can include crop diversification, water conservation, improved seed varieties, soil-health management, integrated nutrient and pest management, weather-based advisories, efficient irrigation, agroforestry, reduced tillage and better post-harvest management. The suitability of a practice varies by commodity, agro-climatic region, farm size and local resource conditions. Consequently, adoption depends not only on technical usefulness but also on finance, training, trust, risk perception and access to collective infrastructure.

Farmer Producer Organizations provide an institutional platform through which smallholders can address these barriers collectively. By aggregating input demand and farm output, an FPO can lower procurement costs, standardize quality, create marketable volumes and negotiate with larger buyers. FPOs may also facilitate

licenses, crop planning, primary processing, storage, credit, insurance and extension services. Collective action theory explains that aggregation can reduce market failures, but its effectiveness depends on member participation, transparent rules, leadership, professional management and equitable benefit distribution (Markelova et al., 2009; Bikkina et al., 2018). An FPO that exists only as a legal entity without active transactions, reliable services or member trust is unlikely to produce meaningful rural transformation.

Digital market integration extends the collective model beyond local physical markets. Platforms such as e-NAM, ONDC, GeM, business-to-business portals and private agritech marketplaces can improve price discovery, buyer reach, transaction records and market transparency. Digital integration can also connect traceability, quality certification, logistics and finance. Yet digital onboarding is not equal to active commercial use. FPOs require trained personnel, reliable connectivity, standardized product information, digital payments, grading capacity and fulfilment systems. The central question is therefore not whether FPOs, CSA and digital platforms exist separately, but how they can be strategically integrated into one agribusiness system.

This study conceptualizes a climate-smart FPO as a professionally managed farmer-owned enterprise that combines collective action with climate-resilient production, data-supported decisions, value addition and diversified market access. Rural transformation is treated as a multidimensional outcome reflected in improved income stability, employment, entrepreneurship, social inclusion, ecological performance, institutional capacity and reduced vulnerability. The framework therefore moves beyond the narrow assumption that rural development can be inferred from the number of organizations formed or technologies distributed

2. Problem Statement

The expansion of FPOs in India represents a major policy effort to organize smallholders into viable agribusiness enterprises. Nevertheless, institutional formation does not automatically generate climate resilience, stronger market power or sustainable financial performance. Many organizations face insufficient working capital, limited professional management, weak member participation, inadequate storage and processing infrastructure, and dependence on a small number of buyers. Climate-smart practices may also remain confined to training programmes when farmers lack finance, demonstrations, localized advice or a clear economic incentive for adoption.

Digital market platforms create additional opportunities, but the level of active integration remains uneven. An FPO may be technically registered on a platform yet conduct few transactions because of quality inconsistency, fragmented logistics, limited digital literacy or an inability to meet buyer specifications. There is therefore a research need for a unified management framework that explains how FPO capacity, climate-smart production and digital markets jointly influence sustainable agribusiness performance and rural transformation.

3. Objectives of the Study

1. To examine the strategic role of FPOs in promoting climate-smart agricultural practices among smallholder farmers.
2. To analyse how digital market integration can improve price discovery, market diversification and value-chain participation.
3. To identify governance, leadership, financial, infrastructural and inclusion factors that influence FPO sustainability.
4. To interpret recent official indicators relating to FPO registration, digital-market linkage, credit support and women's participation.
5. To develop an integrated conceptual framework connecting FPO capacity, CSA adoption, digital market integration and rural transformation.
6. To propose testable hypotheses and practical policy directions for future empirical research.

4. Hypotheses

- H1: FPO institutional capacity positively influences members' adoption of climate-smart agricultural practices.
- H2: Climate-smart agricultural practice adoption positively influences sustainable agribusiness performance.
- H3: Digital market integration positively influences market diversification, price realization and sales stability.
- H4: Digital market integration mediates the relationship between FPO institutional capacity and sustainable agribusiness performance.
- H5: Governance quality and policy support positively moderate the relationship between FPO institutional capacity and CSA adoption.
- H6: Women and youth inclusion positively influences social sustainability, enterprise innovation and rural employment outcomes.

5. Literature Review

5.1 Climate-Smart Agriculture and Smallholder

Resilience

CSA has developed as an integrated response to the combined problems of food security, rural poverty and climate change. The framework is commonly organized around productivity, adaptation and mitigation. Ma and Rahut (2024), drawing together evidence from nineteen studies, report that CSA adoption can improve yields, farm income, resilience and economic diversification, although adoption determinants vary across households and locations. Access to extension, training, information, credit and membership in farmer organizations repeatedly emerges as a positive institutional influence. This observation is important because climate adaptation is rarely achieved through a one-time technology purchase. It requires learning, experimentation, risk-sharing and continued advisory support.

Evidence from the Indo-Gangetic Plains also indicates that adoption of multiple CSA practices is affected by household, farm, institutional and market characteristics (Aryal et al., 2018). The implication is that promotion based only on technical merit may produce uneven results. Farmers compare expected benefits with labour requirements, uncertainty, initial investment and compatibility with existing practices. The Technology Acceptance Model suggests that perceived usefulness and ease of use influence adoption, while Diffusion of Innovation theory emphasizes relative advantage, compatibility, complexity, trialability and observability (Davis, 1989; Rogers, 2003). FPOs can improve these conditions through demonstrations, peer learning, group procurement and shared equipment.

CSA also requires a supportive policy environment. FAO emphasizes coherence across agricultural, environmental and climate policies and highlights the need for alliances involving producer organizations, extension systems, finance providers, NGOs and private enterprises. This aligns with the present argument that FPOs can function

as local coordination institutions rather than merely marketing bodies.

5.2 FPOs, Collective Action and Agribusiness

Performance

Collective action allows dispersed producers to pool resources, develop marketable volumes and reduce transaction costs. Markelova et al. (2009) explain that producer organizations can improve smallholder market access when group characteristics, institutional arrangements, products and external support are appropriately aligned. Trebbin (2014) demonstrates the potential role of producer companies in linking Indian smallholders with modern retail, while also showing that organizational intermediation is required to meet standards and coordinate supply.

Indian FPO research consistently identifies capital, governance and managerial capability as central performance conditions. Bikkina et al. (2018) found that FPOs can generate benefits through effective collective action, but insufficient capital constrains their ability to expand services. Suresh and Sreejith (2024) classify enabling and inhibiting factors across economic, social and environmental dimensions. Income improvement, collective bargaining, collaboration, capacity building, branding and marketing support sustainability, whereas capital shortages, weak leadership, poor infrastructure and climate change inhibit it.

Recent studies deepen this organizational perspective. Singh et al. (2026) identify trust, leadership, governance, relational infrastructure and digital capability as important determinants of high-performing FPOs. Rajak and Sathu (2026) show that institutional support from FPOs can improve climate adaptability through behavioural and psychological pathways, including adoption of adaptive practices and enhanced resilience. These findings support the view that the FPO is both an enterprise and a social institution. Its performance depends on commercial discipline and member confidence at the same time.

5.3 Digital Market Integration and Value-Chain Participation

Digital agriculture research has moved from farm-level precision technologies toward platform ecosystems that connect information, transactions and services. Digital platforms can link farmers with market prices, input providers, buyers, logistics, finance and certification. They can reduce information asymmetry and create transaction histories that improve business planning and credit assessment. However, Klerkx et al. (2019) caution that digital agriculture also introduces questions of data ownership, power, exclusion and institutional readiness.

For FPOs, digital integration is organizational rather than purely individual. The enterprise must aggregate product details, grade output, maintain inventories, negotiate contracts and coordinate delivery. Bhowmik and Hazari (2026) identify digital infrastructure, institutional infrastructure, governance, gender inclusion and market linkages as interdependent influences on technology adoption in FPOs. Digital capability must therefore be embedded in management systems, not treated as a separate mobile application.

Digital market integration may also increase the value of CSA. A buyer is more likely to reward climate-smart or sustainably produced commodities when quality, traceability and delivery can be verified. Conversely, farmers may be more willing to adopt a sustainable practice when a reliable market offers a price, contract or cost-saving incentive. This creates a reinforcing relationship between production transformation and market transformation.

5.4 Inclusion, Governance and Rural Transformation

Rural transformation is incomplete when the benefits of collective enterprise remain concentrated among larger or more influential members. Women, tenant cultivators, land-poor households and rural youth may face barriers in membership, decision-making and access to services. Inclusive governance requires transparent membership rules, accessible meetings, representation in boards and

committees, and services suited to different categories of farmers. Women's FPOs can expand leadership and enterprise opportunities, but formal registration must be supported by finance, mobility, digital skills and market relationships.

Governance quality determines whether the organization converts external support into durable capability. Stakeholder theory requires the FPO to create value for members, employees, buyers, lenders, communities and ecosystem partners rather than focusing only on turnover (Freeman, 1984). The Resource-Based View further suggests that durable performance arises when the FPO develops valuable and difficult-to-replicate capabilities, including trust, local knowledge, brand reputation, buyer relationships, quality systems and climate intelligence (Barney, 1991).

The Sustainable Livelihood Framework broadens the evaluation of transformation by considering human, social, natural, physical and financial capital (Scoones, 1998). In this perspective, an FPO contributes to rural transformation when it strengthens skills and leadership, collective networks, soil and water resources, common infrastructure, income stability and access to finance.

5.5 Research Gap

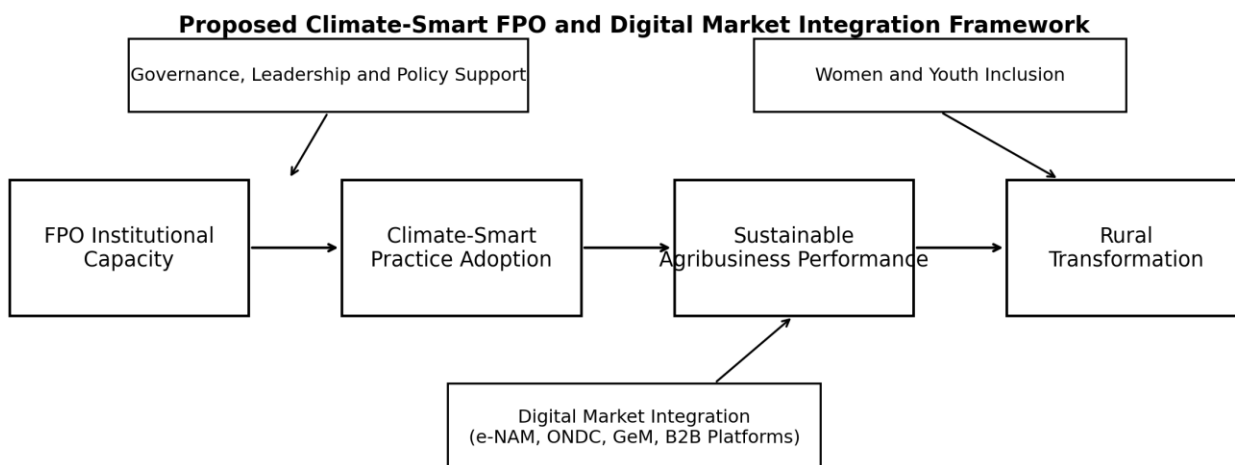
The literature provides strong evidence on CSA adoption, collective action, FPO performance and digital agriculture. However, these streams are often examined separately. CSA studies commonly focus on farm practices and household adoption. FPO studies concentrate on governance, finance or market access. Digital-agriculture studies analyse platforms and technology adoption. There is limited integration of these perspectives into a strategic framework showing how a farmer-owned enterprise can coordinate climate-smart production and digital market participation to generate multidimensional rural transformation.

A further gap concerns the difference between institutional reach and institutional depth. Registration, onboarding and scheme participation are useful

indicators, but they do not directly measure transaction intensity, member benefit, active technology use, climate outcomes or enterprise viability. This paper addresses

these gaps through an integrated framework and a descriptive interpretation of recent programme evidence.

Figure 1: Proposed Climate-Smart FPO and Digital Market Integration Framework



6. Conceptual Framework and Hypothesis Development

The proposed framework positions FPO institutional capacity as the starting construct. Institutional capacity includes member participation, board governance, professional management, financial discipline, extension linkages, common infrastructure and the ability to coordinate collective transactions. Stronger capacity is expected to reduce the cost and uncertainty of CSA adoption by providing training, demonstrations, aggregated input procurement, shared machinery, climate information and access to finance. This relationship forms H1.

CSA adoption is expected to influence sustainable agribusiness performance through lower input waste, improved resource efficiency, reduced production risk, diversified output and stronger quality consistency. The performance construct therefore includes economic, environmental and operational indicators rather than turnover alone. This relationship forms H2.

Digital market integration is treated both as a direct performance driver and as a mediating mechanism. Directly, market platforms can widen buyer access,

improve price discovery and reduce dependence on one local intermediary. Indirectly, digital integration converts FPO capacity into commercial outcomes by recording transactions, communicating supply, coordinating logistics and demonstrating quality. These relationships form H3 and H4.

Governance quality and policy support operate as contextual moderators. Transparent decision-making, trusted leadership, timely working capital, coherent schemes and reliable infrastructure can strengthen the conversion of institutional support into actual CSA adoption. Weak governance can produce the opposite outcome even when financial assistance or training is available. This forms H5.

Women and youth inclusion is a cross-cutting dimension. Inclusive participation can widen the skill base, strengthen social legitimacy, create new processing and service enterprises, and generate rural employment. Where inclusion is only nominal, these outcomes may not emerge. This relationship forms H6.

7. Research Methodology

The study adopts an exploratory, descriptive and analytical conceptual research design. This design is

appropriate because the objective is to integrate multiple research streams and develop a testable strategic

framework rather than claim causal estimates from a new primary survey. The research is based on an integrative review of academic literature and a descriptive analysis of recent public programme information.

The literature base covers collective action, producer organizations, climate-smart agriculture, digital agriculture, technology adoption, stakeholder governance and sustainable livelihoods. Priority was given to peer-reviewed studies with direct relevance to smallholders, FPOs and the Indian agribusiness context, together with established theoretical works. Official evidence was drawn from the Food and Agriculture Organization, World Bank and Government of India releases on FPO registration, financial support, digital-market linkage, infrastructure schemes, turnover and women's participation.

The analytical procedure followed four stages. First, the central constructs and their dimensions were identified.

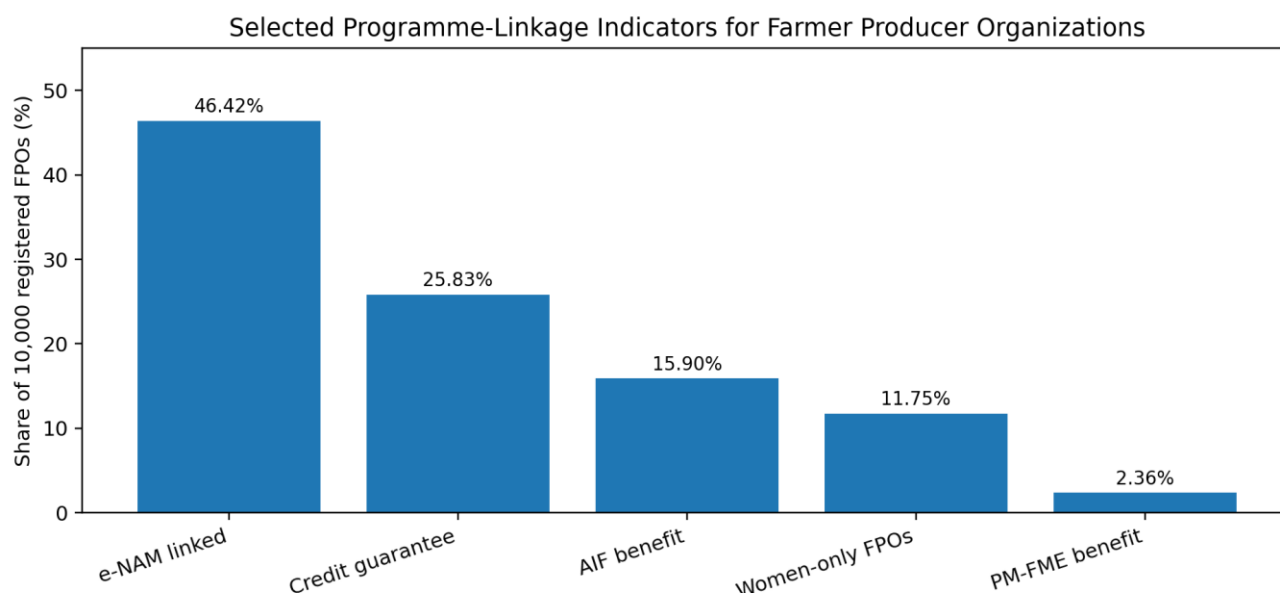
Second, evidence was coded into five themes: institutional capacity, CSA adoption, digital market integration, inclusion and enabling environment. Third, available official indicators were converted into comparable percentages using the 10,000 registered FPOs as a descriptive denominator where appropriate. Fourth, relationships among the constructs were synthesized into the proposed framework and hypotheses.

The percentages are used only for programme-level description. They should not be interpreted as causal estimates or as evidence that every listed FPO is equally mature. Reporting dates differ across indicators, and scheme participation does not necessarily represent active or sustained use. The methodology therefore separates factual programme reach from the conceptual interpretation of institutional depth.

8. Analysis and Findings

Table 1: Selected Official Indicators of FPO Institutional and Market Integration

Indicator	Reported count/value	Reference base	Derived share	Reporting date	Analytical interpretation
Registered FPOs	10,000	10,000 FPOs	100.00%	1 Mar 2026	Large institutional reach; formation is no longer the main constraint.
FPOs linked with e-NAM	4,642	10,000 FPOs	46.42%	31 Oct 2025	Digital-market access has expanded, but more than half were not yet linked.
Credit-guarantee cover	2,583	10,000 FPOs	25.83%	5 Dec 2025	Formal credit support remains materially below total registration.
Agriculture Infrastructure Fund benefit	1,590	10,000 FPOs	15.90%	31 Oct 2025	Common infrastructure support is growing but not yet widespread.
100% women-member FPOs	1,175	10,000 FPOs	11.75%	1 Mar 2026	A visible inclusion base exists, though women-only entities remain a minority.
PM-FME credit-linked subsidy	236	10,000 FPOs	2.36%	31 Oct 2025	Formal food-processing convergence is limited relative to the FPO base.
Cumulative turnover	₹5,035.5 crore	All supported FPOs	Crude mean: ₹50.36 lakh per registered FPO	30 Jun 2025	Shows commercial activity, but the mean should not be treated as a performance benchmark because maturity and activity differ.



Note: Indicators are compiled from official releases with different reporting dates in 2025-2026.

Graph 1: Descriptive Comparison of Selected FPO Programme-Linkage Indicators

Statistical interpretation: The descriptive distribution indicates a clear gap between organizational formation and deeper integration. The e-NAM linkage rate of 46.42% is the largest among the comparable indicators, whereas infrastructure, credit and processing convergence are substantially lower. This pattern suggests that the next

policy stage should emphasize active transactions, financial depth, value addition and enterprise capability rather than registration alone. The 11.75% share of women-only FPOs shows institutional progress in inclusion, but the quality of participation and business outcomes require separate assessment.

Table 2: Thematic Relationship Matrix

Construct	Core dimensions	Primary mechanism	Expected outcome	Key risk
FPO institutional capacity	Governance, management, finance, member participation, infrastructure	Aggregation and coordination	Lower transaction cost and stronger service delivery	Inactive membership or weak leadership
CSA adoption	Water, soil, seed, diversification, climate advice, efficient inputs	Risk reduction and resource efficiency	Stable yields, lower vulnerability, ecological improvement	High initial cost or poor local fit
Digital market integration	e-NAM, ONDC, GeM, B2B, digital payments, traceability	Price discovery and buyer diversification	Better realization and transaction transparency	Onboarding without active sales
Inclusive participation	Women, youth, smallholders, tenant farmers	Broader agency and enterprise creation	Employment, leadership and social sustainability	Nominal representation
Enabling environment	Policy coherence, credit, logistics, extension, data governance	Reduces institutional and market barriers	Scalable and durable transformation	Fragmented schemes and compliance burden

8.1 Institutional Formation Has Outpaced Enterprise Deepening

The registration of 10,000 FPOs represents substantial institutional coverage. However, the comparative indicators show that access to market, finance, infrastructure and processing support has not reached the same scale. This does not imply policy failure; newly formed FPOs require time to develop management systems and buyer relationships. It does indicate that registration should be treated as an input indicator rather than an outcome indicator.

A stronger performance dashboard would track active membership, annual procurement and sales, member price advantage, working-capital turnover, repeat buyers, share of value-added products, climate-risk reduction and member income stability. These measures can distinguish dormant organizations from active agribusiness enterprises.

8.2 Climate-Smart Adoption Requires Collective Business Incentives

The literature suggests that training and information are necessary but insufficient for sustained CSA adoption.

Farmers are more likely to adopt when the FPO reduces the cost of experimentation, secures inputs, arranges equipment and connects the practice with a market or cost advantage. For example, water-saving production becomes more attractive when the FPO provides advisory support, coordinates shared machinery and secures a buyer for quality-assured output.

The FPO can also aggregate climate information. Instead of each farmer independently interpreting weather forecasts, the organization can translate data into crop calendars, procurement plans and collective advisories. This converts information into operational coordination.

8.3 Digital Linkage Must Be Measured through Active Use

The 46.42% e-NAM linkage rate indicates meaningful progress, but the managerial value of digital integration depends on transaction activity. Active use requires standardized lots, quality testing, adequate volumes, clear payment procedures and logistics. Digital-market performance should therefore be measured by the number and value of transactions, buyer diversity, repeat orders, payment time, rejection rates and price differentials relative to local alternatives.

Digital platforms can also support traceability and climate claims. When production records are credible, an FPO can differentiate commodities based on sustainable practices, residue management or efficient water use. Such differentiation may not always produce a price premium, but it can improve access to institutional buyers and long-term contracts.

8.4 Financial and Infrastructure Gaps Limit Value Addition

Credit-guarantee and infrastructure participation rates are lower than digital-market linkage. This pattern matters

because market access without working capital and physical capacity can create an implementation gap. FPOs need funds to purchase member produce, hold inventory, meet quality requirements and manage delayed payments. Storage, grading, processing and transport are equally necessary for commodities that cannot be sold immediately.

The low descriptive share associated with PM-FME convergence indicates a large opportunity for collective processing and rural enterprise development. Value addition can improve shelf life, reduce distress sales and create local employment, but it also introduces quality, food-safety, branding and market risks that require professional management.

8.5 Inclusion Should Be Evaluated through Decision and Benefit Indicators

Women-only FPOs represent 11.75% of the registered base, while official reporting also indicates substantial women membership across the scheme. These numbers demonstrate institutional inclusion, but the quality of empowerment should be assessed through leadership positions, meeting participation, control over income, access to digital tools, enterprise ownership and distribution of benefits.

Youth inclusion is equally important because digital marketing, processing, logistics, data management and equipment services can create skilled rural employment. An FPO that treats young people only as farm labour misses the opportunity to develop rural managers, technicians and entrepreneurs.

9. Analytical and Conclusive Findings

1. Institutional expansion is strong, but the programme indicators reveal a measurable gap between the

number of FPOs registered and the number connected with finance, infrastructure and digital markets.

2. Digital-market linkage is the most advanced comparable indicator at 46.42%, yet active transaction intensity must be examined before concluding that market integration is complete.
3. Credit-guarantee coverage of 25.83% and AIF participation of 15.90% indicate that financial and physical capacity remain important scaling constraints.
4. The crude average turnover of approximately ₹50.36 lakh per registered FPO should be interpreted cautiously because FPOs differ in age, commodity, membership and activity.
5. CSA adoption is more likely to be sustained when FPOs connect technical practices with cost reduction, risk management, collective infrastructure and market incentives.
6. Governance, trust, professional management and member participation are not supporting variables; they are core determinants of whether financial and digital support produces commercial outcomes.
7. Digital onboarding without grading, logistics, fulfilment and payment capability can create symbolic rather than operational integration.
8. Women and youth inclusion can strengthen social sustainability and enterprise innovation when representation is accompanied by decision authority, skills and access to income-generating activities.
9. FPO performance should be measured through member-level and ecosystem-level outcomes, including income stability, price advantage, climate resilience, natural-resource improvement and rural employment.
10. The proposed framework supports future testing through regression, mediation analysis or structural equation modelling using FPO and member-level data.

Table 3: Proposed Hypotheses and Future Empirical Testing

Hypothesis	Independent variable	Dependent variable	Suggested test	Expected direction
H1	FPO institutional capacity	CSA adoption	Multiple regression / SEM	Positive
H2	CSA adoption	Sustainable agribusiness performance	Multiple regression / SEM	Positive
H3	Digital market integration	Market diversification and price realization	Regression / panel analysis	Positive
H4	FPO capacity through digital integration	Sustainable agribusiness performance	Mediation analysis / SEM	Positive indirect effect
H5	Governance quality and policy support	Strength of FPO capacity → CSA relationship	Moderated regression / SEM	Positive moderation
H6	Women and youth inclusion	Social sustainability and rural enterprise innovation	Regression / multi-group SEM	Positive

10. Discussion

The analysis supports a transition from an organization-formation approach to an enterprise-deepening approach. India's FPO policy has created an extensive institutional base, but the next phase must improve the capacity of organizations to conduct repeated transactions, manage risk and generate member benefits. This requires differentiation because FPOs vary by commodity,

geography, maturity, governance and market potential. A uniform support package may be administratively convenient but strategically weak.

The framework also clarifies the complementary relationship between climate-smart production and market integration. Farmers bear the cost and risk of changing practices, while buyers may receive benefits

through quality consistency, traceability or supply stability. FPOs can negotiate arrangements that distribute these benefits more fairly. Without market incentives, climate-smart practices may remain dependent on temporary subsidies. Without climate-smart practices, market integration may increase sales but leave production exposed to water stress, soil decline and extreme weather.

The descriptive programme indicators show why digitalization should be interpreted carefully. e-NAM linkage is important, but it is not a substitute for organizational readiness. The difference between platform presence and platform performance resembles the difference between FPO registration and FPO viability. In both cases, active use, quality of governance and commercial results matter more than formal status.

11. Conclusion

This paper develops a strategic framework for integrating Farmer Producer Organizations, climate-smart agriculture and digital markets within the broader objective of sustainable agribusiness and rural transformation. The core argument is that none of these elements is sufficient in isolation. FPOs without professional capability may remain inactive; climate-smart practices without economic incentives may not be sustained; and digital platforms without quality, logistics and working capital may generate limited transactions.

The recent programme evidence indicates that India has established a large institutional foundation of 10,000 FPOs. The next challenge is to deepen finance, infrastructure, market use, inclusion and climate capability. The comparative percentages suggest that market linkage, credit support and value-addition convergence remain incomplete relative to registration. This creates a clear policy and managerial agenda. A climate-smart FPO should be viewed as a farmer-owned rural enterprise platform. It aggregates production and knowledge, organizes services, supports resource-

The proposed model further extends the unit of analysis from the individual farmer to the FPO ecosystem. A farmer's decision is influenced by organizational services, buyer requirements, infrastructure, finance and peer behaviour. This supports a multilevel research design in which member characteristics, FPO capability and regional policy conditions are analysed together.

The inclusion dimension is especially relevant for rural transformation. Women-only FPOs can strengthen leadership and income control, while youth can provide digital, processing and logistical capabilities. However, inclusion should not be reduced to counts. The distribution of decision power, paid roles, business opportunities and returns must be measure.

efficient practices, creates marketable quality, connects with diverse buyers and distributes value among members. When these capabilities are governed transparently and supported by coherent policy, the FPO can contribute to income stability, ecological resilience, local employment and rural entrepreneurship

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