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**DIGITAL AGRI-FINANCE AND SUSTAINABLE TRADE:
CONCEPTUALIZING FPO ACCESS TO AGRI-DERIVATIVES AND
ORGANIC CERTIFICATION MARKETS**

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Abstract

The evolving landscape of digital finance presents unprecedented opportunities for transforming agricultural markets, particularly through the empowerment of Farmer Producer Organizations (FPOs). This conceptual study explores the intersection of digital agri-finance, agri-derivatives, and organic certification markets, focusing on enhancing FPO participation in sustainable trade. While FPOs have emerged as pivotal institutions in aggregating farmer produce and improving bargaining power, their access to formal financial systems and high-value markets, such as derivatives trading and certified organic supply chains, remains limited.

The existing literature predominantly addresses digital financial inclusion or sustainable agriculture in isolation, with limited insights into how digital finance can enable FPOs to access structured trading platforms and certification-driven markets. This study fills this gap by proposing a conceptual framework that integrates digital finance tools (e-wallets, agri-fintech platforms, and blockchain-based traceability) with FPO-led participation in price risk management via agri-derivatives and market differentiation through organic certification.

The framework emphasizes the enabling role of digital infrastructure, capacity building, and supportive policies in creating inclusive, traceable, and sustainable agricultural value chain. These findings have significant policy implications, advocating an integrated approach that supports digital literacy, regulatory reform, and targeted investment to strengthen FPO access to green and premium markets. This study contributes to ongoing dialogues on sustainable trade and green economy transitions in emerging agricultural systems.

development of equitable assessment frameworks that foster responsible inspiration without penalizing creativity.

Keywords: Digital Academic practices, Digital Agri-Finance, Farmer Producer Organizations (FPOs), Agri-Derivatives, Organic Certification, Sustainable Trade, Green Economy

1. INTRODUCTION

The rapid advancement of digital finance has emerged as a transformative force in the agricultural sector, especially in developing economies such as India, where smallholder farmers often face barriers to accessing formal credit, insurance, and structured markets (FAO, 2021; World Bank, 2022). Digital agri-finance, including mobile banking, e-wallets, agri-fintech platforms, and blockchain-based solutions, offers innovative channels for delivering financial services tailored to agricultural value chains, thereby enhancing efficiency, transparency, and inclusion (Wolfert et al., 2017; Ghosh, 2020).

Amid these developments, Farmer Producer Organizations (FPOs) have gained prominence as collective institutions that enhance smallholder farmers' access to markets, inputs, infrastructure, and financial resources. By aggregating produce, negotiating better prices, and facilitating capacity building, FPOs play a crucial role in empowering farmers and improving their resilience in a liberalized agricultural market environment (Narayanan, 2021; NABARD, 2023). Simultaneously, the growing demand for sustainable agriculture has elevated the importance of organic certification,

a process that ensures adherence to eco-friendly production practices and opens access to premium markets. Likewise, participation in agri-derivative markets offers price risk mitigation through hedging, enabling farmers to better manage volatility and ensure income stability (SEBI, 2022; ICAR-NAARM, 2021). However, FPOs often struggle to access these specialized markets because of regulatory, financial, and informational barriers.

The push for sustainable trade, centered on traceability, inclusivity, and environmental stewardship, underscores the need to integrate digital tools with institutional mechanisms to facilitate FPO access to high-value green markets. However, existing research tends to treat digital finance, organic agriculture, and derivatives trading in silos, lacking a cohesive framework that connects these domains through the lens of FPOs.

This study addresses this conceptual gap by proposing a framework that links digital agri-finance with FPO access to organic certification and agri-derivative markets, thereby facilitating participation in sustainable trade. The framework aims to conceptualize the digital enablers, institutional support systems, and market structures that can help transition FPOs from traditional low-margin markets to inclusive and sustainability-oriented trade ecosystems.

2. REVIEW OF LITERATURE

This review synthesizes existing studies across multiple thematic domains relevant to the conceptual framework, namely, digital finance in agriculture, FPO-led marketing, agri-derivatives, organic certification, and barriers to inclusive agri-market participation. It also draws on relevant theoretical frameworks to establish the foundation for the proposed conceptual model.

2.1. Digital Finance in Agriculture

Digital finance refers to the use of digital technologies, such as mobile banking, e-wallets, fintech platforms, and blockchain, to deliver financial services to underserved rural populations. In the agricultural sector, it enables timely access to credit, insurance, payments, and remittances, helping farmers manage production and market risk (Ghosh, 2020).

Wolfort et al. (2017) emphasize that smart farming technologies, combined with digital financial services, can enhance farm-level decision-making and market connectivity. According to the World Bank (2022), digital financial inclusion reduces transaction costs, improves transparency, and enhances resilience among smallholder farmers in developing countries.

2.2. Role of FPOs in Collective Marketing and Financial Inclusion

FPOs are member-based institutions that aggregate small and marginal farmers to enhance their access to inputs, markets, and financial services. They serve as intermediaries between farmers and financial institutions, enabling greater access to credit, insurance, and structured trade systems (NABARD 2023).

Narayanan (2021) highlights that FPOs enhance farmers' bargaining power, improve price realization, and promote financial literacy. Furthermore, FPOs have increasingly been integrated into government schemes, such as e-NAM and the Formation & Promotion of 10,000 FPOs, to mainstream collective action in agri-markets.

2.3. Concept of Agri-Derivatives and Price Risk Management

Agri-derivatives are financial instruments, such as futures and options contracts, traded on commodity exchanges to hedge price risks. They enable farmers and FPOs to lock in future prices, thus reducing income volatility caused by market fluctuations (SEBI 2022).

Despite this potential, the participation of FPOs in agri-derivative markets is limited due to operational and regulatory challenges. ICAR-NAARM (2021) suggests that capacity building and digital onboarding of FPOs on platforms like NCDEX are essential to democratize access to these instruments.

2.4. Organic Certification and Its Role in Premium Markets

Organic certification validates adherence to ecologically sound farming practices and is a prerequisite for accessing premium domestic and export markets in the EU. Schemes such as PGS-India and the National Programme for Organic Production (NPOP) support farmer groups in obtaining certification.

The FAO (2021) notes that certification enhances credibility, traceability, and consumer trust. However, the cost, complexity, and time involved in the certification processes pose significant entry barriers for smallholders and FPOs (APEDA, 2022). Digitally enabled traceability systems and certification financing have emerged as key enablers.

2.5. Barriers to Market Access and Financial Integration

Despite policy support, FPOs face constraints in accessing agri-derivatives and certified markets (CMs). Key barriers include:

- Low digital and financial literacy among farmer members (Ghosh, 2020)
- Regulatory and institutional bottlenecks (SEBI, 2022)

- Limited access to collateral-free financing
- Lack of trained manpower and technical support to manage derivative contracts and certification protocols (ICAR-NAARM, 2021)

These challenges limit FPOs' ability to participate in higher-value markets and reduce their financial independence.

2.6. Theoretical Foundations

The proposed conceptual framework draws on the following theories.

- **Sustainable Livelihoods Framework (SLF):** Highlights the importance of financial, human, and institutional capital in improving rural livelihoods. Digital finance and FPO-based models align with the SLF by enhancing asset access and risk mitigation (DFID, 1999).
- **Institutional Theory:** Suggests that formal institutions (e.g., certification bodies and financial regulators) shape the structure and behavior of market actors. FPO access to regulated spaces, such as commodity exchanges and certification markets, depends on institutional compliance and support (Scott, 2001).
- **Market Systems Development (MSD):** Emphasizes the need for inclusive and scalable market solutions that empower marginalized actors. When integrated into formal value chains, digital platforms and FPOs create pathways for market-based development (Springfield Centre, 2015) (Figure 1).

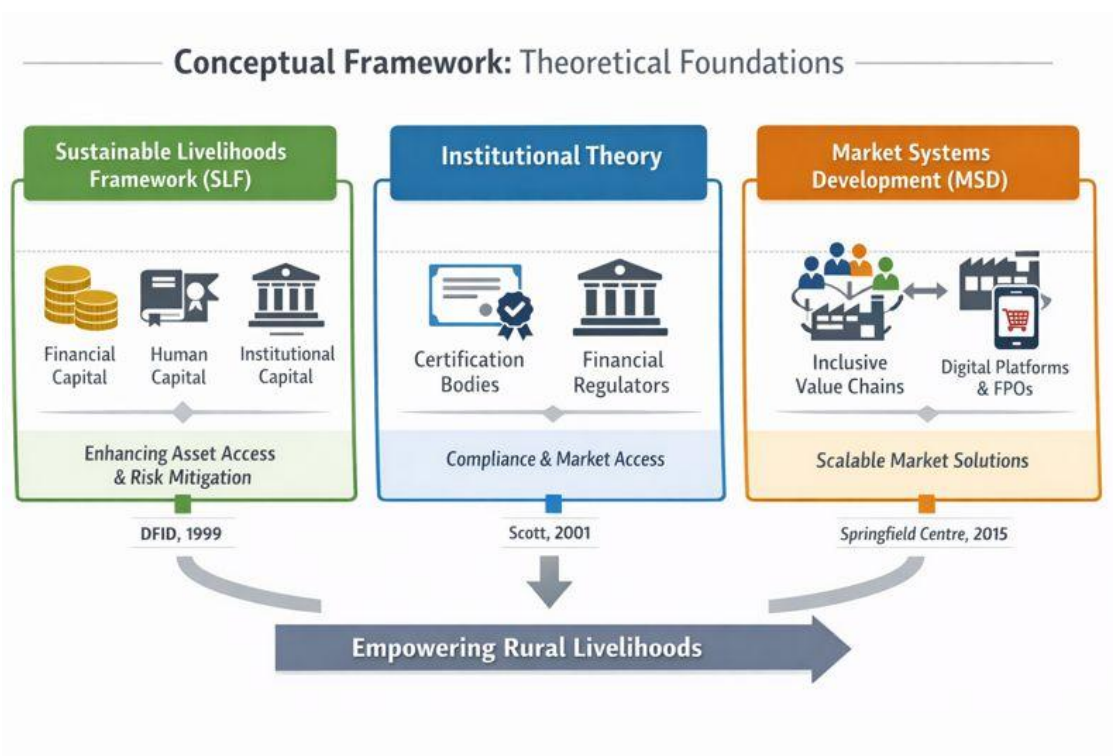


Figure 1. Theoretical Foundations

3. CONCEPTUAL FRAMEWORK

The proposed conceptual framework illustrates the interconnections between digital financial innovations, institutional actors, and market mechanisms that collectively enable Farmer Producer Organizations (FPOs) to access structured and sustainable agri-markets, specifically agri-derivatives and organic certification-based trade. The model integrates financial, institutional, and technological inputs to generate pathways for inclusive and green economic outcomes in agriculture.

3.1. Inputs

These foundational elements provide the necessary ecosystem to support FPO integration into sustainable agri-

markets.

- **Digital Finance Tools:** Mobile wallets, digital credit scoring, blockchain for traceability, agri-fintech platforms (Wolfert et al., 2017; Ghosh, 2020)
- **Regulatory Support:** SEBI norms for FPO participation in agri-derivatives; PGS-India/NPOP guidelines for organic certification (SEBI, 2022; APEDA, 2022)
- **Digital & Physical Infrastructure:** Internet connectivity, agri-market logistics, certification labs, online trading platforms like NCDEX and e-NAM (ICAR-NAARM, 2021)

3.2. Actors

Multiple stakeholders play key roles in enabling FPO to access sustainable trade systems.

- **Farmer Producer Organizations (FPOs):** Aggregators of smallholder farmers, responsible for marketing and collective action (NABARD, 2023)
- **Fintech Firms:** Providers of agri-credit, insurance, and transaction platforms (Ghosh, 2020)
- **Organic Certification Agencies:** PGS-India groups, NPOP-accredited agencies validating eco-friendly farming practices (APEDA, 2022)
- **Commodity Exchanges:** NCDEX, MCX facilitating derivative contracts for risk management (SEBI, 2022)

3.3. Mechanisms

These are the core functional processes that enable transformation within the framework.

- **Access to Agri-Derivatives:** Training and onboarding FPOs to use futures/options for price risk hedging (ICAR-NAARM, 2021)
- **Organic Certification Integration:** Support for certification finance, traceability systems, and market linkage (FAO, 2021)
- **Financial Inclusion:** Delivery of digital credit, insurance, and mobile payments to member farmers through FPO channels (World Bank, 2022)

3.4. Outputs

Tangible results from the interaction of inputs and mechanisms

- **Price Stability:** Through hedging instruments and forward pricing mechanisms
- **Quality Assurance:** Via traceable and certified organic produce
- **Expanded Market Access:** Entry into premium domestic and global markets, supported by digital platforms and certification (Narayanan, 2021)

3.5. Outcomes

Long-term developmental impacts aligned with sustainable agriculture and inclusive trade goals:

- **Sustainable Trade:** Enhanced participation of smallholders in green value chains (Figure 2)
- **Green Economy Integration:** Boosting environmentally friendly production and consumption
- **Farmer Income Enhancement:** Increased profitability through reduced risk and value-added market access (NABARD, 2023; FAO, 2021)

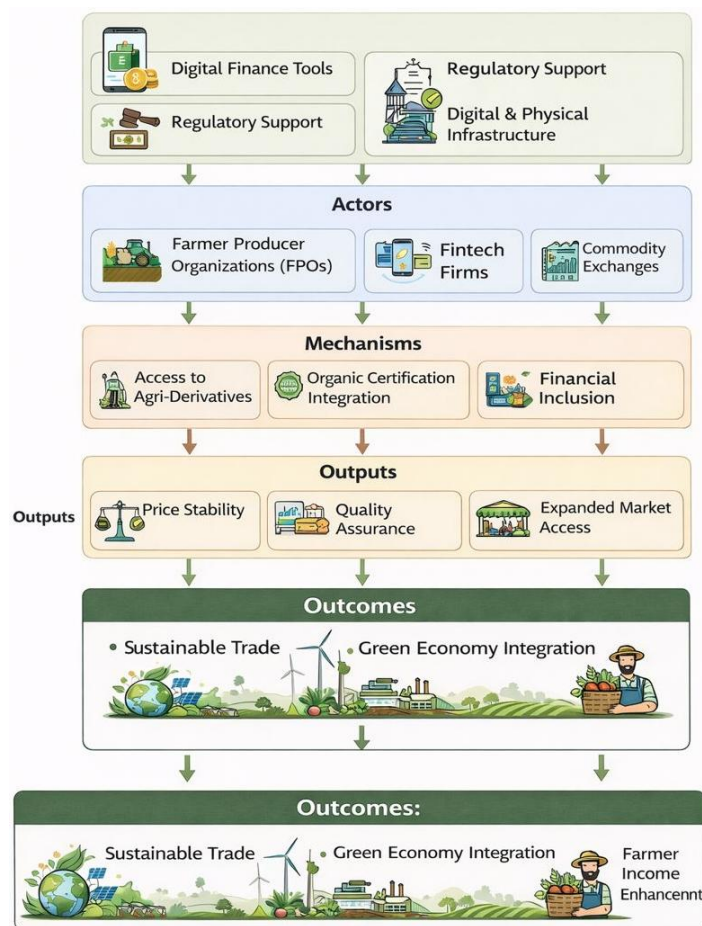


Figure 2: Framework Diagram

4.DISCUSSION

The integration of digital agri-finance with sustainable trade systems presents a transformative opportunity for Farmer Producer Organizations (FPOs) to move beyond traditional markets and engage in value-added, risk-mitigated, and eco-certified agricultural trades. This discussion highlights how digital financial tools serve as critical enablers for FPO participation in agri-derivative markets, organic certification processes, and traceable sustainable value chains, while acknowledging the structural barriers and emerging opportunities in this transition.

4.1. Digital Finance and FPO Participation in Agri-Derivatives

Digital financial services, such as mobile banking, online trading platforms, and agri-fintech applications, have simplified access to commodity derivative markets. These platforms enable FPOs to hedge against price volatility by participating in futures and options contracts on regulated exchanges, such as the NCDEX (SEBI, 2022). Access to such risk management instruments can stabilize farmer incomes, especially for high-risk crops.

However, effective participation requires digital onboarding, awareness training, and credit access to meet the margin requirements. FPOs leveraging digital wallets and real-time payment systems can streamline fund transfers to brokers or clearing houses, thereby reducing transaction delays and risks (ICAR-NAARM, 2021).

4.2. Financing Certification and Compliance via Digital Finance

Organic certification—under schemes like PGS-India and NPOP—demands an upfront investment in compliance, training, internal control systems (ICS), and periodic audits. Digital agri-finance facilitates affordable microcredit, group insurance, and digitally tracked subsidy disbursement, enabling FPOs to overcome the initial cost barrier (APEDA, 2022; Ghosh, 2020).

Blockchain-based traceability systems, supported by digital financing, enhance credibility in global organic markets by verifying compliance histories and transaction records in real time (FAO, 2021).

4.3. Engagement with Sustainable and Traceable Trade Markets

When integrated with certification and price-risk management tools, digital platforms enable FPOs to engage with

premium buyers both domestically and globally. Fintech-driven marketplaces provide traceability, digital invoicing, and transparent payments, which are crucial for entering high-value markets, such as organic exports, institutional procurement, and B2B supply chains (Wolfert et al., 2017).

Through digital documentation and platform participation, FPOs can signal quality assurance, environmental compliance, and price discipline to ethical buyers, fostering trust and long-term market relationships (Narayanan, 2021).

4.4. Challenges and Structural Barriers

Despite this potential, significant barriers impede widespread FPO adoption.

- **Infrastructure Gaps:** Many FPOs lack reliable Internet connectivity, computer systems, and trained personnel to manage digital trading or certification processes (NABARD, 2023).
- **Digital and Financial Literacy:** Limited awareness of fintech tools and derivative mechanisms restricts informed participation (Ghosh 2020).
- **Regulatory Complexity:** Navigating SEBI norms for derivatives and APEDA guidelines for certification requires institutional support and legal literacy (SEBI, 2022; APEDA, 2022).

4.5. Emerging Opportunities

Despite these constraints, several emerging opportunities can bridge this integration gap.

- **Blockchain and IoT:** These technologies provide end-to-end traceability of certified products and improve transparency in agri-supply chains (FAO, 2021).
- **Public-Private Partnerships (PPPs):** Collaborations between fintech startups, agri-input companies, and government agencies can deliver bundled services such as digital credit, input delivery, and certification support (Springfield Centre, 2015).
- **Policy Push:** Government initiatives, such as the *10,000 FPOs scheme*, *e-NAM*, and *Agri Infrastructure Fund*, are creating enabling ecosystems for FPO market inclusion (NABARD, 2023).

5. IMPLICATIONS

The proposed conceptual framework has significant implications for policy, practice, and research. As FPOs seek to harness digital finance for sustainable trade, particularly through agri-derivatives and organic certification, targeted interventions and structural reforms are essential to realize the potential benefits for smallholder farmers and the green economy (Figure 3).

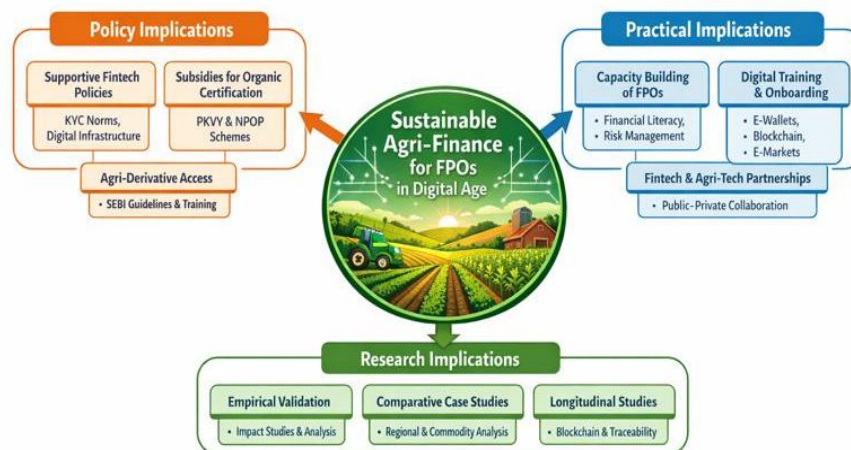


Figure 3: Implications for Sustainable Agri-Finance for FPOs in Digital Age

5.1. Policy Implications

To operationalize digital agri-finance models on a large scale, the following policy interventions are recommended:

- **Supportive Fintech Policies:** Government and regulatory bodies, such as the RBI and NABARD, must create an enabling environment for agri-fintech solutions by streamlining Know Your Customer (KYC)

norms, promoting digital lending, and enhancing digital infrastructure in rural areas (World Bank, 2022; Ghosh, 2020).

- **Subsidies for Organic Certification:** Targeted subsidies and low-interest credit lines should be provided to FPOs for organic compliance and certification processes under schemes such as the Paramparagat Krishi Vikas Yojana (PKVY) and the National Programme for Organic Production (NPOP) (APEDA, 2022; FAO, 2021).
- **Legal Provisions for Agri-Derivative Access:** SEBI and the Ministry of Agriculture should formulate simplified guidelines and provide training modules for FPOs to safely participate in futures and options trading (SEBI, 2022; ICAR-NAARM, 2021).

5.2. Practical Implications

For implementation on the ground, institutions, NGOs, and agri-enterprises should focus on the following:

- **Capacity Building of FPOs:** Structured programs in financial literacy, price-risk management, and certification processes must be rolled out across regions through KVKs, ATMA, and NABARD-supported institutions (NABARD, 2023).
- **Digital Training and Onboarding:** Tailored digital literacy programs covering mobile transactions, e-wallets, blockchain traceability, and online marketplaces are critical for helping FPOs adopt fintech tools (Wolfert et al., 2017).
- **Collaborations with Fintech and Agri-Tech Firms:** Public-private partnerships (PPPs) involving startups can drive innovation in the last-mile delivery of financial services, certification traceability, and data-driven decision-making for FPOs (Springfield Centre, 2015).

5.3. Research Implications

The conceptual framework opens new avenues for academic exploration and field validation.

- **Empirical Validation of the Framework:** Future quantitative and qualitative studies should test the impact of digital agri-finance interventions on FPO performance in terms of market access, income stability, and environmental outcomes (Narayanan, 2021; Ghosh, 2020).
- **Case Studies Across Regions and Commodities:** Comparative research can examine how digital finance enables sustainable trade for different FPO types, such as organic cotton, pulses, and horticulture, across varied agro-climatic zones in India and other Global South contexts.
- **Longitudinal Studies on Traceable Value Chains:** Research on blockchain-based organic certification systems and their effects on buyer trust, compliance costs, and export potential would add value to the sustainable trade literature (FAO, 2021; World Bank, 2022).

6. CONCLUSION

This conceptual study explores the transformative nexus between digital agri-finance and sustainable agricultural trade, emphasizing the critical role of Farmer Producer Organizations (FPOs) in accessing agri-derivative markets and organic certification systems. By proposing a framework that integrates digital finance tools, institutional actors, and sustainable market mechanisms, this study addresses a vital gap in the current literature at the intersection of financial inclusion, price risk mitigation, and eco-certified value chains.

Digital agri-finance, comprising mobile banking, agri-wallets, fintech lending, and blockchain applications, has the potential to revolutionize how smallholder farmer collectives engage with high-value markets. When effectively leveraged, these technologies can democratize access to price discovery platforms, reduce the cost of organic certification, and enhance transparency and traceability in agri-supply chains. This, in turn, strengthens the FPOs' position as facilitators of inclusive, climate-smart, and premium agricultural trade.

FPOs are uniquely positioned to function as institutional bridges between grassroots producers and evolving digital marketplaces. However, realizing this potential requires a coordinated effort from policymakers, development practitioners, and the private sector. Integrated strategies involving enabling policy frameworks, capacity development, and technology infrastructure are essential to support FPOs in adopting and scaling digital financial innovations.

In conclusion, unlocking FPO access to agri-derivatives and organic certification through digital finance is not only a

matter of efficiency—it is a pathway toward a resilient, equitable, and green economy. Future research and on-ground interventions must continue to evolve this conceptual vision into a replicable model for sustainable rural transformation.

7. STATEMENTS & DECLARATIONS:

Use of AI Statement

The authors declare that they have not used generative artificial intelligence, specifically ChatGPT in the writing of this manuscript and/or in the creation of images, graphics, tables, or their corresponding captions

Conflict of Interest and Declarations:

Authorship contribution statement: Siddalingaswamy M G, Shifa Fathima A: Carrying the Experimental work, Data curation and writing the original manuscript and original draft. Safeer Pasha M: Supervision and reviewing the manuscript.

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