

CHAPTER-10

**BRIDGING THE RURAL CREDIT DIVIDE FOR SUSTAINABLE AGRICULTURE:
THE ROLE OF AGRI-FINTECH IN FINANCIAL INCLUSION**Gowsia Bashir¹, Bilal Farooq¹ & Natasha Saqib¹¹Department of Management Studies, South Campus, University of Kashmir, IndiaCorresponding author: shahgousia321@gmail.com

Cite this chapter as: Bashir, G., B. Farooq & N. Saqib. Bridging the Rural Credit Divide for Sustainable Agriculture: The Role of Agri-Fintech in Financial Inclusion. In: Bhat, A., A. Sultan, D. Kolhe & P. Banerjee. 2026 Digital Agriculture and Economic Transformation. The AgEcon Frontiers, Faisalabad, Pakistan, pp: 148-159. <https://doi.org/10.66529/book.9786277945022.2026.ch10>
A Publication of The AgEcon Frontiers Received: 26-May-2026 Revised: 05-June-2026 Accepted: 07-June-2026

Abstract

The institutional lockout of smallholder farmers in formal financial institutions is one of the oldest developmental paradoxes facing emerging economies, such as India. The importance of agriculture to the national income and rural employment notwithstanding, farmers still remain over-reliant on informal, expensive credit sources that keep them in debt and traps of agricultural desperation. The current chapter engages in a methodical review of how the merging of agricultural enterprise and financial technology in combination called Agri-FinTech is radically remaking the rural finance landscape. Based on this background, the chapter theorizes Agri-FinTech as an ecosystem that includes digital lending applications, mobile-based financial services, blockchain-based supply chains, and data-driven credit evaluation applications. It critically examines the role these innovations play in making credit more accessible, lowering transaction costs and facilitating last mile delivery of financial services. Along with its potential, the chapter also covers some of the major challenges, such as the digital divide, regulatory uncertainty, data privacy issues, and infrastructural constraints that can impede its widespread adoption. The discussion also gives policy and strategic suggestions to governments, financial institutions, and technology providers to create an inclusive and sustainable Agri-FinTech ecosystem. The chapter ends with a reflection on the future opportunities, with a focus on the involvement of emerging technologies and integrated financial models in enhancing financial inclusion and rural development. The chapter ends with reflective evaluation of the research implications, research methodological limitations and a roadmap of future scholarly research.

Keywords: Agri-FinTech, Financial Inclusion, Rural Credit, Digital Finance, Mobile Banking, Blockchain, Credit Assessment, Agricultural Development, Inclusive Growth.

1. Introduction

The primary role of agriculture in the Indian socioeconomic structure is to form not just an effective production system but the base on which rural life, food security and national identity are built. Agriculture is economically vital and structurally vulnerable, supporting the livelihoods of almost half the population, and accounting for about 17.18 per cent of the Gross Domestic Product of the country (Arena et al., 2023; Shahbaz et al., 2013). This weakness is not an accident but a structural product of a complex of structural disadvantages: land fragmentation, climatic unpredictability, inefficiencies in the input market, post-harvest losses and most importantly, the long-term structural inadequacy of institutional financial access. Such mutually reinforcing limitations drastically limit agricultural output and farmer well-being, making the industry especially vulnerable to external shocks.

Institutional credit is an essential facilitator of economic dynamism, which facilitates entrepreneurship, influences technological adoption and helps reduce poverty in development settings (Yadav et al., 2015). Access to formal credit is, in turn, consequential in the Indian context in terms of smallholder farmers, marginal cultivators, and the population of rural micro-entrepreneurs historically marginalised by traditional banking architecture. As the All India Rural Financial Inclusion Survey conducted by NABARD (2019) determined, about 61 per cent of all agricultural households that access credit do so via institutional sources; however, this figure disguises the continued prevalence of marginalization among the rest of the population, with most of them continuing to be trapped in informal credit markets that are full of predatory and exploitative interest rates and terms.

The strong position of institutional access to credit in the Indian agricultural policy has been long recognised since the post-independence period, as the various policy regimes have struggled to move farmers off moneylenders and to banks, cooperatives and microfinance institutions (Kumar et al., 2017). Availability of sufficient, timely and affordable credit increases investment potential, risk management and enhances efficiency at the farm level (Pandey, 2017; Memmel et al., 2019). It also has downstream benefits to welfare, empirical studies show that agricultural access to credit decreases poverty by increasing household productivity and income (Awotide et al., 2015; Luan et al., 2016). Yet these policy promises, acute regional and intra-community inequalities, and continue to exist, and farmers in geographically remote or economically lagging districts continue to be systematically under served by formal financial institutions (Bhuvana et al., 2016; Jegadeeshwaran et al., 2020). This problem is worsened by geographical obstacles, which are accompanied by the lack of financial literacy, and concrete measures must be taken to promote financial inclusion. In the international development context, fintech has become a game-changer that encourages financial inclusion, which is a tool to deal with income inequality and a facilitating infrastructure that fits the United Nations Sustainable Development Goals, especially SDG 1 (No Poverty), SDG 8 (Decent Work and Economic Growth), SDG 9 (Industry, Innovation and Infrastructure) and SDG 10 (Reduced Inequality). In the context of Indian agriculture, fintech solutions involving mobile banking, digital credit evaluation, crop insurance solutions, peer-to-peer lending and e-marketplace infrastructure have a unique potential, namely, precisely due to the fact that they are designed to bypass the institutional bottlenecks that conventional banking systems have failed to overcome (Kumar and Parida, 2013).

There is significant evidence of digital financial services being effective in enabling underserved populations by facilitating their access to formal financial systems (Azimi, 2022; Liu, 2021). In the developing world of the context, the structure gaps left by traditional banking have been filled by fintech, especially in rural and agrarian societies (Azmeah, 2025). New evidence in the global context confirms that fintech innovations are not only enhancing economic resilience but also initiating environmentally friendly agricultural activities (Demir et al., 2022; Morgan, 2022).

This chapter contributes tripartitely to this growing literature. First, it offers a conceptually based explanation of structural aspects of the rural credit divide that contextualizes the current Agri-FinTech developments in wider political economy of Indian agricultural finance. Second, it charts the shifting Agri-FinTech ecosystem, evaluating critically how certain technological interventions can overcome credit access barriers and facilitate sustainable farming practices. Third, it propels an ordered agenda of research in the future and the methodological constraints that define current scholarship.

2. Theoretical Framework

A rigorous analysis of Agri-FinTech adoption necessitates a theoretical framework that can adequately account for both the technological and sociological dimensions of innovation diffusion among farming communities. Two complementary theoretical constructs provide this analytical scaffolding: the Technology Acceptance Model (TAM) and Rogers' Diffusion of Innovations Theory (DOI). While both frameworks originate in broader information technology and social science traditions, their application to the Agri-FinTech context yields distinctive and practically significant insights.

3. Diffusion of Innovations Theory (DOI)

The Diffusion of Innovations Theory initially developed by Rogers in 1962 and later expanded upon in numerous editions (Rogers, 2003), is a potent conceptual tool to study the uptake of fintech solutions in agricultural contexts. This theory assumes that over time, innovations disseminate through social systems via communication channels, with the rate of adoption influenced by the perceived attributes of the actual innovation (Keyling et al., 2015). In line with this model, farmers will embrace technological changes when they believe that they provide a relative advantage over the current practices, are compatible with existing agricultural standards, and are not too complex to implement (Chawla et al., 2024). In the case of Agri-FinTech platforms, this suggests that the social legitimacy of established local players can be a significant aspect of platform adoption as important as the technical characteristics of the platform itself. DOI identifies four basic components of the innovation diffusion process: To begin with, the innovation itself should provide relative advantage which can be demonstrated. In the case of Agri-FinTech platforms, it involves providing practical enhancements compared to traditional credit providers in terms of quicker loan issuance, lower interest rates, less paperwork and increased repayment options. Second, the speed of diffusion and its extent is dependent on communication channels. The process of adoption is greatly enhanced by the development of awareness in terms of trusted networks such as the farmer producer organisations, agricultural extension agents, local radio and of late, social media channels that operate in local languages. Third, Time Diffusion is slow; platforms have to be designed to support varying learning curves and have continuous onboarding support. Fourth, the social system which involves the cultural norms, institutional trust, gender relations, and power relations has a strong moderating effect on adoption behaviour.

4. Technology Acceptance Model (TAM)

The Technology Acceptance Model by Davis (1989) provides a psychologically based explanation of the way people consider and make a decision about utilization of new technologies. TAM assumes that the behavioural intention to use the technology is determined by two main perceptual constructs as Perceived Usefulness (PU) and Perceived Ease of Use (PEOU), and predicts actual use. In the Agri-FinTech setting, Perceived Usefulness is how the farmer thinks that a digital financial service will positively impact his or her productive capacity or wellbeing, whereas Perceived Ease of Use is how the technology is viewed as needing a low level of cognitive and operational effort. A more accessible and user-friendly Agri-fintech system with voice-based navigation in a local language, which does not necessitate any previous formal education to be used and works well on a low-bandwidth network will have significantly higher adoption rates compared to a more advanced one that is not easily accessible. The policy implication is obvious: the design of technology needs to be radically human-centred and context-sensitive in order to gain the scale of adoption needed to have systemic impact. The DOI and TAM synthesis give the analytical lens a comprehensive look. Whereas TAM sheds light on individual-level cognitive determinants of adoption, DOI puts them in the context of social ecology of rural societies.

5. Conceptualising Agri-FinTech: An Ecosystem Perspective

The conceptual category of Agri-FinTech can be described as the use of financial technology (defined widely as the utilization of digital infrastructure to provide financial products and services (Knewton and Rosenbaum, 2020)) to the opportunities and challenges facing the agricultural sector. It is not a single technological artefact but a stratified interdependent architecture of digital platforms, data infrastructures, algorithmic tools, regulatory frameworks and institutional actors, all of which render financial services accessible, affordable and suitable to agricultural communities (Joy et al., 2024). This ecosystem has a number of unique yet interdependent technological streams. Digital lending apps use alternative data sources satellite imagery, weather patterns, transaction history, mobile usage data to create credit profiles of farmers with no collateral or credit history. Mobile financial services can expand the geographic coverage of the formal finance in remote locations that lack physical banks, or where physical bank access is challenging. Blockchain supply chains are more efficient in terms of traceability and transparency to ensure farmers are fairly paid by the market and financing institutions can track the use of agricultural credit. The use of artificial intelligence and machine learning applications offers predictive analytical services that can enhance risk assessment, crop advisory services and insurance underwriting (Varma et al., 2022). Agri-FinTech is a naturally fitting concept in the context of the wider fintech agenda of disrupting traditional financial structures that can exclude and democratising access (Setiawan et al., 2021). This democratisation is urgently needed in the Indian context. Impenetrability, power imbalances and financial exclusion has long been the hallmark of the agricultural value chain consisting of input procurement, production, processing and market access. The agri-FinTech platforms can be seen as a structural intervention in this value chain, not just dealing with access to credit in a vacuum but with the whole information and financial infrastructure within which agricultural activity is enclosed (Cao et al., 2021). This transformational potential has been gaining recognition by the policy environment in India. An enabling policy infrastructure under which Agri-FinTech ventures can be implemented is a set of governmental initiatives- the National e-Governance Plan in Agriculture (NeGPA), the Rashtriya Krishi Vikas Yojana (RKVY), the Pradhan Mantri Fasal Bima Yojana (PMFBY), the Pradhan Mantri Krishi Sinchai Yojana (These projects are indicative of the understanding among the state that technological innovation and institutional change must occur in a sequential manner in case the agricultural credit markets can operate in an equitable and efficient manner.

6. Agri-FinTech and Sustainable Farming: Pathways and Evidence.

Agri-FinTech and sustainability agenda are one of the most significant intersections in the modern discourse of agricultural development. The demands of global sustainability, especially as embedded in the United Nations Sustainable Development Goals and the Paris Agreement on climate change, require radical changes in the nature of the financing and organisation and governance of agricultural systems. This part of the argument suggests that financial technology is an essential facilitator of this change (Patil et al., 2025; Wang et al., 2025). The correlation between financial access and the use of agricultural technologies has long been a topic in the development economics literature: the ability of farmers to invest in productivity-enhancing and environmentally friendly technologies is critically limited by the availability of credit (Sadia, 2018). Smallholder farmers who make up the majority of the farming population of India have long been unassailable by formal credit because they cannot offer acceptable security, because of the high costs of transacting with small loans and the riskiness of rain-based agriculture. These

structural barriers can be directly tackled by fintech innovations in four keyways. Credit assessment using digital lending platforms that utilize alternative data analytics enables the use of digital lending platforms without the use of conventional collateral frameworks. Through satellite photography of farmland, weather information, market price history and mobile payment history, these sites build sophisticated profiles of creditworthiness that encapsulates agricultural potential as opposed to past financial records. This algorithmic democratisation of credit scoring is a massive shift of the logic of gatekeeping of traditional banking (Kishor et al., 2025; Wang et al., 2025). Online services that provide real-time loans disbursement, and payments processing will enable farmers to respond to market demands and availability of inputs in real time (Chatterjee and Singh, 2022). Blockchain applications can ensure that farmers can get the price they have negotiated at the point of sale, rent-seeking behaviour of exploitative middlemen is eliminated, and consumers can verify the provenance and sustainability credentials of agricultural products due to their ability to create immutable, verifiable records of transactions throughout the value chain (Vignesh et al., 2024). This traceability system will both lessen the information asymmetry between buyers and sellers and establish the mechanisms of verification that sustainability certification schemes need to operate credibly. Farm management software and digital ledger applications help farmers who have not been part of formal documentation systems to keep records systematically. According to the report by Hao et al. (2024), farmers with verifiable records of their activities have much higher chances of securing formal credit and insurance products, which form a virtuous cycle, as digital literacy and access to financial products support each other. The sustainability impact of such financial innovations is not only on the short-term productivity. Financial products powered by FinTechs, such as peer-to-peer lending, mobile microloans, payment facilitation services and blockchain-enabled traceability systems are being specifically designed in such a way that they encourage the application of sustainable agricultural practices, such as organic certification, climate-smart agricultural practices, and reduced-input production systems (Indrianingsih, 2025). These innovations represent the infantile building blocks of an actually sustainable agricultural finance system by establishing direct financial connections between verifiable sustainability results and investment streams (Wang et al., 2025). Mapanje et al. (2023) show that financial inclusion through fintech can generate visible positive outcomes in agricultural productivity and income distribution, with the benefits of the former being stronger in terms of previously marginalized groups. Mukhopadhyay (2020) sets up that digital financial tools that have the capability to provide real-time information significantly minimise the resource utilisation inefficiencies of smallholder farmers. Chatterjee and Singh (2022) record the use of digital payment systems to automate the process of obtaining agricultural inputs, in order to make timely access to seeds and fertilisers which would otherwise be delayed by the logistics of cash-based transactions. Jain and Gabor (2020) examine the impacts of fintech adoption on transaction cost reduction, concluding that the cost of financial intermediation is directly reduced by lower costs, which are directly converted into increased farm-level investment capacity. According to Kumar and Parida (2013), the use of fintech, which lowers the information cost of adopting climate-smart technology, is an indirect force of environmental sustainability in agriculture. Vasudevan et al. (2025) affirm that fintech not only increases access to growth capital, but also encourages green farming, whereas Sharma et al. (2024) name social influence, performance expectancy and convenience as the key factors by which integration of fintech promotes sustainable agriculture. The macroeconomic spillovers recorded by Bilal Khan et al. (2021) are more generalized, with the authors having established that agricultural productivity is increased by the introduction of digital-based financial inclusion, and rural infrastructure growth is triggered

by the latter. The broader economic value of FinTech is far more extensive than farm uses and is a key component of modern economic revolution in various sectors (Sharma et al., 2025). With artificial intelligence, its intersection forms specifically strong synergies, with an implication to sustainable agriculture: AI-powered predictive analytics, paired with fintech payment and lending infrastructure, can form integrated platforms, and provide personalised credit, insurance and agronomic advisory services at scale (Alam et al., 2025; Mei et al., 2025). The financial inclusion aspects of such integrated systems tap into the dreams of vast groups of people who were not traditionally included in formal economic activities, such as women farmers, tribal peoples and landless rural agricultural workers (Benni, 2023).

7. Challenges and Structural Constraints in Agri-FinTech Adoption

An honest evaluation of the disruptive nature of Agri-FinTech should be checked by an understanding of the daunting structural barriers that hinder its implementation at scale. These are not technical issues but highly structural in rural India and they are entrenched in the social, institutional and infrastructural realities of rural India. Probably the most fundamental obstacle to Agri-FinTech adoption is the digital divide. Although mobile phone penetration in India has increased remarkably, there are still enormous gaps in access to smartphones, access to reliable internet connectivity and digital literacy, especially among geriatric farmers, women, and geographically marginalized communities. The second set of constraints is regulatory uncertainties. The fintech industry exists on the nexus of various regulatory regimes of banking regulation, telecom policy, consumer protection law, data governance framework and resulting regulatory fragmentation imposes regulation burdens on innovators and uncertainty on investors. Third structural challenge is data privacy concerns. The alternative data models on which most Agri-FinTech credit assessment systems are built include the collection and processing of large amounts of personal and behavioural data of farmers. Without a well-developed data governance system and clearly defined consent procedures, this data harvesting poses real threats of abuse, discrimination and loss of privacy. Poor rural electricity access, unreliable internet access, lack of access to banking correspondents and underdeveloped logistics infrastructure all add to the limitations on the operational feasibility of digital financial services in rural agricultural population centers. Lastly, cultural and institutional barriers Weak trust in digital systems, gender-based limitations to female financial autonomy, the institutional inertia of old credit delivery systems and the political economy of agricultural credit subsidies is path dependent and hinders the structural transformation of rural financial markets even with the availability of the right technological tools.

8. Conclusion

Rural credit divide is one of the most enduring and significant structural failures in the development project of India. Over the decades policy intervention priority sector lending requirements, agricultural credit subsidies, cooperative banking growth have only been partially successful in reaching the entire array of the farming populace of India with formal financial services. The advent of Agri-FinTech represents a truly new chance to overcome the shortcomings of these previous solutions, leveraging the computational capabilities of digital technology to overcome the information asymmetries, transaction costs and geographic constraints that have historically kept smallholder farmers out of formal credit markets. The Agri-FinTech ecosystem of digital lending services, mobile financial services, blockchain-based supply chain infrastructure and AI-based credit analysis has a high potential to change the rural financial landscape. Its ability to increase access to credit, lower transaction costs, facilitate sustainable agricultural activities and

last-mile financial services is a significant improvement on the capabilities of traditional banking architecture. Both theoretical frameworks discussed in this chapter Technology Acceptance Model and Diffusion of innovations theory offer very strong conceptual mechanisms to explain the social and cognitive processes that influence the adoption patterns of farming people. Nevertheless, the disruptive nature of Agri-FinTech is not automatic or predetermined. Its realisation requires enduring, concerted action on the part of several actors: governments that focus on rural digital infrastructure and make possible the enabling regulatory environment; financial institutions that adopt technological collaboration as opposed to institutional conservatism; technology providers that reward inclusivity of design over elegance of engineering; and civil society actors that invest in the financial and digital literacy of the farming communities. In the absence of these enabling conditions, it will be easy to have Agri-FinTech reproducing instead of addressing the current trends of exclusion into the more connected, more literate and more prosperous layers of the farming population and leaving out the neediest of the needy. The way ahead is neither technological nor institutional but inherently integrative: an Agri-FinTech vision based on the realities of rural Indian life, responsive to the agency of farming communities and accountable to the development goals that provide the social purpose of this whole enterprise.

9. Policy Implications and Strategic Recommendations

To realise the transformative potential of Agri-FinTech within the Indian agricultural setting, a multi-actor policy response is needed, which should address the structural constraints identified in the previous section. Rural digital infrastructure investment should be a priority of governments as a precondition of Agri-FinTech viability. Broader connectivity via broadband, consistent power supply and available banking correspondent networks are not fringes but rather pillars of the digital financial economy to get where it intends to go. Regulatory sandboxes should also be established by policy frameworks to enable fintech innovators to experiment and develop products within controlled settings prior to full scale implementation to alleviate the innovation chilling effect of early regulatory shutdown. Financial institutions, especially those in the public sector (such as banks) and regional rural banks, which have traditionally limited their credit delivery models to rural areas, should appreciate Agri-FinTech not as a threat but as an enabler infrastructure that can help reach a broader audience and cut down on costs of credit delivery. Appropriate regulatory frameworks can bring together the institutional credibility and ability of the former to mobilise deposits and the technological adaptability and data analytics of the latter through strategic alliances with traditional financial institutions. The principle of human-centred design needs to be internalised by technology providers to develop Agri-FinTech solutions in rural Indian settings. This involves investing in vernacular language interfaces, voice activated navigation, offline support and low bandwidth optimisation. It also implies substantive interaction with agricultural populations in the co-design of platforms and avoiding the lure of foisting urban and educated-user assumptions into agricultural settings, which are bound to fail. Civil society groups and agricultural extension systems play a crucial role in facilitating the digital and financial literacy gaps which limit the adoption of Agri-FinTech. Gender, age, and literacy-based, long-lasting, community-based financial literacy initiatives are invaluable complements to technological innovation. Supply-side technological innovation will only extend to those farming households already proximate to formal economic participation without these demand-side investments.

10. Research Implications

This chapter has a number of implications as far as the academic study of agricultural finance, rural development and digital innovation is concerned. Collectively, such implications imply the

way of how scholarly work on Agri-FinTech should become more profound to be able to keep up with the fast-changing empirical situation. To begin with, the chapter highlights the importance of interdisciplinary research on Agri-FinTech. The phenomenon lies at the crossroads of financial economics, development studies, information technology, agrarian sociology and policy; any discipline-specific scholarship will inevitably result in a partial picture of its dynamics and effects. Researchers have to develop intellectual depth to address theoretical traditions across disciplines and the methodological flexibility to apply quantitative, qualitative and mixed-method techniques when the research question requires. Second, the theoretical frameworks implemented in this chapter TAM and DOI though enlightening are not adequate as independent analytical resources in the Agri-FinTech context. Both models were conceived in environments that were way different than the structural environment of rural Indian agriculture. The following scholarship must strive to indigenise these frameworks, to include context-relevant variables agrarian class relations, caste and gender relations, institutional trust paths, seasonal financial cycles that are not systematically captured in their initial formulations. Establishing a theory of Agri-FinTech adoption in Indian agriculture based on context is a major and addressable research issue.

11. Limitations and Future Research Directions

To be intellectually honest in presenting the contributions of this chapter, it would be necessary to explicitly recognize the limitations of this chapter. These restrictions are both natural to the nature of the inquiry and are methodologically particular and their acknowledgment is aimed at directing rather than limiting future scholarly activity in the field. To begin with, this chapter is an empirical investigation, but it is a synthesis of concepts and a review. It bases its arguments on an interaction with the existing scholarship, policy documents and secondary evidence, as opposed to primary data gathered using fieldwork, surveys or experimental designs. Second, the literature consulted in this chapter, although representative of the existing scholarship, is always vulnerable to publication bias. The Agri-FinTech literature has grown at a very fast pace over the past few years, and a considerable percentage of the published studies indicate high adoption rates, better welfare, sustainability. The literature on failure cases, unintended consequences and negative outcomes is underrepresented systematically in the published literature, which could lead to an overly positive image of the developmental impact of Agri-FinTech. Third, the geographic scope of the chapter as India is suitable, as it is a large country that depends on agriculture and the presence of fintech, but does not allow a direct generalisation of its findings to other contexts of developing countries. The above limitations do not preclude investigation but instead provide a structured agenda upon which further investigation should be conducted. The below areas of study are the most impactful and addressable gaps in terms of academic research in the Agri-FinTech field. The most urgent priority is the empirical measure of the impact of Agri-FinTech on farmer welfare. The second critical research frontier is the gendered aspects of Agri-FinTech. Female farmers and rural female entrepreneurs encounter unique obstacles to the adoption of digital financial services include lower rates of mobile phone access, limited financial independence in patriarchal family arrangements, lower average digital literacy, and underrepresentation as direct beneficiaries of agricultural credit programs. A study that specifically examines gender-differentiated adoption patterns, the effects and platform design needs, is necessary should Agri-FinTech be able to realise its potential of inclusive development. An example of a research frontier with theoretical and practical implications is the integration of Agri-FinTech with new technologies artificial intelligence, satellite remote sensing, Internet of Things agricultural sensors and advanced climate modelling. There is an urgent need to conduct research on the architecture, governance and development impacts of these integrated systems. Lastly, longitudinal study on the viability of Agri-FinTech

adoption tracking to monitor input usage, land management practices, carbon footprint and biodiversity over longer time frames is a research priority whose value will only grow as the need to transform the agricultural system in response to the escalating climate change mounts pressure. Credible empirical connections between digital financial inclusion and environmental sustainability indicators would be a potent argument in support of integrating Agri-FinTech in national and international sustainable development policies.

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