The Academic
International Journal of Multidisciplinary Research

An Online Peer Reviewed / Refereed Journal
Volume 3 | Special Issue 2 |September 2025
ISSN: 2583-973X (Online)
Website: www.theacademic.in

Technology Enabled Crop Insurance the Convergence of Fintech and Agritech

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DOI : https://doi.org/10.5281/zenodo.17370958

ARTICLE DETAILS

Research Paper

Accepted: 02-09-2025

Published: 25-09-2025

Keywords:

Crop insurance, Fintech, Agritech, Risk management & Technology adoption

ABSTRACT

The intersection of financial technologies (fintech) and agricultural technologies (agritech) is revolutionizing crop insurance by increasing accessibility, efficiency, and farmer-focused solutions. Using a qualitative research design based on computational literature analysis, this study investigates the intellectual space of technology-enabled crop insurance. Natural Language Processing methods, namely topic modelling and text clustering, are utilized on an academic text corpus to reveal prevailing themes, theoretical foundations, and research gaps. The review is structured in interrelated thematic clusters across technological innovations, adoption dynamics, regulatory issues, and farmer-oriented outcomes. The prominent themes are digital and data-driven solutions, efficiency and cost-effectiveness, trust and transparency, smallholder inclusion, and agricultural resilience. The study establishes that technology-facilitated crop insurance is a multifaceted change in need of congruence across innovation, access, and risk management frameworks. Managerial implications point to the importance of contextually sensitive design of products and adherence to transparency in managing claims. The research makes contributions to scholarship by showing how computational text analysis can be used to synthesize literature and establish directions for further studies,

including empirical research in adoption behaviour and comparative studies of traditional versus technology-facilitated models. Theoretically, the results affirm the applicability of innovation diffusion, technology acceptance, and institutional theories, calling for their fusion with risk management and resource-based approaches. The research ends on a note citing empirical data, longitudinal research, and state-of-the-art NLP techniques as the keys to developing further the knowledge and practice of technology-enabled crop insurance.

INTRODUCTION

Fintech-agritech convergence in the provision of technology-enabled crop insurance reflects the integration of fintech and agritech, providing innovative channels for managing agricultural risks in an efficient and more inclusive way. This model improves risk management with the integration of digital financial services and sophisticated agricultural technologies, improves access to insurance in a timely fashion, and supports the financial protection of farming households.

The fintech-agritech convergence in providing technology-enabled crop insurance can be placed in several theoretical frameworks. The Diffusion of Innovation Theory offers a framework for interpreting why farmers and stakeholders take up digital insurance platforms, with relative advantage, compatibility, and trialability as key factors influencing adoption behaviour. This is reinforced by the Technology Acceptance Model, where perceived ease of use and perceived usefulness emerge as critical factors that drive user acceptance of fintech-enabled solutions, especially in rural agricultural settings where levels of digital literacy are wide-ranging. Collectively, these theories capture the level of adoption as well as the drivers of user acceptance, providing a multidimensional analysis of the shift from conventional to tech-infused insurance practices.

At an overall institutional and organizational level, the Resource-Based View highlights how fintech and agritech companies use unique technological competencies to develop added-value solutions that conventional insurance arrangements find difficult to imitate. Institutional Theory explains further how policy interventions, social norms, and regulatory schemes influence the design and diffusion of such insurance models, specifically within developing economies that are themselves extremely susceptible to systemic risks in agriculture. Lastly, the Risk Management perspective supplies the theoretical foundation for considering how digital tools improve risk monitoring, identification, and mitigation in

agricultural insurance. Together, these theories present a unified platform to study not only the technology adoption process but also the institutional and strategic aspects underlying the efficiency of technology-based crop insurance.

The recent trends in crop insurance point to the increasing blending of digital finance and ag agritech to offer more efficient, transparent, and farmer-friendly solutions. Cellular-based platforms, satellite information, and blockchain frameworks are becoming more popular to enhance risk assessment and claim settlement, symbolizing a shift towards precision and inclusion in agricultural risk management (Babcock, 2015; Jensen & Barrett, 2017). Notwithstanding the developments, there are some challenges that remain. Farmers in most developing economies encounter some levels of low digital literacy, poor infrastructure, and hesitance towards technology-based financial products (Abraham & Pingali, 2019). In addition, there are challenges in terms of regulatory complexity, privacy of data, and interoperability requirements among fintech and agritech systems (Hess & Hazell, 2020). While technology can lower transaction costs and expand access, the differential pace of adoption across regions creates a formidable challenge to the full potential benefits. These realities highlight the need to anchor innovation in context-related challenges so that technology-supported crop insurance becomes both scalable and inclusive.

Agriculture continues to be extremely susceptible to climate uncertainty, natural calamities, and market volatility, rendering risk management products like crop insurance critical to upholding farmer livelihoods. Conventional insurance programs are then prone to inefficiencies, slow disbursement of claims, high administrative expenses, and restricted outreach, especially among rural and resource-poor areas. While the intersection of agritech and fintech holds out new promises of improving accessibility, transparency, and efficiency in the delivery of crop insurance, there are strong impediments in the areas of adoption, trust, regulatory harmonization, and infrastructural preparedness. These challenges cause a disconnect between the possibility of technology-driven insurance solutions and their practical effectiveness in protecting farmers against risk, hence there is a need for empirical research into the drivers, constraints, and implications of using fintech and agritech in crop insurance systems.

The purview of this research is limited to examining the intersection of fintech and agritech in the realm of technology-enabled crop insurance, with a special emphasis on the way these innovations are being accounted for within current scholarly literature. As the study is qualitative, the analysis will only be confined to the introduction and literature review parts of peer-reviewed research articles, where issue framing, trends, and theoretical premises are most discernible. Through Natural Language Processing (NLP) methodologies, the research seeks to systematically extract themes, patterns, and conceptual

connections from the corpus of literature. The value of this study is in its capacity to yield systematic enlightenment regarding the state of affairs in knowledge, uncover uncharted research frontiers, and guide empirical studies in the future. Additionally, the results will be anticipated to inform academic knowledge and practical debate around how technology-based insurance products can be developed to mitigate the chronic issues the agriculture industry continues to witness.

LITERATURE REVIEW

The convergence of financial technologies (fintech) and agricultural technologies (agritech) had been increasingly seen as instrumental in making crop insurance schemes more accessible and efficient. Fintech innovations, including mobile payment technologies, blockchain, and digital credit scoring, were said to lower transaction costs and enhance claim settlement procedures, thus making insurance more accessible to smallholder farmers (Mhlanga, 2020; Kumar et al., 2021). Digital financial services also supported premium collection and subsidy payment, which optimized insurance business and avoided administrative bottlenecks (KPMG, 2019). Agritech solutions such as remote sensing, satellite imaging, and Internet of Things (IoT)-based monitoring supported better yield estimation and risk estimation, enhancing the credibility of crop insurance products (Jain et al., 2019; Dile et al., 2021). The use of machine learning models on large amounts of data gathered from farm sensors and climate data systems improved efficiency by enabling faster and more transparent claim validation (Baudron et al., 2022). Research also showed that fintech–agritech complementarities, e.g., digital platforms integrating financial access and farm advice services, promoted the adoption of crop insurance by excluded rural communities (Arun & Kamath, 2015; Choudhary & Suri, 2022). Additionally, the integration of satellite-based index insurance models with mobile penetration was emphasized as a key promoter in bridging the protection gap for the climate-exposed smallholder farmers (Greatrex et al., 2015; Jensen et al., 2018). Overall, the literature illustrated that fintech and agritech innovations had not only helped enhance operational effectiveness in the delivery of crop insurance but also enhance the resilience and inclusiveness of agricultural insurance markets.

The uptake of technology-facilitated crop insurance had been held back by a set of barriers and challenges that hindered its capacity to enhance agricultural resilience. One major challenge was low awareness and digital literacy among smallholder farmers, which limited their access to mobile applications and remote-sensing-based insurance products (Marr et al., 2016; Leclerc et al., 2020). Trust gaps in digital insurance programs also emerged, as farmers tended to view them as confusing, secretive, and ill-adapted to the specificities of local agriculture (Patnaik & Das, 2019). Sparse infrastructures,

including poor internet coverage and limited smartphone access, contributed to further digital exclusion, especially in rural and remote areas (Lybbert & Carter, 2015). Basis risk in index-based insurance, high transaction costs, and data quality problems made technology-led models less appealing (Elabed & Carter, 2014; Khalil et al., 2019). Regulatory and institutional impediments, as well as insurance systems in most developing nations, being vague on digital innovations and data-sharing arrangements, resisted large-scale uptake (Carroll et al., 2022). Climate uncertainty and lack of trustworthy weather data also diminished the credibility of index-based insurance products, deterring farmer enrolment (Vroege et al., 2019). Last but not least, socio-economic elements such as poverty, gender inequality, and cultural aversion to digital finance had their role in low adoption despite the presence of technologically sophisticated solutions (Amjath-Babu et al., 2020). Together, the literature showed that technology-enabled crop insurance had huge promise but was being held back by structural, behavioural, and institutional obstacles that had to be overcome in order to cover more people.

The infusion of digital technologies had greatly impacted risk management practices and enhanced farmer resilience to climate and market shocks. Digital platforms allowed farmers to access updated weather forecasts, crop advice, and market intelligence, which enhanced decision-making and minimized exposure to production risks (Klerkx et al., 2019; Addom et al., 2020). Adoption of mobile-based apps and online advisory services increased adaptive capacity through improved resource allocation and crop diversification measures (Babcock, 2015; Rijswijk et al., 2019). Big data analytics and remote sensing permitted more accurate tracking of crop status, which not only enabled insurance programs but also promoted preventive risk reduction measures at the farm level (Antle et al., 2017). Blockchain and digital ledger technologies were utilized to facilitate transparency and traceability across agricultural value chains, thus lowering transaction risk and building trust between stakeholders (Tripoli & Schmidhuber, 2018). Digital financial inclusion, through e-wallets and mobile banking, was also shown to enhance farmers' capacity to respond to financial shocks by increasing access to credit and savings tools (Beaman et al., 2014). In addition, research identified that digital integration promoted collective resilience through linking farmers to virtual networks of knowledge, farmer organizations, and digital markets, enhancing social safety nets and market resilience (Pigford et al., 2018; Sheng et al., 2021). Overall, digital integration was revealed to reshape risk management in agriculture through encouraging adaptive approaches, financial stability, and systemic resilience across farming communities.

OBJECTIVES

1. To investigate the role of fintech and agritech in improving accessibility and efficiency of crop insurance.

2. To discuss the challenges and obstacles impacting the technology-enabled crop insurance adoption.

3. To assess the effect of digital integration on risk management and resilience among farmers.

RESEARCH METHODOLOGY

The research utilizes a qualitative research approach based on computational literature analysis to investigate the intersection of fintech and agritech in the area of technology-enabled crop insurance. The method is designed to pull and scrutinize thematic and conceptual tendencies from academic discourse, specifically as defined in introductory and literature review sections of published scholarship. Through this exclusive use of secondary sources, the research eschews primary data gathering and instead leverages a well-designed corpus of already existing literature as the main dataset for analysis.

The study uses a descriptive and exploratory approach, incorporating Natural Language Processing (NLP) methods for studying academic texts. In contrast to traditional empirical approaches, the research does not involve numerical data or participant inquiry but focuses on the systematic examination of textual content. The goal is to chart intellectual boundaries of the subject by discerning salient themes, theoretical foundations, and knowledge silences in current work, thus developing a systematic knowledge of how technology-facilitated crop insurance has been theorized in academic literature.

The dataset comprises a purposively sampled corpus of scholarly journal articles, book chapters, and expert reports on fintech, agritech, and crop insurance. The development of this corpus was a three-step process. First, core texts were found from reference lists and academic sources that directly engaged with digital finance, agriculture technology, and risk management. Second, the Introduction and Literature Review parts of each of the chosen works were taken out, as these two parts usually express conceptual framing and theoretical orientation of studies. Third, the materials taken out were merged into a single textual corpus, which was then used as the main input for computational analysis. This method guaranteed relevance and consistency of the dataset.

Two NLP techniques, namely complementary to each other, were utilized for corpus analysis: topic modelling and text clustering. Topic modelling in the form of Latent Dirichlet Allocation (LDA) was used to reveal underlying themes in the literature by clustering words that regularly co-occur. The analysis consisted of text preprocessing, tokenization, lemmatization, and iterative training of the LDA

model to produce interpretable topic models. Concurrently, text clustering was employed to cluster documents based on semantic similarity. This step consisted of vectorizing the corpus via term frequency–inverse document frequency (TF-IDF), applying dimensionality reduction to maintain significant structure, and running a clustering algorithm like K-means to segment the texts into thematic groups of coherence. Collectively, these strategies offered both granularity and structure for the intellectual landscape of the field.

Several precautions were employed in order to increase the rigor of analysis. The topic modelling and clustering parameters were iteratively optimized to provide coherent and interpretable results. Subsequently, the computational results in the form of keyword lists and discovered clusters were qualitatively cross-checked with available literature in order to validate whether they were interpretable and if their interpretation was consistent with known scholarly discourse. This machine-based analysis and human explanation triangulation makes the findings more dependable. Methodological transparency was also ensured by explicitly recording every step so that future studies can replicate it.

DISCUSSION

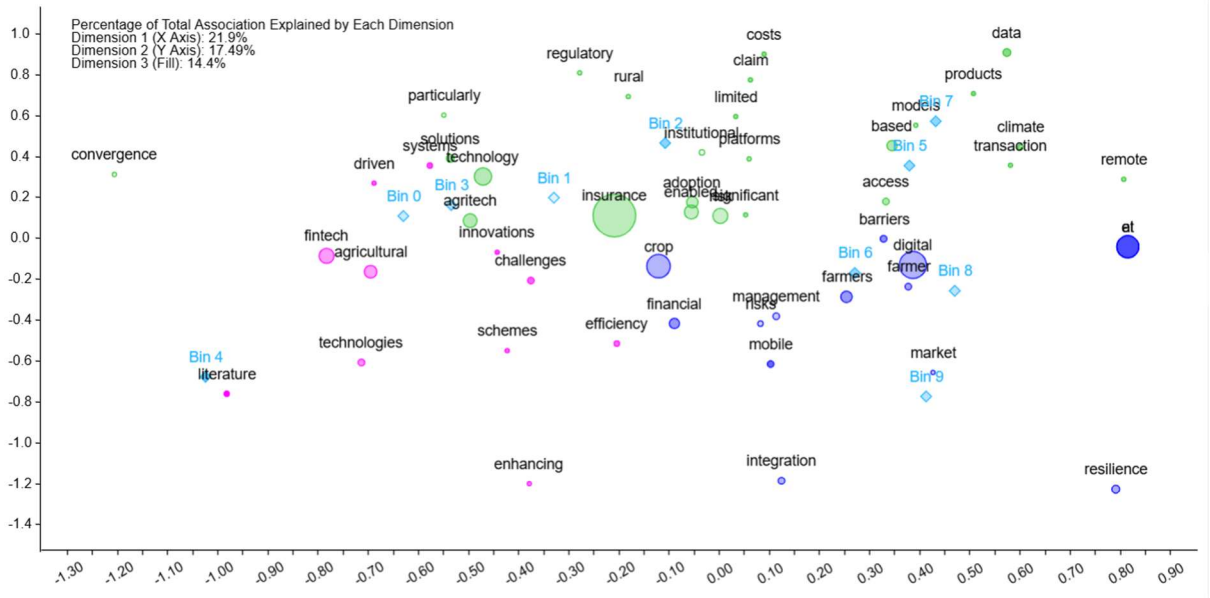
Topic modelling analysis:

The topic modelling of the qualitative data on technology-enabled crop insurance shows a collection of discrete but related thematic clusters that define the discourse in this area. The model captured several themes that cross-cut technological innovations, adoption dynamics, regulatory issues, and farmer-centric benefits. For example, one key theme highlights digital and data-intensive solutions enabled by artificial intelligence, remote sensing, and regulatory frameworks, emphasizing the contribution of advanced analytics to enhancing agricultural risk evaluation. Another cluster is focused on patterns of adoption and climate-related imperatives, mentioning how digital platforms in aggregate enhance agricultural

resilience alongside credit and financial access constraints. These results indicate that the scholarly literature is subject to strong influences by technological innovation and contextual determinants informing their integration into agricultural systems in rural areas.

Another set of themes revolves around efficiency, cost savings, and reliability in agritech solutions, with constant mentions of product examples and empirical analysis of how effective they are. Hand in hand with this is the discussion of institutional and blockchain-driven mechanisms for better claims handling and insurance transparency. In addition, access and inclusion strategies for smallholder farmers topic shows a high research focus on equity, participation, and reduction of structural impediments. Clusters surrounding fintech platforms, market transactions, and administrative procedures reflect an increased academic interest in the financial structures underpinning crop insurance. While at the same time, issues like literature gaps, perceived variability, rural constraints, and data limitations continue to remain, indicating the core issues that continue to influence academic research as well as real-world implementation. These topics taken together serve to strengthen the multi-faceted nature of technology-enabled crop insurance, where fintech and agritech converge and have to be viewed not merely as a technological development but also as a socio-economic and institutional change.

Text clustering analysis:



The text clustering resulted in three separate thematic clusters that capture together the intellectual profile of technology-enabled crop insurance studies. The first cluster revolves around technological and institutional innovations, including terms like digital, agritech, platforms, regulatory, and adoption. The

cluster highlights the contributions of digital systems, regulatory regimes, and institutional frameworks to the adoption and dissemination of technology-enabled crop insurance initiatives. The second cluster identifies farmer-focused and financial aspects, with the key word's farmers, schemes, access, inclusion, barriers, and financial. This cluster documents the discussion on accessibility, equity, and addressing the difficulties of incorporating fintech solutions into rural agriculture settings, specifically in strengthening smallholder resilience and financial inclusion. The third cluster identifies efficiency, risk, and resilience, tying the terms management, mobile, resilience, costs, and risk. This reveals the research focus on efficiency in operations, mobile technology utilization, and the larger purpose of building agricultural resilience through risk management measures. Combined, these clusters show that the literature is informed by a triad of mindsets: technological and institutional enablers, inclusion policies centered on farmers, and efficiency-oriented risk management strategies. The discussion concludes that the intersection of fintech and agritech in crop insurance is not just a technological advancement but a multifaceted change necessitating alignment in innovation, access, and resilience models.

CONCLUSION

We analysed the convergence of fintech and agritech using a qualitative, NLP-informed critique of published research literature in the subject area of technology-facilitated crop insurance. With the application of topic modelling and clustering analysis to a pre-curated corpus of literature reviews and introductions, the study was able to determine thematic clusters for technological and institutional enablers, farmer-inclusive access and inclusion, and efficiency-led risk management. The study highlights that crop insurance through technology is not simply a technical solution but a multifaceted change that involves techno-institutional convergence as well as realignment of socio-economic realities.

1. Managerial Implications

For policymakers and practitioners alike, the findings underscore the importance of crafting insurance products that are technologically advanced and contextually accessible. FinTech and agritech company managers can apply knowledge about obstacles like digital literacy, infrastructural deficiencies, and trust deficits to develop solutions adapted to smallholder farmers' needs. Additionally, the grouping of themes around resilience and efficiency indicates that managers ought to emphasize cost-effectiveness and transparency in managing claims, thus fostering trust and uptake by farmers.

2. Research Implications

The research adds to scholarly research through the articulation of how the literature conceptualizes technology-enabled crop insurance and the mapping of unexplored areas. The dependency upon computational text analysis proves the utility of NLP methods in combining high amounts of literature, providing a replicable framework for future reviews across interdisciplinary disciplines. The outcomes also suggest more empirical studies on farmer adoption behaviour, policy support's influence, and cross-country assessments, thus laying new foundations for systematic research.

3. Theoretical Implications

Theoretically, the analysis reiterates the applicability of theories like the Diffusion of Innovation Theory, Technology Acceptance Model, and Institutional Theory to explaining digital crop insurance adoption and institutionalization. The findings imply that these theories need to be further complemented by risk management and resource-based views to explain both the behavioural and structural processes involved. This theoretic cross-pollination promotes a more comprehensive conceptual basis to research at the crossroads of fintech, agritech, and insurance.

4. Future Directions

Subsequent research needs to transcend descriptive and conceptual investigations and seek out empirical data drawn from various geographical and socio-economic situations. Longitudinal research can offer insights into the course of farmer take-up of technology-backed insurance over time, especially in the face of climate change and policy changes. In addition, comparative studies between conventional and technology-based models might provide data on cost-effectiveness, inclusion, and resilience impacts. Lastly, combining advanced NLP and machine learning techniques with empirical field research may provide more nuanced insights into the dynamic discourse and practice of digital crop insurance.

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