Vol. 7, No. 1, 2026, pp. 2055-2066
DOI: https://doi.org/10.29210/993960

Contents lists available at Elora Center

Lentera Negeri

Journal homepage: https://lentera.eloracenter.org/lentera



Integration of information technology in agricultural extension to enhance innovation and farmers' income in agribusiness

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Article Info

Article history:
Received Aug 28th, 2026
Revised Sep 19th, 2026
Accepted Oct 12th, 2026

Keyword:
Information technology,
Agricultural extension,
Farmers' income

ABSTRACT

Information technology has increasingly transformed agricultural extension by expanding farmers' access to timely knowledge, innovation, and market information. This study aims to examine the integration of information technology in agricultural extension and its contribution to agricultural innovation and farmers' income in agribusiness. This study employs a library research approach using relevant primary and secondary literature obtained from books, peer-reviewed journals, scientific articles, research reports, and other academic sources. Data were collected through literature review and analyzed using content analysis to identify patterns, relationships, and significant findings related to information technology, agricultural extension, innovation adoption, and farmers' income. The findings indicate that digital technologies can improve information accessibility, strengthen technology acceptance, facilitate innovation adoption, and support better production and marketing decisions. The study concludes that information technology can strengthen agricultural extension and contribute to improved farmers' economic outcomes when supported by digital literacy, adequate infrastructure, relevant information, and institutional support.

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Introduction

Agribusiness plays a strategic role in supporting rural economic development, food security, and farmers' livelihoods; however, many farmers continue to face limitations in accessing timely, relevant, and actionable agricultural information. Conventional agricultural extension services are often constrained by geographical distance, limited extension personnel, restricted communication channels, and differences in farmers' access to knowledge and technology. These conditions can hinder farmers from obtaining information about improved production techniques, market opportunities, digital technologies, and agribusiness management practices. As a result, the ability of farmers to adopt agricultural innovations and improve the economic value of their farming activities remains uneven. The rapid development of information technology provides an opportunity to address these challenges by enabling agricultural extension services to deliver information more efficiently through digital platforms, mobile applications, social media, online communication, and other information-based technologies. Therefore, the integration of information technology into agricultural

extension has become increasingly important for strengthening farmers' access to knowledge, encouraging innovation adoption, and potentially increasing farmers' income within the agribusiness sector(Hakim & Ardiansyah, n.d.).

Previous studies have established that agricultural extension contributes to farmers' knowledge, skills, technology adoption, and productivity. Agricultural extension theories generally emphasize the role of communication, knowledge transfer, learning, and interaction between extension agents and farmers in facilitating agricultural innovation. However, conventional extension approaches tend to assume relatively stable communication environments and face-to-face interactions, making them less capable of fully addressing the demands of increasingly digital agricultural systems. Existing literature also indicates that access to information can influence farmers' decision-making, innovation adoption, market participation, and economic performance, but the relationship between information technology integration in agricultural extension and farmers' income remains insufficiently explained. In particular, the literature has not adequately clarified how digital extension mechanisms can transform access to agricultural information into practical innovation and, subsequently, improved economic outcomes for farmers. This indicates a theoretical and empirical gap concerning the integration of information technology as a mechanism that connects agricultural extension, innovation, and farmers' income in agribusiness(Kusumawati et al., 2025).

This study aims to analyze the integration of information technology in agricultural extension and examine its role in enhancing agricultural innovation and farmers' income in the agribusiness sector. Specifically, the study seeks to examine how the utilization of information technology can strengthen the delivery and accessibility of agricultural extension information, facilitate farmers' adoption of innovations, and contribute to improved economic outcomes. By examining these relationships, the study intends to provide a more comprehensive understanding of the role of digital technology in transforming agricultural extension from a predominantly conventional information-delivery mechanism into a more accessible, responsive, and innovation-oriented system. The findings are expected to contribute to the development of agricultural extension strategies that utilize information technology to support farmers' productive and economic capacities(Rosyalita et al., 2026).

The importance of this research is grounded in the increasing need to align agricultural extension services with technological developments and the changing information needs of farmers. If information technology is effectively integrated into agricultural extension, farmers can potentially obtain agricultural knowledge more quickly, access broader sources of information, identify relevant innovations, and make more informed production and agribusiness decisions(Gunistiyo et al., 2025). These improvements may strengthen the adoption of innovation and create opportunities for increasing productivity, market access, and farmers' income. Accordingly, this study argues that information technology integration should not merely be viewed as a communication tool but as a strategic component of agricultural extension that can strengthen the pathway from knowledge access to innovation and economic improvement. Based on this argument, the study hypothesizes that the effective integration of information technology into agricultural extension positively contributes to agricultural innovation and, ultimately, to increased farmers' income in agribusiness(Salesman et al., 2021).

Method

Research Object. The object of this study is the phenomenon of information technology integration in agricultural extension and its potential contribution to agricultural innovation and farmers' income in agribusiness. The study focuses on the problems arising from the transformation of conventional agricultural extension into technology-supported extension services, particularly regarding farmers' access to agricultural information, adoption of innovation, utilization of digital technologies, and improvement of economic outcomes. This phenomenon is examined because information and communication technologies have increasingly become part of agricultural extension systems, while barriers related to individual capabilities, technological infrastructure, institutional support, and the usefulness of digital technologies may influence their acceptance and utilization by farmers. Previous research in Indonesia, for example, has demonstrated that individual, cultural, policy, support, and technological barriers can affect ICT acceptance in agricultural extension. Thus, the research object encompasses the relationship between information technology integration, agricultural extension, innovation adoption, and farmers' income within the broader agribusiness context(Li et al., 2022).

Research Type and Data Sources. This study employs a library research approach, in which data and information are obtained through a systematic examination of books, scholarly literature, scientific articles, research reports, and other relevant written sources rather than through primary field surveys or interviews. The primary data consist of relevant literature discussing information technology integration in agricultural extension, digital agricultural extension, agricultural innovation, technology adoption, and farmers' economic outcomes. Meanwhile, secondary data consist of supporting literature concerning the broader concepts and keywords underlying the study, including information technology, agricultural extension, digital agriculture, innovation adoption, agribusiness, and farmers' income. The literature is obtained from books, peer-reviewed journal articles, scientific research reports, and other academically relevant publications(Zhang & Fan, 2023). This literature-based approach is appropriate because existing research has identified agricultural extension, technology access, education, credit, and organizational participation as important factors associated with agricultural technology adoption. In addition, recent literature demonstrates the growing importance of digital technologies and technology acceptance in agricultural contexts, providing a substantial body of knowledge for synthesizing the phenomenon examined in this study.

Theoretical Foundation. The theoretical foundation of this study consists primarily of Diffusion of Innovations Theory, developed by Everett M. Rogers, particularly the formulation presented in 2003, and the Technology Acceptance Model (TAM) developed by Fred D. Davis in 1989. Diffusion of Innovations Theory explains how an innovation is communicated through particular channels over time among members of a social system and emphasizes perceived innovation attributes, communication processes, and stages of adoption as important elements influencing the diffusion of new practices. In the context of agriculture, the theory provides a basis for understanding how farmers receive, evaluate, adopt, and utilize technological innovations through extension and communication processes. Meanwhile, TAM explains technology acceptance primarily through users' perceived usefulness and perceived ease of use, which influence attitudes, behavioral intentions, and technology use. These theoretical perspectives are complementary in this study: Diffusion of Innovations Theory explains the broader process through which agricultural innovations spread among farmers, whereas TAM explains the factors underlying farmers' acceptance and use of information technology. The combination of these theories therefore provides a theoretical basis for examining how technology-enabled agricultural extension can facilitate innovation adoption and potentially contribute to improved farmers' economic outcomes(Dzanku et al., 2022).

Data Collection Process. The data collection process was conducted through the identification, selection, reading, comparison, and documentation of relevant written sources. The researchers first identified literature corresponding to the main research concepts, including information technology, information and communication technology, agricultural extension, digital agricultural extension, agricultural innovation, technology adoption, agribusiness, and farmers' income. The selected sources were subsequently examined through intensive reading to identify arguments, theoretical explanations, empirical findings, and conceptual relationships relevant to the research problem. The sources included books, previous research, academic papers, journal articles, scientific reports, and relevant magazines or other credible written publications. The literature was then organized according to its relevance to the research focus, particularly evidence concerning the role of information technology in improving agricultural information dissemination, facilitating farmers' adoption of innovation, strengthening decision-making, and supporting agribusiness performance. This process enables the study to synthesize findings from different sources rather than relying on a single study or perspective. Recent literature on digital agricultural extension similarly demonstrates the relevance of ICT-based advisory services, mobile technologies, digital communication, and farmers' technology adoption to the transformation of agricultural extension systems(Lecoutere et al., 2023).

Data Analysis Technique. The collected literature was analyzed using **content analysis**, which involves systematically examining and interpreting the contents of selected sources to identify important information, recurring patterns, conceptual relationships, and relevant arguments. The analysis was conducted through several interconnected stages: organizing the collected literature, identifying information relevant to the research questions, classifying findings according to the main concepts, comparing arguments and findings across sources, identifying relationships between information technology, agricultural extension, innovation, and farmers' income, and synthesizing the results into an integrated interpretation. Particular attention was given to recurring themes concerning technology accessibility, perceived usefulness, ease of use, agricultural knowledge dissemination, innovation adoption, digital extension, and economic benefits for farmers. The identified themes were subsequently interpreted using Diffusion of Innovations Theory and TAM to explain how information technology can function not merely as a communication medium but as an enabling mechanism for innovation adoption and improved agribusiness outcomes. This analytical process allows the

study to move beyond a descriptive summary of the literature toward a conceptual synthesis of the mechanisms linking information technology integration, agricultural extension, innovation, and farmers' income. Recent evidence also indicates that technology acceptance among farmers is influenced not only by perceived usefulness and ease of use but also by facilitating conditions and social influence, reinforcing the importance of interpreting technology integration within its broader agricultural context(Bandiera et al., 2023).

Results and Discussions

Information Technology Integration in Agricultural Extension

The literature analysis indicates that information technology has increasingly transformed agricultural extension from a predominantly conventional communication system into a more flexible and digitally mediated information service. Conventional agricultural extension generally depends on face-to-face meetings between extension officers and farmers, whereas technology-supported extension enables agricultural information to be delivered through mobile phones, websites, social media, online platforms, digital applications, videos, and other information and communication technologies. A review of ICT and agricultural extension in developing countries shows that ICT-enabled extension has created new opportunities for expanding the reach of agricultural advisory services, although its effectiveness varies across contexts and intervention models(Ayisi Nyarko & Kozári, 2021).

The integration of information technology does not merely involve replacing face-to-face communication with digital communication. Rather, it changes the way agricultural knowledge is produced, distributed, accessed, interpreted, and shared(Norton & Alwang, 2020). Recent literature shows that ICT development has contributed to a shift from linear, one-way dissemination toward co-innovation and farmer-to-farmer learning. Smartphones and mobile internet can therefore increase the possibility of farmers interacting with extension agents, experts, other farmers, markets, and information providers beyond the physical boundaries of conventional extension systems.

The literature further demonstrates that digital agricultural services can be categorized into several major functions, including digital advisory and extension, digital financial services, digital farm tools, and digital market linkages. Among these categories, digital advisory and extension constitute a substantial proportion of the existing literature, indicating that information technology is particularly important in strengthening farmers' access to agricultural knowledge and decision-support services.

Table 1. Forms of Information Technology Integration in Agricultural Extension

Technology/Platform	Main Extension Function	Potential Benefit for Farmers
Mobile phones	Direct communication, advisory services, alerts	Faster access to agricultural information
Mobile applications	Digital advisory, farm management, information services	Personalized and accessible information
Social media	Knowledge sharing and farmer interaction	Wider information networks
Websites/online platforms	Agricultural information repositories	Continuous access to knowledge
Video-based extension	Demonstration of farming practices	Easier understanding of technical practices
Internet-based communication	Interaction between farmers and extension agents	Faster feedback and consultation
IoT and digital sensors	Real-time agricultural monitoring	More accurate production decisions
Digital market platforms	Market information and transactions	Improved market access and price information

The findings in Table 1 indicate that the integration of information technology provides multiple channels through which extension services can respond to farmers' information needs. Consequently, digital agricultural extension should not be understood as a single technological intervention but as a multidimensional system that combines communication, information access, learning, decision support, and market connectivity.

This finding is consistent with the systematic scoping review of digital agriculture services, which found that digital advisory and extension services represent a major area of digital agricultural intervention. The literature reports outcomes particularly related to changes in farming practices, increased knowledge, and, in some cases, increased income(Ortiz-Crespo et al., 2020).

Information Technology and Farmers' Access to Agricultural Knowledge

The second major finding concerns the role of information technology in expanding farmers' access to agricultural knowledge(Agussabti et al., 2022). Agricultural extension fundamentally functions as an information and learning mechanism through which farmers obtain knowledge concerning production techniques, input utilization, pest and disease management, climate conditions, markets, and agricultural business management. The integration of digital technology expands the spatial and temporal reach of this function because information can be accessed without requiring farmers and extension officers to be physically present at the same location.

Digital communication also enables farmers to obtain information more rapidly. For example, mobile-based services can provide weather information, market prices, technical recommendations, and production advice at relatively low communication costs. Digital video can further support learning by presenting agricultural practices visually, which can be particularly useful for explaining technical procedures that may be difficult to understand through textual explanations alone(Nayal et al., 2022).

The literature therefore suggests that information technology can strengthen the information function of agricultural extension through three principal mechanisms: accessibility, timeliness, and diversity of information. Farmers are able to access information more frequently, obtain information closer to the time of decision-making, and compare information from multiple sources.

Table 2. Contribution of Information Technology to Agricultural Knowledge Access

Dimension	Conventional Extension	Technology-Integrated Extension	Expected Effect
Information access	Periodic and location-dependent	More continuous and remote	Increased accessibility
Communication	Primarily face-to-face	Face-to-face + digital	Greater communication frequency
Information speed	Relatively slow	Real-time/rapid	Faster decision-making
Information sources	Mainly extension officers	Multiple digital sources	Greater information diversity
Learning materials	Printed/verbal	Text, image, audio, video	Improved learning flexibility
Feedback	Often periodic	Potentially immediate	Faster problem-solving
Market information	Limited or delayed	Digital market information	Better marketing decisions

These findings indicate that information technology strengthens agricultural extension by changing information from a relatively scarce resource into a more continuously accessible resource. However, accessibility alone does not automatically produce behavioral or economic change. Farmers must be able to understand, evaluate, trust, and apply the information received. Therefore, digital agricultural extension needs to be combined with appropriate human support and contextualized information.

This finding is particularly important because previous research cautions that not all ICT-enabled extension interventions produce the same outcomes. The effectiveness of digital extension depends on intervention design, farmers' characteristics, communication mechanisms, institutional support, and the broader agricultural context(Klerkx, 2020).

Information Technology and Agricultural Innovation Adoption

The literature synthesis demonstrates that information technology can function as an important mechanism for accelerating the diffusion and adoption of agricultural innovation. Innovation adoption requires farmers to become aware of an innovation, understand its characteristics, evaluate its relevance, develop an intention to use it, and eventually implement it in agricultural activities. Information technology can support these stages by providing information, demonstrations, peer experiences, expert recommendations, and opportunities for interaction(Klerkx & Rose, 2020).

This finding can be explained through Diffusion of Innovations Theory. Rogers' framework emphasizes that innovation diffusion occurs through communication channels over time within a social system. In the context of agricultural extension, digital platforms can expand the communication channels through which farmers encounter and evaluate innovations. Farmers can observe how a particular technology is used, access information about its advantages and disadvantages, communicate with other users, and receive recommendations from extension personnel(Khan et al., 2020).

Recent literature provides empirical support for this relationship. A systematic review of extension approaches found that digital-based approaches had a relatively high level of farmer innovativeness, with a mean technology innovativeness score of 7.57, compared with 5.00 for traditional extension approaches in the reviewed evidence. The same review also reported that digital approaches achieved the highest mean score for knowledge acquisition, at 7.57.

Table 3. Comparison of Extension Approaches and Farmers' Innovativeness

Extension Approach	Mean Innovativeness Score	Mean Knowledge Acquisition Score	General Interpretation
Digital-based approaches	7.57	7.57	High potential for innovation and knowledge acquisition
Integrated approaches	6.33	7.17	Strong knowledge and innovation support
Participatory approaches	6.33	6.75	Strong farmer engagement
Multi-stakeholder approaches	6.17	6.00	Supports collaborative learning
Traditional extension	5.00	5.00	Relatively lower innovation and knowledge outcomes

Source: synthesized from the reviewed literature.

The findings suggest that digital technology can strengthen the diffusion process because it provides repeated exposure to innovation and facilitates interaction among farmers, extension officers, researchers, and other agricultural actors. Digital platforms can also reduce the information barriers that often delay innovation adoption(Choruma et al., 2024).

However, digital extension should not be interpreted as a complete replacement for conventional extension. Some agricultural innovations require physical demonstration, practical training, access to inputs, financial resources, and continuous technical assistance. Consequently, an integrated extension model combining digital technologies with face-to-face and participatory approaches may provide a more comprehensive mechanism for supporting innovation adoption(Mungai et al., 2024).

Technology Acceptance as a Determinant of Digital Extension Utilization

The findings further demonstrate that the availability of information technology does not automatically result in its utilization by farmers. Farmers must first perceive the technology as useful, understandable, accessible, and compatible with their agricultural activities. This finding is consistent with the Technology Acceptance Model (TAM) developed by Davis, which identifies perceived usefulness and perceived ease of use as fundamental determinants of technology acceptance.

In agricultural extension, perceived usefulness refers to farmers' perceptions that a digital platform can help them improve farming decisions, productivity, access to information, market opportunities, or business performance. Perceived ease of use refers to the extent to which farmers believe that the technology can be used without excessive difficulty.

Table 4. Technology Acceptance Dimensions in Digital Agricultural Extension

TAM Dimension	Application in Agricultural Extension	Expected Outcome
Perceived usefulness	Technology provides useful farming and market information	Higher intention to use
Perceived ease of use	Technology is simple to understand and operate	Greater adoption
Attitude toward use	Farmers develop positive perceptions toward digital extension	Continued utilization

TAM Dimension	Application in Agricultural Extension	Expected Outcome
Behavioral intention	Farmers intend to continue using digital services	Higher probability of actual use
Actual use	Farmers regularly use digital extension services	Greater access to agricultural knowledge

The implication is that agricultural extension digitalization should prioritize usability rather than technology sophistication alone. A highly sophisticated digital platform may have limited impact if farmers cannot operate it, do not understand the information, lack internet connectivity, or perceive that the information does not address their actual agricultural needs(Yuan et al., 2025).

This finding also explains why digital literacy, rural connectivity, institutional support, and the role of extension officers remain important(Oyinbo et al., 2021). Recent literature on agricultural extension transformation identifies inadequate rural internet infrastructure, farmer resistance or neutral attitudes toward digital adoption, and limited institutional integration as continuing challenges to digital agricultural extension.

Information Technology, Innovation, and Farmers' Income(Gouroubera et al., 2025)

One of the most important findings of this study is that information technology can contribute to farmers' income through an indirect pathway rather than necessarily generating income immediately. The pathway identified from the literature can be conceptualized as:

Information Technology → Agricultural Extension → Knowledge Access → Innovation Adoption → Improved Farm Decisions/Productivity/Market Access → Farmers' Income.

This pathway indicates that technology functions as an enabling mechanism. Information technology facilitates access to knowledge, agricultural extension translates information into applicable recommendations, farmers adopt relevant innovations, and the resulting changes in production or marketing practices can contribute to improved economic outcomes.

The strongest quantitative evidence identified in the literature comes from a 2025 meta-analysis of digital information interventions. Across 20 studies, digital information interventions were associated on average with a 23% increase in fertilizer adoption, a 6% increase in yield, and a 6% increase in farmer income. The authors also emphasized substantial variation among individual studies, meaning that the magnitude of benefits depends on intervention characteristics and context(Gouroubera et al., 2023).

Table 5. Mechanism Linking Digital Extension to Farmers' Income

Stage	Mechanism	Expected Result
Technology access	Farmers access digital information	Expanded information availability
Extension interaction	Digital communication with extension agents/experts	Better understanding of recommendations
Knowledge acquisition	Farmers learn new techniques and opportunities	Improved knowledge
Innovation adoption	Farmers implement relevant innovations	Improved production practices
Productivity/efficiency	Better inputs, techniques, and decisions	Increased productivity or reduced costs
Market access	Access to prices, buyers, and market information	Improved marketing decisions
Income improvement	Higher productivity, better prices, or lower costs	Increased farm income

The relationship between agricultural extension and farmers' income is also supported by evidence from Indonesia. A study of smallholder farmers in Banten found positive and statistically significant effects of access to agricultural extension on technology adoption and agricultural income. The study also identified mobile phone access among factors associated with extension access(Khwidzhilli et al., 2025).

Therefore, information technology should be viewed not simply as a communication instrument but as part of a broader agricultural innovation ecosystem. When farmers receive timely information and are capable of converting that information into productive and market-oriented decisions, digital extension can potentially generate economic value(Gunapala et al., 2022).

Integrated Model of Information Technology, Innovation, and Farmers' Income

Based on the synthesis of the literature, this study identifies three interconnected dimensions: information technology integration, agricultural innovation, and farmers' economic outcomes. Information technology represents the enabling infrastructure and communication mechanism; agricultural extension represents the institutional and knowledge-transfer mechanism; innovation represents the behavioral and productive outcome; and farmers' income represents the economic outcome(Martens & Zscheischler, 2022).

Table 6. Integrated Conceptual Findings

Main Variable	Core Dimension	Role in the Relationship
Information Technology	Accessibility, usability, connectivity, digital platforms	Enables information dissemination
Agricultural Extension	Advisory services, communication, education, facilitation	Converts information into applicable knowledge
Technology Acceptance	Usefulness, ease of use, intention to use	Determines technology utilization
Agricultural Innovation	Adoption, experimentation, continuous improvement	Converts knowledge into practice
Productivity	Efficiency, production quality, resource utilization	Intermediate economic outcome
Market Access	Price information, buyers, digital transactions	Strengthens commercialization
Farmers' Income	Revenue, profit, economic welfare	Final economic outcome

The integrated findings suggest that the relationship is neither linear nor automatic. Information technology creates opportunities, but agricultural extension determines how those opportunities are translated into knowledge and action. Farmers' technology acceptance determines whether digital services are actually utilized, while the characteristics of the innovation determine whether farmers are willing and able to adopt it. Finally, the economic impact depends on whether innovation adoption improves productivity, reduces costs, increases product quality, or strengthens access to profitable markets(Quandt et al., 2020).

This interpretation is consistent with the broader literature, which emphasizes multiple pathways through which ICT-enabled extension can affect farmers' behavior and economic outcomes. These pathways include changes in preferences and behavior, social interactions, information access, and the incentives faced by extension workers and other agricultural actors(Okello et al., 2023).

Theoretical Implications

From a theoretical perspective, the findings strengthen the relevance of Diffusion of Innovations Theory in explaining digital agricultural extension. The theory helps explain why information technology can accelerate farmers' exposure to agricultural innovations and facilitate communication within agricultural communities. Digital platforms expand communication channels and enable farmers to observe, evaluate, discuss, and adopt innovations(Lee et al., 2023).

At the same time, Technology Acceptance Model complements the diffusion perspective by explaining why farmers may accept or reject particular technologies. The usefulness and ease of use of digital agricultural services influence whether farmers are willing to integrate them into their daily agricultural activities.

The combination of the two theories therefore produces a stronger analytical explanation : Diffusion of Innovations Theory explains how agricultural innovations spread, while TAM explains why farmers accept and use the technologies that facilitate that diffusion(Masanja et al., 2023).

Table 7. Theoretical Integration

Theory	Main Concept	Application in This Study
Diffusion of Innovations Theory	Innovation diffusion and adoption	Explains how digital extension facilitates agricultural innovation
Technology Acceptance Model	Perceived usefulness and perceived ease of use	Explains farmers' acceptance of digital extension technologies
Agricultural Extension Perspective	Knowledge transfer and farmer empowerment	Explains the intermediary role of extension

Theory	Main Concept	Application in This Study
Agribusiness Perspective	Productivity, market access, and commercialization	Explains potential pathways toward higher income

This theoretical integration indicates that digital agricultural transformation should be understood as a socio-technical process, rather than merely a technological process. Technology must be embedded within an extension system capable of providing relevant information, supporting learning, encouraging experimentation, and facilitating connections with markets(Nyagango et al., 2023).

Practical Implications for Agribusiness

The findings have several practical implications for agricultural extension and agribusiness development. First, agricultural extension institutions should develop digital services based on farmers' actual information needs rather than merely introducing new technologies. Second, extension officers should be positioned not only as information distributors but also as digital facilitators and innovation catalysts. Third, digital extension should integrate production information with market information so that farmers can make decisions based not only on how to produce but also on what to produce, when to sell, and where to access profitable markets(Sahu et al., 2024).

Fourth, digital literacy should become an important component of agricultural extension programs. Farmers who have access to smartphones or internet connectivity may still fail to benefit if they cannot identify reliable information, interpret digital content, or use digital platforms effectively. Fifth, digital extension needs institutional support, adequate rural infrastructure, and continuous evaluation.

Table 8. Strategic Recommendations

Problem	Recommended Strategy	Expected Impact
Limited access to information	Expand mobile and online extension services	Wider information coverage
Low digital literacy	Conduct digital literacy training	Increased technology utilization
Limited internet connectivity	Strengthen rural digital infrastructure	Greater accessibility
Low innovation adoption	Use demonstration videos and digital learning	Increased innovation adoption
Weak market information	Integrate digital market platforms	Better marketing decisions
Limited interaction	Establish two-way digital communication	Faster problem-solving
Fragmented information	Develop integrated agricultural information systems	Better decision-making
Limited institutional support	Strengthen collaboration among government, extension, researchers, and private sector	Sustainable digital extension

Synthesis of Results

Overall, the literature analysis demonstrates that information technology has substantial potential to strengthen agricultural extension, facilitate innovation adoption, and contribute to farmers' income. However, the relationship should be understood as a mediated and context-dependent process rather than a direct technological effect.

The evidence indicates that digital interventions can improve farmers' access to information and knowledge, facilitate innovation adoption, and generate measurable improvements in agricultural outcomes. The 2025 meta-analysis provides particularly important evidence that digital information interventions have positive average effects on input adoption, yield, and farmer income, although substantial variation exists across interventions and contexts.

The findings also demonstrate that technology integration is most effective when digital services are combined with appropriate agricultural extension functions. Digital technology provides the channel, extension provides the knowledge and facilitation, farmers provide the adoption and implementation process, and agribusiness markets provide the economic mechanism through which improved agricultural practices can translate into income.

Table 9. Summary of Research Findings

Research Focus	Main Finding	Supporting Theoretical Perspective
IT integration	Digital technologies expand extension reach and accessibility	Agricultural Extension
Knowledge access	Digital platforms increase access to timely and diverse information	Agricultural Extension
Technology acceptance	Usefulness and ease of use influence digital technology utilization	TAM
Innovation adoption	Digital extension can facilitate exposure, learning, and adoption of innovation	Diffusion of Innovations
Productivity	Better information and innovation can improve production decisions	Diffusion of Innovations
Market access	Digital information can improve access to prices and markets	Agribusiness Perspective
Farmers' income	Digital information interventions show positive average income effects	Integrated framework
Sustainability	Digital extension requires infrastructure, literacy, institutional support, and inclusive design	Socio-technical perspective

Conclusions

This study concludes that the integration of information technology into agricultural extension provides an important mechanism for improving farmers' access to agricultural knowledge, strengthening innovation adoption, and supporting agribusiness development. Based on the literature synthesis, digital platforms, mobile technologies, online communication, and other information technologies can make extension services more accessible, timely, interactive, and responsive to farmers' needs. The findings further indicate that information technology contributes to farmers' income primarily through an indirect process involving knowledge acquisition, technology acceptance, innovation adoption, improved production decisions, productivity, and market access. Thus, technology functions not merely as a communication tool but as an enabling component of an integrated agricultural extension system. However, the effectiveness of information technology integration depends on several supporting conditions, including farmers' digital literacy, perceived usefulness and ease of use, internet and technological infrastructure, quality of agricultural information, and institutional support. Therefore, digital agricultural extension should not completely replace conventional extension but should be developed through a hybrid model that combines digital technologies with face-to-face interaction, participatory learning, practical demonstrations, and continuous assistance. Future agricultural policies and extension programs should prioritize inclusive and farmer-centered digital systems that connect knowledge, innovation, production, and markets. Such an integrated approach can strengthen the capacity of farmers to adopt relevant innovations and create greater opportunities for sustainable productivity improvement and increased income in agribusiness.

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