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Role of Information and Communication Technologies (ICTs) in Agricultural Extension

Subhajit Chakraborty

Research scholar, Uttar Banga Krishi Vishwavidyalaya Cooch Behar, West Bengal

Corresponding author email ID: subhaextension@gmail.com

A B S T R A C T

Information and Communication Technologies (ICTs) have emerged as transformative tools in agricultural extension by enhancing the efficiency, reach and effectiveness of knowledge dissemination to farming communities. This article examines the role of ICTs in modernizing agricultural extension systems, with particular emphasis on the tools and platforms used, their impact on farmers' knowledge and adoption behavior and the challenges limiting their effectiveness. ICT tools such as radio, television, mobile phones, internet-based platforms, social media, decision support systems and digital advisory services complement conventional extension approaches and address long-standing constraints related to manpower shortages, geographical isolation and information delays. ICT-based extension significantly improves farmers' access to timely and reliable information, enhances awareness and adoption of improved agricultural practices, increases productivity and income and supports risk management and sustainable farming. A part from the uses of ICT, it also faces critical challenges, including the digital divide, low digital literacy, inadequate infrastructure, content relevance issues and institutional and governance constraints, which limit equitable access and impact. Overall, the importance of ICT-enabled extension is a key component of future strategies for sustainable agricultural development and improved farmer livelihoods.

Keywords: Agricultural Extension, Digital Agriculture, Farmer Advisory Services, Technology Adoption, Sustainable Agriculture

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1. INTRODUCTION

In order to reduce the gap between agricultural research and farmers' fields, agricultural extension has always been essential. In the past, printed materials, field demonstrations and in-person contacts were the main ways that extension disseminated knowledge (Prajapati et al., 2025). Although these techniques have greatly aided in the advancement of agriculture, they are frequently hampered by a lack of labor, high expenses, geographical obstacles and delays. The fast development of information and communication technologies (ICTs) in recent decades has revolutionized the creation, exchange and use of agricultural knowledge. ICTs have become effective instruments for bolstering agricultural extension systems globally, ranging from radio, television and mobile phones to the internet, social media, decision-support systems and digital advisory platforms (Khan et al., 2024). Faster, more accurate and farmer-centric information transmission channels are required due to the increasing complexity of agriculture, which is fueled by climate change, market volatility, environmental concerns and the need for sustainable intensification. ICT-enabled extension has the potential to improve farm-level decision-making by giving farmers real-time, location-specific and need-based advice (Badavath et al., 2024; Pradhan et al., 2025). ICTs

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can serve as force multipliers by extending the reach of extension beyond institutional and physical barriers in developing nations like India, where a significant number of farmers are smallholders with limited access to official extension services. Governments, academic institutions, commercial companies and non-governmental organizations have all contributed more money to digital agricultural projects over time. Information on crop production, pest and disease management, weather forecasts, input availability and market prices is now frequently shared through mobile-based advisory services, interactive voice response systems, e-extension portals, community radio, social media groups and smartphone applications (Burman et al., 2022). In addition to improving information availability, these technologies facilitate two-way contact, allowing farmers to ask questions, exchange experiences and give extension organizations feedback.

2. CHALLENGES FACED BY YOUTH IN AGRICULTURE

Agricultural extension presently uses a variety of ICT platforms and technologies to help farmers make decisions and spread information. Radio and television are examples of traditional mass media that still have a significant impact, particularly in rural regions with poor internet access. A wide audience may obtain timely information on government initiatives, weather alerts and better practices in local languages through farm radio programs, community radio stations and agricultural television channels. In extension, mobile phones have become one of the most important ICT tools. Crop warnings, pest alarms and weather-based suggestions are frequently sent via voice messages, Interactive Voice Response (IVR) systems and Short Message Service (SMS) (Rohit et al., 2024). Mobile apps, which include interactive features, tailored alerts and multimedia material, have become more and more popular as smartphones become more widely used (Prusty et al., 2021; Prusty & Panigrahi et al., 2020). Access to verified agricultural information is further improved by digital platforms such as knowledge management systems, farmer helplines and e-extension portals (Vardhan et al., 2021). Extension services now have a new dimension because to the internet and social media. Peer-to-peer learning, farmer-to-expert connections and the quick spread of ideas are all made possible by platforms such as Facebook, Telegram, YouTube and WhatsApp. In order to give location-specific and data-driven alerts, extension programs are increasingly using decision support systems, geographic information systems (GIS) and remote sensing technologies (Devi et al., 2025). When combined, these ICT technologies form a diverse extension ecosystem that enhances the efficacy and efficiency of agricultural information transfer while complementing conventional methods.

3. IMPACT OF ICTS ON FARMERS' KNOWLEDGE, ADOPTION AND PRODUCTIVITY

ICT-based agricultural extension improves farmers' knowledge, attitudes and adoption of better practices, according to empirical data from systematic studies. Farmers may make well-informed decisions about crop selection, input utilization, pest and disease control and post-harvest procedures when they have access to timely and trustworthy information. By putting farmers in close contact with markets, institutions and specialists, ICTs also lessen information asymmetry. According to a number of studies, digital platforms and mobile-based alerts greatly increase farmers' knowledge of suggested technology and government assistance initiatives (Badavath et al., 2024; Prusty et al., 2020). Videos and pictures are examples of multimedia content that improves comprehension and memory of information, especially for farmers with poor literacy levels (Panwar & Sahoo, 2025). By facilitating horizontal information flow among farmers via social networks and online forums, ICTs also speed up the dissemination of inventions. ICT-enabled extension has been linked to better farm incomes, lower input costs and higher crop yields in terms of economic results (Ghosh et al., 2025; Kumar et al., 2025). While market information services facilitate improved price realization and marketing choices, weather forecasts and early warning systems assist farmers in managing climatic hazards. Additionally, by offering site-specific advice, ICTs assist precision agriculture techniques, encouraging resource efficiency and environmental sustainability.

4. CHALLENGES AND LIMITATIONS OF ICT-BASED EXTENSION

One of the most significant community characteristics that might influence migration, production and stability is diversity (Mounika *et al.,* 2022). ICT uptake and successful usage in agricultural extension confront a number of obstacles despite their potential advantages. The digital gap, which is defined by unequal access to devices, internet connectivity and digital skills, is one of the main obstacles. ICT-based services are frequently less beneficial to small and marginal farmers, women farmers, older farmers and farmers in distant locations (Vardhan *et al.,* 2022; Das et al., 2025). The efficacy of ICT technologies is further limited by inadequate digital literacy and language obstacles. The relevance and usability of many digital platforms are diminished by inadequate localization. Consistent access to digital services is also hampered by infrastructure-related problems including erratic power

supplies and inadequate network coverage. Furthermore, farmers may get confused and misinformed due to the dubious reliability and quality of information shared through unofficial internet channels. The cost of gathering, drying and processing botanicals, as well as the amount of seed utilized and lost as a result of pest damage and pesticidal treatment, were taken into account while analyzing the benefit ratio of botanicals over traditional pesticides (Mounika *et al.*, 2022). Inadequate coordination amongst stakeholders, insufficient digital tool proficiency among extension staff and sustainability concerns pertaining to financing and upkeep of ICT projects are examples of institutional obstacles (Saha et al., 2025). Concerns about data security and privacy are becoming more significant, especially as big data and digital agricultural databases are used more often. A comprehensive strategy that incorporates technology solutions, policy support, capacity building and inclusive design is needed to address these issues.

5. CONCLUSION

By increasing the reach, speed and efficacy of information delivery through prompt, individualized and interactive services, information and communication technologies (ICTs) have become essential to the modernization of agricultural extension systems, as the systematic review of literature shows. Farmers' knowledge, adoption of better practices, productivity, income, risk management and sustainable farming decisions have all been demonstrated to be positively impacted by ICT-based extension; however, these advantages are not guaranteed and rely on variables like accessibility, content relevance, digital literacy, institutional support and infrastructure availability. Therefore, a blended extension approach that combines digital tools with in-person interactions, farmer organizations and local institutions supported by enhanced rural digital infrastructure, promotion of digital literacy, public-private partnerships, capacity building of extension professionals and ongoing monitoring and evaluation to ensure inclusive and effective outcomes must be used to address persistent issues like the digital divide, limited user capacity and governance constraints.

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