Digital Inclusion in Agriculture: Managing ICT Capacity-Building

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ABSTRACT: In recent years, digital technology has made tremendous inroads into various aspects of life, including agriculture. What was once a sector defined by traditional practices is now undergoing a technological transformation, from precision farming to digital marketplaces (FAO, 2020). However, not all farmers are experiencing the benefits of this shift equally. There exists a significant gap, commonly referred to as the "digital divide," between those who have access to and can effectively use digital tools and those who cannot (World Bank, 2019). This divide is especially evident in the context of digital marketing platforms—online spaces that allow farmers to connect with buyers, obtain fair prices for their produce, and access marketrelated information without relying on intermediaries (eNAM Portal, 2023). In a state like Haryana, known for its robust agricultural output, this digital disconnect becomes an important issue to explore (Verma, 2022).

[Priya, L. **Digital Inclusion in Agriculture: Managing ICT Capacity-Building.** *The International Journal of Interpretation, Observation and Analysis*, 2025; Volume 4, Issue 1:224-227 (October-December). ISSN 2349-0713, Peer-reviewed (online/offline), Refereed, Indexed and International Journal (Since 2013), Global Impact Factor: 6.205

Keywords: Information communication technologies, sustainable farming, agriculture, rural development, artificial intelligence

Introduction:

The core purpose of this research is to understand how digital technologies, specifically marketing platforms, are being perceived and used by farmers in Haryana. While many governmental and private initiatives aim to promote digital agriculture, the on-ground reality often reveals a slower pace of adoption (NABARD, 2021). This study focuses on the awareness levels of farmers regarding digital platforms that support the marketing and sale of agricultural products. It seeks to examine how much farmers know about these platforms, the extent to which they use them, and the various socio-economic and infrastructural factors that enable or hinder this process (Singh & Mehta, 2020). Beyond simply identifying a gap, the study intends to offer practical recommendations that can bridge it (Ali et al., 2020). Haryana presents a particularly compelling case for this type of research. Located in northern India, the state has long been at the forefront of India's Green Revolution and continues to play a major role in feeding the nation (Agricultural Census, 2016). Despite this progressive image, the digital dimension of agriculture has not seen equally widespread adoption (Chand et al., 2021). Although mobile phones are widely used, and there is a growing presence of internet connectivity in rural areas, the leap from basic digital use to more complex, transaction-based activities like online marketing of crops remains limited (Mittal & Tripathi, 2009). One of the key reasons for this limited adoption is a lack of awareness. Many farmers are either unaware of digital marketing platforms or do not fully understand how these platforms function (Desai & Patil, 2022). Digital awareness is often closely linked with factors such as age, education, landholding size, and proximity to urban centers (Rathore, 2021). For instance, younger farmers or those with higher levels of formal education are generally more comfortable navigating digital environments (Bala & Verma, 2022). The broader national push for digital transformation, led by initiatives like Digital India, has certainly laid the groundwork for technological integration in rural areas (GOI, 2020). The government has introduced several digital services aimed at farmers, including portals for subsidies, weather updates, crop advisory, and market prices (Kumar et al., 2021). Despite these efforts, the effectiveness of such services is diminished if farmers are not digitally literate (Digital Green, 2021). There is also a cultural aspect at play. Many farmers have relied for generations on traditional marketing methods, and making a shift to unfamiliar digital systems can be intimidating (Meena & Singh, 2022).

Access to information on agricultural technology is a critical determinant of agricultural productivity. Farmers need relevant and timely information and knowledge to effectively plan and adopt farming practices (Masuki et al., Citation2010). Smallholder farmers need access to information about agricultural technologies to make informed adoption decisions. Traditionally, farmers have relied on research institutions, extension agents, and NGOs for information about new technologies. However, the traditional extension system is ridden with human

resources challenges, a lack of accountability, and overly generalized messages (Davis, Citation2020). Furthermore, face-to-face extension campaigns often struggle to reach farmers in remote areas and are significantly constrained during crises that limit physical contact, such as the COVID-19 pandemic.

The rise of information and communication technologies (ICTs) such as the Internet and mobile phones offers innovative solutions to overcome these hurdles (Emeana et al., Citation2020). ICTs have resulted in the emergence of digital advisory services, commonly called e-extension, ICT-based extension, or ICT for agriculture. These platforms provide farmers with timely and site-specific advice on agricultural practices, input use, crop planting dates, local weather predictions, market prices, and access to social networks (Emeana et al., Citation2020; Evans, Citation2018).

The growing availability of ICT applications has led to significant growth in digital extension services. Observational and experimental studies have evaluated the impacts of these tools on outcomes such as knowledge, awareness, adoption of certain technologies, choice of market channel, health, profit, and income (see for example Aker et al., Citation2016; Arouna et al., Citation2021; Kiiza & Pederson, Citation2012). Recent studies have further expanded the scope of ICTs in agriculture, exploring their roles in data management systems (Mushi et al., Citation2023), accountability tools (Namyenya et al., Citation2022), and the factors affecting the adoption of actual ICT tools (Smidt & Jokonya, Citation2022). Despite these efforts, a comprehensive synthesis of evidence of ICT's impact across different outcomes remains needed.

This study aims to bridge this gap by systematically reviewing the role of ICTs in agriculture, focusing on four key outcomes: awareness, adoption of agricultural technologies, yield, and income. These outcomes are the most frequently studied pathways for ICTs impact on agriculture (Ayim et al., Citation2022). Our analysis includes studies that describe and estimate the relationship between ICT use and these outcomes. This study provides a comprehensive review to inform policies and practices, leveraging ICTs for agricultural development. To our knowledge, this is the first systematic review to consolidate results from different disciplines, primarily economics, and includes studies evaluating the relationship between ICT use and these outcomes.

This study builds on previous reviews of ICTs in agriculture. Aker (Citation2011) highlighted the potential of ICT tools (voice, text, Internet, and mobile money transfers) and proposed randomized controlled trials (RCTs) to rigorously evaluate their impact. Since then, several RCTs have been conducted, providing robust evidence. Zhang et al. (Citation2016) reviewed ICT-based information dissemination models in China to share knowledge and experiences in applying emerging ICTs to disseminate agricultural information to farmers. They identified seven models that improve economic, social, and environmental sustainability. Nakasone et al. (Citation2014) examined ICTs in agriculture markets, and found positive impacts at the macro level, but mixed impacts on income at the micro level. Recently, Abate et al. (Citation2023) reviewed ICT tools for market participation and identified barriers to scaling. Ayim et al. (Citation2022) conducted a scoping review of ICT use in African agriculture, examining tools developed, countries using them, study frameworks, and challenges. Essentially, the application of digital communication technology in agriculture is vast and developing rapidly, and there is a need to evaluate its impact on smallholder farmers (Emeana et al., Citation2020).

Smartphones can transform Indian agriculture, but affordability, digital literacy, connectivity and language barriers to access remain barriers to adoption and utilization. The government should support farmers through subsidized smartphones with data plans, rural connectivity and education on digital skills and resources. Increasing the agricultural information available in local languages will help to reduce some of the barriers to access, particularly for older farmers and farmers who may have more limited education. Digital tools and incentives, such as social media or applications, could increase youth engagement and interest in progressive farming. Closing the youth technology and non-smartphone user gap will depend on localized training and low-cost plans and programs. Nevertheless, a true game-changer will be a holistic approach to agricultural transformation, which incorporates education, technology and funding.

LITERATURE REVIEW ICT

in agriculture has revolutionized how farmers manage their farms, access markets, and communicate (Kumar et al., 2021). Digital platforms such as eNAM, AgriBazaar, and KisanMandi allow for real-time price tracking and broader market access (Chand et al., 2021). These tools have reduced information asymmetry and increased income opportunities (Ali et al., 2020). Mobile apps and SMS services offer advisory, weather updates, and pest alerts, which increase efficiency and sustainability (Mittal & Tripathi, 2009). Financial tools such as digital payments and insurance products are also reducing dependence on traditional credit systems (World Bank, 2019). In Haryana, despite infrastructure and literacy advantages, adoption of

digital tools remains limited due to lack of training and language barriers (Desai & Patil, 2022). Platforms often do not cater to rural sensibilities, making them inaccessible to a large user base (Rathore, 2021). Successful international cases (e.g., Kenya's M-Farm, China's Rural Taobao) emphasize the importance of support systems in driving digital adoption (FAO, 2020). These systems must be inclusive to ensure benefits reach women and marginal farmers (Mehta & Kapoor, 2020).

Farmers' Adoption of Digital Platforms: National and Global Trends

Global adoption varies by access to infrastructure, policy support, and digital literacy (OECD, 2020). In China and Kenya, platforms enabled direct market access and pricing transparency (UNDP, 2021). In India, urban farmers adopt faster than rural counterparts. In Haryana, eNAM is gaining attention, but awareness and use remain low among older, less-educated farmers (eNAM Portal, 2023; NABARD, 2021). Perceived usefulness and ease of use, as framed by TAM, influence adoption (Davis, 1989). Lack of awareness and digital skills hamper usage despite available infrastructure (Digital Green, 2021).

Influencing Factors: Demographic, Technological, and Social

Younger, educated farmers adopt digital tools more readily (Bala & Verma, 2022). Older farmers and those with small landholdings face greater barriers (Ali et al., 2020). Internet connectivity and smartphone access are major challenges (GOI, 2020). Platforms need to be more localized and user-friendly (Saksena, 2018). Cultural resistance and lack of community usage deter adoption. Gender inequality further limits access for women farmers (Kaur & Sharma, 2020).

Research limitations/implications

The qualitative analysis from in-depth interviews established these quantitative understandings related to the adoption of smartphones among the farmers for agricultural innovations. In the course of interviews, the participants from varied backgrounds emphasized the factors such as knowledge transfer, agricultural extension, digital divide, digital marginalization, rural digital access, educational digital gap, socio-economic access and disparity, mobile device penetration, digital literacy programs, affordable internet access, public–private digital partnerships and technology adoption. All these perspectives are pitched for inclusive technologies for the attainment of farmers' empowerment.

Practical implications

This study used surveys and interviews to provide a stronger and richer understanding of farmer behaviours and technology uptake, as well as system-level barriers. Survey methods provided the basis for quantitative data so researchers can examine patterns in, for example, smartphone ownership, app usage or access to digital services across a wider sample of farmers. Mixed-methods research facilitated the researchers gaining context on the reasons behind those patterns using interviews, such as trust in technology, cultural practices, digital literacy or access to a local innovation ecosystem.

Social implications

Smartphone adoption among Indian farmers has profound social implications. It empowers rural communities through access to timely agricultural information, reduces generational and regional gaps in digital usage and fosters peer-to-peer learning via social media. With affordable access, even marginalized groups gain digital inclusion, enhancing equity. These devices also facilitate economic mobility by connecting farmers directly to markets and financial services. However, challenges such as misinformation and digital literacy persist. Overall, smartphones are reshaping rural identities, transforming traditional farming into a more connected, informed and resilient livelihood.

Originality/value

This study extends the diffusion of innovation theory by contributing to a deeper understanding of the socio-technical dynamics influencing digital transformation in agriculture. Its application in study provides newer insight into the stages of adoption – knowledge, persuasion, decision, implementation and confirmation. This study highlights the practical implications, indicating the role of village headmen, extension communication officers, subsidies for farmers to procure smartphones and conducting digital media campaigns, which have sought an overhaul in the public policy. This study also focuses on innovative digitalized agriculture, which has the potential to significantly advance the sustainable development goals by enhancing productivity, reducing environmental impact and promoting inclusive growth.

Digital Agriculture and Information and Communication Technology for Ensuring Sustainable Development in India

India is described as an agricultural powerhouse on a global scale due to its vast agri-ecological diversity. Even though attaining food adequacy in production, India still faces issues related resource-intensive agriculture and less farmer productivity, raising poverty and malnutrition. The involvement of information and communication technology (ICT) in evolving agriculture has become even more essential. It assists farmers with timely information related to environmental conditions, soil health, and crop management and beyond it, where it has the potential to stimulate growth in agricultural productivity and

promote sustainable farming through informed decision-making and resource management. This paper reviews the relevance of ICTs in farming for rural development, food security, and resilience. Newer technologies such as 5G, AI, and cloud computing provide exciting new possibilities to explore for a robust vision for Indian agriculture that is organised, data-oriented, and productive.

It can stimulate economic development through improved access to markets and knowledge sharing, with ICT playing an important role in supporting rural communities. However, challenges such as limited connectivity and low digital literacy must be addressed to facilitate widespread adoption of ICTs. ICT in agriculture draws parallels to the "Third Green Revolution," where there is a need to strive towards more affirmative inclusion of small farm households and women, especially amongst developing countries. Enhancing the agenda of sustainability through ICT and sustainable practices will be a major strategy in creating ecological balance, environmental health, and resilience for agricultural systems for the future.

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