

**DIGITAL AGRICULTURAL EXTENSION SYSTEMS, MOBILE
COMMUNICATION ADOPTION, AND FINANCIAL INCLUSION AMONG
SMALLHOLDER FARMERS IN SOUTHWEST NIGERIA**

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Abstract

This study examined the relationship between digital agricultural extension systems, mobile communication adoption, and financial inclusion among smallholder farmers in Southwest Nigeria. The increasing integration of Information and Communication Technologies (ICTs) into agricultural practices has transformed rural farming systems by improving access to extension services, financial products, market information, and digital payment systems. Despite the growing penetration of mobile technologies in Nigeria, many smallholder farmers still face barriers to effective utilization of digital agricultural and financial services. The study adopted a descriptive and analytical review approach using secondary data from scholarly journals, government publications, and institutional reports. The findings revealed that mobile communication technologies such as smartphones, SMS platforms, mobile applications, WhatsApp groups, and mobile banking systems significantly enhance farmers' access to agricultural information and financial services. The study further identified education, income level, digital literacy, network availability, and infrastructural development as major determinants of adoption. However, challenges including poor internet connectivity, low digital literacy, inadequate electricity supply, and limited rural banking infrastructure continue to hinder effective financial inclusion among rural farmers. The paper concludes that digital agricultural extension systems have substantial potential to promote agricultural productivity, financial accessibility, and rural economic development in Southwest Nigeria. The study recommends increased government investment in rural digital infrastructure, farmer

digital literacy programmes, and collaborative partnerships between financial institutions, telecommunication providers, and agricultural extension agencies.

Keywords: *Digital Agriculture, Financial Inclusion, Mobile Communication, Smallholder Farmers.*

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1. INTRODUCTION

Agriculture remains a critical sector in the Nigerian economy, contributing significantly to employment generation, food security, poverty reduction, and rural development. In Southwest Nigeria, smallholder farmers dominate agricultural production activities such as cassava farming, cocoa cultivation, maize production, poultry, fisheries, and vegetable farming. Despite their contributions to national food supply, many smallholder farmers continue to experience low productivity, poor access to extension services, limited market information, and inadequate access to financial services.

Traditional agricultural extension systems in Nigeria have long been constrained by inadequate manpower, poor transportation facilities, limited funding, and weak institutional support. These limitations have significantly reduced the effectiveness of extension delivery to rural farmers. Consequently, digital agricultural extension systems have emerged as innovative alternatives for improving agricultural communication and knowledge dissemination among farmers.

Digital agricultural extension systems involve the use of Information and Communication Technologies (ICTs), including mobile phones, internet platforms, SMS services, mobile applications, social media platforms, and digital advisory tools, to provide agricultural information and extension services to farmers. The rapid expansion of mobile communication technologies across Nigeria has created opportunities for improved farmer-extension interactions, digital financial transactions, and enhanced rural inclusion.

Financial inclusion refers to the availability and accessibility of affordable financial services such as savings, credit, insurance, digital payments, and mobile banking to underserved populations. For smallholder farmers, financial inclusion plays a significant role in improving access to agricultural credit, input financing, savings mobilization, and investment opportunities. Mobile communication technologies have increasingly become essential tools for facilitating financial inclusion in rural communities.

In recent years, mobile banking applications, USSD banking systems, digital wallets, and fintech platforms have expanded financial access among rural populations in Nigeria. However, the extent to which smallholder farmers utilize these digital financial services remains uneven due to infrastructural, educational, and socioeconomic challenges.

This study therefore examines digital agricultural extension systems, mobile communication adoption, and financial inclusion among smallholder farmers in Southwest Nigeria with a view to identifying the determinants, benefits, constraints, and policy implications for sustainable rural development.

2. LITERATURE REVIEW AND THEORETICAL FRAMEWORK

2.1 Digital Agricultural Extension Systems

Digital agricultural extension systems refer to technology-driven mechanisms for disseminating agricultural information and advisory services to farmers through digital communication platforms. These systems facilitate rapid information sharing relating to weather forecasts, market prices, pest management, disease control, fertilizer application, and improved farming practices.

The increasing use of mobile technologies has transformed agricultural extension delivery by reducing communication barriers between farmers and extension officers. Common digital extension platforms used in Nigeria include:

- Short Message Service (SMS)
- Mobile agricultural applications
- WhatsApp farmer groups
- Interactive voice response systems
- E-extension portals
- Community radio integrated with mobile feedback systems
- Social media platforms.

Digital extension services improve access to timely and accurate agricultural information, thereby enhancing productivity and farm decision-making.

2.2 Mobile Communication Adoption among Farmers

Mobile communication technologies have become increasingly important in rural agricultural development. Mobile phones enable farmers to communicate with extension officers, access financial services, obtain weather information, and monitor market trends.

The adoption of smartphones and mobile applications among farmers has expanded significantly due to declining device costs and improved network coverage. Studies indicate that younger and more educated farmers are more likely to adopt digital communication technologies than older farmers.

Factors influencing mobile communication adoption include:

- Educational attainment
- Income level
- Digital literacy
- Age
- Network availability
- Affordability of devices
- Electricity supply
- Awareness of digital services.

The use of mobile communication technologies has also facilitated the integration of financial technology services into agricultural systems.

2.3 Financial Inclusion and Rural Development

Financial inclusion refers to the provision of affordable, accessible, and sustainable financial services to individuals and businesses, particularly underserved rural populations. Financial

inclusion among smallholder farmers enhances savings culture, credit accessibility, investment capacity, and agricultural productivity.

Digital financial services available to rural farmers include:

- Mobile banking
- USSD banking
- Digital payment systems
- Microfinance services
- Agency banking
- Fintech applications
- Mobile wallets.

The adoption of digital financial systems has improved financial transactions in rural communities by reducing transaction costs and promoting cashless economic activities.

However, financial exclusion remains prevalent among many rural farmers due to:

- Inadequate banking infrastructure
- Low literacy levels
- Poor internet connectivity
- Distrust in digital systems
- Limited digital skills.

2.4 Theoretical & Empirical Review

This study is anchored on the Technology Acceptance Model (TAM) developed by Davis (1989). The theory explains that individuals adopt technologies based on perceived usefulness and perceived ease of use. Farmers are more likely to adopt digital agricultural and financial technologies when they perceive such technologies as beneficial and user-friendly.

The Diffusion of Innovation Theory by Rogers (2003) also supports this study by explaining how innovations spread within social systems over time. Adoption depends on factors such as awareness, compatibility, simplicity, observability, and trialability.

Recent empirical studies have increasingly examined the nexus between digital agricultural extension systems, mobile communication adoption, and financial inclusion among smallholder farmers in Nigeria and other developing economies. These studies provide evidence that digital technologies significantly improve agricultural productivity, access to financial services, and rural economic development.

Agricultural Finance studies have shown that exposure to digital agricultural technologies positively influences farmers' productivity and financial accessibility. Kolapo and Didunyemi (2024) investigated the effects of agricultural smartphone application exposure among 380 smallholder farmers in Southwest Nigeria. The study employed a counterfactual framework and found that exposure to smartphone applications significantly increased adoption rates, farm-level productivity, and technical efficiency among farmers. The researchers concluded that digital agricultural applications serve as important tools for disseminating extension information and improving farm management decisions.

Similarly, Ogunfolaju, Ahmed, and Kolawole (2026) examined the adoption of digital financial services among 812 smallholder farmers in North Central Nigeria. Using descriptive statistics and Pearson correlation analysis, the study found that farmers widely utilized mobile money services, ATM platforms, digital withdrawals, and electronic balance-checking services. The study further revealed a significant relationship between educational level and digital financial service adoption. The authors concluded that literacy and digital awareness are critical determinants of financial inclusion among rural farmers.

Another related study by Kolawole et al. (2025) assessed knowledge and adoption of digital financial services among smallholder farmers in Kogi State, Nigeria. The study reported that Point-of-Sale (POS) services, ATM cards, and mobile banking platforms were the most commonly used digital financial tools among farmers. Multiple regression analysis showed that age, educational attainment, farm size, annual income, and extension contact significantly influenced digital financial service adoption. The study also identified fraud concerns, high transaction charges, and limited awareness as major barriers to adoption.

In a study on digital agriculture adoption barriers in rural Nigeria, John, Sule, and Ismail (2025) utilized qualitative mixed methods involving interviews, focus groups, and literature review across Ogun, Kano, Benue, and Ebonyi States. The study found that infrastructural deficiencies, digital illiteracy, poor internet connectivity, and cultural resistance significantly limited farmers' willingness to adopt digital agricultural systems. The authors emphasized the need for stronger government support, digital literacy training, and rural ICT infrastructure development to improve adoption rates.

Arowolo et al. (2024) investigated the influence of financial inclusion on climate change adaptation strategies among smallholder farmers in Oyo State, Nigeria. Using a Multivariate Probit (MVP) model, the study found that access to credit facilities, bank account ownership, and extension services significantly influenced farmers' adoption of climate adaptation practices. The researchers concluded that financial inclusion enhances farmers' adaptive capacity and agricultural resilience.

Furthermore, a study on the effectiveness of digital extension services in Kebbi State revealed that access to digital tools, educational level, farmer group membership, and access to credit significantly influenced the adoption of digital extension systems among rural households. The study established that digital extension services positively affected farmers' productivity, income generation, and technology adoption behavior.

A recent study published in the Cambridge University Press examined the impacts of smartphones on agricultural intensification in Nigeria. The researchers found that smartphones significantly improved farm management practices, access to information, and decision-making processes among rural households. The study further noted that smartphone adoption contributed positively to agricultural intensification and rural economic outcomes.

In Ogun State, Nigeria, another empirical investigation examined farmers' willingness to adopt digital application tools such as Akilimo and herbicide calculator applications. The findings revealed that internet access, smartphone ownership, training, awareness, and educational level significantly influenced willingness to adopt digital agricultural applications. The study also found gender disparities in adoption patterns, with female farmers exhibiting lower adoption willingness than male farmers.

Muritala (2025) examined financial inclusion as a catalyst for agricultural growth among smallholder farmers in Ilorin, Nigeria. Using regression and instrumental variable estimation

techniques, the study established that access to formal financial services, including mobile money and microfinance services, significantly improved farm productivity, investment decisions, and household income among farmers.

More recently, studies on generative artificial intelligence and digital readiness among Nigerian farmers indicate increasing digital transformation in rural agriculture. Research conducted in 2025 showed that a majority of small-scale farmers owned smartphones, had internet connectivity, and increasingly utilized AI-powered digital tools for accessing agricultural information and conducting farm-related research. However, access to extension services remained relatively low, highlighting the continuing need for improved digital extension delivery systems.

Overall, the reviewed empirical studies demonstrate that digital agricultural extension systems and mobile communication technologies significantly improve financial inclusion, agricultural productivity, information dissemination, and rural economic development among smallholder farmers. Nevertheless, persistent challenges such as low digital literacy, inadequate rural infrastructure, poor internet connectivity, cybersecurity concerns, and high technology costs continue to hinder widespread adoption in Nigeria. These findings underscore the need for targeted government interventions, digital literacy programmes, rural ICT infrastructure investment, and stronger collaboration among agricultural institutions, financial service providers, and telecommunication companies.

3. METHODOLOGY

The study adopted a descriptive survey and analytical review approach using secondary data sources. Relevant data were obtained from academic journals, conference papers, government reports, institutional publications, and credible online databases relating to digital agriculture, mobile communication, and financial inclusion in Nigeria.

The study area comprises Southwest Nigeria, including Lagos, Ogun, Oyo, Osun, Ondo, and Ekiti States. The region is characterized by active agricultural production and increasing penetration of mobile communication technologies.

The study reviewed relevant literature published between 2020 and 2026 to identify trends and patterns relating to digital agricultural extension systems and financial inclusion among smallholder farmers.

Data were analyzed using descriptive analysis and thematic content evaluation.

4. FINDINGS AND DISCUSSION

4.1 Digital Agricultural Extension Systems among Smallholder Farmers

The findings revealed that mobile phones remain the most widely used digital communication tools among smallholder farmers in Southwest Nigeria. Farmers increasingly utilize WhatsApp groups, SMS services, YouTube tutorials, and agricultural mobile applications to access extension information.

Digital extension systems have significantly improved:

- Access to agricultural information
- Communication with extension officers
- Awareness of improved farming practices
- Weather forecasting
- Pest and disease management
- Market information dissemination.

The use of digital platforms has also reduced the limitations associated with conventional extension systems, especially in remote rural communities.

4.2 Mobile Communication Adoption and Financial Inclusion

The study found that mobile communication technologies contribute significantly to financial inclusion among smallholder farmers. Mobile banking systems, USSD services, and fintech applications enable farmers to:

- Transfer funds
- Save money digitally
- Access microcredit
- Receive payments

- Purchase farm inputs
- Participate in digital marketplaces.

Farmers who actively use mobile communication technologies demonstrate higher levels of financial inclusion compared to non-users. Smartphone ownership also positively influences farmers' participation in digital financial systems.

Agency banking and mobile money services have further improved rural financial accessibility by reducing the distance between farmers and formal financial institutions.

4.3 Determinants of Adoption

The major determinants influencing adoption of digital agricultural and financial technologies include:

- Education level
- Income status
- Age
- Digital literacy
- Network accessibility
- Availability of electricity
- Affordability of smartphones
- Awareness programmes
- Institutional support.

Educated farmers are more likely to utilize mobile banking applications and digital extension platforms effectively. Similarly, younger farmers tend to adopt digital technologies faster than older farmers.

4.4 Challenges Limiting Adoption

Despite the growing opportunities associated with digital systems, several challenges continue to hinder effective adoption among rural farmers.

These include:

- Poor internet connectivity
- Unstable electricity supply
- High cost of smartphones and internet data
- Low literacy levels
- Cybersecurity concerns
- Inadequate training opportunities
- Language barriers
- Weak rural financial infrastructure.

Digital illiteracy remains one of the major barriers preventing rural farmers from maximizing the benefits of digital agricultural and financial services.

5. CONCLUSION AND RECOMMENDATIONS

The study examined digital agricultural extension systems, mobile communication adoption, and financial inclusion among smallholder farmers in Southwest Nigeria. The findings demonstrate that digital technologies have transformed agricultural communication and improved rural financial accessibility through mobile banking, fintech services, and digital extension systems.

Mobile communication technologies significantly enhance farmers' access to agricultural information, extension services, financial products, and market opportunities. However, infrastructural deficiencies, low digital literacy, poor connectivity, and affordability challenges continue to hinder widespread adoption among rural farmers.

The integration of digital extension systems and financial technologies therefore remains essential for promoting sustainable agricultural development, poverty reduction, and rural economic transformation in Nigeria.

Recommendations

Based on the findings, the study recommends that:

1. Government should improve rural ICT infrastructure and internet connectivity.
2. Financial institutions should expand rural mobile banking and agency banking services.
3. Agricultural extension agencies should organize regular digital literacy training for farmers.
4. Telecommunication companies should provide affordable internet and agricultural data packages for rural users.
5. Digital agricultural platforms should incorporate local languages to improve accessibility.
6. Government should strengthen collaboration among fintech firms, agricultural institutions, and extension agencies.
7. Rural electrification projects should be intensified to support digital technology utilization.
8. Youth participation in digital agriculture and aggrotech innovation should be encouraged through grants and capacity-building initiatives.

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