VOL. 13 NO. 1,
AUGUST, 2026
E-ISSN 3027-0995
P-ISSN 3026-8265

African Scholar Publications & Research International
www.africanscholarpub.com

Journal of Biotechnology and Agricultural Research (JBAR)

Digitization in Agriculture and Food Security in Sub-Saharan Africa: A Systematic Review

Dr. Funso O. Alabuja; Ejiofor D. Chukwubuike; Lateefah O. Lama-Abdul; & Olabiyi Fatimah Adebisi
Department of Agricultural Economics, University of Abuja
DOI: https://doi.org/10.70382/ajbar.v13i1.032

Abstract

Digitization is increasingly recognized as a transformative force in Sub-Saharan Africa's (SSA) agricultural sector, with significant implications for productivity enhancement and food security improvement. This systematic review examines the role of digital technologies in agriculture, focusing on their contributions to food availability, accessibility, utilization, and stability across SSA. The study adopts a systematic literature review (SLR) methodology, drawing evidence from peer-reviewed journals and reports published by institutions such as the World Bank, FAO, IFAD, and the African Development Bank between 2015 and 2025. Findings reveal that digital agriculture interventions, including mobile advisory systems, precision agriculture tools, digital financial services, and e-market platforms, significantly improve agricultural productivity, reduce transaction costs, strengthen market integration, and enhance farmers' access to financial services. However, adoption remains uneven due to infrastructural deficits, digital illiteracy, gender inequality, and weak institutional frameworks. The review concludes that while digitization holds strong potential to transform food systems in SSA, its effectiveness depends on enabling environments such as infrastructure development, inclusive policies, and capacity building. The study recommends strengthening digital infrastructure, improving literacy programs, and expanding public–private partnerships to accelerate inclusive digital transformation in agriculture.

Keywords: Digitization, Digital Agriculture, Food Security, Sub-Saharan Africa, Precision Agriculture, ICT, Mobile Advisory Services, Financial Inclusion.

Introduction

Agriculture remains a central pillar of economic development in Sub-Saharan Africa (SSA), playing a critical role in employment generation, income distribution, and overall national economic performance. According to the World Bank (2024), the sector accounts for

approximately 60–65% of total employment in many SSA countries and contributes between 20% and 30% of Gross Domestic Product (GDP). Despite this dominant role, agricultural productivity in the region remains relatively low compared to global standards. This persistent underperformance is largely attributed to structural constraints such as limited mechanization, weak rural infrastructure, inadequate access to improved inputs, and ineffective agricultural extension systems. These challenges are further compounded by increasing climate variability, which continues to threaten farming systems and reduce yield stability.

Food insecurity represents another major developmental concern across SSA. The Food and Agriculture Organization (FAO, 2023) estimates that over 278 million people across Africa are undernourished, with the highest concentration found in Sub-Saharan Africa. This situation reflects a long-standing paradox: despite the region's vast agricultural potential, including arable land and a large farming population, food production systems remain inefficient and unable to meet growing demand. Structural inefficiencies in production, distribution, and market access continue to undermine efforts toward achieving sustainable food security.

In response to these challenges, digitization has emerged as a strategic pathway for transforming agricultural systems in the region. Digital agriculture involves the integration of advanced technologies such as mobile-based platforms, artificial intelligence, blockchain systems, remote sensing tools, and Internet of Things (IoT) applications to improve agricultural decision-making, enhance productivity, and optimize value chains. These technologies enable farmers and stakeholders to access real-time information, improve resource allocation, and reduce inefficiencies across production and marketing processes.

The rapid expansion of mobile connectivity across SSA, with penetration rates exceeding 80% in several countries (GSMA, 2023), has created a strong enabling environment for digital transformation in agriculture. Mobile phones, in particular, have become a key entry point for delivering agricultural services, especially to smallholder farmers in rural areas. However, despite this progress, the adoption and impact of digital technologies remain uneven across the region. Variations in infrastructure availability, digital literacy levels, gender inclusion, and policy coherence continue to influence the extent to which farmers can benefit from digital agriculture innovations.

Overview of Digitization in Agriculture

Digitization in agriculture refers to the integration of digital technologies into agricultural production, processing, storage, and distribution systems with the aim of improving efficiency, productivity, sustainability, and resilience. It represents a structural shift from traditional, experience-based farming systems to data-driven and technology-enabled agricultural practices in which decisions are informed by real-time information and predictive analytics.

In Sub-Saharan Africa (SSA), the evolution of digital agriculture is largely driven by the widespread adoption of mobile-based advisory systems that provide farmers with timely and localized information on weather conditions, pest outbreaks, soil management practices, and market prices. These systems reduce information gaps and strengthen decision-making, particularly among smallholder farmers who often lack access to formal extension services.

In addition, precision agriculture technologies such as GPS-enabled devices, remote sensors, and drones are increasingly being used to optimize input application, improve field monitoring, and enhance crop yields. These tools allow for site-specific farm management, reducing wastage of inputs such as water, fertilizers, and pesticides while improving productivity outcomes.

Digital financial services also play a significant role in transforming agricultural systems by expanding farmers' access to credit, savings, and insurance products. This financial inclusion enables investment in improved inputs and technologies, thereby increasing production capacity. Similarly, digital market platforms and e-commerce systems reduce dependency on intermediaries by directly linking farmers to buyers, improving price transparency, and strengthening market efficiency.

Furthermore, the integration of big data analytics enhances forecasting and planning by providing predictive insights into weather patterns, yield outcomes, and market fluctuations. Collectively, these technologies are reshaping agricultural value chains in SSA by improving efficiency, reducing risks, and strengthening productivity systems.

Food Security Framework

Food security is defined by the Food and Agriculture Organization (FAO, 2023) as a condition in which all individuals, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their dietary needs for an active and healthy life. This concept is multidimensional and is commonly structured around four interrelated pillars: availability, accessibility, utilization, and stability.

Food availability refers to the consistent presence of adequate food supplies through domestic production, imports, or food aid. Food accessibility focuses on the ability of individuals and households to obtain food through both economic means, such as income and prices, and physical means, such as infrastructure and market access. Utilization relates to the proper biological use of food, which depends on adequate nutrition, clean water, sanitation, and health conditions. Food stability, on the other hand, reflects the consistency of food availability and access over time, ensuring that households are not exposed to frequent disruptions caused by shocks such as climate variability, conflict, or market instability.

Together, these dimensions emphasize that food security is not determined solely by agricultural production but also by the efficiency, inclusiveness, and resilience of food systems.

Digital Agriculture Ecosystem

The digital agriculture ecosystem refers to the interconnected network of actors, technologies, institutions, and enabling environments that collectively support the development, diffusion, and utilization of digital innovations in agriculture. It is a dynamic system in which multiple stakeholders interact to generate value and improve agricultural outcomes.

At the center of this ecosystem are farmers, particularly smallholder farmers, who serve as the primary users of digital agricultural technologies. Their participation is largely influenced by access to infrastructure, affordability of technologies, and level of digital literacy. Agribusinesses also play a key role by integrating digital solutions into input supply chains, production systems, and distribution networks, thereby improving efficiency and reducing operational costs.

Technology providers, including startups, telecommunication companies, and software developers, are responsible for designing and delivering digital platforms that support agricultural transformation. Governments contribute by establishing regulatory frameworks, investing in rural infrastructure, and implementing policies that promote digital inclusion and innovation. Financial institutions, including banks and fintech companies, facilitate access to credit, insurance, and digital payment systems that enable farmers to adopt and sustain new technologies.

The effectiveness of this ecosystem is determined by the strength of supporting conditions such as infrastructure availability, institutional coordination, human capital development, and innovation

capacity. Weaknesses in any of these components can limit adoption rates and deepen existing inequalities within rural agricultural communities.

Theoretical Framework

This study is anchored on four complementary theoretical perspectives that collectively explain the adoption, diffusion, and impact of digitization in agriculture.

The Diffusion of Innovation Theory (Rogers, 2003) explains how new technologies spread within a social system over time. It emphasizes that adoption is influenced by perceived relative advantage, compatibility with existing practices, complexity, trialability, and observability. In SSA, adoption is strongly shaped by peer influence, social learning, and extension networks, which determine how quickly farmers embrace digital innovations.

The Sustainable Livelihoods Framework (DFID, 1999) provides a multidimensional perspective on how digitization strengthens livelihood assets. It highlights improvements in human capital through knowledge and skills development, financial capital through access to digital financial services, social capital through improved networking and information sharing, physical capital through better infrastructure access, and natural capital through efficient resource use.

The Endogenous Growth Theory (Romer, 1990; Lucas, 1988) emphasizes that long-term economic growth is driven by internal factors such as innovation, human capital, and knowledge accumulation. Within agriculture, digitization acts as a catalyst for productivity growth by enabling continuous innovation and improving resource efficiency.

The Information Asymmetry Theory (Akerlof, 1970) explains how unequal access to information creates inefficiencies in markets. Digital platforms help reduce these inefficiencies by improving transparency in pricing, weather forecasting, and input availability, thereby strengthening farmers' bargaining power and market participation.

Research Design

This study adopts a Systematic Literature Review (SLR) design to examine the relationship between digitization in agriculture and food security outcomes in SSA. The SLR approach is appropriate because it enables a comprehensive and unbiased synthesis of existing empirical and theoretical studies rather than relying on isolated or single-case findings.

The review process is guided by the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework, which ensures transparency, consistency, and replicability in study selection and analysis. Through this approach, relevant studies are systematically identified, screened, and analyzed based on predefined inclusion criteria. This method also allows for the integration of diverse findings across different contexts, thereby providing a more holistic understanding of how digital agriculture influences food security in SSA.

Sources of Data

This study relies exclusively on secondary data sources drawn from credible academic and institutional repositories. These include peer-reviewed journal articles, conference papers, policy documents, and reports from recognized international development organizations.

Relevant literature was obtained from major academic databases such as Google Scholar, Scopus, Web of Science, and ScienceDirect. In addition, institutional publications from organizations such as the Food and Agriculture Organization (FAO), World Bank, International Fund for Agricultural

Development (IFAD), and African Development Bank (AfDB) were included to provide contextual and policy-relevant insights.

The selection of these sources is based on their academic credibility, methodological rigor, and relevance to digital agriculture and food security discourse. Emphasis was placed on studies that provide empirical evidence or strong theoretical contributions to understanding the role of digitization in agricultural transformation within SSA.

Analytical Approach

The study adopts thematic synthesis and content analysis to identify and interpret recurring patterns across the selected literature. This involves systematically examining studies based on key analytical dimensions, including the types of digital technologies applied in agriculture, observed food security outcomes, adoption barriers, and geographic contexts within SubSaharan Africa.

In addition, a directional effect approach is employed to categorize findings according to their reported impact, classifying them as positive, neutral, or negative. This enables a structured comparison of evidence across studies and supports a clearer synthesis of how digitization influences agricultural and food security outcomes in the region.

Food Availability

Digital agriculture plays a significant role in strengthening food availability across SubSaharan Africa by improving agricultural productivity, reducing inefficiencies in production systems, and enhancing farmers' access to critical production-related information. A key mechanism through which this occurs is the provision of digital advisory services, which deliver timely and location-specific guidance on weather patterns, pest management, soil conditions, and optimal planting and harvesting periods. This enables farmers to make more informed decisions that directly improve farm output and reduce losses associated with poor timing or outdated practices.

Empirical evidence consistently shows that farmers who adopt digital advisory platforms experience yield improvements ranging from 10% to 30% depending on crop type, level of adoption, and environmental conditions (World Bank, 2024). These gains are largely attributed to improved coordination of farm activities, more efficient use of inputs such as fertilizers and improved seeds, and better response to climate-related risks.

Digital platforms enhance access to agricultural inputs by connecting farmers directly with suppliers, reducing delays and ensuring timely availability of essential resources. Precision agriculture technologies also contribute to improved productivity by enabling more efficient application of inputs, thereby increasing output while minimizing waste. Collectively, these digital interventions strengthen overall food supply by reducing production constraints and improving efficiency within farming systems, ultimately contributing to higher and more stable levels of food availability across the region.

Food Accessibility

Digital agriculture significantly enhances food accessibility by reducing transaction costs, improving market efficiency, and strengthening linkages between farmers and consumers. One of the most important pathways through which this occurs is the expansion of mobile-based financial systems, particularly mobile money platforms, which enable farmers to conduct transactions more easily without relying on physical cash exchanges or traditional banking infrastructure. This improves their ability to sell agricultural produce, purchase inputs, and engage in broader economic activities with reduced delays and lower operational costs.

In addition, digital e-commerce and agricultural marketplace platforms have transformed how agricultural goods are traded by directly connecting farmers to buyers, including wholesalers, retailers, and end consumers. This reduces the dominance of intermediaries who often inflate prices and distort market value, thereby allowing farmers to receive more competitive and fair prices for their produce. As a result, farmers' income levels improve, which in turn enhances their capacity to access food and other essential household needs.

Furthermore, improved market transparency through digital platforms ensures that farmers have real-time access to price information, demand trends, and market locations. This reduces information gaps and strengthens bargaining power, enabling more efficient decision-making regarding when and where to sell produce. Collectively, these digital innovations enhance both physical and economic access to food by making markets more efficient, inclusive, and responsive, particularly for smallholder farmers in Sub-Saharan Africa.

Food Utilization

Digital agriculture contributes to improved food utilization by strengthening knowledge and awareness related to nutrition, dietary practices, food safety, and post-harvest management. Through mobile-based extension services and digital advisory platforms, farmers and rural households gain access to practical information on balanced diets, food preparation methods, and proper storage techniques, which collectively enhance the nutritional value and safety of food consumed at the household level.

A particularly important contribution of digital tools is their role in improving household nutrition outcomes in rural communities, especially among women, who are often responsible for food preparation and family nutrition. By providing targeted information on dietary diversification, infant feeding practices, and nutrient-rich food combinations, digital platforms help to reduce malnutrition and improve overall health outcomes within farming households.

In addition, digital technologies support improved post-harvest handling by offering guidance on storage methods, drying techniques, and processing practices that reduce spoilage and food contamination. This helps to preserve food quality and extend shelf life, thereby increasing the effective utilization of available food resources.

Digital interventions enhance food utilization by ensuring that available food is not only sufficient but also safe, nutritious, and efficiently used to meet the dietary needs of individuals and households across Sub-Saharan Africa.

Food Stability

Digital technologies contribute significantly to food system stability by strengthening the ability of agricultural systems to anticipate, respond to, and recover from environmental and economic shocks. Food stability focuses on maintaining consistent access to sufficient and nutritious food over time, ensuring that temporary disruptions do not result in prolonged food shortages or insecurity. In Sub-Saharan Africa, where agricultural production is highly dependent on climatic conditions, digital technologies have become important tools for improving resilience and reducing uncertainty within food systems.

One of the major contributions of digital agriculture to food stability is the use of early warning systems and climate forecasting technologies. These systems provide farmers with timely information on changing weather conditions, rainfall patterns, drought risks, floods, and pest outbreaks. Access to such information allows farmers to make proactive decisions regarding planting periods, irrigation schedules,

crop selection, and harvesting activities. As a result, the likelihood of production losses caused by unexpected environmental events is significantly reduced.

Real-time monitoring technologies, including satellite systems, remote sensing tools, and Internet of Things (IoT)-based devices, further strengthen food stability by continuously tracking agricultural and environmental conditions. These technologies provide accurate information on crop performance, soil moisture levels, and potential disease outbreaks, enabling rapid intervention before problems become severe. Early identification of risks helps farmers minimize losses and sustain production levels even under challenging conditions.

Digital platforms improve resilience by facilitating faster dissemination of information during emergencies and supporting coordinated responses among farmers, governments, and agricultural institutions. By reducing vulnerability to climate variability, market fluctuations, and production shocks, digital technologies help maintain more reliable food supplies over time. Consequently, digital agriculture enhances the long-term sustainability and stability of food systems across Sub-Saharan Africa.

Table 4.1: Digitization and Food Security Linkages

Dimension	Digital Contribution	Effect
Availability	Precision agriculture	Increased productivity
Accessibility	Digital markets	Improved access
Utilization	Nutrition platforms	Better dietary outcomes
Stability	Climate ICT tools	Enhanced resilience

Challenges of Digitization

Despite the significant benefits associated with digital agriculture, several structural, institutional, and socio-economic challenges continue to limit its adoption and effectiveness across Sub-Saharan Africa. These barriers contribute to uneven implementation and reduce the ability of many farmers, particularly smallholder farmers, to fully benefit from digital innovations.

One of the major constraints is inadequate infrastructure, particularly poor internet connectivity, unstable electricity supply, and weak telecommunications networks in rural communities. Digital agricultural systems largely depend on reliable access to electricity and internet services for communication, information exchange, and operation of technology-based platforms. However, many rural areas in SSA continue to experience limited access to these essential facilities, thereby restricting the functionality and accessibility of digital tools. Farmers in remote locations often encounter difficulties accessing real-time information and online services due to weak network coverage and unreliable power supply.

Another significant challenge is the existence of a persistent digital divide between urban and rural populations. Differences in educational attainment, digital literacy levels, and access to technological devices create disparities in the ability of farmers to adopt and effectively utilize digital solutions. While urban populations generally have greater exposure to technology and digital skills, many rural farmers face challenges in understanding and operating digital platforms. Low literacy levels and limited technical knowledge can reduce confidence in technology adoption and slow the diffusion of digital innovations within farming communities.

Gender inequality also remains a major barrier to inclusive digital agriculture. Women play critical roles in agricultural production across SSA, yet they frequently encounter obstacles that limit their access to

digital technologies. Factors such as lower ownership of mobile devices, limited financial resources, socio-cultural restrictions, and reduced access to education often place women at a disadvantage. As a result, female farmers may be excluded from opportunities associated with digital advisory services, digital finance platforms, and online market systems, thereby widening existing inequalities.

The high cost associated with digital technologies further constrains adoption among smallholder farmers. Technologies such as smartphones, precision farming equipment, drones, sensors, and internet services often require financial investments beyond the capacity of many rural farmers. In situations where farmers operate with limited income and inadequate access to credit facilities, technology adoption becomes difficult. This financial barrier reduces the scale at which digital agriculture can be implemented and limits its potential impact on productivity and food security.

In addition, policy inconsistency and weak institutional frameworks continue to affect the growth and sustainability of digital agriculture initiatives. In many countries within SubSaharan Africa, fragmented policies, inadequate regulatory systems, and weak implementation mechanisms create uncertainty for investors and technology providers. Limited coordination among government institutions and stakeholders can also slow the development and expansion of digital agricultural programs. Consequently, the absence of strong and consistent policy support reduces scalability and limits the long-term effectiveness of digital transformation efforts in agriculture.

Although digitization offers substantial opportunities for improving agricultural productivity and food security, addressing these infrastructural, social, economic, and institutional barriers remains essential for achieving broader and more inclusive adoption across Sub-Saharan Africa.

Discussion

The findings of this study demonstrate that digitization plays a transformative role in improving food security across Sub-Saharan Africa through its positive influence on agricultural productivity, market efficiency, and resilience within food systems. The review shows that digital technologies create opportunities for farmers to access timely information, improve production practices, reduce inefficiencies, and strengthen connections across agricultural value chains. These improvements collectively contribute to the four dimensions of food security: availability, accessibility, utilization, and stability.

The findings reveal that digital technologies enhance food availability by increasing agricultural productivity through improved access to advisory services, precision farming techniques, and production-related information. Farmers who utilize digital platforms are able to make more informed decisions regarding planting schedules, pest management, input application, and harvesting activities. Such improvements contribute to higher yields and reduced production losses, ultimately increasing food supply within the region.

The study further indicates that digitization strengthens food accessibility by improving market systems and reducing transaction costs. Digital financial services and online agricultural marketplaces create direct linkages between farmers and buyers, reducing dependence on intermediaries and improving price transparency. These developments improve farmers' income levels and increase their purchasing power, thereby enhancing their ability to access food and other essential resources.

In addition, the findings suggest that digital technologies support food utilization through improved access to nutritional information, food safety practices, and post-harvest management knowledge. Digital extension systems provide educational resources that help households adopt healthier dietary practices and reduce food losses. Furthermore, technologies such as climate forecasting systems and

early warning mechanisms contribute to food stability by enabling farmers to anticipate and respond effectively to environmental risks and production shocks.

Despite these positive outcomes, the findings also indicate that the impact of digitization across Sub-Saharan Africa remains uneven due to several structural and institutional constraints. Weak infrastructure, including poor internet connectivity and unreliable electricity supply, limits access to digital technologies, particularly in rural areas where agricultural activities are concentrated. Similarly, disparities in education and digital literacy affect farmers' ability to effectively utilize digital tools and services.

The study further highlights the influence of social inequalities, particularly gender disparities, on technology adoption and access. Women farmers often face barriers related to limited access to digital devices, financial resources, and educational opportunities, reducing their participation in digital agriculture initiatives. In addition, inconsistent policy environments and weak institutional support mechanisms reduce scalability and limit long-term sustainability of digital interventions.

These findings suggest that while digital agriculture possesses significant potential to transform food systems and improve food security outcomes, its effectiveness depends heavily on the presence of enabling environments that support inclusive participation and sustainable implementation. Investments in digital infrastructure, capacity building, supportive policy frameworks, and targeted inclusion strategies are therefore essential for maximizing the benefits of agricultural digitization across Sub-Saharan Africa.

Conclusion

The findings of this study indicate that digitization represents a significant driver of agricultural transformation and improved food security in Sub-Saharan Africa. Through the integration of digital technologies such as mobile advisory services, precision agriculture tools, digital financial systems, and online market platforms, agricultural systems have become more efficient, productive, and responsive to emerging challenges. These technologies enhance farmers' access to information, improve decision-making processes, and strengthen agricultural value chains, thereby contributing positively to food availability, accessibility, utilization, and stability.

The study further demonstrates that digitization supports increased productivity by enabling efficient use of agricultural inputs, reducing production losses, and improving farm management practices. It also strengthens market access by connecting farmers directly with buyers and financial services, reducing transaction costs and improving income opportunities. In addition, digital technologies improve resilience within food systems through climate forecasting tools, early warning systems, and real-time monitoring mechanisms that help farmers respond effectively to environmental and market-related risks.

Despite the considerable opportunities associated with digital agriculture, its overall effectiveness and sustainability depend heavily on the existence of enabling conditions. Inadequate infrastructure, low levels of digital literacy, gender inequalities, and weak institutional frameworks continue to limit adoption and create disparities in access and benefits. Therefore, the successful implementation of digital agriculture initiatives requires supportive infrastructure, inclusive policy environments, and continuous investment in human capacity development to ensure that the benefits of digitization are widely shared across different groups within society.

Recommendations

Based on the findings of this study, several recommendations are proposed to enhance the effectiveness of digitization in agriculture and maximize its contribution to food security in Sub-Saharan Africa.

1. **Expansion of Rural Digital Infrastructure**: There is a need for increased investment in rural digital infrastructure, particularly in areas relating to internet connectivity, electricity supply, and telecommunications networks. Many rural communities in Sub-Saharan Africa continue to experience limited access to reliable digital infrastructure, which restricts the adoption and effective use of digital agricultural technologies. Governments, telecommunications providers, and development agencies should prioritize the expansion of broadband services, rural network coverage, and stable power supply systems to improve access to digital platforms and services. Improved infrastructure will enhance connectivity and facilitate wider participation in digital agriculture initiatives.
2. **Promotion of Digital Literacy and Capacity Building**: Governments and relevant stakeholders should implement comprehensive digital literacy and capacity-building programmes aimed at improving farmers' knowledge and technical skills in the use of digital technologies. The adoption of digital solutions depends not only on access to technology but also on the ability of users to effectively understand and apply these tools. Training programmes should focus on practical areas such as mobile technology use, digital financial services, online market platforms, and information management systems. Particular attention should be given to rural farmers and smallholder producers who often have limited exposure to digital technologies.
3. **Development of Inclusive Policies and Reduction of Inequalities**: Policies designed to promote digital agriculture should incorporate measures that address existing inequalities, particularly those related to gender, income, education, and geographic location. Women farmers and vulnerable populations frequently face barriers in accessing digital technologies due to socio-economic and cultural limitations. Therefore, governments should develop targeted interventions such as subsidized access to digital devices, gendersensitive training initiatives, and support programmes that encourage wider participation. Ensuring inclusive access will help reduce disparities and improve equitable distribution of the benefits of digital transformation.
4. **Strengthening of Regulatory and Institutional Frameworks**: There is a need to establish stronger and more coordinated regulatory frameworks that support innovation while ensuring the protection of users and digital systems. Effective regulations relating to data protection, cybersecurity, digital transactions, and technology standards are necessary to create confidence among users and investors. Governments should also strengthen institutional coordination among agricultural agencies, technology providers, and development organizations to ensure effective implementation of digital agriculture strategies. A stable policy environment will facilitate long-term investment and sustainable growth within the sector.
5. **Promotion of Public–Private Partnerships and Innovation**: Public–private partnerships should be encouraged to support the development and expansion of digital agricultural solutions. Collaboration among governments, private technology companies, financial institutions, research organizations, and development partners can facilitate knowledge sharing, technological innovation, and resource mobilization. Such partnerships can also improve access to funding opportunities and accelerate the development of affordable, scalable, and locally relevant digital solutions for farmers. Strengthening these collaborations will contribute to sustainable implementation and wider adoption of digital technologies in agriculture.

Future Research Directions

Future research on digitization in agriculture and food security in Sub-Saharan Africa should focus on more context-specific and in-depth investigations to better understand its long-term effectiveness and sustainability. There is a need for country-specific and comparative regional studies that examine how

digital agriculture performs under different institutional, climatic, and socio-economic conditions across SSA, rather than relying solely on broad regional generalizations. In addition, longitudinal studies are required to assess the long-term impacts of digital technologies on agricultural productivity, income stability, resilience, and overall food security outcomes, since most existing studies are largely cross-sectional in nature.

Further research should also explore the gendered dimensions of digital agriculture to better understand the barriers and opportunities affecting women's access to and use of digital technologies, with the aim of developing more inclusive and equitable digital solutions. Emerging technologies such as artificial intelligence, blockchain, drones, and advanced satellite systems should also receive greater scholarly attention, particularly in terms of their potential to transform agricultural value chains and improve efficiency in production and distribution systems within SSA.

Moreover, future studies should investigate the policy and governance environment shaping digital agriculture, including issues related to regulation, data protection, cybersecurity, and institutional coordination, as these factors significantly influence adoption and effectiveness. Finally, research should focus on sustainable scaling strategies, including public–private partnerships, financing models, and community-based digital initiatives, to ensure that the benefits of digital agriculture are widely accessible, affordable, and sustainable for smallholder farmers across the region.

References

Aker, J. C. (2017). Mobile phones and agricultural information systems in Sub-Saharan Africa. *Economic Development and Cultural Change, 65*(3), 563–587.

Akerlof, G. A. (1970). The market for "lemons": Quality uncertainty and the market mechanism. *Quarterly Journal of Economics, 84*(3), 488–500.

Alabi, R. A. (2021). Mobile banking adoption and smallholder farmers' access to credit in Nigeria. *African Journal of Agricultural Economics, 16*(2), 45–60.

Ayim, C., Kassahun, A., Addo, A., & Asante, M. (2022). Digitalization and smallholder agriculture in Africa: Implications for productivity and inclusion. *Technology in Society, 68*, 101–118.

Courtois, P., & Subervie, J. (2015). Farmer bargaining power and mobile phone use in Burkina Faso. *World Development, 70*, 46–63.

DFID. (1999). *Sustainable livelihoods guidance sheets*. Department for International Development.

FAO. (2022). *Digital agriculture in action*. Food and Agriculture Organization of the United Nations.

FAO. (2023). *The state of food security and nutrition in the world*. Food and Agriculture Organization of the United Nations.

GSMA. (2023). *The mobile economy: Sub-Saharan Africa report*. Global System for Mobile Communications Association.

Hanna, R. (2018). Digital governance and policy frameworks in developing economies. *Journal of Development Policy, 34*(2), 112–130.

IFAD. (2023). *Rural development report: Leveraging digital technologies*. International Fund for Agricultural Development.

Jain, S., Singh, R., & Patel, M. (2025). Smart agriculture and productivity enhancement using AI systems. *Computers and Electronics in Agriculture, 210*, 107–118.

Kansiime, M. K., et al. (2019). Digital agriculture and climate resilience in East Africa. *Agricultural Systems, 176*, 102–113.

Khatri, S., et al. (2024). AI-driven pest management and agricultural productivity. *Precision Agriculture, 25*(1), 89–104.

Lucas, R. E. (1988). On the mechanics of economic development. *Journal of Monetary Economics, 22*(1), 3–42.

Mittal, S., & Mehar, M. (2016). Agricultural information systems and market efficiency in India. *Agricultural Economics Research Review, 29*(2), 221–230.

OECD. (2022). *Digital transformation of agriculture: Policy challenges and opportunities*. Organisation for Economic Co-operation and Development.

Paliszkiewicz, J., et al. (2022). Smart irrigation systems and water efficiency. *Sustainability, 14*(8), 4512.

Rogers, E. M. (2003). *Diffusion of innovations* (5th ed.). Free Press.

Romer, P. M. (1990). Endogenous technological change. *Journal of Political Economy, 98*(5), S71–S102.

Salemink, K., Strijker, D., & Bosworth, G. (2017). Rural development and digital exclusion. *Journal of Rural Studies, 54*, 1–10.

Schimmelpfennig, D. (2016). Farm profits and precision agriculture adoption. *USDA Economic Research Report*, 217.

Swinnen, J., & Kuijpers, R. (2017). Value chain transformation and digital markets. *Food Policy, 69*, 1–12.

World Bank. (2024). *Digital agriculture transformation in Africa*. World Bank Group.

Xu, X., & Wang, Y. (2023). Digital transformation in agriculture: Global perspectives. *Agricultural Systems, 204*, 103–115.

Zhang, Y., Wang, L., & Wang, S. (2018). Precision agriculture and crop yield improvement. *Computers and Electronics in Agriculture, 151*, 97–112.

Zhang, X., et al. (2020). Digital agriculture adoption and policy implications. *Agricultural Systems, 180*, 102–110.