

The Role of Digital Farming Tools on Crop Production among Small Scale Farmers in Ondo State, Nigeria

Ajibare, Abike Yemisi¹, Ogunjobi, Olanrewaju Pius^{2*}, Olalekan Oluwaseun Matina³, Adedayo, R. Olumuyiwa⁴, Joshua, Grace⁵, Arogundade, Damilola Adetutu⁶

¹Department of Science Education (Agricultural Education Unit), Faculty of Education, Federal University Oye-Ekiti, Ekiti State, Nigeria

²Department of Vocational and Industrial Technology Education (Agricultural Education option), Bamidele Olumilua University of Education, Science and Technology, Ikere Ekiti, Ekiti State, Nigeria.

³Department of Agricultural Science and Technology, Bamidele Olumilua University of Education, Science and Technology Ikere Ekiti, Nigeria.

^{4,5}Department of Vocational and Technical Education (Agricultural Education option), Ekiti State University, Ado Ekiti, Ekiti State, Nigeria.

⁶Department of Soil Science, University of Ibadan, Oyo State, Nigeria.

*Corresponding Author

DOI: <https://doi.org/10.51244/IJRSI.2026.1304000246>

Received: 24 March 2026; Accepted: 02 April 2026; Published: 19 May 2026

ABSTRACT

Crop production is crucial to humanity as it provides food security which is the most fundamental for energy, growth, and health thereby preventing malnutrition, providing the essential raw materials for industries, generating employment of various kinds to supporting vast populations particularly in rural areas thus reducing poverty and hunger, driving economic growth and development by creating jobs, generating income and supporting related sectors while also playing a vital role in environmental sustainability. Sustainable farming practices protect soil, conserve water, enhance biodiversity, mitigate climate change and community well-being through resource management and rural development. In essence, agriculture underpins human survival, societal development, and economic stability, making it indispensable for global well-being. Therefore, it will be of great importance to include digital farming tools that use a data-driven approach to increase productivity, efficiency and sustainability in agriculture which is crucial for meeting the food demands of a growing population while minimizing environmental impact among small-scale farmers in Ondo State, Nigeria. This paper looks at the meaning of digital farming and its relevance in crop production, examples of digital farming tools, how small-scale farmers can be benefited using digital farm tools. It was suggested among others that small-scale farmers should be encouraged to start with clear goals and pilot farm before embarking on the use of digital farming tools, government should prioritize training and support for small-scale farmers through agricultural extension services or farmer networks because digital literacy can be a major barrier to its adoption, ensure reliable technical supports, establishment of farmer groups or digital platforms like WhatsApp groups or online forums to share experiences, learn best practices, and access timely information on weather, markets and agronomy.

Keywords: Digital farming tools, Crop production, Small-scale, Farmers

INTRODUCTION

Digital farming is the integration of modern technologies, such as Global Positioning System (GPS) and satellite imagery, to optimize agricultural outcomes. Digital agriculture also can be refers to as the use of computers and other electronic devices in farming and other agricultural endeavors. Narendra *et al* (2019) defined digital

agriculture as ICT and data ecosystems to support development and delivery of timely, targeted (localized) information and services to make farming profitable and sustainable (socially, economically and environmentally) while delivering safe, nutritious and affordable food for the teeming population. Digital agriculture enables farmers and other stakeholders in the agriculture value chain to increase food production using advanced technologies incorporated into a single system. Digital agriculture is a database that contains various information about cultivation, from soil conditions to market assessments, as well as optimal decision operations that aid in making the best choices throughout several agricultural production and distribution processes. This approach will help farmers save time and money, making a more efficient use of crop inputs while measurably improving crop yield and quality (Adding, 2021). Digital farming also known as precision agriculture or smart farming, digital agriculture, smart agriculture or electronic farming (e-farming) is the use of digital technologies in the agricultural sector, including sensors, satellite imagery, drones, GPS mapping, analytical tools and artificial intelligence (AI) to optimize crop production. Digitization can be defined as the use of digital technologies, innovations, and data to transform the business models and practices across the agricultural value chain and address structural bottlenecks in, productivity, post-harvest handling, market access, finance and supply chain management (Tsan *et al*, 2019).

Digital agriculture enables farmers and other stakeholders in the agriculture value chain to increase food production using advanced technologies incorporated into a single system. Digital farming empowers smallholder farmers in Nigeria by bridging the knowledge gap, connecting them to fair-trade buyers, and enabling financial inclusion through mobile technology. This not only improves their livelihoods but also creates a more sustainable food system. By integrating advanced technologies such as data analytics, machine learning, sensors, drones, GPS, and satellite imagery into traditional farming practices, digital agriculture aims to optimize crop production and resource use. As the population increases and climate change pressures intensify, leveraging technology to improve agricultural productivity and sustainability is not just beneficial but it is essential using digital tools.

In Ondo State, even though the farmers are gradually adopting the use of digital farming to manage their enterprise because it allows farmers to collect and analyze data on soil quality, crop health, weather patterns, and other variables in real-time, enabling them to make more informed decisions about planting, irrigation, fertilization, and pest and disease control. In digital farming, Internet of Things (IoT) devices can be used to monitor and control various aspects of agricultural production. For example, smart irrigation systems can adjust watering based on real-time weather and soil conditions, optimizing water usage and reducing waste. Digital agricultural innovations also include digital agricultural solutions and services that encompass services and products offered to end users with the support of digital agricultural technologies. Embracing this transformation is not merely a choice, it is a necessity for global food security and environmental stewardship in Ondo State.

Small-scale farmers are individuals that cultivate plots of land often less than two hectares. They are the backbone of agriculture. According to Ajibare, et al (2025) small-scale agriculture is farming operations that typically involve smaller land areas, often less than two hectares, which is approximately five acres. They said that these farms often prioritize both sustenance and profit, with some focusing on producing food for their consumption while also selling surplus to the local market. They are the ones nurturing the crops that feed families and communities, fostering rich biodiversity, and playing a crucial role in poverty reduction. Agriculture is a major contributor to Nigeria's gross domestic product and small-scale farmers play a dominant role in this contribution (Sabo, et al, 2017). Small-scale farming is vital to large population sectors in Nigeria. It is becoming more relevant as a complement to commercial growing, supplying specialist markets that may require small quantities of specific product. Small-scale farmers are individuals who cultivate small plots of land often less than 2 hectares, relying mainly on family labour, growing food for both subsistence and local markets and playing a crucial role in food security and rural economies. According to FAO (2013), small-scale farmers are farmers who manage areas varying from less than one hectare to 10 hectares. The organisation said that these small-scale farmers are characterized by family-focused motives such as favouring the stability of the farm household system, using mainly family labour for production and using part of the produce for family consumption. Bisht, et al (2022) explained that small-scale farmers is often associated with more sustainable agricultural practices such as crop rotation reduced chemical inputs and biological control. It means small-scale farmers are more likely to use sustainable farming practices like growing a diversity of crops and planting cover crops to improve soil health. Olufolaji (2014) said that smallholder farms produce more than large farms. He

said that the inverse relationship phenomenon exists in farm size and their productivity, as smallholder farmers decide which crop to will give them the best harvest income with minimum inputs. This implies that small-scale farmers are technically more efficient in term of food production.

However, despite their immense contribution, smallholder farmers in Ondo State still face a multitude of challenges. For instance, limited access to resources like fertilizers, quality seeds, and irrigation systems hinders their productivity. Information about best practices, market trends, and weather forecasts often remains elusive. These constraints can trap farmers in cycles of low yield and food insecurity. But a new wave of hope is surging across the nation and most especially in Ondo State and among the small-scale farmers that is, the wave of digital innovation. Understanding the socio-economic determinants and perception-driven adoption behaviour of smallholder farmers in Ondo State has both academic and policy significance. From a scholarly perspective, it fills a gap in the literature by linking traditional adoption frameworks with emerging digital tools in a West African setting. For policymakers and agricultural stakeholders, such insights are critical for designing interventions, such as tailored training, subsidized service models, and cooperative pooling arrangements that can lower barriers and enhance inclusive uptake. Moreover, because smallholders are essential to Nigeria's food security strategy and rural livelihoods, understanding how best to integrate drones into smallholder practice could yield tangible sustainability benefits that align with national agricultural modernization plans (Jellason et al. 2025). This study therefore investigates the socio-economic characteristics and perception factors that influence the adoption of drone technology for smart farming among smallholder farmers in Ondo State, Nigeria. By foregrounding farmers' lived experiences and adoption determinants, it contributes to both the evidence base and policy discourse on digital agriculture transformation in sub-Saharan Africa.

Objectives

The broad objective is to assess the role of digital farming tools on crop production among small scale farmers in Ondo State, Nigeria

The specific objectives were to:

1. examine role of digital farming
2. examine the factors affecting farmers' role of digital farming in the study area.

LITERATURE REVIEW

The growing integration of digital technologies into agriculture has renewed scholarly interest in understanding the determinants of technology adoption among smallscale farmers, particularly in developing economies especially where structural and institutional constraints persist.

Conceptualizing Digital farming in Smart Agriculture

The rapid evolution of smart agriculture has positioned digital farming as one of the most influential digital innovations shaping contemporary farming systems. Smart agriculture emphasizes the use of data-driven tools to enhance productivity, optimize resource use, and improve environmental sustainability, with drones serving as a critical data acquisition platform within this framework (Lowenberg-DeBoer & Erickson, 2019). Recent studies highlight that agricultural drones enable high-resolution monitoring of crop health, soil variability, irrigation efficiency, and pest dynamics, thereby supporting site-specific management practices that are particularly relevant for climate-sensitive and resource-constrained farming systems (Turner et al. 2020; Ayamga et al. 2021). Beyond their technical capabilities, scholars increasingly conceptualize digital farming as a socio-technical system whose effectiveness depends on integration with farmer knowledge, institutional support structures, and digital infrastructure (Klerkx et al. 2019). This broader conceptualization underscores that the successful deployment of digital farming in smallholder agriculture hinges not only on technological performance but also on the socio-economic and behavioural contexts in which farmers operate.

Socio-Economic Characteristics and Digital Farming

Recent adoption literature consistently demonstrates that farmers' socio-economic characteristics play a decisive role in shaping the uptake of digital and precision agriculture technologies. Education, farm size, income level, farming experience, and access to institutional support have been identified as key determinants influencing both adoption capacity and willingness (Lowenberg-DeBoer & Erickson, 2019; Adebayo & Ogunleye, 2021). Empirical evidence since 2019 indicates that educated farmers are more likely to understand and utilize complex technologies such as smart agriculture, while larger farm sizes increase the economic feasibility of capital-intensive innovations through scale advantages (Schimmelpfennig, 2020; Ayamga et al., 2021). In developing country contexts, income constraints, limited access to credit, and weak extension systems further condition adoption outcomes, often excluding smallholders from the benefits of advanced technologies (Ogunleye & Adegbite, 2022). These findings suggest that socio-economic characteristics do not operate in isolation but interact with broader institutional environments to influence technology adoption trajectories, particularly in smallholder-dominated regions such as Ondo State.

Digital Farming and its Roles

Digital tools from mobile applications to weather data platforms are emerging as game-changers, empowering smallholder farmers to overcome these long-standing obstacles. For generations, small-scale farmers have relied on experience passed down through families and communities to nurture crops and raise livestock. This is where digital farming comes to the rescue. By leveraging mobile applications, online platforms, and other digital tools, farmers can bridge the knowledge gap and gain access to a wealth of resources, including up-to-date Agricultural Information. Digital platforms provide comprehensive information on planting techniques, pest control methods, and crop management tailored to specific locations and weather conditions. It provides access to real-time data on optimal sowing times or targeted pest control solutions based on the latest research all at fingertips of farmers. The digital world transcends geographical boundaries. Online forums and communities connect farmers with their peers across the globe allowing them to learn from successful practices implemented in different regions. This cross-pollination of ideas fosters innovation and empowers farmers to adapt proven techniques to their contexts (Trendor, et al, 2019 and Foutas, et al, 2020).

Importance of Digital Agriculture

According to Antle and Basso (2020) and Addom (2021) who posited that the importance of digital agriculture could be the following;

- Digital agricultural technologies can monitor factors such as moisture, nutrient trends, soil composition, and wind patterns of arable land. The digital agriculture system collects data accurately (such as weather information) using external sources. The combined data is examined and interpreted to help the farmer make better decisions. Robotics and advanced equipment quickly put these decisions into action with greater accuracy, and farmers can receive real-time feedback on the effects of their actions. Farmers rely on cutting-edge technologies to collect and analyze data from their farms to maximize their harvests.
- Accurate weather predictions, yield mapping, variable-rate applications (of water, herbicides, and fertilizers), and GPS guiding systems are all components of digital agriculture.
- Digital agriculture technologies work on the Internet of Things (IoT) principles. These technologies include sensors, telecommunication systems, unmanned aerial systems, machine intelligence, automation, and other advanced machinery.
- Digital agriculture systems offer a unique perspective that improves the capacity to make and apply decisions. Improve decision-making by providing real-time insights for better timing of operations.
- The current generation of farmers utilizes robots to plant and harvest crops.
- Aerial drones can be used to provide insights that humans would miss on the ground. Information gathered by drones can be used in various ways including improving harvest time, irrigation, and pest control.

- Digital agriculture technologies reduce climate change vulnerabilities by predicting weather forecasts. Digital agriculture can improve farmers' capacity to respond to weather conditions affected by climate changes through accurate climate forecasts to make better decisions regarding various livelihood strategies thanks to information distributed to communities via radio broadcasts and mobile communications.
- Bulletins and notifications from extension services, which are digitally enabled services, can support agricultural producers unaware of digital technologies. Digital farming tools are technologies like sensors, drones, satellites, AI, and mobile apps that collect, analyze, and use data to make farming more efficient, productive, and sustainable, allowing for precise decisions on irrigation, fertilization, pest control, and resource management from planting to harvest. These tools often called smart farming or precision agriculture, optimize farm operations by providing real-time insights into soil health, weather, and crop status, reducing waste and increasing yields.
- Optimize Inputs by applying water, fertilizer, and pesticides only where and when needed, reducing waste and cost. Increase yield and quality through data-driven practices that lead to healthier crops and better output.,
- Enhance sustainability by minimizing environmental impact through precise resource use and streamline operations from planning to sales, digital tools simplify complex tasks.
- Smallholder farmers can now bridge the gap between farm and market, ensuring they receive a just reward for their produce. Traditionally, smallholder farmers have limited options when it comes to selling their crops. They often rely on local markets with restricted reach or worse, middlemen who take a hefty cut of the profits. This not only limits their income but also reduces their control over pricing and distribution.
- Precision farming replaces a one-size-fits-all approach with a targeted strategy. By collecting and analyzing data on various aspects of their fields, farmers can identify areas with specific needs. This allows for better resource management. Imagine applying fertilizer only to areas that require it, or adjusting irrigation based on real-time soil moisture data. Precision farming helps farmers optimize water usage, fertilizer application, and other resources, leading to significant cost savings.
- Increased Yields: With a deeper understanding of their crops' health and environmental conditions, farmers can make adjustments to maximize yields. This might involve using targeted pest control measures or adjusting planting times based on weather forecasts.

While this traditional knowledge sharing holds immense value, it can be limited by factors like as suggested by Trendor, et al (2019):

- Geographic Scope: Local knowledge may not address challenges specific to a different climate or soil type.
- Outdated Information: Agricultural practices and technologies constantly evolve, and traditional methods may not reflect the latest advancements.
- Limited Accessibility: Disseminating information through word-of-mouth can be slow and exclude farmers in remote areas.

Examples of Digital Farming Tools

Researchers like Narendra, et al (2019) and Tsan, et al (2019) gave examples of digital learning tools which include:

- Artificial intelligence (AI): Advanced farming approaches use artificial intelligence (AI) in agriculture by applying computer or machine learning from data to bring efficiencies and solutions to farming and the food supply. Supported by AI, farmers can make better informed decisions based on large and complex data sets. For instant, AI algorithms used in agriculture, specifically in digital farming, can identify images and patterns in data, and continuously learn from this information, then adjust to make more timely and better

agronomic recommendations to optimize crop production for smallholder farmers. The performance of these algorithms is also enhanced over time, with the inclusion of new data like incorporation of new sources of field-specific data or hyper local weather information, resulting in faster and more precise agronomic recommendations. Farmers rely on cutting-edge technologies to collect and analyze data from their farms to maximize their harvests. Digital agricultural technologies can monitor factors such as moisture, nutrient trends, soil composition, and wind patterns of arable land.

- **Internet of Things Devices:** Internet of Things for Post-Harvest Management helps monitor storage conditions like humidity, temperature, and pests. It improves food security, protects grain quality, reduces spoilage during storage and transit. Sensors and IoT (Internet of Things) devices also used for measuring soil moisture, nutrient levels and crop health in real-time for precise monitoring.
- **GPS and Precision Guidance:** Used in tractors and machinery for accurate planting, spraying, and variable rate application of inputs.
- **Data Analytics and AI (Artificial Intelligence):** Platforms that process sensor/imagery data to predict and analyze data from sensors, satellites, and historical records to provide insights on best planting times, disease risk, and optimal harvest or yields, disease risk, and provide management recommendations.
- **Farm Management Software (FMS):** Integrates data from various sources to offer comprehensive farm planning, tracking, and analysis. It provides consumers and regulators adequate knowledge about food from farm to fork, ensuring safety and authenticity that will help to meet export requirements and identifies bottlenecks in production.
- **Mobile Applications and Digital Platforms:** Connect farmers directly to markets, provide weather forecasts, offer advice, and facilitate transactions. Imagine a farmer, toiling under the sun, nurturing a bountiful harvest. But when it comes time to sell their crops, they face a harsh reality of limited reach and exploitative middlemen. This is the plight of many smallholder farmers, a challenge that significantly hinders their ability to earn a fair profit for their hard work.

The digital agriculture system collects data accurately (such as weather information) using external sources. The combined data is examined and interpreted to help the farmer make better decisions. Robotics and advanced equipment quickly put these decisions into action with greater accuracy, and farmers can receive real-time feedback on the effects of their actions. Accurate weather predictions, yield mapping, variable-rate applications (of water, herbicides, and fertilizers), and GPS guiding systems are all components of digital agriculture. Digital agriculture can improve farmers' capacity to respond to weather conditions affected by climate changes through accurate climate forecasts. A silent force drives the Nation's food security and rural economy through the smallholder farmer.

Empowering Small-Scale Farmers through Digital Platforms

Digital farming platforms are revolutionizing this dynamic. These online marketplaces connect farmers directly with consumers or fair-trade buyers, eliminating the need for exploitative middlemen. Farmers can list their produce, set their prices, and receive a larger share of the profits, in cash crops. Additionally, these platforms often offer features like secure payment processing and logistics support, streamlining the entire sales process.

Transparency and Knowledge at their Fingertips. Digital farming empowers smallholder farmers beyond just market access. Price comparison tools allow them to compare prices across different markets, ensuring they get the best deal for their crops. Market trend analysis features provide valuable insights into consumer demand and future pricing fluctuations, allowing farmers to make informed decisions about planting and harvesting cycles.

The Future of Fair and Sustainable Agriculture. By bridging the gap between farm and market, digital farming is not just improving the lives of smallholder farmers, it also create a more sustainable and equitable food system. With greater transparency and control, farmers are incentivized to adopt sustainable practices, leading to healthier crops and a reduced environmental footprint.

The digital revolution in agriculture is still unfolding among small-scale farmers but its potential to empower small-scale farmers and create a more just and sustainable food system is undeniable. As digital farming continues to evolve, we can expect even more innovative solutions that will transform the agricultural landscape for the better. Smallholder farmers the backbone of food production globally, most especially Nigeria, often face significant hurdles such as:

Limited access to financial services. This lack of financial inclusion hinders their ability to invest in critical resources like seeds, fertilizers, and irrigation equipment, ultimately restricting productivity and income. Traditionally, financial services have been largely out of reach for many smallholder farmers. Geographical remoteness, complex paperwork, and a lack of formal credit history can create barriers to obtaining loans from traditional banks. This limited access to credit restricts farmers' ability to invest in improvements, hindering their ability to adapt to changing weather patterns, adopt new technologies, or scale their operations.

Digital farming solutions are revolutionizing this landscape. By leveraging mobile technology and online platforms, these solutions connect farmers directly with microfinance institutions and other lenders. This streamlines the loan application process, often eliminating the need for extensive paperwork. Additionally, digital tools can collect and analyze farm data, creating a creditworthiness profile based on a farmer's production history and land ownership. This data-driven approach allows lenders to better assess risk and offer financial products tailored to the specific needs of smallholder farmers.

Furthermore, mobile payment platforms play a crucial role in ensuring secure and transparent financial transactions. Farmers can receive loans and repay them directly through their mobile phones, eliminating the risks associated with cash handling. This transparency also builds trust with lenders, potentially leading to more favorable loan terms for farmers in the long.

The foundation of precision farming hinges on the power of data. Digital tools play a crucial role on:

- **Soil Conditions:** Sensors embedded in the ground can provide real-time data on factors like moisture levels, nutrient composition, and acidity. This allows for targeted fertilizer application and irrigation practices.
- **Weather Patterns:** Advanced weather monitoring systems can track rainfall, temperature, and humidity fluctuations. This helps farmers anticipate potential threats like frost or excessive rain and take necessary precautions.
- **Crop Health:** Drones equipped with multi-spectral cameras can capture detailed images of crops, revealing potential diseases, nutrient deficiencies, or pest infestations. With this information, farmers can implement targeted interventions to ensure healthy crops.

Digital farming tools boost crop production by enabling precision agriculture, using data from sensors, drones, and satellites to optimize resources (water, fertilizer, pesticides), monitor crop health in real-time, automate tasks, and provide data-driven insights for better decision-making, leading to higher yields, reduced costs, and improved sustainability. These technologies shift farming from generalized practices to targeted interventions, managing variability within fields for maximum efficiency (Ogunjobi & Owoseni, 2025).

METHODOLOGY

This study adopted a descriptive survey research design to assess the role of digital farming tools on crop production among small scale farmers in Ondo State, Nigeria. The descriptive design was considered appropriate because it allows for the systematic collection of quantitative data from a defined population in order to describe existing conditions, identify relationships among variables. This approach is widely used in agricultural technology adoption studies, particularly where the objective is to capture farmers' characteristics, roles and behavioural responses within real-world production systems.

The study was conducted in Ondo State, located in southwestern Nigeria. Ondo State lies between latitudes 5°45' and 8°15' North and longitudes 4°20' and 6°05' East. The state is characterized by a tropical climate with distinct wet and dry seasons, making it suitable for the cultivation of arable crops such as maize, cassava, rice, yam,

vegetables, and legumes. Agriculture constitutes a major livelihood activity in the state, with farming systems dominated by smallholder farmers who rely largely on rain-fed production and traditional farming practices.

Ondo State was purposively selected because of its significant agricultural potential, growing interest in agricultural modernization, and increasing exposure to digital and smart farming initiatives promoted by government agencies, research institutions, and private agribusiness actors. These characteristics make the state a suitable location for examining the role of digital farming tools on crop production among small scale farmers in Ondo State.

A multi-stage sampling technique was employed to select respondents for the study.

In the first stage, two Local Government Areas (LGAs): Akure South and Ifedore were purposively selected based on their high concentration of arable crop farmers and accessibility for data collection. In the second stage, farming communities within the selected LGAs were identified with the assistance of agricultural extension officers and farmer associations.

In the third stage, a random sampling technique was used to select individual farmers from the identified communities. This ensured that each farmer had an equal chance of being included in the sample, thereby reducing selection bias. A total of 120 smallholder farmers were selected for the study. This sample size was considered adequate for statistical analysis and consistent with similar empirical studies on digital farming (technology adoption) among smallscale farmers in developing countries. The study relied primarily on primary data, collected through the use of a structured questionnaire administered to sampled farmers. The questionnaire was designed to elicit quantitative information relevant to the study objectives. Socio-economic characteristics were measured using standard categorical and continuous variables. Role of digital farming tools on crop production among small scale farmers in Ondo State was measured using a 5-point Likert scale, ranging from *strongly disagree (1)* to *strongly agree (5)*, based on statements relating to perceived usefulness, ease of use, cost, and relevance to farming activities. Data collected were coded and analyzed using appropriate statistical software. Descriptive statistical techniques were used. Descriptive statistics such as frequencies, percentages, means, and standard deviations were used to summarize the socio-economic characteristics of respondents and describe the roles of digital farming tools on crop production among small scale farmers in Ondo State.

RESULTS AND DISCUSSION

This section presents and discusses the findings of the study on the role of digital farming tools on crop production among small scale farmers in Ondo State, Nigeria. The analysis was based on data obtained from 120 arable crop farmers in Akure South and Ifedore Local Government Areas. Descriptive statistics (frequencies, percentages, and means) were used to address the study objectives.

Socio-Economic Characteristics of Respondents

The socio-economic profile of respondents provides insight into the background conditions that may shape digital farming adoption decisions. The results indicate that most respondents (54.2%) were between 36 and 55 years, representing an economically active and innovation-capable age group. Farming was male-dominated, consistent with patterns reported in Nigerian agriculture. Although one-third of respondents had no formal education, nearly one-quarter attained tertiary education, suggesting a moderate potential for technology comprehension. The predominance of smallholder farmers (<2 ha) confirms that drone adoption decisions occur within resource-constrained production systems.

The results from the survey indicate that smallscale farming in the study area was dominated by economically active individuals. Most respondents were within the middle-age bracket, suggesting that farming in Ondo State is largely undertaken by individuals with sufficient physical capacity and decision-making responsibility. This age structure has important implications for technology adoption, as farmers within this group are generally more open to innovation than older farmers, while still possessing adequate farming experience to evaluate new technologies.

Gender distribution shows a clear predominance of male farmers. This reflects the gendered nature of land ownership and access to productive resources in southwestern Nigeria, where men are more likely to control farm assets and make strategic production decisions. Educational attainment among respondents varied, but a substantial proportion had at least basic or secondary education. This level of literacy is critical for understanding and engaging with digitally driven technologies such as drones, GPS, AI which require some degree of technical comprehension and interpretation of data outputs.

Farm size results confirm the dominance of smallscale agriculture in the study area, with most respondents cultivating less than five hectares of land. While this reinforces the relevance of the study to smallscale systems, it also highlights a structural limitation to digital farming adoption, given the relatively high cost of technology and the limited economies of scale available to small farms. Farming experience among respondents was generally moderate to high, indicating that farmers possess substantial practical knowledge, which can either encourage innovation, when traditional methods prove insufficient or reinforce resistance to change.

Table 1: Socio-Economic Characteristics of Respondents (n = 120)

Variable	Category	Frequency	Percentage (%)
Age (years)	26–35	14	11.7
	36–45	32	26.7
	46–55	33	27.5
	56–65	28	23.3
	66–75	13	10.8
Sex	Male	81	67.5
	Female	39	32.5
Marital Status	Single	21	17.5
	Married	74	61.7
	Separated	7	5.8
	Divorced	3	2.5
	Widowed	15	12.5
Education Level	No formal education	40	33.3
	Primary	26	21.7
	Secondary	26	21.7
	Tertiary	28	23.3
Farming Experience	< 5 years	28	23.3
	5–10 years	33	27.5
	> 10 years	59	49.2
Farm Size	< 2 ha	68	56.7
	2–5.99 ha	37	30.8
	> 6 ha	15	12.5
Household Size	1–5 persons	40	33.3
	6–10 persons	38	31.7
	> 10 persons	42	35.0

Source: Field Survey, 2025.

Roles of Digital Farming

The respondents strongly agreed that digital farming can improve productivity and efficiency (mean = 3.99) and can help reduce labour and time costs (mean = 3.91). This reflects farmers’ recognition of digital farming as modern tools that can ease farming activities and enhance output. This is in tandem with the findings of Adekoya et al, (2022) on their studies on Farmers’ Perception and Willingness to Adopt Technology in Agriculture in Nigeria where majority of their respondents opined that digital farming utilization enhanced agricultural

productivity Another important perception is that digital farming can help detect pests and diseases early (mean = 3.90). This shows that farmers understand the role of digital farming in crop monitoring and in preventing yield losses due to infestations.

However, the highest-rated statement was that digital farming are too complex for smallscale farmers (mean = 4.73). This finding is very significant. It suggests that, although farmers see the benefits, they also feel that the technical requirements of operating digital farming are beyond their current capacity. This aligns with the general challenges of technological adoption in rural areas, where training and technical support are often limited. On the encouraging side, a high mean score (4.18) was recorded for willingness to use digital farming if training is provided. This shows that the barrier of complexity is not permanent; with the right training and extension support, many farmers are open to adoption.

In summary, farmers in the study area perceived digital farming as useful and beneficial in improving productivity, reducing labour, and detecting pests and diseases. Yet, the perception of complexity remains a major concern. The strong willingness to adopt training suggests that policies promoting capacity-building and extension services can play a decisive role in translating awareness and positive perceptions into actual adoption.

Table 2: Roles of Digital farming

Roles of digital farming Statement	Mean	Remark
Digital farming improve productivity & efficiency	3.99	Agree
Digital farming reduce time & labour costs	3.91	Agree
Digital farming detect pests & diseases early	3.90	Agree
Digital farming are too complex for smallholder farmers	4.73	Strongly Agree
Willingness to use Digital farming if training is provided	4.18	Agree
Grand Mean	4.14	

Source: Field Survey, 2025.

Factors affecting the roles of Digital Farming

The results in Table 3 show that all the listed factors significantly influenced the adoption of digital farming. The grand mean of 4.52 indicates a very strong agreement among respondents that these factors play a key role. The high cost of digital technology (mean = 4.73) and lack of financial support (mean = 4.73) were rated the highest, confirming that affordability is the biggest challenge to adoption. Farmers recognised that digital farming are expensive and beyond the reach of smallholders unless loans or subsidies are provided. Knowledge and training issues also emerged clearly. Both limited training opportunities (mean = 4.48) and lack of technical knowledge (mean = 4.44) were considered significant, showing that farmers are interested but lack the skills and opportunities to learn how to use drones. Institutional and infrastructural challenges were also highlighted. Government regulations (mean = 4.48) and poor internet connectivity (mean = 4.23) were identified as additional hurdles that make it difficult to fully adopt the technology.

In general, these results suggest that while farmers are open to digital farming adoption, cost and training are the most critical issues, supported by policy and infrastructure barriers. Addressing affordability through financial schemes and providing structured training programs could significantly improve adoption rates.

Table 3: Factors affecting the roles of Digital Farming

Factors	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Mean	Remark
High cost of technologies	88 (73.3)	32 (26.7)	–	–	–	4.73	Strongly Agree
Lack of technical knowledge	53 (44.2)	67 (55.8)	–	–	–	4.44	Agree
Access to financial support would encourage	88 (73.3)	32 (26.7)	–	–	–	4.73	Strongly Agree

Government regulations make adoption difficult	60 (50.0)	58 (48.3)	2 (1.7)	–	–	4.48	Agree
Poor internet connectivity	69 (57.5)	25 (20.8)	11 (9.2)	15 (12.5)	–	4.23	Agree
Limited access to training programs	60 (50.0)	58 (48.3)	2 (1.7)	–	–	4.48	Agree
Grand Mean						4.52	Agree

Source: Field survey, 2025

CONCLUSION

In conclusion, the integration of digital tools into farming practices is not just about optimizing crop yields and resource management. It is about empowering smallholder farmers with financial inclusion. By bridging the gap between farmers and financial institutions, digital farming solutions unlock a world of possibilities, allowing smallholders to invest in their farms, increase their incomes, and become more resilient in the face of a changing agricultural landscape. The world’s population is growing, and so is the demand for food. By harnessing the power of data, automation, and connectivity, digital tools enable farmers to grow more with less stress, adapt to changing climates, and meet the rising demand for food more sustainably. To meet this challenge, farmers are turning to digital farming a revolutionary approach that leverages technology to optimize yields and resource management. It has potential to revolutionize farming among smallholder farmers by empowering them with valuable information, market access and financial services. At the heart of digital farming lies precision farming, a data-driven strategy that empowers farmers to make informed decisions about their crops. Digital agriculture is more than just a technological upgrade, it represents a paradigm shift in how farmers cultivate crops and manage farm operations.

RECOMMENDATIONS

Based on the findings, it was recommended among others that:

1. The Small-Scale Farmers Should Be Encouraged To Start With Clear Goals And A Pilot Farm Before Embarking on The Use of Digital Farming Tools.
2. Government Should Prioritize Training And Support For Small-Scale Farmers Through Agricultural Extension Services Or Farmer Networks Because Digital Literacy Can Be A Major Barrier To Adoption.
3. Ensure Reliable, Stable Internet Connectivity And Reliable Electricity, Establishment Of Farmer Groups Or Digital Platforms Like Whatsapp Groups Or Online Forums to Share Experiences, Learn Best Practices, And Access Timely Information On Weather, Markets and Agronomy.
4. Traditionally, Financial Services Have Been Largely Out of Reach For Many Smallholder Farmers. Government Should Adequately Fund Small-Scale Farmers.

REFERENCES

1. Adebayo, O. O., & Ogunleye, K. Y. (2021). Institutional barriers to smart agriculture in sub-Saharan Africa. *African Journal of Science, Technology and Innovation*, 13(2), 112–129.
2. Addom, B.K. (2021). Digitalization and Smallholder Agriculture. [https:// d4ag.com](https://d4ag.com).
3. Adding, A. (2021). Structure of a Digital Agriculture System and Agriculture Risk Due to Climate Change. *Agriculture and Agricultural Procedia* 1, 42-51. <https://doi.org/10.1016/j.aaspro.2010.09.006>
4. Ajibare, A.Y., Ogunjobi, O.P., & Owolabi, M. (2025). Impact of Agricultural Education on the Productivity of Small-Scale Agriculture in Ekiti State, Nigeria. *Nigerian Journal of Engineering, Technology, Science and Environment*. 1(01). [www. Njetse.dsust.edu.ng](http://www.Njetse.dsust.edu.ng)
5. Antle, J. & Basso, B. (2020). Digital Agriculture to Design Sustainable Agricultural System. *Nature sustainability*, 3(4), Article 4. <https://www.nature.com/articles/541893-020-0510-0>
6. Bisht, O. I. Ayua, G. A. Bichi, S. S. Usman, I. A. & Lawal, F. K. (2022). Impact of Creative Teaching on Interest in Basic Science among Varied-ability Upper Basic Science Students in Makurdi, Nigeria. *Umaru Musa Yaradua University Journal of Education*. 11(1), 15-22.

7. Food and Agriculture Organisation of the United Nations (FAO) (2013). Smallholders and family farmers. <http://openknowledge.FAO.org/handle/20500.14283/ar588e>
8. Fountas, S. Espejo-Garcia, B. Kasimati, A. Mylonas, N. and Darra, N. (2020). Opportunities. IT Professional, 22(1), 24-28 <http://eeexplore.lee.org/abstract/document/8994135>
9. Narendra, V.N. Sahana, S. & Chaithrashree, J. (2019). Digital Agriculture. Bulletin of Environment, pharmacology and life sciences 8(6):164-170. Online ISSN 227-1808. <http://www.beppls.com>.
10. Ogunjobi, O.P and Owoseni, K.P. (2025). Effect of Technology-Enhanced Instructions
11. on Students' Learning Outcome in Agricultural Science in Ekiti State Senior Secondary Schools. International Journal of Research and Scientific Innovation (IJRSI). Online E-Journal ISSN 2321-2705| DOI: 10.51244/IJRSI | XII (I) 178
12. Ogunleye, K. Y., & Adegbite, O. (2022). Policy readiness for drone-based agriculture in Nigeria. Technological Forecasting and Social Change, 181, 121759.
13. Olufolaji, S. O. (2014). Human Capital Development and Sustainable Development: Evidence from Nigeria. Studia Universita Babeş-Bolyai Oeconomica. 67(1), 63-77.
14. Sabo, B. B. Isals, D. Chamo, A. M. and Rabiu M.A. (2017). Role of Smallholder Farmers in Nigeria's Food Security. Scholarly Journal of Agricultural Science 7(1), 1-5. <http://www.scholarly-journal.com/SJAS.ISSN227-71118>.
15. Trendor, N. M., Varas, S. & Zeng, M. (2019). Digital Technologies in Agriculture and Rural Area-Status Report. Rome. Licence:cc by nc-sa 3.0 igo. <https://www.researchgate.net/publication/3440415000> .
16. Tsan, M., Totapally, S., Hailu, M. and Addom, B.K. (2019). The digitalisation of African Agriculture Report, 2018-2019. Wageningen: Technical Centre for Agricultural and Rural Cooperation ACP-EU(CTA) and Dalberg Advisers.

Ethical Considerations

Ethical Approval: ethical approval was obtained before the research was carried out.

Conflict of Interest: There is no conflict of interest among the authors.