

Farmers' Perception toward Utilization of Drone Technology for Smart Farming in Ondo State, Nigeria

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DOI: <https://doi.org/10.51244/IJRSI.2026.13020012>

Received: 05 February 2026; Accepted: 11 February 2026; Published: 24 February 2026

ABSTRACT

This study assessed the perception-driven utilization of drone technology for smart farming among smallholder farmers in Ondo State, Nigeria. Specifically, the study: examined the socio-economic characteristics of arable crop farmers influencing the utilization of drone technology for smart farming in Ondo State; examined farmers' perceptions of drone technology and; examined the factors affecting the utilization of drone technology. Using a descriptive survey design and multi-stage sampling, primary data were collected from 120 arable crop farmers in Akure South and Ifedore LGAs. Descriptive statistics were employed. A descriptive survey design was used. Data was collected from 120 farmers selected through multi-stage sampling across Akure South and Ifedore LGAs using a structured questionnaire. Descriptive statistics (frequencies, percentages, means, and grand means) were employed. The findings revealed that most respondents were male, within the productive age group of 36–55 years, and smallholder farmers cultivating less than 2 hectares. Farmers generally had a positive perception of drones, with grand mean values above 4.00, indicating strong agreement that drones improve productivity, save time, and detect pests and diseases. However, drones were also perceived as complex. The major factors affecting adoption were high cost, lack of technical knowledge, poor internet connectivity, restrictive government regulations, and limited training opportunities. The findings contribute to policy and extension strategies for scaling precision agriculture in sub-Saharan Africa.

Keywords: Farmers, Perception, utilization, drone technology, smart farming.

INTRODUCTION

Agriculture remains the backbone of Nigeria's economy, accounting for roughly one-quarter of the nation's gross domestic product and employing an estimated 70–80% of the rural labour force, most of whom are smallholder farmers working on plots smaller than five hectares (Path of Science, 2024). Agriculture in Ondo State reflects this national pattern: predominantly smallholder and rain-fed, with limited access to modern inputs, weak irrigation coverage, and persistent constraints in productivity and rural incomes (Path of Science, 2024). In this context of structural challenges, precision agriculture, especially drone-based tools have emerged on the global research and policy agenda as a potential transformative technology capable of enhancing efficiency, environmental sustainability, and farm profitability.

Unmanned aerial vehicles (UAVs), commonly referred to as drones, provide farmers with real-time, high-resolution data on crop health, soil conditions, water stress, nutrient deficiencies, pest infestations, and other agronomic variables. These capabilities reduce wasteful input use, enable targeted interventions, and can improve crop yields while mitigating environmental risks (Alih, 2025; Farmonaut, 2024). In developed agricultural systems, drones are increasingly used for tasks such as crop mapping, variable rate application of fertilizers and pesticides, and multispectral analysis that informs decision-making at field scale. Emerging evidence suggests that similar applications have begun to take root in sub-Saharan Africa, albeit unevenly and with substantial barriers to adoption (Singh et al., 2025).

In Nigeria, interest in precision agriculture has grown alongside government-backed modernization initiatives and private sector investments. A recent industry analysis estimates that the adoption of digital agricultural tools (including drones) is accelerating, driven by the need to enhance crop monitoring, reduce post-harvest losses, and bolster food security outcomes for a population experiencing persistent food insecurity (Kasenzu, 2024). However, despite these drivers, overall technology adoption remains constrained by multiple socio-economic and institutional challenges. For example, high upfront capital costs, as much as USD 12,000 per drone unit pose significant affordability hurdles for smallholders, while limited extension services and regulatory ambiguities further dampen uptake in rural areas (Guan et al, 2025).

These structural constraints underline the importance of understanding which farmers adopt and why, as well as how perceptions of drones influence adoption behaviours. Adoption of agricultural innovations, particularly digital or precision technologies, is not determined solely by the objective performance advantages of the technology; rather, it is fundamentally mediated by socio-economic characteristics and perception-driven behavioural responses among farmers (Nyairo et al, 2025; Mpho et al, 2021). In the Technology Acceptance Model (TAM) and Diffusion of Innovations frameworks applied to agriculture, perceived usefulness, perceived ease of use, relative advantage, and compatibility with existing practices are key determinants of adoption willingness and eventual uptake (Ajakaiye, 2023). These models have been successfully applied to assess digital tools adoption among rural farmers in other developing contexts, illustrating the interplay between perceptions and structural attributes such as education, age, farm size, income, and access to infrastructure (Nafar, 2025; Puska, 2024).

Across smallholder farming systems, socio-economic factors consistently influence not only the capacity but also the readiness to accept innovations. Education level enhances farmers' ability to interpret and act on new information, thereby fostering positive perceptions about the technology's utility. Farm size often determines economies of scale, with larger operators more likely to absorb fixed technology costs and generate returns on investment. Farming experience can shape risk perceptions and willingness to experiment with new practices, while household income and access to credit directly impact affordability (Mamabolo, 2025; Gokool, 2023). Beyond individual profiles, external institutional factors such as availability of extension services, cooperative membership, and participation in training programs have also been identified as facilitators of technology adoption (Barman et al., 2024). These socio-economic determinants function both independently and interactively with perception dimensions, shaping adoption outcomes in complex ways.

Empirical studies in neighbouring sub-Saharan contexts support this multidimensional adoption lens. For instance, research in Malawi found that smallholder farmers who interacted with drone-derived data were better able to make informed crop decisions that reduced input use and improved farm productivity, but uptake was limited by cost, data privacy concerns, and lack of institutional support (McCarthy, 2023). Similarly, studies of digital technology adoption among smallholders in South Africa show that education, income, and technology costs significantly influence farmers' perceptions and willingness to adopt digital tools (Kwao et al., 2024). These findings underscore the need to situate any assessment of drone adoption within the socio-economic realities of the target population rather than assuming universal uptake based solely on technical performance.

In Nigeria specifically, evidence on adoption patterns for digital and precision agriculture tools remains sparse, particularly in the context of smallholder cropping systems that dominate regions like Ondo State. Although local research has explored thematic areas such as smartphone app use and other forms of digital advisory services among smallholders in Southwest Nigeria, there is limited peer-reviewed research concentrating on

drone adoption and the factors that shape farmer perceptions (Odhiambo & Kipkorir, 2024). The relative novelty of drone technology in local smallholder settings, combined with capital intensity and limited infrastructure makes Ondo State an ideal empirical context for advancing this research frontier.

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, Robinson & Ogbaga, 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 empirical evidence base and policy discourse on digital agriculture transformation in sub-Saharan Africa.

Objectives

The broad objective is to assess farmers' perceptions and adoption of drone technology for smart farming in Ondo State, Nigeria.

The specific objectives were to:

1. examine farmers' perceptions of drone technology
2. examine the factors affecting farmers' adoption of drone technology 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 smallholder farmers, particularly in developing economies where structural and institutional constraints persist.

Conceptualizing Drone Technology in Smart Agriculture

The rapid evolution of smart agriculture has positioned drone technology 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, Lucieer, & Wallace, 2020; Ayamga, Tekinerdogan, & Kassahun, 2021). Beyond their technical capabilities, scholars increasingly conceptualize drone technology as a socio-technical system whose effectiveness depends on integration with farmer knowledge, institutional support structures, and digital infrastructure (Klerkx, Jakku, & Labarthe, 2019). This broader conceptualization underscores that the successful deployment of drones 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 Technology Adoption

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 drones, 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.

Perception and Adoption Dynamics

Perception has emerged as a central explanatory variable in recent technology adoption studies, especially for digital innovations that require new skills and behavioural adjustments. The Technology Acceptance Model and related frameworks emphasize that perceived usefulness and perceived ease of use are critical drivers of farmers' intention to adopt new technologies (Venkatesh, Thong, & Xu, 2021). Contemporary studies show that farmers are more inclined to adopt drone technology when they perceive clear agronomic and economic benefits, such as improved yield monitoring, reduced input waste, and enhanced decision-making accuracy (Turner et al., 2020; Ayamga et al., 2021). Conversely, perceptions of high cost, technical complexity, and incompatibility with existing farming practices significantly deter adoption among smallholder farmers (Klerkx et al., 2019; Ogunleye & Adegbite, 2022). Importantly, recent literature emphasizes that perception mediates the relationship between socio-economic characteristics and adoption behaviour, indicating that positive perceptions can partially offset structural constraints when supported by training, demonstrations, and peer learning mechanisms (Adebayo et al., 2022). Understanding these perception-driven dynamics is therefore essential for designing policies and interventions aimed at scaling drone-based smart farming in resource-constrained agricultural systems.

METHODOLOGY

Research Design

This study adopted a descriptive survey research design combined with analytical techniques to examine the socio-economic determinants and perception-driven adoption of drone technology for smart farming among smallholder 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, and test hypotheses related to technology adoption behaviour. This approach is widely used in agricultural technology adoption studies, particularly where the objective is to capture farmers' characteristics, perceptions, and behavioural responses within real-world production systems.

Study Area

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 emerging adoption patterns of drone technology within smallholder farming systems.

Sampling Procedure and Sample Size

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 technology adoption among smallholder farmers in developing countries.

Sources and Methods of Data Collection

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 and hypotheses.

Measurement of Variables

Socio-economic characteristics were measured using standard categorical and continuous variables. Perception of drone technology 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.

Method of Data Analysis

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 their perceptions of drone technology.

RESULTS AND DISCUSSION

This section presents and discusses the findings of the study on farmers' perception on the utilization of drone technology for smart farming 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 technology 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 smallholder 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, which require some degree of technical comprehension and interpretation of data outputs.

Farm size results confirm the dominance of smallholder agriculture in the study area, with most respondents cultivating less than five hectares of land. While this reinforces the relevance of the study to smallholder systems, it also highlights a structural limitation to drone adoption, given the relatively high cost of drone 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.

Perception of Drone Technology

The respondents strongly agreed that drones can improve productivity and efficiency (mean = 3.99) and can help reduce labour and time costs (mean = 3.91). This reflects farmers’ recognition of drones 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 Drone Technology in Agriculture in Nigeria where majority of their respondents opined that drone utilization enhanced agricultural productivity. Another important perception is that drones can help detect pests and diseases early (mean = 3.90). This shows that farmers understand the role of drones in crop monitoring and in preventing yield losses due to infestations.

However, the highest-rated statement was that drones are too complex for smallholder 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 drones 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 drones 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 drones 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: Farmers’ Perceptions of Drone Technology

Perception Statement	Mean	Remark
Drones improve productivity & efficiency	3.99	Agree
Drones reduce time & labour costs	3.91	Agree
Drones detect pests & diseases early	3.90	Agree
Drones are too complex for smallholder farmers	4.73	Strongly Agree
Willingness to use drones if training is provided	4.18	Agree

Grand Mean	4.14	
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Source: Field Survey, 2025.

Factors Affecting the Adoption of Drone Technology

The results in Table 3 show that all the listed factors significantly influenced the adoption of drone technology. The grand mean of 4.52 indicates a very strong agreement among respondents that these factors play a key role. The high cost of drones (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 drones 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 drone 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 Utilization of Drone Technology

Factor	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Mean	Remark
High cost of drones	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 AND POLICY IMPLICATIONS

Policies should focus on lowering cost barriers, cooperative access, and sustained training to convert positive perceptions into utilization. The results confirm that drone utilization among smallholder farmers in Ondo State is perception-driven rather than demographically determined. Farmers are receptive to innovation but

constrained by affordability, skills, and institutional support. Addressing these barriers is crucial for scaling smart farming technologies in Nigeria.

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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.