Innovations

How Artificial Intelligence is Revolutionizing Agricultural Business in Nigeria?

[1] Aladejebi, Olufemi; [2] Amao-Taiwo, Bukola; [3] Oshinowo Bamidele

[1] University of Lagos, Business School, Akoka, Lagos, Nigeria

[2] University of Lagos, Nigeria Entrepreneurship and Skills Development Centre (ESDC), Akoka, Lagos, Nigeria

[3] University of Lagos, Faculty of Management Sciences Akoka, Lagos, Nigeria

Corresponding Author: Aladejebi, Olufemi

Abstract: *Artificial intelligence (AI) is also becoming an acknowledged game-changer in the world of agriculture, and it has the potential to increase productivity, efficiency, and food security. This paper discussed how AI can transform agriculture in Nigeria, its present use, opportunities, challenges and the possible effects. Qualitative research design was used, and semi-structured interviews with major stakeholders of active Nigerian agribusiness firms using AI were used. The companies offered their experience with AI-driven tools such as chatbots, predictive analytics, recommender systems, and pest detection models. The results showed that the early adoption of AI is transforming the agricultural practices by enhancing crop monitoring, improving farmer-market connections, optimising the use of inputs, and minimizing losses after harvesting. The companies cited positive effects of AI on productivity, farmer earnings, and rural development, and it was considered essential in enhancing food security and financial inclusion. But still, there were recurring issues that were found such as inadequate digital infrastructure, disjointed datasets, lack of digital literacy, and high implementation expenses. To solve these, companies implemented strategies like incremental implementation, open source technologies, offline solutions and collaborations with research institutions. The report concludes that AI can revolutionize the agricultural industry in Nigeria and lead to a tremendous economic growth, as long as systemic obstacles are overcome. Strategies to improve rural digital infrastructure, building centralised agricultural data systems, improving digital literacy, establishing inclusive financing systems, and collaboration between government, academia and the business sector are all recommended. These results can play a role in the continued discussion of digital agriculture and can serve as a means to implement AI usage in Sub-Saharan Africa on a larger scale.*

Keywords: *Artificial Intelligence, Agriculture, Nigeria, Food Security, Digital Transformation*

Introduction

As the most populous country in Africa with more than 220 million individuals, Nigeria is experiencing unparalleled problems in food security and agricultural sustainability. Population growth, climate change, and the emerging market pressures are causing tremendous transformation pressures on the agricultural sector which is traditionally the backbone of the Nigeria economy. As the global food demand is estimated to rise by 70 percent by 2050, novel solutions are badly required to improve agricultural productivity, sustainability, and efficiency of resources (MDPI, 2024).

The advent of artificial intelligence (AI) technologies is offering revolutionary possibilities in changing the way agriculture is done globally. Upcoming technological advances in digital technologies, particularly in the area of artificial intelligence (AI), are potentially of significant value to the agricultural industry (Amoussohoui, et al., 2024). Such technologies include machine learning algorithms, computer vision systems, predictive analytics, precision agriculture systems, and automated decision-making systems, which can greatly increase the productivity and sustainability of the farm.

In Nigeria, the agricultural sector faces multiple interconnected challenges that limit its potential contribution to economic development and food security. These challenges include poor land tenure system, low level of irrigation farming, climate change and land degradation, low technology adoption, high production cost and poor distribution of inputs, limited financing, high post-harvest losses and poor access to markets (FAO, 2024). Additionally, food inflation reached 40.53 percent in May 2024, driven by factors including currency depreciation and high transportation and import costs (Relief Web, 2024).

These issues combined with the current speed of AI technologies development present both a pressing need and a special chance of transforming agriculture. The application of AI in agriculture has already proven to have a lot of potential in developed nations, having shown improvements in yield, resource use and environmental viability. Yet, the way these technologies were adapted and implemented in the context of developing countries, especially in the situation in Nigeria, with its vast majority of smallholder agricultural systems is under-researched.

The Nigerian digital context is highly dynamic, and the penetration of mobile phones and internet access are opening up opportunities to AI-powered agricultural implementations. The importance of AI is recognized by the government, as demonstrated by the National Artificial Intelligence Strategy (2021), which implies the political interest in using these technologies to develop the country. Nevertheless, to translate this commitment into scalable solutions to serve millions of

smallholder farmers, thorough knowledge and insights into the issues, opportunities, and strategies of implementation are needed.

The economy of Nigeria is supported by agriculture, which plays a major role in terms of employment, food security and gross domestic product (GDP). The agriculture sector constitutes nearly 25.2 percent of the GDP of Nigeria in 2023, and about 36 percent of the working population, which is mainly comprised of smallholder agriculture (World Bank, 2023). It is a varied sector that includes staple crops (cassava, maize, yam, cocoa), livestock and fisheries (Food and Agriculture Organization [FAO], 2023). Nevertheless, there remain the problems related to low productivity, climate variability, ineffective use of resources, and post-harvest losses, which have led to food insecurity in an estimated number of 26 million Nigerians (FAO, 2023).

Artificial intelligence (AI) has the transformative potential to solve these problems. AI which can be explained as the creation of systems that can carry out certain activities that need human intelligence, including learning and decision-making, is transforming the agricultural industry across the world with precision farming, predictive analytics, and automation (Russell and Norvig, 2021). Artificial intelligence technologies have improved crop productivity by 15-20 percent and resource efficiency in developed nations (Liakos et al., 2018). Adoption of AI in Nigeria is in its infancy but on the rise with the help of government efforts, technological development in the private sector, and international collaborations. To mention just a few, AI-powered drones and mobile apps are used to monitor crops and to provide advisory services in such states as Kaduna and Ogun (Audu&Adegbenjo, 2022). This research paper discusses the potential of AI to transform agriculture in Nigeria, including its opportunities, challenges, and strategic execution pathsway to boost sustainability and productivity.

Research Aim and Objectives

The general aim of this study is to provide a comprehensive analysis of how artificial intelligence is revolutionizing agriculture in Nigeria, specific objectives are:

- To examine the current state of AI applications in Nigerian agriculture, including existing initiatives and their impacts.
- To identify and evaluate opportunities for AI in areas such as precision farming, supply chain management, and climate adaptation.
- To assess the challenges and barriers to AI adoption, encompassing infrastructure, human capital, financial, and policy dimensions.
- Assess the potential impacts of AI adoption on agricultural productivity, farmer incomes, food security, environmental sustainability, and rural development in Nigeria.

- To develop a strategic framework and recommendations for policymakers, stakeholders, and practitioners to enhance AI implementation in Nigerian agriculture.

Literature Review

Artificial Intelligence (AI) in agriculture is a wide field of technologies, such as machine learning, computer vision, natural language processing, robotics, and expert systems. They allow automated decision making, pattern recognition and predictive analytics that can have a substantial positive impact on the productivity and sustainability of agriculture (Liakos et al., 2018; Kamilaris and Prenafeta-Boldu, 2018). Machine learning algorithms have the potential to examine big data to determine trends in crop development, pest infestations, weather fluctuations, and trends in the market (Chlingaryan, Sukkarieh & Whelan, 2018). Computer vision has also been extensively utilized in automated crop surveillance, crop disease, and post-harvest quality evaluation (Patricio and Rieder, 2018). Natural language processing can also be used to enable farmer-friendly interfaces to access AI-powered advisory services, simplify the use of complex digital tools by smallholder farmers (Tripathi et al., 2023). Agricultural technology innovation is defined as the creation, adaptation and use of new tools, techniques and systems that enhance productivity, efficiency and sustainability (World Bank, 2023). This, in the Nigerian case, includes both the high-tech solutions like AI-powered predictive systems and more locally adjusted technologies that would work within the capacities of smallholders and the realities of the environment (Audu and Adegbenjo, 2022; Ayoola et al., 2025). Agricultural innovation ecosystem is multi-stakeholder by nature, which means that it entails farmers, technology developers, research institutions, extension services, financial institutions, and government agencies (Araujo et al., 2021). The introduction of AI into this ecosystem would not only need the technological advancement but also institutional cooperation and capacity building to make innovations inclusive and sustainable in solving the agricultural problems in Nigeria.

Theoretical Review

Technology Acceptance Model (TAM)

Technology Acceptance Model: Technological Innovation Technological innovation: The current Technological Acceptance Model, which was initially developed by Fred Davis (1989) offers a powerful theoretical framework to understand the process and reasons behind the adoption of new technologies by farmers. Davis (1989) wrote his master-piece on TAM in the MIS Quarterly, Vol. 13, No. 3, pp. 319-340. The model suggests that the perceived usefulness and perceived ease of use are two

important factors that should be used in deciding on technology adoption (Davis, 1989).

TAM has been used comprehensively in the agricultural setting to explain the adoption of digital technologies by farmers. Some of the benefits of applying Artificial Intelligence (AI) to the agricultural sector will include savings in the production factors, labor expenses, and labor time and decreased soil compaction (Springer, 2021). The benefits, however, can be achieved upon the acceptance and the real use of AI technologies by farmers.

More recent research has confirmed the relevance of TAM to the adoption of AI in agriculture. According to the model, the intention of farmers to adopt AI technologies depends largely on two beliefs, which are perceived usefulness (the extent to which farmers think AI can improve their farming performance) and perceived ease of use (the extent to which farmers think they can use AI without effort). External variables, including system characteristics, training and social influences, also affect these perceptions.

Diffusion of Innovation Theory

The theory of Diffusion of Innovation explains how innovations and products are introduced and accepted by a population with special emphasis to the early adopters (Krotkin and Pence, 2001).

Another critical theoretical perspective of the adoption of AI in agriculture is Rogers Diffusion of Innovation Theory (2003). The fifth edition of Diffusion of Innovations was published in Free Press, New York in 2003 by Rogers (2003). The theory describes the process of the dissemination of new ideas through the channels of communication in the course of time, where innovations are seen at the beginning as uncertain and risky (Rogers, 2003). The theory determines five attributes that have an impact on the speed of adoption relative advantage, compatibility, complexity, trial ability, and observability. The theory can be applied to AI in agriculture in Nigerian to understand why farmers are early adopters and others are laggards. The process of innovation-decision includes five steps, namely, knowledge, persuasion, decision, implementation, and confirmation. It is important to understand these stages to come up with effective AI implementation strategies in agricultural environments in Nigeria.

Theory of Sustainable Development

The normative framework of how AI can contribute to agricultural development is presented in Sustainable Development Theory. A potential technology in this 5th industrial revolution to get us nearer to zero hunger by 2030 Goal 2 of the United Nations Sustainable Development Goals (UNSDG) (Frontiers, 2024) could be Artificial Intelligence (AI). The theory focuses on the economic, social and

environmental aspects of development. In AI implementation in agriculture, this is translated to technologies that do not only boost productivity and profitability but also make the environment sustainable and socially equitable. In the case of Nigeria, this implies that AI solutions should be financially feasible to smallholder farmers, culturally acceptable in the current cultural settings, and eco-friendly.

Digital Divide Theory

The Digital Divide Theory is particularly relevant to AI adoption in developing countries like Nigeria. This goal cannot be achieved unless the digital divide among different populations is addressed (Frontiers, 2024). The theory explains disparities in access to and use of digital technologies based on factors such as income, education, age, gender, and geographic location. In Nigerian agriculture, the digital divide manifests in various forms: urban-rural connectivity gaps, educational disparities affecting technology literacy, gender-based access limitations, and age-related adoption differences. Understanding these divides is essential for developing inclusive AI implementation strategies that benefit all categories of farmers.

Conceptual Review

Overview of Nigerian Agriculture

Agriculture continues to serve as a cornerstone of Nigeria's economy, accounting for 25.2% of the Gross Domestic Product (GDP) in 2023 and employing about 36% of the labour force, which equates to nearly 38 million people (World Bank, 2023). The sector supports livelihoods in rural communities where more than 60% of the population resides, producing both staple crops such as cassava, yam, and maize—and cash crops like cocoa and palm oil (FAO, 2023). Despite its scale and diversity, agricultural growth has remained sluggish, with a 1.8% growth rate in 2023, falling short of the overall national growth rate of 2.5% (World Bank, 2023). Structural inefficiencies, limited mechanization, and an overreliance on rain-fed systems underpin this stagnation, constraining the sector's capacity to meet domestic demand and contribute to broader economic transformation.

The productivity gap in Nigerian agriculture is stark, with maize yields averaging 1.8–2.2 tons per hectare compared to a global average of 5.8 tons (FAO, 2023). Post-harvest losses of 20–40% for key crops, coupled with inadequate storage facilities and weak supply chain infrastructure, undermine food availability (Audu & Adegbenjo, 2022). Climate variability poses further risks, affecting over 60% of rain-fed farms, while irrigation infrastructure covers less than 1% of arable land. Consequently, food insecurity remains pervasive, affecting more than 26 million Nigerians (FAO, 2023). These challenges highlight the fragility of the system and

reinforce the urgency for technological interventions that can enhance resource use, improve resilience, and address persistent inefficiencies.

Smallholder farmers dominate the sector, cultivating plots of less than two hectares and accounting for nearly 80% of production (FAO, 2023). Yet their limited access to credit, improved seeds, fertilisers, and modern technologies constrains adoption of innovative practices. Recognising these constraints, government initiatives such as the National Agricultural Technology and Innovation Policy (NATIP, 2022–2027) and the Nigeria Artificial Intelligence Research Scheme (NAIRS) aim to drive innovation and promote the integration of digital technologies in agriculture (FMARD, 2022; Audu & Adegbenjo, 2022). However, implementation gaps persist, and without deliberate efforts to bridge the technology divide, smallholders risk being excluded from emerging opportunities. Within this context, artificial intelligence offers a pathway for transformation by enabling precision agriculture, predictive analytics, and data-driven decision-making that can enhance productivity and food security in Nigeria.

Technology Adoption Patterns in Nigerian Agriculture

Technology adoption in Nigerian agriculture has historically been slow and uneven. Mechanization remains minimal, with only 0.3 tractors available per 1,000 hectares compared to 8 in developed economies, which underscores a persistent productivity gap (FAO, 2023). Yet, the rapid spread of mobile phones since the early 2000s has introduced a digital shift, with ownership among farmers reaching 89% by 2023, though only 40% use these devices for agricultural purposes such as accessing extension services or checking market prices (GSMA, 2024). Early innovations like SMS-based advisory platforms, which had reached 15% of farmers by 2015, laid the foundation for more advanced digital interventions, including artificial intelligence (Audu & Adegbenjo, 2022). Current digital infrastructure provides further opportunities, though unevenly distributed. While internet penetration in rural areas stands at 36% and mobile network coverage has expanded to 85%, only 20% of farmers have reliable internet access due to gaps in affordability and speed disparities between rural and urban regions (World Bank, 2023). Although Nigeria's National Broadband Plan (2020–2025) seeks to bridge this divide, rural connectivity lags behind, creating limitations for AI applications that depend on real-time data transfer.

The readiness of farmers to adopt digital and AI-driven solutions remains limited, reflecting issues of literacy, affordability, and access. Only 8% of smallholders are currently using AI tools, largely within donor-funded or pilot projects (Audu & Adegbenjo, 2022). A considerable proportion of farmers about 60% lack basic digital skills, particularly in northern states where literacy rates are lower (GSMA, 2024). Nonetheless, surveys suggest significant latent demand: nearly 70% of

farmers indicate a willingness to adopt AI if provided with training and subsidies, though fewer than 25% currently access such programmes (GSMA, 2024). Younger farmers under 35 demonstrate greater uptake (15%) compared with older counterparts (5%), driven by higher exposure to digital technologies (FAO, 2023). This generational shift suggests that AI adoption may accelerate with demographic change, provided that systemic barriers are addressed through targeted interventions.

Existing AI Applications and Initiatives

The Nigerian agricultural landscape is witnessing the gradual introduction of AI applications through government, private sector, and academic initiatives. At the policy level, the Federal Ministry of Agriculture and Rural Development (FMARD) has embedded AI into the National Agricultural Technology and Innovation Policy (NATIP, 2022–2027), supporting the Nigeria Artificial Intelligence Research Scheme (NAIRS), which funds AI-based projects in crop monitoring and extension delivery (FMARD, 2022). NAIRS has already supported 10,000 farmers in northern states, particularly in maize and sorghum production (GSMA, 2024). Complementing this, the Agricultural Transformation Agenda Support Programme (ATASP) has scaled AI-driven extension services in partnership with technology firms, reaching over half a million farmers by 2024 (FAO, 2023). Private agritech startups are spearheading innovation, with Kitovu using AI-driven soil analytics to raise maize yields by 15% among 10,000 farmers in Oyo and Kwara states (GSMA, 2024). Apollo Agriculture applies machine learning for yield forecasting, enhancing productivity by 12% for 8,000 farmers in Kaduna (Audu&Adegbenjo, 2022). Farmcrowdy leverages AI for market intelligence, connecting 25,000 farmers to buyers while cutting post-harvest losses by 10% in cassava and maize value chains (FAO, 2023). More recently, Crop2Cash launched its FarmAdvice hotline in July 2024, offering AI-powered advisory services to half a million farmers across 13 states, increasing household incomes by as much as 70% (GSMA, 2024).

Academic and research institutions also play an integral role in piloting AI solutions tailored to local contexts. The University of Nigeria, Nsukka, has developed the Nsukka Yellow Pepper project, which uses AI-based pest detection to achieve 20% yield gains for 2,000 farmers in Enugu state (AI4AFS, 2024). Similarly, the International Institute of Tropical Agriculture (IITA) has pioneered cassava disease detection models, helping 5,000 farmers in Ogun and Delta states reduce crop losses by 15% (FAO, 2023). Ahmadu Bello University, in collaboration with tech firms, has piloted AI-based soil fertility models on 1,000 hectares in Kaduna, strengthening evidence on the potential scalability of AI for sustainable intensification (GSMA, 2024). These efforts highlight a growing ecosystem of government, private, and academic initiatives, yet they remain fragmented and

often limited in scope, underscoring the need for greater coordination, investment, and farmer-oriented delivery mechanisms.

Precision Farming and Crop Management

Precision farming in Nigeria leverages AI to optimise crop production through data-driven decisions, with the potential to increase yields by 15–20% across diverse agro-ecological zones (Audu &Adegbenjo, 2022). Remote sensing technologies analyse satellite imagery to monitor crop health and soil conditions, a critical intervention for the 60% of farms dependent on rain-fed agriculture. For example, Farmonaut's satellite-based platform has improved maize and yam productivity by 20% for 5,000 smallholders in Jos by enabling early interventions (Farmonaut, 2025). Drone applications further complement this process by providing real-time crop monitoring; a pilot in Kano State by Omdena demonstrated 10–15% reductions in losses for cassava and maize (Omdena, 2025). IoT sensors, when integrated with AI, support precision decisions on soil moisture and nutrient use, improving resource efficiency by 15% among cassava farmers in Oyo State (Eli-Chukwu, 2019). Similarly, machine learning algorithms applied to crop health assessment achieve 85–95% accuracy, with Ogun State pilots reducing disease-related losses by 12% for horticultural farmers (Farmonaut, 2025). Collectively, these technologies highlight how precision farming can address Nigeria's systemic productivity constraints.

Smart Irrigation and Water Resource Management

Given that only 1% of Nigeria's arable land is irrigated, AI-driven irrigation solutions are vital for sustainability. Smart scheduling systems use weather and soil data to reduce water waste by 20–35%, with solar-powered systems in Kaduna increasing yields by 10% for 1,500 farmers (Ogunleye & Akintade, 2024). AI also strengthens water quality monitoring in riverine areas such as Delta State, where contamination threatens 30% of farms, ensuring safer irrigation practices (Adeniyi et al., 2024). Beyond immediate water management, AI-driven drought prediction tools are being piloted by NiMet to provide early warnings, reducing crop losses by 15% for 10,000 farmers in northern Nigeria (Okolo, 2024). These interventions underscore how AI can mitigate the effects of water scarcity and climate variability, both of which are central challenges for Nigeria's agriculture.

Soil Health and Nutrient Management

Soil degradation affects approximately 70% of Nigeria's arable land, reducing nutrient efficiency and threatening sustainability (CGIAR, 2025). AI applications in soil testing and analysis provide tailored fertility recommendations, as demonstrated by IITA's pilot in Ogun State, which improved yields by 15% for 5,000 farmers (IITA, 2025). Fertilizer optimisation platforms such as GeaGrow further

reduce excess input use by 20–30%, saving costs and boosting efficiency for cassava farmers in Oyo (Ojo et al., 2025). Emerging applications also include AI systems for monitoring soil carbon levels, supporting Nigeria's commitments to carbon sequestration and climate mitigation (Chatterjee et al., 2024). These examples show how AI not only addresses immediate production needs but also aligns with long-term sustainability goals.

Empirical Review

Aaraujo, Peres, Barata, Lidon & Ramalho (2021) explored the main challenges and obstacles to adoption of agricultural technologies in the wider context of Agriculture 4.0. The authors synthesized the evidence on emerging technologies, including AI, IoT, robotics, and big data, and categorized the barriers into technical, financial, organizational, and institutional barriers by using a conceptual review methodology. Their results showed that high cost, inability to learn, poor infrastructure and fragmented governance systems are limiting factors to adoption especially in developing nations. It was concluded that until these barriers are managed systematically, the transformative potential of Agriculture 4.0 will be constrained, particularly in the case of smallholder dominated economies.

Audu and Adegbenjo (2022) paid attention to the area of artificial intelligence application in agriculture and, in particular, in Nigeria. It was a narrative review of academic literature, policy reports, and case-studies with the purpose of identifying the opportunities and challenges of AI adoption. It was identified that AI can play an important role in the field of crop monitoring, pest detection, soil analysis, yield forecasting, and supply chain optimization. Adoption is however hampered by lack of access to infrastructure, high implementation cost, lack of digital literacy, unreliable power supply and poor regulatory frameworks. The authors concluded that although AI has potential to revolutionize agriculture in Nigeria, it will have to be successful through policy changes, infrastructural development and farmer capacity building.

Ayoola et al. (2025) examined the obstacles and the opportunities of artificial intelligence integration into agricultural extension services in Abuja, Nigeria. The authors used a quantitative survey research design and collected data on 200 rural farmers in five area councils. Results revealed that socio-demographic characteristics like age, education level, cooperative membership, and extension contact played an important role in determining readiness to adopt AI. Farmers were ready to implement AI when they received training and subsidies, yet there were restrictions, including low internet connection, expensive device prices, and low digital literacy. It was concluded that AI in agricultural extension could improve in decision-making and livelihoods, but needs specific government and the private sector intervention to address the infrastructural and human-capacity bottlenecks.

Chatterjee, Kumar and Mishra (2024) analyzed how artificial intelligence can be used in soil management as an opportunity of smart agriculture. The authors evaluated the use of AI to test soil, forecast the soil fertility, and monitor nutrients using a mixed-method approach that involved the analysis of secondary data and conducting case-based reviews. The results showed that AI-based soil sensors and predictive models enhanced soil health diagnostics and nutrient efficiency up to 20 percent. It concluded that AI has a substantial part to play in sustainable agriculture because it can reduce soil erosion and utilisefertiliser more efficiently, but widespread implementation would need infrastructural investment and training of farmers.

Adeniyi, Onyekwena and Adeyemi (2024) assessed the application of AI in irrigation in Nigeria. The methodology was the synthesis of the results of 45 empirical studies published in 2015-2023, including the topics of irrigation scheduling, water quality monitoring, and drought prediction. The results revealed that AI-based irrigation systems saved 25-40 percent of water and enhanced crop production in semi-arid areas. Nevertheless, the lack of internet access in rural areas and the high prices of AI sensors were also mentioned as the limitations. The authors concluded that AI-based irrigation has a transformative potential in the drought-prone Nigeria agriculture, though policies need to overcome infrastructural shortfalls and cost-reduction in order to be scaled up.

Liakos, Busato, Moshou, Pearson &Bochtis (2018) surveyed the part played by machine learning methods in agriculture and their implementation in practice. Being a systematic literature review, the authors analyzed applications in the areas of yield prediction, disease detection, weed recognition, and soil monitoring in several countries. Results showed that machine learning models could predict crop yields and detect early disease with prediction accuracies of 85-95 per cent, greatly increasing the efficiency of decision making. It was concluded that machine learning has a great potential in achieving sustainable agriculture, but there are still issues regarding data availability, transparency of algorithms, and access to technology by farmers, especially in developing countries.

Eli-Chukwu (2019) has reviewed the applications of artificial intelligence in agriculture but in global perspectives. Following a narrative review approach, the author emphasized AI applications in robotics, expert systems, computer vision, and monitoring based on the IoT. Results showed that AI-based solutions enhanced crop management, pest control, and post-harvest, which resulted in yield gains and cost savings in a number of studies. The conclusion highlighted that AI can play a crucial role in the modernisation of agricultural systems, and in developing countries such as Nigeria, the use of AI is limited by low infrastructure, low levels of digital literacy, and high technology prices.

Ojo, Adeyemi and Okonkwo (2025) created and tested a mobile application called GeaGrow, which can forecast the level of nutrients in soil and give recommendations to farmers in Nigeria on the use of fertilizers. The researchers conducted a pilot test on the tool using a field-based pilot methodology on 3,000 smallholder farmers in Oyo state. The results showed that GeaGrow correctly estimated nutrient requirements that resulted in cost-saving of 10 percent on fertilizer inputs and 12 percent of yield increases in cassava. It was concluded that AI-based mobile applications can help to close knowledge gaps in soil fertility management, increase resource efficiency, and improve productivity among smallholder farmers, as long as access to digital solutions is increased in rural communities.

Ogunleye & Akintade (2024) streamlined the water management in agriculture by implementing the AI-based solar irrigation systems. The research design was case studies of solar irrigation pilot projects conducted in Kaduna and Katsina states, which combine AI algorithms to control the flow of water according to soil and weather data. The results indicated that 20-35% water waste was cut and crop yield was raised by approximately 10 percent on 1,500 farmers. The authors concluded that AI-enabled irrigation has the potential to transform Nigeria dryland agriculture, although it requires scalability through high cost of installation and low technical capacity in rural regions.

Methodology

Research Design

The qualitative research design used in this study was suitable in investigating complex and context-based phenomena in the agricultural sector in Nigeria. The qualitative methodology allowed to gain a deeper insight into the perception, implementation, and experience of artificial intelligence by various stakeholders. This design was able to offer more detailed data on the barriers and opportunities related to the use of AI in agriculture by concentrating on meanings, experiences, and processes instead of numeric patterns (NCBI, 2022).

Population and Sampling

The sample population included various stakeholder groups that were involved in agricultural production in Nigeria. The inclusion criteria were that participants had to be farmers who were in active agricultural activities for at least three years, owned or managed any size of agricultural land, were aged 18 years and above, and had to sign a written consent to take part. The farmers who had less than three years of farming experience, were not actively involved in production, and those who were not willing to give informed consent were not included in the study. Participants were recruited using a purposive sampling strategy based on their

relevance, knowledge, and experience in agricultural practices and exposure to digital innovations.

The companies interviewed for this study were included in the sample population, as they represent key players in the agricultural sector, particularly those integrating technology and digital innovations into farming practices. These companies are:

- **Farmstarck (under Starcks Novation Limited)** – Sector: AgriTech / Social Commerce / Food Security
- **Agromall** – Sector: Digital Agriculture
- **Fieldfarm** – Sector: AgriTech / Cash Crop Farming
- **OLAM Agric** – Sector: AgriTech / Agriculture Production
- **Nature Next** – Sector: Agriculture / AI Integration
- **Farm Crowdy** – Sector: AgriTech / Full Farm Circle Management
- **Cabax Farms** – Sector: Palm Oil Production
- **Ceres Vantage Limited** – Sector: Precision Farming (Mushroom Farming)
- **AgriSeal Limited –** Sector: Agriculture
- **Metallic Integrating technology limited –** Sector :Climate and smart Agriculture
- **Okitipupa Oil palm plc:** Sector – Oil palm production and processing
- **Agroxchange Technology Services Limited –** Sector: Agriculture
- **Nature next Limited –** Sector: Farming

These companies provided valuable insights into the adoption of AI and other digital innovations within the Nigerian agricultural sector, helping to further understand the intersection of technology and agricultural practices in the country

Key Informant Interviews

Primary data were collected through semi-structured key informant interviews, each lasting approximately 45–60 minutes. The interview guide covered five thematic areas: (i) current experiences with AI and related digital initiatives, (ii) implementation challenges and success factors, (iii) stakeholder perspectives on opportunities and barriers, (iv)assessments of the policy and regulatory environment, and (v) future recommendations for sustainable AI integration in agriculture. The semi-structured format ensured consistency across interviews while allowing participants the flexibility to elaborate on emerging issues and contextual realities.

Data Analysis

Data obtained through interviews was analysed through content and thematic analysis procedures. Coding of transcripts was done manually using both deductive

(theory-driven) as well as inductive (data-driven) methods. The codes were then grouped into categories which were then narrowed down into larger themes that captured trends across the data set. A cross-case analysis was also enabled to make comparisons between the perspectives of various stakeholder groups and thus make the interpretation richer and stronger. This method of analysis helped to identify common themes, original insights, and contextual factors that have an impact on the adoption of AI in agriculture in Nigeria.

Trustworthiness and Rigour

Towards a quality research, the principles of trustworthiness were put in place. The credibility was achieved by a long-term interaction with the participants and cross-checking of the point of view between stakeholder groups. It was also done to make it easier to transfer since it presented thick descriptions of the context and characteristics of the participants. Reliability was met by ensuring that the research process was well documented in terms of coding decisions and procedures used in the analysis. This was to ensure confirmability through the use of an audit trail of data sources, coding memos and interpretations to minimize the researcher bias and enhance transparency.

Analysis and discussion

Analysis of AI Adoption in Nigerian Agriculture: Interview Insights

The integration of Artificial Intelligence (AI) into Nigerian agriculture has shown potential to significantly transform the sector, particularly in boosting agricultural productivity, enhancing income generation, ensuring food security, and fostering rural development. Insights gathered from interviews with several agricultural companies reveal key trends and barriers in the implementation of AI, as well as the anticipated future impact of this technology. This analysis discusses the adoption of AI based on common responses from participants, highlighting the benefits and challenges they encountered, and concludes with a summary of the findings.

Basic Information and Awareness of AI

Most of the companies interviewed highlighted that their awareness of AI came through various channels, including educational curricula, press releases, and exposure through technical partners. One company representative mentioned, "We came to know about AI through our curriculum in computer science, which eventually led us to integrate AI into our operations." Another participant noted, "Through a colleague in procurement, we were introduced to AI technologies, and we began exploring how to incorporate them into our system." These responses

reflect how AI awareness in the agricultural sector is growing, largely driven by education and the proactive engagement of key stakeholders in the industry.

AI Tools and Their Selection

The most prevalent answer when addressing the AI tools used by their companies was the utilization of AI-driven chatbots, predictive analytics, recommendation engines, and risk assessment models. One of the companies wrote, "To support farmers and merchants in real-time, we introduced AI-based chatbots. This was a vital tool so as to minimize the obstacles of knowledge and to enhance the education of farmers. Also, crop data, weather and pricing trend predictive analytics were often cited as tools that assisted companies to make smarter decisions. One of the interviewees explained that we apply predictive analytics to understand crop cycles, weather patterns, and pricing patterns to make the best possible planting and trading decisions. This has greatly minimized loss and enhanced efficiency of the farms.

The other important AI tool was the recommendation engine that is used to match products of farmers with potential buyers. One company justified it by saying, our recommendation engine does not only increase sales, but it also builds a personalized marketplace experience by matching the right buyers and the right products. The tools were selected due to the direct impact on the three main areas of inefficiency of agriculture, including knowledge deficit, market failure, and food waste, and the scalability of the solutions to increase alongside the growing business.

Impact on Income, Agricultural Productivity, and Food Security

The companies are confident that the use of AI has made a great difference to income and productivity. One of the respondents said, "AI has helped us to make superior product recommendations and procurement optimization, directly driving transaction volume and revenue. Another respondent said, "We could minimize waste of input through AI-driven insights, and thus increase gross profit margins. Crop cycle, weather forecasting, and pricing predictive analytics have also contributed to better decision-making, which has minimized the number of losses at the end of the harvest and increased the total yields.

The most popular response to the question of agricultural productivity was that AI, including predictive analytics and automated pest detection, have assisted in enhancing the efficiency of agriculture. According to one of the company representatives, the implementation of AI to detect early disease and pest management has enabled us to reduce the harm caused to crops, which has increased the survival rate of crops in addition to the reduction of the expensive interventions. Also, most of the interviewees focused on how AI could be applied to

guarantee food security. As one respondent pointed out, AI-based systems assist in minimizing food waste by enhancing supply chain control and matching the supply and demand in a more precise manner, which has significantly contributed to food security in Nigeria.

The development of the rural areas also became one of the main themes. As mentioned by one of the companies, AI-driven tools have enabled smallholder farmers that have given them the knowledge and resources necessary to boost their productivity even in isolated regions. Some of the companies cited that AI-enabled fintechs, including credit scoring and risk profiling, have facilitated access to funding by the smallholder farmers, which is also adding to the rural economy.

Competitive Advantage through AI

The interviewees agreed that AI gives a competitive edge. Most noted the role of AI-powered technologies, including intelligent market matching and real-time assistance, as having enabled them to surpass their rivals. One of the companies elaborated, AI enables us to match farmers and buyers at a faster rate than the conventional market places. This saves a lot of time to sale, enhances trust and increases the level of conversions. The other participant stressed that their AI-driven chatbot offers 24/7 support and replies to the questions of farmers in native languages, which cannot be offered by competitors.

Moreover, AI application in data-led insights has given firms an advantage. Our AI has already been used to provide predictive analytics data of pricing, weather, and crops. This enables the farmers to make informed decisions, a fact that creates loyalty and customer retention power, said one of the interviewees. Individualization of services, via AI-driven content and social commerce, also became one of the differentiators. We do not just fall back on stagnant listings. One of the companies said that our AI is a combination of content and commerce and an interactive and engaging experience.

Barriers to AI Implementation and Mitigation Strategies

The advantages notwithstanding, a number of obstacles to AI adoption were found. The main challenges that were mentioned frequently were data gaps, inadequate infrastructure, and low digital literacy. According to one of the respondents, agricultural data is disaggregated and we had a hard time finding quality and reliable data in the rural regions. Other interviewees stated that a significant challenge is the connectivity problems in the rural community. This compelled us to come up with light models that were capable of operating in low-bandwidth conditions.

Another major hindrance of AI was cost. One of the participants said, AIs cost a lot to implement, particularly when a small business is concerned. We also adopted it step

by step, beginning with the simplest types of AI applications such as chatbots and then gradually integrating more sophisticated systems. In order to handle these issues, firms have developed different approaches that include exploiting alliances, open-source applications, and educating users. One of the mentioned companies added, "We have collaborated with research organizations and non-governmental organizations to fill in data gaps and we have conducted pilot projects to build trust and inform farmers about the importance of AI.

Minimizing Barriers for Future AI Adopters

When asked questions concerning how to reduce barriers to future adopters of AI, the majority of respondents pointed out that they should invest in digital infrastructure and data collection. One of the interviewees suggested starting with building an infrastructure that would facilitate AI tools, including a good internet connection and apps that can be used without the internet. Moreover, firms recommended that companies should work with local partners to guarantee enhanced data access and enhance digital literacy. One of the respondents stated that the main way to develop trust and confidence in AI solutions involves training programs and practical demonstrations.

The Future of AI in Nigerian Agriculture

The future of AI in Nigerian agriculture appears promising, with interviewees projecting widespread transformation in the next decade. One respondent claimed, "In the next 10 years, AI will revolutionize agriculture in Nigeria by increasing efficiency, reducing costs, and unlocking new markets." Another interviewee mentioned, "AI will create new jobs in AI services, smart farming, and fintech, contributing to economic growth and innovation." The widespread adoption of AI is expected to foster innovation ecosystems, enhance food security, and provide inclusive opportunities for rural communities.

Government, Universities, and Tech Companies' Role in AI Adoption

The interviewees highlighted the significance of the government, universities, and tech firms to facilitate the use of AI. Government was encouraged to devise policies that can facilitate AI innovation, incentives in terms of tax reductions and grants to businesses that invest in AI. One of the respondents added that the government must look into development of clear policies and better infrastructure, including broadband and access to power to enable AI to be more accessible. It was recommended that universities should revise curricula and develop practical AI skills, with one of the respondents commenting, Universities should invest in research projects and collaborate with businesses to create applied AI solutions.

The tech companies were also encouraged to come up with affordable and local AI products and assist SMEs by training and mentoring them.

Advice for Entrepreneurs Considering AI Adoption

The recommendation on the entrepreneurs to adopt AI was explicit. According to one of the respondents, one should begin with a real problem that AI can address. Do not embrace AI simply because it is a fashionable thing to do, but one should make sure it is solving particular aches in your business. Another interviewee suggested, "Invest in data collection at the beginning. The machine can only be as good as its information. Lastly, some of the respondents highlighted the need to educate users, pilot projects, and scaleable implementation. One interviewee has stated that it is good to start small, test the solutions, and scale up as results show.

Summary of Findings

Theme	Findings
AI Awareness	AI awareness emerged from educational programs, press releases, and networking.
AI Tools Used	AI-powered chat bots, predictive analytics, recommendation engines, and machine learning for forecasting and pest detection.
Impact on Income	AI adoption has boosted income by optimizing procurement, reducing waste, and increasing revenue through better market matching.
Impact on Agricultural Productivity	AI has improved productivity through better decision-making, reducing post-harvest losses, and improving crop yields.
Impact on Food Security	AI has helped ensure food security by reducing waste, improving supply chain management, and stabilizing prices.
Barriers to AI Adoption	Data fragmentation, poor infrastructure, high costs, and digital literacy challenges were key barriers.
Mitigation Strategies	Companies overcame barriers by using lightweight models, building partnerships, and focusing on education.
Future of AI in Agriculture	AI is expected to increase efficiency, drive innovation, and create new markets for Nigerian agriculture in the next decade.
Advice for Entrepreneurs	Focus on solving specific problems, start small, invest in data collection, and ensure user education and scalability.

Source: Researcher's compilation

Discussion of Findings

Current State of AI Applications in Nigerian Agriculture

The interviews showed that Nigerian farming enterprises like Farmstarck, Agromall, Fieldfarm, and Cabax Farms are already implementing AI into their business models albeit at different degrees of maturity. An example is Farmstarck, which uses chatbots, predictive analytics and recommendation engines to assist farmers with knowledge, access to the market, and logistics and Agromall, which uses recommender systems and pest-detection models such as XGBoost to offer precision advisory services. These results show that there is a gradual, albeit uneven, spread of AI in agribusinesses. This is in accordance with Audu and Adegbenjo (2022) who discovered that adoption of AI in Nigeria remains on its infancy but is gaining momentum in fields like crop monitoring, soil health management and yield prediction. On the same note, Eli-Chukwu (2019) pointed out that the introduction of AI in the world agricultural sector has mostly been focused on enhancing efficiency and minimizing waste, which is similar to the reasons that the Nigerian companies interviewed indicated.

The Precision Farming, Supply Chains, and Climate Adaptation opportunities to AI

Interviewees noted that AI is being used to streamline production and market efficiencies, especially by using predictive analytics, pest detection and market-matching tools. As an example, the recommendation engines of Farmstarck were focused on the supply-demand mismatch, whereas the pest sensors of Agromall reduced the losses of yields. Such applications can be repeated in precision farming and supply chain management, which is also reflected by the findings of Chatterjee, Kumar, and Mishra (2024) which indicate that AI-controlled soil and nutrient management enhances efficiency by 20 per cent, and Adeniyi, Onyekwena, and Adeyemi (2024) which found that AI-controlled irrigation reduced water waste by up to 40 per cent. In addition to productivity, AI was also viewed by firms as a source of food security and rural growth by increasing the incomes and competitiveness of farmers in the market. This aligns with the findings of Liakos et al. (2018), who found that machine learning in agriculture can yield 85-95 per cent crop and yield predictions, which provide important benefits to climate adaptation and sustainability.

Potential Problems and Obstacles to AI Adoption

Although there was hope, businesses noted that there were still ongoing challenges such as data silos, poor digital infrastructure, lack of trust in digital tools by the farmers and the high cost of implementation. Cabax Farms said that there was bad electricity and internet connections whereas Farmstarck said that a lack of unified

datasets was hindering the creation of strong models. In the quest to overcome them, firms employed the following strategies: gradual AI implementation, collaboration in data collection, and offline applications building. These results are consistent with those provided by Araujo et al. (2021), who have indicated the infrastructural vulnerabilities and skills gaps as the key obstacles to the uptake of agricultural technologies in the rest of the world. Likewise, Ayoola et al. (2025) found that farmers in Abuja, Nigeria, were willing to use AI, but digital literacy and costs continued to be a barrier. These similarities indicate that structural and behavioural obstacles to AI adoption are present in agribusinesses in Nigeria, and resolution needs to be systemic through collaboration between the private sector, government, and research institutions.

Effects of AI on Productivity, Incomes, Food Security and Rural Development

The analysis of the interview revealed that the adoption of AI has a transformative effect in a variety of dimensions. Firms saw that AI technology decreases inefficiencies, enhances food production, and can be used to better connect farmers with markets, which boosts their earnings and enhances food security. An example was Farmstarck in which automation in customer service and logistics was stressed as a cost-saving method directly affecting profitability. Agromall reported that artificial intelligence (AI) on pest detection and crop forecasting minimized losses after harvest and increased yields. These are reminiscent of empirical findings, including Ojo, Adeyemi, and Okonkwo (2025), who revealed that AI-based soil nutrient devices lowered the use of fertilizers by 10 percent and enhanced cassava yields by 12 percent, and Ogunleye and Akintade (2024), who found that AI-based irrigation technology raised yields in Kaduna by 10 percent. More generally, PwC (2025) estimated that AI would bring up to $15.7 billion of economic value to Nigeria by 2030, and agriculture was one of the primary players. Therefore, the effects that were found by companies in this research are echoed by the empirical predictions, which proves the potential of AI in increasing the productivity of agriculture, rural development, and the resilience of food systems in Nigeria.

Conclusion

The paper has explored how artificial intelligence can revolutionize the agriculture sector in Nigeria, its current uses, opportunities, challenges, and possible effects on the productivity, incomes and food security. The analysis of the interview showed that the use of AI in Nigerian agribusiness is at the initial level, but it is becoming popular with the help of such companies as Farmstarck, Agromall, Fieldfarm, and Cabax Farms. To solve the inefficiency of production, distribution, and market access, these companies are implementing AI equipment, including chatbots and predictive analytics, pest detection systems, and recommender engines.

The empirical data proves that AI is potentially transformative in the areas of precision farming, supply chain optimization, irrigation control, and soil fertility measurements (Audu and Adegbenjo, 2022; Chatterjee et al., 2024; Adeniyi et al., 2024). The authors concluded that the use of AI increases productivity, post-harvest losses are minimized, the income of farmers is increased, and food security is improved. Moreover, it can lead to rural development through financial inclusion and data-driven analysis. Nevertheless, the study also pointed to systemic obstacles, including inadequate infrastructure, disjointed datasets, digital illiteracy, and high implementation cost, which are also in line with previous studies by Araujo et al. (2021) and Ayoola et al. (2025). These obstacles suggest that although AI can transform the agriculture sector in Nigeria, its advantages can be enjoyed only with the conscious policy encouragement, capacity building, and infrastructure investment.

Policy Recommendations

- Broadband, rura electrification, and low-cost internet expansion investments are needed to scale AI use in agriculture. This is in line with the objectives of the National Broadband Plan (2020-2025) though the rural farming communities require center-stage implementation.
- In order to prevent data fragmentation, the government and the private sector must work together to design centralized agricultural data platforms. The common datasets will enhance precision of AI models and promote innovation in fields like yield prediction and pest identification.
- Farmer, extension agent, and agribusinesses training programmes must be given priority to establish digital literacy. AI and machine learning should be incorporated in agricultural courses in universities and agricultural colleges to produce a workforce that is ready to work in the future.
- Since adoption of AI is very expensive, financial assistance programs like subsidized loans, tax incentives, and grants are to be put in place. The joint development of local AI solutions might also be useful in lowering the costs by establishing public-private partnerships.
- To adopt it efficiently, there should be cooperation between government, research institutions, and tech companies. Applied research ought to be spearheaded by universities and such innovations can be transformed by agritech firms into scaleable products. Enabling regulations should be offered by the policymakers to drive responsible AI usage.
- The government needs to develop AI-specific policy dealing with data governance, ethics and privacy in agriculture. This will foster trust in farmers and make sure that they follow international best practices and encourage innovation.

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