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TRANSFORMING NIGERIAN AGRICULTURAL SYSTEM THROUGH THE USE OF ARTIFICIAL INTELLIGENCE: AN EXPLORATORY REVIEW

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Abstract
Artificial Intelligence (AI) is rapidly emerging as a transformative tool in modern agriculture, offering innovative solutions to challenges affecting productivity, sustainability, and food security in Nigeria. The paper reviewed Agricultural transformation using Artificial Intelligence. AI technologies such as precision farming, drones, machine learning, remote sensing, robotics, and predictive analytics enable farmers to make informed decisions, optimize resource utilization and reduce production costs. Beyond productivity, AI supports sustainable agriculture by pAromoting efficient resource management, reducing environmental degradation, and advancing climate-smart farming practices. In the area the food security, AI contributes through improved crop monitoring, enhanced weather forecasting, efficient supply chain management, and reduction of post-harvest losses. Despite these potential benefits, the adoption of AI in Nigerian agriculture remains constrained by several factors. Key challenges include inadequate infrastructure, limited digital literacy among farmers, high cost of technology, weak policy and institutional support and limited access to reliable data and electricity. It was concluded that with proper implementation and targeted investment, AI can significantly transform agricultural production systems. This will require investment in digital infrastructure, farmer education and training, policy support and government commitment, affordable access to technology and promotion of research and innovation. The paper concludes based on this review, the following recommendations. The government should invest heavily in rural infrastructure, including electricity, internet connectivity; transportation networks build capacity and willingness to embrace networks. Farmers should build capacity and willingness to embrace modern technologies and adopt AI- based farming practices to improve productivity.
Keywords: *Artificial Intelligence, Agricultural Transformation, Food Security, Sustainability, Adoption.*

Introduction
Agriculture is the bedrock of sustainability of any economy. Agriculture remains one of the most important sectors of the Nigerian economy. It provides employment, income, raw materials, and food for a large proportion of the population. The sector contributes significantly to the country's Gross Domestic Product (GDP) and serves as a major source of livelihood for rural households. Specifically, agriculture employs over 70% of the labor force

and contributes approximately 22-25% of the country's GDP (Etim, 2020; Food and Agricultural Organization, 2022). 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 Nigerian economy (Aladejebi, Amao-Taiwo & Oshinowo, 2026).

Other challenges include low productivity, poor access to modern technologies, climate change, pest and disease outbreaks, inadequate extension services, post-harvest losses, and food insecurity. These challenges have hindered the ability of the agricultural sector to meet the increasing food demand of the growing population. In search of a better strategy, organizations are turning to Artificial intelligence for its transformative potential to solve these problems (Aladejebi *et al,* 2026).

Artificial Intelligence (AI) the ability of computer systems and machines to perform tasks that require human intelligence, such as learning, problem-solving, prediction, and decision-making offers potential solution to these challenges. AI involves the use of machines and algorithms to simulate human intelligence and provide promising opportunities for agriculture. By integrating AI into agriculture, farmers, extension agents and researchers can make more informed decisions, reduce inefficiencies, and improve overall productivity. AI supports farming decisions using data and works with sensors, drones, and software systems (Mudashir, Beatrice, Joseph, Oluwamayowa, Theophilus, Ayoola, Samson, 2025). To emphasize the relevance of AI, Liakos, Busato, Moshou, Pearson & Bochtis (2018) stated that AI applications span a wide spectrum of uses. These include predictive analytics for crop yield estimation, computer vision for pest and disease detection, machine learning algorithms for optimizing fertilizer and irrigation use, and natural language processing tools that facilitate personalized farmer communication.

In agriculture, key AI technologies include machine learning, robotics, drones, remote sensing, smart sensors, satellite imaging, and predictive analytics. These technologies help farmers improve farm management practices, monitor crop and livestock performance, predict weather conditions, detect diseases early, and optimize the use of agricultural inputs.
In Africa, AI is being used in a variety of agro-ecologies to solve particular problems and raise agricultural output. AI in agriculture presents a picture full of opportunities and answers to the urgent problems that the continent's farmers face. It has the potential to reduce information asymmetries, improve access to agricultural advisory services, and strengthen rural learning ecosystems.

Therefore, given its relevance, AI represents a viable pathway for enhancing productivity, food security and sustainable practices in Nigeria's agricultural system (Obasi**,** Tenebe., Obasi., Jokthan, Adjei &, Keyagha 2024).

Artificial intelligence and Agricultural Productivity in Nigeria

Productivity is the measure of how efficiently resources such as land, labor, capital, time, and technology are used to produce goods and services. Productivity is the efficient use of resources to produce goods and services. Agricultural productivity refers to the quantity of output obtained from a given quantity of inputs such as land labor and capital. Productivity is also expressed as the quantity of crops or livestock produced per unit of land, labor, or other resources (Jhingan, 2018; Olukosi & Erhabor 2015).

Adopting new methods like precision farming, with the application of AI to agriculture holds great promise. For example, if a farmer harvests more bags of maize from the same hectare of land through improved farming methods and technologies like precision farming, the farmer's productivity has increased. However, Olawumi, Oyediji, Bamidele, Eleke Olaitan, Sennuga, (2025) reported that agricultural productivity in Nigeria remains low by global standards due to a host of persistent challenges—among them climate

variability, pest outbreaks, soil degradation, and limited access to finance, markets, and untimely agronomic information.

AI improves agricultural productivity by enabling farmers to make better and faster decisions, through technologies such as machine learning, drones, sensors, satellite imaging, and smart mobile applications. Farmers can monitor crop growth, soil conditions, weather patterns, and pest outbreaks in real time. These technologies reduce guesswork and improve efficiency. Liakos et al. (2018) observed that AI-powered precision agriculture helps farmers apply water, fertilizers, and pesticides only where needed, thereby reducing waste and increasing crop yields. Adopting new methods like precision farming, with the application of AI to agriculture holds great promise.

AgricKonnect (2025) stated that AI in farm management can increase yield up to 30%. Smart irrigation systems powered by AI can determine the exact amount of water required by crops, especially in drought-prone regions of Northern Nigeria. These innovations boost productivity while reducing environmental harm by reducing excessive water use, chemical inputs, and greenhouse gas emissions. AI techniques when applied to agricultural processes tend to increase productivity and efficiency. AI-powered solutions will not only enable farmers to do more with less, it will also improve quality and ensure faster go-to-market for crops (Mudashir *et al*, 2025).

AI also assists in pest and disease detection and equally provides recommendations for treatment by using image recognition and predictive models, farmers can identify crop diseases early and take preventive actions before major losses occur. This is important for crops such as rice, maize, cassava, and tomatoes, which are often affected by pests and diseases in Nigeria. This is ordinarily very difficult for a rural farmer to achieve in a short time under non- smart farming practices (Spoorthiy, 2024).

Instances exist in the use of AI technologies in some States in Nigeria. Aladejebi et al., (2026) in their work noted that 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. The International Institute of Tropical Agriculture (IITA) has pioneered cassava disease detection models that helped 5,000 farmers in Ogun and Delta States to reduce crop losses by 15%. Also, machine learning algorithms applied to crop health assessment achieved 85–95% accuracy, with Ogun State pilots reducing disease-related losses by 12% for horticultural farmers. A pilot case study on tomato farming in Kaduna conducted by Bisi et al., (2026) used modern technologies like irrigation systems, drones and AI – based monitoring systems to improve efficiency and productivity. The result revealed 25% reduction in water usage which led to 15% increase in harvest. It was validated through comparative analysis with traditional farming methods.

The study also noted that Farmonaut's satellite-based platform has improved maize and yam productivity by 20% for 5,000 smallholders in Jos by enabling early interventions. This shows that AI and modern agricultural technologies can improve productivity as well as to ensure food security in Nigeria.

Furthermore, AI-powered advisory platforms provided farmers with weather forecasts, planting recommendations, fertilizer application schedules, and market prices through mobile phones. This is particularly valuable because Nigeria faces shortages of agricultural extension officers. Traditional extension services in Nigeria, though essential, face significant limitations, including paucity of personnel, inadequate funding, logistical inefficiencies, and difficulties in reaching remote farming communities. One major problem for farmers in rural areas is inadequate access to extension agents, and studies from Africa show that digital AI advisory systems can significantly improve farmer productivity and income (Mudashir, et al. 2025). Smart farming technologies powered by AI enable farmers to use resources more efficiently, thereby increasing crop yields while reducing production costs. AI-based systems also assist farmers in making informed decisions through real-time

information on weather conditions, market prices, and pest control measures. This is especially important in Nigeria, where many smallholder farmers lack access to adequate agricultural extension services (Mudashir *et al.* 2025). Therefore the application of AI in agriculture has significant potential to improve yield, reduce cost, thereby increasing productivity (AgricKonnect, 2025).

Nigeria cannot be left out of the adoption of AI technologies in agriculture. Platforms such as Zenvus and Hello Tractor have demonstrated how AI can improve productivity by equipping farmers with data on soil conditions, rainfall forecasts, mechanization scheduling, and pest incidence. These platforms combine satellite imagery, sensor data, and machine learning models to generate actionable insights that are both scalable and cost-effective (Olusanya *et al.* 2025).

AI and Sustainability in Nigerian Agriculture

Sustainability in agriculture refers to farming practices that meet present food needs without damaging the environment for future generations. Beyond productivity, AI contributes to sustainable agriculture in several ways. AI supports efficient resource management, precision farming reduces excessive use of fertilizers, pesticides, and water, thereby minimizing soil degradation, water pollution, and greenhouse gas emissions. These promote environmentally friendly farming practices and enhance productivity, efficiency and sustainability through efficient resource utilization, and climate-smart agriculture. AI-enhanced early warning systems can alert farmers of potential pest outbreaks, disease infestations, or extreme weather events, allowing them to implement proactive mitigation strategies. These innovations boost productivity while reducing environmental harm by reducing excessive water use, chemical inputs, and greenhouse gas emissions (Bisi *et al*. 2026).

In Nigeria, irregular rainfall, flooding, desertification, and rising temperatures threaten agricultural production. AI systems analyze the climate data and provide early warning signals that help farmers adjust planting dates, crop varieties, and irrigation practices. Furthermore, AI promotes sustainable land use and soil conservation. Smart sensors and satellite technologies can monitor soil fertility and detect land degradation, hence the need for application of AI approach for disease control and management (Mudashir *et al.* 2025).

AI and Food Security in Nigeria

According to the Food and Agriculture Organizations of the United Nations by 2050 global food production should increase by 70% to feed 9.6 billion people worldwide. Unless some drastic measures are taken, there may be disasters of food shortages (FAO, 2023).Food security means that people have consistent access to sufficient, safe, and nutritious food. USAID, (1995) in Amanze and Adiaha (2009) defined food security as when all people at all times have access to sufficient safe and nutritious food to maintain healthy and active life.

In simple terms, food security includes both physical and economic access to food that meets people's dietary and food preferences.Food security is built on three pillars: food availability, food access and food utilization. It is a complex sustainable development issue linked to health through malnutrition, and also sustainable to economic development, environmental and trade. Food security is achieved only when individuals have consistent physical, social, and economic access to sufficient, safe, and nutritious food that meets dietary needs for an active life (FAO, 2023).

Nigeria continues to struggle with food insecurity due to population growth, insecurity in farming regions, climate change, poor food distribution system and poor agricultural productivity. Amanze and Adiaha (2009) in their work on "Food security, Agriculture and National Development: an intergral part of the 7th point agenda" stated that there is enough food in the world to feed everyone adequately, but the problem is distribution. At the national level, Nigeria can employ the large data gathering and information processing systems based on AI to get insights into the country's annual estimates of food mass flows, including imports, exports, distribution, consumption, surplus food production, and final

disposal (Bisi, *et al*. 2026). AI can improve food security by increasing food production and reducing losses across the agricultural value chain. Also, it can help meet rising demand for food and support a more inclusive and sustainable food system by enhancing the resilience of farming methods; reducing the cost of inputs and services to underserved farmers; and improving market access to facilitate smallholder farmer integration and achieving food security in Nigeria.

Predictive analytics can forecast crop yields, detect supply shortages, and improve food distribution systems. AI also improves storage and logistics management, reducing post-harvest losses that account for a significant percentage of food waste experienced by subsistence farmers in Nigeria (Zhang & Wang, 2021).

Moreover, AI enhances market access for farmers by connecting them directly with buyers through digital platforms (Ayoola F J, Joseph B, Beatrice I O, Mudashir AO, Ugochinyere P E, Oluwamayowa J.J .Abubakar,T.T & Samson O .S.2025). This reduces exploitation by middlemen and increases farmers' incomes, enabling them to invest more in food production. Research also shows that sustainable agricultural systems supported by modern technologies are necessary for long-term food security in Nigeria. Merely increasing crop yields without environmental sustainability may worsen land degradation and future food shortages.

Furthermore, AI plays a critical role in improving food security in Nigeria. Food security exists when people have physical and economic access to sufficient, safe, and nutritious food at all times. By improving crop production, reducing post-harvest losses, and enhancing supply chain management, AI can help ensure stable food availability and accessibility. AI-powered digital platforms also connect farmers to markets, financial services, and agricultural information, thereby improving rural livelihoods and food distribution systems.

Challenges Limiting AI Adoption in Nigeria.

Adoption in agriculture refers to the decision and continuous use of a new agricultural innovation, technology, or farming practice by farmers after becoming aware of it. Adoption involves farmers accepting and applying improved farming methods such as AI technologies, improved seed varieties, fertilizers, irrigation systems, mechanized equipment, pest control measures, and modern agronomic practices in order to improve productivity, income, and food security (Nura, 2022). Studies on agricultural innovation in Nigeria have shown that the adoption of modern technologies contribute significantly to increased agricultural productivity and rural development. AI-driven predictive models can process large volumes of climate data to produce precise forecasts on rainfall trends, drought probabilities, and temperature variations. This empowers farmers to make well-informed decisions regarding planting and harvesting timelines (Mudashir, *et al.* 2025).

However, despite the enormous potentials of AI technologies in increasing productivity, achieving food security and promoting sustainable agricultural practices, adoption of AI remains low (Nura, 2022; Mudashir *et al.* 2025). They further highlighted several factors that limit the adoption of AI in Nigerian agriculture. These factors include poor digital infrastructure and internet connectivity in rural areas, high cost of AI technologies and smart devices, low digital literacy among smallholder farmers, inadequate electricity supply, limited government policies and investment in agricultural technology, and lack of technical expertise and data management systems.

Furthermore, Bisi et al. (2026) noted that setback such as poor connectivity, inadequate infrastructure and socio-economic constraints hamper direct adoption in Nigeria. These challenges are particularly common among rural farmers, many of whom are females and lack access to credit facilities and land. The adoption of AI technologies in Nigerian agriculture can be facilitated through the use of Internet of things (IoT) and data analytics. For monitoring the animals on a farm and their health, internet of things (IoT) devices

employing different types of sensors video/image processing and classification capabilities, along with vocalization (sound) based livestock analysis have been a subject of intense research IoT is not common in the rural areas where farming activities naturally take place (Bisi, *et al,* 2026). They further stated that challenges such as the proper dissemination of AI technology and the need for sustainable strategies must be addressed.

In India, AI has been used to address agricultural challenges and the country is now enjoying increased productivity, resource management, and market access. The same is not yet true for Nigeria. The differences arise as a result of limited technological infrastructure, lower levels of digital literacy among farmers, and less structured government support for digital agriculture. Also, several specific factors or barriers that hinder the widespread adoption of AI and related technologies in Nigeria have been identified. These include limited access to reliable internet connectivity and insufficient technical support. These challenges are particularly pronounced in rural areas and contribute to disparities in the adoption of advanced agricultural technologies such as AI among farmers in Nigeria (Olawumi *et al,* 2024). These studies collectively suggest that the successful implementation of AI technologies in Nigerian agriculture requires a focus on both the technological and socio-economic aspects as done in advanced countries like India.

Conclusion

AI has the potential to revolutionize agriculture in Nigeria by improving productivity, promoting sustainable farming practices, and strengthening food security. Through precision agriculture, climate-smart farming, disease detection, predictive analytics, and digital advisory systems, AI can help Nigerian farmers produce more food efficiently while conserving natural resources. However, achieving these benefits will require investment in digital infrastructure, farmer education, supportive government policies, and affordable access to technology.

The way forward for adoption of AI in agriculture/Recommendations

1. Investment in digital infrastructure: The introduction of AI to agriculture will be enabled by other technological advances, including big data analytics, robotics, the internet of things, the availability of cheap sensors and cameras, drone technology, and even wide-scale internet coverage on geographically dispersed fields (Spoorthiy, 2024)The government and private organizations should invest in rural internet connectivity, electricity supply, and digital communication systems to support the use of AI technologies in agriculture. This is essential in rural areas where the farming activities are carried out.
2. Farmer Education and Training: Farmers should be trained on the use of AI-based agricultural tools and digital platforms through extension services, workshops, and agricultural institutions by the government. The skillup programmes in ICT organized for the youths in most States in Nigeria should be equally tailored to help farmers master AI technologies.
3. Policy Support and Government Commitment: The government should formulate policies that encourage the adoption of AI in agriculture through subsidies, grants, and incentives for technology developers and farmers. The essence of policy support and government commitment is essential for the adoption and use of AI technologies by the farmers.
4. Strengthening Agricultural Extension Services: AI-powered extension systems should complement traditional extension services to ensure that farmers receive timely information on weather, pests, diseases, and market opportunities.
5. Strengthening Agricultural Extension Services: Universities, research institutes, and technology companies should collaborate in developing affordable and locally adaptable AI solutions suitable for Nigerian farmer, (Russell & Norvig, 2021).

6. Affordable Access to Technology: Financial support such as soft loans, subsidies, and cooperative financing should be provided to enable smallholder farmers to acquire AI tools and smart farming equipment. This support is critical for rural farmers who are mostly resource poor.
7. Public-Private Partnerships: Collaboration between government agencies, private technology firms, financial institutions, and international organizations should be encouraged to expand access to AI technologies.
8. Researchers should focus on developing affordable, locally adaptable, and farmer-friendly AI solutions tailored to Nigerian agriculture that integrate indigenous knowledge and local farming practices.

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