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Economic Effects of Artificial Intelligence (AI)-Driven Mechanization on Farm Labour in Nigeria's Agricultural Sector: A Conceptual Review

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Abstract

The review brings to light the economic effects of AI-driven mechanization on farm labour in Nigeria's agricultural sector. The review is organized as an overview of AI-driven mechanization in the Nigerian agricultural sector, key AI mechanization technologies in Nigeria and their applications, economic effects of AI on farm labour and challenges to the use of AI-driven mechanization in the Nigerian agricultural sector. Artificial Intelligence (AI) is poised to transform farming by reducing labour needs while increasing food production. As AI automation progresses, it is expected to gradually replace human labour, particularly on farms, where robots and autonomous machines will manage operations and utilize predictive analytics for decision-making. The adoption of new technology and mechanization in agriculture can significantly enhance food production. However, it warns that the implementation of AI might lead to challenges such as unemployment among unskilled labourers. Additionally, inadequate connectivity in rural areas could hinder AI effectiveness. Recommendations include improving connectivity and infrastructure, training extension personnel on AI, and making agriculture more appealing to youth, especially graduates.

Keywords: Artificial Intelligence, Mechanization, Farm Labour, Agricultural Sector

Introduction

According to the United Nations Department of Economic and Social Affairs (UNDESA, 2019), Nigeria holds the title of the most populous country in Africa, with an estimated population of approximately 200 million people, making it the sixth most populous nation globally. This large population is experiencing rapid growth, evidenced by an annual growth rate of 2.5%, which positions Nigeria to potentially double its population within the next 30 years and ascend to the status of the third most populous country in the world (UNDESA, 2019) Despite this demographic expansion, Nigeria's economy has faced notable adversity in recent years, primarily due to falling oil prices and the impacts of the COVID-19 pandemic. The economic contraction,

however, began to show signs of recovery in the fourth quarter of 2020 (Shola et al., 2021). However, key sectors of the Nigerian economy, particularly the agricultural sector, still lack significant technological innovation, which may hinder sustainable economic growth moving forward (Shola et al., 2021)

Agriculture remains a linchpin of Nigeria's economy. Currently, agriculture contributes 23.16-25.87% to real GDP and grew by 0.07% year-on-year in Q1 2025, contributing 23.33% to aggregate GDP; employment in agriculture was 34.31% in 2023 (Nigerian Bureau of Statistics (NBS), 2025). 5). The sector accounts for 34.31% of employment, though other estimates put employment at 70% of households or roughly 140 million people (Food and Agriculture Organization (FAO), 2023). It provides food security, raw materials for agro-allied industries, foreign exchange earnings, and a market for industrial products. Crop production dominates the sector, accounting for 66.76% of its nominal value (NBS, 2025). Before the discovery of crude oil in 1956, Nigeria was an agrarian economy and global agricultural powerhouse. In the 1960s the country controlled 42% of global groundnut oil trade, 27% of world palm oil, and 18% of cocoa trade (FAO, 2023). Agriculture was the major source of foreign exchange through exports of groundnuts, cocoa, palm oil, rubber, and hides/skins; food was abundant and Nigeria was self-sufficient, with agricultural exports accounting for over 70% of total exports in 1960 (Shaibu, 2023). The oil boom of the 1970s shifted government focus to petroleum because of shorter-term profits. Agriculture's share of GDP fell from 60% in 1960 to less than 10% by 1978, and Nigeria moved from food self-sufficiency to a net food importer; trend analysis shows a steady downward GDP share in 1960-1969, stagnation during 1970-1985, and a slight recovery from 1986 to 2020 with policy interventions (Shaibu, 2023). Crop production constitutes the major agricultural activity, with key staples such as rice, maize, sorghum, millet, cowpea, yam, and cassava experiencing increased production in 2025 relative to 2024, largely due to improved agricultural inputs and government support programmes (FAO, 2023). However, this growth has not translated into food self-sufficiency, as Nigeria remains a net food importer; between 2016 and 2019, agricultural imports were valued at ₦3.35 trillion, exceeding exports valued at ₦803 billion by more than fourfold (FAO, 2023).

Recent studies identified overlapping structural, economic, and security challenges. Insecurity such as banditry, insurgency, and farmer-herder clashes have displaced farmers, especially in the major agrarian states such as Benue and Borno. Over 1,356 farmers were killed between 2020 and 2024, and many fields remain uncultivated as families flee during planting season (Awakessien, 2026). In Benue, Nigeria's "Food Basket" state, farmers have lost billions in investments, and many have abandoned their farms entirely (Awakessien, 2026). Structural and economic challenges further constrain the growth of Nigeria's agricultural sector. Although agriculture remains a vital contributor to the country's GDP and a major source of employment, it is largely

dominated by smallholder and subsistence farming systems, which limit productivity and commercialization. Nevertheless, the adoption of artificial intelligence (AI) technologies holds considerable potential to transform the sector by improving productivity, resource efficiency, decision-making, and overall agricultural sustainability.

Objectives of the Review: This paper focuses on evaluating the economic effects of AI-driven mechanization on agricultural labour in Nigeria. The paper specifically focused on;

i. the overview of AI-driven mechanization in Nigerian agricultural sector;
ii. key AI mechanization technologies in Nigeria and their applications;
iii. economic effects of AI on farm labour, and;
iv. challenges to the use of AI driven mechanization in Nigerian agricultural sector.

Methodology

The articles that were included in this review were obtained from peer-reviewed academic journals, government reports and institutional databases such as Food and Agriculture Organization (FAO), International Institute for Tropical Agriculture (IITA). Literature was sourced from Google Scholar and Elicit using keywords from the review topic. Articles were selected based on relevance to the review topic.

Overview of AI-Driven Mechanization in the Nigerian Agricultural Sector

Artificial Intelligence (AI) refers to the ability of machines to replicate intelligent human behaviour, involving the creation of algorithms and systems capable of executing tasks such as visual perception, speech recognition, decision-making, and language translation (Russell & Norvig, 2020). In the agricultural sector, AI encompasses machine learning, computer vision, and data analytics to enhance farming practices, boost crop yields, and optimize resource utilization. This includes the utilization of AI-driven drones, crop monitoring sensors, predictive analysis for weather, pest and soil conditions, and automated machinery powered by AI for tasks like planting and harvesting (Mcintosh, 2021). These technologies are designed to enhance and exceed natural processes while being grounded in them, affecting all areas of agricultural management, including propagation, cultivation, livestock management, crop health, pest control, harvesting, and yield optimization.

The emergence of AI during the 4th Industrial Revolution presented both significant prospects and challenges for developing nations, including Nigeria. While AI has the potential to enable these countries, particularly in the "global south," to accelerate their development and achieve substantial economic growth, potentially contributing more than US$15 trillion to the global economy, there is a prevailing concern that these benefits may not be equitably distributed. Without intentional policies, strategic actions, and cooperation among key stakeholders, developing countries may find themselves at risk of being left behind in this technological advancement (Schwab, 2016; Price Waterhouse Coopers [PWC], 2017).

Artificial Intelligence (AI) has emerged as a transformative technology that holds the potential to significantly reshape the processes surrounding agricultural knowledge. AI-driven mechanization in Nigerian agriculture refers to the integration of advanced technologies such as machine learning, robotics, and the Internet of Things (IoT) to automate traditional farming processes (Kolawole, 2024). It influences how this knowledge is generated, processed, and disseminated to farmers. The applications of AI in agriculture cover a wide range of functionalities, including predictive analytics that assist in estimating crop yields, computer vision technologies that aid in the detection of pests and diseases, and machine learning algorithms designed to optimize the use of fertilizers and irrigation systems (Adeyemi et al., 2025). Furthermore, natural language processing tools play a critical role in facilitating personalized communication between farmers and agricultural experts; collectively, these AI applications contribute to more efficient, informed, and responsive agricultural practices, thereby enhancing productivity and sustainability in the agricultural sector (Ojo et al., 2020)

Globally, agricultural advisory services are integrating AI-driven platforms that leverage real-time environmental and agronomic data to offer tailored recommendations for farmers. This evolution aims to enhance decision-making accuracy and mitigate climate-related risks. In sub-Saharan Africa, various innovative digital tools, including Precision Agriculture for Development (PAD), eSoko, and IBM's Agrolink, are emerging to support smallholder farmers. (Adeyemi et al., 2025) These tools deliver critical information such as automated messages, market updates, and crop management strategies directly to farmers through mobile phones and voice systems in their native languages (Bulus et al., 2021). Nigeria is also embracing this technological shift, exemplified by platforms like Zenvus and Hello Tractor, which utilize AI to boost agricultural productivity by providing farmers with vital data regarding soil conditions, rainfall forecasts, mechanization schedules, and pest occurrences, these platforms integrate satellite imagery, sensor data, and machine learning models to produce actionable and economically feasible insights (Ojo et al., 2020) This shift is critical for Nigeria, where the agricultural sector employs over 60–70% of the population but remains hampered by low productivity and climate vulnerability (Kolawole, 2024).

Key AI Mechanization Technologies in Nigeria and their Applications

The adoption of AI in Nigerian mechanization focuses on transforming static machinery into smart systems that can adapt to environmental data, in the following ways:

i. Precision Tractor-Hailing

Precision tractor is a digital platform that uses Artificial Intelligence of Things (AIoT), Global positioning System (GPS) and mobile applications to connect smallholder farmers with tractor services on demand, operating like Uber services such as Hello Tractor utilize AI and GPS to bridge the mechanization gap (Okamgba, 2025). It addresses Nigeria's low tractor

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density of 13 tractors per 100km² vs global average of 200 tractors and high reliance on manual labour (Okamgba, 2025). Hello Tractor, founded in Nigeria in 2014, connects tractor owners to farmers and has serviced 2,425 hectares of land with small and medium service support to 3,541 farmers; by connecting them to tractor owners via a hailing app (Adamu-Ahmed et al., 2024). The system uses predictive analytics to schedule maintenance and optimize fuel consumption of the tractors; collectively these platforms shift mechanization from asset ownership to service access, making precision agriculture financially viable for smallholder farmers and contributing to Nigeria's food security and rural job creation agenda. (Adamu-Ahmed et al., 2024).

ii. Autonomous Aerial Surveillance Mechanization

Autonomous aerial surveillance is an emerging key AI technology in Nigeria. According to McCarthy et al. (2023), autonomous aerial surveillance uses unmanned aerial vehicles (UAV), also known as AI-powered drones and satellites, for real-time crop monitoring. This technology is strengthening mechanization by enabling automated crop monitoring and precision input management for smallholder systems. UAVs Startups such as AirSmat and Zenvus employ computer vision to detect early signs of disease, nutrient deficiency, and pest invasion; the UAV's have multispectral sensors that can detect crop stress, pests, and nutrient deficiencies several days before visible symptoms, allowing targeted spraying and reducing chemical use (Idu, 2025). In sub-Saharan Africa, studies show pooled disease detection accuracy of 90.2% and yield prediction $R^2 = 0.841$, confirming UAVs are technically ready for deployment even under resource constraints with benefits including early pest detection, input optimization, and yield forecasting (McCarthy et al.. 2023). By integrating autonomous flight planning and edge AI, UAVs shift mechanization from manual scouting to data-driven, site-specific decisions, improving productivity on farms under 2 hectares without requiring farmer ownership of the technology (Olusanya et al., 2025).

iii. Smart Irrigation and Soil Sensors

Smart irrigation and soil sensors are another key AI mechanisation technology advancing Nigerian agriculture. Smart irrigation systems use IoT controllers, solenoid valves, weather data, and AI algorithms to automate water delivery by analyzing soil moisture, crop type, and evapotranspiration to optimise irrigation timing and volume without human input (FAO, 2023). In Nigeria, solar-powered IoT pumps deployed in Kano, Sokoto, and Kebbi address water scarcity and labour shortages while improving water use efficiency under programs by the Federal Ministry of Agriculture and Rural Development (FMARD) and National Agricultural Land Development Authority (NALDA) (Olaniyi et al., 2022).

AI-controlled irrigation systems adjust water flow based on real-time soil moisture and weather patterns, these systems ensure optimal hydration while conserving water resources, which is essential in drought-prone regions; data for agricultural

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production are so numerous, it is now possible to standardize and enhance production protocols. (Olusanya et al., 2025). Data is collected using various sources, such as soil sensors, automated irrigation systems, satellite-based imagery, local weather systems, etc. providing actionable insights which help farmers make decisions to improve sustainability and efficiency and improve profitability (Olusanya et al., 2025). Predictive analytics of these data optimize the potential for healthy crop and livestock production, and data-driven agriculture informs precision farming which substantially reduces costs and inputs, e.g., water and pesticide application and fuel costs (Olusanya et al., 2025). Soil sensors complement this by measuring moisture, temperature, pH, and NPK, then transmitting data via GSM or LoRa for AI-driven insights on crop health and fertilizer needs (International Institute for Tropical Agriculture (IITA), 2021). Sensor networks enable field studies and precision agriculture demonstrations, while smart irrigation provides data for research on sustainability and climate adaptation (Adeyemi & Idowu, 2020).

iv. Post-Harvest Automation

Post-harvest automation is a critical AI mechanisation technology reducing food loss and improving value chains in Nigeria. It integrates AI-powered sorting, drying, milling, packaging, and cold storage systems that monitor moisture content, detect spoilage, and optimize processing without manual labour (FAO, 2023). In Nigeria, where 30-40% of perishable crops are lost post-harvest, solar-powered cold rooms and automated dryers deployed by NALDA and International Fund for Agricultural Development (IFAD) in Benue, Kaduna, and Oyo states are improving shelf life and market access for tomatoes, cassava, and grains (Adeyemi & Idowu, 2020). AI vision systems now sort fruits by size, colour, and defects, while IoT sensors track temperature and humidity in storage to prevent aflatoxin and waste (IITA, 2021).

In the cassava and palm oil value chains, AI is being integrated into processing lines for intelligent sorting and grading. Using hyperspectral cameras, these systems identify defects and command robotic arms to divert substandard produce (CreedTec, 2025).

Economic Effects of AI on Farm Labour

The integration of Artificial Intelligence (AI) in agriculture is catalyzing a shift from labour-intensive traditional farming to capital- and skill-intensive "Precision Agriculture." This transition is characterized by significant productivity gains, structural labour displacement, and a widening wage gap between technical and manual workers. The transition from manual labour to AI-driven automation offers several measurable advantages for the Nigerian landscape:

1. **Task Automation.** The most prominent economic effect is the displacement of routine manual labour, AI-driven systems such as autonomous harvesters and robotic weeding platforms target repetitive, physically demanding tasks. Nigeria's agricultural sector relies heavily on manual, semi-skilled labour for routine tasks such as weeding, pesticide application, and harvesting (Veriv Africa, 2025). Projections suggest that full

adoption of AI in Nigeria's agriculture could potentially replace the need for repetitive tasks (Veriv Africa, 2025). AI is increasingly replacing semi-skilled labour in harvesting, sorting, and pesticide application. Research indicates that AI simultaneously displaces routine work while intensifying productivity concentration among leading firms (Datti, 2025). Unlike previous industrial shifts that replaced mechanical tasks, Also AI now automates cognitive-mechanical tasks like crop health assessment and selective spraying (PWC, 2025).

2. Wage Polarization and the Skill Premium

AI mechanization in Agriculture increases wage polarization and the skill premium for farm labour by automating routine manual tasks while raising demand for tech-savvy workers. Autor et al. (2023) show that automation replaces routine task raising returns for skilled workers, AI is reshaping the agricultural wage structure by creating a skill premium for workers capable of managing digital systems. AI-related skills (e.g., drone operation, data analytics command a significant wage premium. Recent data suggests a 56% wage premium for AI skills globally, up from 25% in previous years (PWC, 2025). Economists distinguish between jobs at high risk of substitution and those with high complementarity, where AI boosts productivity and wages for workers who use the technology to enhance their performance (Pizzinelli, 2024).

3. Productivity and Capital Intensity

AI increases Total Factor Productivity (TFP) by optimizing inputs like water, fertilizer, and labour. Industries highly exposed to AI have seen 3x higher growth in revenue per employee compared to less-exposed sectors (PWC, 2025). In addition, AI models facilitate accurate yield prediction and early disease detection, leading to higher revenues per acre (Datti, 2025). The application of precision also reduces pesticide and fertilizer waste, significantly cutting operating expenses (Agri Business Review, 2024).

4. Regional and Structural Economic Shifts

AI mechanization is causing regional and structural economic shifts in Nigeria farm labour market. Regional labour demand is moving from labour- abundant areas to mechanized areas where AI irrigation, drones and tractors reduce the need for manual labour workers (Olaniyi et al, 2022). This shifts rural-urban migration patterns, farmers now need fewer workers but higher digital literacy which creates wage polarization and forces labour to reskill, the effect is higher productivity per worker (Adeyemi & Idowu, 2020).

Challenges to the Use of AI-Driven Mechanization on Farm Labour in the Nigerian Agricultural Sector

The transition from manual labour to AI-driven automation offers several measurable advantages for the Nigerian landscape. In Nigeria, the adoption of AI-driven mechanization, ranging from autonomous tractors to precision drones, presents a complex paradox, while these technologies offer a solution to Nigeria's low agricultural productivity and high post-harvest losses, they introduce significant structural and socioeconomic

challenges to a labour force that currently accounts for approximately 35% of the nation's total employment (Datti, 2025). Challenges of AI-driven mechanization on farm labour in Nigeria include:

1. The Digital Skills Gap and Worker Exclusion

A significant knowledge gap exists between existing traditional farming practices and the technical requirements of AI systems. Most rural smallholder farmers and labourers lack the digital literacy required to interact with AI-powered mobile apps or maintenance software (Eleke et al., 2024). The shift from "manual labour" to "technical management" requires a workforce skilled in data analytics and drone operation, research indicates that without targeted training, Nigeria's youth will be sidelined by high-skill AI systems (International Monetary Fund (IMF), 2026; Omole & Fasina, 2024).

2. Infrastructure and Connectivity Barriers

AI systems are only as effective as the infrastructure supporting them, which is a major bottleneck in Nigeria. AI-driven precision agriculture relies on stable 4G/5G networks and GPS. Inadequate broadband connectivity in rural Nigeria often renders these systems ineffective, creating a digital divide where only farms near urban hubs benefit (Datti, 2025). Also, the lack of a stable electricity supply for charging drones, sensors, and autonomous equipment remains one of the top-ranked barriers to AI adoption in Nigeria (Adegoke et al., 2025).

3. Economic Barriers and Market Consolidation

The high cost of AI-driven mechanization risks concentrating agricultural wealth in the hands of a few. With farm sizes typically averaging 1–2 hectares, the initial investment in AI hardware is economically unfeasible for the average Nigerian farmer (Omole & Fasina, 2024). Studies by Bolana and Oyeyemi (2021) shows that fewer than 10% of smallholder farmers have access to formal agricultural credit needed to adopt modern technologies, forcing them to rely on informal sources with high interest rates and limited capital; about 27% of households are constrained due to collateral demands, low financial literacy and bureaucratic processes often leaving them unable to compete with large agribusinesses that utilize AI to lower unit costs.

4. Socio-Cultural and Security Challenges

AI adoption in Nigeria faces unique local constraints beyond just the technical. Some rural communities view AI as foreign or complex, leading to cultural resistance, especially when AI data-driven insights contradict traditional indigenous knowledge (Ifejesu, 2021). Also, vandalism, theft, and the general insecurity in farming regions (such as farmer-herder conflicts) pose a high risk to expensive AI sensors and machinery left in the field (American University of Nigeria [AUN], 2025).

Conclusion

The study highlights overview of AI-driven mechanization in Nigerian agricultural sector, key AI mechanization technologies in Nigeria and their

applications economic effects of AI on farm labour and challenges to the use of AI driven mechanization in Nigerian agricultural sector. As AI automation progresses, it is expected to gradually replace human labour, particularly on farms, where robots and autonomous machines will manage operations and utilize predictive analytics for decision-making. The adoption of new technology and mechanization in agriculture can significantly enhance food production. However, the paper also reveals that implementation of AI might lead to challenges such as unemployment among unskilled labourers. Additionally, inadequate connectivity in rural areas could hinder AI effectiveness.

Recommendations

Based on the findings for this review paper, the following recommendations were made;

1. The government should improve broadband connectivity and infrastructure in rural areas in Nigeria;
2. Agricultural agencies and research bodies should train extension personnel on AI since they are the ones to train farmers on the AI application;
3. The government should make agriculture more appealing to youths, especially graduates in Nigeria by providing credit facilities.

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