

## Introduction

Agriculture is a vital sector that supports the livelihoods of billions of people globally and is crucial for ensuring food security, as ensured by its mechanisation. Agricultural mechanization plays a crucial role in enhancing food security worldwide by improving productivity, efficiency in food production, access to credit facilities and improved seedlings (Bhooshan et al., 2024). Mechanization has revolutionized farming practices, leading to increased agricultural productivity and food availability in many parts of the world. The global perspective on agricultural mechanization reveals that mechanization has significantly transformed farming practices, leading to increased productivity, improved efficiency, and enhanced food security (Zou & Mishra, 2024).

Developing economies like Brazil emerged as a major player in precision farming, with its vast agricultural lands, leveraging on benefits of precision farming techniques and technologies like satellite imagery, drones, and yield monitors to optimize their crop production and improve overall efficiency. This has resulted in increased agricultural production and the ability to meet the growing food demands of their populations (Sousi et al., 2024). The global experience provides valuable lessons and insights into the potential benefits and challenges of mechanization, which can inform strategies and approaches to enhance food security in Nigeria and other African developing economies.

Agricultural mechanization is the replacement of human and animal labour by mechanical devices in farming activities as it embraces the manufacture, distribution and operation of all types of tools, implements, machines and equipment for agricultural land development, farm production and crop harvesting, and primary processing (Simalenga, 2020). The overdependence on subsistence agriculture has led to sluggish development in urban areas and skewed income distribution (Davies, 2019). Interestingly, the United Nations Food and Agriculture Organization (FAO) and

the United Nations Industrial Development Organization (UNIDO) shared a common ground that the goal of agricultural mechanization is to reduce labour, increasing the level of cultivated land, moving toward industrialization and strengthening the market for rural economic growth and ultimately improving the livelihoods of farmers are the goals of mechanization (Emami et al., 2018).

The commitment of African Union (AU) to Agriculture mechanisation to ensure food security on the African continent is amplified by the seven Malabo Declaration commitments; recommit to the principles and values of the Comprehensive Africa Agriculture Development Programme (CAADP) process, enhance investment finance in agriculture, end hunger in Africa by 2025, reducing poverty by half by 2025 through inclusive strategies. The Rwanda success story in agriculture mechanisation over the last years reflects dedication to strengthening each segment of the agriculture value chain through targeted mechanization interventions, increased roles of the private sector, emphasis on research and skill development, and the creation of village mechanization centers. In Rwanda, from 2005 to 2014, average agricultural output grew by more than five per cent, while the average annual machinery growth rate was almost three per cent. Hence, Rwanda was named as the best-performing country in implementing CAADP's seven commitments (The Malabo Montpellier Panel, 2019).

Agricultural mechanization faces numerous challenges that have hindered its widespread adoption and impact on food security. Limited access to appropriate and affordable machinery, inadequate infrastructure, inadequate and politicised policies fraught with leakages, dearth of institutional frameworks, and a lack of skills and training in modern agricultural practices are among some of the key challenges (Kassamba et al., 2024). These factors have contributed to low productivity,

high post-harvest losses, and limited food availability in many African countries, including Nigeria. Understanding these challenges is crucial for designing effective interventions and policies that can address the specific needs and constraints of the African context.

According to Dizengoff, Iceland has more tractors per hectare of cropland than any other nation in the world with 37.2 tractors per 1,000 people, while Nigeria has 0.223 tractors per 1,000 people. This means that Iceland has almost one tractor for each farmer and 166 times more mechanised in their farming than Nigeria. Statistics reveal that Nigeria needs at least 746,666 tractors equipped with tillers and other support gadgets to sufficiently mechanise agriculture going by best practices. Absence of committal to the replacement of the aging, worn out, and broken-down tractors further hinder Nigeria's agricultural potential Stakeholders in Nigeria have fewer tractors than minnow countries like Serbia & Montenegro with 400,000, Pakistan with 320,000, or Uzbekistan with 170,000 tractors (Okojie, 2019).

In Nigeria, the federal government's efforts as seen in the 2024 budget, which allocated N134.54 billion to the agricultural sector, representing 1.32 per cent of the total budget of N27.5 trillion, which is minimally higher than the 2023 allocation grossly. The inadequate budgetary allocation to Nigeria's agriculture could be counterproductive to issues of 500,000 dry farming hectares mechanisation, rehabilitation of irrigation facilities and dams, storage, and research and development, thereby negatively impacting farmers' productivity and food security. Government-initiated policies, such as the Anchor Borrowers Program (ABP), National Agricultural Technology and Innovation Plan (NATIP), aim to diversify the economy away from oil are always fraught with poor implementation or hijacked by political cronies (Ojabello, 2023).

It is against this background that this study seeks to assess the level of agricultural mechanization for food security in Benue and Niger states, and to identify challenges of agricultural mechanization on food security in these two states of Nigeria.

## **Methodology**

To effectively carry out this study, the exploratory research design was adopted while extensively making use of secondary data generated through journal publications, the internet, library sources, and other documented materials relevant to the study of agricultural mechanisation and food security. The research was conducted by examining literature concerning challenges of agricultural mechanisation, food security, and the status of mechanisation. The literature was obtained through searches in publicly available material, literature from non-serial publications, official reports, and conferences particularly if they have been cited by other references.

## **Conceptual Framework**

### **Agricultural Mechanization**

Agricultural mechanization is a cross-cutting hybrid term that includes several disciplines due to its broadness with intersections with economic aspects beyond agriculture itself. According to Babajide (2019) agricultural mechanization is the application of tools, implements, and powered machinery as inputs to achieve agricultural production. This definition failed to view agricultural mechanization as the replacement of human and animal labour by mechanical devices in farming activities.

Makanjuola (2019) submitted that agricultural mechanization embraces the manufacture, distribution and operation of all types of tools, implements, machines and equipment for agricultural land development. This definition contrasted with the concept that mechanization only means the application of engineering principles to crop production only. Ogunlowo (2019) define agricultural mechanization as the process of development and application of machines in the farming process. It may also be defined as the introduction of tools, implements, machines, equipment and technology in the cultivation of farm lands and processing of food. The above definitions limit agricultural mechanization to mean the application of engineering principles to crop production only. This study therefore defines agricultural mechanization as the engagement of manufacture, distribution and operation of all types of advanced equipment, seeds, and inputs in the farming process towards ensuring productivity, efficiency, and food security.

### **Food Security**

Food security according to Food and Agricultural Organisation (FAO) (2011) exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for active and healthy life. Thus, to achieve food security in Nigeria is a task that requires a holistic approach in terms of commitment, knowledge and skills acquisition by all categories of individuals especially the youths at all levels of education. Food security is usually framed in four dimensions food availability, access to food, food use, utilization and food stability (FAO, 2016a). The Sustainable Development Goals Two (SDG), a position of world leaders, opines to end hunger, achieve food security and improved nutrition, and promote sustainable agriculture (UNDP, 2020). Indicators for this goal are for example the prevalence of diet, prevalence of severe food insecurity, and prevalence of stunting among children less than five years of age. SDG 2 has eight targets and 14 indicators to measure

progress (United Nations, 2017). This study conceptualises food security to exclude livestock management.

## **Empirical Review**

### **Status of agricultural mechanization and Food Security**

Haider and Joshy (2024) employed quantitative research design to interrogate the nexus between rice yield and farm mechanization in India. The study engaged time series data and simple regression model between on the relationship between the independent and dependent variables. Findings from the study situated that there is a strong relationship between rice yield and the sale of tractors as against consumption of fertilizers on rice yield. The study opined that there is a need for the principle of public distribution system in India to tractor distribution system to those farmers who cannot afford it due to lack of money.

Ibrahim (2024) interrogated status of agricultural mechanization and its implication on crop production In Kurfi Local Government Area, Katsina State Of Nigeria. The study engaged multi stage sampling techniques to collect information on the socio-economic characteristics, agricultural machines available and equipment used for specific farm operations. Results from the study submitted that status of agriculture mechanisation is still low as vast majority of peasant farmers have limited access to modern inputs and other productive resources and are unlikely to have access to pesticides, fertilizers, hybrid seeds and irrigation facilities.

Zou and Mishra (2024) investigated the nexus between food security and modernising smallholder agriculture in China. The study in an exploration of Machinery Services and Labor Reallocation in China, puts forward a framework of vertical division of labor and specialized production in

agriculture. We posit that hiring machinery services could be a pathway to connect smallholders with modern agriculture and achieve food security in China. Using household-level data from China on farm productivity, food security, and rural households' welfare. The result of investigations revealed that mechanization services increased rural Chinese families' food security and agricultural productivity. Hiring machinery services improves smallholders' income by influencing the input efficiency of maize production. At the same time, increased mechanization implied greater participation in off-farm work, as more family labor and time are allocated to off-farm work, which results in higher total income and increased consumption expenditures.

Issaka et al. (2022) interrogated Ghana's profitability of agricultural mechanization services and its consequences on food security and poverty alleviation. The study used content analysis and discussion from existing studies to achieve the objectives of the research. The findings of the study emphasize that, agricultural mechanization is a panacea to food security and poverty alleviation in emerging country such as Ghana.

Jin and Chen (2024) analysed the pathways and mechanisms facilitating the integration between smallholder farmers in mountainous regions and modern agriculture. The study adopted regression and moderation models to analyze survey data from smallholder farmers in Yunnan Province, China, it explored the "trickle-down effect" of the influence of new agricultural entities on the mechanization levels of smallholder farmers in these regions. Findings from the study revealed that, the mechanization levels of smallholder farmers in mountainous areas were primarily influenced by their social and natural resources, as well as internal mutual assistance behaviours. Agricultural enterprises demonstrated a significant driving effect in promoting the mechanization levels of smallholder farmers categorized as "non-cooperative members" or those who had not

received free training. Conversely, farmer cooperatives only exhibited a significant effect in elevating the mechanization levels of cooperative members.

Meng et al. (2024) attended to the nexus between agricultural mechanization and rural workers mobility which shares interconnection with food security. The study utilised household-level data from 2003 to 2013 and employ China's Agricultural Machinery Purchase Subsidies (AMPS) as a quasi-experiment to examine the causal effects of mechanization on rural worker mobility. The result that emanated from the study opine that, on average, the agriculture mechanisation programme significantly promote mechanization in treated villages, and raise rural households' migrant labour day by 15 per year. The benefits are more pronounced for households with heavy reliant on agriculture and young, educated males. Mechanism analysis indicates that mechanization affects worker mobility primarily by displacing agricultural labour inputs rather than expanding land scale. There is the need for this study with focus on Niger and Benue states to engage States specific study in order to draw valid conclusion.

Zhao et al. (2024) engaged agricultural technology innovation and food security in China as of great significance for high-quality agricultural development. The study identified the coupling coordination relationship between the two systems and the influencing factors to accelerate the realisation of high-quality development of Chinese agriculture. The study employed spatial and temporal coupling characteristics of the two using the entropy value method, coupling coordination degree model, and exploratory spatial data analysis, and it screens for important influencing factors using the grey correlation model. The main results show that the coupling coordination relationship between agricultural technology innovation and food security in China is at a dissonant stage, but the value of the coupling coordination degree increases from 0.2076 to 0.3437 during the period of study, and the level of coordination gradually improves. The degree of coupling coordination

in the provincial space exhibits a distribution pattern of “high in the east and low in the west”. The areas of high value are primarily situated in the provinces of Shandong, Jiangsu, and other provinces along the southeastern coast of China, while the areas of low value are mainly located in the provinces of Qinghai, Ningxia, and other provinces in inland northwest China. The Moran’s index of provincial coupling coordination is greater than 0, showing a certain positive correlation, and there is a significant pattern of spatial aggregation. The correlation coefficients between the influencing factors and the degree of coupling coordination are all greater than 0.35, indicating a moderate or high correlation, but the significance of technological support capacity and food distribution security increased over time.

## **Theoretical Framework**

### **The New Growth Theory**

The New Growth Theory was primarily developed by economists Paul Romer and Robert Lucas in the 1980s and 1990s. It emerged as a response to limitations in traditional growth theories, which did not fully account for technological innovation and knowledge as key drivers of long-term economic growth. While Paul Romer emphasized that knowledge and innovation are critical for economic growth, and unlike traditional inputs (like labor and capital), they have increasing returns to scale. Robert Lucas highlighted the role of human capital and education in economic development. further expanding the framework of the New Growth Theory. Romer and Lucas together laid the foundation for understanding how knowledge, technology, and human capital can drive sustained growth within an economy. This thus emphasised the role of agriculture mechanisation as a veritable tool to achieve food security (Lucas, 1988; Romer 1990).

The New Growth Theory emphasizes the role of technological innovation, knowledge, and human capital in driving sustained economic growth, particularly in developing nations. While agricultural mechanization refers to the introduction of technology, such as tractors, harvesters, and irrigation systems, to enhance farm productivity, New Growth Theory opines that, sustained technological advancements, like agricultural mechanization, lead to improved productivity and long-term economic development (Adegboye, 2022). In Benue and Niger States, where agriculture is a primary economic activity, mechanization becomes essential for improving food security and economic resilience.

However, the status of mechanization in Benue and Niger States remains low despite the recent effort by the state governors in the areas of tractorization, primarily due to inadequate numbers of modern farming equipment, politicalised policies, and crowding out of private investors in the value chain of agriculture mechanisation. This aligns with the New Growth Theory's assertion that growth in developing nations is often limited by insufficient investments in technology and human capital (Lucas, 1988). Smallholder farmers, who make up the majority of the agricultural sector in these states, typically rely on manual labour and traditional farming techniques, which limits productivity. New Growth Theory suggests that technological innovation, supported by knowledge transfer and education, can drive economic transformation in such regions. If policies were implemented to promote access to mechanized tools and the necessary training for their use, these states could experience significant improvements in agricultural productivity, leading to enhanced food security.

Despite its potential, challenges to mechanization in North central region; high costs of acquiring machinery, farmland insecurity from farmers herders clash, incessant cattle rustling, inadequate

infrastructure, and limited access to financing. These obstacles hinder the ability of farmers to embrace mechanized farming, which is necessary for improving food security (Alston et al., 1996). According to New Growth Theory, the growth potential of any economy depends on the ability to overcome such barriers by fostering an environment that encourages innovation and investment in technology. Developing nations like Nigeria can achieve this by implementing supportive policies that reduce the cost of agricultural machinery, improve infrastructure, and provide affordable financing options for farmers. The theory does not adequately address the issue of income inequality. While it emphasizes that investment in human capital and innovation can lead to economic growth, it does not fully explain how the benefits of growth are distributed across society. Some critics argue that policies based on New Growth Theory may lead to a widening gap between rich and poor, as only those with access to education and resources are able to benefit from technological advancements. Such measures would allow farmers in Benue and Niger States to access modern equipment, increasing their productivity and contributing to food security.

### **Discussion of Findings**

The findings from review of literature reveals that status of agriculture mechanisation in Nigeria negatively influence food security. This poor intersections between status of agriculture mechanization and food security could be explained by agriculture mechanisation deficit, dearth of tractorisation, amplified by continual reliance on traditional farming methods, politicised government policies fraught with leakages, dearth of institutional frameworks, dearth of maintenance culture among farmers leading to frequent breakdowns and reduced lifespan of machinery, making it difficult for smallholder farmers to access and utilize them. This low status of agriculture mechanisation has contributed to low productivity, high post-harvest losses, and limited food availability which grossly threaten national security. Findings from this study align

with previous study of Haider and Joshy (2024); Issaka et al. (2022); Jin and Chen (2024). Due to the poor status of agriculture mechanisation in Nigeria, this study contradicts the works of Zou and Mishra (2024); Meng et al. (2024). zhao et al. (2024).

The results from empirical literature affirmed that challenges of agricultural mechanization in Nigeria negatively influence food security capabilities. This challenge could be rationalised as structural due to the absence of enabling policies. This could be explained by the presence of limited private sector participation in the value chain of agriculture, which is mostly tied to the whims and caprices of political office holders and not driven by the aims of making a profit and matching up with global best practices. The dominant presence of government, riddled with leakages and corrupt practices, thus crowded out innovative private investors. This position confirms earlier submissions on the challenges of agriculture mechanization and food security by Elbashi (2024); Adegboye (2022); Daum et al. (2021); Tiwari et al. (2017); Daum and Birner (2017).

### **Challenges of Agricultural Mechanization and Food Security**

Elbashi (2024) investigated challenges of agricultural mechanization and food security in Saudi Arabia. Study identified loss of agricultural land due to urbanization and industrialization further emphasizes the need for efficient production methods. Findings from the study advanced precision agriculture for the precise application of agricultural inputs such as seeds, fertilizers, water, pesticides, and energy, with the ultimate objective of reducing the costs of such inputs, increase yield, improve returns, and mitigate the environmental risks of farming. The study was done in Saudi Arabia as state specific study while this study will interrogate beyond agriculture mechanization challenges in Benue and Niger States.

Adegboye (2022) interrogated challenges and prospects of mechanised agriculture and food security in Nigeria. The study employed explanatory research design with reliance on field study, interview, observations and extant literature. Findings from the study submitted that low level of agricultural mechanisation is traceable to challenges of affordability of mechanisation, non-availability of mechanisation. Study submitted that challenges around land tenure and land clearing outrightly reduce the household farmer to compete favourable amidst arrays of challenges bedeviling his capabilities. The study was a country specific study while this study is states specific hence different datasets are engaged.

Daum et al. (2021) examined opportunities and challenges of digital tools of Uber for tractor hire using Hello Tractor in Nigeria and EM3 Agri-Services in India. The study engaged mixed-methods approach of approximately 400 respondents and comprising a participatory mapping tool, focus group discussions, interviews with tractor owners and other stakeholders, and a survey among farmers. Results from the study revealed that the Uber for tractor models have indeed the potential to reduce transaction costs for service providers, in particular the owners of several tractors, by enabling the monitoring of tractors and operators through GPS devices. Farmers who access services have, so far, only indirectly benefitted from the new digital tools, because they still relied on “analog” solutions - booking agents and phone calls - rather than a smartphone app to request services. Study shows that Uber for tractors is a pioneering concept, but investment in enabling conditions, such as digital literacy and network coverage, is required to harness the full potential of such digital innovations for smallholder farmers in the developing world.

Tiwari et al. (2017) investigated skill development among youth under food processing training programmes (Rashtriya Krishi Vikas Yogan), Agriculture University, Kota-India. The study engaged total sample of 125 trainees through random sampling for 5 training programme. Findings

from the study showed that trainings were considered very useful in income generation and self-employment. The study concluded that through skill development in processing of different produce, not only inculcated skills among trainees but it also made them confident, skilled, experienced and gave them opportunities of income generation through self-employment and empowerment.

Tufa et al. (2024) engaged mixed method research design to interrogate nexus between food security and Willingness to pay for agricultural mechanization services by smallholder farmers in Malawi. The study estimates the farmers' willingness to pay for mechanization services using the double-bounded contingent valuation method and data from 1,512 households. Analysis from the study revealed that, on average, farmers are willing to pay 11%, 33%, and 5% more than prevailing market rates for land preparation, maize shelling, and transportation services, respectively. The study conclude that Private sector-led mechanization services hold a promise to address challenges borne out of the mismatch between the economies of scale of machines and farm size. That the high demand for mechanization services among smallholder farmers points to the need for making the machinery available to rural communities through mechanization service providers or machinery hiring centers run by the private sector.

Daum and Birner (2017) examined the governance challenges involved in government and private sector efforts to promote mechanisation in smallholder-based farming systems. The study developed a conceptual framework that combines the agricultural innovation system approach with the concepts of New Institutional Economics. Two qualitative empirical methods were used to apply the framework: the Net-Map technique, which is a participatory mapping tool, and expert / key informant interviews. The findings of the study revealed that market failures of access to spare-parts supplies and credit, dearth of institutions on skill development of tractor-operators and

technicians. The study focused on smallholder-based farming systems while this study is Benue - Niger states specific study

## Conclusion

The study concludes that status of agriculture mechanisation in Nigeria is not only poor and backward but has a negative influence on food security as productivity could not match population growth and production is still at subsistence level.

This study also opine that prevailing agriculture mechanisation challenges is structural, due to the non-productive and dominance presence of government which negatively affect food security in Nigeria, as innovative private investors are crowded out of agriculture, due to policies fraught by leakages and corrupt practices.

## Recommendations

Based on these findings, the study recommends that;

- i. All tiers of government should extensively subsidize agriculture to achieve tractorisation, tractor hiring services, cooperatives and corporate participation in agricultural mechanization, local manufacturing and assembling, and import duty waivers to ensure food security.
- ii. All tiers of government should incentivise private sector participation so as to inject innovative technologies into agriculture to quicken the achievement of the Sustainable Development Goal Two. The establishment of demonstration farms in all LGAs to showcase mechanized farming practices, LGAs maintenance centre for mechanics towards transfer technology, and farmers provision of credit facilities for profiled farmers





