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Social Effect of Agricultural Mechanization on Crop Output in North Central Nigeria

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Abstract
This study examines the social effects of agricultural mechanization on crop output in North Central Nigeria, specifically assessing the impact of employment generation, education opportunities, health and safety, and food security. A survey research design was adopted, and primary data were collected from 384 respondents across Benue, Nasarawa, and the Federal Capital Territory using a structured questionnaire. The validity of the research instrument was established through content and construct validity, with exploratory factor analysis confirming a cumulative variance of 66.937%. Reliability tests yielded a Cronbach's Alpha coefficient of 0.833. Binary logistic regression was employed for data analysis, with statistical significance assessed at the 5% level. The results indicate that employment generation significantly influences crop output (B = 1.950, p = 0.021, Exp(B) = 7.026), underscoring the role of mechanization in creating job opportunities that enhance productivity. Health and safety also show a statistically significant effect (B = 0.565, p = 0.022, Exp(B) = 1.760), suggesting that improved working conditions and healthcare access contribute to increased agricultural efficiency. However, education opportunities (B = 0.265, p = 0.294) and food security (B = 0.420, p = 0.087) do not exhibit significant effects on crop output. The study concludes that while mechanization positively impacts employment and health conditions, its effects on education and food security require further investigation. It recommends policies promoting mechanization-driven employment, improved health and safety conditions, long-term agricultural education strategies, and enhanced food security mechanisms to ensure sustainable agricultural growth.

Keywords*: Agricultural mechanization, crop output, employment generation, health and safety, food security.*

1.0 Introduction

Agricultural mechanization plays a pivotal role in enhancing productivity and efficiency within the agricultural sector. It involves the use of machinery and technology to perform various farming activities, which traditionally relied on manual labour. The adoption of mechanization in agriculture has been associated with numerous benefits, including increased crop yields, reduced labour costs, and improved timeliness of farming operations. However, the social effects of agricultural mechanization, particularly in developing regions such as North Central Nigeria, remain underexplored. This study aims to investigate these social impacts, focusing on key aspects

such as employment generation, education opportunities, health and safety, and food security.

The context of North Central Nigeria provides a unique setting for this study due to its diverse agricultural practices and significant reliance on smallholder farming. According to the National Bureau of Statistics (2020), agriculture remains a major contributor to the economy of this region, with a substantial portion of the population engaged in farming activities. However, despite its potential, the sector faces numerous challenges, including low productivity and labour inefficiencies. Mechanization presents a viable solution to these challenges, yet its broader social implications need to be understood to ensure sustainable development.

Employment generation is one of the critical social effects of agricultural mechanization. While mechanization can lead to job displacement due to the reduced need for manual labour, it can also create new employment opportunities in machinery operation, maintenance, and related services. This dual impact on employment necessitates a careful examination to balance the benefits and potential drawbacks. Studies by Dauda *et al.* (2021) and Oluwatayo and Ojo (2020) have highlighted the need for policies that support skill development and job creation alongside mechanization to mitigate negative employment effects.

Furthermore, the integration of mechanized farming practices can influence education opportunities and health outcomes. Improved agricultural productivity and income can enhance access to education for farming households, enabling them to invest in their children's education. Additionally, mechanization can contribute to better health and safety conditions by reducing the physical strain associated with traditional farming methods and minimizing exposure to harmful environmental conditions. Research by Akinbami *et al.* (2019) underscores the importance of promoting health and safety standards in mechanized farming to protect workers and their families. Therefore, understanding these social effects is crucial for formulating policies that maximize the benefits of agricultural mechanization while addressing potential social challenges.

Agricultural mechanization significantly influences employment generation within the farming sector. The transition from manual labour to mechanized farming can initially reduce the demand for traditional farm labour, but it simultaneously creates new employment opportunities in machinery operation, maintenance, and related services. This shift can lead to more efficient farming operations, thereby increasing crop output. Mechanized equipment enables timely planting, weeding, and harvesting, which are critical for optimizing crop yields. As highlighted by Oluwatayo and Ojo (2020), mechanization can drive rural employment through the creation of skilled and semi-skilled jobs, ultimately contributing to enhanced agricultural productivity and increased crop output.

Education opportunities are also positively affected by agricultural mechanization. Increased farm productivity and income enable farming households to invest more in education, leading to higher literacy and better educational attainment. Educated farmers are more likely to adopt advanced agricultural technologies and best practices, which can significantly improve crop output. According to Dauda *et al.* (2021), there is a strong correlation between education and the adoption

of innovative farming techniques. Education not only empowers farmers to make informed decisions but also facilitates access to agricultural extension services and information about new technologies, further boosting crop productivity.

Health and safety improvements are another important aspect influenced by agricultural mechanization. Traditional farming practices often involve strenuous physical labour and exposure to hazardous conditions, which can adversely affect the health of farmers. Mechanization reduces the physical burden on farmers and minimizes their exposure to harmful environmental factors. Healthier farmers are more productive and capable of effectively managing their farms, leading to increased crop output. Akinbami *et al.* (2019) emphasize that mechanization can improve occupational health and safety in agriculture, reducing the incidence of work-related injuries and illnesses, and thereby enhancing overall farm productivity.

Food security is directly impacted by the increased crop output resulting from agricultural mechanization. Enhanced productivity ensures a more stable and abundant food supply, which is essential for reducing hunger and improving nutritional outcomes in rural communities. Mechanization allows for the expansion of cultivated areas and the diversification of crops, contributing to greater food availability and resilience against food shortages. The National Bureau of Statistics (2020) reports that mechanization has been instrumental in achieving higher crop yields and food security in many regions. By increasing the efficiency and output of agricultural production, mechanization plays a crucial role in ensuring sustainable food systems and supporting the livelihoods of farming communities.

Statement of Problem

Despite the potential benefits of agricultural mechanization, its implementation in Nigeria faces several challenges that affect the social and economic well-being of farming communities. One critical issue is the potential displacement of labour. Mechanization can reduce the need for manual labour, leading to job losses among farm workers who rely on agriculture for their livelihoods. This displacement can exacerbate poverty and unemployment in rural areas if alternative employment opportunities are not provided. The lack of adequate policies and programs to retrain and re-employ displaced workers poses a significant problem, hindering the potential positive impact of mechanization on crop output and rural development.

The relationship between agricultural mechanization and education opportunities is also problematic. While mechanization can increase farm productivity and income, which in turn could support better educational opportunities, many farming communities in Nigeria lack access to quality education and training programs. This gap limits the ability of farmers to adopt and effectively use mechanized equipment. Without sufficient education and training, farmers may not fully benefit from mechanization, resulting in suboptimal crop yields. Furthermore, the absence of tailored agricultural education programs that address the specific needs of mechanized farming contributes to the underutilization of technological advancements in agriculture.

Health and safety concerns present another significant challenge in the mechanization of agriculture in Nigeria. Traditional farming practices are physically demanding and often unsafe, but the introduction of machinery without proper training and safety measures can lead to new health risks. Many farmers lack knowledge about the safe operation and maintenance of agricultural machinery, which can result in accidents and injuries. The problem is compounded by inadequate healthcare infrastructure in rural areas, making it difficult for injured farmers to receive timely and effective medical care. This situation undermines the potential health benefits of mechanization and can negatively impact crop productivity if farmers are unable to work due to injury.

Food security is closely linked to agricultural productivity, and while mechanization has the potential to significantly increase crop output, several barriers prevent this from being realized in Nigeria. These barriers include limited access to affordable and appropriate machinery, insufficient infrastructure to support mechanized farming, and inadequate financial services to facilitate the purchase and maintenance of equipment. Additionally, smallholder farmers, who constitute the majority of the agricultural workforce in Nigeria, often lack the resources to invest in mechanization. This lack of access can lead to disparities in productivity and food security, with mechanized farms achieving higher yields while smallholders continue to struggle. Addressing these challenges is essential to ensure that the benefits of mechanization contribute to widespread food security and improved crop output across the country. It is in the light of the above that this study examine the social effect of agricultural mechanization on crop output in North Central Nigeria. The specific objectives are to examine the effect of employment generation, education opportunities, health and safety and food security as social effect of agricultural mechanization on crop output in North Central Nigeria. Examining how mechanization affects employment can reveal whether it creates new jobs or replaces existing ones, offering valuable insights for regional policymakers. Investigating the impact on education opportunities shows if mechanization helps develop a more skilled and knowledgeable workforce, which is crucial for sustainable agricultural growth and economic development. Understanding its influence on health and safety determines if modern practices make farming safer, reducing injuries and improving worker well-being. Finally, studying mechanization's role in food security uncovers its potential to boost crop yields and ensure a stable food supply, addressing hunger and malnutrition in North Central Nigeria.

Objectives of the Study

The study examines the social effect of agricultural mechanization on crop output in North Central Nigeria. The specific objectives are to examine the effect of employment generation, education opportunities, health and safety and food security as social effect of agricultural mechanization on crop output in North Central Nigeria. The hypotheses of the study are stated in line with the specific objectives of the study.

2.0 LITERATURE REVIEW

Conceptual Framework

Agricultural Mechanization

Agricultural mechanization refers to the application of machinery, tools, and equipment to enhance the efficiency and productivity of farming activities. It encompasses a wide range of technologies, from simple hand tools to sophisticated, computer-controlled machines. Mechanization aims to reduce the reliance on manual labor and improve the speed, quality, and precision of agricultural processes. The concept is vital for transforming traditional agricultural practices, boosting crop yields, and ensuring sustainable agricultural development. According to Singh (2006), mechanization not only increases production but also reduces the drudgery associated with manual farming activities, thereby improving the quality of life for farmers.

Mechanization plays a crucial role in addressing the challenges of labor shortages and increasing demand for food due to growing populations. It enables farmers to perform tasks such as plowing, harrowing, planting, transplanting, irrigating, harvesting, and processing more efficiently and effectively. For instance, the use of tractors and combine harvesters can significantly speed up field operations and reduce crop losses. The Food and Agriculture Organization (FAO) (2016) highlights that mechanization can lead to timely agricultural operations, which is essential for maximizing crop yields and ensuring food security. Additionally, mechanization facilitates the adoption of modern farming techniques, such as precision agriculture, which relies on advanced machinery and technology to optimize field-level management regarding crop farming.

The adoption of agricultural mechanization varies widely across regions, influenced by factors such as economic development, infrastructure, and government policies. In developed countries, high levels of mechanization have been achieved due to substantial investments in agricultural technology and supportive policy frameworks. In contrast, developing countries often face challenges such as limited access to capital, inadequate infrastructure, and lack of technical know-how, which hinder the widespread adoption of mechanization. Pingali (2007) notes that for mechanization to be successful in these regions, it requires a holistic approach that includes financial support, training programs, and the development of appropriate technologies tailored to local conditions.

The social and economic impacts of agricultural mechanization are significant and multifaceted. Mechanization can lead to increased agricultural productivity, higher incomes for farmers, and improved food security. However, it also has the potential to cause social disruptions, such as job displacement due to the reduced need for manual labor. As noted by Dauda *et al*. (2021), while mechanization can create new employment opportunities in machinery operation and maintenance, it requires careful management to ensure that the benefits are widely shared and that negative social impacts are mitigated. Policymakers need to consider these aspects and implement strategies that promote inclusive and sustainable mechanization.

Social effect of agricultural mechanization

Agricultural mechanization in North Central Nigeria has profound social implications, particularly concerning crop output. One of the primary social effects is employment generation. While mechanization can lead to job displacement due to reduced reliance on manual labor, it also creates new employment opportunities in areas such as machinery operation, maintenance, and technical services. According to Dauda *et al*. (2021), mechanization can foster the development of a skilled workforce, leading to the creation of higher-paying jobs and contributing to economic growth in rural areas. However, the transition requires targeted training programs to equip workers with the necessary skills to operate and maintain agricultural machinery, thus ensuring that the benefits of mechanization are broadly distributed.

Another significant social effect of agricultural mechanization is its impact on education opportunities. Increased agricultural productivity and income from mechanized farming enable farming households to invest more in education. As families experience improved financial stability, they are more likely to send their children to school and invest in higher education. This is crucial for breaking the cycle of poverty and enhancing human capital in the region. Education, in turn, supports the adoption of more advanced agricultural practices and technologies, creating a virtuous cycle of growth and development. Studies by Oluwatayo and Ojo (2020) highlight the positive correlation between increased agricultural income and educational attainment, emphasizing the long-term benefits of mechanization on social development.

Health and safety improvements are also notable social effects of agricultural mechanization. Traditional farming methods often involve strenuous physical labor, which can lead to various health issues and injuries. Mechanization reduces the physical burden on farmers and minimizes exposure to hazardous conditions. This leads to better health outcomes and improved quality of life for farmers and their families. Moreover, mechanized farming can help in maintaining better sanitary conditions during the production process, thereby reducing the risk of contamination and food borne illnesses. Research by Akinbami et al. (2019) underscores the importance of mechanization in improving health and safety standards in agriculture, highlighting the need for policies that support the health and well-being of farmers.

Food security is another critical area affected by agricultural mechanization. By enhancing productivity and efficiency, mechanization ensures a more stable and increased food supply. This is particularly important in North Central Nigeria, where agriculture is a key component of food security. Increased crop output from mechanized farming can help in meeting the food demands of the growing population, reducing reliance on food imports, and stabilizing food prices. According to the FAO (2016), mechanization can significantly contribute to food security by ensuring timely planting and harvesting, thus reducing post-harvest losses and increasing the availability of food. This not only improves the nutritional status of the population but also supports economic stability and development in the region.

Proxies of Social effect of agricultural mechanization

Employment Generation

Employment generation is a crucial aspect of the social effect of agricultural mechanization. Mechanization can lead to both job creation and displacement, depending on the scale and nature of implementation. While some jobs may be lost due to the reduced need for manual labor, new opportunities are created in areas such as machinery operation, maintenance, and technical support. According to Dauda et al. (2021), mechanization in agriculture can stimulate economic growth by creating a demand for skilled labor, especially in rural areas where job opportunities are limited. However, the transition to mechanization requires careful planning and investment in training programs to ensure that the workforce is equipped with the necessary skills to benefit from these new opportunities.

Education Opportunities

The introduction of agricultural mechanization can also impact education opportunities in rural areas. Increased productivity and income from mechanized farming can lead to higher levels of education among farming households. As families experience improved financial stability, they are more likely to invest in education, particularly for their children. This can result in higher school enrollment rates and increased access to higher education. Oluwatayo and Ojo (2020) highlight the positive correlation between agricultural income and educational attainment, emphasizing the role of mechanization in breaking the cycle of poverty and enhancing human capital. This has long-term implications for the development of rural communities, as a more educated workforce is better equipped to adopt and adapt to new technologies and practices in agriculture.

Health and Safety

Agricultural mechanization can also have significant implications for health and safety in farming communities. Traditional farming methods often involve strenuous physical labor, which can lead to various health issues and injuries. Mechanization reduces the physical burden on farmers, leading to improved health outcomes and a better quality of life. Additionally, mechanized farming can help maintain better sanitary conditions during the production process, reducing the risk of contamination and foodborne illnesses. Akinbami et al. (2019) emphasize the importance of mechanization in improving health and safety standards in agriculture, highlighting the need for policies that support the health and well-being of farmers. This aspect of mechanization is particularly crucial in regions like North Central Nigeria, where access to healthcare services may be limited.

Food Security

Food security is a key concern in agricultural development, and mechanization can play a significant role in improving food security in rural areas. By enhancing productivity and efficiency, mechanization ensures a more stable and increased food supply. This is particularly important in regions like North Central Nigeria, where agriculture is a key component of food security. Increased crop output from mechanized farming can help meet the food demands of the growing

population, reduce reliance on food imports, and stabilize food prices. The Food and Agriculture Organization (FAO, 2016) notes that mechanization can significantly contribute to food security by ensuring timely planting and harvesting, thus reducing post-harvest losses and increasing the availability of food. This has both immediate and long-term benefits for the nutritional status and economic stability of rural communities.

Crop Output

Crop output, also known as agricultural or crop yield, refers to the quantity of agricultural produce harvested per unit area of land over a specific period. It is a critical measure of agricultural productivity and plays a significant role in food security, economic development, and sustainability. Crop output is influenced by various factors, including agronomic practices, weather conditions, soil fertility, pest and disease management, and the use of technology and mechanization. One of the key determinants of crop output is agronomic practices, which encompass all activities involved in crop production, such as land preparation, planting, fertilization, irrigation, and crop protection. According to Pandey *et al*. (2020), adopting appropriate agronomic practices tailored to specific crops and agro-ecological zones can significantly increase crop output. Sustainable practices, such as conservation agriculture and integrated pest management, not only enhance productivity but also promote soil health and environmental sustainability.

Weather conditions play a crucial role in determining crop output. Temperature, rainfall, humidity, and sunlight are essential factors that influence crop growth and development. Extreme weather events, such as droughts, floods, and heatwaves, can have detrimental effects on crop output. Climate change is exacerbating these challenges, leading to increased variability in weather patterns and posing risks to agricultural production. According to Lobell *et al.* (2011), climate change is projected to reduce crop yields globally, particularly in tropical regions, highlighting the urgent need for adaptation strategies and resilient crop varieties. Soil fertility is another critical factor affecting crop output. Soil provides essential nutrients and water to plants, and its health directly impacts crop growth. Poor soil fertility can lead to nutrient deficiencies in crops, affecting their yield and quality. Sustainable soil management practices, such as organic matter addition, crop rotation, and balanced fertilization, can improve soil fertility and enhance crop output. Studies by Lal (2020) emphasize the importance of soil health in sustainable agriculture and the need for conservation practices to protect soil resources for future generations.

The use of technology and mechanization has revolutionized agricultural production and significantly increased crop output. Mechanized equipment, such as tractors, harvesters, and irrigation systems, has enabled farmers to increase efficiency and productivity. Precision agriculture technologies, such as GPS-guided machinery and remote sensing, have further optimized crop management practices, leading to higher yields and resource savings. According to Rejesus *et al.* (2019), adopting modern agricultural technologies can result in significant yield increases and economic benefits for farmers, highlighting the importance of innovation in enhancing crop output.

Theoretical Framework

Theories of Agricultural Mechanization

Agricultural mechanization is underpinned by several theoretical frameworks that elucidate its role and impact on farming systems. These theories are discussed as follows:

a) Innovation Diffusion Theory

One primary theory is the Innovation Diffusion Theory by Everett Rogers, which explains how, why, and at what rate new ideas and technologies spread within a culture. In the context of North Central Nigeria, this theory helps to understand how mechanized farming practices are adopted by farmers. The rate of adoption is influenced by factors such as the perceived benefits of mechanization, compatibility with existing practices, complexity, trialability, and observability. The theory suggests that for mechanization to be effective in increasing crop output, it must be perceived as beneficial and accessible to farmers. This has implications for the study as it emphasizes the need for awareness and education programs to facilitate the adoption of mechanized farming.

b) Resource-Based Theory

Another relevant framework is the Resource-Based Theory of the Firm, which focuses on the resources and capabilities that firms possess to achieve competitive advantage. Applied to agriculture, this theory suggests that access to and effective use of machinery, technology, and human resources are critical for enhancing productivity. In North Central Nigeria, the availability of mechanized equipment and skilled labor can significantly influence crop output. The theory underscores the importance of investing in agricultural machinery and training for farmers to enhance their capabilities. For the study, this implies that examining the distribution and utilization of resources such as machinery and skilled labor is essential to understand the social effects and overall impact on crop output.

c) Human Capital Theory

The Human Capital Theory is also pertinent, positing that investments in education and training improve worker productivity. In the context of agricultural mechanization, this theory highlights the importance of educating farmers and agricultural workers about modern farming techniques and machinery operation. In North Central Nigeria, the effective implementation of mechanization depends not only on the availability of equipment but also on the knowledge and skills of the workforce. The theory suggests that enhancing human capital through education and training can lead to better management of mechanized farming, resulting in increased crop output. The study needs to consider the current levels of education and training among farmers and the impact of improved human capital on the success of mechanization initiatives.

Several key implications can be found from the application of these theories to the study. First, the Innovation Diffusion Theory suggests that policymakers and agricultural stakeholders should focus on creating conducive environments for the adoption of mechanized farming. This includes developing infrastructure, providing financial incentives, and conducting outreach programs to demonstrate the benefits of mechanization.

Second, the Resource-Based Theory of the Firm implies that the success of mechanization depends on the availability and efficient use of resources. This requires targeted investments in agricultural machinery and the development of supportive services such as maintenance and repair facilities. Ensuring equitable access to these resources is crucial for maximizing the benefits of mechanization across different farming communities.

Lastly, the Human Capital Theory emphasizes the need for continuous education and training for farmers. By improving the skills and knowledge of the agricultural workforce, the adoption and effective use of mechanized technologies can be enhanced, leading to better crop management and higher yields. For the study, this means assessing the current educational initiatives and identifying gaps that need to be addressed to support the mechanization process.

Empirical Reviews

Ogunkunle, Olatunji and Taiwo (2022) examined the effect of Agricultural Mechanization on Production and Farmers Economy in Nigeria: A Case Study of Lagos State. The investigative research approach method was employed to retrieve information from farmers through a structured questionnaire. A five rating scale questionnaire was utilized for the respondents to show their level of agreement or disagreement. The percentage was used to analyze the respondents' bio-data. At the same time, the mean was employed to answer the research questions. The null hypotheses were tested using Chi-square statistics at 0.05 significant levels. The results revealed that agricultural mechanization increased the cultivated land, crop yields, and farmers' income with cumulative means of 2.34, 1.07, and 1.44, respectively. Socioeconomic characteristics, available technology, and government policies influenced agricultural mechanization with cumulative means of 1.93, 1.24, and 1.79, respectively. The entire six hypotheses were rejected based on the results of the Chi-square statistics with the calculated X^2 values of 8,989.09, 473.59, 3,977.42, 2,192.63, 226.07 and, 1,878.05; and critical X^2 values of 46.19, 46.19, 36.42, 31.41, 21.03, and 31.41, for the significant effect on the size of land cultivated, crop yield, farmer's income, socioeconomic characteristics, available technology, and government policies respectively. The study showed that agricultural mechanization had a significant influence on crop production and farmers' income. Therefore, there is a need to improve the available technologies and formulate and implement policies to make agricultural mechanization accessible and sustainable.

Wang & Sun (2014) carried out an empirical research of agricultural mechanization on the effect of increasing famers' income. This study selected the data from 1981 to 2011 to establish the model of empirical analysis, to test through the unit root, cointegration and Granger causality and to conduct the VAR analysis. It considered that mechanization had a significant effect on increasing famers' income. The increase of farmers' income can effectively promote agricultural mechanization. At last, it put forward the corresponding policy suggestion on the basis of empirical results.

Peng, Zhao & Liu (2022) examined the impact of agricultural mechanization on agricultural production, income, and mechanism: evidence from Hubei Province, China. Based on field survey

data on farmers, this study analysed the influence of agricultural mechanization level on agricultural production and income by utilizing a sample-modified endogenous merging model and a threshold effect model. The level of mechanization has a significant positive impact on the cost, output value, income and return rate of all types of crops. For every 1% increase in the level of mechanization, the yields of all crops, grain crops and cash crops increase by 1.2151, 1.5941 and 0.4351%, respectively. Heterogeneity analysis shows that the level of mechanization has a certain threshold effect on income, with a greater effect occurring after the threshold. A test of action mechanism shows that the mechanization level can increase income via a factor intensification path and quality improvement path, with the partial mediation effects of the two paths being 28.8 and 27.4%, respectively. It is recommended to increase subsidies to purchase agricultural machinery, research and promote machinery suitable for cash crops, increase the level of socialized agricultural services, and improve the ability of farmers to apply novel agricultural machinery and tools so as to increase their operating profits.

Khalequzzaman & Karim (2007) studied of agricultural mechanization and its impact on rural environment in Sirajganj District, Bangladesh. Most of the farmers (80%) of the village said that fertility of soil was increased by agricultural mechanization. Farmers of the village seemed that layer of water was decreasing by deep tube well, as a result less water was being up taking by wells and tube wells. Beneficiary earthworm and insects were destroyed by spraying pesticides. Animal draft power was decreasing with the increase of power tiller. As a result, cow dung is decreasing day by day. So, farmers used excessive chemical fertilizers instead of compost, which create toxicity in soil. Finally they stated that many peoples are being jobless which creates social problems. Eighty per cent farmers informed lack of spray machine for pesticides spray and high price of pesticides, and lack of fuel and high price of fuel for power tiller and power pump. Sixty per cent respondents claimed that lack of power tiller for tillage operation and lack of power pump for irrigation. Ninety per cent villagers told about improper supply of electricity.

3.0 METHODOLOGY

Research Design

This study used survey research design. It is a procedures in quantitative research in which investigators administer a survey to a sample or to the entire population of people to describe the attitudes, opinions, behaviours, or characteristics of the population.

Study Area

The study area is North Central Nigeria comprising seven States of Benue, Nasarawa, Plateau, Kogi, Niger, Kwara and the Federal Capital Territory (FCT)

Sampling Technique

Purpose sampling was used to sample three out of the seven states based on the ease of data gathering The States are Benue, Nasarawa and the Federal Capital Territory. These States were selected on the basis of proximity and ease of data collection. Simple random sampling was therefore be used to select the respondents from study area.

Sample Size

The sample for the study was determined using the formula for determining sample size of an unknown population. The formula is as shown:

$$n = \frac{Z^2 Pq}{e^2}$$

Valid where,

n = sample size
Z = the value on the Z table at 95% confidence level =1.96
e = Sampling error at 5%
p = maximum variability of the population at 50%. i.e. (0.5)
q = 1-p = 0.5
n = 384

Hence, 384 respondents from the study area were used for the study.

Data Collection

The study is based on the primary data collected from the selected respondents in the study area using a structured questionnaire. Using an open ended questions, the researchers will employed 5 point Likert scale to collect the data from the respondents. The scale is SA = Strongly agree, A = Agree, D = Disagree, SD = Strongly disagree.

Validity and Reliability

The validity test was carried out to check the ability of the research instrument to measure the variable it was intended to measure. Both content and construct validity were employed. While content validity was tested through the expert contributions, construct validity was tested with the use of factor analytical tool that considered Kaiser-Meyer-Olkin (KMO) and Bartlett's Test of Sphericity. To establish the validity of the instrument, a pre-test study was carried out with thirty percent of the total sample of the study (115 respondents) and the result of the pre-test study was subjected to exploratory factor analysis and the result is shown in Tables 1 to 2.

Table 1: KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.907
Bartlett's Test of Sphericity	Approx. Chi-Square	7.320
	df	10
	Sig.	.000

A pre-test was conducted. The input variable factors used for this study were subjected to exploratory factor analysis to investigate whether the constructs as described in the literature fits the factors derived from the factor analysis. From Table 1, the Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy (0.907) indicates that the dataset is highly suitable for factor analysis, as values above 0.80 suggest strong correlations among variables, enhancing the validity of the instrument. Additionally, Bartlett's Test of Sphericity, with a Chi-Square value of 7.320,

degrees of freedom (df) of 10, and a significance level of 0.000, confirms that the correlation matrix is not an identity matrix, meaning the variables are sufficiently interrelated for meaningful factor analysis. These results validate the instrument's construct validity, ensuring it effectively measures the intended concepts in the study. The KMO result in this analysis surpasses the threshold value of 0.50 as recommended by Hair, Anderson, Tatham, and Black (1995).

Table 2: Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	1.233	24.667	24.667	1.233	24.667	24.667	1.207	24.141	24.141
2	1.084	21.687	46.353	1.084	21.687	46.353	1.076	21.530	45.670
3	1.029	20.584	66.937	1.029	20.584	66.937	1.063	21.267	66.937
4	.880	17.598	84.535						
5	.773	15.465	100.000						

Extraction Method: Principal Component Analysis.

The results of the factor analysis, as shown in the Total Variance Explained table, indicate that three components have eigenvalues greater than 1, suggesting they are significant factors in explaining the variability in the dataset. The first component has an initial eigenvalue of 1.233, accounting for 24.667% of the variance, while the second and third components have eigenvalues of 1.084 and 1.029, explaining 21.687% and 20.584% of the variance, respectively. Together, these three components explain a cumulative variance of 66.937%, demonstrating that they capture a substantial portion of the variance in the instrument's ability to measure what it is intended to assess. This supports the validity of the instrument, as it suggests that multiple constructs contribute meaningfully to the measurement. The Extraction Sums of Squared Loadings further confirm that the same three components retain their significance after extraction, maintaining their original variance contributions. This consistency highlights the robustness of the identified constructs, reinforcing the reliability of the instrument. Additionally, the Rotation Sums of Squared Loadings show slight variations in variance distribution among the three components after rotation, with the first, second, and third components explaining 24.141%, 21.530%, and 21.267% of the variance, respectively. The cumulative variance remains at 66.937%, demonstrating that the factor rotation does not compromise the explanatory power of the components but instead optimizes their interpretability. The presence of two additional components (fourth and fifth) with eigenvalues below 1 (.880 and .773) suggests that they contribute minimal variance (17.598% and 15.465%, respectively) and may not be necessary for inclusion. However, excluding any of the three significant components would reduce the explained variance below an acceptable threshold for validity, weakening the instrument's ability to capture the full scope of the measured construct. Therefore, all three extracted components should be retained to ensure the instrument's validity, as they collectively account for a sufficient proportion of the variability needed for accurate measurement.

Table 3: Reliability of Instrument

Variable	Cronbach Alpha
Crop output in North Central Nigeria (COP)	.824
Employment generation (EPG)	.899
Education opportunities (EDO)	.800
Health and safety (HAS)	.810
Food security (FSC)	.832
Overall Coefficient	**.833**

The reliability of the instrument, as assessed by the reported reliability coefficients, indicates a high level of internal consistency across all measured constructs. The values range from 0.800 to 0.899, all of which are above the generally accepted threshold of 0.70 for Cronbach's alpha, demonstrating that the instrument is reliable. The highest reliability coefficient is observed in Employment Generation (EPG) with a value of 0.899, suggesting that the items measuring this construct are highly consistent and dependable. This means that responses related to employment generation are stable and likely to produce consistent results over repeated measurements, strengthening the credibility of the instrument in assessing this factor. Other constructs also exhibit strong reliability, further reinforcing the instrument's dependability. Crop Output in North Central Nigeria (COP) has a reliability coefficient of 0.824, indicating a high level of consistency in measuring agricultural productivity. Similarly, Food Security (FSC) has a reliability score of 0.832, suggesting that the instrument effectively captures the dynamics of food security in the study area. The constructs of Health and Safety (HAS) and Education Opportunities (EDO) show reliability values of 0.810 and 0.800, respectively, both of which meet the required threshold for reliable measurement. These values confirm that the instrument maintains stability in its measurement of key socio-economic factors influenced by agricultural performance.

Model Specification

The model specification for this study will establishes the relationship between the dependent and the independent variables of the study. The logit regression model will be used and is stated implicitly as;

$$COP = f(EPG, EDO, HAS, FSC) \quad (i)$$

Where,
EPG = Employment generation,
EDO = Education opportunities,
HAS = Health and safety
FSC = Food security as social effect of agricultural mechanization
COP = Crop output in North Central Nigeria.

In explicit form

$$\frac{\text{Log}\,(COP = 1)}{(1 - P(COP = 1)} = \beta_0 + \beta_1 EPG + + \beta_2 EDO + \beta_3 HAS + \beta_3 FSC + U_t \quad (ii)$$

Where,
P(COP=1) = represents the probability of exceeding the crop output benchmark.
β_0 = the intercept (constant)
β_1 - β_4 = Logit regression coefficients
U_t: Error term representing unaccounted factors crop output in North Central Nigeria

A priori expectations:
The signs for all the estimated variables in the model (β_1 - β_4) are expected to be positive.
Dependent Variable: In a logit model is modeled as a binary outcome, where 1 represents exceeding a crop output benchmark and 0 represents not meeting it.
The independent variables are represented by 1 if there is employment generation, education opportunities, health and safety and food security and 0 otherwise

Method of Data Analysis
Binary logistic regression was used to estimate objectives one to four of the study. The hypotheses of the study were tested by the probability values of the estimates. The following decision rules were adopted for accepting or rejecting hypotheses. *If the probability value of* b_i [*p* (b_i) > critical value] we accept the null hypothesis, that is, we accept that the estimate b_i is not statistically significant at the 5% level of significance. *If the probability value of* b_i [*p* (b_i) < critical value] we reject the null hypothesis, in other words, that is, we accept that the estimate b_1 is statistically significant at the 5% level of significance.

4.0 Results and Discussion
Based on the specified logit regression model, the expected result of this study is a significant positive relationship between agricultural mechanization and crop output in North Central Nigeria. Specifically, it is anticipated that employment generation, education opportunities, health and safety, and food security, as social effects of agricultural mechanization, will all positively influence the probability of exceeding the crop output benchmark. This suggests that improvements in these areas due to mechanization will enhance crop productivity, reflecting in higher crop output levels. The logit coefficients for employment generation (β_1), education opportunities (β_2), health and safety (β_3), and food security (β_4) are all expected to be positive, indicating that as these social effects improve, the likelihood of surpassing the crop output benchmark increases. This section presents the results of the logistic regression and its interpretation and discussion for the model of the study.

Table 4. Classification Table.

	Observed		Predicted		
			COP		Percentage Correct
			.00	1.00	
Step 0	COP	.00	0	104	.0
		1.00	0	280	100.0
	Overall Percentage				72.9

a. Constant is included in the model.
b. The cut value is .500
Source: Author's computation, 2023

The classification table provides insights into the predictive accuracy of the model in assessing the social effects of agricultural mechanization on crop output in North Central Nigeria. In Step 0, where no predictors have been included, the model classifies all cases into a single category, correctly predicting all 280 cases where crop output (COP) increased (1.00) with 100% accuracy, but failing to predict any cases where crop output remained unchanged (0.00), resulting in 0% accuracy for that category. The overall classification accuracy stands at 72.9%, suggesting a strong baseline tendency for mechanization to be linked to increased output, but also highlighting an imbalance in the dataset. This could imply that additional social factors, such as access to mechanized equipment, labor market adjustments, and land ownership, may influence the relationship between mechanization and crop output. With a cut value of 0.500, the model assigns cases to category 1.00 when the predicted probability is at least 50%, reinforcing the need for additional explanatory variables to enhance predictive accuracy, particularly in identifying cases where mechanization does not lead to increased output. Further analysis incorporating social factors like employment shifts, education, and health impacts of mechanization could strengthen the model's ability to capture the relationship between mechanization and crop output, leading to more effective policy recommendations for agricultural development in North Central Nigeria..

Table 4. Model Summary.

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	4.272[a]	.690	.742

The model summary assesses the goodness-of-fit and explanatory power of the logistic regression model examining the social effects of agricultural mechanization on crop output in North Central Nigeria. The -2 Log Likelihood value of 4.272 indicates how well the model fits the data, with lower values suggesting a better fit. The Cox & Snell R Square value of 0.690 and the Nagelkerke R Square value of 0.742 demonstrate that the model explains a substantial portion of the variability in crop output due to mechanization, with Nagelkerke's R Square suggesting that up to 74.2% of the variation is accounted for by the included predictors. The termination of estimation at the fourth iteration, due to parameter estimates changing by less than 0.001, signifies model convergence and stability. These results indicate that the model has strong explanatory power, reinforcing the

relevance of mechanization's social effects on crop output. However, further refinement with additional predictors, such as access to mechanized tools, labor displacement, and financial constraints, could enhance the model's predictive accuracy and provide deeper insights into the socio-economic dynamics of agricultural mechanization in the region.

Table 4: Hosmer and Lemeshow Test

Step	Chi-square	df	Sig.
1	3.095	7	.698

Source: Author's computation, 2025

The Hosmer and Lemeshow Test assesses the goodness-of-fit of the logistic regression model examining the social effects of agricultural mechanization on crop output in North Central Nigeria. The test produces a Chi-square value of 3.095 with 7 degrees of freedom and a significance level (p-value) of 0.698. Since the significance value is well above the conventional threshold of 0.05, the null hypothesis that the model fits the data well is not rejected. This indicates that the model's predicted probabilities align closely with the observed outcomes, reinforcing its reliability in explaining variations in crop output due to mechanization. The high p-value suggests no significant deviation between expected and actual classifications, further supporting the model's robustness. However, while the model demonstrates a good fit, incorporating additional socio-economic factors such as access to credit, mechanization costs, and farmer education levels could enhance its explanatory power and policy relevance.

Table 5: Omnibus Tests of Model Coefficients

		Chi-square	df	Sig.
Step 1	Step	11.306	4	.023
	Block	11.306	4	.023
	Model	11.306	4	.023

Source: Author's computation, 2025

The Omnibus Tests of Model Coefficients evaluate the overall significance of the logistic regression model assessing the social effects of agricultural mechanization on crop output in North Central Nigeria. The test results show a Chi-square value of 11.306 with 4 degrees of freedom and a significance level (p-value) of 0.023. Since the p-value is below the conventional 0.05 threshold, the null hypothesis that none of the predictor variables contribute to the model is rejected. This indicates that the independent variables included in the model significantly improve its ability to predict changes in crop output due to mechanization. The consistency of the Chi-square values across the Step, Block, and Model tests further confirms that the predictors collectively enhance the model's explanatory power. However, while the model demonstrates statistical significance, further refinement such as incorporating additional social and economic factors could provide

deeper insights into the broader impacts of mechanization on agricultural productivity.

Table 6: Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B)	
								Lower	Upper
Step 1[a]	EPG	1.950	.842	5.356	1	.021	7.026	1.030	1.151
	EDO	.265	.252	1.102	1	.294	1.303	.795	2.138
	HAS	.565	.247	5.229	1	.022	1.760	1.084	2.858
	FSC	.420	.245	2.929	1	.087	1.522	.941	2.463
	Constant	-.129	.358	.131	1	.718	.879		

a. Variable(s) entered on step 1: EPG, EDO, HAS, FSC.

Source: Author's computation, 2025

Legend: EPG = Employment generation, EDO = Education opportunities, HAS = Health and safety FSC = Food security,
COP = Crop output in North Central Nigeria

The logit regression estimates presented in Table 6 assess the influence of employment generation (EPG), education opportunities (EDO), health and safety (HAS), and food security (FSC) on crop output (COP) in North Central Nigeria. The results indicate that EPG has a statistically significant effect on COP, with a coefficient (B) of 1.950, a standard error (S.E.) of 0.842, and a Wald statistic of 5.356. The significance value (p = 0.021) is below the 5% threshold, confirming that employment generation significantly influences crop output. The odds ratio (Exp(B)) of 7.026 suggests that an increase in employment generation due to mechanization is associated with a 7.026 times higher likelihood of increased crop output. The confidence interval for Exp(B) (1.030–1.151) further supports this positive effect. These findings imply that mechanization, by creating job opportunities in agriculture, plays a crucial role in enhancing productivity and economic stability in the region.

Education opportunities (EDO) do not significantly impact crop output, as indicated by its p-value of 0.294, which exceeds the 5% significance level. The coefficient (B) of 0.265 suggests a positive but statistically insignificant relationship between education opportunities and crop output. The odds ratio (Exp(B)) of 1.303 implies that an increase in educational opportunities slightly raises the likelihood of increased crop output, but the confidence interval (0.795–2.138) includes 1, indicating that the effect is not strong enough to be considered statistically meaningful. This result suggests that while agricultural education and training programs may contribute to productivity improvements, their immediate impact on crop output remains uncertain, potentially due to the

time required for skill development to translate into increased efficiency.

Health and safety (HAS) demonstrate a statistically significant relationship with crop output, with a coefficient (B) of 0.565 and a Wald statistic of 5.229. The p-value of 0.022 confirms significance at the 5% level, and the odds ratio (Exp(B)) of 1.760 indicates that improved health and safety conditions increase the likelihood of higher crop output by 1.76 times. The confidence interval (1.084–2.858) supports this conclusion. These findings suggest that better working conditions and improved health services for farmers may enhance productivity by reducing labor shortages due to illness or injury. Thus, policies aimed at improving rural healthcare access and workplace safety in agriculture could positively affect output levels.

Food security (FSC) has a coefficient (B) of 0.420 and a Wald statistic of 2.929, but its p-value of 0.087 exceeds the 5% significance threshold, indicating that its effect on crop output is not statistically significant. The odds ratio (Exp(B)) of 1.522 suggests that food security increases the likelihood of higher crop output by 1.522 times, but the confidence interval (0.941–2.463) crosses 1, further reinforcing the lack of strong statistical evidence. While food security remains an important factor in agricultural sustainability, its direct impact on short-term crop output may be less pronounced than other factors like employment generation and health and safety. The constant term (-0.129, $p = 0.718$) is also not significant, implying that additional explanatory variables may be needed to fully capture the determinants of crop output. These results highlight the need for targeted policies to strengthen food security mechanisms and further investigate their role in agricultural productivity.

Discussion of result

The findings of the current study align with previous empirical studies in demonstrating the positive impact of agricultural mechanization on crop production and farmers' livelihoods. The significant effect of employment generation (EPG) on crop output (COP) in North Central Nigeria, with an odds ratio of 7.026 ($p = 0.021$), supports the conclusions of Ogunkunle et al. (2022) and Wang & Sun (2014), who found that mechanization significantly increased cultivated land, crop yields, and farmers' income. Similarly, Peng et al. (2022) established that mechanization enhances agricultural production through increased efficiency and return on investment. The convergence of these findings suggests that agricultural mechanization plays a critical role in fostering productivity and economic stability across different regions. However, the divergence arises in the extent of mechanization's impact. While Peng et al. (2022) found a 1.2151%–1.5941% increase in crop yields per 1% rise in mechanization levels, the current study provides a direct logit regression estimate showing mechanization’s effect on employment generation and output likelihood rather than specific yield percentages. This distinction highlights the unique approach of the current study in assessing mechanization's social effects rather than solely its technical efficiency.

Despite the convergence in the significance of mechanization, the current study diverges from previous research in its findings on education opportunities (EDO) and food security (FSC). While prior studies, such as those by Wang & Sun (2014), emphasized the role of education in

mechanization adoption and income growth, the present study finds no statistically significant relationship between education opportunities and crop output ($p = 0.294$). This suggests that although education may influence long-term agricultural improvements, its immediate impact on output remains uncertain in the study area. Similarly, while food security (FSC) exhibits a positive relationship with crop output ($Exp(B) = 1.522$), its effect is not statistically significant ($p = 0.087$). This contrasts with previous studies that have linked food security to improved agricultural sustainability (Khalequzzaman & Karim, 2007). The novelty of the current study lies in its examination of the broader social effects of mechanization, including employment, health, and safety, rather than just productivity and economic gains. By integrating these social dimensions, the study provides a more holistic understanding of mechanization's role in agricultural transformation in North Central Nigeria.

5.0 CONCLUSION AND RECOMMENDATIONS

Conclusion

The study examines the impact of agricultural mechanization on crop output in North Central Nigeria, focusing on employment generation, education opportunities, health and safety, and food security. The findings reveal that employment generation has a significant positive effect on crop output, highlighting the role of mechanization in creating job opportunities that enhance agricultural productivity. Health and safety improvements also contribute significantly to increased crop output, suggesting that better working conditions and healthcare access for farmers can enhance labor efficiency. However, education opportunities and food security do not show statistically significant effects on crop output, indicating that while they may influence agricultural development in the long run, their immediate impact on productivity is limited. These results underscore the need for policies that prioritize employment generation and health and safety improvements while also strengthening agricultural education and food security measures to ensure sustainable growth in the sector.

Recommendations

i. Government and private sector investments should focus on expanding mechanized farming to create more job opportunities and improve agricultural productivity.

ii. Policies should prioritize better healthcare access, workplace safety measures, and occupational health programs to reduce labor shortages caused by illness or injury.

iii. While education did not show an immediate impact on crop output, long-term strategies should emphasize skill development and training to enhance efficiency in mechanized farming.

iv. Efforts should be made to improve food availability and access through better storage facilities, supply chain management, and farmer support programs to enhance agricultural sustainability.

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