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Assessment of Extent of Farm Mechanisation and Technical Efficiency of Cassava Production in Oyo State, Nigeria

Olatunji A. Hamzat*, Muktarh A. Yusuf**, Oludare D. Taiwo***, Ayorinde Adesanlu****

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ABSTRACT

This study assessed the extent of farm mechanization and technical efficiency of cassava production in Oyo State Nigeria. The objectives were to profile the socio-economic characteristics of farmers, describe the extent of mechanization, and examine the effect of extent of farm mechanization on technical efficiency. Three hundred and seventy-two (372) cassava farmers sampled using a multi-stage sampling technique, and the data were analyzed with descriptive statistics and Cobb Douglass stochastic frontier model. Findings indicated that 80 percent of those involved in cassava farming were men with average age and farm size of 53 years and 0.75 hectares respectively which indicates that it was dominated by the smallholders. Mechanization as a whole was low (9%), and little mechanization was adopted beyond land clearing and ridging with most other activities being done manually. Supporting the findings on the frontier estimations was the fact that farm size proved to be a determining factor in cassava production while experience, accessibility of credit and extension services reduced inefficiency. Extent of Farm mechanization was not statistically significant but it has a negative coefficient which implies that it reduces inefficiency when implemented. In the study, it is concluded that the levels of efficiency have been high together with structural limitations in credit, extension, infrastructure and mechanization. Such limitations if improved will boost cassava production.

1. Introduction

Mechanization of farms is a central issue in the revolution of the farming systems, especially in the developing countries where farming practices tend to be constrained when it comes to its productivity and sustainability. The cost of the products likely to be produced by industry is significant since in sub-Saharan Africa, agriculture is labor-based and therefore, mechanization in the region can greatly contribute to technical efficiency, crop output and reduce the drudgery of manual farming (Daum, 2023; Mohammed et al., 2023). Nevertheless, even though mechanization has its advantages, they have not been satisfied in Nigeria, the largest cassava producer in the world, and the spread of mechanization is still low, which is applied mostly by large-scale farmers (Eze et al., 2023). Cassava production, one of the most important sources of food and income products in Nigeria has been experiencing a stagnation in

*, **, ***, **** Department of Agribusiness Management, Federal College of Animal Health and Production Technology, Ibadan, Oyo State, Nigeria. E-mail addresses: hamzatolatunji22@gmail.com (O. A. Hamzat - Corresponding Author), mukhtar228@gmail.com (M. A. Yusuf), domefranka@yahoo.com (O. D. Taiwo), adesanluayorindeafolabi@gmail.com (A. Adesanlu).

productivity, and in most cases the yields tend to be below the potential as a result of the ineffective use of modern agriculture techniques (Ikuemonisan & Akinbola, 2021).

This paper examined the extent of farm mechanization and technical efficiency of production of cassava in Oyo State, Nigeria by looking at the connection between farm mechanization activities and the agricultural output. As Nigeria has the strategic advantage of being a leading nation when it comes to cassava production in the world, mechanization needs to be adopted to enhance its efficiency and sustain food security and livelihoods of smallholder farmers (Adebayo, 2023). The objectives of the study are to determine the socio-economic attributes of cassava farmers and the degree of mechanization; as well as ascertain the factors that define the technical efficiency. Taking these aspects into consideration, the research can be valuable to the policymakers, agricultural stakeholders and farmers to contribute to the current reforms in modernizing the Nigerian agricultural sector and improving the efficiency of cassava production (Lu et al., 2024; Oyewo & Oladeebo, 2023).

2. Literature review

In reviewing the relevant literatures touching on farm mechanization and technical efficiency in cassava production, research studies on the connection between organizations like farm mechanization and agricultural productivity especially with reference to smallholder systems have been conducted. Mechanization has been identified as a significant aspect in enhancing agricultural production, diminishing drudgery in addition to elevating technical efficiency because of the smoothing out of the labour-intensive activities (Lu et al., 2024). Nonetheless, when compared to other developing countries, especially within sub-Saharan Africa, the use of mechanized farming is low because of its exorbitant prices, infrastructural gaps, and lack of access to funds (Oyewo & Oladeebo, 2023).

It has been well established that mechanization helps raise efficiency through cost savings and retention of important farming processes such as weeding, planting, and harvesting at the right time (Gathala et al., 2021). Nonetheless, the benefits of mechanization as far as efficiency is concerned is unevenly distributed regionally and on crops. Whereas the use of mechanization has demonstrated significant enhancement in grain and cereal cultivation, the adoption of machineries in cassava farming has lagged behind as the majority of cassava farmers continue to use traditional and labour-intensive ways of farming (Sims & Kienzle, 2019). The main reason behind this is the small scale of cassava cultivation as most farms are not more than one hectare, which makes it financially unviable to spend resources investing in large-scale machinery (Daum, 2023).

Technical efficiency as the factor of how it is possible to make the highest output using the certain set of inputs has been actively used in agriculture to control the performance of farmers with reference to their resource usage (Battese et al., 2004). The research has proved that smallholders' farmers who implement mechanized farming are more likely to demonstrate enhanced levels of technical efficiency as opposed to their counterparts who embrace traditional farming practices (Jensen et al., 2024). Nevertheless, studies concerning cassava production particularly have pointed out that the efficiency advantages of the mechanization process have been restricted by the fact that the low mechanization levels have imposed constraints on consumers by preventing them to access appropriate machinery, funds, and professional knowledge (Peng et al., 2022).

Moreover, there is a lack of sufficient literature on how mechanization has been adopted in cassava cultivation in particular geographical locations especially in the state of Oyo, Nigeria. Although research done before has considered the general technical efficiency of smallholder farmers in other regions of Nigeria (Ogundari & Ojo, 2020), only a few have taken a look at the role of mechanization in cassava production efficiency in the state of Oyo. This evidently indicates the necessity of studying the issue, as Nigeria happens to be the world leader in cassava production, but the country has not reached its farming potential owing to the ineffective farming methods (Ikuemonisan & Akinbola, 2021).

This paper thus attempts to address this gap by assessing the extent of mechanization in cassava production in Oyo State and its effects on the level of the technical efficiency. The study of these dynamics will help in giving useful information to the policymakers and certain stakeholders to create specific interventions to enhance better mechanization in adopting and increasing the productivity of cassava in Nigeria.

3. Research Methodology

The research was carried out in Oyo State in Nigeria. Oyo state located in southwestern Nigeria, has a diverse agro-ecological landscape that supports the cultivation of crops such as cassava (Awotona, 2020). Agriculture remains a major livelihood source, engaging a large proportion of the rural population and contributing to the state's economy (Okonta et al., 2023)

A multi-stage sampling technique involving four stages was adopted to select 372 cassava farmers for the study. In the first stage, three agro-ecological zones were purposively selected from the four zones in Oyo state due to their prominence in cassava production. These zones include the Ibadan zone, Okeogun zone, and Oyo zone. The second stage involved purposive selection of six Local Government Ares (LGAs) based on the intensity of the cassava farming activities predominant in these LGAs. These comprised of three LGAs from Ibadan zone (Lagelu, Akinyele, and Ido), two LGAs from Okeogun zone (Saki East and Saki West), and one LGA from the Oyo zone (Afijio), selected proportionally across the zones. In the third stage, two communities were randomly selected from each of the six LGAs, resulting in a total of 12 communities. In the fourth stage, 31 cassava farmers were randomly selected from each community using the Yamane scientific formula used in calculating sample size.

The Yamane formula (Yamane 1967) was used to select the sample size at a 95% confidence level.

$$n = \frac{N}{1+N(\alpha^2)} \quad (1)$$

Where: n = sample size, N = Sample frame (5314 cassava farmers. List of cassava farmers was obtained from ADP, Oyo state), and α^2 = Precision level (0.05).

Primary data were used. The information was collected on 2025 farm socio-economic and institutional aspects of cassava farmers under production conditions; an organized questionnaire was used to gather cassava farming operation and practice. The application of the Kobo tool app was chosen as more preferable since it guarantees the accuracy of gathering information.

Data collected were analyzed using descriptive statistics and stochastic frontier production model. Technical efficiency of cassava production was estimated using Cobb-Douglas Stochastic Production function. The stochastic frontier production functions have been considered very helpful as it is used to

measure not only technical efficiency sources in production but also the impact of measurements of errors not considered as inherently related to production (Battese et al., 2004).

Model specification

The functional form is implicitly specified as follows;

$$\text{Ln } Y_i = \beta o + \beta_1 \text{Ln} X_1 + \beta_2 \text{Ln} X_2 + \beta_3 \text{Ln} X_3 + \beta_4 \text{Ln} X_4 + V_i — U_i \quad (2)$$

Where, Ln = Natural logarithm to base e, Y_i = Cassava tuber (kg) of the i^{th} farm, X_1 = Cassava stem (bundle), X_2 = Labor (man days), X_3 = Farm size (ha), X_4 = Herbicides (liters), β_1 — β_4 are parameters to be estimated, β_0 is intercept, V_i is error term not under the control of farmers and U_i is error term under the control of farmers. Variation arising from technical inefficiencies of the farmer.

$$TE = \frac{Yi}{Y*} \quad (3)$$

where; TE_i = Technical efficiency of the i^{th} farm; Y_i = Actual production of the i^{th} farm; Y^*= Frontier production of the i^{th} farm.

$$\mu_i = \delta_0 + \delta_1 Z_{1i} + \delta_2 Z_{2i} + \delta_3 Z_{3i} + \delta_4 Z_{4i} + \delta_5 Z_{5i} + \delta_6 Z_{6i} + \delta_7 Z_{7i} + \delta_8 Z_{8i} + + \delta_9 Z_{9i} + \delta_{10} Z_{10i} + \delta_{11} Z_{11i} + \varepsilon \quad (4)$$

μ_i = Technical inefficiencies of the i^{th} cassava farmer, δ_0 = Constant term, Z_1= Age of the i^{th} farmer (years), Z_2 = farming experience of the i^{th} farmer (years), Z_3 = Educational of the i^{th} farmer (years), Z_4= Household size of the i^{th} farmer (number), Z_5 = Extent of farm mechanization (index), Z_6= Credit access (yes=1, No=0), Z_7= Extension contact (Number of visits), Z_8= Sex (Male=1, Female=0), Z_9= Distance from farm to market (km), Z_{10}= Distance from farm to health facility (km), Z_{11}= Distance from farm to house (km), δ_1 —δ_8 = coefficients of the maximum likelihood estimates

4. Results and Discussion

4.1. Socioeconomic and institutional characteristics of cassava farmers

The finding on Table 1 reveals that cassava cultivation is dominated by men (89.3%) and the average age of the farmer is 53 years implying involvement of elderly households. This concurs with Adebayo et al. (2022) who indicated that the root crop production in Nigeria is dominated by aging farmers. More than half of them (55.3%) had secondary education, which is moderate literacy and can carry with them the ability to adopt innovations (Oyetunde-Usman & Olagunju, 2019). The majority also lacked access to credit (83.3%), which works as a limiting factor similarly to Ololade and Olagunju (2020). The average size of land worked by farmers was 0.75 ha and is further proof of the smallholders' dominance (Nwaobiala, 2021). The accessibility of markets and services, predominantly within the radius of 1-3 km means that transaction costs and ease of access are decreased (FAO, 2020).

Table 1. Distribution of Socioeconomic characteristics of cassava farmers

Variables	Dominant indicators	F	%	Mean	St.Dev
Sex	Farmers that were male	332	89.3	Na	Na
Age	Farmers between 51-60 years	166	44.7	53.39	8.27
Education	Farmers with secondary education	206	55.3	Na	Na
Credit access	Farmers that had no access to credit	310	83.3	Na	Na
Extension access	Farmers that had access to extension	238	64.0	Na	Na
Farming experience	Farmers between 1-10 years	137	36.7	9.13	3.47
Household size	Household members within 7-11	182	49.0	7.63	2.63
Farm size	Farm size between 0.51-0.91 hectare	189	50.8	0.75	0.34
Distance from house to farm	Distance between 1-3km	335	90.0	1.55	1.02
Distance from farm to health facility	Distance between 1-3km	362	97.3	1.40	0.88
Distance from farm to market	Distance between 1-2km	355	95.3	1.35	0.66

Source: Computation from field survey, 2025

4.2 Extent of farm mechanization

The result in Table 2 indicates that the production of cassava in the study area relies heavily on the traditional methods thus the extent of mechanization averages at 9%. The adoption levels of land clearing and ridging were the highest with 17.6% and 17.0 %, respectively since they are labor intensive and at times require the use of tractors in the cooperatives. The Daudu et al. (2022) and Edeh and Ugwu (2023) have made similar observations of the improvement of timeliness and yield through mechanized land preparing and ridging. By comparison, planting, fertilizer, and harvesting were done manually, which highlights the so-called mechanization gap identified by Sheahan and Barrett (2017), and harvesting manually is directly linked to post-harvest losses of up to 22%, as noted by Mbanasor et al. (2023). Altogether, the extremely low degree of mechanization shows the remaining structural obstacles, which are consistent with Sims and Kienzle (2019), who also attribute the root crops mechanization deficiency in Africa to financial and technological constraints.

Table 2. Distribution of Cassava farmers by Extent of Farm mechanization

Farming activities	Traditional method		Mechanised method	
	Frequency	%	Frequency	%
Land clearing	307	82.4	65.0	17.6
Ridging	309	83.0	63	17.0
Planting	372	100.0	0	0.0
Fertilizer application	372	100.0	0	0.0
Weeding	304	81.7	68	18.3
Pesticide application	345	92.8	27	7.2
Harvesting	372	100.0	0	0.0
Average	0.91		0.09	

4.3 Effect of Extent of Farm Mechanisation on Technical Efficiency of Cassava farmers

According to the stochastic frontier result (Table 3 and 4), the size of the farms in question is very potent to increasing cassava production which resonates with recent findings that availability of land is a key factor to productivity in Nigeria (Abdu-Raheem *et al*, 2023). Labor and agrochemicals were not very substantial, but their indicators are a manifestation of mixed efficiency among smallholders (Amaza *et al.*, 2010; Edaba *et al.*, 2023). Extension services and access to credit together with farmer experience minimize inefficiency and aligns with the studies regarding the significance of knowledge and institutional backing (Edaba *et al.*, 2025; Ogundari & Brummer, 2011). On the other hand, the further distances between the markets and health facilities leads to more inefficiency, which indicates transaction and health-related obstacles to performance (Abdulai & Huffman, 2000; Rwomushana *et al.*, 2025). Although the sign of extent of farm mechanization was not substantial, the fact they are negative proves that better use of it may reduce the level of inefficiency (Muinga & Marechera, 2020). The presence of a substantial gamma (0.59) also supports the fact that inefficiency is a major contributor to the difference in the output among cassava farmers.

Table 3. Maximum likelihood estimates (stochastic frontier analysis)

Variables	Coefficient	Standard error	t-ratio
Constant	0.9807	0.8347	1.1749
Ln(cassava bundle)	-0.1219	0.4923	-0.2451
Ln(Labour)	0.0971	0.0802	1.2096
Ln(Farm size)	0.9632**	0.4849	1.9866
Ln(Agrochemical)	-0.0159	-0.0452	-0.3526
Inefficiency model			
Constant	-0.0159	0.2781	-0.0575
Sex	0.0199	0.0799	0.2483
Age	0.0074	0.0057	1.2955
Education	-0.0048	0.0122	-0.3942
Household size	0.0261	0.0222	1.1730
Experience	-0.0238***	0.0057	-4.1962
Credit access	-0.3269***	0.1354	-2.4147
Extension access	-0.1842***	0.0624	-2.9509
Distance from farm to market	-0.2384***	0.0551	-4.3290
Distance from farm to health facility	0.1123**	0.0497	2.2618
Distance from farm to house	0.0526	0.0365	1.4401
Extent of mechanization	-0.0887	0.2921	-0.3043
Sigma-squared (σ^2)	0.0159***	0.0041	3.8906
Gamma (ϒ)	0.5896***	0.1148	5.1366

Source: Computation from field survey, 2025

******* significant at 1%, ** significant at 5%, * significant at 10%

4.3.2 Technical efficiency scores in cassava production

The technical efficiency distribution in Table 4 revealed that the cassava farmers are doing reasonably well on average with an average efficiency of 0.92 and the largest proportion (67.3%) of the cassava farmers having efficiencies between 0.91 to 1.00 meaning an excellent proximity to best-practice production. Such high mean can be correlated with latest observations in South-South Nigeria where cassava growers who were cooperative finished with an average technical efficiency of 0.92 in the place of 0.85 among non-cooperative growers (Okeke et al., 2021). The range measured by the minimum of 0.64 and maximum of 0.99 also indicates that some variability exists but confirms that the cases of inefficient performance are comparatively low.

Table 4. Distribution of Cassava farmers by Technical Efficiency scores

Technical Efficiency scores	Frequency	Percentage
0.61-0.70	1	0.7
0.71-0.80	19	12.7
0.81-0.90	29	19.3
0.91-1.00	101	67.3
Minimum TE	0.64	
Maximum TE	0.99	
Mean TE	0.92	

Source: Computation from field survey, 2025

5. Conclusions and Recommendations

The paper revealed that cassava producers in Oyo State work had low extent of mechanisation with near frontier production with an average efficiency of 0.92, the factors that influence it the most include farm size, experience, credit, distance to market and extension services. Inefficiency, however, is aggravated by long distance to health care services while distance to market reduces it. Though the use of mechanisation was not found to have had a statistically significant effect, its adverse implication serves to testify its potential negative impact on inefficiency in case it was being adopted. The research suggests that accessibility of credit, extension and rural infrastructure should be worked on in order to maintain efficiency. Improved knowledge on market accessibility, training of farmers and improved market linkage should be offered along financing of services to mechanise farm activities at affordable and low costs through cooperatives and public-private partnerships. Such aspects would boost efficiency, minimize drudgery, and make cassava even more relevant in food security.

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