

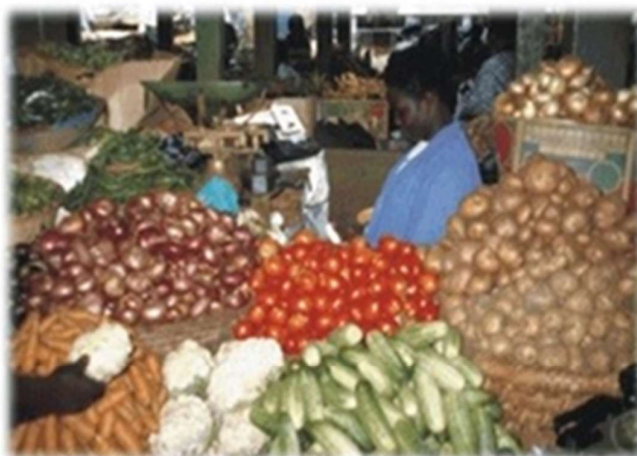
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Professor A. O. Ajao





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Production Efficiency Analysis of Irish Potato Farmers in some selected Local Government Areas of Plateau State, Nigeria

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Abstract: This study analysed production efficiency of Irish Potato farmers in some selected Local Government Areas (LGAs) of Plateau State, Nigeria. A multistage random sampling technique was used in selecting the sample size for this study. The primary data collected were analysed using double bootstrap Data Envelopment Analysis (DEA) and truncated regression. Results of the Variable Return to Scale (VRS) DEA shows average technical efficiency (TE) for radial, non-radial and bias-corrected estimates to be 0.90, 0.70 and 0.68, respectively. The mean allocative and economic efficiency levels were found to be 0.74 and 0.64 respectively. The estimated radial TE scores were higher than the bias-corrected TE scores indicating overestimation of the radial scores. The regression result shows age, household size, extension contact and transportation costs have significant effects on technical efficiency while farming experience has significant influence on economic efficiency of farmers. In conclusion the Irish Potato farmers were operating below the production possibilities frontier, indicating there is room for efficient use of input resources. The study, therefore, recommends availability of input resources at affordable rate to Irish potato farmers and training of the farmers on effective inputs resource management as a potential measure to enhance their farm-level production efficiency.

Keywords: bootstrapping, data envelopment analysis, Irish potato farmers, technical efficiency, truncated regression

INTRODUCTION

Irish potato (*Solanum tuberosum* L.) is a globally important tuber plant producing high yields of nutritionally valuable food in form of tubers that belongs to the family Solanaceae. The crop was first cultivated in South America and easily substitutes for cereals in many developing countries; making it very crucial for food security. Global output of Irish potato is about 388 million metric tonnes with an average yield per hectare of 20,110.8 kg/ha (Obi-Egbedi & Gulak, 2020). Over half of the global output is produced in developing countries; almost one-third of the output is harvested in China and India alone, while China is the leading producer in the world with 99 million metric tonnes (Obi-Egbedi & Gulak, 2020). Irish potato production in Africa is estimated at 25 million metric tonnes with average yield per hectare of 13,215.4 kg/ha, and per capita consumption of 18.76 kg/capita/year (FAO, 2021). Based on global ranking, Algeria is the leading producer of Irish potato in Africa with a production of 4,606,400 metric tonnes, followed by Egypt (4,325,480 metric tonnes) and South Africa (2,450,540 metric tonnes). Nigeria's production of 1,284,370 metric tonnes ranks seventh in Africa after Morocco (1,924,870 metric tonnes), Tanzania (1,749,201 metric tonnes) and Kenya, the fourth to sixth largest African producers of Irish Potato (FAO, 2020).

The crop is one of the major sources of income for the rural farmers in Plateau State, and in many other African producing communities (Hudu *et al.*, 2023). About 95 percent of the total Irish potato produced in Nigeria comes from Plateau State; because the weather condition in the state is suitable for Irish potato production. Other Irish

potato producing areas such as Obudu in Cross River State, Mambila Plateau in Taraba State, and parts of Kaduna State account for the remaining 5 percent (Hudu *et al.*, 2023). The crop can be processed into other Potato food products such as chips, crisps and flour, and also used as food ingredients. Non-food uses include starch for industry, animal feed, glue as well as seed tubers for planting (Uche *et al.*, 2020).

Although Nigeria despite being the seventh largest producer of Irish potato in Africa, and with the potential of Irish potato production for economic growth and sustainability, domestic Irish potato production has not increased sufficiently to meet the increasing demands. The demand for Irish potato in Plateau and Nigeria at large is however growing faster than expected, with consumption broadening across all socio-economic class. Thus, Irish potato farmers in Plateau State are not getting optimum return from the resources committed to their Irish potato production due to their inefficiency in the use of available resources.

There are considerable numbers of Irish potato specific studies (Wuyep *et al.*, 2013; Zemba *et al.*, 2013; Jatbong, *et al.*, 2018; Panwal, 2018; Obi-Egbedi & Gulak, 2020;) in Plateau State coupled with the evidence of existing few efficiency studies in particular such as Jwanya *et al.*, 2014 on technical efficiency of Irish potato farmers: a stochastic frontier approach; Obi-Egbedi & Gulak (2019), a comparison study on performance of Translog and Cobb-Douglas models in estimation of technical efficiency in Irish potato production, and Hudu *et al.*, (2023) on economic efficiency of small-scale Irish potato farmers in Nigeria and Kenya. But this study analysed the productive efficiency of Irish

potato farmers in the five LGAs majorly known for Irish potato production using double bootstrap data envelopment analysis (DEA) approach. Based on that, the specific objectives were to estimate the levels of technical, allocative and economic efficiency scores of Irish potato farmers, and also to determine the factors influencing technical, allocative and economic efficiency of Irish potato farmers.

METHODOLOGY

Study area - The study area is Plateau State, which is located in the North Central Nigeria. The State lies between Latitude 8° North and 10° North and Longitude 7° East and 11° East of the prime meridian (Uche *et al.*, 2020). The State covers a land area of approximately 26,026 km² with a total population of 3,206,531 and a population density of 103.73 persons per km² based on the 2006 census figure, as well as their 2020 projected population of 5,400,974 with a population density of 174.67 per km² (National Bureau of Statistics NBS, 2020). Plateau State comprises 17 Local Government Areas. The climate on the plateau is tropical but cooler than the surrounding lowlands (Uche *et al.*, 2020). The State is about 1,250m above sea level, and has a near temperate climate with an average annual temperature range from 13 °C to 22 °C in the study area which is required for sprouting of the Irish potato tubers. The warmest temperature usually occurs in the dry season months of March and April while the coolest month is between December and February (Malum & Damwesh, 2023). The mean annual rainfall varies from 131.75cm in the Southern part to 146 cm on the Plateau in the Northern part, and the main cash crop grown in the study area aside Irish Potato includes Maize, Finger-millet, Yam, Wheat, Barley, and Sorghum.

Sampling procedure and sample size - multi-stage random sampling procedure was adopted for this study to select Irish potato farmers from the five (5) major Irish potato producing Local Government Areas (LGAs) in Plateau State, Nigeria. The first stage involved purposive sampling of five (5) major Irish potatoes producing LGAs out of the 17 LGAs in Plateau State based on relative production capabilities, concentration of Irish potato farmers as well as weather adaptability. These selected LGAs include: Barkin-ladi, Bokkos, Jos South, Mangu and Riyom. The next stage involved a simple random sampling of five (5) districts from each of the five (5) LGAs based on productivity level, giving a total of twenty-five (25) districts. The

last stage involved a random sampling of Irish potato farmers from the 25 districts in proportion to their size. Thus, a total of three hundred and sixty-three (363) Irish potato farmers were selected for the study. The sample frame of 3,911 farmers constitutes list of Irish potato farmers in the five LGAs obtained from Plateau State Agricultural Development Programme (PADP). The sample size for the study was determined by a simplified formula for proportion developed by Yamane (1967).

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

Where;

n = sample size

N = total population (3911 Irish potato farmers)

e = sampling error (5% = 0.05).

Data collection - This study used primary data, which was collected with the help of trained and experienced agricultural extension agents during the 2022 production season. The information collected were on inputs used and their cost, output produced and output price, while information on the possible factors affecting Irish potato production as established in the literature, as well as the socio-economic characteristics of the Irish potato farmers were also elicited from the respondents with the aid of structured questionnaires.

Analytical approach - Conventional DEA models (radial and non-radial or slack-based measure SBM). To analyse the objectives of this study, the two common types of conventional DEA techniques from the input-oriented approach were applied: radial and non-radial or slack-based measure (SBM). On one hand, the radial DEA model gives the same specified proportional changes by which all outputs (inputs) are increased (reduced) simultaneously to become efficient and does not consider slacks in resource usage directly. On the other hand, a non-radial DEA model known as the slack-based measure of technical efficiency gives a different proportion and can deal directly with slacks in the efficiency estimation (Aung *et al.*, 2021).

Radial DEA measure of technical efficiency scores - Given the output y (Irish potato produced) and inputs set (farm size, seed, fertiliser, labour and herbicides and pesticides and access to credit), the input-based technical efficiency of the DEA framework for the j^{th} Irish potato farmer, TE_j is defined as: $TE_j = \min \theta_j, \lambda \theta_j \dots \dots \dots (1)$

Subject to: $Y_j \leq Y\lambda$, $\theta_j X_j \geq X\lambda$, $\lambda \geq 0$, $\sum_{j=1}^N \lambda_j = 1$

Where; θ_j = the technical efficiency scores with $0 \leq \theta_j \leq 1$. If $\theta_j = 1$, the farm is technically efficient.

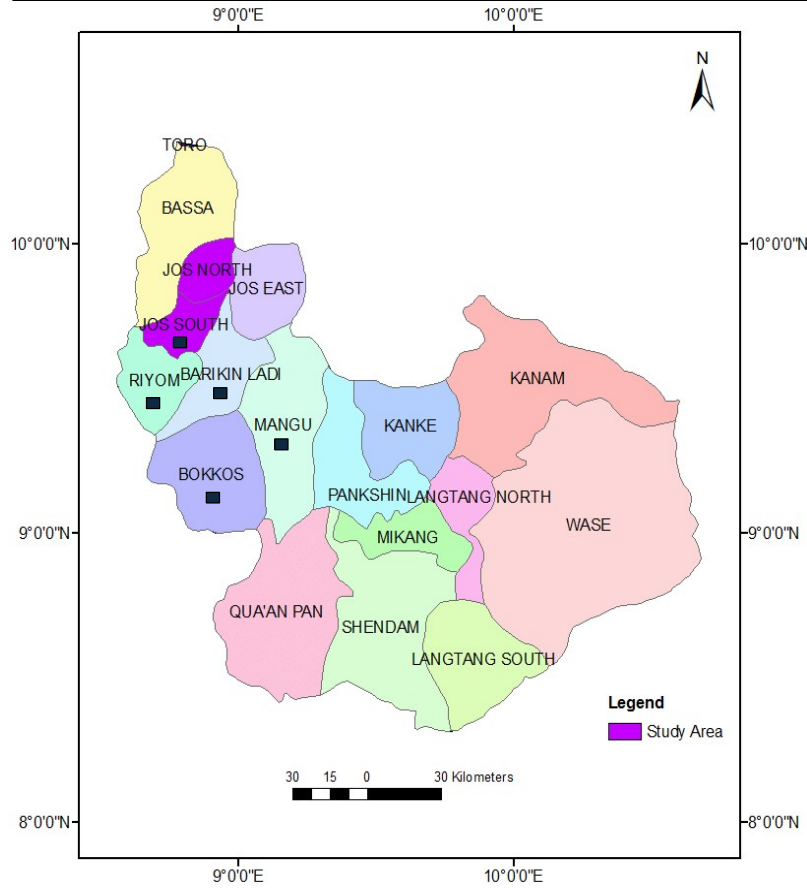


Figure 1: Map of Plateau State Nigeria showing the selected study area
Source: Department of Geography and Planning, University of Jos, 2022.

The vector λ is an $N \times 1$ vector of weights that defines the linear combination of the peers of the j^{th} farm. The first constraint in equation (1) is with respect to the output of the Irish potato farmers. Y_j , tonnes (t) of Irish potato produced per farm in previous production cycle, is the actual level of output of the j^{th} farm compared with the theoretically efficient farm ($Y\lambda$) output vector. The second constraint concerns the inputs of Irish potato produced. Seven main inputs used per farm in previous production cycle, namely; X_1 = farm size (hectares), X_2 = quantity of seed (kg), X_3 = fertiliser (kg), X_4 = labour (man-days), X_5 = herbicide (litres), X_6 =pesticides (litres), X_7 =access to credit (amount accessed ₦), are incorporated into the VRS DEA model in equation (1). $\theta_j X_j$ = the actual level of input used by the j^{th} farm multiplied by its level of efficiency (θ_j). $X\lambda$ = the minimum input use of the theoretically efficient Irish Potato farmers, given the actual level of output produced by the j^{th} farmer. If the solution in equation (1) is smaller than one, the quantity of input used by that Irish potato farmer can be reduced to as low as $X\lambda$ to produce the same level of output. If the solution in equation (1) turns out to be $\theta_j = 1$, that Irish potato farmer's inputs level is as small as the level of input used by the theoretically

efficient farmer at a given same level of output. The third constraint in equation (1) is the convexity constraint, $\sum_{j=1}^N \lambda_j = 1$ for assuming the variable returns to scale (Coelli *et al.*, 2005).

Non-radial DEA or slack-based measure (SBM)

In order to capture the percentage of reduction in the use of any individual input, a non-radial DEA or slack-based measure of technical efficiency model was applied, the mathematical properties of which can be found in (Aung *et al.*, 2021). The slack-based measure of technical efficiency method is expressed as follows:

$$\min_{\rho} = \frac{1 - \left(\frac{1}{m}\right) \sum_{i=1}^m s_i^{-} / x_{ik}}{1 + \left(\frac{1}{s}\right) \sum_{r=1}^s s_r^{+} / y_{rk}} \quad (2)$$

Subject to

$$x_{ik} = \sum_{j=1}^n x_{ji} \lambda_j + S_i^{-1}, i = 1, \dots, m$$

$$y_{rk} = \sum_{j=1}^n Y_{rj} \lambda_j - S_r^{+}, r = 1, \dots, S$$

$$\lambda_j \geq 0, j = 1, \dots, n; S_i^{-1} \geq 0, i = 1, \dots, m;$$

$$S_r^{+} \geq 0, r = 1, \dots, s$$

where, ρ denotes the slack-based measure of technical efficiency of decision making units (DMUs) associated with s output set y_{rk} (s = Irish potato produced) and m input set X_{rk} (m = land, seed, fertiliser, labour, and herbicides/pesticides); λ_j = a non-negative vector

that allows the production possibility set construction for DMUs j ; n = is the number of DMUs ($j = 1, \dots, n$); S_i^{-1} and S_r^{+} are denoted as slacks associated with inputs x (input excess) and output vector y (output shortfalls), respectively. $S_i^{-1} = 0$ implies no input excess and $S_r^{+} = 0$ implies no output shortage for all i and r .

More so, two additional measurements of efficiency were established, taking into account input prices: allocative and economic efficiency. Allocative efficiency (AE) evaluates farmers' potential to utilise resources in ideal quantities given input prices, whereas the economic efficiency (EE) is a product of technical and allocative efficiency (Hassan, 2021). The economic efficiency is assessed in two steps: firstly, a cost-minimising vector of input quantities is determined, given the input prices under VRS assumption as follows.

$$\text{Min} x_j^*, \lambda \quad w_i', x_i^* \dots \dots \dots (3)$$

Subject to

$$\begin{aligned} -Y_j + Y\lambda &\geq 0, \\ x_i^* - X\lambda &\geq 0, \\ N1' \lambda &= 1 \\ \lambda &\geq 0, \end{aligned}$$

Where; Y_j is the output level and $Y\lambda$ is output vector, $X\lambda$ is input vector. The economic efficiency (EE) of the i -th, farm is then estimated as the ratio of the minimum cost to observed cost,

$$EE = w_i', x_i^* / w_i', x_i \dots \dots \dots (4)$$

Where w_i' is the input price vector for the i -th farm and x_i^* is the cost-minimising vector of input quantities for the i -th farm, given the input prices w_i' .

Residually, the allocative efficiency would be calculated as

$$AE_i = EE_i / TE_i \dots \dots \dots (5)$$

Where, EE_i is the economic efficiency of i -th is farm and TE_i is the technical efficiency of i -th farm. Like TE, the value for AE and EE will be $\leq$ one with highest efficiency equal one and present on frontier.

Truncated regression model

Simar & Wilson (2007) advocated the use of the truncated regression model that considers explicitly the bounded domain of the DEA efficiency estimates. Taking this critique into consideration, this study adopted the truncated regression model as follows:

$$\hat{\delta}_j = \beta Z_j + \varepsilon_j \geq 1 \dots \dots \dots (6)$$

Where; $\hat{\delta}_j$ is, called the technical efficiency score with the range from 1 to infinity and Z_j is a vector of individual farm characteristics assumed to affect the choice and use of output and inputs, β is a vector of parameters to be estimated, and ε_j is a continuous random variable, distributed

as $N(0, \delta_\varepsilon^2)$ with left truncation at $1 - \beta Z_j$ for each farm j , and assumed to be independent of Z_j . Adopting the truncated regression for equation (6), this procedure avoids boundary problems since the estimated value of technical efficiencies are typically defined on the interval (0,1), with, in general, few values, if any, close to 0 but some values of 1.

The truncated equation is described as follows:

$$y_i^* = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \beta_{10} X_{10} + \beta_{11} X_{11} + \beta_{12} X_{12} + \beta_{13} X_{13} + u \quad (7)$$

Where; y_i^* = Latent dependent variable representing the efficiency score for farm i .

X_1 = sex (male = 1, female = 0); X_2 = age (years); X_3 = marital status (single = 1, married = 2, divorced = 3); X_4 = level of education (primary = 1, secondary = 2, tertiary = 3, adult/informal = 4); X_5 = household size (number of household in person); X_6 = primary occupation; X_7 = secondary occupation; X_8 = farming experience (years); X_9 = quality of planting seed (kg); X_{10} = extension contact (weekly = 1, monthly = 2, quarterly = 3, annually = 4); X_{11} = Membership of farm group (yes = 1, no = 0); X_{12} = transportation cost (naira ₦); X_{13} = land acquisition (purchased = 1, rented/leased = 2, inheritance = 3, gift = 4, others specify = 5); X_{13} = access to credit (yes = 1, no = 0), β_0 = constant term, $\beta_1 - \beta_{13}$ = regression coefficients, and u = error term that is independently and normally distributed with zero mean and constant variance σ^2 .

RESULTS AND DISCUSSION

Summary statistics of variables in the models.

Table 1 provides the summary statistics of the inputs and output variables used in estimation of the VRS DEA function. The average production of Irish potato during the season is 63.46 kg/ha with output ranged between 9 to 243 bags/ha. The Irish potato farm size ranged between 0.5 to 3 hectares with a mean of 1.47 hectares. Quantity of seeds used among Irish potato farmers ranged between 1 to 8 kg/ha with a mean of 2.48kg/ha. The fertiliser uses among Irish potato farmers during the season ranged between 1 to 22kg/ha with a mean of 7.78kg/ha. Labour is usually distributed between the various farm operations ranging from land preparation to harvesting of product. The labour used during the season ranged between 2 to 5 man-day/ha with an average of 5.36 man-days/ha. Herbicide used among farmers stood between 2 to 16 litres/ha with a mean of 6.89 litres/ha while that of pesticide ranged between 1 to 9 litres/ha with a mean of 3.12 litres/ha.

Table 1: Summary Statistics of Variables in the DEA VRS Function

Variables	Unit	Mean	Minimum	Maximum
Seed	Bag/kg	2.480 (1.279)	1	8
Farm size	Ha	1.428 (0.584)	0.5	3
Fertiliser	Bag/kg	7.782 (3.822)	1	22
Labour	Man-days	5.368 (3.316)	1.94	4.55
Output	Kg/ha	63.461 (39.236)	9	243
Herbicide	Litre	6.897 (3.026)	2	16
Pesticide	Litre	3.121 (1.457)	1	9
Access to credit	Dummy	0.615 (0.487)	0	9

Source: Field Survey, 2022. Values for standard deviation in parenthesis

Estimation of Irish Potato farm level technical efficiency scores.

Table 2 presents the results of the technical efficiency scores from the input-oriented VRS DEA models.

Table 3: Distribution of Irish Potato Farmers by Technical Efficiency Scores

DEA VRS assumption technical efficiency						
Radial TE Non-radial (Slack-based) TE Bias-corrected TE						
Efficiency Range	Frequency	Percent	Frequency	Percent	Frequency	Percent
< 60	8	6.6	36	29.8	39	32.8
60 – 79	24	19.8	55	45.4	45	37.8
≥80	89	73.6	30	24.8	35	29.4
Total	121	100	121	100	119	100
Efficiency scores						
Mean	0.90		0.70		0.68	
Minimum	0.47		0.37		0.26	
Maximum	1		1		1	
Std. Dev.	0.15		0.17		0.16	

Source: Field Survey, 2022. Std. Dev. = Standard Deviation

Technical efficiency for radial measure ranges from 0.47 to 1 with a mean of 0.90 and standard deviation of 0.15. Thus, the most technically efficient farmer is operating on the frontier in this model. Therefore, if the average Irish potato farmer in the sample was to achieve the technical efficiency level of its most efficient counterpart, then the average Irish potato farmer could reduce 10 percent [i.e. $(1-0.90) \times 100$] of input use without changing output level. A similar calculation for the most technically inefficiency farmer reveals input saving of 53 percent [i.e. $(1-0.47) \times 100$].

However, in the magnitude of the non – radial technical efficiency score under VRS DEA was at an average of 0.70 with a low of 0.37 and a high of 1, with a standard deviation of 0.17. Again, the most technically efficient farmer is operating on the frontier. It suggests that if the average farmer was to achieve the technical efficiency level of its most

efficient farmer, then the average farmer could achieve an input saving of 30 percent while the least efficient farmer would achieve an input saving of 63 percent. So, the feasible input reduction was 30 percent [i.e. $(1 - 0.70) \times 100$]. Theoretically, the average technical efficiency derived from the radial model was 20 percent higher than that obtained through non – radial measure, which means radial measure over-estimated the technical efficiency score because it does not take into consideration the slacks in efficiency estimation, which in turn leads to bias result. In other words, the technical efficiency scores obtained from the input-oriented radial measure is higher than the non-radial measure because the radial measure ignores the possibility of slack that may occur in the constraints but the non-radial approach accommodates such slack in the estimation process and provides more precise technical efficiency scores. This result is in line with the finding of (Bitrus *et al.*, 2020).

The bias-corrected technical efficiency (BCTE) ranges from 0.26 to 1 with a mean of 0.68, and a standard deviation of 0.16. Again, the most technically efficient farmer is operating on the frontier. This average score of the BCTE highlights that there is substantial potential for input reduction at 32 percent [i.e. $(1 - 0.68) \times 100$]. This further suggests that if the average Irish potato farmer was to achieve the technical efficiency level of its most efficient Irish potato farmer, then the average Irish potato farmer could achieve an input saving of 32 percent while the least efficient farmer would achieve an input saving of 74 percent. Conversely, on average Irish potato farmers can increase their current output level by 32 percent without increasing the existing levels of inputs. This implies Irish potato farmers on average could decrease input use by 32 percent to get the output they are currently

getting if they use inputs efficiently. This result aligned with the work of Anang *et al.* (2020), with technical efficiency estimate under CRS, VRS and bias-corrected technical efficiency scores of 0.52, 0.72 and 0.57, respectively in smallholder maize production in Northern Ghana. The findings also are in accordance with the study of Kirimov (2013), who estimated non-bias and bias-corrected efficiency scores of 67 percent and 59 percent respectively, for Potato farm in Uzbekistan but contradict the study of Anang *et al.* (2020), who reported a higher bias-corrected technical efficiency score.

Estimation of allocative and economic efficiency scores for Irish potato farmers

Table 3 presents the results of the allocative and economic efficiency scores of Irish Potato farmers obtained from VRS-DEA model.

Table 3: Distribution of Allocative and Economic efficiency Scores Irish Potato Farmers

DEA VRS assumption efficiencies estimate				
Allocative Efficiency AE		Economic Efficiency EE		
Efficiency Range	Frequency	Percent	Frequency	Percent
≤ 0.49	21	7.14	62	20.13
0.5 – 0.59	34	11.04	77	25.00
0.6 – 0.69	57	18.51	57	18.51
0.7 – 0.79	83	26.95	56	18.18
0.8 – 0.89	70	22.73	32	10.39
≥ 0.9	42	13.64	24	7.79
Total	308	100	308	100
Efficiency scores				
Mean	0.74		0.64	
Minimum	0.33		0.22	
Maximum	1		1	
Std. Dev.	0.14		0.16	

Source: Field Survey, 2022. Std. Dev. = Standard Deviation

From the VRS DEA results obtained, the average allocative efficiency of the Irish Potato farmers was 0.74, with minimum and maximum efficiency scores of 0.33 and 1 respectively, meaning that if these farmers operated at full allocative efficiency, they could lower their production costs by 0.26 percent while producing the same amount of output. The average economic efficiency level is 0.64, with minimum and maximum efficiency scores of 0.22 and 1 respectively. That means a farmer with an average level of economic efficiency may cut the current average production costs by 36 percent to reach the minimum cost level while maintaining the same output level. This also indicates that, Irish potato farmer with a mean level of economic efficiency

would save production cost by 36 percent [$(1 - 0.64/1) \times 100$] to reach the level of most economically efficient producer. This study is in consonance with the findings of Gautam *et al.* (2020) which stated that an improvement in water management practices can optimise irrigation efficiency, leading to higher profits for the farmers by with irrigation efficiency score of approximately 37 percent but reveals a lower efficiency scores compared to the efficiency scores reported by Hassan, (2021).

Determinant of efficiency

The estimation results of the bootstrapped truncated regression for the Irish potato farmers are presented in Table 4.

Table 4: Bootstrapped truncated regression analysis

Variable	DEA VRS Assumption					
	Technical Efficiency	Allocative Efficiency	Economic Efficiency			
	Coeff.	p-value	Coeff.	p-value	Coeff.	p-value
Sex	0.0227 (0.0367)	0.536	0.0347 (0.0223)	0.118	-0.0020 (0.0213)	0.926
Age	-0.0049* (0.0028)	0.084	-0.0052 (0.0019)	0.787	-0.0011 (0.0018)	0.552
Education level	-0.0188 (0.0247)	0.445	-0.0097 (0.0133)	0.466	0.0046 (0.0125)	0.711
Household size	0.0153* (0.0080)	0.057	-0.0039 (0.0048)	0.416	0.0031 (0.0045)	0.493
Primary occupation	0.0024 (0.0104)	0.815	-0.0011 (0.0063)	0.856	-0.0046 (0.0050)	0.442
Secondary occupation	0.0017 (0.0134)	0.897	-0.0048 (0.0081)	0.555	-0.0001 (0.0077)	0.987
Farming experience	0.0022 (0.0037)	0.554	0.0028 (0.0025)	0.271	0.0047** (0.0024)	0.046
Quality of planting seed	0.0048 (0.0115)	0.676	-0.0019 (0.0079)	0.807	0.0053 (0.0076)	0.482
Extension contacts	-0.1427*** (0.0387)	0.000	0.0084 (0.0230)	0.714	0.0140 (0.0216)	0.517
Membership of farm group	0.0517 (0.0397)	0.193	-0.0282 (0.0241)	0.242	-0.0145 (0.0227)	0.524
Transportation cost	-5.32e-06** (2.42e-06)	0.028	-3.33e-07 (1.51e-06)	0.825	1.50e-06 (1.41e-06)	0.287
Land acquisition	0.0175 (0.0159)	0.271	-0.0005 (0.0109)	0.961	0.0103 (0.0103)	0.318
Access to credit	-0.4581 (0.0332)	0.168	-0.0215 (0.0216)	0.320	-0.0225 (0.0196)	0.251
Constant	0.9797*** (0.1517)	0.000	0.8127*** (0.0931)	0.000	0.6358*** (0.0878)	0.000
Sigma	0.1503*** (0.0112)	0.000	0.1537*** (0.0083)	0.000	0.1542*** (0.0072)	0.000
Wald chi ² (14)	33.52***		8.21		10.20	
Log likelihood	60.70		163.61		138.46	

Source: Field Survey, 2022.

1. Significant at 10%, 5%, and 1% correspond to *, **, and ***, respectively.

2. The bootstrapped standard errors are shown in parenthesis

The result in Table 4 shows age was only positively and significantly associated with technical efficiency at the 10 percent level. This implies that technical efficiency increases with age of farmers. This result also is in line with the findings of (Jirgi *et al.*, 2015) and Chepng'etich *et al.* (2014) that revealed positive and significant relationship between technical efficiency and age of farmers. Similar result was also obtained by (Mukhtar *et al.*, 2018). In accordance with *a priori* expectation, agricultural extension contact has a positive effect on technical efficiency and was statistically significant at the 1 percent level. This result contradicts the finding of Anang *et al.* (2020) who observed a negative association between extension contact and technical efficiency but on the other hand agreed with the result reported by (Jirgi *et al.* 2015). According to Jirgi *et al.* (2015) farmers

who have access to agricultural extension obtain better skills and knowledge over time from the extension agents. The skills help them to improve on their farm management practices that can enhance efficiency. The result also shows there are a negative relationship between household size and technical efficiency though it is statistically significant at the 10 percent level. This implies that in some rare cases the smaller the household size the better and more efficient the Irish potato farming as compared to popular believe and assumption of farming with larger household size participation usually result to efficient productivity. This result is at variance with *a priori* expectation but consistent with the findings of Anang *et al.* (2020) on smallholder maize production in Northern Ghana. Transportation cost has a positive influence on technical efficiency and was statistically significant at the 5 percent level.

The results in Table 4 further revealed there is a significant negative relationship between farming experience and economic efficiency at 5 percent level, signifying that farming experience do not necessarily translate to improvement in economic efficiency. That is to say, though farming experience as a variable is important but not sufficient in enhancing economic efficiency. This result contradicts the notion that experiences in farming tends to increase farmers' capacity to do better, believing that the higher the farmer's farming experiences the more efficient his productivity level. Also, farmers with more years of farming experience are better placed to acquire the knowledge and skills necessary for choosing appropriate new farm technologies over time, manage the field effectively and allocate the resources wisely.

CONCLUSION AND RECOMMENDATIONS

In agricultural production and policy debates, efficient allocation of resources has become very imperative and has led many agricultural stakeholders to take the issue of evaluating agrarian practices into consideration. Consequently, the best way to improve output is for farmers to minimise input use or assign their resources efficiently. The bootstrap procedure adopted minimised the sample sensitivity due to biased and serially correlated estimates. After correcting for bias, the average technical efficiency score tends to be lower for bias-corrected (bootstrapped) DEA measure than the conventional DEA measures. The regression result revealed that extension contact, age, transportation cost, and household size were the major significant factors influencing technical efficiency of Irish potato farmers while access to credit, household size and extension contact were the variables with significant impact on allocative efficiency. This study has logical implication for understanding and controlling productive efficiency of Irish potato production among farmers in Plateau State, Nigeria. Of course, like many other studies, some work remains to be done. A future study can investigate the impacts of farm and farmer characteristics on technical, allocative and economic efficiency using the double bootstrap DEA approach to improve robustness of the efficiency scores. In that case, the efficiency measures consider differences in the sources from which errors originate. That perspective can attempt to distinguish between errors arising from farmer discretion and errors arising from systematic factors. From the findings, increase in extension contact or more access to extension agents would help in bringing changes in existing cultivation practices, and improve technical and managerial skills of Irish potato farmers. Irish potato farmers should be encouraged to form and actively participate in various farm groups or cooperatives, this will enhance their access to credit,

markets information and sources of inputs which will further improve their production efficiency.

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Effect of Credit Utilisation on the Technical Efficiency of Late-Season Maize Production in Yewa Division of Ogun state, Nigeria

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Abstract: Farmers' limited access to agricultural credit facilities is a major factor limiting agricultural productivity in Nigeria, and this in turn affects the efficiency of production. Hence, this study aims to examine the effect of credit utilisation on the technical efficiency of late-season maize production in Yewa Division of Ogun State, Nigeria. Primary data were obtained from one hundred and twenty (120) maize farmers using a random sampling technique. A stochastic frontier approach was used to generate technical efficiency estimate and Tobit regression model was applied to examine the effect of credit utilisation on the technical efficiency of late-maize production in the study area. Result of the logit regression model of the determinants of maize farmers' accessibility to credit showed that large household size (1.3483; $p < 0.01$); education (0.2281; $p < 0.01$) and cooperative membership (0.1052; $p < 0.05$) increased the likelihood of maize farmers' accessibility to credit facilities in the study area, but male farmers are less likely to benefit from the credit services like their female counterparts. Technical efficiency estimates ranged between 0.06 and 0.91 (mean value = 73%); and the coefficient values of seed quantity (0.6281), fertiliser (0.5319) and labour (0.6481) indicate that a one percent increase in each of these inputs would increase maize output by 0.3829, 0.4791 and 0.3629, respectively. The inefficiency effects of the frontier model revealed formal education and sex of the farmer as being positively influential in determining the technological gap in attaining the desired frontier in late-season maize production systems. The need for enhanced credit accessibility to improve farmers' technical efficiency in the study area was therefore essentially recommended.

Keywords: Credit utilisation, technical efficiency, late-season maize, stochastic frontier model, Ogun State

INTRODUCTION

Agriculture is a key sector of the economy of most countries of the African continent, serving as the main source of food, employment, income and other livelihood means for the teeming population. Despite its vast multisectoral importance, productivity in the agricultural sector is still very low in many African countries (Nakano and Magezi, 2020), partly due to large areas of uncultivated arable land estimated as almost 60% for the continent (Zedillo, 2015). For instance, while the maize sub-sector in the Tanzanian agricultural sector was ranked the second position out of the six flagship agricultural sectors behind cotton up till year 2017 (WFP, 2017), Wossen *et al* (2017) reported that the cultivation of drought tolerant improved maize varieties reduced yield variability by 53% and the probability of food scarcity by 84%.

Maize is a crop of notable interest for food security in many parts of sub-Saharan Africa (SSA). Household food security implies the existences of sufficient, safe and nutritious food available comprising key concepts on sustained basis for all people in all times at prices commensurate with their income (Rukhsana *et al.*, 2017). As in other countries of SSA, maize is an important crop in Nigeria (van Ittersum *et al.*, 2016), where it is largely cultivated by smallholder farmers over 6.5 million hectares of land across diverse agroecological zones of the country (Onumah *et al.*, 2021); being by far the largest cereal crop in terms of area and

production volume and is the most consumed staple food in Nigeria. Approximated 80 percent of the maize grain in Nigeria is consumed by man and his farm animal; aside the relevance of the remaining 20 percent, useful by pharmaceutical industries, food manufacturers, breweries, flour mills, among other industries (Onumah *et al.*, 2021). With a per capita consumption of about 35 kg per person per year, maize accounts for an estimated 10% of the daily calorie intakes in the country. The crop is also an important source of cash income for farmers and contributes significantly to agro-industrial development particularly in the livestock feed industry (Wossen *et al.*, 2017).

While the level of production of this cereal, widely consumed by numerous households in most African countries, makes it possible to cover their food needs, yet the marketable surpluses generated are still not sufficient to meet the foreign exchange needs of most countries in the continent (MAEP, 2017), the insufficient surplus being largely associated with low yield of this important annual cereal crop (Zedillo, 2015). Among several factors causing low productivity in maize yield (e.g. low adoption of modern technologies, such as fertilisers, modern varieties; and poor agronomic practices), previous studies have linked the lack of access to credit as a major obstacle to maize yield (e.g. Guirkingner and Et Boucher, 2008; Nakano *et al.*, 2016). Credit has been identified as a key factor, providing critical support service for increased

agricultural productivity. Credit supply facilitates adoption of innovations, leading to increased farm productivity and income, encourages capital formation and improves marketing efficiency (Otsuka and Larson, 2016). In addition, it enables farmers to purchase inputs, hire labour and procure equipment and improved seed varieties for increased agricultural production. The need for credit is more acute in the rural areas, because access to financial resources is lowered by low productivity and widespread poverty of the rural farm sector. This low productivity is purely due to the fact that they produce for subsistence consumption and a little marketable surplus. Access to credit enhances farmers' ability to acquire productive factors (such as farmlands, skilled and unskilled labour, among others); and affords them the opportunity to deploy modern farm technology to boost production, thereby increasing their production efficiency and consequently, profit margin (Antwi and Onumah, 2020).

Agricultural credit has been reported as an effective tool for sustainable agricultural development in several places in the world. It has positive impact on smallholder farmers' productivity as it enables them to access inputs such as fertilisers, improved seeds and to hire labour when needed. Credit accessibility increases households' per capita income and can be a powerful tool to increase farmers' productivity, wellbeing and food security. Indeed, agricultural credit enhances productivity and improves standards of living by breaking the vicious cycle of poverty that small-scale farmers are prone to (Antwi, 2020). However, despite this positive effect of agricultural credit in improving farms productivity as well as farmers' well-being in general, the expected nexus between farmers and credit sources is still very weak. To improve farmers' access to credit sources therefore, there's the need to strengthen the capacity of critical operators in the credit management system, educate farmers on the merits of credit-use and the procedures for access, and seek to link formal and informal financial service delivery systems.

Many a times, farmers obtain agricultural credit and use it for other purposes, underscoring the ethical and legal purposes for such loan facilities. As a result, they inadvertently face difficulties in their loan obligations (repayment) to the lending institutions. To this effect, a number of recent studies perceive as challenging the high profiling of agricultural credit revealing controversial effects of it on agricultural productivity (e.g., Njeru *et al.*, 2016; Nakano and Magezi, 2020). In Nigeria, in similar vein, Agbodji and Johnson, (2019) equally considered their finding so challenging, establishing contrasting impact of cash credit on maize productivity. The foregoing scenarios notwithstanding, a number of studies have established the positive effects of farmers' access to

credit on agricultural productivity (e.g., Khandker and Et Koolwal, 2014 and Akudugu, 2016). These controversies often constrict the feasibility of securing financial support for agricultural production, especially among late season maize farmers, due to the heightened fear of unexpected shocks occasioned by adverse weather condition. Hence, the aim of investigating the effect of credit utilisation on the technical efficiency of late-season maize farming systems among farmers in the derived savanna zone of Yewa division in Ogun state is justified.

METHODOLOGY

Study area - The study area is Yewa Division of Ogun State, Nigeria. This division of Ogun State is bounded in the West by the Republic of Benin, East by Abeokuta division, North by Oyo State, and South by Lagos and the Atlantic Ocean. The Division is composed of five (5) Local Government Areas (LGAs), namely Yewa South (Ilaro), Yewa North (Ayetoro), Imeko-Afon (Imeko), Ado-Odo/Ota (Ota) and Ipokia (Ipokia), with a total land mass of about 5,878 km². The people are predominantly Yewas, Aworis and Eguns which are Yoruba speaking.

Sampling technique and method of data collection - A multistage random sampling technique was used for this study. In the first and second stages, two (2) Local Government Areas (LGAs) - namely Yewa North and Yewa South - and three (3) communities per LGA were purposively selected due to the prevalence of late-season farming activities in those areas (citation). In the third stage, two (2) villages were randomly selected from each of the six communities to give a total number of twelve (12) sampled communities. Lastly, at the community level, late-season maize farmers were randomly selected proportionate to the size (number) of practitioners in those communities. Primary data were obtained from the sampled farmers using structured questionnaire, which were administered directly on the respondents. From the retrieved questionnaires, only one hundred of twenty (120) were found useful for the data analysis, as some were discarded for their paucity of sufficient information.

Methods of data analysis - The study data were analysed using descriptive and inferential statistical tools. Descriptive statistics were used to present the socio-economic characteristics of the late-season maize farmers, and to identify the sources of credit facilities available to them. Logit model was used to estimate the determinants of credit accessibility by the maize farmers. The choice of the logit model was premised upon dichotomous nature of the dependent variable, being a dummy. Several studies on access to credit have shown that there exists some heterogeneity between credit users and non-credit users. Several models used in

measuring credit-use fail to meet the statistical assumptions necessary to validate the conclusions based on the hypotheses tested. To overcome this problem with regards to the use of a linear probability model, the logit and probit models have been recommended as more appropriate (Gujarati, 2004). This study adopted the use of logit model since the probabilities are between 0 and 1. The binary logit model is used in this study, and was specified as follows:

$$\ln(P_i/(1-P_i)) = \beta_0 + \beta_1 X_1 + \dots + \beta_9 X_9 + e_i$$

Where:

P_i = probability of farmer's accessibility to credit for late-season maize production

$1-P_i$ = probability of not accessing credit for production

β_0 = Intercept

β_i (1,2,3,...,9) = Regression coefficients,

X_i (1,2,3,...,9) = Independent variables, and

e_i = error term.

The independent variables specified as factors influencing farmer's decision to access credit for production and are defined below: X_1 = Sex (1=male, 0=female), X_2 = Age (years), X_3 = Household size (number), X_4 = Education (years), X_5 = Farming experience (years), X_6 = Farm size (Ha), X_7 = Type of labour engaged (1=Hired, 0 otherwise), X_8 = Cooperative membership (Yes= 1, 0 otherwise), X_9 = Distance to credit source (km).

Technical efficiency estimates in late-season maize production systems

Stochastic frontier approach was used to estimate the technical efficiency of arable crop farming in the study area. The concept of the Stochastic frontier approach depicts a normal production setting that is bedevilled with varied number of factors some of which not under the influence of the producer. The production process may have some stochastic components that are not associated with inefficiency such as luck, weather, measurement errors in the dependent and independent variables. These resulted in the introduction of the stochastic error term which represents different set of errors which were hitherto added to the inefficiency of the producer. The generalised deterministic frontier production function is expressed below:

$$\ln Y = \alpha_0 + \alpha_1 \ln x_1 + \alpha_2 \ln x_2 + \alpha_3 \ln x_3 + \alpha_4 \ln x_4 + \alpha_5 \ln x_5 + V_i - U_i$$

Where:

$\ln$ is logarithm to base e;

Y = Maize output (kg), X_1 = Quantity of seeds (kg),

X_2 = Quantity of fertilisers used (kg), X_3 = Quantity

of chemical used (litres), X_4 = Quantity of labour

(manday), X_5 = Land area cultivated (ha); and V_i =

Assumed to be independently and identically distributed random errors that have normal distribution. The technical inefficiency effects, U_i is defined as:

$$U_i = \beta_0 + \beta_1 Z_1 + \beta_2 Z_2 + \beta_3 Z_3 + \beta_4 Z_4 + \beta_5 Z_5$$

where: Z_1 = Age of the farmer (years); Z_2 = Household size (number); Z_3 = Formal education (in years); Z_4 = Farming experience (in years); and Z_5 = Sex of the farmer (1=female; 0= male)

Effect of credit utilisation on the technical efficiency of the surveyed farmers

To determine the effects of credit utilisation on technical efficiency of the farmers, a Tobit model was used. The structural equation of the Tobit model is given as:

$$y_i^* = Z_i \beta + \varepsilon_i$$

The model assumes that there is an underlying stochastic index equal to $(Z_i \beta + \varepsilon_i)$ which is observed only when it is some number between 0 and 1; otherwise, y_i^* qualifies as an unobserved latent (hidden) variable. The dependent variable is not normally distributed since its values range between 0 and 1. The empirical Tobit model for this study therefore takes the following form:

$$y_i^* = \beta_0 + \sum_{n=1}^8 \beta_n Z_n + \varepsilon_i$$

Where: Y = Technical efficiency scores of the maize farmer, which ranges between 0 and 1.

Z_1 = Age of the farmer (years), Z_2 = Farming

experience (years), Z_3 = Education (years of

schooling), Z_4 = Sex of household head (1 = if male

and 0 = otherwise), Z_5 = Farm size (hectares), Z_6 =

Previous credit obtained (₦), Z_7 = Interest rate (%),

Z_8 = Amount of credit used for late-season maize

production in the 2017/2018 cropping season (₦), Z_9

= Membership of social organisation (Yes=1, and 0

otherwise) and ε_i = Error term.

RESULTS AND DISCUSSION

Socio-economic characteristics of maize farmers

The result of the analysis showed that majority of the maize farmers were male, representing about 86.7% of the sampled farmers. This can be attributed to the fact that men always have more rights to land as a productive resource than their women spouses. The male dominance of agriculture as a source of livelihood to the rural populace stems from the laborious nature of farming operations from tillage to harvest, which the female folks may not easily undertake. This is because peasant farming operations require a lot of energy and are labour intensive, especially under the rural, small-scale engagements, where crude farm implements are still largely adopted.

The distribution of the respondents based on age brackets revealed that the youngest maize farmer was 29 years old while the average farmer was about 42 years old. Majority (49.2%) of the maize farmers were between the ages of 31-40 years,

28.3% were between 41-50 years while 19.2% were between 51-65 years and only 3.3% of the farmers were below 31 years of age while the maximum age of the maize farmers is 65 years. This means that majority of the maize farmers were within the working age bracket. It can be said that maize farmers in the study area were relatively young and falling within their economically active age. Other implication is that maize farmers in the study area could be more effective in land husbandry activities such as weeding, land preparation, digging and planting since these tasks require physical efforts which could positively influence their efficiency level.

Marital status is expected to influence respondents' level of responsibilities which could have positive or negative influence on their disposition to economic activities. Majority (88.3%) of the respondents were married, indicating that they were settled family persons who needed credits to expand their maize farming production. This could enable them to increase their farming output and income with the resultant ability to cater for the

family's needs. It could also have implication for the supply of family labour to the respondents.

Education is an important socio-economic factor that influence farmer's decision making because of its influence on farmers' awareness and adoption of innovations that can bring about increase in productivity. The results in Table 1 revealed that 20.8% of maize farmers had no formal education while 79.2% of the farmers had one form of education or the other; about 20.0% had primary education, 43.3% had secondary education and 15.8% had tertiary education. This result showed that majority (79.2%) of the maize farmers in the study area had one form of formal education or the other implying that there is potential for increased maize production since education will enable farmers to have access to information on new agricultural innovation which can be adopted to enhance their productivity. The result is in conformity with the study of Achille and Dewanou (2023) who observed that productivity of maize farming with access to credit was influenced by being formally educated.

Table 1: Distribution of the socio-economic characteristics of the respondents

Variables	Response options	Frequency	Percentage	Mean
Sex	Male	104	86.7	42 years
	Female	16	13.3	
Age	≤ 30 years	4	3.3	
	31 - 40 years	59	49.2	
	41 - 50 years	34	28.3	
	51 - 60 years	12	10.0	
	61 - 65 years	11	9.2	
Marital Status	Single	8	6.7	
	Married	106	88.3	
	Separated	6	5.0	
Formal education	No formal education	25	20.8	
	Primary education	24	20.0	
	Secondary education	52	43.3	
	Tertiary education	19	15.8	
Household Size	3 - 6	61	50.8	7 members
	7 - 10	44	36.7	
	11 - 15	15	12.5	
Farm size	≤ 1.0	50	41.7	1.67ha
	1.1 - 2.0	39	32.5	
	2.1 - 3.0	16	13.3	
	> 3.0	15	12.5	
Farm experience	1 - 10 years	64	53.3	14 years
	11 - 20 years	34	28.3	
	21 - 30 years	15	12.5	
	31 - 35 years	7	5.8	
	Total	120	100.0	

Source: Field Survey Data, 2023

The distribution of the respondents based on household size revealed that over half (50.8%) of the respondents had a family size ranging between 3-6 members while 36.7% had a family size ranging between 7-10 members in their households and about 12.5% of maize farm households had a family

size ranging between 11-15 people. The average maize farm household was composed of 7 people. Manual labour is observed to be a significant production input in smallholder agriculture which can influence productivity through increase in efficiency. Family size represents the number of

persons that depend on the income generated from the farm and, thus, is likely to influence the farmer's attitude towards managing the farm.

Land expansion is still regarded as an important source of agricultural growth in Nigeria. Evidence in Table 1 revealed that majority (41.7%) of farmers in the study area had farm sizes ranging ≤ 1.0 ha, 32.5% of farmers had farm sizes ranging from 1.1 – 2.0ha, 13.3% of the farmers had farm size ranging from 2.1 – 3.0ha while only 12.5% had farm sizes more than 3.0 ha with the average farm size put at 1.67 hectares. It is important to note that all the maize farmers had less than 6ha implying that they are all small-scale farmers. Farmers are often encouraged to increase their scale of operations to take advantage of economies of scale and sometimes economies of scope. However, small farmers are better able to utilise efficiently small blocks of land and are more likely to practice intensive farming and fulfil market niches for special farm products.

The results on Table 1 also showed that over half (53.3%) of the respondents had maize farming experience ranging between 1-10 years while 28.3% had maize farming experience ranging between 11-20 years and only 18.3% had more than 20 years of maize farming experience. The average maize farming experience was about 14 years. This

implies that maize farmers were quite experienced in the production of maize in the study area. Experience which is often correlated with age can enhance people's efficiency in terms of allocation of resources, implementation of agronomic practices and reduction of risks through acquisition of better understanding of production practices and marketing. The finding is consistent with the study of Otsuka and Larson (2016) who argued that access to credit enables farmers to adopt the best production technologies and acquire quality input; and also afford them the opportunity to hire quality labour, which ensures they set up production under the most optimal conditions.

Sources of credit facilities available to the farmers

The results of the characteristics of credit available to the maize farmers are presented in Figure 1. Cooperative societies, Commercial Banks, friends and family and money lenders were the only sources of credit available to the farmers in the study area. The result as revealed shows that the major (65.0%) sources of credit available to the maize farmers in the study area was co-operative societies. Others include friends and family (36.7%), money lender (32.5%) and commercial banks (15.8%).

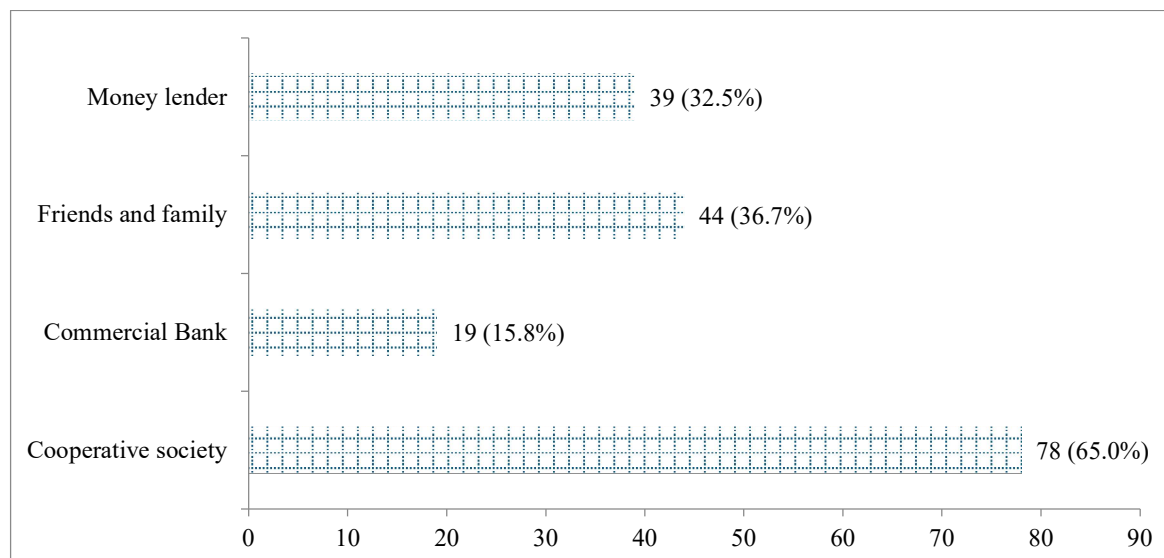


Figure 1: Credit available to the surveyed farmers
Source: Field Survey Data, 2023

The implication is that the major sources of credit among the respondents were non-institutional credit sources. Credit from non-institutional sources is more attractive, because there is little or no insistence on collateral security. On the other hand, formal sources of credit had low patronage from the farmers, which may be due to lack or limited presence of banks in the study area coupled with delay in approval and disbursement of loan and insistence on collateral security.

Determinants of maize farmers' accessibility to credit facilities

The empirical result discussed in this section is based on the Logit model specifications. The log-likelihood of -60.461, and the LR (χ^2) of 42.724 (significant at 1% level), implies that the overall model is fitted and the independent variables included in the model are collectively able to explain the farmers access to credit. Nine (9) variables were hypothesised to explain factors affecting maize

farmer's access to credit. Out of these four (4) of the variables were found to be significant. The maximum likelihood estimates of the logistic regression model show that sex, household size, formal education, farming experience and cooperative membership were important factors influencing farmers' access to credit in the study area.

Sex of household head is significantly related to the dependent variable, and it is significant at 1% probability level. The result of the logit model also revealed that the variable has a negative relationship implying that male headed household

uses credit less than female headed households or the male headed households would be less likely to go for credit. Household size is significantly related to the dependent variable. It is also significant at 1% probability level and increase in it would increase access to credit use. The positive relationship between household size and access to credit is that farmer who had small size of household can utilise more credit for labour and other farm inputs and therefore, this will increase the demand for credit and therefore, as demand increase there will be a chance of access to credit.

Table 2: Parameter estimate of factors influencing maize farmers' access to credit facilities

Variables	Coefficient	Standard error	z- ratio
Constant	1.9531	1.8222	1.072
Sex	-0.2756***	0.0916	-3.009
Age	-0.1230	0.5300	-0.236
Household size	1.3483***	0.1076	12.527
Years of formal education	0.2281***	0.0569	4.011
Farming experience	0.2068	0.6572	0.315
Farm size	-0.2874	0.2945	-0.976
Type of labour engaged	-0.0214	0.0262	-0.818
Cooperative membership	0.1052**	0.0492	2.137
Distance to credit source(s)	-0.0103	0.1205	-0.085
log-likelihood	-60.4606		
LR (Chi ²)	42.7238		

***, **, and * implies significant at 1%, 5% and 10%, respectively.

Source: Field Survey Data, 2023

Education level of household head affected access to credit positively and was statistically significant at 1% level of probability. This may probably mean that literate farmers have more exposure to the external environment and information which helps them easily associate to credit sources. Cooperative membership is another factor, which is significantly related to the access to funding sources, and is significant at 5% probability level. The probability of accessing credit was therefore, positively influenced by cooperative membership. This is due to the fact that cooperatives provide credit from their own source for members only. While for non-members except input credit no other type of credit was provided.

Technical efficiency of late-season maize farming

Maximum Likelihood Estimate (MLE) of the parameters of the stochastic frontier production model used in estimating technical efficiency of late season-maize production in Yewa Division of Ogun State, Nigeria is presented in Table 3. The result reveals that seed fertiliser and labour of the estimated coefficients of the parameters of production function were positive which confirm to a *priori* expectations and were statistically significant at 1 percent level while chemical and land area cultivated was negative, positive and not significant.

The sigma squared and the gamma (0.3396), (0.8027) were statistically significant at five and one percent respectively. The sigma squared indicates the goodness of fit and correctness of the distributional form assumed for the composite error term. The Gamma implies the existence of technical inefficiency among maize farmers and account for 80.3% of the variations in the output level of maize produced in study area. This confirms that in the specified model, there was presence of one-sided error component. It also implies that the effect of technical inefficiency was significant and that a classical regression model of production functions based on ordinary least squares estimation would be an inadequate representation of the data. Thus, the variance parameters confirm the relevance of the stochastic production function. The variables that were statistically significant can be discussed thus:

The coefficient of seed (0.6281) was positive and statistically significant at one percent level. This implies that one percent increase in viable seed quantity would lead to increase in maize yield by 0.6281 percent. This implies that seed is a positive factor influencing maize output in the area. It indicates that higher seed rate would result in high crop population and subsequently higher yield. The finding agrees with the findings by Diamoutene and Jatoe (2020) that seed was a positive determinant of

maize output among maize farmers in Ogbomoso
south LGA in Oyo State Nigeria.

Table 3: Maximum Likelihood Estimates of the Stochastic Production Function

Variables	Coefficient	Standard-error	t-ratio
Constant	3.5435***	0.6534	5.423
Seed	0.6281***	0.0695	9.040
Fertiliser	0.5319***	0.0748	7.114
Chemical	-0.1671	0.9732	-0.172
Labour	0.6481***	0.0813	7.976
Land area cultivated	0.6813	0.9818	0.694
Inefficiency model			
Constant	-0.0614	0.9762	-0.063
Age	0.0039	0.6667	0.006
Household size	-0.7219	0.8917	-0.810
Years of formal education	-0.1209***	0.0396	-3.054
Farming experience	0.1183	0.0753	1.571
Sex of the farmer	-0.2586***	0.0993	-2.605
Sigma-squared	0.3396**	0.1481	2.292
Gamma	0.8027***	0.2325	3.453

*** and ** implies significant at 1% and 5% respectively.

Source: Field Survey Data, 2023

The elasticity of production with respect to fertiliser (0.5319) was positive and statistically significant at one percent level. The use of fertiliser will improve soil fertility leading to increase in yield of maize. However, fertiliser make its best contribution to the enhancement of soil fertility only if it falls within a hierarchical system of good technological measures and the doses used are related to crop plants, soil, climate and culture technology. The result of the study is in conformity with the work of Usman *et al.* (2015) who found fertiliser to be significant in white maize production.

The elasticity of production with respect to labour (0.6481) was positive and statistically significant at one percent level. This implies that one percent increase in man days of labour, *ceteris paribus*, would lead to increase in maize yield by 0.6481 percent. The quick and effective weeding by hired labourers may be responsible for the increased productivity of maize in the study area. Accordingly, the production of maize in the area does not involve much of farm mechanisation but used traditional technology that relies heavily on labour.

The inefficiency parameters included in the model specifically, those related to farmers' socio-

economic characteristics were also presented in Table 3. The signs in the inefficiency model were explained in the opposite way such that a negative sign indicates increase in technical efficiency while positive sign indicates a decrease.

Technical efficiency distribution of the late-season maize farmers

Table 4 shows the distribution of technical efficiency of the farmers in the study area, and it reveals that 14.2 percent had technical efficiency of less than 0.60 and about 48.3 percent had technical efficiency between 0.61 – 0.80. The mean technical efficiency was 0.73 which indicates that the average farmer obtained 73 percent of maximum attainable output for a given input level. This indicates that in the short run, there is scope for increasing technical efficiency in maize production by 27 percent in the study Area. This implies that to improve the technical efficiency of the maize farmers, their knowledge, skills and awareness level need to be improved. The present finding corroborates the findings of Wondimu and Hassen (2014) who reported high mean technical efficiency in maize production in Dhidhessa District of Illuababora Zone, Ethiopia.

Table 4: Distribution of maize farmers based on their technical efficiency levels

Variables	Frequency	Percentage
≤ 0.40	4	3.4%
0.41 – 0.60	13	10.8%
0.61 – 0.80	58	48.3%
> 0.80	45	37.5%
Total	120	100.0

Minimum = 0.0624; Average = 0.7321; Maximum = 0.9077

Source: Field Survey Data, 2023

Effect of credit utilisation on the technical efficiency of maize farmers

The results in Table 5 showed the estimates from the Tobit regression of credit utilisation against predicted technical efficiency scores to determine its effect as a factor on farm efficiency. The model was correctly estimated since the model Log likelihood function was 62.4552 and it was strongly significant at 1% level. Among the selected variables, four were found to have a significant contribution on technical efficiency namely: age, education, farm size and amount of credit used for maize production in the 2017/2018 cropping season.

Age of the farmer showed a negative effect on technical efficiency of the farms, and it was significant at 1% level. This means that older farmers were less technically efficient in maize production than their younger counterparts. The

finding is attributed to the fact that older farmers in the study area are relatively more reluctant to take up better technologies, instead they prefer to hold to the traditional farming methods thus become more technically inefficient compared to their younger counterparts. This negates the finding of Sani and Oladimeji. (2017) who opined that age of household head is critical for occupational experience and responsibility, and in consonance with the findings of Abdulazeez *et al.* (2018) who observed the mean age of rice farmers to be 42 years and concluded that farmer's age significantly influence the production-related decision process among arable crop farmers.

Farmers' education showed a positive effect on the technical efficiency as hypothesised and was significant at 1% level. The results indicated that a unit increase in the years spent in school will increase technical efficiency.

Table 5: Tobit regression estimates of the effect of credit utilisation on the technical efficiency of late-season maize farming

Variable	Coefficient	Standard error	t-ratio
Constant	0.8699***	0.1500	5.801
Age of the farmer	-0.0289***	0.0024	-12.150
Farming experience	0.0024	0.0046	0.509
Education	0.1009***	0.0110	9.171
Sex of household head	-0.0113	0.0505	-0.224
Farm size	0.0878***	0.0159	5.523
Previous credit obtained	-0.0020	0.0232	-0.087
Interest rate	0.0047	0.0204	0.231
Amount of credit utilised	0.0486***	0.0057	8.564
Membership of social organisation	-0.0659	0.0461	-1.429
Sigma	0.1438***	0.0093	15.492
Log likelihood function	62.4552***		

*** and ** implies significant at 1% and 5%, respectively.

Source: Field Survey Data, 2023

Farm size was found to have a positive effect on technical efficiency as hypothesised and it was significant at 1% level. According to the results, an increase in the size of the farm increases the technical efficiency of the maize farmer. It may be argued that farmers with larger farm sizes can engage productive resources more effectively, thus reducing soil fertility losses, and making their farming operations more efficient. Reverse is the case for farmers with small units of land, since the land is cultivated every year, thus reducing its productivity, and with resultant technical inefficiency effect.

Amount of credit used for late-season maize production also showed a positive and significant influence on technical efficiency at 1% level. According to the findings, farmers who had access to more credit showed higher levels of technical efficiency than those who failed to access credit in the same production season.

CONCLUSION

The study concludes that, the stochastic production function of the coefficients of farm seed, fertiliser and labour were found to be positive and significantly affect maize output of the farmers with the mean technical efficiency is 0.864 (or 86.4%) an indication that the farmers are fairly technical efficient in maize production. This indicates that there is scope to further increase the output by 13.6% without increasing the levels of inputs. It therefore suggests that productivity and output of the farmers can be increase for every increase in the resource efficiency use of the farmers. The inefficiency effects model revealed that formal education and sex of the farmer have positive effects on technical efficiency. Finally, the Tobit regression model estimation revealed that technical efficiency was positively influenced by education, farm size and amount of credit utilised all at 1% level; and negatively influenced by age.

RECOMMENDATIONS

In line with the finding of this study, it was recommended thus, that:

- i. Amount of credit used for late-season maize production in the last cropping season positively and significantly influenced the technical efficiency of the maize farmers. Therefore, enhanced access of late-season maize farmers to financial facilities, through such institutions as cooperatives and agricultural/micro finance banks, must be facilitated in the study area, for improved technical efficiency in the maize production systems.
- ii. Inefficiency of operations (up to 26.79%) was established in late-season maize production systems among farmers in the area. Thus, integrated efforts that will improve the existing level of input utilisation, and corresponding policy measures towards reducing inefficiency levels, will have paramount importance in improving food sufficiency in the study area.
- iii. Improved education among maize farmers will equally improve access to credit funding and thus, simplified literacy modes that are applicable to credit outsourcing is recommended for maize farmers in the study area.
- iv. Engaging larger farm plots will enable maize farmers utilise their resources more effectively, thus reducing soil fertility losses, and increasing technical efficiency in maize production.

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Constraints Affecting Nutritional Status of Women Farmers in Oyo State, Nigeria

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Abstract: Women play a significant role in agricultural production; their contribution is as high as between 60 and 90 percent of the total task for food production. This study focused on the constraints affecting the nutritional status of women farmers in Oyo State. Specifically, the study examined the socio-economic characteristics, investigated the food insecurity status, examined the nutritional status, and investigated the constraints affecting the nutritional status of women farmers. Using multistage sampling, 177 women farmers were selected. Data was collected via interviews and analysed with descriptive statistics (frequency and percentage) and Weighted Mean Score (WMS). The mean age was 48.25 years. About 68.4% were married with an average household size of 5. Household members have to eat a limited variety of foods due to resource constraints (WMS = 1.08). A positive and non-significant relationship exists between constraints and nutritional status ($r = 0.437$) and ($p = -0.059$). Extension workers and the government should provide assistance in helping them to have access to soft loans.

Key words: Women farmers, food insecurity, nutritional status and constraint

INTRODUCTION

According to the International Journal of Science and Research (n.d.) (2009), agriculture remains the dominant sector in the rural areas of Nigeria and provides for two-thirds of Nigerians who are low in income. According to Okunade (2021), women's involvement in agriculture goes beyond just farming; they are central to the three main components of food security: food availability, food accessibility, and food utilisation. This means that the role of women is not just about producing food but also about ensuring it's available in the market so that families can afford it and that it's properly prepared for consumption. Despite the critical role women play in food production and management of natural resources, the major barrier for women farmers is their lack of access to productive resources such as land, credit facilities, and modern farming technologies (Okunade, 2006). Land ownership is a particularly significant issue. In many patriarchal societies, customary laws and traditions prevent women from owning or controlling land, restricting their ability to make independent decisions or use land as collateral for loans (Okunade, 2006). This lack of access to financial resources also prevents them from investing in improved seeds, fertilisers, and labour-saving machinery, forcing them to rely on traditional, less efficient farming methods. Lack of access to and control over land has intensified women's difficulties, their access to credit and technical assistance, and their participation.

In Nigeria, the Women-in-Agriculture (WIA) model employs female extension agents to deliver culturally appropriate nutrition messaging, overcoming religious and social barriers that typically exclude women from mainstream advisory services (HarvestPlus CGIAR, 2022). These peer-led platforms enhance both information uptake and trust, making them a valuable route for expanding nutrition programming (Alemu *et al.*, 2025). Beyond knowledge transfer, such initiatives strengthen

women's agency in decision-making regarding food production, household dietary planning, and health-seeking behaviour (Akinyele *et al.*, 2022; FAO, 2023).

METHODOLOGY

The study was carried out in Oyo State, Nigeria. Oyo State consists of 33 local government areas. Oyo State is made up of four agricultural zones, namely the Ibadan/Ibarapa zone, the Oyo zone, the Ogbomoso zone, and the Saki zone. In Oyo State, Ogbomoso and Oyo were selected based on rurality.

Multistage sampling technique was used in selecting respondents in the study area. The first stage involved random selection of 50 percent of agricultural zones, namely Ogbomoso Agricultural Zone and Oyo Agricultural Zone. The second stage involved random selection of three blocks from Ogbomosho and Oyo agricultural zones. The third stage involved random selection of 40 percent of the cells in each block, and the last stage involved random selection of 40 percent of registered rural women farmers from each of the selected cells, therefore making a total number of 177 respondents who were sampled.

Primary data was collected through the use of a well-structured interview schedule, which was subjected to both descriptive (frequency, percentage, and Weighted Means Score (WMS)) and inferential (Pearson Product Moment Correlation (PPMC)) statistical tools were used for the analyses. The Food and Nutrition Technical Assistance (FANTA) scale was used to measure food insecurity. It was measured on a three-point rating scale of Not at all = 0, Sometimes = 1, Often = 2, and Very often = 3. The maximum score was 27, while the minimum score was zero. The mean score was 6.41; high was 20.3%, moderate was 32.2%, and low was 47.5%, respectively.

The dependent variable of the study is the nutritional status of the women farmers, and this was

measured with the use of consumption patterns. This was measured on a five-point rating scale with the scoring order of every day = 4, once a week = 3, two to four times a week = 2, once a month = 1, and several times a month = 0, respectively. The source of information was measured as either yes or no. Thereafter the mean and standard deviation were used to categorise the respondents into high, medium, and low. The minimum score was zero (0), while the maximum was 112.

RESULT DISCUSSION

Socioeconomic characteristics of women farmers

Table 1 revealed that respondents' mean age, household size, and farm size were 48.25 years, 5 members, and 2.0 hectares of land, respectively. This implies that the majority of the respondents are in their active and productive age as average household members with a farm size less than or equal to 2 hectares, practicing subsistence farming with a mean annual income of 561114.29 naira, which may not adequately cater for their needs. This

finding is in line with Dube (2020), that the majority of farmers tend to be in the 35-60 age range, which is indicative of the ageing nature of rural populations in many developing countries.

This implies that farmers in the study area are dominated by aged women. About 68.9% of the respondents were married, which is expected to influence the level of food provision to the household this finding corroborates with the findings of Akintonde *et al.* (2019) that being married as a status suggests a high degree of level of responsibility and a great capability for sound rational decisions. Married individuals are more likely to participate in agricultural activities and experience higher agricultural productivity due to shared responsibilities and experiences. It was also revealed in the study that about 37.1% of the respondents spent between 1 and 6 years in school. This result is consistent with studies indicating that low educational attainment among rural farmers can limit access to new agricultural techniques and hinder productivity (Ganiyu and Rahman, 2021).

Table 1: Socioeconomic characteristics of women farmers (n = 177)

Variable categories	Socioeconomic characteristics	Frequency	Percentage	Mean
Age	≤ 34	3	1.7	48.25
	35 – 45	75	42.5	
	46 – 56	72	40.7	
	57 – 67	26	14.7	
	≥ 68	1	0.6	
Marital Status	Single	12	6.8	68.4
	Divorced	12	6.8	
	Widowed	21	11.9	
	Separated	11	6.2	
	Married	121	68.4	
Household size	≤ 3	6	3.4	5.38
	4 – 5	92	52.0	
	6 – 7	72	40.6	
	8 – 9	7	4.0	
Farm size (hectares)	≤ 2	118	66.8	2.166
	2.1 – 4	44	24.8	
	4.1 – 6	10	5.6	
	6.1 – 7	5	2.8	
	≥ 200,000	6	3.4	
Income	201,000 - 400,000	53	29.9	561.114
	401,000 - 600,000	63	35.5	
	601,000 - 800,000	37	20.9	
	801,000 – 1,000,000	10	5.6	
	1200000 – 1,400,000	6	3.4	
Years of schooling (years)	≥ 2,600,000	2	1.1	10.33
	≤ 0	4	2.3	
	1 – 6	61	34.5	
	7 – 9	4	2.3	
	10 – 12	67	37.9	
	13 – 15	17	9.6	
	16 - 18	24	13.6	

Source: Field Survey, 2025

Respondents' household food insecurity status

Table 2 showed that household members must eat a limited variety of foods due to lack of

resources, which ranked first with a WMS of 1.08. This is followed by household members eating non-preference food with WMS of 1.01. Next, household members have to eat fewer meals in a day because there was no enough food (WMS = 0.95), and household members eating smaller meals than the members wanted because there was no enough food (WMS = 0.84). Others are in the following order: worry that household members will not have enough food (WMS = 0.81), lack of resources to get food of any kind (WMS = 0.74), also ate foods that were not

satisfying to them due to lack of resources (WMS = 0.42), household members going to sleep at night without eating any food, hence no enough food in the house (WMS = 0.21) and household spend a full day and night without eating because there was insufficient food ranked (WMS = 0.20).

This also shows the unavailability of the required quantity of food the household needs to function rightly, and this means the households may not be able to sustain themselves for a long period of time, which is a sign of poverty.

Table 2: Distribution of respondents according to rank order of household food insecurity status.

Scale	WMS	Rank
In the past 4 weeks, did you worry that your household would not have enough food?	0.42	7 th
In the past 4 weeks, were you or any household member not able to eat the kinds of food you preferred because of lack of resources?	1.01	2 nd
In the past 4 weeks, did you or any household member have to eat a limited variety of foods due to lack of resources?	0.84	4 th
In the past 4 weeks, did you or any household member have to eat some foods that you really did not want to eat because of lack of resources to obtain other types of food?	1.08	1 st
In the past 4 weeks, did you or any household member have to eat smaller meal than you felt you needed because there was not enough food?	0.95	3 rd
In the past 4 weeks, did you or any household member have to eat fewer meals in a day because there was not enough food?	0.81	5 th
In the past 4 weeks, was there ever no food to eat of any kind in your household because of lack of resources to get food?	0.74	6 th
In the past four weeks, did you or any member of your household spend a full day and night without eating because there was insufficient food?	0.21	8 th

Source: Field Survey, 2025

WMS: Weighted mean score

Rank order of constraints to nutritional status

Table 3 shows that lack of credit facilities was the most ranked of all the constraints, with a WMS of 2.46. This is closely followed by poor road network (WMS = 2.26), and next to it is the poor storage (WMS = 2.07). Other constraints are in the following order: Pest and disease (WMS = 2.00), Lack of input (WMS = 1.98), Nomadic invasion of farmland (WMS = 1.85), Low processing capacities (WMS = 1.80), crop failure and food to keep during farming season in preparation for scarcity (WMS = 1.72) Absence of value addition (WMS = 1.71), poor transportation (WMS = 1.65), poor family income (WMS = 1.62), low income of household head and technical know-how (WMS = 1.60), unstable market situation (WMS = 1.58), absence of varieties of food

(WMS = 1.44), societal value (WMS = 1.37), societal consideration (WMS = 1.16), keeping of more dependants than the family can cope with (WMS = 1.14), and bad relationship (WMS = 0.89) while spouse irresponsibility ranked lowest with WMS of 0.68. Access to credit would enable farmers to invest in better tools, fertilisers, and irrigation systems, which are essential for increasing food production and improving the nutritional status of their families (Akinmoladun *et al.*, 2016).

This implies that women farmers in the study are being faced with constraints that have a direct implication on the agricultural production systems, the availability and accessibility of food, and the general welfare of respondents.

Constraints affecting nutritional status of women farmers in Oyo State, Nigeria

Constraint	WMS	RANK
Lack of credit facilities	2.46	1 st
Lack of input	1.98	5 th
Poor storage	2.07	3 rd
Crop failure	1.72	8 th
Low processing capacities	1.80	7 th
Poor transportation	1.65	11 th
Pests and diseases	2.00	4 th
Spouse irresponsibility	0.68	21 st
Nomads' invasion of farmland	1.85	6 th
Technical know-how	1.60	13 th
Societal consideration	1.16	18 th
Unstable market situations	1.58	15 th
Absence of value addition to agric. products to increase shelf-life	1.71	10 th
Societal value	1.37	17 th
Poor road network	2.26	2 nd
Bad relationship	0.89	20 th
Keeping of more dependants	1.14	19 th
Low income of household head	1.60	13 th
Poor family income	1.62	12 th
Absence of variety of food	1.44	16 th
Food to keep during farming season in preparation for scarcity	1.72	8 th

Source: Field Survey, 2025

WMS: Weighted mean score

Nutritional status of respondents

Table 4 showed that palm oil ranked first with WMS of 3.20. This is followed by vegetable with WMS of 3.06. Next is well water (WMS = 2.97). Others are in the following order: Garri (WMS = 2.94), Yam (WMS = 2.88), Bread (WMS = 2.79), Vegetable (WMS = 2.69), Vegetable oil (WMS = 2.68), Fruits (WMS = 2.68), Meats (WMS = 2.64), Fish (WMS = 2.40), Maize (WMS = 2.39), Rice (WMS = 2.18), Melon (WMS = 2.10), Borehole (WMS = 1.97), Pure water (WMS = 1.95),

Banana (WMS = 1.84), Beans (WMS = 1.80), Iru (Locust bean) (WMS = 1.79) Potato (WMS = 1.72), Fufu (WMS = 1.69), Seed nut (WMS = 1.67), Egg (WMS = 1.58), rainwater (WMS = 1.00), Coconut oil (WMS = 0.88), Cocoyam (WMS = 0.79), Fat and Oil (WMS = 0.60) and Tap water rank lowest with (WMS = 0.60) respectively. Vegetables such as leafy greens provide essential nutrients like folate, potassium, and vitamin C, which support immune function, blood pressure regulation, and digestive health (Akinmoladun *et al.*, 2018).

Table 4: Nutritional status of the respondents

Food Items	WMS	Rank
Yam	2.88	5 th
Maize	2.39	12 th
Rice	2.18	13 th
Potato	1.72	20 th
Plantain	1.64	23 rd
Banana	1.84	17 th
Cocoyam	0.79	27 th
Bread	2.79	6 th
Garri	2.94	4 th
Fufu	1.69	21 st
Beans	1.80	18 th
Egg	1.58	24 th
Meat	2.64	10 th
Fish	2.40	11 th
Vegetables	3.06	2 nd
Seed (Nut)	1.67	22 nd
Palm Oil	3.20	1 st
Vegetable Oil	2.68	8 th

Food Items	WMS	Rank
Fat and oil	0.60	28 th
Coconut Oil	0.88	26 th
Melon	2.10	14 th
Fruits	2.66	9 th
Iru (Locust Beans)	1.79	19 th
Tap Water	0.43	29 th
Well Water	2.97	3 rd
Rainwater	1.00	25 th
Boreholes	1.97	15 th

Source: Field Survey, 2025

WMS: Weighted mean score

Test of hypothesis

There is no significant relationship between constraints and nutritional status of the respondents.

The result of the Pearson Product Moment Correlation (PPMC) in Table 5 shows the relationship between the constraint and nutritional status of the respondent. Pearson correlation ($r=0.437$, $p=0.059$) indicates a positive significant between constraints and nutritional status among women farmers. Practically, this means that constraints such as lack of credit facilities, lack of input, poor storage, low processing, poor transportation, pests and diseases, unstable market price, poor roads, and absence of varieties reduce

both on-farm production and household purchasing power and so tend to lower dietary diversity and increase vulnerability to undernutrition. This suggests that constraints contribute to poor nutritional outcomes among women farmers (Pierotti *et al.*, 2022; Salawu *et al.*, 2021). The constraints are likely to increase food production and income that promotes better diets, yet those gains must be deliberately translated into nutrition outcomes. Thus, interventions should address constraints alongside other socio-economic and health-related factors for meaningful improvement in nutritional status.

Table 5: Relationship between constraints and nutritional status of the respondents (PPMC)

Variable	r – value	p – value	Remark
Constraints and Nutritional status of the respondent	0.437	- 0.059	NS

Source: Field Survey, 2023

CONCLUSION AND RECOMMENDATIONS

Based on the findings of the study, women farmers are faced with limited access to education in the sense that low educational attainment among respondents can limit access to new agricultural techniques and hinder productivity. Also, since lack of credit facilities, poor road networks, and poor storage are major constraints faced by women farmers on food insecurity, farmers' families should be sensitised to be involved in the maintenance of roads leading to their various communities, and extension workers and the government should provide assistance in helping them to have access to soft loans, good road networks, and good storage facilities in the study area. It is recommended that government agencies intervene on sensitive nutrition components like nutrition education, promotion of dietary diversification, and support for women's decision-making power over household food and income resources.

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Perceived Effectiveness of Climate Change Adaptation Strategies Among Cocoa Farmers in Ogbomoso Agricultural Zone, Oyo State, Nigeria

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Abstract: Climate change poses significant challenges to cocoa farming, affecting productivity, crop quality, and farmer livelihoods due to increased temperatures, erratic rainfall patterns, and vulnerability to pests and diseases. This study assessed the perceived effectiveness of climate change adaptation strategies among cocoa farmers in Ogbomoso Agricultural Zone, Oyo State, Nigeria. Specifically, the study determined the level of adoption of climate adaptation strategies and the level of perceived effectiveness of these adaptation strategies. A multistage sampling procedure was employed to select 172 respondents for the study. Data were collected using a structured interview schedule. The findings showed that agro-forestry (WMS = 3.29), regular pruning of older cocoa branches (WMS = 3.06), planting of climate-resilient cocoa varieties (WMS = 2.97), and climate information and advisory (WMS = 2.64) were the most climate change adaptation strategies adopted and perceived to be moderately effective by cocoa farmers. The study showed that a significant relationship existed between age ($r = 0.373$, $p < 0.05$), number of years spent in schooling ($r = 0.281$, $p < 0.05$), and years of cocoa production experience ($r = 0.488$, $p < 0.05$) and the level of perceived effectiveness of climate change adaptation strategies. In conclusion, most (68%) of cocoa farmers perceived the effectiveness of climate change adaptation strategies as moderate. It was recommended that Extension agencies should collaborate with the Meteorological stations in disseminating accurate weather information regarding the appropriate climate adaptation strategies to the farmers.

Keywords: Perception, Climate change, Adaptation strategies, Effectiveness, Cocoa farmers.

INTRODUCTION

Climate change is the shift or variation in the normal functioning of the atmospheric temperature, weather, and precipitation. It occurs when there's a release of greenhouse gas (GHG), such as carbon dioxide (CO₂), methane, etc, as a result of human activities which in turn affects agricultural production negatively, causing reduction in yield, low profit and lead to food insecurity which hinders the achievement of some Sustainable Development Goals (SDG), Intergovernmental Panel on Climate Change (IPCC, 2022).

According to the Central Bank of Nigeria (CBN, 2023), cocoa beans and their derivatives (like cocoa butter and powder) are the top 3 to 5 non-oil export commodities, which means while contributing a small fraction to the overall GDP, cocoa remains a vital, consistent earner of foreign exchange that underpins the government's current diversification strategy from reliance on crude oil. Deforestation disrupts local weather patterns and causes carbon emissions, contributing to global climate change. As weather patterns evolve, like high temperatures and droughts, farmers aren't able to grow as much cocoa because they are forced to expand into new areas. (Cocoa Life, 2024). Climate change poses significant challenges to cocoa farming, affecting productivity, crop quality, and farmer livelihoods due to increased temperatures, erratic rainfall patterns, and heightened vulnerability to pests and diseases.

Farmers consistently connect shifts in temperature and rainfall to reduced cocoa production. Research by Winston *et al.* (2017) indicates that farmers report declines in both the number and size of cocoa pods due to erratic rainfall

and prolonged dry seasons, disrupting flowering and fruiting cycles. Economically, the reduction in yield and quality translates to lower incomes, a critical concern for farmers. Srinivasa *et al.* (2022) document an increase in pests and diseases, such as the Black Pod, due to warmer and more humid conditions, raising production costs and necessitating more pesticide use.

In response, cocoa farmers are actively implementing various adaptation strategies that blend traditional knowledge and modern practices, although resource limitations hinder their effectiveness. Strategies such as agroforestry and improved agricultural practices are vital for sustainable cocoa production. Farmers engage in agroforestry by planting shade trees to protect cocoa from temperature stress and adopt practices like pruning, mulching, and fertilising to enhance soil health (Orimogunje *et al.*, 2020). Although some strategies are widely perceived as effective, actual effectiveness varies by local context.

However, several studies have assessed the adaptation strategies of climate change by cocoa farmers (Michael *et al.*, 2023; Obaniyi *et al.*, 2023). But the problem lies in the insufficient understanding and information on the factors that shape cocoa farmers' perception about the resultant effect of those adaptation strategies, as observed by Elisha *et al.* (2017), and addressing this gap is the primary motivation for this study. Therefore, this study investigated the level of perceived effectiveness of climate change adaptation strategies among cocoa farmers in Ogbomoso Agricultural Zone, Oyo State. Specifically, the study described the socio-economic characteristics of the respondents, evaluated the frequency of occurrence of types of climate change manifestations among

cocoa farmers, examined the level of utilisation of climate change adaptation strategies, and identified the challenges faced by cocoa farmers in implementing climate change adaptation strategies in the study area. It was hypothesised that a significant difference existed in the perceived effectiveness of climate change adaptation strategies across the selected local government areas.

METHODOLOGY

The study was carried out in the Ogbomoso Agricultural zone, Oyo State, Nigeria. It is situated approximately at the intersection of latitude 8° 8' North and longitude 4° 15' East. The rainy season typically begins in March and continues until November. The dry season is characterised by very hot temperatures, except during the harmattan period when the weather becomes cold and dry. Ogbomoso Agricultural zone is situated in the forest savannah transitional zone, a unique ecological niche that allows for the cultivation of both forest crops (like cocoa and oil palm) and savannah crops (like yams, maize, and cashew). (Owoade & Akinwale, 2019) A multistage sampling technique was employed in selecting the respondents for the study. Ogbomoso Agricultural zone, which consists of 5 local government areas, was selected for the study. The reason for the choice of the area is the high concentration of cocoa farming activities in the area, which ensures the data collected are relevant to the research objectives. The first stage in the sampling involved a selection of the 3 rural local government areas in the zone, which are Ogooluwa, Surulere, and Oriire. The population of the study includes 676 registered cocoa farmers in the Ogbomoso Agricultural Zone. Registered cocoa farmers were found in 41 villages in Ogooluwa, 42 villages in Surulere, and 19 villages in Oriire local government. This sampling procedure was employed to narrow the study's scope to specific local areas that were confirmed to have a significant population of the target group (registered cocoa farmers), ensuring that the study effectively captured insights relevant to cocoa farming activities. The second stage involved the random selection 20% of registered cocoa farmers from each village. Iwo- ate, Pere, Idere, Otamokun, Idi araba, Elegu, Ibere, and Fade were selected from Ogooluwa Local Government; Alaroponla, Elesun, Adegbite, and Opeola were selected from Oriire Local Government, and Sungbe, Gbena, Iresaadu, Lekewogbe, Oke Asa, Labode, Ikunsin, and Fasina were selected from Surulere Local Government. This stage was employed to introduce randomness and reduce selection bias in choosing the specific villages from a list for this study, so that every village with registered cocoa farmers had a chance of being included, and to improve the representativeness of the sample. The third stage involved a random selection of 25% of registered

cocoa farmers from each village, which will constitute 172 respondents for the study. This final stage was used to select the specific respondents from the chosen villages in a non-biased manner, which ensures that the final sample is statistically representative of the population of interest.

RESULTS AND DISCUSSION

Respondents' Socioeconomic Characteristics

Respondents' Age - Results presented in Table 1 revealed a significant portion (47.6%) of cocoa farmers fell within the age range of 41 to 50 years, while 21.5% were aged between 31 and 40 years, and 18% were aged between 51 and 60. Additionally, 7% were above 60 years old, and 5.8% were below or equal to 30 years old. The mean age was 46 years for the cocoa farmers, which indicates that the majority of the cocoa farmers sampled were adults within this age range, implying their activeness and capability in engaging in cocoa production and contributing immensely to the agricultural output in the study area. This study aligns with Abidogun *et al.* (2019), who noted a higher percentage of cocoa farmers fell within the age range of 41-50 years in Southwest, Nigeria.

Sex - The results presented in Table 1 further revealed that the majority (91.9%) of cocoa farmers were male, with only 8.1% being female. This implies that both males and females are involved in cocoa production, although males dominate the sector. The results indicate that cocoa production in the study area is predominantly handled by males, which is common in African farm households. This aligns with previous results, such as Adeola *et al.* (2022), who reported that the majority (91.2%) of cocoa farmers were male in Africa.

Marital Status - The results presented in Table 1 further observed that the majority (95.9%) of the cocoa farmers were married, while 4.1% were single. The results indicate that a significant portion of the cocoa farmers were married, which could maximally contribute to increased production levels, particularly through the provision of unpaid labour from household members. This aligns with the results of Oladokun *et al.* (2025), who also found that the majority (99.05%) of cocoa farmers were married, and Onemolease *et al.* (2025) also reported that (95%) of the cocoa farmers surveyed were married in Ondo State, Nigeria.

Number of Years Spent in Schooling - The results presented in Table 1 further show that the number of years spent in schooling has a mean of 16 years. These results indicate that all cocoa farmers were literate, albeit with a relatively low level of education. This suggests that respondents will adapt to and adopt any form of innovation that can enhance their farming system. This relates to the results of Martins *et al.* (2021), who found that (66.1%) of farmers were formally educated.

Household Size of the Respondents - The results presented in Table 1 further observed that the mean household size is 5 people. This indicates that the typical cocoa farming household has a relatively average family size, potentially influencing their livelihood, resource allocation, and climate change adaptation strategies. This result is further supported by Onemolease *et al.* (2025) who also noted that cocoa farmers in the study area had household sizes ranging between 3 - 20 in a household in Ondo State, Nigeria.

Years of cocoa production experience - Result presented in Table 1 further shows that approximately 40.2% of respondents had between 11 and 20 years of cocoa production experience followed by 36.6% with less than or equal to 10 years of experience, 16.3% had between 21 and 30 years of experience, 5.3% with 31 and 40 years of experience and with 1.8% had above 40 years of experience in farming. The mean years of experience for cocoa farmers were approximately 17 years. This suggests a significant level of experience among cocoa farmers, which may contribute to their expertise and proficiency in farming activities. This aligns with the results of Oluyole *et al.* (2015) who reported a mean farming experience of 18 years for cocoa farmers. These

results further reinforce the notion that cocoa farming in Nigeria is largely undertaken by experienced individuals who have spent a considerable number of years in the agricultural sector.

Cocoa farm size - The results presented in Table 1 further illustrate that 87.2% of cocoa farmers cultivate farm sizes ranging from 2 to 3 hectares, 8.2% cultivate less than or equal to 1 hectare, and 4.7% cultivate above 3 hectares of cocoa farmland. The mean farm size for cocoa production was 2.4 hectares. These results suggest that cocoa production in the study area is primarily carried out on small to medium-sized farms, as the vast majority of farmers cultivate between 2-3 hectares. This prevalence of relatively smaller farm sizes suggests that cocoa farming might largely be a smallholder activity, potentially influencing production capacity and the adoption of large-scale farming technologies. This result aligns with Ayodele *et al.* (2020), who noted that a significant portion of cocoa production occurs on farms within the 2 to 3-hectare range, indicating a consistent pattern of small to medium-scale operations. Kolapo *et al.* (2025) also found that the mean farm size of cocoa farmers was 2.3 hectares.

Table 1: Distribution of respondents by socioeconomic characteristics (n = 172)

Variables categories	Socioeconomic characteristics	Frequency	Percentage	Mean
Age (years)	≤30	10	5.8	46
	31-40	37	21.5	
	41-50	82	47.6	
	51-60	31	18	
	Above 60	12	7	
Sex	Male	158	91.9	
	Female	14	8.1	
Marital status	Married	165	95.9	
	Single	7	4.1	
Number of years spent in schooling	≤6	4	2.4	16
	7-12	18	10.5	
	13-18	130	75.6	
	Above 18	20	11.6	
Household size (people)	≤5	119	69.2	5
	6-10	50	29.1	
	Above 10	3	1.8	
Years of cocoa production experience	≤10	63	36.6	17
	11-20	69	40.2	
	21-30	28	16.3	
	31-40	9	5.3	
	Above 40	3	1.8	
Cocoa farm size (hectares)	≤1	14	8.2	2.4
	2-3	150	87.2	
	Above	8	4.7	

Source: Field survey, 2025

Level of adoption of Climate Change Adaptation Strategies by Cocoa Farmers

The results presented in Table 2 show that planting of shade or cover trees (Agroforestry) ranked 1st with a weighted mean score of 3.29, followed by regular pruning of older cocoa branches, which ranked 2nd, with a WMS of 3.06. Planting of climate resilient cocoa varieties was ranked 3rd with a WMS of 2.97, climate information and advisory was ranked 4th with a WMS of 2.64, integrated pest management was ranked 5th with a WMS of 2.45, application of fertiliser was ranked 6th with a WMS of 2.27, control of soil erosion was ranked 7th with a WMS of 1.48, and changing the planting date of cocoa was ranked 8th with a WMS of 0.74. This result indicates that cocoa farmers in the study area are employing various climate change adaptation strategies, with agroforestry (planting shade or cover trees) emerging as the most widely adopted practice. Regular pruning of older cocoa branches and planting climate-resilient cocoa

varieties are also prominent adaptation methods among farmers. These strategies likely help farmers mitigate climate-related stressors and promote sustainable cocoa production. The result can inform policy and extension services to prioritise support for agroforestry and climate-resilient practices. By promoting these adaptation strategies, stakeholders can enhance the resilience and livelihoods of cocoa farmers in the face of climate change. Oluyole *et al.* (2024) indicated that cocoa farmers widely adopt practices such as planting shade trees (agroforestry) and using improved, climate-resilient cocoa varieties to cope with changing climatic conditions. They also noted that farmers engage in improved cultural practices like pruning to maintain farm health, agroforestry (planting shade trees), using improved crop varieties (implicitly climate-resilient ones), and integrated pest management (IPM) as key adaptation measures to mitigate climate change effects.

Table 2: Distribution of respondents according to the level of adoption of climate change adaptation strategies by cocoa farmers

Statements	WMS	Rank
Planting of shade/cover tree (Agroforestry)	3.29	1st
Application of fertiliser	2.27	6th
Planting of climate-resilient cocoa varieties	2.97	3rd
Integrated pest management	2.45	5th
Control of soil erosion	1.48	7th
Changing of planting date of cocoa	0.74	8th
Climate information and advisory	2.64	4th
Regular pruning of older cocoa branches	3.06	2nd

WMS= Weighted Mean Score

Source: Field survey, 2025

Level of perceived effectiveness of climate change adaptation strategies

The results presented in Table 3 show that regular pruning of older cocoa branches ranked (1st) with a weighted mean score of 3.41, followed by planting of shade or cover trees (Agroforestry), which ranked (2nd) with a WMS of 3.39. Climate information and advisory ranked (3rd) with WMS of 3.20, planting of climate-resilient cocoa varieties ranked (4th) with WMS of 3.14, application of fertiliser ranked (5th) with a WMS of 2.88, integrated pest management ranked (6th) with WMS of 2.09, and control of soil erosion ranked (7th) with WMS of 1.93. These results imply that cocoa farmers find regular pruning of older cocoa branches and agroforestry practices (planting shade or cover trees) to be the most effective climate change

adaptation strategies. Climate information and advisory services, as well as planting climate-resilient cocoa varieties, are also considered effective strategies. This result corroborates the result of Oluyole *et al.* (2020), who highlight that farmers who implement good agricultural practices, including regular pruning and the adoption of improved climate-resilient cocoa varieties, experience better yields and more sustained production in the face of climate variability. Onemolease *et al.* (2025) also indicate that practices such as pruning, and the planting of new, resilient cocoa seedlings are seen by farmers as effective in improving farm productivity and resilience against environmental stresses.

Table 3: Distribution of respondents by the level of perceived effectiveness of climate change adaptation strategies by cocoa farmer

Statement	WMS	Rank
Planting of shade/cover trees (Agroforestry) regulates farm temperature.	3.39	2nd
Planting of climate-resilient cocoa varieties maintain consistent cocoa yield.	3.14	4th
Climate information and advisory	3.20	3rd
The use of integrated pest management controls pest outbreaks on the farm.	2.09	6th
Control of soil erosion prevents loss of nutrients during flooding.	1.93	7th
The practice of regular pruning of older cocoa branches improves air circulation.	3.41	1st
The application of fertiliser boosts tree immunity.	2.88	5th

WMS = Weighted Mean Score

Source: Field survey, 2025

Categorisation of the level of effectiveness of climate change adaptation strategies by cocoa farmers

The data in Table 3 shows the distribution of the respondents by categorisation of the level of effectiveness of climate change adaptation strategies in the study area. Using the mean and standard deviation as a categorisation index, the result indicates that (16.3%) of cocoa farmers perceived their strategies as highly effective. Also, cocoa farmers generally perceive their adaptation strategies as moderately effective, supported by the grand mean of 20.04 and the largest segment of respondents (68.0%). This suggests that while the adaptation strategies employed, such as agroforestry or planting of shade trees, are providing discernible benefits and mitigating some climate risks, they are not yielding complete solutions for the majority of farmers, while (15.7%) found the adaptation strategies to be of low effectiveness.

This result implies that while the majority of cocoa farmers are proactively engaging in adaptation strategies, as evidenced by only 15.7% reporting low effectiveness, their strategies are generally falling short of providing optimal protection against climate change, with 68.0% achieving only moderate effectiveness. This strongly suggests that the core challenge is not a lack of farmers' awareness or effort, but rather systemic constraints such as limited access to finance and extension services, which prevent the majority from successfully implementing the most effective measures needed to reach the highly effective tier. This result corroborates with Frank *et al.* (2021), which indicates that most farmers perceived the benefit to be a little bit higher (i.e., moderate) than the cost because their capacity to fully implement highly effective strategies is limited by external constraints.

Table 4: Categorisation of the level of effectiveness of climate change adaptation strategies by cocoa farmers

Level of effectiveness	Range	Class interval	Frequency	Percentage
Low	$\bar{x} - 1\sigma$	≤ 17.88	27	15.7
Moderate	$\bar{x} \pm 1\sigma$	17.89 – 22.20	117	68.0
High	$\bar{x} + 1\sigma$	Above 22.21	28	16.3
Total			172	100.0

Mean ($\bar{x}$) = 20.04

Standard Deviation (σ) = 2.16

Source: Field survey, 2025

Challenges faced by cocoa farmers in implementing climate change adaptation strategies

The results presented in Table 4 revealed that cocoa farmers faced the following challenges with their percentage in descending order respectively; 94.8% of difficulty in climate change prediction, 93% of uncertainty of weather patterns, 92.4% of lack of policy incentives, 90.7% of inadequate training or technical support, 76.2% of limited access to technology, 71.5% of lack of access to climate resilient cocoa varieties, 70.9% of difficulty in accessing markets for diversified crops, 41.9% of lack of financial resources, 33.7% of lack

of knowledge and information about climate change adaptation strategies.

These results indicate that cocoa farmers encounter significant challenges when attempting to implement climate change adaptation strategies. The most pressing issues include difficulties in predicting climate change and the uncertainty of weather patterns. Additionally, a lack of policy incentives, insufficient training, and limited access to technology further impede farmers' ability to adapt. Several research findings supported this, such as Martins *et al.* (2021), they noted that farmers face challenges related to the high cost of labour and limited access to land and inadequate information on

weather. Adeyemo *et al.* (2019) also implicitly point to the lack of financial resources as a barrier, as farmers often diversify due to insufficient income

from cocoa. It also suggests that limited access to markets for new ventures (diversified crops) can be a challenge.

Table 5: Distribution of respondents by the challenges faced by cocoa farmers in implementing climate change adaptation strategies

Challenges	Frequency	Percentage
Lack of financial credit	72	41.9
Lack of access to climate-resilient cocoa varieties	123	71.5
Inadequate training or technical support	156	90.7
Uncertainty of weather patterns	160	93.0
Difficulty in accessing markets for diversified crops	122	70.9
Lack of knowledge and information about climate change adaptation strategies	58	33.7
Lack of policy incentives	159	92.4
Limited access to technology	131	76.2
Difficulty in climate change prediction	163	94.8

Source: Field survey, 2025

Test of Hypothesis

Relationship between the socioeconomic characteristics of cocoa farmers and the perceived effectiveness of climate change adaptation strategies. Pearson Product-Moment Correlation analysis result presented in Table 5 shows a notable and significant relationship between socioeconomic attributes of the respondents and the perceived effectiveness of climate change adaptation strategies. Specifically, there exists a positive correlation between the age of the respondents and the perceived effectiveness of climate change adaptation strategies ($r = 0.373$, $p < 0.05$). This suggests that as the age of cocoa farmers increases, their perceived effectiveness of climate change adaptation, strategies also tend to increase, indicating that the older farmers may have more experience or knowledge about effective adaptation measures. Furthermore, a significant positive correlation is observed between the number of years spent in schooling of the respondents and the perceived effectiveness of climate change adaptation strategies ($r = 0.281$, $p < 0.05$). These

results suggest that formal education plays a role in enhancing their understanding and application of adaptation measures, which indicates that farmers who spent more years in school tend to perceive climate change adaptation strategies as more effective. Lastly, a significant positive correlation is observed between the years of farming experience and the perceived effectiveness of climate change adaptation strategies ($r = 0.488$, $p < 0.05$). This suggests that farmers with more years of experience tend to perceive climate change adaptation strategies as more effective, suggesting that knowledge and experience gained over time may enhance their ability to adapt to climate change. Consequently, based on these results, the null hypothesis, which stated no significant link between the socioeconomic characteristics of the respondents and the perceived effectiveness of climate change adaptation strategies, is thereby rejected in favour of the alternative hypothesis. This underscores the important role played by socioeconomic factors such as the age of the respondents, number of years spent in schooling, and years of farming experience in cocoa farming.

Table 6: Pearson correlation analysis showing a significant relationship between selected socioeconomic characteristics of the respondents and the perceived effectiveness of climate change adaptation strategies

Socio-economic variables	r-value	p-value	Remark
Age	0.373	0.000	Significant
Number of years spent schooling	0.281	0.000	Significant
Years of farming experience	0.488	0.000	Significant
Farm size	0.136	0.075	Not Significant

Source: Field Survey, 2025

*Correlation is significant at the 0.05 level (2-tailed)

CONCLUSION AND RECOMMENDATIONS

In conclusion, most (68%) of the cocoa farmers perceived the effectiveness of climate change adaptation strategies as moderate. Planting of shade or cover trees (Agroforestry), regular pruning of older cocoa branches and planting of climate resilient cocoa varieties were the most

adopted climate change adaptation strategies in the study area. However, farmers face considerable challenges in implementing these strategies, primarily the inherent difficulty in predicting climate change and uncertainty in weather patterns. It was recommended that Extension agencies should collaborate with the Meteorological stations in

disseminating accurate weather information regarding the appropriate climate strategies to the farmers.

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Determinants of Cost Efficiency among Cassava Processors in Oyo State, Nigeria

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Abstract: One of the emerging trends for national sustainable development is striving to attain efficiency in production and marketing of agricultural produce. Cost efficiency is crucial in ensuring productivity and profitability, especially in competitive sectors like agriculture where input cost can significantly affect both productivity and profitability. Most of the cost efficiency studies that were available on cassava focused on farmers alone, neglecting other actors in cassava value chain. This study investigated the cost efficiency level of cassava processors and its determinants in Oyo state. The study was based on primary data obtained from 256 processors drawn through multi-stage sampling procedure. Data were analysed using descriptive statistics, budgetary analysis and stochastic frontier analysis (SFA). The result showed that 98.9% of the respondents were female with average age of 50 years. Most of the processors (93.4%) were married with average household size of 6. The result also showed that 34% of the respondents were educated, 96.5% were members of cooperative societies and 94.9% had access to credit. The average processing experience was 16.8 years among respondents. The benefit cost ratio was 1.30 indicating that cassava processing was a profitable enterprise in the study area. The average cost efficiency among the respondents was 0.98. Labour cost, cassava tuber cost, firewood cost and water cost were found to influence total cost of processing. Socio-economic variables influencing cost of efficiency were household size, processing experience, credit access and cassava farm ownership. The study recommended that the government should make affordable credit facilities available to cassava processors. This will empower the processors for competitive advantage, resulting in improved cost efficiency.

Keywords: Cassava processors, Cost efficiency, Budgetary analysis, Stochastic frontier analysis.

INTRODUCTION

In Nigeria, agriculture has continued to play a dominant role in the provision of food, raw materials for industries, employment, and foreign exchange earnings, which are used in financing developmental activities (Chijioke et al., 2021). However, instead of adopting the global agribusiness approach and practices, agriculture in Nigeria has been largely considered as a development programme, without drive for effective and efficient resource management (Ikuemonisan et al., 2020). Root and tuber crops such as cassava (*Manihot* spp.) have a significant place in the economy. These crops not only contribute to the share of agriculture in Nigeria economy but possess a great potential and comparative advantage to compete in the liberalised economy (Akinola et al., 2020). As a food crop, cassava has some significant inherent characteristics that make it attractive to farmers, processors, marketers and consumers in Nigeria. Firstly, it is rich in carbohydrates, especially starch, and consequently has multiplicity of end uses (Okoye et al., 2021). Secondly, it is available all year round, making it preferable to other more seasonal crops such as grains, peas, beans, and other crops for food security (Akinola et al., 2020).

The demand for cassava roots and products is high and fast rising. However, the current food production is far from being able to meet the food needs of the geometrically growing population in the sub-region. Despite its contribution to the economy, Nigeria's agricultural sector faces many challenges that affect its profitability (FAO, 2023). A key challenge for the majority of farmers and processors is access to finance, and it is a key impediment to

improving the efficiency of their production and adopting better technologies in the cassava processing activities. The challenges facing cassava processing and marketing increase by degrees on a yearly basis even though the subsector is experiencing a production boom. The huge cassava output in Nigeria, which was put at about 34 million metric tons (FAO, 2023), was produced by thousands of small-scale farmers in the remote rural areas. These farmers were faced with myriad problems, which ranged from high transportation costs, lack of knowledge of the products market, lack of rural market infrastructures, and inaccessibility to market information, resulting in cost inefficiency (Akinwalere, 2022). Other problems included lack of standard weights and measures in the cassava products market.

In Nigeria, cassava market is unstable because of price fluctuation with the risk of soaring prices due to lack of market information or when the market in a certain place is not connected to markets in other places thus declining their income (Suryani et al. 2023). Several policies related to the development of cassava production and processing have been initiated such as the Presidential Initiative on Cassava and the FADAMA projects. However, these initiatives have failed to adequately incorporate strategies for combating perennial constraints to effective and efficient cassava product marketing in Nigeria. There is also the problem of the exploitative tendencies of the middlemen in the cassava product marketing chain (Isitor et al., 2019; Suryani et al. 2023).

Despite the contribution of cassava products to human diet, its production, processing

and marketing are in the hands of smallholder farmers and processors who are resource poor and as such, cannot afford all it takes to boost the sector. These cassava processors and marketers are constrained with diverse problems that range from production to marketing. However, research on cassava has focused more on pre-production issues to the neglect of post-harvest issues like processing, marketing, storage and consumer demand. Ali et al., (2023) investigated the determinants of the output of cassava products in an attempt to bridge the rapidly increasing demand and supply gap in cassava processing in Ogun State and concluded that there is need for an intervention to have a cassava production efficiency and also provision of a good road network for cassava farmers which will reduce the cost of cassava roots at both the farm gate and retail markets.

Cost efficiency, also known as economic efficiency, results from both technical efficiency and allocative efficiency. It refers to a producer's ability to produce the maximum possible output from a given quantity of inputs at the lowest possible cost. Cost efficiency measures the effectiveness or competence with which the physical aspects of marketing are performed. Cassava processing is mainly a small-scale operation, with current small-scale technologies still suboptimal, resulting in high use of resources (energy, water, firewood, product losses) and high production costs (Nzudie et al. 2020). Improving the efficiency of small-scale equipment, their design, safety, and ergonomics is therefore essential for the competitiveness of cassava value chains (Edeh et al. 2020), together with the ability of small-scale processors to access investment capital (Nzudie et al. 2020).

Cost efficiency is also concerned with how effectively price reflects the costs of moving the output through the marketing system. It is suggested that the inefficiency of farmers in the use of various farm resources and farm inputs led to unprofitable production. This therefore made it necessary for empirical measures of efficiency to determine the profit that could be obtained by improving performance in cassava production with a given technology (Ologbon et al., 2021). For cassava products, lowering the costs through efficient processing and marketing systems may be as important as increasing cassava production. Expansion of processing and marketing must greatly enhance productivity, income, and employment opportunities for the cassava sector. This study aimed to identify the key determinants of cost efficiency among cassava processors in Oyo State, Nigeria.

METHODOLOGY

The study was carried out in Oyo State on Latitude 8°00' North and Longitude 4°00' East. The total landmass area is about 28,454 square kilometre

and total population which is estimated at 5,591,58 as of 2006 census provision figures. Oyo state is an inland state with its capital in Ibadan. The state has four agricultural zones and has thirty-three (33) Local Government Areas (LGAs). The population of this study include all the processors of cassava (into Garri) in Oyo State Nigeria. However, a representative sample of the population were drawn to cover the study area.

Multistage sampling technique was used for select respondents for the study. At stage one, purposive selection of Oyo State, due to high presence of cassava processing activities. Stage two involved a purposive selection of twelve percent (12%) of the thirty-three (33) local government areas (LGAs) in the selected state to give a total of four (4) LGA(s): which are Surulere, Orire, Ogo-Oluwa, and Oyo West. This is based on the knowledge that there exist high level of cassava processing activities (Oladele, 2001).

At stage three, two wards were randomly selected to give a total number of sixteen (16) villages and at stage four, sixteen (16) respondents were randomly selected from a list generated from cassava processor association groups in each of the 16 selected villages, which resulted in a total of 256 respondents for the study.

Budgetary analysis

Budgetary analysis was used to determine the profitability of Garri production in the study area. The gross margin was represented as:

$$GM = TR - TVC \dots\dots\dots (1)$$

Rate of Returns on Investment (ROI) analysis was used to determine the amount of profit made when one Naira is spent on cassava processing. It is the ratio of Net Return to the Total Cost of processing. The bigger it is, the better the profit made on Garri. It is expressed as:

$$ROI = (N.R.)/(T.C) \times 100/1 \dots\dots\dots (2)$$

Where G.M = Gross margin; TR = Total revenue; TVC = Total variable cost and T.C. = Total cost

Net revenue (N.R.) = Total revenue – Total cost
Stochastic Frontier Analysis (SFA) was used to analyse the cost efficiency of the processors. SFA can help understand the cost efficiency of the respondents by considering both random errors and inefficiencies when applied to cassava processing operations (Coelli et al., 1997).

The inefficiency term was modelled as a function of factors that influence inefficiency in cassava processing operations. The cost frontier function was modelled as:

$$\ln C = \beta_0 + \sum_{i=1}^6 \beta_i \ln P_i + \beta_7 \ln Y^* + V_i U_i$$

Where C = the cost of cassava processing (₦); P1 = the price per kg of cassava tubers processed (₦); P2 = the average wage rate per man day of labour (₦); P3 = the average price per bundle of firewood (₦); P4 = the average price per litre of

water (₦); P_5 = the depreciated cost of processing tools and equipment (₦); Y^* = the total output (Garri) measured in kg; V_i = a normally distributed random error and U_i = efficiency component.

Where U_i is defined by:

$$U_i = \delta_0 + \sum \delta_i Z_i$$

Where: Z_1 = age; Z_2 = gender; Z_3 = household size; Z_4 = education; Z_5 = processing experience (in years); Z_6 = credit access and Z_7 = farm ownership.

δ_0 and δ_i are parameters to be estimated ($i = 1, 2, \dots, 7$) together with the variance parameter.

RESULTS AND DISCUSSION

Socioeconomic characteristics of Respondents

The age distribution of respondents as presented in Table 1 reveals 0.8% of cassava

processors were between the ages of 20-30 years, while the highest 41.0 % were between 51-60 years. The age group is closely followed by 41-50 with 40.2%, while those above 60 years' account for only 6.6% of processors. The mean age of Garri processors in the study area is 50.34 years. The study revealed cassava processors are young, active and agile.

Most cassava processors in the study area are female (98.9%) and only 1.2% are male. This result is like that of Isitor et al., (2019) and Aungwa et al., (2019). The male counterparts are probably involved in the production process while female is dominant in the processing and marketing enterprises (Adeosun et al., 2023).

Table 1: Distribution of Cassava Processors according to the socioeconomic characteristics (n=256)

Variables	Response categories	Frequency	Percentage (%)	Mean
Age (Years)	≤ 30	2	0.8	50.34
	31- 40	29	11.3	
	41-50	103	40.2	
	51- 60	105	41.0	
	> 60	17	6.6	
Gender	Male	3	1.2	6
	Female	253	98.8	
Marital Status	Single	8	3.1	
	Married	239	93.4	
	Separated	1	0.4	
	Widow	8	3.1	
Household Size	≤ 5	105	41.0	6
	6-10	151	59.0	
Educational level	Non-formal education	43	16.8	
	Primary school uncompleted	6	2.3	
	Primary school completed	87	34.0	
	Secondary school uncompleted	36	14.1	
	Secondary school completed	70	27.3	
Membership of	Yes	14	5.5	
	No	247	96.5	
Cooperative Society	Yes	9	3.5	
	No	243	94.9	
Credit Access	Yes	13	5.1	
	No	243	94.9	
Amount of credit obtained	< ₦200,000	18	7.0	₦320,000
	₦200,000-₦500,000	163	63.7	
	₦500,001-₦1,000,000	69	27.0	
	>₦1,000,000	6	2.3	
Processing Experience (years)	≤ 5	3	1.17	16.8
	6-10	55	21.48	
	11-15	68	26.56	
	15-20	72	28.13	
	>20	58	22.66	

Source: Field Data Survey, 2025

Cost and Returns Analysis of Garri Processing

The costs and return of cassava processing is presented in Table 2. The table highlights key processing indicators such as the variable cost, total revenue, gross margin, net returns and benefit cost ratio. The total cost of cassava tubers (35.20%)

forms a significant portion of the total cost of processing cassava in the study area. The cost of labour constituted 7.17% followed by the cost of firewood 1.89%. The cost of transport, water, and rent constituted 1.02%, 0.43% and 0.20% of the total cost respectively.

The low cost of transport, water and rent can be attributed to the fact that most processors got water freely from nearby streams, wells or rivers and they sell their Garri around the processing plants which are usually in open spaces or by the roadside around other foodstuff sellers. The total variable cost incurred was ₦344,325.40 and represents 95.20% of the total processing cost. Depreciation on equipment was ₦829.48 and represented only 0.22% of the total cost while the total fixed cost incurred was ₦17,283.28. The total revenue generated indicates the amount of cassava processed to Garri and sold. The revenue generated from processing of cassava to Garri in the study area was ₦465,607.50.

The gross margin which is the Total revenue (TR) less the Total variable cost (TVC) deduced was ₦121,282.10 and the profit or net

returns which is the gross margin less the Total Fixed cost was ₦103,928.50 per processing cycle. The positive gross margin and positive net returns suggest the processors in the study area make a profit of ₦103,928.50 from the cassava processed and sold. This result is similar to the findings of Oladejo (2017), Obayelu et al., (2018) and Adeosun et al., (2023) who reported that cassava processing was a profitable venture.

The rate of return on investment (ROI) of 28.7% indicates the processors earned 28.7% profit on every naira invested. The benefit cost ratio of 1.30 implies that for every ₦1 invested in processing cassava to Garri, a return of ₦1.30 and profit of 0.29 is earned. This study thus affirmed that cassava processing to Garri is a profitable and viable business venture in the study area.

Table 2: Cost and returns of Garri process (₦/month)

Items	Amount (₦)	%TC
Variable cost		
Total cost of Cassava tubers	127,304.69	35.20
Labour cost	27,437.89	7.17
Total Cost of water	1,639.00	0.43
Transportation cost	3,910.45	1.02
Total cost of Firewood	7,239.84	1.89
Rent	197,000	0.20
Total Variable Cost (TVC)	344,325.40	95.20
Depreciation on equipment	829.48	0.22
Total Fixed Cost (TFC)	17,283.28	
TC (TFC + TVC)	361,679.68	
Total Revenue (TR)	465,607.50	
Gross Margin (TR - TVC)	121,282.10	
Profit	103,928.50	
ROI (NR/TC*100)	28.7%	
BCR (TR/TC)	1.30	

Source: Field Data Survey, 2025

Cost Efficiency of Cassava Processors by the Stochastic Frontier Analysis

The maximum likelihood estimates of the parameters of the stochastic cost frontier model in estimating the cost efficiency among cassava processors in the study area were presented in Table 3. The Wald chi-square statistic of 74062.43 with a p-value of 0.0000 indicated a strong model fit, suggesting that the variables collectively have a significant effect on cost efficiency. The log-likelihood function of 626.37 indicated that the value maximises the joint densities in the estimated model (Ogunwande and Adesokan, 2020).

Significant variables were identified at 1%, 5% and 10% significant levels, contributing significant insights to the cost efficiency of cassava processors. The model included the cost of labour, cost of cassava tuber, cost of firewood and cost of

water as cost function input variables. It also evaluated inefficiency model estimating the socio-economic variables of respondents.

Table 3 revealed that the cost of labour, cassava tuber, cost of firewood and cost of water were significant variables influencing the total cost of cassava processing. The magnitude of the price of labour, cassava tuber, firewood and water implied that one increase in the unit cost of these variables will lead to increase in the total cost of processing ceteris paribus. This finding conformed to the apriori expectation that the estimated factors had positive influence on the total cost incurred on cassava processing. This result is suggestive that the cost of variable inputs was highly important in the total processing cost of cassava in the study area. This is like the findings of Adeosun et al., (2022).

Table 3: Maximum Likelihood Estimates of Parameters of Stochastic Frontier Analysis

Normalised Variables	Parameters	Coefficient	Standard Error	Z Value	P- Value
Constant	β_0	0.82684	0.05202	15.89	0.000
Labour cost	β_1	0.07097	0.00644	11.02***	0.000
Cassava Tuber cost	β_2	0.83306	0.00755	110.27***	0.000
Firewood cost	β_3	0.07343	0.00571	12.85***	0.000
Water cost	β_4	0.00002	0.0000	5.31***	0.000
Inefficiency Model					
Age	Z_1	0.00004	0.02109	0.00	0.998
Gender	Z_2	0.10399	1.02498	0.10	0.919
Household Size	Z_3	0.44626	0.13315	3.35***	0.001
Education	Z_4	0.00605	0.07291	0.08	0.934
Processing Experience	Z_5	-0.04597	0.02519	-1.82*	0.068
Credit Access	Z_6	-1.89147	0.99645	-1.90*	0.058
Farm ownership	Z_7	0.60126	0.19412	3.10**	0.002
Constant	Z_0	-7.40619	2.51577	-2.94	0.003
Wald chi ² (4) = 74062.43					
Prob > chi ² = 0.0000					
Log likelihood = 626.369					

*10% level of significance; **5% level of significance; *** 1% level of significance

Factors affecting the inefficiency of the cassava processors such as household size ($p = 0.001$), processing experience ($p = 0.068$), credit access ($p = 0.058$) and cassava farm ownership ($p = 0.002$) as presented in Table 3. Since this is an inefficiency model, the positive coefficients of household size and Cassava farm ownership have had a negative effect on cost efficiency. This is similar to Akinola et al., (2020) and Adeosun et al., (2022) findings. The household size, farm ownership, which were significant at 1% and 5% respectively, decreased cost efficiency. This could imply that family members were not available for use in the processing activities and that farm ownership may bring about not dedicating enough attention to the processing activities.

The negative coefficient of processing experience (-0.0459), which was significant at 10% revealed that processors with higher processing experience are more cost efficient. This result suggested that experience in cassava processing contribute positively to cost efficiency. This meant the more experienced the processor, the more cost efficient he would be in allocating available resources. The negative coefficient of credit access (-1.8914) which was negative and significant at 10%, revealed that the higher the credit access, the

higher the cost efficiency of the cassava processors. This implied that increase in credit access increases the cost efficiency of the cassava processors. This result is similar to the findings of Adeosun et al., (2022), Ogunleye, (2018) and Elegbede et al., (2018) who reported that increase in credit access and processing experience improved efficiency and strengthened productivity.

The distribution of the cost efficiency of cassava processors is presented in Table 4. The cost efficiency ranged between 0.7451 and 0.9962 with a mean cost efficiency of 0.9784. The mean output of 98% revealed that there is the potential for cassava processors to increase their output by 2% under the present technology along the cassava processing value chain by eliminating inefficiency arising out of inappropriate allocation of resources and response to prices. The majority of the cassava processors (99.22%) operated on the highest efficiency cost frontier of 0.90-1.00. The minority who were 0.78%, operated below the average cost efficiency frontier at 0.71- 0.90. This result indicated that cassava processors in the study area are cost efficient in their processing activities, suggesting that cassava processing in the study area is profitable and sustainable.

Table 4: Cost efficiency distribution of Cassava processors

Cost Efficiency	Frequency	Percentage (%)
0.71 – 0.80	1	0.39
0.81-0.90	1	0.39
Above 0.90	254	99.22
Mean	0.9784	
Minimum	0.7451	
Maximum	0.9962	
Total	256	100.00

Source: Field Data Survey, 2025

Challenges militating against Cassava processors

Cassava processors in the study area face a range of challenges militating against efficient cassava processing activities. Cassava processors' responses to the challenges militating against them in the study area is presented in Table 5. High cost of processing input, unstable market price, inadequate capital and government policies were the topmost (100%) identified challenges while insecurity problem (35.80%) was the least

identified. Financial limitation poses a great challenge to processors with majority facing inadequate capital, unstable market price and unstable government policies. These challenges collectively are likely to affect the profitability and growth of cassava processing to Garri in the study area. The processing function, efficiency and performance are threatened by these challenges militating against the respondents.

Table 5: Distribution of Cassava Processors by Challenges faced

Challenges faced by Cassava Processors	Frequency	Percentage (%)
Government Policies	256	100
High cost of Processing Input	256	100
Inadequate Capital	256	100
Unstable Market Price	256	100
Inadequate Credit facilities	255	99.6
Transportation	245	95.7
Inadequate Processing machine	240	93.4
Storage Problem	240	93.4
Marketing Problem	218	84.8
Land Tenure Problem	210	81.7
Inadequate Water Supply	202	78.6
Insecurity Problem	91	35.8

Source: Field survey, 2025

CONCLUSION AND RECOMMENDATIONS

Based on the study's findings, it concluded that credit access significantly enhanced cost efficiency among cassava processors in Oyo state. The study revealed that socio-economic factors such as processing experience, credit access, household size and farm ownership influence cost efficiency. Cassava processing in Oyo state is efficient, profitable and a viable agribusiness, with total processing cost being influenced by input prices such as the labour cost, cassava tuber cost and input cost. In spite of the profitability nature of the venture, cassava processors are still faced with challenges such as high cost of processing input, unstable market price, inadequate capital, government policies, inadequate credit and transportation facilities. The study recommended that the government should make available affordable credit facilities to cassava processors. Credit access will empower the processors for competitive advantage, resulting to improved cost efficiency.

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Gendered Control of Post-Harvest Decisions and Its Impact on Rice Losses in Southwest Nigeria

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Abstract: Rice is a major staple crop in Nigeria, but post-harvest losses (PHL) remain high at 15–30%. Women dominate the most labour-intensive post-harvest operations such as parboiling and drying but are often excluded from decision-making and technology access. This gender asymmetry may be responsible for continued PHL despite technology availability. The research investigates the influence of gendered control over post-harvest choices on technology adoption and measurable rice losses in Southwest Nigeria. Cross-sectional mixed-methods design was employed in Osun and Ekiti States rice clusters. Survey, participatory decision-making matrix, and standardised field loss assessment were employed in collecting data from 300 households. Descriptive statistics, binary logistic regression, and structural equation modelling (SEM) were employed in analysing the data, augmented by thematic analysis of qualitative data. Women did most of the parboiling (95%) and drying (88%) work, but men still had overall control of major money and technology decisions, i.e., storage (75%) and marketing (70%). Female decision-making households were 3.37 times more likely to store hermetically ($p < 0.01$). Field results indicated significantly lower mean loss in female-managed households (10.2%) compared to male-managed households (16.8%, $p < 0.001$). SEM confirmed that women's decision-making authority tamed losses indirectly by higher adoption of improved technologies. Empowerment of women to engage in post-harvest decision-making has a profound influence on loss-reduction technology adoption and PHL reduction. Interventions that make technologies available without transforming intra-household power relations can realise partial success.

Keywords: Post-harvest losses, gender, decision-making, rice, food security, value chain

INTRODUCTION

Rice is arguably the most important staple food in Nigeria, both from domestic food security and Nigeria's economy. Nigeria is the largest producer of rice in West Africa, with production in recent years averaging between 8.0 and 9.1 million tonnes per year, but demand has always been more than the supply (Adewumi et al., 2022; Gao et al., 2023). Current consumption is 7.7 million tonnes of milled rice per annum, driven by increased urbanisation and dietary change, making the country dependent on imports to meet the gap (Ragasa et al., 2019). Rice has become part of diets for both rural and urban parts of Southwest Nigeria, namely Ekiti and Osun States, recording its crucial place in local household economies and national food security (Nwankwo & Iheanyi 2025; Afolayan et al., 2024; Ojo et al., 2025).

Despite production increases, post-harvest losses (PHL) remain a major problem. Studies estimate that 15% to 30% of Nigerian rice production is lost after harvesting, mainly at the drying, storage, and milling phases (Affognon et al., 2015; Ogundele, 2022). Such inefficiencies equate to wastage of labour, land, and capital, as well as reduced incomes for households and national food self-sufficiency (Adewumi et al., 2022). Having PHL resolved is thus as vital as increasing output if

Nigeria is to achieve its food security target (Ojo et al., 2025; Adeagbo et al., 2026).

The rice value chain is also extremely gendered. Gender participation refers to the physical involvement of men and women in post-harvest tasks such as parboiling, drying, and milling, while decision-making power reflects control over strategic choices, including technology adoption, storage methods, and marketing decisions. Although women participate extensively in post-harvest rice operations in Nigeria, their involvement rarely translates into authority over key decisions that determine efficiency and loss outcomes. Land preparation, irrigation, and ploughing are the exclusive domains of men, while sowing, transplanting, parboiling, drying, milling, and retailing are major areas where women are involved (Nwankwo & Iheanyi 2025; Ragasa et al., 2019). However, women's heavy labour input is not matched with decision-making authority or productive resource access, primarily due to socio-cultural customs (Doss & Quisumbing, 2020). The disparity constrains their ability to implement technologies such as hermetic storage and improved parboiling technologies that have been established to reduce post-harvest losses (Gaya et al., 2017).

Gender relations have been shown to impact agriculture productivity, innovation

adoption, and household welfare (Farnworth et al., 2020). In Nigeria, though, little evidence is available to link intra-household decision-making power directly with measurable PHL effects. This is a significant gap, particularly in Southwest Nigeria, where rice is a staple and source of livelihood, and where women are over-represented in post-harvest activities. While women dominate post-harvest labour, participation does not necessarily translate into control over strategic decisions such as storage, marketing, and technology use (Awosanmi et al., 2024). Unlike most prior studies that rely on self-reported losses, this study uses gravimetric field measurement and applies structural equation modelling to trace the causal pathway from gendered decision power to technology adoption and loss reduction.

This study focuses on decision-making power rather than mere labour contribution. This study addresses this gap by investigating the relationship between gendered control of post-harvest decisions and rice losses in Southwest Nigeria. The specific objectives of the study are to assess and map gender roles in post-harvest rice

handling across Ekiti and Osun States; to examine the relationship between women's decision-making power and adoption of improved, waste-reducing practices; to quantify and compare rice losses between male- and female-managed post-harvest operations and to recommend gender-sensitive strategies to reduce waste and enhance equity in the rice value chain. Unlike most previous studies that rely on self-reported post-harvest losses, this study employs gravimetric field measurement to objectively quantify losses and applies structural equation modelling (SEM) to empirically trace the pathway linking gendered decision-making power, technology adoption, and post-harvest loss reduction in Nigerian rice systems.

METHODOLOGY

Study area

The research was conducted in Ekiti and Osun States, which are prominent rice-producing clusters in Southwest Nigeria. The states were purposively selected due to their prevalence of smallholder rice cultivation, parboiling, and high engagement of women in post-harvest activities.

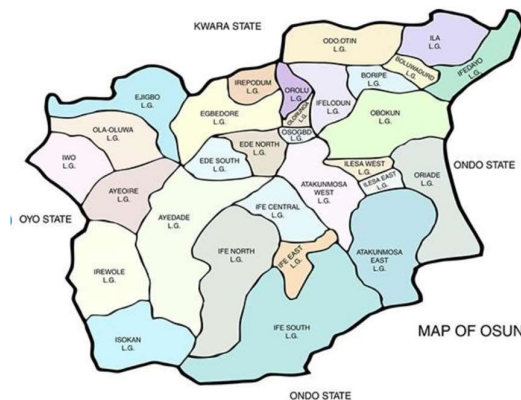


Fig 1: Map of Osun state

Research Design - Cross-sectional mixed-methods design was employed, combining quantitative and qualitative data. Statistical measurement of post-harvest losses and richer insights into intra-household decision-making dynamics were enabled by this design.

Sampling Procedure and Sample Size - A multistage stratified sampling technique was employed to ensure representativeness across the two selected states, Osun and Ekiti. In the first stage, rice-producing local government areas (LGAs) were identified in each state with the assistance of the Agricultural Development Programmes (ADPs). Three LGAs were purposively selected from each state based on their high concentration of rice farmers. These were Egbedore, Oriade and Obokun LGAs in Osun State, and Irepodun/Ifelodun, Ikole, and Ido/Osi LGAs in Ekiti State.



Fig 2: Map of Ekiti state

In the second stage, two communities were randomly selected from each of the chosen LGAs, resulting in a total of twelve communities, six in Osun and six in Ekiti. The selected communities included Iwaraja and Iloko in Oriade, Erinmo-Ijesa and Ibokun in Obokun LGAs; Osuntedo and Iragberi in Egbedore; Iyin-Ekiti and Awo-Ekiti in Irepodun/Ifelodun; Ikole-Ekiti and Oke-Ako in Ikole; as well as Ido-Ekiti and Usi-Ekiti in Ido/Osi.

At the third stage, rice-farming households in each community were stratified according to the gender of the primary post-harvest manager. The strata comprised male-managed, female-managed, and jointly managed households. In the final stage, households were randomly selected within each stratum. A total of fifty households were selected from each LGA, giving 150 households per state and a combined sample of 300 rice-farming households across both states. The sample size was determined

using Cochran's (1977) formula for finite populations.

It is important to note that households were classified based on the primary post-harvest decision-maker, not on household headship. Female-managed households refer to households in which a woman had primary authority over post-harvest handling, storage, and technology decisions, irrespective of whether the household head was male or female. Male-managed households are those where men exercised this authority, while jointly managed households are those where decisions were shared (Aduwo *et al.*, 2017).

Data Collection - Four complementary instruments were employed to obtain comprehensive and reliable data for this study. The structured household survey served as the primary quantitative instrument. It gathered detailed information on the socioeconomic characteristics of respondents, household decision-making dynamics, and the extent of technology adoption among rice farmers.

In addition to the survey, focus group discussions (FGDs) were organised to gain deeper insights into community attitudes, gender norms, and the factors influencing women's involvement in post-harvest decision-making. The discussions were conducted separately for male and female groups to encourage open and uninhibited participation.

A decision-making matrix was also utilised as a participatory tool to identify the specific roles of household members in post-harvest and income-related decisions. Through this matrix, it was possible to determine whether the husband, wife, both jointly, or other household members were primarily responsible for various post-harvest activities and financial decisions.

A loss-on-field assessment was carried out to objectively measure physical post-harvest losses. Gravimetric methods were used in line with standard procedures to estimate percentage weight losses during drying, storage, and milling stages. Rice sub-samples were collected from participating households to ensure accuracy and comparability across different processing stages.

Ethical approval for the study was obtained from the Research Ethics Committee of First Technical University, Ibadan, Nigeria, and informed consent was obtained from all participants prior to data collection. This ensured that the study adhered to the ethical standards governing research involving human participants.

Data Analysis - Quantitative data were analysed with the help of Stata 17 and R software. Descriptive statistics (means, percentages, cross-tabulations) characterised households and integrated gender roles. Binary Logistic Regression was used to identify determinants of technology adoption with explanatory variables as decision-maker gender, education, income, landholding size, and access to extension. Structural Equation Modelling (SEM) examined hypothesised relations between decision-making power, resource access, application of improved practices, and post-harvest losses. χ^2/df , CFI, TLI, RMSEA, and SRMR were used to measure model fit. Normality of loss distributions was assessed using Shapiro-Wilk tests, and homogeneity of variance using Levene's test; where mild deviations occurred, the large sample size justified the use of parametric tests. Quantitative results were triangulated with the findings to provide validity and reliability.

RESULTS AND DISCUSSION

Socioeconomic Characteristics

The socioeconomic characteristics of the 300 households surveyed are as presented in Table 1. The respondents' age was a mean of 42.5 years (± 11.4), which is indicative of a population well within the working age cohort. The household size was a mean of 6.2 members (± 2.1). The respondents had gone to school for a mean of 8.1 years (± 3.9).

Female-headed household accounted for 23.7% of the sample. The landholding size averaged 2.4 hectares (± 1.6), supporting the dominance of smallholder farming systems. Farming as a principal occupation was claimed by 81.5% of the households. Extension and credit were claimed by 41.2% and 34.6% of the interviewees, respectively. Average annual household income was ₦185,400 ($\pm 96,700$).

Table 1: Socioeconomic Characteristics of Respondents (n = 300)

Variable	Mean / % (SD)
Mean Age (years)	42.5 (± 11.4)
Household Size (average)	6.2 (± 2.1)
Education (mean years)	8.1 (± 3.9)
Female-headed household (%)	23.7 %
Average Landholding (ha)	2.4 (± 1.6)
Primary Occupation: Farming (%)	81.5 %
Access to Extension Services (%)	41.2 %
Access to Credit (%)	34.6 %
Average Household Income (₦'000)	185.4 (± 96.7)
Use of Storage method inc. Hermetic	75.3%

Source: Field Survey 2025

Post-Harvest Gender Roles

Post-harvest gender roles are shown in Table 2. Women handled most of the parboiling (95%), drying (88%), and winnowing (82%). Men dominated transport (75%) and purchasing storage

technology (75%). Decision-making in the issue of marketing was largely in the hands of men (70%), while decision-making in handling for storage was largely joint (50%).

Table 2: Division of Labour and Decision-Making in Post-Harvest Activities

Activity	Female (%)	Male (%)	Joint (%)	Primary Decision-Maker
Parboiling	95	2	3	Female (92%)
Drying	88	5	7	Joint (65%)
Winnowing	82	8	10	Female (85%)
Storage (Handling)	45	30	25	Joint (50%)
Storage (Tech Purchase)	15	75	10	Male (75%)
Transportation	10	75	15	Male (80%)
Marketing (Pricing/Sales)	35	70	15	Male (70%)

Source: Field Survey 2025

Determinants of Adopting Waste-Reducing Practices

Table 3 shows the binary logistic regression findings for adopting hermetic storage technology. The model was significant, $\chi^2(5) = 63.82$, $p < 0.001$, and the Nagelkerke R^2 was 0.324, correctly classifying 78% of cases.

Female decision-making significantly improved the chances of adoption (OR = 3.37, $p = 0.002$). Access to extension services (OR = 2.63, $p =$

0.011), education (OR = 1.13, $p = 0.031$), and income (OR = 1.002, $p = 0.042$) were also important determinants. Size of landholding was not significant. Although household income was statistically significant, the odds ratio (1.002) indicates that its substantive effect on adoption is very small, suggesting that decision-making authority and extension access matter more than income in driving technology adoption.

Table 3: Logistic Regression of Factors Influencing Adoption of Hermetic Storage

Variable	β	S.E.	Odds Ratio [Exp(β)]	p-value
Female Decision-Maker (1=Yes)	1.215	0.401	3.371	0.002
Access to Extension (1=Yes)	0.967	0.382	2.630	0.011
Education Level (Years)	0.121	0.056	1.129	0.031
Household Income (₦'000)	0.002	0.001	1.002	0.042
Landholding Size (Hectares)	0.105	0.183	1.111	0.565
Constant	-3.901	0.842	0.020	<0.001

Source: Field Survey 2025

Quantitative Loss Differences by Management Type

Table 4 displays measured post-harvest loss. Female-managed households reported a mean total loss of 10.2%, while male-managed and jointly

managed households reported losses of 16.8% and 11.6%, respectively. Independent samples t-tests confirmed that losses were also significantly lower in female-managed households ($t(298) = 5.83$, $p < 0.001$).

Table 4: Mean Percentage Weight Loss by Management Type and Activity

Post-Harvest Activity	Female-Managed (%)	Male-Managed (%)	Jointly Managed (%)
Parboiling	3.1 (± 1.2)	4.8 (± 2.1)	3.5 (± 1.4)
Drying	4.5 (± 1.8)	7.2 (± 2.5)	5.1 (± 2.0)
Storage (3 months)	2.6 (± 1.1)	4.8 (± 1.9)	3.0 (± 1.3)
Total Average Loss	10.2	16.8	11.6

Source: Field Survey 2025

Structural Equation Modelling of the Decision-Power-Loss Pathway

SEM was employed to investigate the following hypothesised pathways: female decision-making influence, resource access, adoption of improved practices, and post-harvest losses. Model

fit was acceptable: $\chi^2/df = 1.89$, CFI = 0.96, TLI = 0.95, RMSEA = 0.055, and SRMR = 0.048.

Key outcomes are presented in Table 5. The level of decision-making power among women positively influenced the adoption index ($\beta = 0.61$, $p < 0.001$). Having access to resources positively influenced adoption ($\beta = 0.27$, $p = 0.004$). Enhanced

practice adoption was associated with a strong linkage with reduced losses ($\beta = -0.52$, $p < 0.001$). The overall effect of female decision-making power

on reducing losses through adoption was sizeable (-0.31), while the direct effect was negligible (-0.14 , $p = 0.081$).

Table 5: SEM Standardised Direct, Indirect, and Total Effects

Relationship	Direct Effect	Indirect Effect	Total Effect	p-value
Decision Power → Adoption Index	0.61	–	0.61	<0.001
Resource Access → Adoption Index	0.27	–	0.27	0.004
Adoption Index → Total PHL	-0.52	–	-0.52	<0.001
Decision Power → Total PHL	-0.14	-0.31	-0.45	0.081 / <0.001*
Resource Access → Total PHL	-0.08	-0.13	-0.21	0.218 / 0.007*

Source: Field Survey 2025

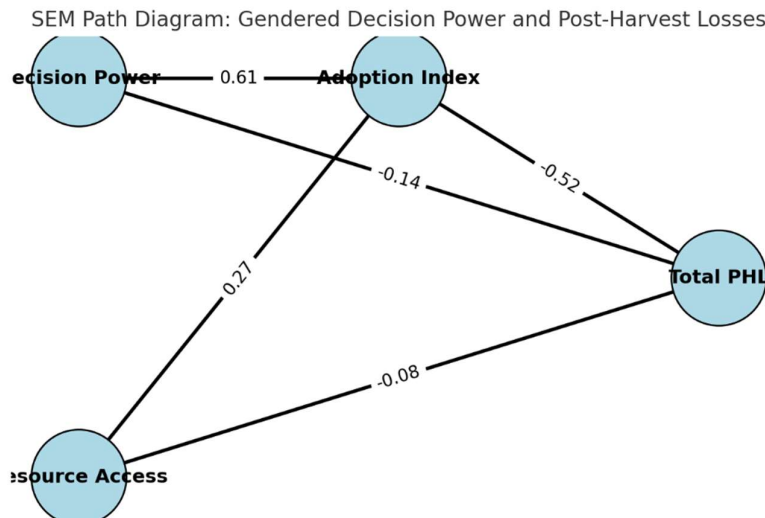


Fig 3: SEM Path Diagram

The study analysed the effect of gendered post-harvest management on technology use and rice loss in Southwest Nigeria. New evidence from the findings indicates that although women contribute most of the labour in technically challenging post-harvest activities, they remain left out of significant decision-making roles, particularly technology purchasing and marketing. This disconnection has implications for post-harvest efficiency and loss reduction.

The focus group discussion findings further reinforced the quantitative findings. For instance, a female participant from Ekiti State observed that, "We are the ones that parboil and dry the rice every day, but when it comes to buying storage bags or deciding when to sell, it is usually the men that decide." Furthermore, a male participant from Osun observed that:

"Women do most of the work after the harvest, but men will be the ones to decide because they own the land."

Another female participant stressed the significance of decision-making:

"If women can be allowed to decide on storage, we will be able to decide on storage options that will avoid spoilage."

The descriptive analysis confirmed that women dominated parboiling, drying, and winnowing but not technology purchasing and marketing decisions, which were controlled by men. This aligns with earlier studies in Ghana and Ethiopia, where women's processing dominance did not directly translate into decision-making authority (Ragasa *et al.*, 2019). The Nigerian context deepens this by showing that denial of decision-making does not merely perpetuate inequality but has measurable effects on efficiency and quantifiable post-harvest loss.

The regression result confirmed that households where women had post-harvest decision-making authority were 3.37 times more likely to adopt hermetic storage technologies. This result confirms the use of intra-household power dynamics in driving innovation adoption, as put forward by Doss & Quisumbing (2020). Theoretically, this suggests that bargaining and agency among households, rather than resource endowments, are better predictors of adoption in smallholder rice systems. Access and extension education also raised adoption, highlighting institutional assistance and human capital (Farnworth *et al.*, 2020; Asfaw *et al.*, 2019).

Quantitative farm data corroborated the efficiency returns of women's leadership. Female-headed household had significantly lower mean losses (10.2%) compared to male-headed households (16.8%). This is consistent with evidence presented by Peterman *et al.* (2014), testifying to women's meticulous management of crops. In addition to corroborating efficiency returns, the finding implies that programmes aimed at rice loss reduction not only need to induce technologies but also specifically augment women's agency to make decisions on post-harvest options, as their leadership evidently reduces wastage.

The SEM results helped to add further insight. The results indicated that female decision-making power reduced post-harvest losses primarily by its indirect influence on technology adoption, rather than directly by exerting an effect on efficiency. This finding highlights the mechanism whereby empowerment produces quantifiable impact: by enabling women to adopt and employ improved practices. Methodologically, it is a step ahead because SEM has never been employed previously to empirically track the decision-adoption-loss sequence in Nigerian rice systems. Theoretically, it adds strength to models that define empowerment as a process and not an endpoint but as a driver to technological and productivity performance (Quisumbing *et al.*, 2015; Meinzen-Dick *et al.*, 2019).

Taken collectively, these findings indicate that interventions to address post-harvest inefficiencies must accomplish more than provide technologies. Projects that provide hermetic bags, improved parboiling kit, or drying mats without altering intra-household power dynamics can reproduce current inequalities in addition to limited gains. Interventions involving gender-responsive training, promoting women's cooperatives, and increasing women's access to extension and finance, on the other hand, have the potential to transform efficiency and equity effects.

Despite the impacts, there are several limitations of this study that should be acknowledged. First, the cross-sectional design limits the extent to which changes in intra-household decision-making power and technology adoption can be accounted for over time. Intra-household gender relations are dynamic, and the associations observed here should thus be interpreted as correlational rather than strictly causal. Second, while the post-harvest losses were objectively measured using gravimetric methods, some survey components related to decision-making roles may be subjected to recall bias or social desirability bias, especially in contexts where gender norms strongly influence how responsibilities are reported. Third, endogeneity could be a concern between decision-making power and technology adoption: households adopting improved technologies may subsequently

empower women, rather than necessarily prior empowerment. While SEM helps to model indirect pathways, this cannot be eliminated. Finally, focusing on Ekiti and Osun States may make the generalisation of results to other rice-producing regions rather different in socio-cultural dynamics questionable. Future studies to be implemented longitudinally or in panel data from multiple regions would go further in yielding stronger causal inference and broader applicability.

CONCLUSION AND RECOMMENDATIONS

This study examined how gendered control of post-harvest decisions affects technology adoption and rice losses in Southwest Nigeria. The evidence shows a clear disjuncture: women contribute the bulk of labour in critical post-harvest stages such as parboiling and drying, yet men retain control over strategic decisions, particularly regarding technology acquisition and marketing. Logistic regression and SEM analyses demonstrated that empowering women in decision-making significantly increases the likelihood of adopting improved storage and handling technologies, which in turn reduces post-harvest losses. Female-managed households recorded substantially lower rice losses than male-managed ones, highlighting the efficiency benefits of inclusive decision-making.

The study's contribution lies in empirically establishing the causal chain connecting women's decision-making authority, adoption of improved practices, and measurable reductions in losses.

Based on these findings, the study recommends that interventions should prioritise the strengthening of women's decision-making power within households so that they can participate fully in technology adoption, training, and resource allocation. The dissemination of technologies such as hermetic storage, improved parboiling equipment, and modern drying facilities should be gender-sensitive and explicitly designed to reach women. Extension and training services should integrate gender-responsive modules, ensuring that women, who are central to post-harvest handling, are recognised as primary beneficiaries. Women's cooperatives should also be promoted and strengthened as a means of improving access to finance, information, and bargaining power in marketing. Furthermore, interventions should be location-specific, considering the institutional and infrastructural realities of Ekiti, Osun, and other rice-producing regions of Nigeria.

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Inclusive Credit Policies and Access to Agricultural Credit among Women Farmers in Osun State, Nigeria

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Abstract: Women play a central role in Nigerian agriculture, contributing 60–80% of farm labour, yet face significant barriers to accessing formal credit. This study examined the socio-economic characteristics of women farmers in Osun State, their credit sources, utilisation patterns, determinants of credit access, and constraints to credit access. A multistage sampling procedure was used to select 120 respondents. Data were analysed using descriptive statistics, probit regression, and Likert scale. The results revealed that the respondents had a mean age of 40.21 ± 15.17 years, household size of about 7 persons, spent about 10 years in school, and mean farm size of 2.5 ha. Credit access stood at 70.8%, with microfinance banks as the dominant source (45%). However, 80% of recipients considered their loans insufficient, and 60.8% reported repayment difficulties. Result of the Probit regression analysis revealed that age ($\beta = 0.17$, $p < 0.1$), marital status ($\beta = 0.56$, $p < 0.1$), education ($\beta = 0.48$, $p < 0.05$), farm size ($\beta = 2.12$, $p < 0.1$), primary occupation ($\beta = 1.12$, $p < 0.05$), cooperative membership ($\beta = 1.16$, $p < 0.05$), collateral ($\beta = 2.78$, $p < 0.1$), and interest rate ($\beta = 0.16$, $p < 0.1$) significantly influenced access to credit. Major constraints included lack of collateral (mean = 3.87), high interest rates (mean = 3.75), difficulty in getting surety (mean = 3.70). This study, therefore, recommended that government should prioritise gender-responsive financial schemes, flexible collateral requirements, expanded cooperative membership, and targeted financial literacy training to improve agricultural credit accessibility and utilisation among women farmers.

Keywords: Women, Credit policy, Utilisation, Probit regression

INTRODUCTION

Agriculture remains a central driver of economic growth, poverty reduction, and food security in developing economies, particularly in sub-Saharan Africa. In Nigeria, the sector contributes over 25% of Gross Domestic Product (GDP) and employs more than 70% of the labour force, making it a critical pillar of national development (National Bureau of Statistics, 2021; Oyedade *et al.*, 2021). Beyond its economic role, agriculture stimulates growth in other sectors and is vital for achieving global poverty reduction targets (IDA, 2009). Yet, the sector's success depends heavily on farmers' access to resources especially agricultural credit which enables investment in improved technologies, expansion of production, and increased incomes. Limited access to credit constrains smallholder farmers, who dominate the sector, resulting in low input use, reduced productivity, and persistent rural poverty (Asogwa, *et al.*, 2014; Simonyan *et al.*, 2010).

Small-scale farmers cultivate most of Nigeria's farmland and supply the bulk of its food. Women play a vital role in this process, constituting 60–80% of the agricultural labour force (Nagac & Hauwa, 2016; Alkire *et al.*, 2013; FAO, 2011) and contributing across the value chain from land preparation, planting, input application, harvesting, processing, and marketing (Folarin *et al.*, 2021; Azeez *et al.*, 2021). These contributions are essential to household welfare, food security, and national poverty reduction (FAO, 2014, 2016). However, women farmers face persistent barriers, including unequal land access, inadequate inputs, limited extension services, and restricted credit (Ganiyu *et al.*, 2021; FAO, 2019b; Croppenstedt *et al.*, 2013; Odoemenen and Obinne, 2010).

Agricultural credit is widely recognised as a catalyst for agricultural transformation, enabling farmers to acquire modern inputs, adopt improved technologies, expand production, and meet household needs (Asom *et al.*, 2023; Balana, *et al.*, 2022; Sanglay *et al.*, 2021; Gulati and Juneja, 2019; Jimi *et al.*, 2019; Mogues, 2015; Ibrahim and Aliero, 2012). In Nigeria, finance comes from formal institutions (e.g., Bank of Agriculture, Nigerian Agricultural Cooperative and Rural Development Bank), semi-formal sources (microfinance institutions, cooperatives, NGOs), and informal lenders (moneylenders, friends, relatives). While informal credit often requires fewer conditions, it typically provides smaller loans with shorter repayment terms, limiting its effectiveness for agricultural investment.

High transaction costs, risk aversion, and structural constraints limit credit market participation among women farmers (Balana & Oyeyemi, 2022; Ayeomoni *et al.*, 2016; Boucher, 2008). Other barriers include distance to lenders, long processing times, high interest rates, small loan sizes, and low income (Hananu *et al.*, 2015; Kosgey 2013; Odoemenem & Obinne, 2010). There are also socio-economic factors that influence women farmer's access to credits, which include farming experience, land size, asset value, expenditures, income, collateral, and commercialisation level (Aliero *et al.*, 2017; Ololade *et al.*, 2013; Oyedele *et al.*, 2009). Low financial literacy also limits farmers' ability to secure favourable credit terms (Ugoani *et al.*, 2015), while cultural norms in some regions further exclude women (Okojie *et al.*, 2010).

Women's lack of land titles and collateral, smaller loan sizes, and exposure to discriminatory lending, push many toward informal credit, which restricts investment capacity and limits productivity

(Khandker *et al.*, 2016; Fletschner *et al.*, 2010). Evidence showed that women with access to credit are more likely to invest in farm improvements and household welfare (Doss, 2018; Fletschner and Kenney, 2014), whereas financial exclusion perpetuates low productivity and vulnerability (Attamah *et al.*, 2020). Socio-cultural factors, including patriarchal land tenure and male-dominated financial decision-making, further constrain access.

To address rural financing gaps, Nigerian government introduced and implemented policies and schemes such as the Agricultural Credit Guarantee Scheme Fund (ACGSF), Nigerian Incentive-Based Risk Sharing System for Agricultural Lending (NIRSAL), Growth Enhancement Scheme, and the Anchor Borrowers' Programme. State-level initiatives include the Special Emergency Agricultural Loans Scheme and the Small and Medium Enterprises Equity Investment Scheme. The policies were put in place with a view to guaranteeing sustainable availability and accessibility of credit funds to the agricultural sector, to enhance national food and nutrition security, to reduce liquidity constraints within agricultural production, to increase agricultural productivity, to enhance employment creation, and to improve livelihood diversification, thereby leading to a vibrant rural economy (Bassey, 2016; Ojiako, 2012; Adetiloye, 2012). Though some successes through these schemes have been documented, most of the challenges facing agricultural credit markets in Nigeria remain unresolved, because many programmes fail to address gender-specific constraints, suffer from weak monitoring, bureaucratic bottlenecks, and uneven benefit distribution (Balana *et al.*, 2022; Adegbite and Machethe, 2020; Wossen *et al.*, 2017; Awotide *et al.*, 2015).

In Osun State, persistent gaps in agricultural finance continue to limit women farmers' access to formal credit, with implications for farm investment, income, and food security. Despite their participation in agricultural activities, women farmers face structural, institutional, and socio-cultural barriers that limit their ability to obtain agricultural credit. Empirical evidence showed that the effectiveness of credit in improving agricultural outcomes depends critically on whether farmers can access adequate and timely financing under favourable conditions (Kaye *et al.*, 2024; Chaiya *et al.*, 2023; Rahimah *et al.*, 2018; Boucher *et al.*, 2008, 2009; Feder *et al.*, 1990). Understanding the determinants of credit access is therefore essential for designing effective and inclusive agricultural finance policies.

Against this backdrop this study examined the socio-economic characteristics of small-scale women farmers in Osun State, profiled their sources

of agricultural credit, examines utilisation patterns, analysed determinants of credit access, and explored constraints to financial inclusion. The findings aimed to inform gender-responsive credit policies that can improve women farmers' participation in formal financial markets and support inclusive agricultural development.

METHODOLOGY

The study was carried out in Osun State, Nigeria. Osun State is an inland state in South-Western Nigeria, and it lies within the tropical rainforest region. Its capital is Osogbo and is located between latitude 7° 40'N and 7°45'N and longitude 4° 28'E and 4° 37'N of the Greenwich Meridian. It is bounded to the north by Kwara State, to the east partly by Ekiti State and partly by Ondo State, to the south by Ogun State and to the west by Oyo State. The state covers an area of approximately 10,456 km² with a total population of 3,146,959 (NPC 2006). The state comprises 30 local government areas which are primarily inhabited by core Yoruba people. There are two main seasons; the rainy season which operates between March to October with relatively dry season from November to March. Annual rainfall average is 1570mm while temperature ranges from 25 to 27.5. Osun state lies within the tropical rainforest. Osun state is an agrarian state with large production of some varieties of annual crops, like maize, rice, cowpea, yam, cassava and cocoyam as well as perennial crops such as cocoa, kolanuts, plantain and oil palm.

A multi-stage sampling technique was employed in selecting the samples needed for the study. The first stage involved a purposeful selection of four local government areas based on the population of small-scale women farmers in the state. The local government areas are Ife central, Ilesha-west, Obokun and Osogbo local government. At the second stage, three communities were purposively selected from each of the local government areas, the communities include: Agowande, Ilupeju, Oba-ife, Igbona, Oke-Ake, Agbagbooro, Aba-Somisemu, Adaowode, Otan-Ile, Ilase, Ereja and Isokun. At the third stage, 10 respondents were randomly selected from each community. This was done by collecting the lists of female farmers in this towns from the ADPs under each local government areas, in totality, 120 female farmers were selected.

Primary data were collected through a semi-structured and pre-tested questionnaire administered to women farmers in the selected LGAs. The instrument captured information on socio-economic characteristics (age, household size, education, farming experience), credit information (sources of credit, amount received, interest rates, utilisation of the credit). The questionnaire was validated through expert review and pilot testing in non-sampled LGAs in each state. The Cronbach's

alpha coefficient for internal reliability exceeded 0.70, indicating satisfactory consistency. Data were analysed using descriptive statistics, Probit Model and Likert scale.

Model Specification

Probit Model

The probit model was employed to estimate the determinants of credit accessibility due to its effectiveness in handling dichotomous variables. According to Nagler (1994), the probit model constrains estimated probabilities to lie between 0 and 1, while relaxing the assumption that the effect of independent variables is constant across all predicted values of the dependent variable. In this framework, the observed variable Y takes binary values of 1 or 0. However, there is an unobserved, latent continuous variable (Y^*) that determines the value of Y (Kuwornu *et al.*, 2012). The binary variable Y represents whether a household has access to credit, which in this study is defined as whether or not a household borrows. It is assumed that (Y^*) can be stated as follows:

$$Y_i^* = \beta_0 + \beta_1 X_i + \varepsilon_i \dots\dots\dots (1)$$

and that:

$$Y_i = 1 \text{ if } Y_i^* > 0 \dots\dots\dots (2)$$

$$Y_i = 0 \text{ if } Y_i^* \leq 0 \dots\dots\dots (3)$$

Positive values relating to Y^* are recognised as $Y=1$, while negative or zero values of Y^* are taken to be $Y=0$. $Y=1$ if a farmer has credit access and 0 if otherwise,

X_1 = age of the female farmers (years),

X_2 = marital status (1=married, 0=otherwise),

X_3 = educational (years spent in school)

X_4 = household size (number of persons)

X_5 = farm size (hectares),

X_6 = farming experience (years),

X_7 = Primary occupation (1=farming, 0=otherwise)

X_8 = membership of cooperatives (member=1, otherwise 0)

X_9 = collateral (1=yes, 0=no)

X_{10} = interest rate (%)

ε = error term.

Likert's scale

The constraints to credit access by the women farmers were measured using Likert's scale. The constraints to credit access were measured by asking the respondents to respond to a list of 7 constraints on a 5- point Likert scale from Strongly Agree (5), Agree (4), Undecided (3), Disagree (2) and Strongly Disagree (1). The maximum score was 35 while the minimum score was 7. Mean was obtained for each of the statements and used to rank the constraints.

RESULTS AND DISCUSSION

Socioeconomic characteristics

Table 1 summarised the socio-economic characteristics of the respondents. Approximately 38.3% of respondents were household heads, while 50.8% were married. Marital status is important in rural economies because married women often combine farming responsibilities with domestic care and may access loans for both agricultural purposes and household consumption during off-seasons. This dual responsibility can influence the type, size, and utilisation of loans obtained. The mean age of respondents was 40.21 ± 15.17 years, suggesting that the majority were middle-aged and within their economically active years. Farmers in this age group often possess practical farming experience, social networks, and resilience to production shocks, yet may also face physical limitations compared to younger farmers (Mpuga, 2010). The average household size was 7 ± 2.91 persons, consistent with rural Nigerian norms. Large household sizes can increase dependency ratios, intensifying the need for external financial support to sustain both farm and household consumption. Majority (58%) of respondents identified farming as their primary occupation, and they reported an average of 11.4 ± 6.99 years of farming experience. Such experience often correlates with improved farm management skills, better risk assessment, and more effective credit utilisation (Oladeebo and Oladeebo, 2008). However, prolonged exposure to low-resource farming without adequate financial support can also perpetuate low productivity cycles.

In terms of land tenure, only few (28%) of the women purchased their farmland, while 20% inherited it. The mean farm size was 2.5 ha, indicative of smallholder operations. Limited land size not only constrains production capacity but also reduces collateral value, a critical barrier for women in formal credit markets (Ghebru *et al.*, 2014). The respondents had a mean educational attainment of 10.5 ± 5.20 years, which is relatively high for rural women in Nigeria and suggests potential for higher adoption of improved agricultural technologies and credit management (Osondu *et al.*, 2015; Jirgi, 2021). Cooperative membership stood at 36%, indicating that majority of the women farmers did not belong to cooperative societies. Given that cooperatives often serve as an entry point for credit access, technical training, and marketing support, the relatively low membership rate pointed to an untapped channel for improving women's agricultural financing.

Table 1: Socio-economic characteristics of the women household

Variable	Freq	Percentage	Mean	Standard Deviation
Household head	46	38.3		
Marital status (married)	61	50.8		
Age			40.21	15.17
Household Size			7	2.9
Primary Occupation				
Agriculture	70	58		
Traders	26	22		
Artisans	9	7.5		
Civil servants	15	12.5		
Farming experience			11.4	6.99
Farmland				
Purchase	34	28		
Inheritance	24	20		
Lease	43	35.5		
Rent	19	16.5		
Education			10.5	5.20
Farm size (Ha)			2.5	1.35
Access to credit(yes)	85	70.8		
Membership of Association (yes)	46	36		

Source: Data Analysis, 2023

Credit facilities available and types of cooperative associations they belong to

Figure 1 illustrates the distribution of credit sources utilised by respondents. Microfinance banks emerged as the predominant source (45%) of credit, reflecting their growing role in rural financial inclusion due to relatively flexible lending criteria and smaller loan sizes more suitable for smallholders (Nathanel *et al.*, 2022; Mulatu 2021). These institutions are also more likely to design loan products tailored to agricultural cycles, although interest rates may still be high by commercial standards. Cooperative societies, serving 36% of respondents, emerged as one of the most vital and trusted sources of credit. Their group-based structure enables members to pool resources, reduce transaction costs, and substitute collective guarantees for traditional collateral, thereby widening access to credit for those excluded from formal banking channels (Olomola and Gyimah-Brempong, 2014). Cooperative loans are often

aligned with agricultural production cycles, offer more flexible repayment schedules, and foster mutual accountability among members, which can improve repayment performance. The Bank of Agriculture accounted for 5% of credit access, online banking for 12%, and commercial banks for another 5%. Commercial banks tend to require higher-value collateral and formal documentation, creating barriers for smallholder women farmers (Akram *et al.*, 2020). Informal lenders: including rotating savings associations (30%), moneylenders (17%), and family/friends (20%) also played a significant role. These informal channels offer speed, flexibility, and fewer bureaucratic requirements, making them especially attractive during peak agricultural seasons (Moahid and Maharjan, 2020; Naidoo, 2015). However, they often involve higher implicit costs and shorter repayment periods, which may strain farmers' liquidity.

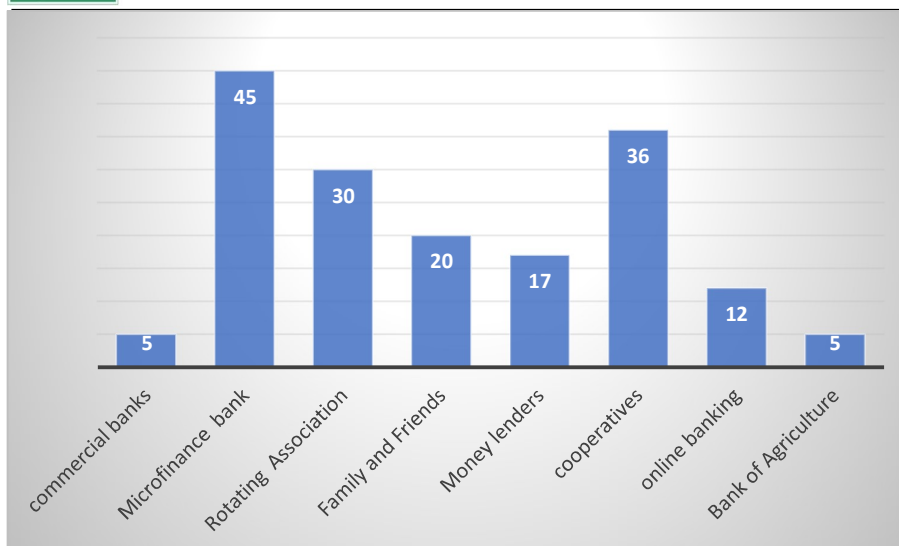


Figure 1: Showing Information about Various Credit Facilities.

Figure 2 showed that the women farmers who were members of cooperative societies belonged to different types such as credit cooperatives (45%) which had the highest patronage, market cooperatives (46%), multipurpose cooperatives (15%), and consumer

cooperatives (4%). The dominance of credit and market cooperatives reflects their dual function in facilitating access to finance and providing market linkages, which together can improve farm profitability.

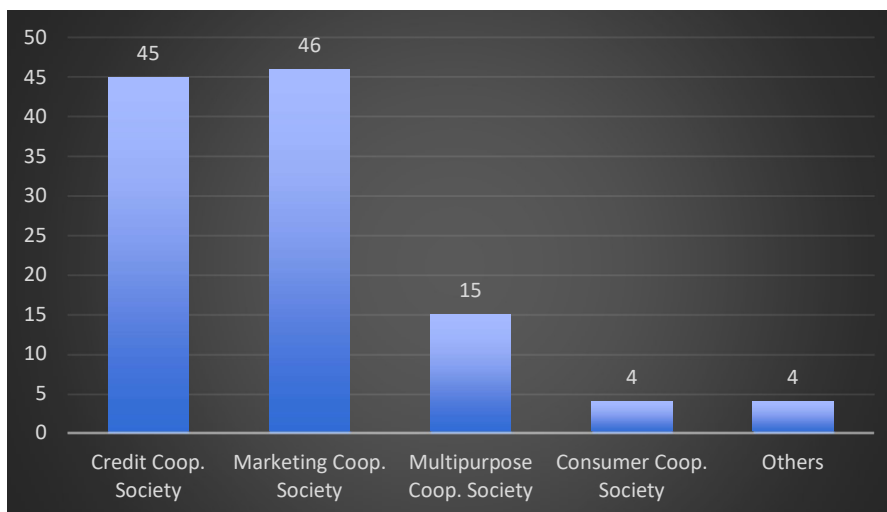


Figure 2: Types of cooperative association that the respondents belonged to

Credit access, Sufficiency, Utilisation, and Repayment

Table 2 revealed that 70.8% of respondents had access to credit, defined here as receiving at least 70% of the amount requested, while 29.2% were unsuccessful in obtaining credit. Loan disbursement modes were split between cash (46.7%) and non-cash forms (53.3%), such as input vouchers or direct provision of agricultural inputs. Loan adequacy remains a pressing challenge: 80% of those who accessed credit considered the amounts insufficient for their farming needs, while only 20% reported sufficiency. This insufficiency likely

contributed to the observed credit diversion patterns, where 50.8% of beneficiaries spent about 50% of the loan on farming activities, 30% allocated about 75%, and only 19.2% dedicated more than 75% of loan value to agriculture. Similar trends have been reported in Ghana and Kenya, where farmers channel part of agricultural loans to pressing household needs (Danso-Abbeam *et al.*, 2016).

Repayment capacity was limited, with 60.8% of borrowers struggling to repay loans. High default rates undermine lender confidence and reduce the willingness of financial institutions to extend future credit, creating a cycle of exclusion.

These findings suggest that without addressing loan adequacy, repayment schedules, and monitoring

mechanisms, credit programmes may not fully achieve their intended productivity gains.

Table 2: Credit access, Sufficiency, Utilisation, and Repayment

Variable	Freq	Percentage
Access to credit facilities		
Received up to 70% requested for	85	70.8
Did not received up to 70% requested for	35	29.2
Sufficiency of the credit funds		
Yes	24	20.0
No	96	80.0
Repayment challenges		
Yes	47	39.2
No	73	60.8
Form of credit that they have access to		
Cash	56	46.7
Non-Cash	64	53.3
How the credit funds were used for agricultural purposes		
Less than or equal to 50%	61	50.8
Less than or equal to 75%	36	30.0
Above 75%	23	19.2

Source: Data Analysis, 2023

Determinants of access to credit among the women farmers

The probit regression results presented in Table 3 showed that age ($\beta = 0.17, p < 0.1$), marital status ($\beta = 0.56, p < 0.1$), level of education ($\beta = 0.48, p < 0.05$), farm size ($\beta = 2.12, p < 0.1$), primary occupation ($\beta = 1.12, p < 0.05$), membership of cooperatives ($\beta = 1.16, p < 0.05$), collateral ($\beta = 2.78, p < 0.1$), and interest rate ($\beta = 0.16, p < 0.1$) each had a positive and statistically significant effect on the probability of women farmers accessing credit. This indicated that socio-economic, institutional, and financial factors collectively influenced women's participation in the rural credit market.

Age was found to be positively correlated with credit access, suggesting that as women farmers grow older, their likelihood of securing loans increases. Age plays a role in shaping decision-making ability, risk perception, and relationships with lenders. Young farmers are often energetic, have higher income-earning potential, and are more willing to invest in productive ventures. Middle-aged farmers tend to show stronger credit demand due to greater family and enterprise responsibilities, whereas older farmers may face reduced credit demand, partly due to declining labour capacity and fewer working household members (Mpuga, 2010). In contexts where informal lending dominates, older farmers often rely on community-based lenders rather than formal credit providers. This study aligns with Olagunju *et al.*, (2015) and Mpuga (2010), who reported that age positively influenced both the decision to apply for and the amount of credit requested. Marital status was also positively and significantly associated with

credit access, with married respondents being 5.6% more likely to secure loans. This may reflect lenders' perception that married individuals are more responsible, stable, and less mobile, reducing the perceived risk of default. Married farmers may also have stronger household networks and social credibility, which can increase trust between borrower and lender. Similar observations were made by Afolabi (2020) and Ololade and Olagunju (2013), who noted that marital stability enhances creditworthiness by signalling reliability and long-term settlement in a given location.

Education exhibited a positive and significant relationship with credit access. Higher educational attainment enhances farmers' ability to navigate loan application procedures, understand repayment terms, and manage borrowed funds effectively. This finding corroborates Akinrotimi *et al.* (2024) and Tang *et al.* (2010), who reported that education increases farm households' capacity to acquire and utilise credit for productive purposes. Education also facilitates access to information about available credit schemes, thereby improving participation in formal financial markets. Farm size had a positive and significant effect on credit access, highlighting the role of land as both a productive asset and a form of collateral. Larger farms tend to result to greater production potential and income-generating capacity, which improves the farmer's creditworthiness. This aligns with Otunaiya *et al.* (2014), who stressed that access to land is a critical driver for female smallholders, especially in contexts where customary land tenure restricts women's ownership rights. In many parts of Nigeria, women are excluded from land inheritance, so those

with land holdings have a distinct advantage in accessing formal credit.

Primary occupation was also significant, with farming as the main occupation increasing the likelihood of credit access. This suggests that women whose livelihoods depend predominantly on agriculture are more motivated to seek and use credit for productive purposes. Conversely, those with other primary occupations may lack the incentive or time to pursue agricultural loans. Membership in cooperative societies significantly and positively influenced credit access. Cooperatives often serve as intermediaries between lenders and farmers, facilitating bulk loan applications, providing loan guarantees, and offering financial literacy training. This collective bargaining power reduces transaction costs for lenders and improves farmers' chances of securing credit. This is in line with the findings of Olomola and Gyimah-Brempong (2014), who noted that farmer cooperatives significantly enhance members' access to credit by reducing transaction costs and providing substitutes for traditional collateral.

Collateral availability was another critical determinant. The positive and significant coefficient

indicated that possession of valuable assets increases access to credit, as these can be pledged to secure loans. However, women in rural Nigeria often face challenges in meeting collateral requirements due to limited property ownership. Ghebru *et al.* (2014) emphasised that land tenure security, defined as certainty over land use, control, and transfer rights, is key to enhancing credit access. In Nigeria, less than 3% of land is formally registered with certificates of occupancy, making it difficult for women to use land as collateral. Households that own durable assets, such as jewellery or machinery, are less likely to be credit-constrained from the supply side.

Interest rate also exhibited a positive and significant relationship with credit access, albeit with complex implications. While lower interest rates can encourage borrowing, excessively low rates may reduce lenders' willingness to supply credit. Conversely, high rates can deter borrowers, especially smallholders with thin profit margins. This study's finding aligns with Akpan *et al.* (2014) and Ololade and Olagunju (2013), who found that higher interest rates influence repayment behaviour and borrowing decisions

Table 3: Determinants of Access to credit among the women farmers

Variable	Coefficient	Std. error	P>z	Z
Age	0.1711	0.0941	0.087	1.81*
Marital Status	0.5681	0.3342	0.090	1.76*
Education Level	0.4891	0.1992	0.019	2.49**
Household size	-0.2183	0.3152	0.489	1.24
Farm Size	2.1254	1.5545	0.091	1.69*
Farming experience	-0.0941	0.0471	0.047	0.91
Primary Occupation	-1.120	0.4696	0.032	2.10**
Membership of cooperative	1.616	0.725	0.026	2.34**
Collateral	2.783	1.870	0.054	1.95*
Interest Rate	-0.161	0.090	0.055	1.93*
Constant	4.851	2.080	.020	0.008
Log Likelihood	-21.089			
LR chi (8)	65.86			
Prob > chi2	0.000			
Pseudo R ²	0.5654			

Source: Data Analysis, 2023

Constraints to credit access

Table 4 presents the ranking of constraints faced by women farmers in accessing credit. Lack of collateral was identified as the most severe challenge (mean = 3.87). In many rural communities, women rarely possess legal titles to land or high-value assets, as property rights are often vested in male household members. This absence of recognised collateral locks them out of most formal lending systems, reinforcing gender-based economic exclusion and limiting their capacity to invest in improved farm inputs. High interest rates (mean = 3.75) constituted another major obstacle. Even when women farmers qualify for loans, the high cost of borrowing discourages uptake or leads

to repayment difficulties, especially given the seasonal nature of agricultural income. The difficulty of obtaining sureties (mean = 3.70) further restricts access. Credit institutions often require guarantors with verifiable income or assets, but women farmers' social networks may lack individuals who meet these criteria or are willing to assume the risk. Short repayment periods (mean = 3.56) also present a structural mismatch with agricultural production cycles. Many crops require several months before yielding returns, making it difficult for farmers to generate the cash flow needed to repay loans within the stipulated time. Delays in loan disbursement (mean = 3.52) undermine the timely acquisition of inputs. Late release of funds

forces farmers to miss optimal planting windows, directly reducing yield potential. A lack of awareness of credit opportunities (mean = 3.35) reflects both information gaps and inadequate financial literacy outreach. Many women farmers remain unaware of available schemes or the procedures required to access them, leaving them dependent on informal credit sources with higher risks and costs. Finally, bureaucracy in loan processing (mean = 3.09) adds to the burden.

Lengthy application procedures, complex documentation requirements, and repeated visits to financial institutions discourage women from pursuing formal credit. These findings mirror those of Akinrotimi *et al.* (2024), who documented similar bottlenecks across Nigeria's rural credit systems. Collectively, they pointed to systemic weaknesses in policy design, gender-sensitive financial services, and the tailoring of loan products to agricultural realities.

Table 4: Constraints to Credit Access among the Women farmers

Constraints	SA	A	U	SD	D	Mean
Lack of Collateral	45	39	20	10	6	3.87
High Interest Rate	42	35	22	13	8	3.75
Difficulty in Getting Surety	41	36	21	13	9	3.70
Short Period of repayment	35	34	26	14	9	3.56
Delay in Disbursement	34	33	27	15	11	3.52
Lack of Awareness of credit facilities	31	30	29	17	13	3.35
Bureaucracy in Loan Processing	23	26	30	21	20	3.09

Source: Data Analysis, 2023

CONCLUSION AND RECOMMENDATIONS

This study examined the socio-economic characteristics, sources and patterns of agricultural credit utilisation, determinants of credit access, and constraints faced by women farmers in Osun State. The findings revealed that the respondents were predominantly middle-aged, experienced farmers operating on smallholder plots averaging 2.5 ha. Despite their significant role in agricultural production, only 70.8% accessed credit, with 80% of them reporting the amounts as insufficient for their farming needs. Microfinance banks emerged as the dominant source of credit (45%), while cooperatives, informal lenders, and family/friends filled the gap left by formal financial institutions. The probit regression results showed that age, marital status, education, farm size, primary occupation, cooperative membership, collateral, and interest rate significantly influenced credit access. Key constraints included lack of collateral, high interest rates, short repayment periods, lack of awareness of credit opportunities, and delays in loan disbursement. These results highlight the persistent gender-specific barriers that limit women's ability to secure and utilise credit effectively, thereby constraining agricultural productivity and household food security. Addressing these barriers is essential for unlocking the full potential of women farmers in enhancing rural livelihoods and advancing food security goals.

The following were recommended:

1. There should be policy reforms on collateral requirements to reflect women's limited land ownership, accepting group guarantees or movable assets as security.
2. Cooperative structures should be expanded to encourage and support women's membership in credit and market

cooperatives so as to enhance bargaining power, reduce transaction costs, and increase access to affordable loans.

3. Loan products should be aligned with agricultural production cycles, featuring longer repayment periods and flexible interest rates.
4. Targeted training for women farmers can improve awareness of available credit schemes, enhance loan management, and reduce default rates.
5. Credit providers should implement systems to ensure loans are utilised for intended agricultural purposes, thereby enhancing repayment performance and long-term sustainability.
6. National and state-level programmes must integrate gender perspectives into the design and implementation of rural financing schemes to address structural inequalities

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