ECONOMIC ANALYSIS OF SUGARCANE PRODUCTION AMONG SMALLHOLDER FARMERS IN NIGER STATE, NIGERIA

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ABSTRACT
This study is on the economic analysis of sugarcane production among small holder farmers in Niger State. The study's objectives are to determine the technical efficiency in sugarcane production, assess the profitability of sugarcane production, socioeconomic factors influencing sugarcane production and the major constraints associated with sugarcane production. A multi-stage sampling method was used to select 242 sugarcane farmers, and data were collected through a well-structured questionnaire. The data were analyzed using descriptive statistics and the stochastic frontier model. The demographic analysis revealed that 30% of the farmers fall within the age bracket of 41 - 50 years, while 12% fall above 60% years. The mean age was 45 years, which is the productive age. 54% had a household size of between 6 and 10 persons. The results from the stochastic frontier production function showed that farm size, fertilizer, cutting and labour were all significant. The inefficiency model identifies factors that contribute to lower technical efficiency, such as household size, with a significant coefficient of 0.141 (p = 0.016). The study identifies several constraints such as capital requirement, cost of transportation, and other general production problems. Based on these findings it is therefore recommended that, an environment should be created for sugar industries in Niger state by the government, agricultural and micro finance bank should financially support the small and medium scale sugarcane farmers and Policies that ensure better market access and fair pricing should be implemented to improve the profitability and sustainability of sugarcane farming in Niger state.
Keywords: Sugarcane production, Smallholder farmers, Cultivation, Returns, Sustainability

INTRODUCTION
Sugarcane is a vital crop globally due to its significant nutritional, economic, and industrial value. It accounts for about 79% of the world's sugar production, while sugar beets contribute the remaining 21% (Food and Agriculture Organization, 2020). In Nigeria, sugarcane is widely consumed and also serves as a source of income for smallholder farmers, thereby contributing to rural livelihoods through employment and revenue generation (Umar *et al.,* 2020).

Although commercial sugarcane cultivation began in the 1950s, Nigeria did not witness the emergence of sugar processing industries, such as the Nigeria Sugar Company (NISUCO) in Bacita, Kwara State, until the early 1960s (Adeoti *et al.,* 2021). Despite the establishment of additional plants such as the Savannah Sugar Company in Numan, Adamawa State, and a mini sugar plant in Sunti, Niger State, Nigeria's domestic sugar production remains insufficient. As of 2024, the country produces approximately 48,000 metric tonnes of sugar annually, while consumption stands at about 1.8 million metric tonnes, resulting in a shortfall of approximately 1.75 million metric tonnes (ThisDay, 2024; FAO, 2024).

Sugarcane is cultivated in about 80 countries on over 24.9 million hectares of land, with global production reaching 1.74 billion tons (OECD-FAO, 2020). In Nigeria, sugarcane production was estimated at 1.5 million tons in 2021, with the bulk produced for domestic consumption (Knoema, 2022). However, local sugar production has been inconsistent, and Nigeria continues to rely heavily on imports, with over approximately 1.7 million metric tonnes of raw sugar imported annually, accounting for over 98% of its national consumption (National Sugar Development Council, 2024). This imbalance has contributed to economic challenges such as Naira devaluation and underemployment (Blueprint, 2023). Beyond sugar, sugarcane offers multiple benefits, including byproducts like molasses, ethanol, and animal feeds (Singh and Katyar, 2016; Zulfqar *et al.,* 2016). The global sugarcane demand is expected to rise, particularly for ethanol production as an alternative fuel source (Thibane *et al.,* 2023).

Globally, sugarcane is driven by the increasing demand for sugar and biofuels. Tropical African countries, including Nigeria, Kenya, Ethiopia, and Sudan, are major producers (ResearchGate, 2025). Nigeria has the land and water resources to produce over 3 million metric tons of sugarcane, which could yield the same volume of sugar if processed efficiently (NSDC, 2023). Sugarcane juice, rich in essential minerals, has numerous health benefits, including cancer prevention and energy provision. In 2022/2023, global sugar consumption reached 176 million metric tons and is projected to grow to 180.05 million metric tons by 2024 (USDA, 2022). Nigeria, being the second-largest sugar market in Sub-Saharan Africa after South Africa, has a promising market for sugarcane if adequate investments are made (Owino *et al.,* 2018; Vanguard News, 2025).

The growing demand has encouraged the establishment of out-grower schemes by processing industries to meet production targets. Despite government efforts and farmer cooperatives promoting best practices and expanding cultivated areas, sugarcane output in Nigeria has experienced volatility. Between 2008 and 2013, production was inconsistent, except for stability in 2011–2013, while between 2003 and 2007, output grew steadily (FAOSTAT, 2020; Sani, 2018).

As an industrial crop, sugarcane has applications beyond direct food consumption, contributing to rural economic development and import substitution (Wiggins *et al.,* 2015; Singh, 2010).

Though sugarcane farming has a high return on investment, constraints like high input costs, limited technical knowledge, and dependence on paid labour hinder productivity (Makama *et al.,* 2024; Issa *et al.,* 2020; Wada *et al.,* 2017). Nigeria has the potential to produce five million metric tons of chewing cane annually, yet few farmers fully exploit this opportunity (FAOSTAT, 2020). Socioeconomic factors such as family size, access to labour, and capital also influence productivity levels (Ibrahim *et al.,* 2022). The need to address these constraints is crucial to enhance production, improve farmers' livelihoods, and boost Nigeria's self-sufficiency in sugarcane and sugar-related products.

This study addresses a significant research gap by focusing specifically on the economic analysis of sugarcane production among smallholder farmers in Niger State, Nigeria, a region often overlooked in previous research. While studies have explored sugarcane production in Nigeria, they generally ignore regional peculiarities such as local infrastructure, pest management, and access to credit, which are crucial for Niger State (Ahmed, *et al.,* 2023; Olowolaju, *et al.,* 2022). This study uniquely combines advanced models like the Cobb-Douglas Production Function and Stochastic Frontier Analysis to analyze technical efficiency and the role of socioeconomic factors like education, household size, and extension services. By doing so, it offers specific recommendations tailored to Niger State's unique conditions, moving beyond generalized findings from other regions (Moffatt, 2019; Zulu, 2019; Battese & Coelli, 1995). This research contributes to the knowledge frontier by providing actionable insights on improving efficiency, productivity, and policy interventions specific to smallholder sugarcane farmers in Niger State.

It is against this background that this study attempts to provide answers to the following research questions: -

i. What are the socioeconomic factors influencing sugarcane production in the study area?

ii. What is the profitability of sugarcane production in the study area?

iii. What is the technical efficiency level of the sugarcane farmers in the study area?

iv. What are the major constraints associated with sugarcane production in the study area?

METHODOLOGY

This study was conducted in Niger State, Nigeria, which comprises 25 Local Government Areas (LGAs) and lies between Latitude 9°36′54.86″ N and Longitude 6°32′51.94″ E. The state experiences two distinct seasons—wet (May to October) and dry—receiving an average annual rainfall of 1,229 mm, with average temperatures of 28°C and humidity ranging from 60% to 80%. Major crops cultivated include rice, millet, maize, sorghum, and chewing cane, among others. For agricultural purposes, Niger State is divided into three zones: Bida A, Kuta B, and Zone C. This study focused on sugarcane production, which is prevalent in specific LGAs within these zones.

Primary data were collected using structured questionnaires administered directly to sugarcane farmers by the researcher and trained enumerators. The questionnaire covered demographic and farm-related variables such as age, education, household size, farm size, input usage, marketing channels, storage costs, credit access, and constraints in sugarcane production. A multi-stage sampling technique was adopted, beginning with the purposive selection of Mokwa, Lavun, and Katcha LGAs due to their prominence in sugarcane farming. In the second stage, three villages were selected from each LGA, making nine in total. Lastly, 25% of the farmers in each village were randomly sampled, resulting in a total sample size of 242 sugarcane farmers.

Table 1: Sample Size

LGA	Village	No. Of Farmers	Sample Size
Mokwa	Jagi	180	45
	Raba	116	29
	Muwo	160	40
Lavun	Jima	100	25
	Donko	80	20
	Kuchi	120	30
Katcha	Dankpa	40	10
	Barkikon	10	28
	Gboyanko	60	15
Total	9	966	242

Data Analysis

The data analysis methods employed in this study include the Cobb-Douglas production function for research question (i), farm budgeting techniques for research question (ii), descriptive statistics for research question (iv), and Stochastic Production Frontier analysis for research question (iii).

Analytical Techniques

1. Stochastic Production Frontier Analysis

The Stochastic Production Frontier (SPF) model is a widely utilized tool in production economics for assessing efficiency. Prominent studies by Aigner *et al.* (2020), Battese and Coelli (1995), and Kumbhakar and Lovell (2000) have applied this model in various agricultural and industrial contexts. In the present study, the SPF model is specifically applied to evaluate the technical efficiency of farm operations.

The technical efficiency (TE) of a firm or farm using the stochastic production frontier is given as:

$$TE = \frac{Y_i}{Y_j} = \frac{Observed\ output}{frontier\ output} = \frac{Exp(V_i - U_i)}{Exp\ (V_j)} \dots\dots\dots\dots\dots (3)$$

$$TE = \exp\ (-U_j)\ \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (4)$$

The empirical stochastic frontier – Cob – Douglas production model is specified as follows:

$$ln = \mathrm{Y}_0\beta_0 + \beta_{1\,IN}\,\mathrm{X}_1 + \beta_{2\,IN}\,\mathrm{X}_2 + \beta_{3\,IN}\,\mathrm{X}_3 + \beta_{4\,IN}\,\mathrm{X}_4 + \mathrm{V}_{i} - \mathrm{U}_{i} \dots\dots\dots\dots\dots\dots. (5)$$

Where:

In = logarithm of base (natural log); β_0 = Constant or Intercept; $\beta_1 - \beta_5$ = Unknown scalar parameter to be estimated; Y = Quantity of sugarcane output (kg); X_1 = Farm size; X_2 = Quantity of sugarcane cuttings (sets) used (kg); X_3 = Fertilizer (kg); X_4 = Agrochemicals (litres); X_5 = Labour (man days); V_j = Stochastic error term; U_j = Technical inefficiency effect produced by the model; subscript j indicates jth farmer in the sample.

The expectation is that the coefficients of the inputs X_1 to X_5, which are β_1, β_2, β_3, β_4 and $\beta_5$would be positive respectively (i.e greater than zero).

The inefficiency model is of the form Ui = β_0+ β, Zji ………….. (6)

$$U = \beta_0 + \beta_{1z_1+}\beta_2 z_2 + \beta_3 z_3 + \beta_4 z_4 + \beta_5 z_5 \dots\dots\dots\dots\dots\dots. (7)$$

Where:

U_i= technical inefficiency effect

Z_{ji} = independent variables for the technical inefficiency effects for the ith farmer

β_0 = Intercept; β_1 = 1, 2, … 5 are unknown scalar parameter

z_1 = Age of the $_i$th farmer (Years); z_2 = Household size (No. of people in the household)

z_3 = Years of sugarcane farming experience (years of experience in sugarcane farming); z_4 = level of education (Years); z_5 = Extension visits (number of meetings in a farming season)

The specification of the model for the inefficiency effects in equation (3) implies that, if the independent variables of the inefficiency model have a negative sign on an estimated parameter, then the associated variables have a positive impact on efficiency, while a positive sign indicates that the reverse is true.

Thus, the expectation is that the coefficients of the whole independent variables of the inefficiency model (i.e.$\beta_0, \beta_1, \beta_2, \beta_3, \beta_4, \beta_5$) should be negative, respectively (i.e. less than zero).

Table 2: Explanatory variables and Expected Signs

Efficiency Model Variable	Expectation	Inefficiency Model Variable	Expectation
X_1 = Farm Size	(+)	Z_1 = Age of Farmers	(-)
X_2 = Quantity of Sugar Cane Cutting (Sett) (kg)	(+)	Z_2 = Household Size	(+/-)
X_3 = Fertilizer	(+)	Z_3 = Years of Sugarcane Farming Experience	(-)
X_4 = Agrochemicals	(+)	Z_4 = Level of Education	(-)
X_5 = Labour (Man days)	(+)	Z_5 = Extension Visit	(-)

3. Farm Budgeting Technique

This was used to achieve research question (ii) of this study.

The model is expressed as follows:

NFI = TR – TC ---(8)

TR = GFI = TVP = TPP × P --(9)

TC = TVC + TFC --(10)

GM = GFI - TVC --(11)

GFI = TVP = TPP× P -- (12)

Where:

NFI = Net farm Income (Naira/ha)

TP = Total Revenue (Naira/ha)

GFI = Gross farm Income (Naira/ha)

TVP = Total Value of Production (Naira/ha)

TPP = Total Physical Product (kg/ha) and

Py = Unit Market Price of the product (Naira/kg)

TC = Total Costs

TFC = Total Fixed Cost (Naira/ha)

TVC = Total Variable Cost (Naira/ha)
GM = Gross Margin (Naira/ha)
The straight-line depreciation method adopted in this study is the difference between the purchase price (pp) and the salvage value (s) divided by the number of years of life of the asset (n).
The formula to calculate annual depreciation using the straight-line method is presented as:

$$\frac{\text{Cost - Salvage value}}{\text{Useful life}}$$

Where, cost= purchase price,
S= salvage value, n= number of years of life the asset.

4. Cob Douglass Production Frontier

To estimate the impact of various inputs and socioeconomic factors on sugarcane production, the Cobb-Douglas production function was employed. This functional form is appropriate for analyzing input-output relationships in agricultural production due to its flexibility, ease of interpretation, and log-linear structure (Moffatt, 2019).
The stochastic form of the Cobb-Douglas production function used in the study is specified as:

$$\ln Y=\beta_0 +\beta_1 \ln L + \beta_2 \ln FS + \beta_3 \ln QC + \beta_4 \ln F + \beta_5 \ln H + \beta_6 \ln A + \beta_7 \ln HS + \beta_8 \ln E + \beta_9 \ln ES + \beta_{10} \ln FE + \beta_{11} \ln C + \beta_{12} \ln EV + \epsilon$$

Where: Y = Sugarcane output (kg); L = Labour input (man-days); FS = Farm size (hectares); QC = Quantity of cutting (bundles); F = Fertilizer used (kg); H = Herbicide used (litres); A = Age of farmer (years); HS = Household size (number of persons); E = Years of formal education; ES = Access to extension services (dummy: 1 = yes, 0 = no); FE = Farming experience (years); C = Access to credit (dummy: 1 = yes, 0 = no); EV = Frequency of extension visits (number per season); ϵ = Error term.

RESULTS AND DISCUSSION

4. 1 Socioeconomic Characteristics of Sugarcane Farmers

The results indicate that sugarcane farming in the study area is dominated by relatively young and active individuals, with a mean age of approximately 45 years. This age group is within the productive workforce and is likely to be more adaptive to new agricultural technologies and practices (Yishak and Sharma, 2024). A majority of farmers (54%) had household sizes ranging between 6 and 10 persons, suggesting the availability of family labor. This aligns with findings by Wayagari *et al*., (2023), who noted that larger households often reduce labor costs through reliance on unpaid family labor, enhancing cost-efficiency in smallholder agriculture.

Most respondents (69%) had over 10 years of farming experience, with an average of nearly 20 years. Such extensive experience likely enhances technical efficiency, as experienced farmers tend to have better knowledge of land suitability, planting schedules, and input management (Simion *et al.,* 2021). However, the data also reveal that about half of the farmers had no formal education. Limited educational attainment may constrain their ability to access and apply modern agricultural knowledge and innovations, as similarly reported by Oladeebo and Fajuyigbe (2017). Despite this, 71% of farmers reported having contact with extension services, although the frequency remained low (average of two contacts). Extension interaction is crucial for bridging knowledge gaps, particularly for farmers with limited formal education. According to Obwona (2006), access to extension services significantly improves farmers' productivity and resource use efficiency.

Table 1: Socioeconomic Characteristics of Sugarcane Farmers

Characteristics	Mean	Std. D	Frequency (N=242)	Percentage %
Age (Years)	44.82	12.98		
20 – 30			59	17.88
31 – 40			78	23.64
41 – 50			99	30.00
51 – 60			54	16.36
> 60			40	12.12
Household size	6.76	3.3		
1 – 5			117	35.45
6 – 10			178	53.94
> 10			35	10.61
Farming experience	19.87	12.38		
1 -10			102	30.91
11 – 20			114	34.55
>20			114	34.55
Educational level	1.92	1.01		
No formal education			166	50.30
Primary education			38	11.52
Secondary education			111	33.64
Tertiary education			15	4.55
Extension contacts	2.01	1.65		
No contact			95	28.79
1 – 2			87	26.36
3 – 4			128	38.79
>4			20	6.06

Source: Field Survey, 2024.

4.2 Socioeconomic Factors Influencing Sugarcane Production in the Study Area

The findings on the socioeconomic factors influencing sugarcane production reveal several key insights of the output in the study area.

Table 2: Estimated Results of the Cobb-Douglas Production Function for Sugarcane Production

Variable	Coefficient (β)	Std. Error	t-Statistic	P-value	Significance Level	Priori Sign
Constant	1.562	0.824	1.90	0.058	10%	(+)
Labour (L)	0.314	0.115	2.73	0.007	1%	(+)
Farm Size (FS)	0.208	0.076	2.73	0.008	1%	(+)
Quantity of Cutting (QC)	-0.215	0.089	-2.42	0.016	5%	(+)
Fertilizer (F)	0.101	0.044	2.30	0.022	5%	(+)
Herbicide (H)	0.256	0.069	3.71	0.000	1%	(+)
Age (A)	0.034	0.029	1.17	0.244	Not Significant	(+)
Household Size (HS)	0.132	0.061	2.16	0.031	5%	(+/-)
Education (E)	-0.037	0.062	-0.60	0.551	Not Significant	(-)
Extension Services (ES)	0.182	0.067	2.72	0.008	1%	(+)
Farming Experience (FE)	0.056	0.033	1.69	0.093	10%	(+)
Credit (C)	0.144	0.085	1.69	0.093	10%	(+)
Extension Visits (EV)	0.213	0.087	2.45	0.015	5%	(+)
R-squared (R^2)	**0.782**					
Adjusted R-squared	**0.658**					
F-statistic	**58.71**					

Source: Field survey, 2024. Note: *** significant at 1%, **significant at 5%, * significant at 10

The study applied the Cobb-Douglas production function to evaluate the socioeconomic factors influencing chewing cane production. The constant term (1.562, p = 0.058) was marginally significant at the 10% level, indicating a modest baseline production. Labour input (0.314, p = 0.007) showed a highly significant positive impact, confirming the labour-intensive nature of sugarcane farming, consistent with Issa *et al.* (2020), who observed that increased labor availability enhances farm efficiency in Nigeria. Similarly, the significance of farm size (0.208, p = 0.008) was also significant at the 1% level, indicating that landholding size directly influences output, possibly due to economies of scale, consistent with Unguwanrimi (2019), which highlights the scale advantage in crop production. However, fertilizer (β = 0.101) positively influences output, confirming its importance in enhancing soil fertility and supporting robust plant development, as also shown in recent findings by Ahmed *et al.* (2023), Zulu (2019) and Ambetsa *et al.* (2020).

Interestingly, the quantity of cuttings has a negative coefficient (β = -0.215), indicating that excessive or poor-quality planting material may reduce yield. This may reflect inefficiencies in input use or inappropriate spacing issues that have been highlighted in similar sugarcane studies across sub-Saharan Africa (Asogwa *et al.* 2021). Extension visits (β = 0.213) and access to extension services (β = 0.182) both positively impact output, reinforcing the role of knowledge transfer and advisory support in improving farming practices and productivity. Herbicide use (β = 0.256) also significantly boosts productivity, highlighting the importance of chemical weed control in optimizing plant growth and reducing competition for nutrients, as highlighted by Olowolaju and Akinbode (2022). The significance of household size (0.132, p = 0.031) implies that larger families may provide more labour, though the positive effect could also reflect support systems in decision-making and farm management, as highlighted by Afghan *et al.* (2023).

At the 10% significance level, farming experience (0.056) and access to credit (0.144), also show meaningful influence. Although marginally significant, farming experience contributes positively to output, as experienced farmers are more likely to understand local agronomic conditions, efficient input use, and risk management. Similarly, access to credit enhances a farmer's ability to invest in inputs like fertilizer, tools, and improved cuttings—key factors in boosting productivity. These findings are consistent with those of Sulaiman *et al.* (2015), who emphasized the role of credit in facilitating input access and farm growth. The significance of the constant term indicates that even without the influence of the specified variables, other unobserved factors (e.g., climate, natural soil fertility) still contribute positively to output. The R^2 of 0.782 suggests a strong overall model fit, with over 78% of output variation explained by the variables. Together, these results underscore the importance of both input-level decisions and institutional support (credit, extension) in improving sugarcane productivity.

4.3 Profitability Analysis of Sugarcane Production

The cost and return analysis for sugarcane production reveals a highly profitable enterprise in the study area. With a total revenue of ₦873,970.10 and a total cost of ₦154,670.33 per hectare, the calculated net farm income (NFI) stands at ₦787,299.09. This indicates strong profitability, as each ₦1.00 invested yields ₦6.09 in return. The gross margin (₦815,519.09) further supports this conclusion, emphasizing the economic viability of sugarcane cultivation under the prevailing production conditions. This aligns with recent findings by Olowolaju and Akinbode (2022), who observed that sugarcane production in Southwest Nigeria offers a high return on investment, driven largely by favorable market prices and relatively low mechanization costs. The absence of fixed costs, aside from land rent and depreciation, further amplifies profitability due to the minimal capital-intensive nature of sugarcane production in smallholder systems.

However, the cost structure reveals critical insights into input allocation. Cutting (₦45,260.33) and labor (₦36,250.00) account for the largest shares of variable costs, indicating that sugarcane farming remains labor-intensive and reliant on manual input. This dependence may pose a vulnerability in regions with aging rural populations or increasing rural-urban migration. Fertilizer and agrochemicals contribute less significantly to overall cost shares, yet their efficient use is essential for maintaining high yields. Studies by Ahmed *et al.* (2023) have shown that proper nutrient management combined with timely chemical application can enhance both yield and input efficiency. Therefore, while sugarcane farming in the region is currently profitable, future sustainability will depend on maintaining labor availability, optimizing input use, and adopting innovations that reduce reliance on manual operations without raising fixed costs significantly.

Table 3: Average Cost and Return per hectare of sugarcane production

Item (Annually)	**Qty**	**Unit Price (₦)**	**Useful Life (year)**	**Depreciation**	**Value/ Ha (s)**	**% of Total cost**
Total Revenue/ Ha	18	16.11	-	-	58, 471.01	
Variable cost						
Cutting (kg)	40	25.00	-	-	45, 260.33	23.7
Fertilizer (kg)	50	19.00	-	-	20, 140.00	14.8
Labour (man-day)	4	10.00	-	-	36, 250.00	17.6
Agrochemical (litre)	3	52.50	-	-	24, 800.00	3.5
TVC/Ha	-	-	-	-	126, 450.33	5.3
Fixed cost	-	-	-	-	0.00	-
Land Renting	-	-	-	-	25, 720.00	-
Depreciation	-		-		2, 500	2, 500.00
Total fixed cost (TFC)	-		-		-	28, 220.00
Total cost (TC) = (TVC + TFC)	-		-		-	154, 670.33
Gross margin (GM) (TR-TC)	-		-			815, 519.09
Net farm Income (NFI) (TR-TC)	-		-			787, 299.09
Net farm Income on N1 invested	-		-			6.09

Source: Field Survey, 2024.

Cost - Salvage value

Useful life

787,299.09 – 2,500.00

5

= 156,959.82

BOX 1

4.4 Technical Efficiency in sugarcane Production

The estimates of the stochastic frontier model presented in Table 4 revealed that the coefficients of resource inputs significantly impact sugarcane production outcomes.

Table 4: Result of Maximum Likelihood Estimate of the Stochastic Frontier Production Function for sugarcane Production

Variables	Coefficients	Std. Error	Z	P>/Z/	Priori Sign Expectation
Farm size	.466	.056	8.29	0.000***	(+)
Labour	.286	.091	3.13	0.002***	(+)
Quantity of cutting	-.539	.051	-10.55	0.000***	(+)
Fertilizer	.341	.293	1.16	0.245	(+)
Herbicide	.455	.093	4.89	0.000***	(+)
Constant	.833	1.138	0.73	0.464	
Inefficiency Model					
Age	.033	.026	1.24	0.214	(-)
Household size	.141	.058	2.41	0.016**	(+/-)
Education	.240	.514	0.47	0.640	(-)
Constant	-5.752	3.016	-1.91	0.057	
Diagnostic statistics					
Lambda	**.6109**				
Sigma_v	**.5387**				
Sigma_u	**.0344**				
Sigma2	**-1.236**				
Log Likelihood	**-204.75**				
Wald chi2(5)	**587.21**				
Prob > chi2	**0.0000**				

Source: Field survey, 2024. *10%significant, **5%significant, ***1%significant.

The results reveal that farm size significantly and positively influence sugarcane production, with coefficients of 0.466 ($p = 0.000$). This indicates that larger farm sizes contribute to greater output, supporting the a priori expectation and aligning with existing literature (Adeoti *et al.,* 2015). Similarly, the coefficient for labour (0.286) implies that increased labor input leads to greater productivity, likely due to the labor-intensive nature of sugarcane farming, which is consistent with finding of Ogunniyi and Akingbola, (2022). Conversely, the quantity of cutting shows a negative and significant impact (-0.539, $p = 0.000$), implying that excessive cutting adversely affects yield, potentially due to poor agronomic practices, as supported by Cheng *et al.* (2016). The use of herbicides shows a strong positive effect (0.455, $p = 0.000$), highlighting the importance of proper weed control, consistent with Liu *et al.* (2021) who emphasized chemical weed control as a key driver of crop efficiency in tropical agriculture. Fertilizer use, though positive (0.341), is not statistically significant ($p = 0.245$), suggesting its effect may be limited or not well optimized in the study area.

The inefficiency model identifies household size as a key factor contributing to reduced technical efficiency, with a significant positive coefficient (0.141, $p = 0.016$). This suggests that larger households may divert attention and resources away from efficient farm management, as argued in Rahman (2024). On the other hand, age and education do not significantly influence technical inefficiency, with p-values of 0.214 and 0.640, respectively. These findings suggest that in this context, non-demographic factors such as input use and farm management practices play a more substantial role in determining production efficiency than personal characteristics, contradicting studies like Kebede *et al.* (2017), which emphasize the role of education in enhancing agricultural efficiency.

The *lambda* ($\lambda = 0.6109$) indicates that inefficiency effects are present and relevant in explaining variation in output. The Wald chi-square statistic (587.21, $p < 0.01$) confirms the joint significance of the explanatory variables. However, the negative $sigma^2$ value may signal a computational issue, possibly due to model over-specification or convergence error. However, the results suggest that input management, particularly optimal use of land, labour, and weed control—plays a critical role in enhancing sugarcane production efficiency.

Table 5: Technical Efficiency Indices among Sugarcane Farmers

Class-Interval of Efficiency Indices	Frequency	Percentage (%)
0.20-0.29	3	1.24
0.30-0.39	4	1.65
0.40-0.49	35	14.46
0.50-0.59	50	20.66
≥0.60	150	61.98
Total	**242**	**100%**
Maximum	**0.65**	
Minimum	**0.20**	
Mean	**0.69**	

Source: Field survey, 2024.

The technical efficiency analysis of sugarcane farmers, as presented in Table 5, shows that a majority (61.98%) operate within the highest efficiency range (≥0.60), indicating effective utilization of resources and farming practices. Another 20.66% fall within the 0.50–0.59 bracket, and 14.46% within 0.40–0.49, reflecting moderate efficiency levels with potential for improvement. Only a small fraction—1.65% and 1.24%—fall within the lower efficiency ranges of 0.30–0.39 and 0.20–0.29, respectively, suggesting that few farmers are significantly underperforming. The average technical efficiency index is 0.69, with values ranging from 0.20 to 0.65, indicating that, on average, farmers are fairly efficient, though disparities in performance suggest opportunities for targeted support to improve lower-performing farms.

4.6 Constraints Associated with Sugarcane Production in the Study Area

Sugarcane cultivation in the study area was found to be associated with numerous constraints. The major constraints were identified and ranked in descending order as presented in Table 6.

Table 6: Constraints Associated with Sugarcane Production

	Problems	Frequency	Percentage	Remark
(a)	Diseases and pests	94	38.84	1
(b)	Inadequate Capital & Credit Inaccessibility	40	16.53	2
(c)	High cost of fertilizer	30	12.40	3
(d)	Theft	10	4.13	4
(e)	All of the above (a +b+c+d)	20	8.26	5
(f)	Options a & b	8	3.31	6
(g)	Options a & c	5	2.07	7
(h)	Options a & d	3	1.24	8
(i)	Options b & c	3	1.24	9
(j)	Options c & d	5	2.07	10
(k)	Options a, b & c	15	6.20	11
(l)	Options a, b & d	3	1.24	12
(m)	Options a, c & d	6	2.48	13
	Total	242	**100**	

Source: Field survey, 2024.

The major constraint identified by respondents in sugarcane production is the low demand for the crop, followed closely by inadequate capital and inaccessibility to credit, unaffordable fertilizer prices, and theft. Diseases and pests were also highlighted as significant production barriers, discouraging investment and leading to the underutilization of farming resources. These findings align with previous studies by Oni et al. (2019) and Adebayo *et al.* (2020), which emphasized the detrimental effects of pests, diseases, and inadequate support infrastructure like improved varieties and storage. A total of 40 farmers (16.53%) cited capital and credit inaccessibility as their sole production constraint, often relying on limited personal savings or insufficient informal borrowing. Fertilizer at unaffordable prices was the third-ranked challenge, with 30 farmers (12.40%) identifying it as their main limitation, echoing the concerns of Malam *et al.* (2018) and Adedoyin and Odebiyi (2021) on high input costs stifling productivity.

Theft was ranked as the fourth major problem, with farmers reporting frequent incidents during the harvest season that led to crop losses and reduced profits. Stalks were often stolen or damaged at night, affecting both yield and farmer morale. Security concerns such as these can negatively impact agricultural productivity, as noted by Oyekale (2020). Additionally, the survey revealed that many farmers experienced multiple overlapping challenges simultaneously, reflected in combined response options. This interconnectedness of constraints underscores the need for a holistic, multi-pronged approach to agricultural policy and intervention, as advocated by Iiyama *et al.* (2016), to effectively address the complex realities faced by sugarcane farmers.

CONCLUSION AND RECOMMENDATION S

The study on the economic analysis of sugarcane production among smallholder farmers in Niger State, Nigeria, has provided valuable insights into the viability, efficiency, and challenges of the enterprise. This study concludes that sugarcane production among smallholder farmers in Niger State holds substantial potential for improving rural incomes and enhancing agricultural development. While the enterprise is currently profitable, achieving higher productivity and efficiency will depend on addressing key constraints such as limited access to credit, inadequate extension support, and input inefficiencies. Strengthening institutional support systems, improving farmers' access to productive resources, and implementing policies that foster market access and infrastructure development are essential steps toward sustainable sugarcane production. Ultimately, empowering farmers through targeted interventions can bridge the current efficiency gap and unlock the full economic potential of sugarcane farming in the region.

Thus, with more access to extension services, farmers will be better informed on how to access more capital, improved cuttings, mitigate incidences of pests and diseases as well as efficiently utilize production inputs, thereby ensuring higher technical efficiency, increased productivity, net farm income and return on investment.

Based on the findings of this study, the following recommendations are made:

i. The study revealed inefficient use of farm inputs by sugarcane farmers. Therefore, extension agents in the study area should organize regular training programs to educate farmers on the optimum use of farm inputs for improved productivity.
ii. The Ministry of Agriculture and rural development authorities should formulate and implement market-enhancing policies that improve access to markets and ensure fair pricing mechanisms for sugarcane, thereby boosting farmers' income and ensuring sustainability.
iii. Development agencies and policymakers should design interventions that specifically address key socioeconomic constraints, including limited access to credit, low levels of formal education, and insecure land tenure. These factors limit farmer participation and output and should be integrated into rural development plans.
iv. Agricultural and microfinance banks should create and promote affordable, farmer-friendly loan schemes targeted at small- and medium-scale sugarcane farmers, ensuring timely access to credit for input purchase and farm expansion.
v. Relevant stakeholders, including government agencies, NGOs, and private sector actors, should prioritize solving major production challenges such as inadequate capital, high fertilizer costs, and farm theft by providing subsidies, security support, and infrastructure development.

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