



## ANALYSIS OF TECHNICAL AND ALLOCATIVE EFFICIENCY OF FARMERS ALONG GINGER VALUE CHAIN IN KADUNA STATE NIGERIA

<sup>1</sup>Alim, S. A., <sup>2</sup>Murtala, N., <sup>2</sup>Abdurrahman, S. and <sup>2</sup>Jibril, S. A.

<sup>1</sup>Department of Agricultural Technology, Kaduna Polytechnic, Kaduna State Nigeria

<sup>2</sup>Department of Agricultural Economics, Abubakar Tafawa Balewa University Bauchi, Bauchi State, Nigeria

**Corresponding Author's Email:** abdulrazaqsalim@gmail.com, **GSM:** 08035096327

### ABSTRACT

The study analyzed the technical and allocative efficiency of ginger farmers along the value chain in Kaduna State, Nigeria, with a view to identifying productivity gaps and their determinants. A multi-stage sampling technique was used to select 301 ginger farmers across major producing Local Government Areas, and primary data were collected through structured questionnaires during the 2025 production season. Data were analyzed using descriptive statistics, a stochastic frontier production and cost function (Cobb-Douglas specification). The results revealed that, ginger production is predominantly carried out by male (65.4%), middle-aged (mean age = 42.3 years), and experienced farmers (mean farming experience = 17.2 years), operating on small-scale farms (mean size = 1.0 ha) with limited access to extension services (8.31%) and credit (5.32%). The stochastic frontier results showed that, labour (0.4234), seed (0.2567), fertilizer (0.1456), agrochemicals (0.0890) and equipment (0.0456) significantly influenced output at 1% and 5% levels. The gamma value of 0.7234 indicated that 72.34% of output variation was due to technical inefficiency. The mean technical efficiency (TE) was 0.7234, implying a 27.66% output gap, while allocative efficiency (AE) was lower at 0.6456, suggesting a 35.44% cost inefficiency. Determinants of efficiency included age, household size, marital status, education and access to extension services. The study concludes that although farmers are moderately efficient, significant inefficiencies persist, particularly in input allocation, thereby limiting productivity and profitability in ginger production.

**Keywords:** Technical, Efficiency, Allocative, Ginger, Production

### INTRODUCTION

Agriculture represents a broad range of human productive activities that include crop production, livestock rearing, forestry, fishing, aquaculture, and other resource-based practices essential for human survival and economic progress. In developing economies such as Nigeria, agriculture remains a cornerstone of national development, serving as a primary source of food supply while simultaneously supporting poverty alleviation, employment creation, and sustainable means of livelihood. Historically, the sector has formed the bedrock of Nigeria's economy, absorbing over 60 percent of the rural workforce and continuing to play a pivotal role in economic diversification and social cohesion (World Bank, 2022; FAO, 2021). Within Nigeria's diverse agricultural system, ginger (*Zingiber officinale*) occupies a particularly important position. It is a perennial crop cultivated mainly for its aromatic rhizome, which is widely used in food processing, beverages, pharmaceuticals, and nutraceutical products. Over the past decade, global demand for ginger has expanded considerably, driven by increasing consumer preference for natural spices, herbal remedies, and functional foods. Consequently, ginger has evolved from a subsistence crop into a high-value export commodity, increasingly recognized for its capacity to generate foreign exchange, enhance rural incomes, and reduce poverty among farming households (Abubakar & Yahaya, 2022; Musa & Salihu, 2023). Nigeria is ranked among the leading producers of ginger worldwide, with Kaduna State serving as the country's major production center. Available estimates indicate that Nigeria produces several tens of thousands of metric tons annually, with approximately 70 percent exported to international markets, highlighting the crop's strong export prospects and relevance to national economic development (FAOSTAT, 2022; Yusuf *et al.*, 2024).



Despite these advantages, Nigeria's share of global ginger output remains relatively low when compared with the vast land area devoted to its cultivation. This imbalance is largely attributed to structural constraints such as the dominance of small-scale farmers, continued reliance on traditional farming methods, limited access to improved planting materials and mechanization, and weak agricultural extension services (Eze *et al.*, 2020; Aliyu *et al.*, 2023). Inadequate irrigation facilities and heavy dependence on rainfall further restrict productivity, particularly under conditions of increasing climate variability. Southern Kaduna, encompassing Kachia, Jaba, Jema'a, and Kagarko Local Government Areas, accounts for a substantial proportion of Nigeria's ginger output, alongside other producing areas such as Kajuru, Kaura, and Zango Kataf. Ginger varieties commonly cultivated in these locations, including *Taffin Giwa* and *Yatsun Biri*, are distinguished by their high oil content and strong aroma, characteristics that make them well suited for industrial processing into oils, oleoresins, and other value-added products (Aliyu *et al.*, 2023). However, inadequate processing facilities, poor storage systems, and weak marketing infrastructure continue to limit the competitiveness of Nigerian ginger within global value chains.

In addition to its economic relevance, ginger holds considerable importance in health, nutrition, and cultural practices. It is consumed in diverse forms such as fresh rhizomes, dried slices, powders, teas, juices, and food additives. Ginger is also widely valued for its medicinal properties, particularly in the management of nausea, digestive disorders, inflammation, and immune system support (Abubakar & Yahaya, 2022). During the COVID-19 pandemic, global consumption of ginger increased markedly as awareness of its immune-boosting potential grew (Onuorah & Ibekwe, 2021). This trend further underscores ginger's resilience and its capacity to support agribusiness development and market expansion at both domestic and international levels.

Despite the significant prospects associated with ginger production, the subsector in Nigeria remains largely underdeveloped. The ginger value chain is marked by several structural and operational weaknesses that limit its effectiveness as a sustainable pathway for employment creation and poverty alleviation, particularly among young people. Key constraints include inadequate access to credit facilities for smallholder farmers, weak coordination between producers and processors, insufficient market information systems, and fragile institutional support mechanisms (Musa & Salihu, 2023). In addition, post-harvest losses, which in some producing areas range between 20 and 30 percent, substantially erode profit margins and undermine the crop's capacity to drive meaningful economic transformation (FAO, 2021). For the youth population, these challenges translate into restricted access to agribusiness opportunities across the value chain, thereby exacerbating unemployment, poverty, and, in certain contexts, social unrest and insecurity, particularly within Southern Kaduna.

Overcoming these challenges necessitates a comprehensive assessment of the ginger value chain and its potential role in employment generation and poverty reduction. The value chain approach provides a holistic perspective by examining interconnected stages of production, processing, marketing, and consumption, while identifying critical bottlenecks and opportunities for targeted intervention. Existing literature suggests that improvements in value chain performance, through strategic investments in processing infrastructure, farmer organizations, extension services, and export facilitation, can generate substantial multiplier effects within rural economies (Yusuf *et al.*, 2024; Aliyu *et al.*, 2023). In the Nigerian context, effective utilization of the ginger value chain presents a viable avenue for youth engagement, entrepreneurial development, and economic diversification away from oil dependence.

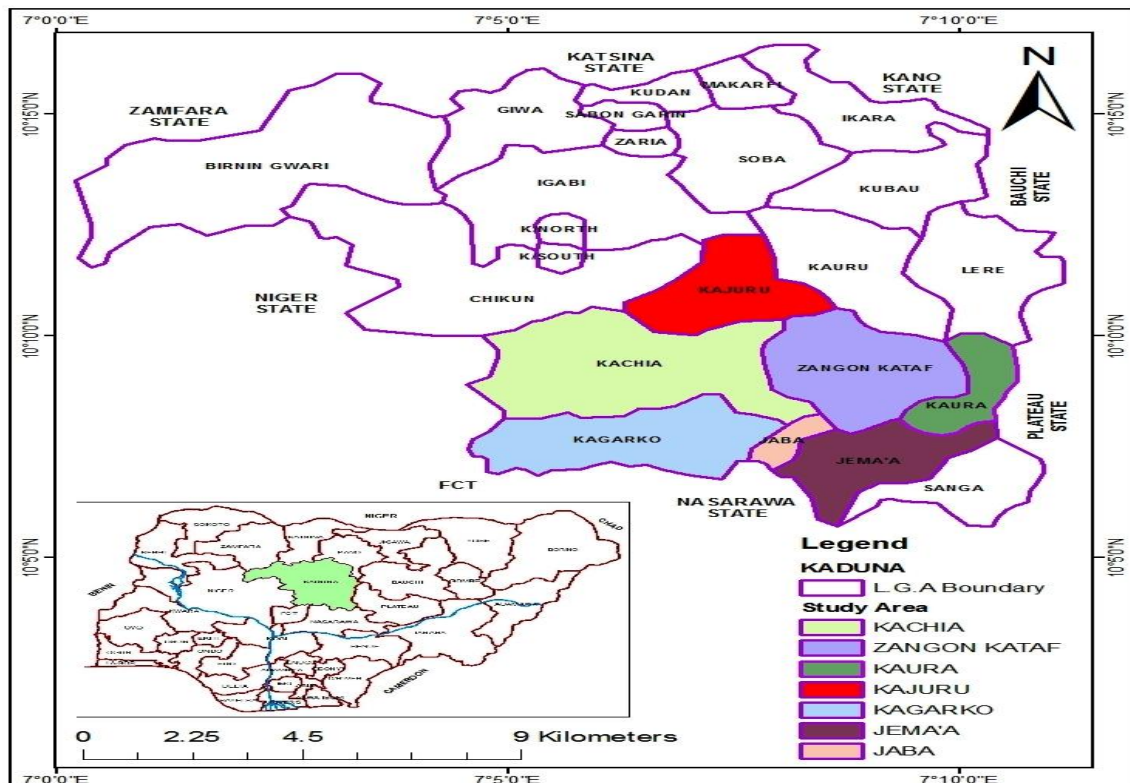
Given the substantial economic opportunities associated with ginger production, processing, and marketing, the crop represents a viable platform for engaging the growing youth population along its value chain as a means of addressing unemployment, poverty, and social instability in the state. However, despite these prospects particularly in Southern Kaduna, full production efficiency of the crop is yet to be achieved. The low yield of the crop had been a source of concern, particularly after the year 2023 fungal infestation of the crop which caused wide spread of damage to ginger in the area. This situation therefore requires examination of the efficiency of the farmers in the production of the crop in the study area to identify the determinants of the Technical and Allocative efficiency of ginger production by the actors.

**METHODOLOGY**

**The Study Area**

The research was conducted in Kaduna State, Nigeria, which lies between Latitude 09°02' and 11°32' North and Longitude 06°15' and 08°60' East of the Greenwich Meridian. Covering an area of approximately 46,016 km<sup>2</sup>, Kaduna State represents about 5% of Nigeria's total land mass of 923,768 km<sup>2</sup>, located in the country's central region. Administratively, the state comprises 23 Local Government Areas (LGAs) with a population of 7.8 million in 2023. With a projected growth rate of 3.2%, the population is estimated to reach 9,837,937 by 2026. The state experiences an average annual rainfall of 1,272.5 mm and relative humidity of 56.64%, while average daily temperatures range from 15.1°C to 35.18°C (Kaduna State Development Plan, 2013).

The soils in Kaduna State are moderately fertile and support continuous cropping of a variety of crops, including ginger, sorghum, cassava, cowpea, soybeans, and cotton (KSG, 2015). The predominant soil types are red-brown to red-yellow ferruginous tropical soils, heavily weathered and laterized, typically developed over granite and gneiss parent materials, as well as Aeolian and sedimentary deposits. The state's vegetation is largely tropical grassland, with tree and plant density decreasing toward the northern areas (Abaje, 2007). According to the Kaduna State Agricultural Survey (2017), 97.3% of farmers use fertilizers, mostly inorganic, while 43.1% use a combination of organic and inorganic fertilizers. Agriculture remains the most significant non-oil economic activity in the state, employing about 79.6% of the labor force (KDGHS, 2015).



**Figure 2:** Map of Kaduna State Showing the Study Area

**Sampling Procedure and Sample Size**

A multi-stage sampling technique was employed to select respondents for the study. The first stage involved purposively selecting seven (7) Local Government Areas in Kaduna State where ginger production was most prominent. The selected LGAs were Kachia, Kagarko, Jaba, Jama'a, Kajuru, Kaura, and Zango Kataf.



The second stage of the study involved the random selection of communities from each of the previously identified LGAs. Using the aggregate sample frame, the sample size of ginger producers was calculated using Taro Yamane’s (1967) formula. For this study, a sample of 320 ginger producers were selected. Details of the communities, sample frames, and corresponding sample sizes are presented in Table 1.

**Table 1: Sampling Frame and Sample Size of Ginger (Producers) Farmers**

LGAs	Communities	Sample Frame	Sample Size
Kachia	Walijo	100	13
	Kuda	120	15
	Kachia	180	23
	Awon	94	12
Kajuru	Maraba Kajuru	78	10
	Kasuwan Magani	104	13
	Kajuru	112	14
Kaura	Manchok	130	17
Zango Kataf	Zango Kataf	80	10
	Zonkwa	105	14
	Fadan Kamanto	60	8
Jaba	Tsakiya	160	21
	Kwoi	170	22
	Gode	150	19
Jama’a	Gidan Waya	200	26
	Kafanchan	70	9
	Kagoma	150	19
Kagarko	Kubacha	210	27
	Jere	120	15
	Kagargo	215	28
<b>Total</b>		<b>2,633</b>	<b>348</b>

**Method of Data Collection**

Primary data were collected through field surveys conducted during the 2025 agricultural seasons across the seven selected LGAs. Structured questionnaires were administered to the randomly selected actors within the ginger value chain to obtain socio-economic and demographic data, as well as information on production, processing, and marketing activities. Data were also gathered on household income patterns, including weekly and monthly earnings and the number of income sources per household. Secondary data were sourced from relevant agricultural development programs and non-governmental organizations. Additionally, Focus Group Discussions (FGDs) were conducted to obtain contextual and historical data that supplemented the primary information.

**Method of Data Analysis**

Descriptive statistics (such as percentage, frequency, mean) and stochastic frontier production function based on the Cobb-Douglas model was applied. The model is specified as:

$$\ln Y_i = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + V_i - U_i \text{----- (1)}$$

Where;

$\ln$  = Natural Logarithm,  $Y_i$  = Quantity of output (kg),

$X_1$  = Quantity of seed used (kg),

$X_2$  = Farm size (ha),

$X_3$  = Quantity of agrochemical (Liters),

$X_4$  = Quantity of fertilizer (kg),

$X_5$  = Labor input used (both family and hired labor) (man days),

$V_i$  = Error term which are random variables,

$U_i$  = Error term which are non-random variables or technical inefficiency effect,

$\beta_0$  = Intercept and  $\beta_1$ - $\beta_5$  = Regression coefficient

The technical inefficiency model is defined by;



$$U_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \delta_5 Z_5 + \delta_6 Z_6 + \delta_7 Z_7 + e_i \text{----- (27) Where,}$$

- $U_i$  = Technical inefficiency effect of the  $i$ th farm
- $Z_1$  = Age (years),
- $Z_2$  = Household size (Number of persons)
- $Z_3$  = Education (years of schooling)
- $Z_4$  = Access to credit (amount borrowed in ₦)
- $Z_5$  = Extension contacts (Number of visits per year)
- $Z_6$  = Membership of association (Years of participation)
- $Z_7$  = Sex of the farmer (male = 1, female = 0),
- $\delta_1 \delta_7$  = Parameters to be estimated and
- $e_i$  = Error term

## RESULT AND DISCUSSION

### Socio-economic Characteristics of Ginger Farmers

The results on the socio-economic characteristics of ginger producers (farmers) in Kaduna State as presented in Table 2 revealed a predominantly male-driven and smallholder-based production system, with 65.4% of respondents being male, reflecting gendered access to productive resources such as land and capital, while 34.6% female participation indicates a still notable but comparatively constrained role of women in primary production; the age structure shows that farmers are largely within their economically active years, with a mean age of 42.3 years and 55.5% falling within the middle-aged category (36–54 years), followed by 28.2% young farmers and 16.3% older farmers, suggesting a relatively strong labour force with both physical capacity and farming experience; marital status further reinforces the availability of household labour, as a substantial majority (67.8%) are married, while 17.2% are single and 14.0% widowed, indicating stable family structures that can support farm operations; this is complemented by a moderate household size averaging 5.1 persons, with 46.8% of households comprising 4–6 members, which is advantageous for labour-intensive activities but may also increase consumption pressure; educational attainment among farmers is relatively moderate, as 34.9% possess tertiary education and 33.6% secondary education, although 18.9% have no formal education, implying that while a significant proportion can adopt improved technologies, a notable segment may still face limitations in accessing and utilizing technical information; in terms of farming experience, producers are highly experienced with a mean of 17.2 years, and 44.7% having over 16 years of experience, indicating deep-rooted indigenous knowledge and technical familiarity with ginger production; however, critical institutional constraints are evident, as only 8.31% of farmers have access to extension services, severely limiting exposure to improved agronomic practices, and an even smaller proportion (5.32%) have access to formal credit, thereby restricting their capacity to invest in inputs and expand production; furthermore, farm size distribution confirms the dominance of smallholder agriculture, with 78.0% cultivating between 0.1 and 1.0 hectare (mean = 1.0 ha), which constrains economies of scale and commercialization potential; overall, the findings suggest that ginger production is sustained by experienced, middle-aged farmers operating within small-scale systems, but their productivity and growth potential are significantly hindered by limited institutional support, financial exclusion, and structural constraints in resource access.

**Table 2: Socioeconomic Characteristics of Ginger Value Chain Actors**

Variables	Farmers		Processors		Marketers	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
<b>Gender</b>						
Male	197	65.4	61	51.3	24	53.3
Female	104	34.6	58	48.7	21	46.7
Total	301	100	119	100	45	100
<b>Age</b>						
Young Farmers (18–35)	85	28.2	30	25.3	14	31.82
Middle-Aged Farmers (36–54)	167	55.5	83	69.7	30	68.18
Older Farmers (55 and above)	49	16.3	6	5.0	0	-
Total	301	100	119	100	44	100
Mean	42.3		40.8		40.27	
Std. Dev	11.5		8.2		7.1	
<b>Marital Status</b>						
Single	52	17.2	15	12.7	4	9.1
Married	204	67.8	82	69.5	36	81.8
Widowed	42	14.0	15	12.7	3	6.8
Divorced	3	1.0	6	5.1	1	2.3
Total	301	100	118	100	44	100
<b>Household Size</b>						
Small (1-3)	80	26.6	24	21.2	18	41.9
Medium (4-6)	141	46.8	61	54.0	17	39.5
Large (7 and above)	80	26.6	28	24.8	8	18.6
Total	301	100	113	100	43	100
Mean	5.1		5.5		5.0	
Std. Dev	2.9		2.7		2.5	
<b>Education Level</b>						
No formal education	57	18.9	10	8.4	2	4.4
Primary	38	12.6	33	27.7	3	6.7
Secondary	101	33.6	31	26.1	23	51.1
Tertiary	105	34.9	45	37.8	17	37.8
Total	301	100	119	100	45	100
<b>Occupational Experience</b>						
Less than 5 Years	26	8.7	17	14.4	11	26.8
5-15 Years	140	46.6	76	64.4	23	56.1
16 Years and above	134	44.7	25	21.2	7	17.1
Total	300	100	118	100	41	100
Mean	17.2		12.2		9.41	
Std. Dev	11.3		7.1		7.17	
<b>Access to Extension</b>						
No	276	91.69	107	91.45		
Yes	25	8.31	10	8.55		
Total	301	100	117	100		
<b>Access to Credit</b>						
No	285	94.68	98	90.74		
Yes	16	5.32	10	9.26		
Total	301	100	108	100		
<b>Farm Size</b>						
0.1-1.0 Hectare	234	78.0				
1.1-2.0 Hectares	58	19.3				
2.1-3.0 Hectares	8	2.7				
Total	300	100.0				
Mean	1.00					
Std. Dev	0.74					



### Technical Efficiency (TE) of Ginger Production

The Stochastic Frontier Production Function estimates as shown in Table 3, revealed a relationship between input use and maximum attainable output, controlling for random shocks. The highly significant positive coefficients for all conventional inputs; Labor (0.4234), Seed (0.2567), Fertilizer (0.1456), Agrochemicals (0.0890), and Equipment (0.0456), confirm their statistically significant contributions to ginger output. This aligns with the factor productivity studies of Suleiman and Bawa (2024), who identified seed quality and labour as the primary yield determinants in Kaduna's ginger belt.

The Gamma ( $\gamma$ ) parameter of 0.7234 is highly significant, indicating that approximately 72.34% of the deviation from the frontier is attributable to technical inefficiency rather than random variability (Battese & Coelli, 1995).

Inefficiency Drivers (TE Model): The negative and significant coefficient for Age (-0.374) suggests that younger farmers are closer to the production frontier. This supports the findings of Sani *et al.* (2024) on the positive correlation between youth and the adoption of improved agronomic practices. The negative coefficient for Household Size (-0.593) implies that larger families, potentially providing more familial labour, enhance technical efficiency, a resource-endowment effect noted by Chindo *et al.* (2023). The positive and highly significant coefficient for Marital Status (0.19) indicates that, *ceteris paribus*, married farmers exhibit higher inefficiency. This counter-intuitive result may reflect increased household consumption pressures diverting resources from production or differing risk preferences, warranting further qualitative investigation as suggested by Okeke and Ude (2024)

**Table 3:** Technical Efficiency among Ginger Farmers

Variable	Coefficient	Std. Error	p-value
Constant	2.4567***	0.1234	0.000
Labor	0.4234***	0.0456	0.000
ln Seed	0.2567***	0.0345	0.000
ln Fertilizer	0.1456***	0.0289	0.000
ln Chemicals	0.089***	0.0234	0.000
ln Equipment	0.0456**	0.0198	0.022
<b>Inefficiency model</b>			
Age	-0.374***	0.108	0.001
Sex	0.32***	0.194	0.099
Marital Status	0.19***	0.013	0.000
Household Size	-0.593***	0.21	0.005
Education Level	-0.342	0.218	0.117
farming experience	0.241	0.214	0.259
access extension	0.192	0.265	0.472
<b>Variance Parameters</b>			
Sigma Square	0.155236		
Gamma ( $\gamma$ )	0.7234		
Log-Likelihood	-145.6789		
Observations	301		

\*, \*\*, \*\*\*, indicate significance at 10%, 5% and 1%, respectively

### Allocative Efficiency (AE) of Ginger Production

The Allocative Efficiency model as shown in Table 4, derived from a Stochastic Frontier Cost Function, assessed farmers' ability to use inputs in optimal proportions given their prices to minimize cost. The positive and significant coefficients for inputs (Labor, Seed, Fertilizer, Chemicals) and output in the frontier model are as expected.

The results showed that, major production inputs significantly influenced cost efficiency in ginger production. Labour has a positive and highly significant coefficient (0.34) at the 1% level,



indicating that efficient utilization of hired and family labour is crucial for minimizing production costs in this labour-intensive enterprise. Seed cost also has a positive and highly significant coefficient (0.23) at the 1% level, implying that appropriate investment in quality ginger rhizomes enhances efficient input allocation. Fertilizer use exerts a positive and significant effect on allocative efficiency with a coefficient of 0.15, highlighting the importance of proper nutrient management. Agro-chemicals have a positive coefficient (0.07), suggesting that judicious use of pesticides and herbicides contributes to cost efficiency by preventing yield losses. Output level records a large positive and highly significant coefficient (0.78), indicating the presence of economies of scale, where higher output levels allow farmers to spread production costs more efficiently.

Inefficiency Drivers (AE Model): The drivers of allocative inefficiency differ markedly from those of technical inefficiency. Education Level (-0.212) and Access to Extension (-0.6662) have significant negative coefficients, strongly indicating that more educated farmers and those with extension contact make more cost-minimizing input allocation decisions. This powerfully corroborates the human capital theory in agriculture advocated by Adebayo and Tanko (2023). Conversely, Age (0.292) has a positive coefficient, signifying that older farmers are *less* allocatively efficient, possibly due to resistance to adjusting input combinations in response to changing market prices. The significant negative coefficient for Marital Status (-0.419) suggests married farmers are *more* allocatively efficient, contrasting with the TE finding and perhaps indicating stronger economic imperative for cost minimization within households.

**Table 4:** Allocative Efficiency of Ginger farmers

Variable	Coefficient	Std. Error	t-Statistic
Constant	3.45***	0.234	0.000
In_labor	0.34***	0.057	0.000
In_seed	0.23***	0.046	0.000
In_fertilizer	0.15***	0.035	0.000
In_chem	0.07**	0.029	0.006
In_Output	0.78***	0.024	0.000
<b>Inefficiency Model</b>			
Age	0.292***	0.046	0.000
Sex	0.209	0.168	0.215
Marital_Status	-0.419***	0.016	0.000
Household_Size	-0.124	0.148	0.406
Education_Level	-0.212***	0.039	0.000
farming_experience	0.441	0.884	0.624
access_extension	-0.666***	0.196	0.001
<b>Variances</b>			
Sigma Square	0.108		
Gamma ( $\gamma$ )	0.7345		
Log-Likelihood	-167.89		
Observations	301		

\*\* ,\*\*\*, indicate significance at 5% and 1%, respectively

### Distribution of Technical (TE) and Allocative Efficiency (AE) among Ginger Producers

The frequency distribution of Technical and allocative efficiency estimates of ginger producers in the value chain is presented in Table 5. The Table indicated a mean TE of 0.7234 (72.34%) suggests that, on average, farmers produce 72.34% of the potential output attainable from their given input bundle. This implies a 27.66% output shortfall due to inefficiencies. The table also revealed only 22.5% of farmers operate at a high-efficiency level ( $TE \geq 0.80$ ), while 28.5% operate at low efficiency ( $TE < 0.60$ ), indicating widespread heterogeneity and significant potential for improvement through better farm management practices.

The Allocative efficiency mean AE of 0.6456 (64.56%) is notably lower than the mean TE, revealing a more severe constraint: farmers are only 64.56% cost-effective in their input allocation. This



indicates that for a given output level, farmers could reduce costs by approximately 35.44% by optimizing their input mix relative to prices. This AE-TE gap underscores a critical knowledge or market failure in factor price responsiveness, a phenomenon detailed by Eze *et al.* (2023).

**Table 5:** Efficiency Distribution among Farmers'

Efficiency Level	TE Frequency	TE Percentage	AE Frequency	AE Percentage
High ( $\geq 0.80$ )	45	22.5	32	16
Medium (0.60-0.79)	98	49	85	42.5
Low ( $< 0.60$ )	57	28.5	83	41.5
Mean	0.7234		0.6456	
Minimum	0.3456		0.2789	
Maximum	0.9567		0.9345	

## CONCLUSION AND RECOMMENDATIONS

The study finds that ginger production in Kaduna State operates at moderate efficiency, with farmers relatively better at producing output (technical efficiency) than at minimizing costs (allocative efficiency). However, inefficiencies persist due to poor resource allocation, limited access to credit and extension services, and the dominance of smallholder farming systems. Socio-economic factors such as age, education, and household characteristics significantly affect performance, emphasizing the role of human capital and institutional support. Although there is potential for improved productivity and cost efficiency especially through scaling up production this potential is constrained by structural and knowledge-related challenges that need to be addressed.

The study therefore recommended the need for an integrated approach to improve ginger farmers' efficiency in Kaduna State by strengthening extension services, improving access to affordable credit, and enhancing farmers' skills through training. Promoting cooperatives, encouraging the adoption of improved technologies, and providing reliable market information that are also key to better decision-making and productivity. Additionally, supporting land consolidation or cluster farming can help farmers achieve economies of scale, reduce costs, and improve overall competitiveness in the ginger value chain.

## REFERENCES

- Abaje, I. B. (2007). *Introduction to soils and vegetation of Nigeria*. Kaduna: Joyce Publishers.
- Abubakar, S., & Yahaya, M. (2022). Economic importance and health benefits of ginger production in Nigeria. *Nigerian Journal of Agricultural Economics*, **12**(2): 45–56.
- Adebayo, A. A., & Tanko, L. (2023). Human capital and allocative efficiency among smallholder farmers in Nigeria. *Journal of Agricultural Economics and Development*, **15**(1): 23–35.
- Aliyu, A., Mohammed, S., & Yakubu, M. (2023). Value chain analysis and constraints of ginger production in Northern Nigeria. *African Journal of Agricultural Research*, **19**(4): 210–222.
- Battese, G. E., & Coelli, T. J. (1995). A model for technical inefficiency effects in a stochastic frontier production function. *Empirical Economics*, **20**(2): 325–332.
- Chindo, A., Musa, I., & Abdullahi, U. (2023). Household labour and farm efficiency in northern Nigeria. *Journal of Rural Development Studies*, **18**(2): 78–90.
- Eze, C. C., Anyaegbunam, H. N., & Okonkwo, C. O. (2020). Constraints to ginger production in Nigeria. *International Journal of Agricultural Policy and Research*, **8**(3): 101–110.
- Eze, C. C., Okeke, C., & Ibrahim, S. (2023). Input price responsiveness and allocative efficiency among spice farmers in Nigeria. *Agricultural Economics Review*, **14**(1): 66–79.
- FAO. (2021). *Nigeria agricultural sector review*. Rome: Food and Agriculture Organization.
- FAOSTAT. (2022). *FAO statistical database*. Retrieved from <https://www.fao.org/faostat>
- Kaduna State Government (KSG). (2015). *Kaduna State agricultural policy document*. Kaduna: Ministry of Agriculture.
- Kaduna State Development Plan. (2013). *Development strategy and implementation plan*. Kaduna State Government.



- KDGHS. (2015). *Kaduna State household survey report*. Kaduna: National Bureau of Statistics.
- Musa, A., & Salihu, B. (2023). Constraints and opportunities in ginger value chain development in Nigeria. *Journal of Agribusiness and Rural Development*, **17**(2): 89–102.
- Okeke, M. N., & Ude, C. C. (2024). Behavioral drivers of agri-enterprise investment among rural youth in Northern Nigeria. *Journal of Agricultural and Resource Economics*, **49**(1): 45-62
- Onuorah, C., & Ibekwe, U. (2021). COVID-19 and the rising demand for medicinal crops in Nigeria. *Health and Agriculture Journal*, **9**(1): 55–63.
- Sani, A., Bello, M., & Ibrahim, Y. (2024). Youth participation and agricultural productivity in Northern Nigeria. *Journal of Agricultural Extension*, **28**(1): 34–48.
- Suleiman, A., & Bawa, D. (2024). Input productivity and efficiency of ginger farmers in Kaduna State. *Nigerian Journal of Agricultural Production*, **21**(1): 112–125.
- World Bank. (2022). *Nigeria development update: Agriculture for economic transformation*. Washington, DC: World Bank.
- Yusuf, S., Ibrahim, A., & Lawal, M. (2024). Ginger export potential and value chain performance in Nigeria. *International Journal of Agricultural Economics*, **10**(1): 15–29.