



Production Risk and Productivity of Smallholder Onion Farmers in Taraba State, Nigeria

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KEYWORDS

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ABSTRACT

This study examined the production risks and productivity of smallholder onion farmers in Taraba State, Nigeria. The study specifically analyzed the production risk associated with onion production for each input, assessed the contribution of major production inputs to onion output, and estimated the returns to scale in onion production. A multistage sampling procedure was used to select 254 onion farmers from Jalingo, Ardo-Kola, and Wukari Local Government Areas of Taraba State. Primary data were collected during the 2025 cropping season using semi-structured questionnaires. The collected data were analyzed using Cobb-Douglas production function model. The results revealed that Fertilizer, seed, and agro-chemicals played a significant role in increasing output and reducing production risk, while labour remains a major source of yield variability. The findings also revealed that seed ($\beta = 0.424$, $p < 0.01$), fertilizer ($\beta = 0.475$, $p < 0.01$), and labour ($\beta = 0.096$, $p < 0.01$) had positive and statistically significant relationship with onion output, while agro-chemical use had a positive but statistically insignificant relationship ($\beta = 0.004$, $p = 0.485$); with seed and fertilizer exercise the strongest relationship on productivity. The estimated return to scale indicated increasing returns to scale, implying that farmers were still operating below the optimum production level and could increase output by more efficiently utilizing available resources. The study concluded that onion production in Taraba State has considerable potential for improved productivity if farmers are supported with quality inputs, extension services, and improved production practices. The study recommended that farmers should be encouraged to use improved onion seed and fertilizer appropriately. Although seed and fertilizer contributed positively to onion output, their risk-reducing relationship was not statistically significant. Therefore, farmers should focus on using good-quality seed and applying fertilizer at recommended rates rather than simply increasing the quantities used.

CITATION

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INTRODUCTION

Onion (*Allium cepa* L.) is one of the most widely cultivated vegetable crops in the world because of its nutritional, medicinal, and economic importance. It is commonly used in the preparation of soups, stews, sauces, and several local dishes consumed daily in many households. Apart from improving the taste and flavour of food, onions also provide essential vitamins and minerals that contribute to healthy living (Olanrewaju et al., 2021). In many parts of Sub-Saharan Africa, onions and other vegetables serve as relatively cheap and accessible sources of nutrients such as vitamins, zinc, iron, and proteins required for proper body functioning (Osei et al., 2017; Robert et al., 2021).

Globally, onion production occupies an important position in vegetable farming. According to the Food and Agriculture Organization (FAO, 2020), onion cultivation covers approximately 5.4 million hectares, with annual production estimated at over 104 million tons worldwide. Countries such as India, China, the United States, Egypt, and Turkey rank among the leading onion producers globally. In Africa, Nigeria is recognized as one of the major onion-producing countries, with production estimated at 1.55 million tons in 2022 (FAO, 2024). Onion farming in Nigeria is largely dominated by smallholder farmers who cultivate the crop under both rain-fed and irrigated conditions.

In Taraba State, onion farming has become an important agricultural activity among rural households, especially during the dry season. The state possesses favourable climatic conditions, fertile soils, and extensive inland valleys that support vegetable production across many communities. Onion farming, therefore, provides employment opportunities, income, and livelihood support to many farming households within the state. Despite these favourable conditions, onion production in Taraba State has remained unstable over the years. Fluctuations in output have been linked to factors such as limited access to improved inputs, pest and disease infestations, declining soil fertility, inadequate extension support, and inefficient use of production resources (TADP, 2021).

Improving agricultural productivity remains one of the key strategies for increasing farmers' income and strengthening food security. Productivity analysis is important because it helps to determine how efficiently farmers combine production inputs such as seed, fertilizer, labour, and agrochemicals to generate output. Understanding the contribution of these inputs to onion production can assist policymakers, extension agents, and farmers in making informed decisions regarding resource allocation and improved production practices.

According to Kara et al. (2019), agricultural productivity among smallholder farmers in developing countries is often constrained by poor resource management, inadequate access to modern technologies, and production risks associated with climate variability and pest infestation. Similarly, Osei et al. (2017) observed that vegetable production in Africa is affected by limited access to productive resources and inefficient utilization of available farm inputs.

Several studies have examined agricultural productivity and technical efficiency in Nigeria. Studies such as Khai and Yabe (2011), Rahman et al. (2012), Ambaliet al. (2012), and Yahaya et al. (2019) emphasized the importance of efficient use of inputs in improving agricultural productivity among smallholder farmers. However, there is still limited empirical evidence specifically focusing on onion productivity in Taraba State.

This study was therefore undertaken to analyze the production risks associated with onion production for each input, determine the contribution of production inputs to onion output; and estimate the returns to scale in onion production.

MATERIALS AND METHODS

Study Area

The study was conducted in Taraba State, located in the northeastern part of Nigeria. The state lies between latitude 6°34' and 9°58' North of the Equator and longitude 9°00' and 12°00' East of the Greenwich Meridian. Taraba State shares boundaries with Bauchi and Gombe States to the north, Adamawa State to the east, Plateau, Nasarawa, and Benue States to the west, and the Republic of Cameroon to the south.

Agriculture remains the major occupation of the people in the state, with crops such as onion, tomato, pepper, maize, rice, cassava, and yams commonly cultivated. The climate of the state is characterized by distinct wet and dry seasons, with annual rainfall ranging from 1200 mm to 1800 mm and average temperatures of about 20°C (Oruonye and Abbas, 2011). These climatic conditions make the state suitable for dry-season vegetable production, especially onion farming.

Figure 1 shows the major onion producing areas in Taraba State, Nigeria, highlighting their geographical distribution and concentration. The map provides insight into where onion cultivation is most prevalent in the state and supports understanding of agricultural patterns, economic activities, and resource allocation related to onion production.

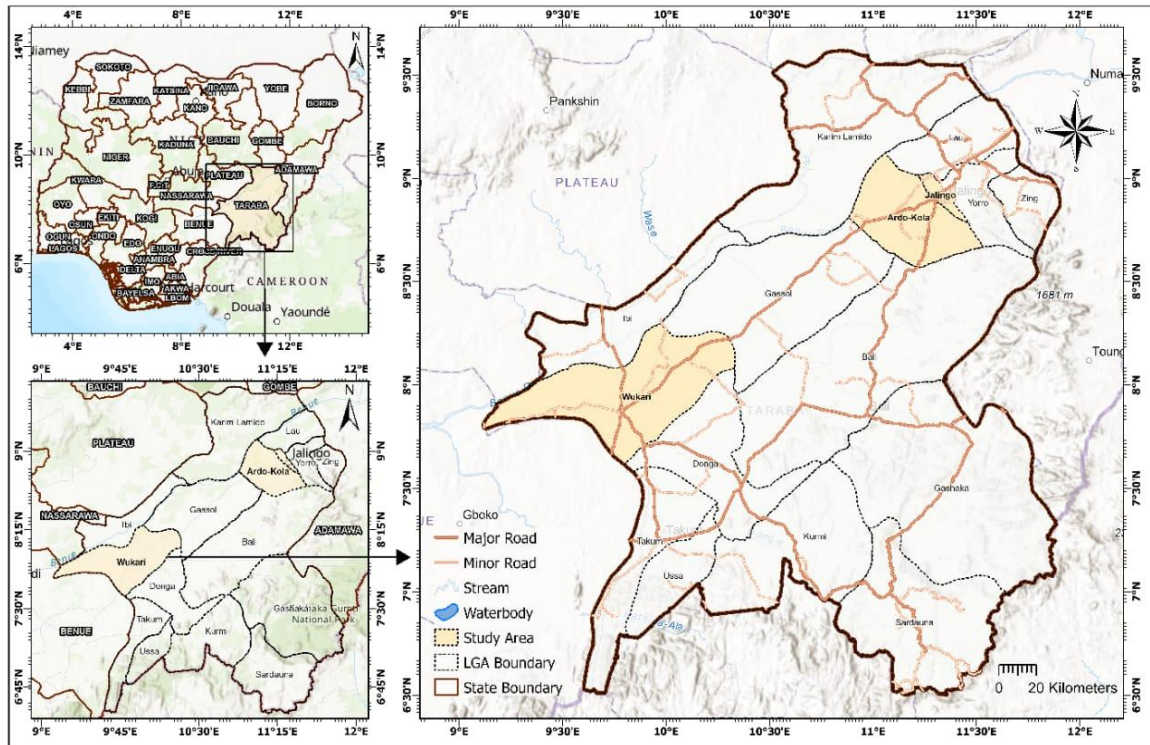


Figure 1: Map of the Study Area

Source: Geography Department, Taraba State University Jalingo, 2024.

Sampling Techniques and Sample Size

A multistage sampling procedure was employed for the study. In the first stage, Jalingo and Ardo-Kola Local Government Areas were purposively selected from Zone I. In contrast, Wukari Local Government Area was selected from Zone II for its prominence in onion production. In the second stage, eleven major onion-producing communities were selected from the chosen Local Government Areas. Through the snowball sampling technique, a total of 752 onion farmers were identified. The sample size of 261 respondents was determined using the Yamane (1967)

sample size formula as cited in Danji et al. (2025). The formula is given as:

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

Where:

n = sample size

N = population size

e = margin of error at 5% (0.05)²

$$\text{Thus, } n = \frac{752}{1 + 752(0.05)^2} = 261$$

Table 1: Sample Design Outlay for the Study Area

S/N	Blocks	Farming Cells	Estimated Population of Onion Farmers	Sample Size of the Onion Farmers
Zone I	Ardo-kola	Pantitugang	85	30
		Mallamhayatu	59	20
		Kantilye	41	14
	Jalingo	Water board	123	43
		Magami	88	31
		Babadidi	72	25
		Nukai	53	18
Zone II	Wukari	Arufu	82	28
		Ndo-katswen	49	17
		Chinkai	54	19
		Tsukondi	46	16
Total	3	11	752	261

Source: Field Survey, Data. 2025.

Sources and Methods of Data Collection

Primary data were collected during the 2025 cropping season using structured questionnaires administered to onion farmers. Information obtained from the respondents included age, educational level, farming experience, household size, extension contact, quantity of inputs used, and total onion output harvested during the production season.

Model Specifications

Stochastic Frontier Model with Flexible Risk Properties
Production Risk

An input is seen as risk increasing when a higher quantity ends up with more output variance, while it is considered risk decreasing if a rise in quantity actually reduces output variance (Ogundari & Akinbogun, 2010). Over the years, the Just and Pope model has been tweaked in a number of different ways, by researchers. In particular, Kumbhakar (2002) brought in a generalized stochastic setup with a

more flexible risk specification. The model basically lets us determine which inputs affect output variance either straightforwardly or indirectly, all inside a stochastic frontier framework.

$g(x_i; \psi) v_i = \psi_0 + \sum_{m=1}^4 \psi_m x_{mi}$ (2)
Where x_i 's represent the input variables, ψ_m 's are the estimated risk model parameters and the v_i 's are the pure noise effects. X_{0i} , denotes land measured in hectare X_{1i} , denotes quantity of seed measured in kilograms X_{2i} , denotes quantity of fertilizer measured in kilograms X_{3i} , denotes agro-chemicals measured in litre, and X_{4i} denotes labour measured in man-days. The Ψ_m 's are the marginal production risks of the individual inputs and if it is positive. it means that the respective input is a risk increasing input. And if Ψ_m becomes negative it means that the respective input reduces output variance. The input factors i.e. seed, fertilizer, agro-chemicals and labour can either increase production risk or decrease it.

Table 2: Variables in the Production Risks Function and their A Priori Expectations

Variable	Description	A priori Expectation
X ₁	Seed	+/-
X ₂	Fertilizer	+/-
X ₃	Agro-chemicals	+/-
X ₄	Labour	+/-

Source: Field Survey Data, 2025

Elasticity and Return to Scale

The output elasticities concerning different inputs depend on the input levels and are typically expressed as functions of these levels

$\frac{\partial \ln E(Y_i)}{\partial \ln X_j} = \{\beta_j + \beta_{jj} \ln X_{ji} + \sum_{k \neq j} \beta_{jk} \ln X_{ki}\}$ (3)

But if the output and input variables have been normalized by their own sample averages, then the first order coefficient can be seen as elasticity values for output relative to those different inputs (and yes, it's evaluated at the variable means). In this study, because the output and input variables were normalized using the standardized mean method, the first order coefficients tied to the input variables can therefore be taken as output elasticities. The overall combined amount of those output elasticities gives you the estimated scale elasticity, which is basically the percent change in output that happens when all inputs shift by 1% at the same time. In other words, scale elasticity captures the returns to scale for the onion producers in the sample.

When the scale elasticity is greater than one, it suggests increasing returns to scale. If the estimate is under one, then it points toward decreasing returns to scale, while if it lands exactly at one, you get constant returns to scale. The input variables used here are seed, fertilizer, agrochemical and labour.

Hypotheses Test

The hypotheses of the study were investigated using the generalized likelihood ratio statistic (LR) stated as: $A = -2\{\text{Log} [(H_o) - \text{Log} (H_a)]\}$.

Where; $\text{Log} [L (H_o)]$ denotes log likelihood of null hypothesis and $\text{Log} [L (H_a)]$ denote log likelihood of alternative hypothesis. The values of $\text{Log} [L (H_o)]$ and $\text{Log} [L (H_a)]$ are provided by the analyzed result of the stochastic frontier analysis.

The Cobb-Douglas production function was used to estimate the relationship between onion output and production inputs. The implicit form of the model is expressed as:

$Y = f(X_1, X_2, X_3, X_4)$

The explicit form of the model is specified as:

$\ln Y = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \mu$

Where:

Y = Onion output (kg/ha)

X₁= Quantity of seed used (kg/ha)

X₂ = Fertilizer used (kg/ha)

X₃= Agrochemicals used (litre/ha)

X₄= Labour input (man-days/ha)

β_0 = Constant term

$\beta_1 - \beta_4$ =Parameters estimated

μ = Error term

The return to scale was estimated as the sum of the production elasticities:

$$RTS = \beta_1 + \beta_2 + \beta_3 + \beta_4$$

RESULTS AND DISCUSSION

Production Risk Estimates of the Farmers

Production risk when it comes to input use is one of the vital things in agricultural production analysis, and it tends to shape how farmers plan. The results shown in Table 3 suggest that seed, fertilizer, and agrochemicals behave as meaningful risk-reducing inputs in onion production within the study area, while labour, on the other hand, is observed as a risk-increasing input. So, in plain terms, when farmers manage seed, fertilizer and agrochemicals well, it should be possible to reduce output variability and also help stabilize yield, even under the same production technology that already exists. A risk averse farmer is usually careful about uncertainties in production, and for that reason they

may cut back on labour use, because labour has been linked with higher yield variability. Instead of that, such a farmer will likely choose to intensify the use of inputs that are more stable and also less risky, like improved seed, fertilizer, and agrochemicals. In doing this, the farmer aims to smooth output swings, and reach a yield pattern that is more consistent and predictable. In a more clear term, the production risk estimates showed that agrochemical use significantly reduced production risk ($\beta = -0.944$, $p = 0.009$) whereas labour significantly increased production risk ($\beta = 4.585$, $p < 0.001$). Seed and fertilizer had negative but statistically insignificant relationship with production risk. This finding agrees with Koye et al. (2022), who reported that input management practices, especially the optimal use of seed and fertilizer, have a significant influence on both efficiency and stability of irrigated onion in Ethiopia.

Table 3: Production Risk Estimate of the Farmers

Variable	Parameter	Coefficient	Std Error	P-Value
Constant	γ_0	-7.96203	4.330773	0.066
Seed	γ_1	-1.750625	3.232949	0.588
Fertilizer	γ_2	-2.236272	4.035992	0.580
Agro chemicals	γ_3	-0.9440263	0.362691	0.009***
Labour	γ_4	4.585251	0.7902513	0.000***

Source: Field Survey Data, 2025

Productivity of Production Inputs

The estimated Cobb-Douglas production function revealed that seed, fertilizer, agrochemicals, and labour positively influenced onion output in the study area. Seed and fertilizer were found to have the strongest positive effect on output, implying that increased use of high-quality seed and proper fertilizer application could significantly enhance onion productivity. This finding agrees with the observations of Rahman et al. (2012), who reported that improved seed varieties and proper fertilizer application significantly increase crop productivity among

smallholder farmers. Similarly, Ambaliet al. (2012) noted that efficient utilization of productive inputs contributes positively to agricultural output.

Labour also contributed positively to onion output, reflecting the labour-intensive nature of onion farming in the study area. Similarly, agrochemical use improved yields by better controlling pests, diseases, and weeds that could reduce them. The positive coefficients on the production inputs indicate that increasing their use within recommended levels would lead to higher onion output among farmers.

Table 4: Output Elasticity for Inputs in the Stochastic Frontier Production Function

Variable	Elasticity
Seed	0.4237
Fertilizer	0.4750
Agro-chemicals	0.0041
Labour	0.0961
Return to Scale (RTS)	0.9989

Source: Field Survey Data, 2025

Returns to Scale

The estimated return to scale was approximately one, indicating increasing returns to scale in onion production. This suggests that farmers in the study area were still operating below the optimum level of production and could increase output by more than a proportional amount through better utilization of available resources. The implication is that improved access to productive inputs

and better management practices could substantially increase onion production in the study area without necessarily expanding the cultivated land area. This finding supports the work of Khai and Yabe (2011), who observed that smallholder farmers in developing countries often operate below optimal production levels due to poor access to productive resources and inefficient resource allocation.

Hypothesis Tests

They maximum likelihood ratio (LR) test was used to look at whether the Cobb-Douglas model fits well, and also to see if production risk plus technical inefficiencies show up in onion production. From Table 5, it seems like the Cobb-Douglas functional form is able to represent the data properly, and it suggests that putting in second-order interaction terms does not really add much to the model explanatory power. Then, the second hypothesis, saying that production risk in input components does not help explain output variability,

was not accepted at the 5% level of significance. In other words, production risk tied to how inputs are used seems to affect onion output significantly in the study area. This result points to the idea that input-driven threats or uncertainties are key for yield steadiness. Similar views were mentioned by Koyeet al. (2022), who found that variability in input use such as fertilizer, seed, and irrigation water significantly shaped onion output for irrigated farmers in the North Gondar Zone of Ethiopia.

Table 5: Results of Hypotheses Test for Parameters in the Stochastic Frontier Function

Null Hypothesis	Log Likelihood of Ho	Log Likelihood of Ha	Test Statistics (λ)	Degree of Freedom	Critical Value (λ_2)	Decision
$H_0: \alpha_{ij} = 0$	528.68	527.49	2.38	1	2.71	Accept H_0
$H_0: \psi_1 = \psi_2 = \dots = \psi_4 = 0$	528.74	590.34	123.22	4	8.76	Reject H_0
$H_0: \delta_5 = \delta_6 = \dots = \delta_{09} = 0$	528.74	590.34	123.22	9	16.27	Reject H_0

Source: Field Survey Data, 2025. Note: Table 1 of Kodde and Palm (1986) using 5% level of significance.

CONCLUSION

The study analyzed the production risks and productivity among smallholder onion farmers in Taraba State, Nigeria. Fertilizer, seed, and agro-chemicals play a significant role in increasing output and reducing production risk, while labour remains a major source of yield variability. The findings also showed that seed, fertilizer, agrochemicals, and labour positively contributed to onion output. The estimated return to scale revealed increasing returns to scale, indicating that farmers still had opportunities to increase production through improved resource utilization and better production practices. The study, therefore, concludes that onion production in Taraba State has considerable potential for increased productivity if farmers are provided with adequate production inputs, extension support, and improved farming technologies.

RECOMMENDATION

Based on the findings of the study, the following recommendations were made:

1. Farmers should be encouraged to use improved onion seed and fertilizer appropriately. Although seed and fertilizer contributed positively to onion output, their risk-reducing relationship was not statistically significant. Therefore, farmers should focus on using good-quality seed and applying fertilizer at recommended rates rather than simply increasing the quantities used.
2. Farmers should be encouraged to adopt proper agrochemical management. Agrochemicals had a positive contribution to onion output and significantly reduced production risk. Extension agents should therefore train farmers on the appropriate type,

- dosage and timing of agrochemical application to improve yield stability and minimize losses.
3. Labour use should be properly planned and managed. Labour had a positive contribution to onion output but was also found to be a significant risk-increasing input. Farmers should therefore improve labour planning, particularly during land preparation, transplanting, weeding and harvesting, while adopting suitable labour-saving practices where applicable.
4. Production risk management should be incorporated into onion production programmes. Since production risk was found to be an important component of onion production, agricultural development agencies should include risk-management strategies in extension programs to help farmers make production decisions that consider both expected output and output variability.

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