

ECONOMICS OF RESOURCE UTILISATION EFFICIENCY AND CONSTRAINTS RELATED TO MAIZE PRODUCTION IN NORTH WEST NIGERIA

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Abstract. This study investigated the economics of resource utilisation efficiency and constraints related to maize production in North West Nigeria. Primary data were collected through well-designed questionnaires administered to 120 proportionally selected maize producers. The researchers analysed the data using descriptive and inferential statistics. The findings indicate that the average age, farming experience, and educational level of the producers are approximately 46 years, 9 years, and 11 years, respectively. Additionally, about 15% of the producers are female and 25% are not members of any cooperatives. The analysis found that land, agrochemicals, labour, fertiliser, and seed are significant factors influencing maize output, as they were statistically different from zero. The first-order derivatives, or partial elasticities of production, serve as measures of resource productivity, with land showing the highest elasticities at approximately 0.29, and agrochemicals the lowest at 0.10. The sum of the partial elasticities, referred to as scale efficiency, is approximately 0.90, indicating decreasing returns to scale. The resource utilisation efficiency analysis of maize producers indicates that

land, agrochemicals, labour, fertilisers, and seeds are under-utilised, as the ratio of marginal value product (MVP) to marginal factor cost (MFC) for each resource is greater than one. The major challenges faced by maize producers are lack of access to land (1st), high fertiliser costs (2nd), and insufficient farm technologies (3rd). To address these challenges, it is recommended that land policies should be formulated to facilitate easier access to land for both male and female farmers, thereby enhancing efficiency and productivity. Additionally, improved seeds, fertilisers, and agrochemicals should be made available to producers at affordable prices.

Keywords: resource utilisation efficiency, constraints, stochastic production, model, maize farmers, North West Nigeria

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INTRODUCTION

The importance and significance of maize

Maize (*Zea mays*) is one of the most commonly grown cereals in the world. It comes after wheat and rice in terms of world importance and is the most significant staple cereal crop with great potential to address the problem of food insecurity in Africa (Abdoulaye et al., 2018). Nigeria is the second-highest producer of maize in Africa, coming after South Africa. The three highest maize-producing countries in Africa (i.e. South Africa, Nigeria, and Ethiopia) accounted for 39 % of the continent's total maize output in 2019 (PWC, 2021). In Nigeria, the top 10 maize-producing states include Plateau, Borno, Katsina, Niger, Bauchi, Gombe, Oyo, Kogi, Kaduna, and Taraba and they accounted for 64 % of maize produced in the country. Maize industries provide employment opportunities for many producers and serve as a source of income and foreign exchange earnings for Nigeria (Abdulaleem et al., 2019; Onuk et al., 2010). Maize is mainly used as animal feed, food, and for industrial purposes such as the production of starch and ethanol. Approximately 45.5% and 6.5% of maize produced in Nigeria is used to manufacture animal feeds and is utilised by brewing companies, respectively. Similarly, 13% of maize produced in Nigeria is used for the manufacture of corn flakes, industrial flour, and other confectionery. The share of household maize consumption is approximately 10–15%. It is crucial for the nation to adopt policies that address the challenges faced by maize farmers to increase productivity. These policies should include promoting high-yield and disease-resistant maize varieties, reviewing non-tariff and tariff barriers affecting maize, encouraging producer aggregation and supporting both forward and backward integration in the supply chain. Additionally, the policies should focus on supporting agricultural research and development, strengthening the value chains of maize-based products, enhancing the role of commodity exchanges, and promoting agricultural mechanization.

Maize is significant to the international food market. In 2019, the USA, China, and Brazil produced the majority of the world's maize, accounting for 62% of global maize production. Table 1 shows the maize output in Nigeria and the world for 2021 and 2022. The Nigerian maize output accounted for 1.07% and 1.09% of the world output of maize in 2021 and 2022, respectively (Table 1).

Table 1. The output of maize in Nigeria and the world

Variables	Output of maize in Nigeria (tons)	World output of maize (tons)
Maize output in 2021	12 948 920	1 207 996 141.74
Maize output in 2022	12 744 450	1 163 497 383.13

Source: FAO, 2022.

In 2019, Africa exported approximately 1.8 million metric tons (MMT) of maize, valued at around 464.9 million USD. Conversely, the continent imported about 12.5 MMT of maize, with a total value exceeding 4 billion USD. This disparity is largely driven by the rapidly growing population, which intensified the demand for maize in Africa for purposes such as industrial processing, human consumption, and manufacturing. The major suppliers of maize to African nations include Ukraine, Argentina, Brazil, the United States, and Romania. Furthermore, African countries continue to import significant quantities of processed maize products, including cornstarch and cornmeal, valued at approximately 82 million USD and 125 million USD, respectively.

The resource utilisation efficiency and the research gap

The maize yield is generally low in Nigeria, having one of the lowest yields in Africa, with widening gaps in Africa compared to the rest of the world (Olaseinde et al., 2023). In 2021, the average maize yield in Nigeria was 2.05 tons ha⁻¹ (FAO, 2024). Resource utilisation efficiency plays a significant role in agriculture, and helps to identify opportunities for increasing productivity with the available resources. Inefficiencies in resource utilisation have a significant effect on the output (Adeyemo and Kuhlmann, 2009). Low agricultural productivity in Nigeria arises from inefficient utilisation of available resources such as fertilisers, pesticides, herbicides, and improved seeds, along with a scarcity of essential technologies. When these resources are available, resource-poor producers often cannot afford to purchase the required quantities (Alabi and Safugha, 2022).

Efficiency with available technology and a resource base can sustain and increase farm productivity (Alabi et al., 2021). One way to increase productivity among farmers is by efficiently utilising all available resources in the production process (Mesike et al., 2009). Due

to low productivity of maize, Nigeria could not meet the large quantity of maize demand, which is approximately 12 to 15 million metric tons annually, bringing a demand-supply gap of close to 4 million metric tons of maize annually. The smallholder maize producers in Nigeria and sub-Saharan Africa are experiencing significant yield gaps due to inefficient resource utilisation, and sub-optimal agricultural practices (Bucagu et al., 2020). Development economists, food analysts, researchers, and policymakers are debating the continued lags in Sub-Saharan African maize yields, and the design of appropriate measures to overcome these yield gaps (Beza et al., 2017; Olaschinde et al., 2023). It is forecasted that there will be a 60% rise in the demand for agricultural output by 2050 (FAO, 2012).

There is a significant yield gap in maize production, and closing this gap can be achieved not only by increasing productivity but also by improving the efficiency of resource utilisation. Closing the yield gaps and improving resource utilisation efficiency are necessary strategies to meet these challenges. Small but productive resource-poor farmers need timely access to the required quantities of inputs to achieve high yields. Although empirical studies have demonstrated the positive effect of resources, such as improved varieties on maize output, none have demonstrated whether this was due to an increase in resource utilisation efficiency or technological change. This study aims to overcome the limitations of previous research and shed light on the dynamics and sustainability of the benefits of resource utilisation efficiency.

Research questions

This research study provided answers to the following research questions:

- What are the factors influencing maize output?
- What is the resource productivity of inputs and input elasticity among maize producers?
- Are maize producers efficient in resource utilisation?
- What are the challenges facing maize producers in the study area?

Objectives of the study

This study investigated the economics of resource utilisation efficiency and constraints related to maize production in North West Nigeria. Specifically, the objectives were:

- To evaluate the predictors affecting maize output

- To estimate the resource productivity of inputs and input elasticity, and input elasticity among maize producers
- To assess resource utilisation efficiency among maize producers, and
- To describe the challenges faced by maize producers in the study area.

MATERIALS AND METHODS

This study was conducted in Kano and Kaduna States, Nigeria. A multi-stage sampling technique was utilised. In the fourth stage, proportionate and random sampling methods were used to select a total sample of approximately 120 maize producers, with 60 respondents from each state. The sampling frame consisted of 171 maize producers. Primary data were collected using a well-designed questionnaire that was subjected to reliability and validity testing. This sample number was determined based on Yamane (1967) as follows:

$$n = \frac{N}{1 + N(e^2)} = \frac{171}{1 + 171(0.05^2)} = 120 \quad (1)$$

where:

n – sample number

N – total number of maize producers (number for the 2 states)

$e = 5\%$.

The Stochastic Production Model (SPM)

According to Alabi et al. (2022), the SPM is stated thus:

$$Y_i = f(X_i, \beta_i) e^{v_i - u_i} \quad (2)$$

$$Y_i = \beta_0 X_1^{\beta_1} X_2^{\beta_2} X_3^{\beta_3} X_4^{\beta_4} X_5^{\beta_5} e^{v_i - \mu_i} \quad (3)$$

$$\ln Y_i = \beta_0 + \sum_{j=1}^5 \beta_j \ln X_i + (v_i - u_i) \quad (4)$$

where:

Y_i – output of maize (kg)

X_i – predictors

β_i – vectors of evaluated parameters

β_0 – constant term

V_i – noise term

U_i – noise term due to TIE (Technical Inefficiency)

X_1 – land (ha)

X_2 – agrochemicals (litres)

X_3 – labour (mandays)

X_4 – fertiliser (kg)

X_5 – seed (kg).

Resource productivity and resource utilisation efficiency

This is given as:

$$MP_x = \frac{P_x}{P_y} \quad (5)$$

$$MP_x \times P_y = MVP_x \quad (6)$$

$$\beta_{ij} = \left[\frac{\bar{Y}_i}{\bar{X}_{ij}} \right] = \frac{P_x}{P_y} \quad (7)$$

$$r = \frac{MVP_x}{P_x} \quad (8)$$

If $r > 1$, the resource is underutilised

If $r < 1$, the resource is overused

where:

MP_x – marginal product of the input

β_{ij} – elasticities of input

P_x – price of the factor input

P_y – price of output

$\bar{Y}_i$ – average output of maize

$\bar{X}_{ij}$ – average of stimulus inputs

MVP_x – marginal value product of each resource employed

MVP_x – P_x optimum resource utilisation

$MVP_x >$

$(<) P_x$ – there is disequilibrium in the use of input that is underutilisation (overutilisation)

r – resource utilisation efficiency

MFC – marginal factor cost = P_x .

Scale elasticities and return to scale

The equation is stated as follows:

$$RTS = \sum \varepsilon_p \quad (9)$$

where:

RTS – return to scale

ε_p – input elasticities (scale elasticities)

Σ – summation symbol.

PCM (Principal Component Model)

The challenges faced by maize producers were submitted to PCM. The model reduces many interrelated challenges to a few unrelated ones.

RESULTS AND DISCUSSION

Summary information of maize producers

The summary information of maize producers is presented in Table 2. The average age, farming experience, and

Table 2. Summary information of maize producers

Variables	Unit of measurement	$\bar{X}_i$	SD
Age	Years	46	11.25
Gender	1 = male; 0 = otherwise	0.85	0.39
Farming experience	years	9	3.71
Household size	number	7	2.72
Educational status	years	11	5.6
Farm size	ha	1.75	0.97
Maize output	kg/ha	1,500	203.01
Member of cooperatives	1 = yes; 0 = otherwise	0.75	0.57

Source: field survey, 2024.

educational status are approximately 46 years, 9 years, and 11 years, respectively. Similarly, gender, household size, and farm size are approximately 0.85, 7 persons, and 1.75 ha, respectively. In addition, the maize output and number of members of the cooperative are approximately 1, 500 kg/ha and 0.75, respectively. The maize producers were literate, had formal education, and were young, energetic, and resourceful. They are smallholder producers who cultivate less than 5 ha of farmland. Approximately 15% of maize producers are male, and 25% are not members of a cooperative association. This outcome agrees with Onuk et al. (2010), who reported that 73.3% of maize producers in Plateau State, Nigeria, are male and that 82% are less than 50 years of age.

The predictors affecting output of maize

The estimates of the stochastic production model are presented in Table 3. The predictors included in the Cobb-Douglas production model include land, agrochemicals, labour, fertiliser, and seed. Land and fertiliser are significantly different from zero at a 1% probability level. Furthermore, agrochemicals and seeds are significantly different from zero at a 5% probability level. In addition, labour is significantly different from zero at a 10% probability level. A 1% increase in fertiliser, keeping all other predictors fixed, will result in an 18.18% increase in maize output. Similarly, a 1% increase in improved seeds, keeping all other predictors fixed, will result in a 14.61% increase in maize output.

The mean Technical Efficiency (TE) score of 72% (0.72) indicates that the average smallholder maize

Table 3. Estimates of the Stochastic Production Model

Variables	Coef	Std. er.	P-value
Land	0.1609***	0.0358	0.000
Agrochemicals	0.1071**	0.0498	0.024
Labour	0.2897*	0.1471	0.042
Fertilizer	0.1818***	0.0404	0.000
Seed	0.1461**	0.0649	0.034
Constant	2.175***	0.4028	0.000
δ^2	4.2574***		
γ (Gamma)	0.8139		
Log-Likelihood	-728.65		
Wald $\chi^2(5)$	89.23***		
Mean efficiency score	0.72		

Source: field survey, 2024.

producer in the sample requires approximately 28% (0.28) more inputs to reach optimal production levels. This implies that, on average, a smallholder maize producer loses about 28% of their potential output due to technical inefficiency (TIE).

In the component of diagnostic statistics, the coefficient of variance ratio (γ), also called gamma, is 0.8139. This reveals that 81.39% of variations in maize output are due to differences in TE. Furthermore, this indicates that 81.39% of random fluctuations in the maize producers' output are due to their inefficiency. Therefore, reducing the effect of the gamma or variance ratio will increase maize output and greatly enhance the TE of the producers. The estimate of total variance (σ^2), also called sigma squared, is 4.2574, which is significantly different from zero at a 1% probability level. This signifies that the model used and data obtained are well-fitted. The log-likelihood is -728.65. This work agrees with the findings of Alabi and Abdulazeez (2018), who reported that land, hired labour, family labour, chemicals, insecticides, fertiliser, and income from other enterprises are significantly different from zero in influencing the output of maize producers in Kaduna State, Nigeria.

Resource productivity of inputs and RTS (Return to Scale)

Table 4 presents the returns to scale (RTS) and resource productivity of inputs. The estimates from the

Cobb-Douglas production function are reported as partial elasticities, providing insight into how relative changes in the predictors affect maize output. These estimates also indicate the resource productivity of the inputs. The estimated coefficients fall between zero and one, thus all marginal products (MPs) are positive and diminishing at the mean of factors. This agrees with a priori expectations and is in line with estimates obtained by Abdulai and Abdulahi (2016), who documented the significant and positive effect of frontier factors on the output of maize producers in Zambia.

A 1% increase in land, agrochemicals, labour, fertilisers, and seeds will result in an increase in cassava output of 0.17%, 0.11%, 0.29%, 0.18%, and 0.15% respectively, with labour and agrochemicals having the highest and lowest elasticities respectively. The inclusion of the first-order derivatives of the output predictors, referred to as scale elasticities, indicates decreasing returns to scale in the frontier model, totalling 0.90. This means that a proportional increase in all predictors will lead to a less-than-proportional increase in the output of smallholder maize producers.

Specifically, the sum of the partial elasticities ($\Sigma \epsilon_p$) of inputs is approximately 0.90, indicating that a 1% increase in all predictors at the sample mean will result in a 0.90 increase in maize output, which is significantly different from zero. This finding aligns with the results of Ogunniyi et al. (2013), who reported an estimated return to scale of 0.54 for cassava farmers in Oyo state, Nigeria.

Table 4. Resource productivity of inputs and RTS

Elasticity (ϵ_p)	Land	Agrochemicals	Labour	Fertilizer	Seed	RTS ($\Sigma \epsilon_p$)
Estimates	0.17	0.11	0.29	0.18	0.15	0.90

Source: field survey, 2024.

Resource utilisation efficiency of maize producers

The resources utilised by maize producers under consideration are land, agrochemicals, labour, fertilisers, and seeds (Table 5). The MPP (Marginal Physical Product) of land is approximately 145.71, and the MPP of agrochemicals is approximately 75. Similarly, the MPP of labour is approximately 27.19, the MPP of fertiliser is approximately 0.9, and the MPP of seeds is approximately 9.

Table 5. Resource utilisation efficiency of maize producers

Resources	MPP	MVP	MFC	r	Remarks
Land	145.71	72,855	9,000	8.095	under-utilization
Agrochemicals	75	37,500	4,000	9.375	under-utilization
Labour	27.19	13,595	5,000	2.719	under-utilization
Fertilizer	0.9	450	300	1.500	under-utilization
Seed	9	4,500	3,000	1.500	under-utilization

Source: field survey, 2024.

The resource utilisation efficiency (r) which is calculated based on the ratio of MVP (Marginal Value Product) to MFC (Marginal Factor Cost), shows that all resources utilised by maize producers are underutilised. This signifies that an increase in resource utilisation will lead to greater efficiency in maize production.

This outcome is in line with the results of Ahmed et al. (2011), who, in their analysis of resource-use efficiency of garlic production in Kano State, Nigeria approximated that organic manure and farm labour were under-utilised, while seeds were over-utilised.

The challenges faced by maize producers

The challenges faced by maize producers are displayed in Table 6. Approximately six (6) challenges facing maize producers were retained by the principal component model (PCM). Lack of access to land was ranked first, with an Eigenvalue of 4.3603, accounting for 30.04% of the challenges faced by maize producers. The high cost of fertiliser, with an Eigenvalue of approximately 3.6033, was ranked second, accounting for 42.20% of the challenges encountered by maize producers. The lack of farm technologies, with an Eigenvalue of approximately 2.8162, was ranked third, accounting for 11.09% of all challenges encountered by maize producers. The challenges identified by the PCM accounted for 80.42% of the total challenges reported by the maize producers. The chi-square value of 3692.78 is significantly different from zero at a 1% probability level, demonstrating that the PCM is well-fitted.

CONCLUSION AND RECOMMENDATIONS

The study investigated the economics of resource utilisation efficiency and constraints related to maize production in North West Nigeria. Primary data were collected using a well-designed questionnaire and a multi-stage sampling approach. In the fourth stage, a proportionate and random sampling technique was employed to select

Table 6. The challenges faced by maize producers

Challenges	Eigen-value	Difference	Proportion	Cumulative	Rank
Lack of access to land	4.3603	0.7570	0.3004	0.3004	1 st
High cost of fertilizer	3.6033	0.7871	0.1216	0.4220	2 nd
Lack of farm technologies	2.8162	0.4121	0.1109	0.5329	3 rd
High cost of chemical	2.4041	0.4810	0.1107	0.6436	4 th
High cost of labour	1.9231	0.8489	0.0902	0.7338	5 th
Lack of improved seeds	1.0742	0.0918	0.0704	0.8042	6 th
Bartlett test of sphericity					
χ^2	3 692.78***				
KMO	0.813				
Rho	1.00000				

Source: field survey, 2024; KMO – Kaiser-Meyer-Olken.

a total sample of 120 maize producers. Both descriptive and inferential statistics were used for data analysis. The findings indicate that maize producers are young, active, and energetic, suggesting their ability to readily adopt research findings, innovations, and new agricultural technologies. Based on the research questions, the following conclusions are drawn:

- What are the factors influencing output of maize?

The fertiliser, agrochemicals, labour, land, and seeds were significantly different from zero in influencing the output of maize. The resource-poor farmers need adequate amounts of quality inputs at the right time to obtain high yields. The inefficiencies in resource use can have a significant effect on the output of maize (Lopez et al., 2019). The inefficient management of fertiliser, for example, is particularly crucial due to the negative impact of excessive nitrogen use on the environment. This outcome is supported by the findings of Mondal et al. (2018), who reported extension services should ensure that farmers apply the recommended technological packages correctly and adequately through effective demonstrations, training, monitoring, and field visits.

- What is the resource productivity of inputs and input elasticity among maize producers?

The resource productivities for land, agrochemicals, labour, fertilisers, and seeds were estimated at 0.17, 0.11, 0.29, 0.18, and 0.15, respectively. They are called the partial or scale elasticity of the value of maize output concerning the inputs. The sum of the partial elasticity yields a return to scale of 0.90, indicating that an average farm in the study area experiences decreasing returns to scale. This outcome implies that increasing all inputs by a certain proportion would result in a less-than-proportionate increase in the output of the small-holder maize farmers, which could be attributed to scale inefficiency among producers. This finding is supported by Oyewo and Fabiyi (2008), who suggested that efforts should be made to expand the present scope of production to realize the potential for increased output by employing more variable inputs.

- Are maize producers' resource utilisation efficient?

The findings have established that land, agrochemicals, labour, fertilisers, and seeds are under-utilised by maize producers. One of the key issues associated with

increased productivity in agriculture is the use of chemical fertilisers. The use of fertiliser in Africa is generally low compared to other developing countries. This result is supported by findings from Lopez et al. (2019), who documented that the low use of fertiliser in Africa might be due to the lack of financial resources among maize producers, the high prices of the fertilisers, or lack of knowledge of where and how to use the fertiliser. According to Onuk et al. (2010), to achieve optimal resource efficiency of variable inputs, policies and programmes should be directed towards maize producers to increase the level of use of these inputs.

- What are the challenges facing maize producers in the study area?

The primary challenges identified by maize producers, along with their associated Eigenvalues, are as follows: lack of access to land (4.3603), ranked first; high cost of fertiliser (3.6033), ranked second; and lack of farm technologies (2.8162), ranked third. These findings align with those of Girei et al. (2018), who reported that high labour costs, inadequate capital, transportation issues, and marketing challenges are significant obstacles for maize farmers in Nasarawa state, Nigeria.

Based on the outcome of this research, the following recommendations are proposed:

- **Review land policies:** Land policies should be revised to ensure easy access to farmland for both male and female farmers, thereby enhancing efficiency and productivity.
- **Provide affordable inputs:** Improved seeds, fertilisers, and agrochemicals should be made available to producers at affordable prices.
- **Enhance credit accessibility:** Government and private organizations should facilitate access to credit for producers at single-digit interest rates for the purchase of essential farm inputs, ensuring that these facilities are free from cumbersome administrative procedures.
- **Implement mechanisation:** Labour-saving technologies and machinery should be introduced to mechanise farming practices, which will, in turn, increase maize output.
- **Strengthen extension services:** Extension services should be deployed in the area to disseminate research findings, innovations, and new technologies to maize producers.

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