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EVALUATION OF FARM PLAN AMONG IRRIGATED MAIZE FARMING HOUSEHOLDS IN LERE LOCAL GOVERNMENT AREA OF KADUNA STATE, NIGERIA

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ABSTRACT

This study evaluated optimal farm plan of irrigated maize production among farmers in Lere, Local Government Area, Kaduna State, Nigeria. Multi-stage sampling technique was used to randomly select 180 maize farmers in the study area. Primary data were collected through the use of questionnaire and analyzed using descriptive statistics, net-farm income model, linear programming model and principal component analysis. The result showed that majority of the maize farmers in the study area were male, their mean age was 36 years. All of the farmers had one form of education or the other. The mean household size of the respondents was 8 persons. The mean years of farming experience was 14 years. Majority (83%) of the respondents considered maize farming as their primary occupation. About 72% of the respondents had a farm size that ranges between 1-3 hectares, with a mean non-farm income of ₦116,388 per month. About 67% were members of cooperative society. Majority of the respondents had access to credit. Irrigated maize production was profitable, with total revenue, total cost and net-farm income of ₦1,952,335.0, ₦493,193.2 and ₦1,459,141.8 respectively, and Return On Investment of 2.96. The result of the Linear Programming analysis showed that labour used (h/ha) was binding, while yield (kg/ha), farm size used (ha), seed used (kg/ha) and fertilizer used (kg/ha) were not binding. The major constraints identified in maize production in the study area were classified under four major components: economic factors (24.64%), institutional factors (25.26%), environmental factors (36.78%) and infrastructural factors (13.37%). The study recommended that in order to ensure efficient utilization of resources in the study area: government should initiate adult education programmes for farmers; policy makers should consider the land consolidation; and farmers should invest in labour saving agricultural machinery.

Key words: Evaluation, Farm Plan and Profitability, Irrigated Maize Farmers, Lere LGA

INTRODUCTION

Nigerians grow maize (Zea mays L.), a significant grain crop, all over the country (Ayodele *et al.,* 2020). In some regions of the country, maize is grown all year round by combining rain-fed maize production, irrigation, and the cultivation of a water-logged area called Fadama (Aasa *et al.,* 2020). The majority of Nigerians eat maize, a significant cereal crop, as their second most important diet after rice (Yahaya *et al.,* 2020). Small-scale farmers are the main producers of maize, which is the second most widely farmed and staple crop among families in Sub-Saharan Africa (Oluoch *et al.* 2022). Nigeria's average grain yield from maize is around 3 tonnes per hectare, while the country's expected annual need of 20 million tonnes has not yet been satisfied (Federal Ministry of Agriculture & Rural Development (FMARD), 2021).

In Nigeria, maize was first grown as a subsistence crop before progressively developing into a commercial commodity that provides raw materials for numerous agro-based industries (International Institute for Tropical Agriculture (IITA), 2021). Many Nigerians rely on it as a source of income, including farmers, marketers, and women who sell boiled or roasted maize. Additionally, agro-based industries use maize as a raw material to produce secondary goods like cornflake and pop-corn (Aasa *et al.,* 2020).

Since it is the main source of energy, it is also essential in the formulation of feed for poultry and other livestock (Ayodele *et al.* 2020). Food and Agriculture Organization (FAO) 2023 reported that maize production decreased by -0.1%, from 12,744 metric tonnes in 2021 to 12,735 metric tonnes in 2022. In 2022, widespread flooding and insecurity caused major crop losses and affected agricultural livelihoods nationwide (FAO 2023). The annual supply-demand mismatch in Nigeria is approximately 4 million tonnes (Okojie, 2022). The export embargo on maize was imposed as a result of the supply shortage (Price waterhouse Coopers (PWC), 2021). Nigeria is in a poor position to compete in the implementation of the Africa Continental Free Trade Area (AfCFTA) due to its current level of maize production and the country's almost zero exports of the crop (PWC, 2021). Adopting measures that would address the difficulties encountered by maize producers and establishing mechanisms to investigate and maximise the potential provided by the AfCFTA are crucial. Ethiopia in East Africa, Egypt in North Africa, Nigeria in West Africa, and South Africa in Southern Africa are the main nations that produce the most maize in their respective regions (Jordaan, 2022).

The top producers of maize in Africa are South Africa (16,800 metric tonnes), Nigeria (12,000 metric tonnes), Ethiopia (10,400 metric tonnes), and Egypt (7,600 metric tonnes), according to the United States Department of Agriculture (USDA, 2023).

The efficiency of farmers, which is influenced by their socioeconomic circumstances and farm features, is the primary determinant of maize output (Ebukiba *et al.,* 2020). Important factors used by farmers in the research area to produce maize include fertiliser, herbicides, insecticides, seed, labour, farm equipment such hoes and cutlasses, and water availability (Yahaya *et al.,* 2020). Nigerian maize production underutilises its resources, resulting in low output and, consequently, low farm revenue (Alabuja *et al.,* 2022).

The optimal farm analysis of maize challenge is figuring out how to develop and manage maize crops on a farm in a way that is both profitable and efficient. This analysis takes into account a number of variables, including market prices, yield potential, input costs, and environmental conditions. Tijani & Sofoluwe (2021). Appropriate farm management techniques such as Linear Programming (LP) are required to guarantee farmers the highest possible return.

Linear programming (LP), as applied to farm planning represents a systematic method of determining mathematically the optimum plan for the choice and combination of farm enterprises, so as to maximize income or minimize costs within the limits of available farm resources (Yang, 1995). Optimum decision making which is based on a quantitative analysis for achieving “desired goal” has been applied to Punjab farmers in India in spite of their complex situation compounded by the difficulty of comprehending the techniques at the initial stage of their learning process (Mehta, 1992). On technical side, the Nigerian farmers like these Punjab farmers are characteristically small-scale farmers who operate using crude implements, cultivate small land holdings and are poor resource-based. They are confronted with myriads of problems, which include optimal resource utilization and meagre resources to raise their incomes and consequently their living standards (Singh, 1978).

The challenge to improve on the contribution of agriculture to the Nigeria economy makes a study of this nature a worthy venture. Besides, most farm management studies in Kaduna State attempted production function analysis revealing the marginality conditions of resource use with respect to production of individual or selected enterprises. Such type of analysis in addition to being very partial in nature addressed only the existing aspect in the organization and operation of the farm business, and fails to answer as to what would be the optimum combination of resources under given restraining conditions. With particular focus on one of the most important cereal crops such as Maize, this study has contributed to knowledge in this way. Nigeria's small-scale farmers, who are known for their inefficient use of resources due to their inability to use the available resources effectively enough to provide the necessary output, are the main producers of maize (Aasa *et al.,* 2020). Farmers frequently lack the education necessary to fully embrace sophisticated agricultural technology (Mariyono *et al.,* 2021). Resources must be used effectively in order to reach the highest possible level of production (Alabuja *et al.,* 2022). It is important to determine whether the farmers are making effective use of the resources at their disposal to boost their current level of maize production, as the current output has fallen short of the potential yield of 5-8 tonnes per hectare (Alabuja *et al.,* 2022). To assist farmers in planning and decision-making on achieving and optimising efficiency in production planning and resource allocation, Linear Programming was created (Alotaibi & Nadeem, 2021).

From the foregoing therefore, the following specific objectives were developed; i. describe the socioeconomic characteristics of maize farmers in the study area; ii. determine the profitability of maize production in the study area; iii. estimate the optimal annual maize production in the study area; iv. estimate the impact of Linear programming-based maize allocation on the farmers in the study area; and v. identify constraints to maize production in the study area.

METHODOLOGY

Study Area

The study was carried out in Nigeria's Kaduna state's Lere local government region. Southern Kaduna state contains the local government area of Lere. Saminaka is where the headquarters are situated. The Saminaka local government area, which was established in 1976, was the basis for the 1991 local government area. Geographically, Lere is situated between latitudes 10°N and 39°N and longitudes 8°E and 57°E. Lere is bordered to the west and south by Kauru local government area, to the north-west by Kubau local government area, to the north-west by Doguwa local government area of Kano state, to the east by Toro local government area of Bauchi state, and to the south-east by Bassa local government area of Plateau state.

The area of Lere is 2,634 km². With a population of 339,740 (National Population Commission, 2006), Lere Metropolis is expected to have 514,242 residents by 2023, assuming a 2.5% annual population growth rate. Kudaru, Lere, Piriga, and Saminaka are the four (4) districts that make up the Lere Local Government Area. The average temperature in Lere is 32 degrees Celsius, and the area receives 1050 millimetres of precipitation annually. There are two different seasons in the research area: the dry season and the rainy season. The surface soils belong to the sandy loam to loam textural class, according to Magaji *et al.* (2022). With several markets in the Lere local government region, trade plays a significant role in the local economy. With a variety of crops cultivated nearby, including rice, groundnuts, cowpeas, millet, maize, and sugar cane, farming is also a significant activity in Lere. Crafts and the breeding of animals are two other significant economic activity in the study area.

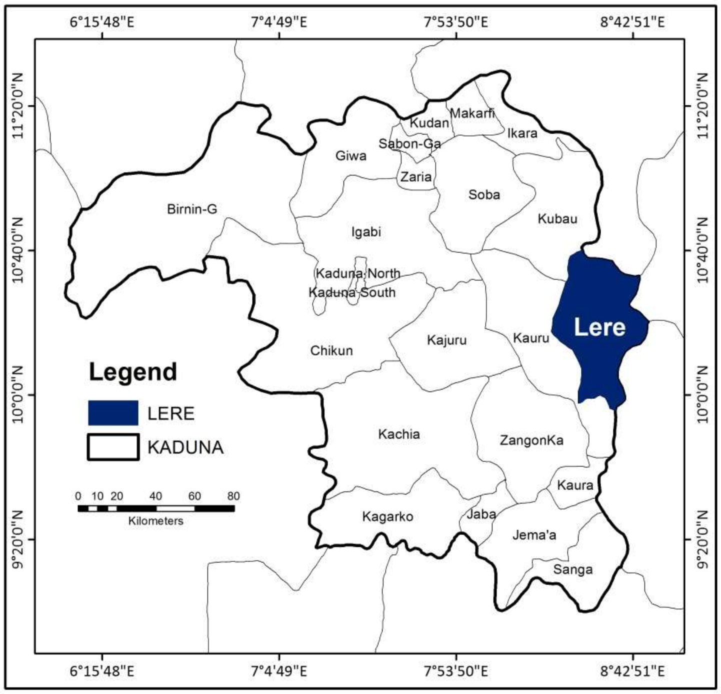

Figure 1. Map of Kaduna State showing Lere L.G.A

Sample Size and Sampling Procedure

The study's respondents were chosen using multi-stage sampling approaches. Because of the area's significance among maize growers, the Lere local government area in Kaduna state was purposefully chosen for the initial stage. In the second step, two districts in the study area—Lere and Piriga—were chosen at random using the ballot box method. Using the ballot box approach, four villages were chosen at random from the first two districts in the third stage. The settlements that were chosen are called Piriga (Kinugu, Patah, Tide, Warsa Piti) and Lere (Dogon Daji, Dokan Lere, Gidan Dutse, Lere). Lastly, farmers were chosen from the sample frame using a straightforward random sampling technique. For this study, a questionnaire was chosen as the research tool. To calculate the sample size from a given population, the Yamane (1967) approach was applied. The following is a mathematical illustration of the Taro Yamane method: = $\frac{N}{(1+N(e)^2)}$

Where:

n = signifies the desired sample size.

N = signifies the finite size of the population under study.

e = signifies the maximum margin of error as will be determined by the researcher (0.10,0.05,0.01).

Table 1: Distribution of Maize Farmers in the Study Area.

LGA	Districts	Villages	Sample frame	Sample size (at 8%)
Lere	Lere	Dogon Daji	605	19
		Gidan Dutse	1000	23
		Lere	904	22
		Ramin kura	4210	29
	Piriga	Garu	3212	29
		Patah	402	16
		Tide	880	22
		Warsa Piti	650	20
Total			11,863	180

Method of Data Collection

According to the study's specific objectives, questionnaires and in-person interviews with the maize farmers in the study area were used to gather primary data. Closed-ended, multiple-choice, and single-choice items were used in the questionnaire's design. Section A of the questionnaire asked about the respondent's background; Section B asked about the respondent's socioeconomic characteristics; Section C asked about the respondents' perception of the profitability of the study area's maize production activities; Section D asked about the factors that influence the study area's optimal annual production of maize; and Section E asked about the respondents' perceptions of the difficulties faced in the study area's maize production activities.

Analytical Technique

In order to achieve the objectives of this study, the following analytical tool were employed:

i. Descriptive statistics, ii. Net-Farm Income model, iii. Linear programming model, and iv. Principal component analysis.

Descriptive statistics

This tool was employed to obtain a summary description of the data collected. This involved the use of table, percentage, mean and frequency distribution to describe the socioeconomic characteristics of the maize farmers. This was used to achieve objective one (1).

Net farm income model

In agricultural economics, the net farm income model is a technique used to determine a farm operation's profitability. To calculate the net income produced by the farm, it considers a number of variables, including input costs, revenue from the sale of crops or livestock, and other expenses. The net farm income model calculates the profit or loss produced by the farm business by deducting all costs from all revenues.

To accomplish goal two (2), the net farm income model was employed. It is said as follows:

$NFI = \Sigma_{PYi} PYi - \Sigma_{PXi} PXj - \Sigma FK$ **……….. (1)**

Where:

NFI = Net farm Income (₦);

PYi = unit price of the output of Maize (₦)

Yi = Total yield of Maize (kg);

PXj = Unit price of variable inputs (₦)

Xj = Quantity of variable inputs (where j=1,2,3……n)

Fk = Cost of fixed inputs (₦) (where k=1,2,3…….n)

Σ = summation sign.

Return on Investment

Expressed as a percentage, the Return on Investment (ROI) is a profitability statistic that contrasts the net profits realised upon exit with the initial investment cost. Investors use it to assess the efficacy and efficiency of their investment plan and capital allocation. It has the following mathematical expression:

Return on Investment (ROI) = Net Return ÷ Cost of Investment × 100

Where:

Net Return = Total profits received

Cost of Investment = Total amount spent

This was used to achieve part of objective two (2).

Straight line depreciation method

The cost of an asset (property or equipment) is dispersed evenly throughout the course of its intended usage by straight line depreciation. Asset cost, usable life, and anticipated salvage value—the amount an asset is likely to be worth at the end of its useful life—are the only three inputs needed to calculate it.

Using the straight-line technique, the yearly depreciation expenditure is calculated as follows: yearly depreciation expense = (Cost - Salvage value)/ Useful life

A portion of objective two (2) was also accomplished with this method.

Linear programming model

Linear programming model are mathematical tools used to optimize the allocation of limited resources to achieve a specific objective. They involve linear equations and inequalities to represent constraints and an objective function to maximize or minimize. It can be expressed in simple form as follows:

Objective Function:

Maximize (or minimize) $Z = c_1x_1 + c_2x_2 + ... + c_nx_n$

Subject to:

$a_{11}x_1 + a_{12}x_2 + ... + a_{1n}x_n \leq b_1$

$a_{21}x_1 + a_{22}x_2 + ... + a_{2n}x_n \leq b_2$

$a_{m1}x_1 + a_{m2}x_2 + ... + a_{mn}x_n \leq b_m$ ………… (2)

Where:

- $x_1, x_2, ... x_n$ are decision variables representing the quantities to be determined
- $c_1, c_2, ..., c_n$ are coefficients of the objective function
- $a_{11}, a_{12}, ..., a_{mn}$ are coefficients of the constraint equations

- b_1, b_2, ..., b_m are the right-hand side values of the constraints
- m is the number of constraints.

This was used to achieve specific objective three (3) and four (4).

Principal component analysis

Constraints faced by small-scale maize farmers were subjected to Principal Component Analysis or Factor Analysis. The model specification:

$x = (x_{1,} x_{2,} x_{3,} \dots \dots x_{p,}$ .... (3)

$\alpha_K = (\alpha_{1k.} \alpha_{2k,} \alpha_{3k,\dots\dots\dots\dots} \alpha_{pk})$ .... (4)

$a_k^T X = \sum_{j=1}^{p} \alpha_{k_j} Xj$ .... (5)

$Var = \lfloor \alpha_k^T X \rfloor isMaximum$ .... (6)

Subject to:

$a_k a_k = 1$ (5)

and

$cov\lfloor \alpha_I^T X - \alpha_2^T X \rfloor = 0$ .... (7)

The variance of each of the principal component are:

$Var\lfloor \alpha_I^T X \rfloor = \lambda_k$ ....(8)

$S = \frac{1}{\cap - 1}(X - X)(X - \overline{} X)^T$ .... (9)

$S = \frac{1}{\cap - 1}\sum_{t=1}^{\cap}(X_1 - \overline{X_i}\,\overline{(X_i} - \overline{X_i)^{t}}$ ....(10)

Where:

X= Vector of p Random Variables.

α_k = Vector p Components.

λ_k = Eigen Value.

T= Transpose.

S= Covariance Matrix.

This was used to achieve objective five (5).

Decision rule for principal component analysis:

Interpretation of the principal components is based on finding which variables are most strongly correlated with each component. Here a correlation above 0.5 is deemed important. Interpretation of the principal component results was in respect to the value that was deemed significant.

Results and Discussion

Socio-Economic Characteristics of the Respondents in the study area

Table 1 revealed that 13% of the sampled respondents were female, while 87% were male. This result implies that there is gender imbalance in maize farming in the study area, with more men participating in maize farming activities compared to women. This result is in agreement with the findings of Yahaya *et al.,* (2020); which reported that majority of maize farmers in the study area are male. The study revealed that majority (61%) of the respondents are between the ages of 30-39; while 22%, 11% and 6% of the respondents were between the ages of 20-29, 40-49 and greater than 50 respectively. 94% of the sampled maize farmers were under 50 years old, with the average age of maize farmers being 36 years old. This suggests that the majority of responders are youthful, physically fit, and capable of adapting to new farming practices. This outcome is consistent with the findings of Bello & Nazifi (2023), who reported that the sampled sole-grown maize farmers' average age was 34 years, suggesting that they were still engaged in farming. Additionally, the majority (56%) had 11–20 years of experience growing maize, according to the results; whereas 33% and 12%, respectively, had 1–10 years and 21–40 years of experience growing maize. Overall, over 67% of research participants had between 11 and 40 years of farming experience. 14 years is the average number of years spent farming. This suggests that the study area's maize farmers possess sufficient agricultural expertise to improve farm management and efficiently distribute resources for maize output. This outcome confirms the findings of Adeagbo *et al.*, (2023), who found that most farmers have an average of 19 years of farming experience and are highly skilled in producing maize. 22% of the sampled respondents had a home size of 1-6 people, 72% had a household size of 7-12 people, and 6% had a household size of 13-18 people, according to table 4.4's description of respondents by household size. Eight people lived in the average household. The findings of Alabuja *et al.,* (2022), who claimed that the majority of the maize farmers in Lere L.G.A. had an adequate supply of manpower for maize production in their study area, are supported by this, which suggests that the study area's maize farmers had an adequate number of unpaid labourers for farm operations. Household income and food needs are also influenced by household size.

All of the respondents in the research region had some kind of education, as indicated by Table 4.5; 44% had basic education, 6% had secondary education, and 50% had non-formal education. Given that half of the respondents had formal education and the other half did not, this finding suggests that farmers in the research area have varying levels of formal education. Farmers' acceptance of contemporary farming methods may be impacted by this. The study's findings are consistent with those of Anthony *et al.,* (2021), who found that farmers' managerial skills for successfully implementing new production technology tend to improve with formal education.

According to the results in table 4.6, 17% of respondents were civil servants, while 83% of respondents regarded maize farming as their principal vocation. This finding suggests that farmers in the research area are heavily dependent on maize production, underscoring the significance of enhancing maize production methods to boost output, revenue, and food security. The findings of Adeola *et al.,* (2023), which claimed that the majority of respondents in the research region had maize farming as their primary occupation, are consistent with this conclusion. The majority of respondents (72%) had farms that were between one and three hectares in size. According to the results in table 4.7, approximately 22% of maize farmers owned more than 3 hectares of land, while 6% owned less than 1 hectare. The average agricultural area owned by maize growers was 3 hectares. This finding suggests that the majority of maize farmers in the research region are subsistence farmers with comparatively limited land holdings devoted to maize production. This outcome is consistent with research by Tahir et al. (2019) and Ebukiba *et al.* (2020), which found that the average farm size of maize producers was 2.75 hectares and 2.58 hectares, respectively.

According to the results in table 4.8, the majority of respondents (72%) reported non-farm incomes of less than ₦100,000 per month, while 6%, 17%, and 6% of respondents reported non-farm incomes of less than ₦299,000, less than ₦499,000, and more than ₦500,000 per month, respectively. The average monthly non-farm income for farmers was ₦166,388. The importance of the non-farm income gap among maize farmers suggests that many of them might be having financial difficulties. Their capacity to invest in inputs and other resources required to increase maize production in the study region may be impacted, and poverty may result. This is consistent with the findings of Ayodeji & Abiodun (2022), who claimed that non-farm revenue will increase household income and complement on-farm labour. About 67% of the respondents in the study area are members of cooperative associations, whereas 33% do not belong to any cooperative, according to an analysis of the respondents' distribution by cooperative association membership. This finding suggests that the majority of research participants benefit from the presumed advantages of cooperative societies. This outcome is consistent with research by Alabuja *et al.* (2022), which found that 66.3% of respondents belonged to a farmers' association. According to Table 1, 61% of the respondents in the research area had access to a formal source of credit, whereas 39% of the respondents did not. This finding suggests that a sizable percentage of respondents possess the funds necessary to make investments in their agricultural businesses. For maize farmers, the absence of formal finance presents a number of difficulties, such as diminished investment potential, susceptibility to shocks, dependence on unofficial financing, and stunted development potential. This outcome contradicts the findings of Biye *et al.* (2022), who found that 40.67% of the study's sampled respondents lacked access to credit.

Table 1: Socioeconomic characteristics of maize farmers in the study area

Variables	Frequency	Percentage	Mean	Std. Dev.
Gender				
Female	24	13		
Male	156	87		
Total	**180**	**100**		
Age				
20-29	40	22		
30-39	110	61	36	8.469
40-49	20	11		
50 and above	10	6		
Total	**180**	**100**		
Experience				

1-10	60	33		
11-20	100	56	14	8.331
21-30	10	6		
31-40	10	6		
Total	**180**	**100**		
Household Size				
1-6	40	22		
7-12	130	72	8	2.718
13-18	10	6		
Total	**180**	**100**		
Educational Qualification				
Non-Formal	90	50		
Primary	80	44		
Secondary	10	6		
Total	**180**	**100**		
Primary Occupation				
Civil Servant	30	17		
Farmer	150	83		
Total	**180**	**100**		
Farm Size				
Less Than 1.00	10	6		
1.00-2.99	130	72	3	4.789
3.00-4.99	20	11		
5.00 and above	20	11		
Total	**180**	**100**		
Average Income				
Less Than 100000	130	72		
100000-299000	10	6	116388.9	189237.7
300000-499000	30	17		
500000 and above	10	6		
Total	**180**	**100**		

Membership of Cooperative		
No	60	33
Yes	120	67
Total	**180**	**100**
Access to Credit		
No	70	39
Yes	110	61
Total	**180**	**100**

Profitability of Irrigated Maize Production

The profitability of maize production in the study region was calculated on a per hectare basis and is shown in table 2. According to Table 2, the total income per hectare was ₦1,952,335 and the total production cost per hectare was ₦493,193.2. Thus, ₦1,459,141.8 is the net farm income. The estimated total variable cost per hectare was ₦481,712.4, or 97.61% of the total output cost. In the research region, the depreciation cost of fixed assets was ₦11,480.9, or 2.3% of the total cost of producing one hectare of maize. This suggests that if output is increased with variable costs, the overall return will rise while fixed costs remain constant. With a rate of return on investment per hectare (per naira invested) of 2.96, the study area's maize production generated a profit of ₦1.96 for every ₦1 invested. This suggests that growing maize in the study area is a profitable endeavour with a high potential for profit. The results of this study are in line with those of Muhammad & Bola (2020), who found that maize production had an increasing return to scale of 2.67.

Table 2: Profitability of maize production in the study area

Variables	Average Quantity/ha	Unit price (₦/kg)	Average value (₦/ha)	% of Total cost
Total Revenue	**3549.7**	**550.0**	**1952335.0**	
Seed (Kg/ha)	11.2	2,650.0	29,680.0	6.0
Fertilizer (Kg/ha	7.2	1,420.0	10,153.0	2.1
Herbicides (L/ha)	9.2	9,185.7	8,4074.8	17.0
Water use (Irrigation cost)			136,694.4	27.7
Land clearing (Man-day)	14.0	1,433.3	20,111.0	4.1
Ridging (Man-day)	5.1	1,433.3	7,378.5	1.5
Planting (Man-day)	38.6	1,433.3	55,274.5	11.2
Fertilizer application (Man-day)	12.6	1,433.3	1,8074.3	3.7
Weeding (Man-day)	42.5	1,433.3	60,862.5	12.3
Pesticides application (Man-day)	9.2	1,433.3	13,124.1	2.7
Harvesting (Man-day)	21.8	1,433.3	31,247.7	6.3
Threshing (Man-day)	10.5	1,433.3	15,037.7	3.0
Total variable cost (TVC)			**481,712.4**	
Fixed cost depreciated	4.0	2,882.2	11,480.9	2.3
Total cost			**493,193.2**	**100**
Net farm income			**14,59141.8**	
Return on investment			**2.96**	

Source: Field survey data, 2024

Estimation of Optimal annual maize production in the study area

Table 3's result demonstrates that, perhaps utilising all available labour, the linear programming model produced an optimal production of 400 kg. This suggests that there was a shortage of labour and that it was used to its full potential. The resources that were not fully utilised were seed, fertiliser, and farm size. For farm size, fertiliser, and seed, the excess values (slack values) for the underutilised resources are 1.94, 10, and 2, respectively. The findings of this study imply that by emphasising effective labour utilisation, farmers in the study area may be able to attain optimal output. Farmers may need to think about reallocating their resources in order to better fit the available farm space and excess inputs in order to maximise their usage of resources. The findings in this study allied with the findings of Mohammed *et al,* (2022), who stated that majority of farmers were fairly efficient in the use of labour in their study.

Table 3 Result of the optimal annual maize production in the study area

Inputs	Value	Status	Slack
Yield (kg/ha)	3600	Not Binding	400
Farm size (ha) used	4.56	Not Binding	1.94
Labour (h/ha) used	120	Binding	0
Seed (kg/ha) used	12	Not Binding	2
Fertilizer (kg/ha) used	60	Not Binding	10

Source: Field survey data, 2024

Estimation of the impact of Linear Programming based maize allocation on the farmers in the study area

The variables preventing the study area's profit maximisation goal from being met, as determined by the results of linear programming, are shown in table 4.12. According to the findings, the model has probably already produced the highest yield feasible given the constraints, as the lagrange multiplier value for Yield is 0 (zero). It may be necessary to spend greater costs that outweigh the advantages in order to push for a higher yield. Additionally, the lagrange multiplier values for seed, fertiliser, and farm size used were all 0 (zero). This suggests that the model has most likely determined the most effective way to allocate these resources and that further use of them would either not yield any appreciable advantage or could have unfavourable effects. . The outcome, which had a lagrange multiplier value of 8106.34, demonstrated that work was completely utilised. The objective value may be raised by 8106.34 (h/ha) for every unit increase in the amount of labour that is available. Given that it hindered the attainment of the profit maximisation goal, this suggests that labour is the limiting resource in the research area's maize production. The findings of Ibrahim et al. (2019), who believed that labour was one of the main limiting constraints in the research area, are consistent with this.

Table 4 Estimation of the lagrange multipliers for binding constraints

Inputs	Final value	Lagrange multiplier
Yield (kg/ha) used	3600	0
Farm size (ha) used	4.56	0
Labour (h/ha) used	120	8106.343125
Seed (kg/ha) used	12	0
Fertilizer (kg/ha) used	60	0

Source: Field survey data, 2024

Constraints faced by Maize farmers in the study area

The constraints faced by respondents in the study area were subjected to principal component analysis model. In the principal component analysis model, constraints with eigen values greater than one (1) were retained and used in the model. The true factors that were retained explained 100% of the variance in the 8 variable components. The result presented in table 5 shows that the Kaiser Meyer-Olkin (KMO) and Bartlett's test of sphericity of 189.92 was significant at 1% level of probability. This demonstrated the feasibility of using the data set for factor analysis. The constraints were classified under four major components: economic, institutional, environmental and infrastructural factors.

Factor 1 (Economic factors): The constraints that load high in factor one includes lack of fertilizer (0.6878) and high cost of labour (0.6418) which explained 24.64% of the variance in the 8 variables scale. Lack of fertilizer limits maize production by reducing nutrient availability for optimal plant growth and yield. High cost of labour constrains maize production by increasing production expenses and reducing profit margins.

Factor 2 (Institutional factors): This was dominated by constraints of lack of fund (0.6154) and access to credit (0.7476). The second factor component explained 25.26% of the variance. Inadequate access to formal source of credit could be due to high interest rate charged by commercial banks or financial institutions.

Factor 3 (Environmental factors): This was dominated by rainfall problem (0.6718), climate related problem (0.6616) and lack of soil fertility (0.6488). The third factor explained 36.73% of the variance.

Factor 4 (Infrastructural factor): This has high cost of transportation (0.7215) as the major challenge to maize production in the study area. The fourth factor explained 13.37% of the variance in the 8-variable scale. The findings in this study is similar to that of Alabuja *et al,* (2022) and Makama *et al,* (2022). They reported lack of fertilizer, lack of capital, climate change, high cost of labour and high cost of transportation to be among the major constraints affecting maize production activities in the study area.

Table 5 Principal component analysis of maize production constraints in the study area

Variables	**Component**			
	Factor 1	**Factor 2**	**Factor 3**	**Factor 4**
Lack of fertilizer	0.6878			
High cost of labour	0.6418			

Lack of fund		0.6154		
Access to loan		0.7476		
High cost of transportation				0.7215
Rainfall problem			0.6718	
Climate related problem			0.6616	
Lack of soil fertility			0.6488	
Percentage of total variance	**24.64**	**25.26**	**36.73**	**13.37**
Kaiser-Meyer-Olkin	**0.5091**			
Bartlett's test of sehericity (Chi-square)	**189.92*** **			

Source: Field survey data, 2024. *** represent significance at 1% level of probability.

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