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UNLOCKING MAIZE POTENTIAL: EFFICIENCY AND CONSTRAINTS ANALYSIS AMONG SOLE GROWN AND INTERCROP FARMERS IN BEBEJI LOCAL GOVERNMENT AREA OF KANO STATE, NIGERIA

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ABSTRACT

This study investigates the efficiency of smallholder maize production systems in Bebeji Local Government Area of Kano State, Nigeria. Using a multistage sampling approach, 103 smallholder maize farmers were selected for data collection. Descriptive statistics and a stochastic frontier model were employed to analyse the data. Results indicate that most sole-grown maize farmers (67.4%) and approximately 50% of intercrop maize farmers achieved an efficiency range of 0.26 - 0.67. Average efficiency levels were significantly ($p<0.05$) below the maximum frontier, with sole-grown farmers reaching 0.33 and intercrop maize farmers achieving 0.16 on average. Positive and significant determinants of maize output were identified for both groups, including inputs such as fertilizer, farm size, labour, maize seed, and agrochemicals. Inefficiency analysis revealed key factors influencing farmers' efficiency, such as age, education, farming experience, extension contact, and cooperative membership. Market costs of inputs and price fluctuations emerged as major constraints to maize production in the study area. Findings underscore the need for targeted training on improved production practices to enhance maize production efficiency in the state.

Keywords: Maize production; intercropping; technical efficiency; constraints

INTRODUCTION

Smallholder farmers play a crucial role in the agricultural landscape, particularly in developing countries, where they form the backbone of food production systems (FAO, 2014). In Nigeria, smallholder farmers are the primary contributors to maize and soybean cultivation, driving the country's agricultural productivity and food security (Adeoye *et al.*, 2019). However, the efficiency and profitability of smallholder cropping systems remain critical concerns with far-reaching policy implications (Adeyemo *et al.*, 2020).

Maize (*Zea mays*) stands as a vital cereal crop worldwide, and its significance in sub-Saharan Africa, including Nigeria, cannot be overstated (FAOSTAT, 2021). With over 50% of cereal crop production allocated to maize in many sub-Saharan African countries, it serves as a staple food and a major income source for smallholder farmers (CDA, 2016). Despite

Nigeria's position as the largest maize producer in Africa, smallholder maize production in the country falls short of achieving optimal yields and efficiency compared to global standards (Akinwale *et al.*, 2018). Enhancing the efficiency of maize cultivation among smallholder farmers is imperative for boosting agricultural productivity and improving the livelihoods of rural communities (Ojiako *et al.*, 2019).

Soybean (*Glycine max*), an important legume crop known for its high protein content, offers significant potential for smallholder farmers. Its versatility and nutritional benefits make it an attractive crop for both domestic consumption and commercial purposes. However, the adoption and profitability of soybean cultivation among smallholder farmers have been relatively low, limiting its contribution to the agricultural sector and rural development (Oladimeji *et al.*, 2020). Understanding the efficiency and profitability of soybean production systems and their interplay with maize cropping systems is essential for formulating effective policies to promote sustainable agriculture and enhance the welfare of smallholder farmers (Olayemi *et al.*, 2021).

Cropping systems employed by smallholder farmers are critical determinants of agricultural efficiency and productivity. Sole cropping, where a single crop is grown continuously without rotation, allows for specialized management practices tailored to the specific crop's requirements (Mafongoya *et al.,* 2017). On the other hand, intercropping, particularly the intercropping of maize with legumes like soybean, offers advantages such as improved nutrient utilization, enhanced pest and disease control, and optimized land utilization (Adeoye *et al.*, 2018). The choice of cropping system significantly influences the profitability and efficiency of smallholder farming operations (Adeleke *et al.*, 2021).

Efforts to enhance the efficiency and profitability of smallholder cropping systems require evidence-based policy interventions. By assessing the economics of sole-grown maize and intercrop maize-soybean production systems among smallholder farmers, this study aims to provide critical insights into the most profitable cropping systems and the factors influencing their efficiency. Such research outcomes hold significant policy implications, as they inform policymakers and stakeholders on strategies to improve agricultural productivity, promote sustainable farming practices, and alleviate poverty among smallholder farmers (Adenegan *et al.*, 2022).

The findings of this study will contribute to the development of targeted policies and interventions aimed at optimizing smallholder farmers' cropping systems, enhancing the efficiency of maize and soybean cultivation, and improving the overall socio-economic well-being of rural communities. By aligning with current global efforts to transform agricultural systems, ensure food security, and promote sustainable development, this research holds immense policy relevance and underscores the urgent need for evidence-based decision-making in the agricultural sector (FAO, 2021).

The conceptual framework employed in this study is based on the integration of the stochastic frontier analysis (SFA) model, the analysis of constraints, and the theoretical underpinnings of agricultural production (Jones *et al.*, 2010; Smith & Johnson, 2015; Brown *et al.*, 2012). The theoretical framework draws on the neoclassical economic theory, which posits that agricultural production is influenced by a combination of inputs and factors that determine the level of output (Coelli *et al.*, 1998; Battese & Coelli, 1995). According to this theory, farmers aim to maximize their output given limited resources, and inefficiencies may arise due to various factors, such as technological limitations, market imperfections, and resource constraints (Rahman *et al.*, 2016; Silva *et al.*, 2019).

The SFA model serves as the analytical tool for assessing the technical efficiency of farmers within the theoretical framework. It comprises two key components: the frontier component, which represents the maximum achievable output given a set of inputs, and the efficiency component, which measures the extent of deviation between actual output and the frontier (Coelli *et al.*, 1998; Battese & Coelli, 1995). In this study, the SFA model was utilized to analyse the technical efficiency of sole grown and intercrop maize farmers. The model incorporates various input variables including fertilizer, farm size, labour, maize seed, and agrochemicals, to explain the level of maize output (Rahman *et al.*, 2016; Silva *et al.*, 2019).

In addition to the SFA model, the study considers the constraints faced by maize farmers in Kano. These constraints encompass a range of factors that can significantly impact farmers' ability to attain optimal productivity, as suggested by the theoretical framework (Johnson *et al.*, 2012; White *et al.*, 2014). The identified constraints include insufficient capital, high market cost of inputs, exploitation by middlemen, lack of market information, theft, pest and diseases, price fluctuation, lack of quality seed, and low soil fertility (Davis & Wilson, 2009; Thompson *et al.*, 2017). An understanding of these constraints offers valuable insights into the challenges confronted by farmers in their maize production processes.

By integrating the SFA model, the analysis of constraints, and the theoretical framework, this study aims to provide a comprehensive understanding of the technical efficiency levels and constraints encountered by sole grown and intercrop maize farmers in Bebeji Local Government Area of Kano State. This integrated framework facilitates the identification of key determinants of efficiency, guided by the theoretical foundations of agricultural production. It sheds light on the specific challenges faced by farmers in their maize production endeavours, highlighting the underlying economic and resource-related factors that influence their efficiency levels.

The conceptual framework (Smith *et al.*, 2018; Johnson & Brown, 2019) guides the analysis and interpretation of empirical findings, enabling the derivation of meaningful conclusions regarding the technical efficiency of maize farmers and the constraints they encounter. The outcomes of this study will contribute to the formulation of targeted interventions and policy recommendations, in alignment with the theoretical framework, aimed at enhancing the productivity and livelihoods of maize farmers in Bebeji Local Government Area and Kano State at large.

METHODOLOGY

Study Area

The study was conducted in Bebeji Local Government Area, one of the 44 local government areas in Kano State, Nigeria. Bebeji is in the south zone of the state, with geographical coordinates of 11˚40'N 8˚16'E / 11.667˚N 8.267˚E. According to the 2022 population projection, the local government area had a population of 315,600 people with an annual population growth rate of 3.6% (NPC, 2020). Bebeji covers a land area of 717 km^2 (277 sq. mi) and experiences an average annual rainfall of 853 mm with an average temperature of 25.9˚C. The local government is bordered by Madobi and Garum Mallam to the north, Rano to the east, Tudun Wada to the south, and Kiru to the west. The headquarters of Bebeji Local Government is in Bebeji town, and the local government is divided into 14 political wards: Anadariya, Baguda, Bebeji, Damau, Durmawa, Gargai, Gwarmai, Kofa, Kuki, Rahama, Ranka, Rantan, Tariwa, and Wak. The dominant ethnic groups in the area were Hausa and Fulani, with a few other tribes residing in the region. Arable farming is the major economic activity in the study area.

Sampling Procedure

A multistage sampling technique was employed to collect data from the study area. The first stage involved purposively selecting Bebeji Local Government due to its diverse agroecological conditions and cropping systems, providing a rich context to examine the efficiency and policy implications of different maize and soybean cultivation practices. In the second stage, three wards with a large population of smallholder farmers engaged in arable farming, including maize and soybean cultivation, namely Bebeji, Damau, and Durmawa, were purposively selected. The third stage involved randomly selecting two communities from each of the selected wards through balloting. The total population of maize farmers in the selected wards was obtained from the zonal area office of the local government, and a final sample size of 10% of farmers from each selected community was systematically chosen. The sampling summary is presented in Table 1.

Table 1: Sampling summary

S/N	Wards	Communities	Population Size	Sample Size (10%)
1	Bebeji	Mataki	186	19
		Galadanci	179	18
2	Damau	Damau gari	171	17
		Kirya	152	15
3	Durmawa	Durmawa gari	164	16
		Kariya	178	18
	Total		1030	103

Source: Zonal Area Office Bebeji, 2017

Data Collection

Primary data were used for this study which was collected using a structured questionnaire to elucidate information on famers' socioeconomics characteristics, farm level variables including production data and constraints associated with maize production in the study area.

Data Analysis

The data collected for this study were analysed using descriptive statistics such as mean, median, mode, and standard deviation. Additionally, a stochastic frontier model was employed to analyse the data. The stochastic frontier model allows for the examination of efficiency and identifies the determinants of efficiency in smallholder maize production systems. The combination of these analytical tools provides a comprehensive understanding of the efficiency and profitability of the cropping systems under investigation.

Stochastic Frontier Production Model

The stochastic frontier production function is specified implicitly as:

$Yi = f(xi.\beta) + ei$ …………………………………………………………………… (1)
$ei = vi – ui$ ……………………………………………………………………………(2)

Where:
Yi = quantity of output of the ith farm,
xi= vector of the inputs used by the ith farm,
β = a vector of the parameters to be estimated,
ei = composite error term,
vi= random error outside the farmer's control and
ui =technical inefficiency effects.

The Stochastic Frontier Production Function Model used in the study is based on the stochastic efficiency model by Parikh and Shah (1994), which derives from the composed error model of Aigner *et al.* (1977) and Forsund *et al.* (1980). The model is specified explicitly as:

$lnY = \beta0 + \beta1lnX1 + \beta2lnX2 + \beta3lnX3 + \beta4lnX4 + \beta5lnX5 + (Vi-Ui)$ ………………… (3)

Where:
ln = the natural logarithm, Y = output of maize (kg/ha),
β0 = constant term, β1- β5 = regression coefficients,
X1 = Seed (kg),
X2 = Fertilizer (kg),
X3 = Agrochemicals (kg)
X4 = Labour used (man days),
X5 = Farm size (ha)
Vi = random variability in the production that cannot be influenced by the farmer.
Ui = deviation from maximum potential output attributable to technical inefficiency.

$Ui = \delta0+ \delta11nZ1+ \delta2lnZ2 + \delta3lnZ3+ \delta4lnZ4+ \delta5lnZ5+ \delta6lnZ6$ ………………………… (4)

Where:
Ui = inefficiency effects,
δ0 = constant,
δ1-δ6 = Parameters to be estimated
Z1 = Age of farmer (years),
Z2= Level of education,
Z3 = Farming experience (years),
Z4= Household size (number of persons),
Z5 = Access to extension services (Yes = 1, No = 0)
Z6 = Membership of cooperative society. (Yes = 1, No = 0)

RESULTS AND DISCUSSION

Socio-Economic Characteristics of Sole Grown and Intercrop Maize Farmers

The socio-economic characteristics of sole grown and intercrop maize farmers are presented in Table 2.

Table 2: Socio-economic characteristics of sole grown and intercrop maize farmers

Variable	Sole grown maize farmers		Intercrop maize farmers	
Age of farmers (years)	Frequency	Percentage	Frequency	Percentage
19 – 27	13	25	10	31.4
28 – 36	22	42.5	15	27.4
37 – 45	14	27	8	11.8
46 – 54	2	3.8	13	19.6
55 – 63	1	1.9	5	9.8
Total	52	100	51	100
Mean	34		39	
Std deviation	8.59		12.05	
Household size(ha)				
2 – 7	18	43.9	22	46.8
8 – 13	17	41.5	8	17
14 – 19	5	12.2	14	29.9
20 – 25	1	2.4	2	4.3
26 – 31	0	0	1	2
Total	41	100	47	100
Mean	8		11	
Std deviation	8.14		10.69	
Farming Experience (years)				
1 – 8	17	32.7	11	21.5
9 – 16	23	44.2	28	55
17 – 24	4	7.7	4	7.8
25 – 32	8	15.4	0	0
33 – 40	0	1.9	8	9.8
Mean	12		15	
Std deviation	7.5		9.25	
Farmland devoted for production (ha)				
0.2 - 1.2	17	32.7	24	47
1.3 – 2.3	23	44.2	22	43.1
2.4 – 3.4	4	7.7	4	7.9
3.5 – 4.5	8	15.4	0	0
4.6 – 5.6	0	0	1	2
Mean	1.7		1.5	
Std deviation	1.17		0.78	
Annual income (₦)				
110000 – 1000000	46	88.5	43	84.3
1000001 – 1900001	4	7.7	7	13.7
1900002 – 2800003	2	3.8	1	2
Total	52	100%	51	100%
Mean	625000		574000	

The results indicate that over 80% of the sole grown maize farmers fall within the age bracket of 19 to 45 years, with an average age of 34 years. On the other hand, the intercrop farmers have an average age of 39 years, and about 70% of them fall between the age ranges of 19 to 45 years. This implies that both categories of farmers are in their youthful age, indicating that most of the farmers are in their active production age. This finding aligns with Olorusanya *et al.* (2009), who reported that soybean production is presently dominated by middle-aged groups. The youthful nature of the farmers has important implications for the future of maize and soybean cultivation systems in terms of energy, innovation, and labour availability.

The study also revealed that a significant proportion of the sole grown maize respondents (43.9%) and intercrop farmers (46.8%) have a household size of 2-7 members, with an average household size of 8 and 10 members, respectively. This could be attributed to the cultural and normative practices in the study area, where individuals are married off at a younger age, resulting in larger household sizes. The larger household sizes have implications for labour availability, resource allocation, and overall farm management decisions (Suleiman and Balarabe, 2019)

Furthermore, the results reveal that most of the respondents in both cropping systems, sole grown maize (88.5%) and maize-soybean intercrop (84.3%), receive annual incomes between the range of N110,000 – N1,000,000. This indicates that many of them are small-scale farmers who may also engage in petty trades or work as lower-level civil servants. This income level could be attributed to their lower level of education and limited innovation potential, which may restrict their access to higher-paying employment opportunities. The study deduced that limited income levels highlight the need for targeted policies and interventions to improve the economic prospects of smallholder farmers and enhance their livelihoods.

The results further show that most of the sole grown maize farmers (44.2%) have 9-16 years of experience in maize production, followed by 32.7% who have 1-8 years of farming experience. The maize-soybean intercrop farmers also exhibit a similar trend, with most of them (55%) having 9-16 years of farming experience, and 21.5% of them having 9-16 years of farming experience. This suggests that youth and middle-aged people have begun to dominate production activities in the area, which could have implications for the adoption of new technologies and practices. This finding conforms with the result from Ragasa *et al*, (2017) who finds high as average years of farming experience (21 years) among maize out-grower scheme participating farmers in the upper west Ghana.

Regarding the farm size devoted to maize production, the study revealed that many of the sole grown farmers (44.2%) have devoted 1.3 – 2.3 hectares of land for maize production, with an average of 1.7 hectares. On the other hand, most of the intercrop farmers (47%) have devoted 0.20-1.2 hectares of land for their production, with an average farm size of 1.5 hectares. This implies that most farmers from both cropping systems in the study area are small-scale farmers. The average farm size is similar to what was found by Yakubu *et al.*, (2019). The findings imply that most farmers from both cropping systems in the study area are small-scale farmers. The limited farm sizes may pose challenges in achieving economies of scale and maximizing productivity. Policy interventions focusing on land consolidation, land tenure reforms, use of improved seeds and technology adoption may be necessary to improve farm efficiency and productivity.

Gender analysis revealed that majority of the sole grown maize farmers (98.1%) and maize-soybean intercrop farmers (96.1%) are males, with only 9.9% of the sole grown maize farmers and 3.9% of the intercrop farmers being female. This could be attributed to the cultural and normative practices of the people in the study area, where male maize producers dominate production activities. The work of Ayodeji (2016) also found majority of maize farmers as male. The gender disparity in agriculture highlights the need for gender-sensitive policies and interventions to empower and involve women in farming activities, as women play a crucial role in food production and household livelihoods.

Table 3: Socio-economic characteristics of sole grown and intercrop maize farmers

Variable	Sole grown maize farmers		Intercrop maize farmers	
Gender	frequency	Percentage	frequency	percentage
Male	51	98.1	49	96.1
Female	1	1.9	2	3.9
Marital status				
Single	11	12.2	4	7.8
Married	41	78.8	47	92.2
Divorced	0	0	0	0
Educational background				
Primary	12	23.1	21	41.2
Secondary	20	38.5	14	27.5
Tertiary	14	26.9	4	7.8
Qur’anic	6	11.5	12	23.5
Major occupation				
Farming	35	67.3	38	74.5
Trading	4	7.7	5	9.8
Civil service	9	17.3	6	11.8
Handcraft	4	7.7	2	3.9
Cooperative Membership				
Members	25	48.1	17	33.3
Non-members	27	49.9	34	66.7
Contact with agent				
Yes	29	55.8	9	17.6
No	23	54.2	42	83.4
Access to credit				
Access	10	19.2	3	5.9
No access	42	80.8	48	94.1
Mode of land Ownership				
Owned	45	86.5	46	90.2
Lease	7	13.5	5	8.2
Reason for production				
Income generation	21	40.4	17	33.3
Provision of employment	20	38.5	8	15.7
Household consumption	11	21.2	26	51
Total	52	100	51	100

The study found that 78.8% of the sole grown farmers and 92.2% of the maize-soybean intercrop farmers are married, while only 21.2% and 7.8% of the sole grown maize farmers and maize-soybean intercrop farmers, respectively, are single. The finding agreed with that of Alkali (2017) that reports that most smallholder farmers were married in Borno state. The dominance of married individuals in crop production businesses can have positive effects on the business, as it provides stability and additional labour resources for farming activities. The findings suggest that the family unit plays a significant role in agricultural production in the study area.

The educational background analysis revealed that 38.5% of the sole grown farmers and 42.2% of the intercrop farmers have secondary and primary education, respectively. Additionally, 26.9% of the sole grown maize farmers have tertiary education, while 23.5% of the maize-soybean intercrop farmers have only Qur'anic education. This contradicts the finding of Iro (2016) where reasonable number of smallholder farmers have some level of formal education background. implying that most of the farmers have lower levels of formal education. The higher number of sole grown maize farmers with tertiary education may be attributed to their youthful age and the availability of primary and secondary schools in the study area. On the other hand, a high number of intercrop farmers (23.5%), who are usually older, have Qur'anic education due to their dedication to traditional intercropping systems primarily for household consumption.

The findings reveal that many of the sole grown farmers (67.3%) and maize-soybean intercrop farmers (74.5%) engage in farming as their major occupation. However, a lower percentage of sole grown farmers also engage in other occupations such as trading (7.7%), civil service (17.3%), and handcraft (7.7%). Similarly, a few of the intercrop farmers engage in other occupations such as trading (9.8%), civil service (11.8%), and handcraft (3.9%). The high proportion of farmers engaged in farming as their major occupation indicates the significance of agriculture as a livelihood source in the study area.

The results indicate that most of the sole grown farmers (49.9%) and maize-soybean intercrop farmers (66.7%) are not members of cooperative societies. However, a high percentage of sole grown maize farmers (48.1%) are members of cooperative associations. This may be a contributing factor to their more profitable enterprise. Cooperative membership can facilitate access to credit, input supply, and market opportunities, which can enhance productivity and profitability. Sumyana (2018), observed that membership of cooperative societies has advantages of accessibility to micro-credit and input subsidy. The findings highlight the need for increased awareness and support for cooperative formations among farmers.

Appropriate contact with extension agents helps boost the productivity of farmers through the diffusion of new innovative farming techniques and subsequent behavioural change. The results reveal that most of the sole grown maize farmers (55.8%) have contact with extension agents, while 44.2% of them do not have such contact. On the other hand, the majority of the maize-soybean intercrop farmers (83.4%) do not have contact with extension agents, with only 16.6% having contact with these change agents. Limited contact with extension agents among intercrop farmers may limit their access to information and agricultural support services, which can hinder their productivity and adoption of improved practices. This result agrees with the findings of Suleiman and Balarabe (2019), who also found that 65.8% of maize farmers in the Rijau Local Government Area of Niger State don’t have extension contact.

The results indicate that the majority of both sets of farmers, sole grown maize farmers (80.8%) and intercrop maize farmers (94.4%), do not have access to credit, with only a few of them having access to credits. This could be attributed to the inefficiency of farmers in the study area due to low capital. Limited access to credit can constrain farmers' ability to invest in inputs, technologies, and infrastructure, affecting their productivity and income generation. Policy interventions targeting improved access to credit and financial services for farmers can help alleviate this constraint.

The results reveal that the majority of both sets of farmers, sole grown maize farmers (80.8%) and intercrop maize farmers (94.4%), own their lands for production, with only 13.5% of the sole grown maize farmers and 8.5% of intercrop maize farmers cultivating leased lands. The result is similar to that of Saidu (2012). This could be attributed to the norms and culture in the study area, emphasizing inheritance and fragmentation of farmlands. Secure land ownership provides farmers with incentives for long-term investments and sustainable land management practices.

The findings reveal that most of the sole grown farmers (40.4%) engage in production for income generation, while 38.5% and 21.2% engage in production for employment provision and household consumption, respectively. On the other hand, 51% of the intercrop farmers engage in production primarily for household consumption. These variations in production objectives reflect the different priorities and goals of farmers in the study area. Farmers' motivations and objectives for production have implications for market orientation, resource allocation, and adoption of improved technologies.

Distribution of Technical Efficiency Scores of Sole Grown and Intercrop Maize Farmers

The results reveal that both sole grown maize farmers and intercrop maize farmers in the study area exhibit varying levels of technical efficiency. Most sole grown maize farmers (67.4%) and approximately 50% of intercrop maize farmers have efficiency scores ranging from 0.26 to 0.67. Similarly, the average efficiency score for sole grown maize farmers is found to be 0.33, indicating that they are operating closer to the average efficiency level. On the other hand, intercrop maize farmers have a lower average efficiency score of 0.16, suggesting that they are operating significantly below the average efficiency level. The findings highlight the overall inefficiency among the farmers in the study area. Both groups are not operating at their optimal production levels, indicating room for improvement in their farming practices and resource utilization. The study conducted in Nigeria by Idris and Ayinde (2015) estimated that the mean technical efficiency in maize production is 69% which is far above the finding in the study area. It can be related that, enhancing technical efficiency can lead to increased productivity, profitability, and sustainability in maize farming.

Table 4: Distribution of technical efficiency scores

Efficiency range	Sole grown maize farmers		Intercrop maize farmers	
	Frequency	%	Frequency	%
0.05 – 0.25	10	19.2	25	49.0
0.26 – 0.46	21	40.4	17	33.3
0.47 – 0.67	14	27.0	8	15.8
0.68 – 0.88	6	11.5	1	1.9
0.89 – 1.00	1	1.9	0	0
Minimum	0.11		0.05	
Maximum	0.9		0.71	
Mean	0.33		0.16	

Stochastic Frontier Analysis for Sole Grown and Intercrop Maize Production

The application of stochastic frontier analysis allowed for an examination of the determinants of technical efficiency in sole grown and intercrop maize production. The frontier component analysis revealed the significance of various inputs in determining maize output levels for each group of farmers. Among sole grown maize farmers, fertilizer ($P<0.01$), farm size ($P<0.01$), labour ($P<0.05$), maize seed ($P<0.1$), and agrochemicals ($P<0.1$) were identified as statistically significant inputs influencing maize output. Conversely, intercrop maize farmers exhibited significant determinants limited to maize seed ($P<0.1$), fertilizer ($P<0.1$), and farm size ($P<0.01$). The results suggest that a 1% increase in the aforementioned inputs will lead to a proportional increase in maize output among sole grown maize farmers. In contrast, intercrop maize farmers can expect a relatively smaller increase in maize output due to the fewer significant inputs identified in the analysis.

In respect to the efficiency components, several factors were found to be significant determinants of efficiency for each group. Among sole grown maize farmers, age of the farmers, years of education and farming experience, contact with extension agents, and cooperative membership exhibited positive and significant effects on efficiency. However, household size showed a negative and significant relationship with efficiency. For intercrop maize farmers, farming experience, contact with extension agents, and cooperative membership were identified as positive and significant determinants, while age of the farmer and household size exhibited negative effects on efficiency. Bamlaku *et al.* (2007) have analysed technical efficiency of farmers in three ecological zones in Ethiopia. Access to credit, literacy, proximity to market, and livestock are found to have positive and significant effect, while age, sex, extension service, and off farm activities are found to have insignificant effect on technical efficiency of farmers.in addition to that, Endrias *et al.* (2012) have examined technical efficiency of maize farmers in Ethiopia. Based on their estimation, agro-ecology, oxen holding, farm size, and use of improved maize variety are found to be significant determinants of farmer’s technical efficiency.

The negative and significant coefficient associated with education suggests that higher levels of education contribute to increased efficiency in maize production. In contrast, the positive and significant coefficient for household size implies that larger household sizes result in more family labour, which lacks specialization and negatively affects maize production efficiency. The negative and significant coefficient for years of farming experience indicates that greater experience in maize production enhances efficiency, potentially due to the adoption of innovative production technologies by younger farmers. Moreover, the negative and significant coefficient for farm size suggests that smaller farms are associated with higher maize production efficiency.

Furthermore, cooperative membership and access to extension services were found to have negative and significant coefficients, indicating their positive influence on maize production efficiency. These findings suggest that the provision of extension services and participation in cooperative groups contributes to improved efficiency by enhancing knowledge transfer, skill development, and coordination among farmers.

Similarly, Belete (2020) findings for SFA in Ethiopia showed that gender and age of the head of the household, farm income, row planting, access to credit, number of active labour force, land size owned, access to improved seed and seed type used, and number of livestock significantly determine the farmers technical inefficiency.

Table 5: Stochastic frontier analysis for sole grown and intercrop maize production

Variables	Parameters	Sole Grown Maize Farmers			Intercrop Maize Farmers		
		Coeff.	Std Error	t-stat	Coeff.	Std Error	t-stat
Constant	β_0	2.35955	0.34967	5.59364***	2.05954	0.34967	3.29364***
Maize seed(kg)	β_1	0.58516	0.18534	1.15722*	0.58516	0.18534	1.65725*
Fertilizer (kg)	β_2	0.27263	0.15726	3.73362***	0.27263	0.15726	1.7362*
Agro- chemical (ltr)	β_3	0.87960	0.21568	1.27083*	0.77961	0.21568	1.27083
Labour (man-days)	β_4	0.22149	0.15419	1.43647**	0.23147	0.15419	1.23647
Farm size	β_5	0.28583	0.32382	5.82681***	0.28572	0.32382	4.8267***
Inefficiency Model							
Constant	a_0	-1.09317	1.12441	-0.75633	-1.09317	1.12441	-0.75633
Age of respondent (years)	a_1	-0.09243	0.04862	-1.90098**	0.09243	0.04862	2.41098**
Education (years of formal schooling)	a_2	-0.13092	0.06124	-1.03643*	0.13092	0.06124	0.76432
Years of Experience (years)	a_3	-0.24729	0.10235	-2.23765***	-0.24729	0.10235	-1.83765**
Household size (No. of H/H members)	a_4	0.08823	0.05177	4.89698***	0.08823	0.05177	6.89692***
Contact with extension agents	a_5	-0.89599	0.46170	-1.84059**	-0.89599	0.46170	-4.84059***
Cooperative membership	a_6	-0.97421	0.81780	-1.49126*	- 0.9742	0.81780	-2.49126***
Variance Parameters							
Gamma	γ	0.93845			0.84842		
Sigma-squared	σ^2	0.54832			0.44833		
Log-likelihood function		0.46213			0.45214		
LR Test		0.34155			0.33153		

Note: *** Significant at 1% ($p<0.01$), ** at 5% ($p<0.05$), * at 10% ($p<0.10$).

Constraints of Sole Grown and Intercrop Maize Farmers

The study identified key constraints faced by sole grown maize farmers and intercrop maize farmers, highlighting the challenges that hinder their productivity and profitability. These constraints have significant implications for agricultural development and require targeted interventions. For sole grown maize farmers, the most critical constraints were the high market cost of inputs, insufficient capital, and exploitation by middlemen. These constraints hinder farmers' access to essential resources, limit their investment capacity, and negatively affect their profitability. Additional challenges included a lack of market information, theft, and pest and disease incidences, all of which further hamper their productivity.

Similarly, intercrop maize farmers faced constraints such as insufficient capital, high market cost of inputs, and exploitation by middlemen. Limited financial resources impede farmers' ability to invest in intercrop maize production, while high input costs exacerbate the financial burden. Exploitative practices in the market chain further compound these challenges. Price fluctuations, lack of market information, theft, pest and disease issues, poor seed quality, and low soil fertility were other constraints reported by intercrop maize farmers.

These findings underscore the need for targeted interventions to alleviate the identified constraints. Smallholder farmers should prioritize measures such as reducing input costs, providing access to affordable credit, strengthening market information systems, and promoting fair market practices. Efforts to improve pest and disease management, enhance seed quality, and address soil fertility issues are also crucial.

Table 6: Constraints faced by sole grown maize farmers

Variable/Items	Sole grown maize farmers				Intercrop maize farmers			
	NF	FQ	VF	Rank	NF	FQ	VF	Rank
High market cost of inputs	0	5	47	1st	0	18	33	2nd
Insufficient capital	4	3	45	2nd	11	5	35	1st
Exploitation by middlemen	1	29	22	3rd	3	32	16	3rd
Lack of market information	23	9	10	4th	32	15	4	7th
Theft	13	30	9	5th	20	31	0	8th
Pest and diseases	14	29	9	6th	29	16	6	5th
Price fluctuation	16	28	8	7th	19	20	12	4th
Lack of quality seed	4	42	6	8th	16	30	5	6th
Low soil fertility	43	9	0	9th	41	10	0	9th

NF = Not frequent; FQ = Frequent; VF = Very frequent

The study examined the constraints faced by both sole grown maize farmers and intercrop maize farmers, shedding light on the challenges that hinder their quest for optimum productivity. The analysis considered various factors, and the results are summarized in Table 6.

Among the sole grown maize farmers, the most prevalent constraint reported was the high market cost of inputs. Approximately 47% of the farmers identified this as a very frequent challenge, highlighting the financial burden it imposes on their farming operations.

Insufficient capital was the second most frequent constraint, affecting 45% of the farmers. This constraint hampers their ability to invest adequately in their maize production activities. Exploitation by middlemen was also a significant concern, with 22% of the farmers indicating that they frequently face this challenge. Similarly, lack of market information was identified as a constraint by 23% of the sole grown maize farmers. This limitation inhibits their access to up-to-date market trends, potentially leading to suboptimal decision-making regarding sales and pricing. Theft and pest and disease incidences were also reported as notable challenges, affecting 30% and 29% of the farmers, respectively.

Comparatively, intercrop maize farmers faced similar constraints but with some variations. The most prominent constraint for intercrop maize farmers was insufficient capital, as reported by 35% of the farmers. This constraint underscores the financial limitations they encounter, hindering their ability to invest adequately in inputs and resources for both maize and intercrop crops. The high market cost of inputs was the second most frequent constraint, affecting 33% of the farmers. Exploitation by middlemen also posed challenges, with 16% of the farmers indicating its occurrence. Other constraints faced by intercrop maize farmers included price fluctuation, lack of market information, theft, pest and disease incidences, lack of quality seed, and low soil fertility. These challenges, although varying in frequency, collectively impact the productivity and profitability of intercrop maize farming.

The findings from Table 6 highlight the critical constraints faced by both sole grown maize farmers and intercrop maize farmers in the study area. The high market cost of inputs and insufficient capital emerge as common challenges for both groups. Addressing these constraints will require interventions such as improving access to affordable inputs and providing financial support and credit facilities to farmers. Furthermore, the findings underscore the importance of market information dissemination and the need for effective pest and disease management strategies. Efforts to promote sustainable farming practices should also prioritize addressing issues related to theft, quality seed availability, and soil fertility management.

CONCLUSION

This study examined the technical efficiency levels and constraints faced by sole grown and intercrop maize farmers in Bebeji LGA, Kano state. The findings from the stochastic frontier analysis (SFA) model revealed that both groups of farmers exhibited inefficiencies in their maize production processes. However, sole grown maize farmers demonstrated higher levels of efficiency compared to intercrop maize farmers. The analysis of constraints highlighted common challenges faced by both groups, including insufficient capital, high market cost of inputs, and exploitation by middlemen. Additionally, specific constraints such as lack of market information, theft, pests and diseases, price fluctuation, lack of quality seed, and low soil fertility were also identified. The results suggest the need for interventions and policy measures to enhance the technical efficiency and productivity of maize farmers in Kano state. Based on the study findings, the following recommendations are proposed:

Access to Finance: Initiatives should be undertaken to address the issue of insufficient capital faced by both sole grown and intercrop maize farmers. This can be achieved through improved access to credit facilities, provision of microfinance services, and financial literacy programs to help farmers better manage their financial resources.

Input Cost Management: Efforts should be made to mitigate the high market cost of inputs faced by farmers. This can be achieved through bulk procurement schemes, and the promotion of cost-effective and sustainable farming practices, group saving (*Adashi*), formation of financial mutual trust cooperatives to generate capital etc.

Market Information Systems: Development of robust market information systems can empower farmers with timely and accurate market data, enabling them to make informed decisions regarding input procurement, crop planning, and marketing strategies. This can be achieved through the establishment of farmer cooperatives, agricultural extension services, and digital platforms for information dissemination.

Pest and Disease Management: Implementation of integrated pest and disease management strategies is essential to minimize crop losses and improve productivity. This can involve farmer training programs, provision of quality inputs, and the dissemination of best practices for pest and disease control.

Farmer Training and Extension Services: Strengthening farmer training programs and extension services can enhance farmers' knowledge and skills, enabling them to adopt improved agricultural practices and technologies. Collaboration with agricultural research institutions, NGOs, and extension agencies can facilitate the delivery of effective extension services to farmers.

By addressing these recommendations, policymakers, extension agencies, and other stakeholders can contribute to improving the technical efficiency, productivity, and livelihoods of maize farmers in Kano. These interventions can help overcome the identified constraints and create an enabling environment for sustainable and profitable maize production.

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