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Technical Efficiency of Sorghum Production in Garu District of the Upper East Region, Ghana

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Abstract

This study analyzed the technical efficiency and identified its determinants in sorghum production. Two-stage sampling technique was used to collect cross-sectional data from 100 smallholder sorghum farmers in Garu district in the upper east region of Ghana using a semi structured questionnaire. The stochastic frontier analysis was used to estimate the level and determinants of technical efficiency while Kendall's coefficient of concordance approach was used to identify and rank the constraints restraining sorghum production. The study revealed that only farm size and fertilizer were found to have a significant influence on the output. Technical efficiency varied widely among sorghum farmers, ranging from 16.14% to 99.11% with a mean technical efficiency of 88.92%. This means that farmers could improve the productivity of sorghum by 11.08% without requiring extra inputs. The main determinants of technical efficiency were age, level of education, association membership, household size, experience, crop variety, and access to extension, access to credit, access to market and distance to market. Major constraints limiting sorghum production were natural disasters, the incidence of pest and diseases, lack of access to credit and high production cost. The study recommends that fertilizer supply at subsidized prices to farmers in the study area should be improved. Also, the Ministry of Food and Agriculture through extension agents should educate farmers on the impact of these farm and farmer specific characteristics on technical efficiency.

Keywords: Sorghum, Technical efficiency, Garu District, Upper East Region, Stochastic frontier analysis, Ghana.
JEL Classification: A12.

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Contents

Contribution of this paper to the literature
This study is the first in literature that employed a production economics technique to estimate the technical efficiency of sorghum production in the study area.

1. Introduction

Sorghum is an essential cereal crop grown worldwide for animal nutrition (Jacob, Fidelis, Salaudeen, & Queen, 2013). This crop is very well adapted to the ecological conditions under which it is traditionally grown (Muyukani & Muthama, 2019). Globally, sorghum is being used in food products and various food items that are made from this crop, including malted drinks, cake, ethylene glycol, flour, sweets and beers (Zalkuwi, 2015). It is usually cultivated in the semi-arid tropics where water availability is limited and mostly exposed to drought (Deb, 2004). In Africa, sorghum is second to maize as the staple grain for millions of people (Mundia, Secchi, Akamani, & Wang, 2019). According to Hariprasanna and Rakshit (2016) over 90% of the world's sorghum harvested areas lie in the developing economies, mainly in Africa and Asia, with Africa contributing about 61% of the production land and 41% of production. Asia, on the other hand, contributes about 22% of the production land and 18% of production (Mundia et al., 2019).

The contribution of the agricultural sector to the general development of Ghana cannot be underestimated as it employs about 50% of the labour force and has contributed 23.6% to the gross domestic product (GDP) of Ghana (GSS, 2014). In 2018, the agricultural sector accounted for about 20.5% of our GDP as compared to the industrial and service sectors, which contributed 31.3% and 48.2% respectively (Ghana Statistical Service (GSS), 2018). The agricultural sector growth in 2018 was 4.8%, relative to a growth rate of 6.1% in 2017. Though the contribution of agriculture to GDP should decrease with development, the growth rate should be persistent over time according to Arthur Lewis theory of development (Lambongang, Ansah, & Donkoh, 2019). Although the agricultural sector's share to the GDP of Ghana is smaller compared to the other sectors, the ripple effect of the inefficiency of the sector on the livelihoods of farmers, food security and other benefits cannot be underrated (Konja, Mabe, & Alhassan, 2019).

The crop sector is the largest (14.5%) contributor to the agricultural sector to GDP (Ghana Statistical Service (GSS), 2018). Even though the crop sector plays a significant role in GDP growth, its yield in Ghana is low, as growth in output over the years has come as a result of an increase in land under cultivation rather than improvement in yields which leads to deforestation and associated effects (Danso-abbeam, Bosiako, Ehiakpor, & Mabe, 2018).

In Ghana, sorghum is usually grown in Guinea and Sudan savanna zones in the Upper West, Upper East and Northern regions of the country with a respective average rainfall of 1000mm and 990mm per year (Darfour & Rosentrater, 2018). Sorghum is seen as a common food crop in Ghana and is among the baseline crops of farmers in the savanna zones (Darfour & Rosentrater, 2018). The researchers noted that sorghum comes after maize and rice concerning the quantity of cereal production, with 12% on aggregate cereal production value.

Studies on the effect of climate change on sorghum yields reveal that there will be enormous yield declines and increased volatility from West Africa (Ray et al., 2019). It is possible that sorghum production will face greater challenges in the future, and people who rely on sorghum as a staple food is likely to face food insecurity (Mundia et al., 2019). In this context, insight into the essentials of sorghum production in the Garu district of the upper east region, compared to other strong sorghum-producing regions will provide a relevant understanding of what factors to consider to increase production and secure food supply.

Many developing economies, including Ghana, have invested a lot in the agricultural sector (Sienso, Asuming-brempong, & Amegashie, 2014). Despite these great investments in agriculture, its productivity in developing economies faces great challenges due to the high degree of the unfamiliarity of farmers with modern technologies, inadequate extension and education facilities, weak infrastructure, among others (Anang, 2016). But in places where inefficiencies exist, trying to implement new technology may not bring the expected results, unless factors related to inefficiency among farmers are identified and dealt with (Dessale & Tegegne, 2017). Therefore, analyzing the technical efficiency of farmers cannot be overemphasized. The measurement of technical efficiency in agric production is a relevant interest for agricultural development and it provides vital information for making relevant decisions in the use of scarce resources and for formulating agricultural policies.

Though there have been numerous empirical studies undertaken to measure the efficiency of agricultural production in Ghana, for example (Bempomaa, 2014; Danso-Abbeam., Dahamani, & Bawa, 2015; Donkoh, 2013; Konja et al., 2019; Sienso et al., 2014; Tambo, 2010) there are no similar studies conducted to measure technical efficiency in sorghum production in the area of study. Thus this study has tried to ascertain information for policy implementation by identifying factors that are associated with technical efficiency in sorghum production in the Garu district of the Upper East region of Ghana.

2. Methodology

2.1. Description of the Study Area

The analysis was undertaken in the Garu district of the Upper East region of Ghana. The district is located in the south-eastern portion of the Upper East region. It occupies an area of 1060.91 square kilometres with an estimated population of about 130,003, comprising 62,025 males and 67,978 females. This accounts for 1.2 per cent of the total population of the region (Ghana Statistcal Service (GSS), 2014). Garu district lies approximately on latitude 11038l N and110 N and longitude 00 06l E and 00 23l E (GSS, 2014). The majority (95.4%) of families in the district are engaged in farming (Ghana Statistcal Service (GSS), 2014) of which majority (98.8%) of these farmers are engaged in crop cultivation (GSS, 2014). The district shares borders to the north with Bawku Municipal, to the south with Bunkpurugu-Yunyoo District; to the west with Bawku West District, and the east with the Republic of Togo. The district is part of the nation's internal continental climate region marked by pronounced dry and wet seasons. Two opposing air masses have an impact on the two seasons. One of them is the cold, dusty and dry harmattan air or the North East Trade winds that often blow in the north-eastern direction from late November to early March. Throughout that period, rainfall is unlikely because the humidity is quite weak, often less than 10 mm and humidity levels rarely exceed 20% all day, but can rise to 60% during the night and early morning (Ghana Statistcal Service (GSS), 2014). Temperature is typically moderate under tropical conditions at this time of year (260-2800 C) (GSS, 2014). Temperatures could reach as high as 3800o C between March and May (Ghana Statistcal Service (GSS), 2014). The maximum monthly mean temperature is 4000o C in April, while the minimum temperature is 180o C in December / January (GSS, 2014).

2.2. Sampling Procedure and Data Collection

The data was collected from smallholder sorghum farmers during the cropping season 2019/2020 with a questionnaire as a research instrument. A two-stage random sampling technique was used. In the first stage, five major sorghum producing communities were randomly selected for the study. With the second stage, there was another random selection of 20 sorghum farmers from each community were selected making a total sample size of 100. The sample size for the analysis was calculated based on Equation 1 below, the following the formula by Yamane (1967).

$$n = \frac{N}{1 + N(\alpha)^2} \qquad (1)$$

$$n = \frac{130003}{1 + 130003(0.1)^2} = 100$$

Where: n is the sample size, N is the total populace and α is the preferred level of accuracy. Therefore, a total of 100 respondents were selected for the interview.

2.3. Data Analysis

The study employed the stochastic production frontier and Kendall's coefficient of concordance. The stochastic frontier production function was employed to estimate the skill of sorghum farmers to use the least possible quantity of inputs under a given technology to produce a greater level of output. Kendall's coefficient of concordance was used to rank constraints face by farmers in sorghum production.

2.3.1. Estimation of TE of Sorghum

According to Aigner, Lovell, and Schmidt (1977) and Meeusen and van Den Broeck (1977). The stochastic frontier production function is expressed in Equation 2 below as;

$$Y_i = f(x_i; \beta) + \varepsilon_i \qquad (2)$$

Where i = 1, 2, 3, 4…..N

$$\varepsilon_i = V_i - U_i \qquad (3)$$

Where Y_i is the output level of the ith farmer, X_i is the vector of the input level used by the ith farmer, β,s are the unknown parameters to be calculated, and εi denotes the stochastic composite error. It is presumed that the two elements of the error terms are individually and equally distributed. Component V_i is an asymmetrically distributed error term that captures production variance due to factors outside the domain of the farmer, U_i is a one-sided error term that captures the inefficiency of the decision-making unit as shown in Equation 3.
Based on this Technical Efficiency was specified as;

$$TE_i = \frac{Y_i}{Y^*_i} = \frac{f(x_i; \beta)\exp(v_i - u_i)}{f(x_i; \beta)\exp(v_i)} = \exp(-u_i) \qquad (4)$$

Where Y_i is the observed output of the ith farmer and Y_i^* is the unobserved output as indicated in Equation 4. Technical efficiency takes a value between zero and one. Thus $0 \le TE, \le 1$. If U_i = 0, then the production firm is 100% efficient and if U_i >0, then there is some inefficiency.

To estimate the determinants of TE, this study followed (Battese & Coelli, 1995).

Table-1. Description of variables in the stochastic frontier translog production model.

Variable	Description	Measurement	Expectation
Y	Quantity of output	Kilogram (50kg/bag)	
S	Quantity of seeds	Kilogram (4kg/acre)	+
L	Quantity of labour	Man-day	+
W	Volume of weedicide	Litres	+
F	Quantity of fertilizer	Kilogram (50kg/bag)	+
Fs	Farm size	Acreage	+
Age	Age of farmer	Number of years	+
Sex	Sex of farmer	Dummy (0=male 1=female)	-
Mstat	Marital status farmer	Dummy (1=married 0=otherwise)	-
EduL	Level of education	Number of years	-
FA	Farmer Association	Dummy (0=yes 1=no)	-
Hhs	Household size	Number of persons	-
Exp	Farming experience	Number of years	-
Vrty	Variety of sorghum	Dummy (0=improved 1=local)	-
AccExt	Access to extension	Dummy (0=yes 1=no)	-
AccCrdt	Access to credit	Dummy (0=yes 1=no)	-
AccMrkt	Access to market	Dummy (0=yes 1=no)	-
Dist	Distance from market	Kilometres	-

Source: Field survey, 2020.

The empirical stochastic translog production function for finding factors affecting the output levels of ith sorghum farm is specified in Equation 5 below;

$$lnY_i = \beta_0 + \beta_1 lnS_i + \beta_2 lnL_i + \beta_3 lnW_i + \beta_4 lnF_i + \beta_5 lnFs_i + \frac{1}{2}\beta_{11} lnS_i{}^2 + \frac{1}{2}\beta_{22} lnL_i{}^2 + \frac{1}{2}\beta_{33} lnW_i{}^2 + \frac{1}{2}\beta_{44} lnF_i{}^2 + \frac{1}{2}\beta_{55} lnFs_i{}^2 + \beta_{12} lnS_i lnL_i + \beta_{13} lnS_i lnW_i + \beta_{14} lnS_i lnF_i + \beta_{15} lnS_i lnFs_i + \beta_{23} lnL_i lnW_i + \beta_{24} lnL_i lnF_i + \beta_{25} lnL_i lnFs_i + \beta_{34} lnW_i lnF_i + \beta_{35} lnW_i lnFs_i + \beta_{45} lnF_i lnFs_i \quad (5)$$

The model assessing the determinants of technical inefficiency is also specified in Equation 6 below as;

$$U_i = \delta_0 + \delta_1 Age_i + \delta_2 Sex_i + \delta_3 Mstat_i + \delta_4 EduYrs_i + \delta_5 FA_i + \delta_6 Hhs_i + \delta_7 Exp_i + \delta_8 Vrty_i + \delta_9 AccExt_i + \delta_{10} AccCrdt_i + \delta_{11} AccMrkt_i + \delta_{12} Dist_i \quad (6)$$

The Table 1 shows the explanatory variables with their hypothesize effects in the stochastic frontier translog production model.

2.3.2. Kendall's Coefficient of Concordance

To rank the limitations faced by sorghum farmers in the district, Kendall's coefficient of concordance was used (Kendall & Smith, 1939). This measure known as Kendall's coefficient of concordance is a non-parametric statistical measure. The measure of agreement between respondents is used to define a set of limitations, from the most important to the least. The major limitations on the development of sorghum were established and the magnitude was assessed at a level of 1-8. The rankings were then subjected to Kendall's coefficient of concordance to know the degree to which various sorghum farmers agreed to the rankings. The minimum score constraint is interpreted as the most pressing constraint after determining the total rank score for each constraint, while the maximum score constraint is defined as the lowest. The Equation 7 shows the mathematical expression of Kendall's coefficient of concordance:

$$W = \frac{12[\sum T^2 - \frac{(\sum T)^2}{n}}{nm^2(n^2-1)} \quad (7)$$

Where W denotes the coefficient of concordance; T represents the sum of ranks for the constraints being ranked; m denotes the number of sorghum farmers; n signifies the number of constraints being ranked. Kendall's coefficient takes a value between 0 and 1. A value of 0 means that there are maximum disagreement and a value of 1 means that there is perfect agreement among sorghum farmers. Here the null hypothesis is that there is no agreement among sorghum farmers.

3. Results and Discussion

3.1. Demographic and Farm-Specific Characteristics of the Farmers

The results in Table 2, reveals that most (35%) of the farmers fell within 30-39 age bracket while 27% were within the ages of 40-49. This result indicates that a relatively economic active adult population are engaged in sorghum production. The results also show that the majority (61%) of the farmers were males whiles 39% were females. Also, the majority (77%) of the farmers have married whiles 23% were unmarried. On average, there were 10 people per household as indicated. The large household size guarantees labour availability and the extension of farm size (Konja et al., 2019). Results in Table 3 further indicate that on the average farmers had been in sorghum farming for 21 years. A large number (56%) of the sorghum farmers did not belong to any farmer Association (FA), while 44% were members of various farmer associations. According to Konja et al. (2019) farmer association membership provides farmers with the opportunity of accessing the information on effective production methods, enjoying discounts when purchasing inputs, as well as enjoying labour support from members. Also, though 49% of the farmers had extension service, 51% did not have access to the extension. Access to extension service helps farmers to get orientation on good agricultural practices (Konja et al., 2019). Farmers with access to extension services are expected to be more technically efficient than their counterparts since they would have more orientation on good agronomic practices than their counterparts.

Table-2. Distribution of respondents by demographic characteristics.

Variable	Range	Frequency	Percentages (%)
Age	20 – 29	8	8.00
	30 – 39	35	35.00
	40 – 49	27	27.00
	50 – 59	22	22.00
	60+	8	8.00
Total		100	100
Household size	1 – 9	59	59.00
	10 – 19	30	30.00
	20 – 29	10	10.00
	30 – 39	1	1.00
Total		100	100
Marital status	Married	77	77.00
	Single	9	9.00
	Divorce	5	5.00
	Widowed	9	9.00
Total		100	100
Sex	Male	61	61.00
	Female	39	39.00
Total		100	100
Access to Credit	Yes	34	34.00
	No	66	66.00
Total		100	100

Source: Field Survey, 2020.

Results from Table 2 also shows that 34% of farmers had access to credit for sorghum production. However, the average total output of sorghum observed in this study was 465kg/acre while the quantity of seed sowed per acre was 4.75kg/acre. The research also revealed that the average quantity of labour employed per care was 8 man-days. Also, an average of 149.5kg of fertilizer was applied for an acre of production of sorghum in the study area.

Table-3. Descriptive statistics of explanatory variables used in the model.

Variable	Mean	Std. Dev.	Min	Max
Age	2.87	1.09	1	5
Sex	0.39	0.49	0	1
Marital status	1.46	0.94	1	4
Level of education	2.52	1.56	0	9
Farmer association	0.56	0.49	0	1
Household size	10.58	6.59	2	30
Experience	21.5	9.32	2	50
Variety	1.91	0.96	1	3
Access to extension	0.51	0.50	0	1
Access to credit	0.66	0.47	0	1
Access to market	0.26	0.44	0	1
Distance	42.03	30.46	1	150
Farm size	3.06	1.45	1	8
Fertilizer	149.5	67.51	50	400
Weedicide	1.76	1.18	1	9
Labour	18.42	8.47	6	70
Seed	4.75	1.18	3	8
Output	465.3	169.66	100	900

Source: Field survey, 2020.

3.2. Empirical Estimation of Stochastic Frontier Production Function

Table 4 presents the maximum likelihood estimation for parameters in the stochastic translog production frontier of sorghum farmers in Garu. From the results, fertilizer and farm size were found to significantly influence the level of sorghum output in the study area. However, variables such as labour, seed and weedicide did not meet the prior expectation and also statistically insignificant. The coefficient of fertilizer was 2.34 and statistically significant at 1%. This implies that holding other variable inputs constant, a percentage increase in the quantity of fertilizer used per acre increases output by 2.34%. Appropriate fertilizer rates have been noted by Kugbe, Mbawuni, and Wisdom (2019) to increase sorghum yield as fertilizer application adds nitrogen to the soil to improve its fertility. From the table, the coefficient of farm size is -1.45 and statistically significant at 1%. This implies that holding all other variable inputs constant, a percentage increase in farmland allocated to sorghum production decreases output by 1.45%. As the farm size of a farmer increases, the law of diminishing returns sets in as the managing ability of the farmer will decrease given the level of technology, this lead to reduced efficiency of the farmer (Dessale & Tegegne, 2017). For instance, farmers may not efficiently combine land with other variable inputs such as labour, seeds and fertilizer as they increase their farmland (Danso-Abbeam. et al., 2015).

The squared variables in the translog stochastic production frontier indicate the effect of continuous use of that variable on output. The interaction terms indicate a complementarity or substitutability of the inputs used on the farm, depending on the sign of the coefficient of the interaction.

Table-4. Maximum likelihood estimates of the stochastic frontier production function.

Variable	Coeffi Cient	Standard error	P-value
Constant	0.54	3.40	0.87
lnSeed	-0.60	1.71	0.72
lnLabour	0.29	1.57	0.85
lnWeedicide	-1.03	0.76	0.17
lnFertilizer	2.43*	1.37	0.07
lnFarmsize	-1.45*	0.94	0.12
lnSeed*lnSeed	1.54***	0.63	0.01
lnLabour*lnLabour	-0.32***	0.13	0.01
lnWeedicide*lnWeedicide	-0.03	0.09	0.71
lnFertilizer*lnFertilizer	-0.08	0.17	0.65
lnFarmsize*lnFarmsize	-0.11	0.13	0.37
lnSeed*lnLabour	0.84**	0.42	0.04
lnSeed*lnWeedicide	-0.20	0.31	0.51
lnSeed*lnFertilizer	-1.14***	0.41	0.00
lnSeed*lnFarmsize	-0.95***	0.38	0.01
lnLabour*lnWeedicide	-0.19	0.18	0.27
lnLabour*lnFertilizer	-0.05	0.29	0.86
lnLabour*lnFarmsize	0.59**	0.30	0.04
lnWeedicide*lnFertilizer	0.34*	0.19	0.08
lnWeedicide*lnFarmsize	0.23	0.20	0.25
lnFertilizer*lnFarmsize	0.34*	0.22	0.12
Sigma squared	0.15		
Gamma	0.80		
Log-likelihood function	23.42		

Note: ***, ** and * represent 1%, 5% and 10% level of significance respectively.

The results from the table indicate that continuous use of seeds has a positive significant effect on sorghum output. The results further postulated that continuous use of labour has a significant negative influence on sorghum output, whilst the continuous use of fertilizer, weedicide and farm size has no significant effect on output. Results in Table 4 also shows that there is significant input complementary effect between "weedicide and fertilizer", "labour and farm size" and "seed and labour" "seed and farm size", "fertilizer and farm size", "seed and fertilizer" in sorghum production in the study area. This means that a joint increase in the level of these factors will lead to an increase in output. "Seed and farm size" and "seed and fertilizer" were found to be substitutes in sorghum production. This indicates that an increase in one of the variables must be accompanied by a decrease in the other.

3.3. Determinants of Technical Efficiency

The results presented in Table 5 identified the factors influencing technical efficiency in sorghum production. From the table, age, level of education, farmer association, household size, experience, seed variety, access to extension, access to credit, and access to market as well as the distance to the market were significant determinants of technical efficiency in the study area. Whereas age, access to credit, access to market, variety and distance from farm to market centre were found to significantly reduce the technical efficiency level of farmers. Other variables such as level of education, farmer association, household size, experience and access to the extension were found to significantly increase the technical efficiency level of the farmers.

The results show that the coefficient of age was positive and significant at 10%. This shows that as the age of a farmer increases by a year, technical efficiency decreases accordingly. The reason for this may be because, as the farmer increases in age, he becomes weak in terms of carrying out farm operations thus decreasing technical efficiency. This outcome is similar to the finding of Katungwe, Elepu, and Dzanja (2017) and Kusse, Gemeyida, and Haji (2019) but contradicts the finding of Abdul-Rahaman (2016) who found age to have a positive significant influence on technical efficiency. The coefficient of the level of education variable was negative and significant at 5%. This implies that technical efficiency increases as the level of education of the farmer increases. Education plays a vital role in enhancing agricultural productivity. For example, farmers who have access to education usually have better access to information about farming technologies and how they are used. Education is assumed to increase the farmer's capability to apply existing technologies and achieve higher efficiency levels (Battese & Coelli, 1995). This agrees to the results of Donkoh (2013) and Konja et al. (2019) but opposes the finding (Ahmad & Singh, 2018) who found Education to have a negative relationship with technical efficiency. The coefficient of farmer association was found to be negative and significant at 1%. This implies that members of farmer association are more technically efficient than non-members of farmer association. This could be because farmer association members receive input and support services from many donors and NGOs (Danso-Abbeam. et al., 2015). Farmers who belong to farmer associations were expected to benefit from better access to inputs such as improved sorghum varieties and information on improved farming practices. Similar results were also realized by Konja et al. (2019) and contrary to the finding of Danso-Abbeam. et al. (2015) and Abdul-Rahaman (2016) who found it to have a negative association with technical efficiency. The parameter estimate of experience was also found to be negative and statistically significant at 1%. This shows that as years pass with continuous sorghum farming, farming experience tends to improve farmers ability to do better, thus they better their technical efficiency. Farmers with more years of farming experience are better placed to acquire knowledge and skills necessary for choosing appropriate new farm technologies over times. This conforms to the results of Danso-Abbeam. et al. (2015) but contrary to the result of Bempomaa (2014) who found the experience to have a negative influence on technical efficiency. The coefficient of household size was negative and significant at 10% implying that as the household size increases the technical efficiency of sorghum production increases as well. It is possible that the household with more members can perform farming activities faster and on time (Kusse et al., 2019). Sorghum production is labour intensive in this regard, the effect of household size on technical efficiency cannot be overemphasized. The coefficient of variety was positive and significant at 10% implying that farmers using an improved variety of sorghum, tend to decrease their level of technical efficiency (Sienso et al., 2014). This could be due to the fact that they farmers aren't aware of the appropriate agronomic practices to be use with the improved sorghum varieties in order to ensure maximum yield.

Access to extension services was negative and statistically significant at 5% indicating that the more the farmer had extension visit the more he/she becomes technically efficient. The constant contact enables the sharing of new farming methods between the extension agent and the farmer, hence providing a platform for improvement in technical efficiency. Access to credit was also found to have a positive coefficient and significant at 1%. This implies that access to credit does not have a positive effect on technical efficiency. However, access to credit was expected to reduce the financial challenges farmers encounter at the start of the production process.

Table-5. Determinants of technical inefficiency in sorghum production

Variables	Coefficient	Standard error	P-value
Age	0.71*	0.42	0.09
Sex	-0.10	0.43	0.80
Marital status	0.10	0.18	0.58
Level of education	-0.52**	0.23	0.02
Farmer association	-2.20***	0.81	0.00
Household size	-0.11*	0.06	0.07
Experience	-0.17***	0.06	0.00
Variety	0.50*	0.32	0.12
Access to extension	-4.11**	1.98	0.03
Access to credit	4.18***	1.24	0.00
Access to market	2.62***	0.92	0.00
Distance	0.01**	0.00	0.04

Note: * = 10% significance level and *** = 1% significance level.

The credit could help farmers to have funding to acquire inputs and also to cultivate their land on time before planting. Access to the market was found to negatively affect the technical efficiency. This is in line with *a priori* expectation because if farmers get access to the market they can reinvest in their farming activities to increase productivity. Finally, the coefficient of distance to market was positive and significant at 5%. This shows that farmers whose farms are far from the market centre have a lower level of technical efficiency. This might be because as farmers are situated far from the market, they would have limited access to inputs and output markets as well limited access to market information (Ahmed, Lemma, & Endrias, 2014). Besides, longer distance to market leads to increased production cost which decreases the benefits accruing to the farmer. Also, long-distance from markets does not motivate farmers in engaging in market-oriented production (Ahmed et al., 2014).

3.4. Percentage Distribution of Technical Efficiency Scores

The Table 6 below presents the frequency distribution of technical efficiencies of the smallholder sorghum farmers in the Garu district. The predicted efficiency levels ranged between 16.14% and 99.11%. The mean technical efficiency level of sorghum farmers in the study area was 88.92%. This indicates that the average sorghum farmer in the study area produces about 88.92% of the potential output given the existing technology available. Thus about 11.08% of output was lost due to inefficiency.

Table-6. Frequency distribution of technical efficiency index**.**

Efficiency score	Frequency	Percentage (%)
< 50	7	7.00
50 – 60	3	3.00
61 – 70	2	2.00
71 – 80	1	1.00
81 – 90	13	13.00
91 – 99	74	74.00
Total	**100**	**100**
Minimum = 16.14% Maximum = 99.11%	Mean = 88.92%	

Note: Standard Deviation = 17.63%.

3.5. Constraints to Sorghum Production

Sorghum farmers were required to identify and rank the factors restraining the production of sorghum. The constraints were ranked in descending order of magnitude. The mean rank indicates the averages as computed by Kendall's coefficient of concordance.

Results from Table 7 indicate that natural disaster was ranked as the first constraint limiting farmers in sorghum production. Agricultural production in the district is mainly rain-fed. Following Bempomaa (2014) rainfall variability as a result of climate change has become a concern for many farmers. During the survey, many farmers raised their concern about the uneven rainfall pattern that has affected their ability to plan properly for their farming activities. Also, the draught was mentioned as another factor which affects the productivity level of sorghum. This finding is supported by Kudadjie, Struik, Richards, and Offei (2004) whose research revealed that insufficient and delayed rainfall was the major constraint faced by farmers in producing sorghum. They stressed that the unreliable nature of rainfall is a key drawback for farmers as their agriculture is characteristically rain-fed. According to them, farmers also clarified that a delay in the start of the rains defers planting, so their local varieties which are late in maturing will likely not survive.The second major constraint limiting sorghum production was the incidence of pest and diseases. According to the farmers, pest and diseases is another factor affecting sorghum production both on the field and in its storage. Following Kudadjie et al. (2004) the incidence of pest and diseases was ranked as the sixth constraint restraining sorghum production in the north-east region of Ghana. In the occurrence of a long dry spell, insects such as black ants tend to confiscate seeds from the soil immediately after sowing, and infilling becomes necessary, which is an additional cost to the farmer. The third constraint faced by farmers in sorghum production is lack of access to credit. Most smallholder farmers cannot afford the necessary inputs needed for sorghum production on time, and that goes a long way to affect productivity. According to Yaw (2018) the credit problem can be looked at from two perspectives. One is farmers' inaccessibility to credit facilities and another been the problem of high-interest rates. Few farmers can access long term loans from financial institutions particularly banks, because the majority of these farmers are typically not credit-worthy because they are incapable to meet the collateral necessities. Farmers lean towards loans from microfinance institutions which also come with the problem of the high-interest rate. Therefore, their revenue from production is worn away after paying such high interests charges. The least constraint faced by farmers was lack of storage facilities. Sorghum produce is also prone to infestation from storage pest, therefore, necessary for farmers to have safe facilities where they can store their produce for future use. This conforms to the study of Yaw (2018). Table 7 below shows the level of agreement among the farmers on the constraints at a significance level of 1%. The null hypothesis that there is no agreement among sorghum farmers is rejected at 1% significance level.

Table-7. Ranking of constraints by sorghum farmers.

Constraint	Mean Rank
Lack of access to credit	3.63
Incidence of pest and diseases	2.71
Lack of access to extension service	4.88
Marketing problems	6.00
Lack of storage facilities	6.44
High production cost	4.25
High labour cost	5.94
Natural disaster	2.14

Source: Field Survey, 2020.

Table-8. Kendall's W Test Statistics.

N	100
Kendall's W	0.424
Chi-square	297.136
Df	7
Asymp. sig.	0.000***

Source: Field Survey, 2020.

4. Conclusion and Recommendations

The study aimed to unravel the technical efficiency level of sorghum farmers including its determinants in the Garu district of the upper east region. We first estimated the level of technical efficiency of sorghum farmers, the determinants of technical efficiency and finally identified and ranked the constraints restraining sorghum production. Results show that sorghum farmers were producing below the production frontier. The level of technical efficiency varied significantly among farmers with a minimum of 16.14% and a maximum of 99.11%. The estimated mean technical efficiency level was 88.92% which means that 11.08% of sorghum output was not realized. The results also indicated that age, level of education, farmer association, household size, experience, variety, access to extension, access to credit, access to the market and distance to the market were the significant variables affecting technical efficiency in sorghum production. Age, variety, access to credit, access to market and distance to the market were found to have an indirect relationship with technical efficiency, whereas the level of education, farmer association, household size, experience and access to extension was found to have a direct relationship with technical efficiency. Results also showed that natural disasters, the incidence of pest and diseases, lack of access to credit and high production cost were the major constraints limiting sorghum production. The study revealed that farm size and fertilizer were found to have a significant influence on sorghum production in the study area.

Based on the highlighted findings, we recommend that the government through the Ministry of Food and Agriculture should educate farmers on climate-smart technologies to help lessen the impact on climate variability that serves as a constraint in sorghum production in the study area. Apart from access to extension, farmers should also be encouraged to form farmer associations where they can learn from one another to correct some of the inefficiencies. Also, the current planting for food and jobs policy should be encouraged and improved to enhance production and productivity in the country as a whole since is a major source of credit for the farmers.

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