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Resource Use Efficiency in Sugarcane Production in Kaduna State, Nigeria: An Application of Stochastic Frontier Production Function

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Authors' contributions

This work was carried out in collaboration between all authors. Author MS designed the study and wrote the first draft of the manuscript. Author ZA reviewed the design, draft of the manuscript and managed the analyses of the study. Author FS performed the statistical analysis and author MAD discussed the results and handled the recommendations. All authors read and approved the final manuscript.

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ABSTRACT

Aims: The aim of the study is twofold; to determine how the resource inputs were efficiently used and describe how socio-economic characteristics of sugarcane farmers affected the efficiency of sugarcane producers in Kaduna state.
Study Design: Primary data were collected for this study from sugarcane farmers through the use of well structured questionnaires.
Place and Duration of Study: This study was carried out in Maigana Agricultural Zone of Kaduna state, Nigeria between September and December 2014 cropping season.

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Methodology: Multistage-stage sampling technique was employed for data collection.
Results: A total of 330 respondents were randomly selected and interviewed. The analysis revealed that the coefficients of the resource inputs farm size, cutting (*sett*), fertilizer, labour and agrochemical had positive sign, thus conformed to the *a priori* expectation. The average practice technical efficiency was found to be 89%
Conclusion: These resource inputs were found to be inelastic and not intensively being utilized. Hence, the farmers should increase the rate of inputs used in order to optimize efficiency in sugarcane production in the study area.

Keywords: Technical efficiency; resource inputs; sugarcane; stochastic production frontier.

1. INTRODUCTION

Sugarcane (*Saccharum officinarum*) is one of the most important crops in the world because of its strategic position and immense uses in the daily life of any nation as well as for industrial uses aimed at nutritional and economic sustenance [1]. Sugarcane contributes about 60% of the total world sugar requirement while the remaining 40% came from sugar beet [1]. It is a tropical crop that usually takes between 8 and 12 months to reach its maturity. Matured cane may be green, yellow, purplish or reddish considered ripe when sugar content is at its maximum [2].

World production of sugarcane stood at 1.5 billion tonnes as of 2008 [3]. Brazil, China, Cuba, Mexico, Pakistan, Thailand, USA, Colombia, Australia and Indonesia are the leading countries in sugarcane production. Brazil, India and Cuba are the leading countries in sugarcane production, producing over half of the total world sugarcane production. Africa in the same reporting period has 1.2 million hectares with 72.1 million metric tons, respectively [2]. The important sugar-producing countries in the tropical Africa are Mauritius, Kenya, Sudan, Zimbabwe, Madagascar, Cote dIvoire, Ethiopia, Malawi, Zambia, Tanzania, Nigeria, Cameroon and Zaire. Nigeria is one of the most important producers of the crop with a land potential of over 500,000 hectares of suitable cane field capable of producing over 3.0 million metric tons of sugarcane. If processed, it will yield about 3.0 million metric tons of sugar [4].

In Nigeria, sugarcane is one of the industrial crops that, before 1982, contributed to elevating the nation's GDP in the agricultural sector. However, little attention was paid to its production after 1982 and this accounted for the collapse of some sugar factories and the consequent increase in unemployment in the country [5]. Nigeria has vast human and natural resources, in terms of land and water, to produce enough sugarcane, not only to satisfy the country's requirement for sugar and bio-fuel, but also for export [4].

Nigeria is the largest consumer of sugar in West Africa and has a large area of cultivable land suitable for the growing of industrial sugarcane [6,7]. Nigeria is noted to be abundantly blessed with human, water and environmental potentials for the production of sugarcane. Areas with high potentials for commercial sugarcane /sugar production have been identified through studies sponsored by the Federal Ministry of Industry and conducted by Dutch consultants HVA in the early eighties. It should be pointed out that most of the areas in the Northern States where water for irrigation is available; sugarcane cultivation in large quantities is feasible. The crop can be rotated or even inter-planted with other crops where land with adequate sources of water abounds like in the various River Basin Development Authority Areas [8].

According to [9], sugarcane is produced and sold in many local government areas (LGAs) of the state, including Makarfi, Giwa and Kudan. About 20 thousand households in the state grew sugarcane in 2013.

Over the years the government has carried out policies aimed at boosting sugarcane production in the country. Some of the policies are: 50% tariff on importation of white sugar, 5% levy on imported raw sugar, 5–year tax waving to sugar refineries and privatization of the major sugar firms in the country, still domestic production of sugar is slightly less than 5% of the country's annual requirement [10].

Despite the laudable government policies and the increase in sugarcane area harvested in Nigeria, the annual sugarcane production and yield from 2008 to 2013 kept on declining with the exception of 2011, 2012 and 2013 where it remained constant. Contrary to this, from 2003 to

2007 the annual sugarcane production and yield were increasing as the area harvested increased as gathered from FAOSTAT annual crops production data.

In addition, the reports of Agricultural Production Survey, conducted by [9] in the years 2010, 2011, 2012 and 2013, showed that the annual quantity of sugarcane production in the state is declining.

The objectives of this study are to determine the resource use efficiency in sugarcane production and the effects of socio-economic factors on efficiency in sugarcane production in the study area.

1.1 Technical Efficiency Measurement Using Stochastic Production Frontier Function

Stochastic production frontier analysis has been widely used to study technical efficiency in various settings since its introduction by [11,12]. The approach has two components: a stochastic production frontier serving as a benchmark against which firm efficiency is measured, and a one-sided error term which has an independent and identical distribution across observations and captures technical inefficiency across production units [13].

According to [14] Stochastic Production Frontier Analysis indicates the maximum expected output for a given set of inputs. It is derived from the production theory and based on the assumption that output is a function of inputs and the efficiency of the producer in using these inputs. The stochastic production frontier assumes that the boundary of the production function is defined by “best practice” firms. It therefore indicates the maximum potential output for a given set of inputs. The difference between observed output and the potential output is generally attributed to a combination of inefficiency and random error.

Following the [15,16] Stochastic Production Frontier (SPF) is defined as:

$$Y_j = f(X_j\,;\,\beta)\ \exp\epsilon \qquad (1a)$$

$$\epsilon = V_j - U_j \qquad i = 1, 2, \ldots\ldots N$$

Where:

Y_j is the output of j firm, X_j is a vector of factor inputs to be used by j firm, β is the vector of unknown parameters to be estimated, ϵ is a composite error term, V_j is the stochastic error term which is associated with random factors outside the farmers control such as topography, weather and it is independent of U_j. The U_j is a one sided error representing the technical inefficiency of firm j. Both V_j and U_j are assumed to be independently and identically distributed with constant variance and zero mean.

The technical efficiency (TE) of a firm using Stochastic Production Frontier is given as:

$$TE = \frac{Yj}{Yj*} = \frac{\text{Observed Output}}{\text{Frontier Output}} = \frac{f(Xj\,;\,\beta)\exp\,(Vj - Uj)}{f(Xj\,;\,\beta)\exp\,(Vj\,)} \qquad (1b)$$

[17] study and measure the productive efficiency (technical, allocative and economic) levels of 231 small-scale sugarcane farmers in the Mpumalanga Province of South Africa using the stochastic frontier production function by Coelli [15]. The study uses sugarcane farm data collected in 2011 from a sample selected randomly. Labour, herbicides and fertilizer are identified as factors that contributed significantly to improved production. The results indicate that the sugarcane farmers lack technical, allocative and cost efficiencies. The mean technical, allocative and cost efficiency estimates are 68.5, 61.5 and 41.8 percent respectively. The study concludes that farmer education, land size, farming experience, and age contributed significantly and positively to productive efficiencies. The policy implication is that there is enough potential for farmers to increase sugarcane production and net profits.

[18] used the stochastic frontier Cobb-Douglas production function to estimate sugarcane technical efficiency in Tanzania. In their study the estimated Maximum Likelihood coefficients for variable inputs showed positive values of 0.0581 and 0.0179 for sugarcane outgrowers and non-outgrowers respectively, which are highly significant. This indicates that an increment of the variable inputs for both outgrowers and non-outgrowers by one percent will increase output by 0.0581 and 0.0179 percent respectively. As the increase in output is small this may indicate that variable inputs are nearly fully utilized. The result also shows the distribution of technical efficiencies of outgrowers and non-outgrowers in Turiani division and was observed that most of the sugarcane farmers (81.43%) are efficient

because they have technical efficiency levels of above 70%.

[19] investigated the technical efficiency of the small scale sugarcane farmers of Swaziland using stochastic frontier production functions for Vuvulane scheme and Big bend individual farmers. The stochastic production frontier function model of the Cobb-douglas type used incorporates a model for the technical inefficiency effects. Farm-level cross-sectional data were collected from 40 sugarcane schemes and 35 individual sugarcane farmers. The results revealed some technical efficiency levels of the sample farmers that are varied widely. For the Vuvulane sugarcane farmers, efficiency ranges from 37.5 to 99.9% with a mean of 73.6%, whilst for the Big bend sugarcane farmers it ranges from 71 to 94.4% with a mean value of about 86%. The sugarcane farmers at Vuvulane over-utilized land. Thus, an appropriate amount of land utilization could increase the sugarcane production for Vuvulane sugarcane farmers. For both groups of farmers, the technical inefficiency decreased with increased farm size, education and age of the sugarcane farmer, but increased when small scale sugarcane farmers engaged in off-farm income earning activities.

[20] studied the technical efficiency of sugarcane production in district Dera Ismail Khan (D. I. Khan) of Pakistan using stochastic production function. The results of their findings revealed that the elasticities of technical efficiency for tractor hours, seed rate, labor days, irrigation numbers, chemical fertilizer, FYM and herbicides were found 0.185, 0.102, 0.145, 0.093, 0.084, 0.073 and 0.05 respectively. All the variables of technical efficiency showed positive and significant effect on the production of sugarcane with the exception of seed in district D. I. Khan. The mean technical efficiency index was 0.77 while the minimum and maximum efficiency values were 0.57 and 0.91 respectively. The mean value suggesting that the farmer's output can be improved 23% through improved resource allocation. The factors affecting technical inefficiency showed negative relationship with inefficiency. The results further indicated that age, experience and education having positive relationship with production and play a vital role in the production of sugarcane.

[21] used the stochastic frontier Cobb-Douglas production function to analyse technical efficiency of sugarcane producing farm units in Ethiopia. The empirical results predict that technical inefficiency effects were significant in explaining the yield for Fincha Sugar Factory (FSF) farm units. The mean technical efficiency was estimated at 84%. The inefficiency model indicated that all farm units were less efficient in their production and lost to the tune of16% of their potential output. These losses differ from one farm units to another. Some Farm units had a slightly higher technical efficiency than farm units. The mean technical efficiency for the farm units was 0.84 compared with the minimum of 49% and 98% of the maximum technical efficiency for the farm units of FSF farming units. This revealing that most farm units have mean technical efficiency of 84%. The predominant variables that induce variation in level of technical efficiency in the study were Seed variety, experience, distance, land fertility, Irrigation settled type, number of plots, trainings, Number of sick leaves, age of the cane, soil type, education, location, irrigation setting time and planting system.

2. MATERIALS AND METHODS

2.1 Study Area

The study was conducted in Kaduna state. The State is located in the north central to middle belt of Nigeria. The state lies between latitudes 9º10' East and 11º30' North and longitudes 6º East and 9º10' North, respectively. It shares borders with Kastina and Kano states to the north, Plateau state to the north-east, Nasarawa state to the south and Niger and Zanfara states to the west. To the south-west, the state shares border with the Federal Capital Territory (FCT). The state has a total land area of about 4.5 million hectares, with an estimated total arable land of about 2.02 million hectares comprising 1.94 million hectares upland and 0.8 million hectares lowland. It has an estimated population of approximately 6,113,503 people with an annual growth rate of 3.2% making it the third most populous state in Nigeria [22].

There are two distinct seasons in the state namely: wet and dry. Wet season generally spans April – October, while dry season falls between October and March. The average rainfall is about 1,482 mm, while temperature ranges from 35ºC to 36ºC during the humid period to as low as 10ºC – 23ºC during the winter periods of November – February. The state falls within the Southern and Northern Savannah Ecological Zones characterized by woodlands with grasses of different species. The soil is developed from undifferentiated complex igneous and metamorphic rocks. The fine top soil coupled with reasonable organic matter in it, enhances the fertility status of especially the Southern part of the state. The physical properties of the soil are moderately good and allow for continuous cropping for a wide variety of crops [9].

About 80 percent of the State's population is engaged in peasant farming producing both food and cash crops. The crops produced in the state include cotton, groundnut, tobacco, maize, beans, guinea corn, millet, rice, ginger, cassava, sugarcane, yam and potatoes. During the dry season, a considerable number of people in the state are engaged in irrigation farming along some major rivers and dams. Low lying fertile land with a lot of alluvial deposit known as the "Fadama" is particularly important for irrigation farming in Kaduna State. The total "Fadama" area in Kaduna state is estimated to be 80,000 ha out of this only 11,000 ha have been put under cultivation. The crops cultivated are mainly vegetables and among the cash crops, there is sugarcane [9].

The state produces over 40,000 MT of sugarcane every year. Makarfi Local Government Area (LGA) accounts for about 39% (15,500MT), Giwa LGA produces 15% (6,200MT) while Kudan LGA 13% (5,200MT) of the total annual state production. Another important aspect of agriculture engaged by the people is the rearing of cattle, sheep, goats, pigs and poultry farming. Kaduna State occupies a very strategic position in terms of its historical role, contemporary political development and economic activities. Kaduna state has 23 LGAs [9].

2.2 Sampling Procedure and Data Collection

For this study, a multi-stage sampling technique was employed. In the first stage, Makarfi, Giwa and Kudan local government areas were purposively selected out of 23 LGAs that make up the state. This was because; they were the most prominent sugarcane producing areas in the state [9]. In the second stage, nine villages were purposively selected out of villages that were prominent in sugarcane production (three from each of the selected LGA). In the third stage, only 25% of the total number of sugarcane farmers in each of the nine villages was randomly selected for this study. This represented a sample size of 330 respondents.

The data for this study was collected from primary source only. The data was obtained using the interview method with well structured questionnaires administered among the respondents. The information collected from the respondents of sugarcane producers included: age, sex, number of years in farming, educational qualification, household size, number of extension contacts, farm size, inputs availability and prices, farming technique, output etc.

2.3 Model Specification

The empirical stochastic frontier – Cobb-Douglas production model is specified as follows:

$$\ln Y_j = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + V_j - U_j \quad (2a)$$

Where:

In = Logarithm to base e (natural log)
β_0 = Constant or intercept
$\beta_1 - \beta_5$ = Unknow scalar parameters to be estimated
Y = Quantity of sugarcane output (Kg)
X1 = Farm size (Ha)
X2 = Quantity of sugarcane cutting (*sett*) used (Kg)
X3 = Fertilizer (Kg)
X4 = Agrochemicals (Liter)
X5 = Labour (Man days)
V_j = Stochastic error term
U_j = Technical inefficiency effect predicted by the model.

Subscript j indicates jth farmer in the sample.

The *a priori* expectation is that the coefficients of the whole inputs X_1 to X_5 which are $\beta_1, \beta_2, \beta_3, \beta_4$ and β_5 should be positive, respectively (i.e. greater than zero).

The inefficiency model is of the form:

$$U_i = \delta_0 + \delta_j Z_{ji} \quad (2b)$$
$$U = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \delta_5 Z_5$$

Where:

U_i = Technical inefficiency effect
Z_{ji} = Values of explanatory variables for the technical inefficiency effects for the i^{th} farmer
δ_0 = Intercept
δ_j = 1, 2, …, 5 are unknown scalar parameters

Z_1 = Age of the i[th] farmer
Z_2 = Household size
Z_3 = Years of sugarcane farming experience
Z_4 = Level of education
Z_5 = Extension contact (number of meetings)

The specification of the model for the inefficiency effects in equation (2b) implies that, if the independent variables of the inefficiency model have a negative sign on an estimated parameter, then the associated variable has a positive impact on efficiency while a positive sign indicates that the reverse is true.

Thus, the *a priori* expectation is that the coefficients of the whole independent variables of the inefficiency model (i.e. δ_1, δ_2, δ_3, δ_4 and δ_5) should be negative, respectively (i.e. less than zero).

3. RESULTS AND DISCUSSION

3.1 Analysis of Inputs Used and Output of Sugarcane Production in the Study Area

Tables 1 shows the summary statistics of the inputs utilized, output and yield of sugarcane cultivated in the study area. The average yield of sugarcane in the study area was found to be 37.60 tonne per hectare. This was obtained by using averagely 3.01 tonne/ha of cutting (sett), 0.16 tonne/ha of fertilizer, 1.51 liter/ha of agrochemical and about 25 man-days/ha of labour, respectively. According to [23], the world average yields of sugarcane in the years 2012 and 2013 were 69.56tonne and 82.09 per hectare, respectively. Nearly 10 – 12 tonnes of cutting (setts), 0.55 tonne of fertilizer and 3.5 liters of herbicide are required to plant sugarcane on one hectare of field [24]. [25] stated that it requires about 50 – 65 man-days on an average per hectare for a normal sugarcane farming, excluding harvesting. The average farm size and output cultivated were found to be 0.49 ha and 20.59 tonne/ha, respectively. Hence, these clearly show that the farmers in the study area were producing far below the potential (frontier) quantity and the resource inputs were not efficiently being utilized, rather underutilized. This was due to the fact that most of the farmers lacked modern and up-to-date knowledge on sugarcane production; they used unimproved *sett*, applied insufficient quantity of fertilizer and agrochemical and maintained the traditional method of farming, thereby producing below the potential quantity.

3.2 Resource Use Efficiency in Sugarcane Production

Considering the recent shortfall in sugarcane production in the study area despite the increase in area of land cultivated, the resource-use efficiency aimed at finding out the technical relationship between resource inputs used and output and which among them was/were not efficiently being utilized in sugarcane production in the study area. The Maximum Likelihood Estimates (MLE) of the stochastic frontier Cobb-Douglas production model for parameters (β_1, β_2, β_3, β_4 and β_5) and that of inefficiency model (δ_1, δ_2, δ_3, δ_4 and δ_5) were estimated using FRONTIER 4.1c software developed by [26] as shown in Table 2.

The estimates revealed that the coefficients of the resource inputs had positive sign, thus conformed to the *a priori* expectation. Farm size, cutting (*sett*) and fertilizer were statistically significant at 1% level each, labour was at 5% level while agrochemical was not statistically significant. These resource inputs were found to be inelastic and not intensively being utilized. Hence, an increase in any of these production resource inputs will also lead to an increase, though less than proportionate in output of sugarcane production in the study area.

Table 1. Input and output levels for sugarcane production in Maigana Agricultural Zone, Kaduna State

Variable	Observation	Maximum	Minimum	Mean	Standard deviation
Output (tonne/ha)	330	165	0.90	20.59	24.77
Yield (tonne/ha)	330	79	11.45	37.60	20.11
Farm size (ha)	330	2.61	0.04	0.49	0.41
Cutting (tonne/ha)	330	25	0.20	3.01	3.57
Fertilizer (tonne/ha)	330	1.30	0.01	0.16	0.19
Labour (Man-day)	330	200	3	25	27.69
Agrochemicals (Litre/ha)	330	6	1	1.51	0.96

Table 2. Result of maximum likelihood estimates of the stochastic frontier production function for sugarcane production

Variables	Coefficient	Standard-error	T-ratio
Constant	4.076	0.245	16.67***
Farm size	0.12	0.022	5.42***
Cutting	0.535	0.053	10.03***
Fertilizer	0.273	0.043	6.33***
Labour	0.11	0.049	2.21**
Agrochemical	0.003	0.022	0.13
In-efficiency model			
Constant	0.01	0.176	0.06
Age	0.008	0.005	1.69*
Household size	0.003	0.017	0.17
Farming experience	-0.054	0.005	-10.37***
Educational level	-0.001	0.036	-0.03
Extension contact	-0.069	0.038	-1.83*
Variance parameters			
Sigma-squared	0.109	0.022	5.01***
Gamma	0.931	0.017	55.95***
Number of observations	330		

*Note: * = Significant at 10%, ** = Significant at 5% and *** = Significant at 1%*

The estimated coefficient of farm size was found to be 0.120. This implies that, sugarcane production in relation to the cultivated farm size in the study area was inelastic; meaning that 10% increase in farm size other things being equal will lead the sugarcane output to increase by less than proportionate margin of 1.2% and vice-versa. This goes in line with the findings of [27] on the resource use efficiency in plantain. The estimated coefficient of farm size in their study was found to be positive and statistically significant at 1% level.

The estimated coefficient of cutting (sett) was 0.535, implying that sugarcane production in relation to the *sett* in the study area was inelastic. As such, 10% increase in cutting (*sett*) *ceteris paribus,* will augment sugarcane output by 5.35% and vice-versa. This indicates that it was not efficiently being utilized in the study area. This accords [28] findings which indicated positive relationship between seed rate used and output and was statistically significant at 5%. Thus, 10% increase in seed rate will correspond to an increase in output by 3.65%.

The estimated coefficient of fertilizer was found to be positive 0.273. Implying that 10% increase in fertilizer, *ceteris paribus,* increases sugarcane output by 2.73%. Hence, fertilizer application in the study area was inelastic and not intensively been utilized. This goes in line with [29]. In his study of urban farming, he found the coefficient of fertilizer to be positive, inelastic (0.4183) and highly significant at 1% level (2.7212).

The estimated coefficient of labour was 0.110 and inelastic. This implies that 10% increase in labour, other things being equal, increases sugarcane output by 1.1%. This reveals that labour in the study area was inelastic too. This agrees with the findings of [30] who revealed labour in the study area to have positive coefficient and statistically significant. This shows how important labour input is in farming, especially in our developing countries where mechanized way of farming becomes unaffordable to majority number of the farmers.

The coefficient of agrochemical was estimated to be positive 0.003 and conformed to the *a priori* expectation but statistically not significant. Hence, application of agrochemicals in the study area was relevant too. Its increase, other things being equal, insignificantly increases sugarcane output. This goes in line to the findings of [31] where coefficient of agrochemical was found to be positive (0.65) but statistically significant at 1% (3.75). This shows that the output of sugarcane is inelastic to the agrochemical used in the area.

In view of the forgoing estimated coefficients of resource inputs used in sugarcane production, it can then be deduced that there is a great potential of increasing the sugarcane output through proper increase and efficient utilization of the resource inputs.

3.3 Effects of Socio-Economic Factors on Efficiency in the Sugarcane Production

The inefficiency model as presented in Table 1 on the other hand reveals that all the estimated coefficients of the socio-economic factors with the exception of age and household size had negative sign, thus conformed to the *a priori* expectation. A negative coefficient in the inefficiency model means positive effect on efficiency (i.e. it increases technical efficiency and production), while a positive one means negative effect on efficiency (i.e. it decreases technical efficiency and production).

The estimated coefficient of age was found to be 0.008, thus failed to conformed to the *a priori* expectation but statistically significant at 10% level (1.69). This implies that there was a positive relationship between technical inefficiency in sugarcane production and the farmers' age in the study area. Hence, the older the farmers of sugarcane, the more technically inefficient they become. Sugarcane farming consumes time more and demands a lot of activities from planting to harvesting which are tougher in nature than other crops farming; it requires at least 4 number of weeding; it takes between 10 and 12 months from planting to harvesting, thus needs someone who is energetic, hardworking and endurable like the younger farmers. Therefore, the older sugarcane farmers were unable to give what was expected from them due to their natural inability (i.e. old age) and thereby led to technical inefficiency in the sugarcane production as shows by the estimated coefficient of the farmers' age. A 10% increase in age of sugarcane farmers in the study area will lead to an increase in technical inefficiency (i.e. decrease in production) by 0.08%. This accords the finding of [32] who in their study of small scale farmers in Nigeria found age to be positively related to inefficiency.

The coefficient of household size was estimated to be positive (0.003) not as expected too and statistically not significant. This implies that there was a positive relationship between technical inefficiency in sugarcane production and the farmers' household size. Farmers with more household size tend to have more free hands in the farm. They use it as their farm main source of labour supply. These free hands usually do no good work (poor workmanship), because they feel that they were discharging free services to their family, as such no money is going to be paid to them after finishing, unlike if they were on hired basis or working in their own personal farms. Thus, they quickly worked in the family's farm within short period, reserved energy and further moved to either their personal farms or where they can labour for money and thereby led to technical inefficiency in their family's (sugarcane) farm. Hence, an increase in household size, other things being equal, influenced technical inefficiency positively, though insignificantly in the study area. This agrees with the findings of [30] who revealed household size in their study area to have positive coefficient (0.24) and statistically significant at 5% level (2.29).

The estimated coefficient of farming experience was negative (-0.054) as expected, thus conformed to the *a priori* expectation and statistically significant at 1% level. This implies that farmers with past sugarcane production experience were more technically efficient in sugarcane production in the study area. In other words, the farmers who have been in sugarcane production for quite long period knew better the suitable land area where the crop can be planted, how to plant it, time of planting, weed control, fertilizer application and other resource inputs efficient utilization than those who had just recently started. Therefore, as farmers' production experience increases by 10% the technical inefficiency in sugarcane production decreases by 0.54% and thereby increasing the output. This goes in line with the findings of [33] where farming experience was found to have negative coefficient (-0.009).

The estimated coefficient of educational level on sugarcane production was negatively related to technical inefficiency (-0.001) as expected but statistically not significant (0.03). Meaning that farmers who had more knowledge and up to date information on sugarcane production have technically increased efficiency in the crop production than those with less, as it has been found in the study area. Most of the farmers who had greater yield of 50 tonne and above per hectare were those who have no formal education but experience and technical know-how in the sugarcane production. Hence, an increase of 10% in educational level on sugarcane production will increase technical efficiency of the farmers by less than proportionate margin of 0.3%. This agrees with

[34] who found educational level of medium scale rice farmers in Benue state to have negative coefficient (-0.7011).

The estimated coefficient of extension contact also conformed to the *a priori* expectation (-0.069) and statistically significant at 10% level. This implies that extension services had a positive effect on sugarcane production technical efficiency. Therefore, farmers who received more and regular contacts were better technically efficient in sugarcane production than those who received less in the study area. Extension contact could be received directly from an extension agent, experienced (sugarcane) farmer or indirectly through the media, such as radio, television, and publications as in agricultural journals and write ups. As such, a 10% increase in extension contact, increases production by less than proportionate margin of 0.69%. This accords [35]. In their research work titled 'Analysis of Production Efficiency of Food Crop Farmers of Bank of Agriculture Loan Scheme in Ogun State' extension contact coefficient was found to be negative as expected (-0.0464) and statistically significant at 1% level (-7.310).

The variance parameters of the frontier production model were represented by Sigma-squared (δ^2) and Gamma (γ). The Sigma-squared indicates the total amount of variance found in the model. Its estimated coefficient in the study area was 0.11 and statistically significant at 1% level. Gamma shows the ratio of variance of the inefficiency terms over the total amount of variance. In another words, Gamma indicates the systematic influences that are unexplained by the production function and the dominant sources of random errors. Its estimated coefficient in the study area was 0.93 and statistically significant at 1% level. This shows that, 93% of the variation in sugarcane output was as a result of the differences in technical inefficiencies of the farmers. Thus, the result reveals that inefficiency effects were present and significant in the study area.

3.4 Technical Efficiency Indices among Sugarcane Farmers

The respective estimated levels of technical efficiency of an individual sugarcane farmer were summarized and presented in Table 3 as obtained from the stochastic frontier production model. It was observed from the study that 0.30% of the farmers had the lowest efficiency levels which ranged from 0.40 to 0.49; whereas the largest percentage (71.52%) of them had efficiency levels from 0.90 and above. The maximum, minimum and mean technical efficiencies for sugarcane farmers in the study area were found to be 0.97, 0.48 and 0.89, respectively. This implies that, the farmer with the best practice had a technical efficiency of 0.97; farmer with the worst practice had a technical efficiency of 0.48 while in general, farmers in the study area had an average practice technical efficiency of 0.89. Judging from this, it is then possible to increase the yield by 11% in the short run using the presently available techniques.

Table 3. Technical efficiency indices among sugarcane farmers

Class-interval of efficiency indices		Frequency	Percentage (%)
0.20–0.29		0	0.00
0.30–0.39		0	0.00
0.40–0.49		1	0.30
0.50–0.59		6	1.82
0.60–0.69		6	1.82
0.70–0.79		12	3.64
0.80–0.89		69	20.91
≥ 0.90		236	71.52
Maximum	0.97		
Minimum	0.48		
Mean	0.89		
Total		330	100

4. CONCLUSION AND RECOMMENDATIONS

It was found in this study that technical efficiency in sugarcane production was positively affected by majority of the socio-economic characteristics of the sugarcane farmers; all the resource inputs used were positively related to the output despite the fact that they were not efficiently being utilized.

The resource inputs used in the study area were not efficiently being utilized. Thus, there is need for training sugarcane farmers on farm inputs optimum utilization by the extension agents in the study area. The farmers should form a formal and strong sugarcane farmers association that would represent their interest. This would help them to have better knowledge, up to date information about sugarcane farming and access to financial and farming technical supports by the government and stakeholders.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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