Technical Efficiency Analysis of Groundnut Production in the Gezira Scheme, Sudan

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Abstract- The primary objective of this study is to measure and evaluate the production efficiency of groundnut crop in Gezira Scheme, to investigate the main tenant-specific factors behind tenants' technical inefficiency in the Gezira scheme. Both primary and secondary data were used for the study purposes .Stochastic frontier production function was estimated using a sample of 150 tenants were collected during season 2011/2012 in the Gezira Scheme. The results show that an average of technical efficiency of 65% for groundnut production is found, implying that scope to increase groundnut yield through the better use of the tenants available resources are exist. Age farmers, education years, sowing date, farm income, irrigation numbers and total labour is the major factors that are associated with changes in groundnut yield. The experience farmers and family size are the appeared to be the most important socio-economic factors determining farmers' efficiencies in groundnut production in Gezira scheme. The results also showed that 94% of groundnut output deviation from normal is due to differences in farmers' level of technical efficiencies as opposite to the conventional random variability. The study recommended improving technical efficiency for groundnut production in the Gezira Scheme.

Index Terms- Technical Efficiency, Production inefficiency, Groundnut, Stochastic Frontier, Gezira Scheme, Sudan.

I. INTRODUCTION

Groundnuts (*Arachis hypogaea*) family leguminaceae, are the edible seeds of a legume plant that grow to maturity in the ground. In Sudan, groundnut is one of the main sources of edible oil production for local consumption and exports [1]. The crop is primarily used for oil extraction in Sudan. It is consumed directly because of its high food value it plays an important role in diets of rural populations, particularly children, because of its high contents of protein, fat, and carbohydrate. Groundnut haulms are nutritious for feeding livestock [2]. Sudan is one of the major groundnut producing countries. The total area under groundnut production is approximately one million hectares with an average yield of 855 kg/ hectares. The crop is grown under irrigation mainly in Gezira scheme, New Halfa scheme, some Northern region and Kassala. Under rain fed the crop grown in western Sudan in Kordofan and Darfor regions [3]. Sudan groundnuts contribution to the total exports of the country is also fluctuating and declining as well, that was attributed to the decrease in the area planted in irrigated sector and to changes in climate in the traditional sector, in addition to the decrease in the international prices which forced the exporters to sell locally [4]. The Gezira scheme is the area that extends from latitude 13º N to latitude 15º N between the Blue and White Niles. The scheme stretches over 115 kilometers south of Khartoum and north of the railway line between Sinnar and Kosti. It covers a net cultivable area of little less than one million hectares (about 2.1 million feddans). Gezira scheme consists of two main parts: Gezira main with an area of 1.1 million feddan and Managil extension of 1.0 million feddan [5]. The main crops grown in Gezira Scheme are cotton, sorghum, wheat, groundnuts, vegetables, fruits, and Fodder, it produces 58% and 23% of the country main export crops, cotton and groundnut, respectively and as such it is a leading source of foreign exchange earnings and raw materials for local industries, and produces 46% and 12% of the country's wheat and sorghum respectively, as well as considerable amount of vegetables [6]. After the Gezira Scheme Act of 2005, farmers are free to manage their productive and economic development and they have the right to participate in planning, management and management of irrigation channels at the level of the field by Water-User Associations (WUAs). This Act of 2005, to influence for rotation in scheme and deterioration area under groundnuts cultivated and lead to low yield in recent years. The Gezira Scheme production of groundnuts sharply dropped from 266 thousand metric tons in 2008/09 season to 68 thousand metric tons in 2009/10 season. Thus due to decreasing in area cultivated and yield from 231 thousand feddan, 1200 kg/feddan in 2008/09 season to 150 thousand feddan, 650 kg/feddan in 2009/10 season, respectively [7]. May be problems behind groundnut productivity deterioration in Gezira Scheme these include such as tenants' technical inefficiency, scheme management inefficiency and scheme management's decisions of area allocation between the different crops. Production can be increased by increasing the technical efficiency of crop using existing technology. If farmers are found to be technical efficiency, production can be increased to a large extent using the existing level of input and available technology. The main aim of this paper was to measure and evaluate the technical efficiency of groundnut producing and to investigate the main tenant-specific factors behind tenants' technical inefficiency in the Gezira scheme.

II. METHODOLOGY

2.1 DATA COLLECTION

Both primary and secondary data were used for the study purposes. Primary data were collected by using structural questionnaire using stratified random sampling techniques through direct personal interviewing, where a sample of 150 tenants from (north, central, and hush) groups was collected during season 2011/2012. Secondary data collected from different relevant sources which include Planning and Socio-

economic Research Administration (PSERA) of the Gezira schemes, Central Bank of Sudan, in addition to different documents, books, internet and journals.

2.2.1 STOCHASTIC FRONTIER PRODUCTION FUNCTIONS:

Technical efficiency is just one component of overall economic efficiency. Technical efficiency is defined as the ability to produce a given level of output with a least amount quantity of inputs under certain technology. Technical efficiency which reflects the ability of a firm to obtain the maximal output from a given set inputs [8]. Early studies focused primarily on technical efficiency using a deterministic production function with parameters computed using mathematical programming techniques. However, with insufficient characteristics of the assumed error term, this approach has an inherent limitation on the statistical inference on the parameters and resulting efficiency estimates. Aigner, Lovell, Meeusen and Battese independently developed the stochastic frontier production function to overcome this deficiency [9], [10].

2.2.2 MODEL SPECIFICATION:

The stochastic frontier production function model for estimating farm level technical efficiency is specified as:

$$lnYi = f(X_i : \beta) + \varepsilon_i \qquad (1)$$

Where
i= 1,2,……..n

$\ln Y_i$ is the logarithm of output, X_i denotes the actual input vector, β is vector of production function and ε is the error term that is composed of two elements, that is:

$$\varepsilon_i = V_i - U_i \qquad (2)$$

Where v_i is the symmetric disturbances assumed to be identically, independently and normally distributed as N (0, σ^2 v) given the stochastic structure of the frontier. The second component ui is a one-sided error term that is independent of v_i and is normally distributed as (0, σ^2u), allowing the actual production to fall below the frontier but without attributing all short falls in output from the frontier as inefficiency

2.2.3 MODEL BUILDING

The model included the tenant's factors influencing the farmer technical efficiency. Stochastic Production Frontier Model of the Cobb-Douglas form was used to find out the tenants' technical efficiency for groundnut production in Gezira scheme.

$$lnyi = \beta 0 + \sum_{j=1}^{9} \beta j \, lnXij + Vi - Ui \qquad (\mathbf{3})$$

Where:

ln = the natural logarithm ,yi = yield of groundnut (sack / faddan); X_1 = Tenancy location (1 when location at the head of the canal, 2 when location at the middle and 3 when location at the tail); X_2 = Age (years of interviewed tenant); X_3= Education (schooling years of interviewed tenant); X_4= Sowing date (dummy variable which receives one when at the optimum time and zero, otherwise); X_5= Farm income (SDG); X_6 = off- farm income (SDG); X_7 = Number of irrigations; X_8= Number of weeding; X_9= Total labour (number of labor in mandays); B0 and βj are unknown parameters to be estimated for the variables, respectively. vi represent the statistical error and the other factors which are beyond the tenants control such as weather, topography and other factors which are not included and may be either positive, negative or zero. ui is non negative random variable, The ui in the stochastic production frontier model is a non-negative random variable, associated with the tenants' technical inefficiency in production and assumed to be independently distributed, such that the technical inefficiency effect for the ith tenant, ui, will be obtained by truncating at zero of the normal distribution with mean, μi, and variance, δ2, such that

$$Ui = \delta 0 + \sum_{s=1}^{4} \delta s Zsi \qquad (4)$$

Where:

Z_{1i} = Education level (0 when illiterate, 1when khalwa, 2 when primary, 3 when intermediate, 4 when secondary, 5 when university);

Z_{2i} = Tenants experience (number of years spent as a tenant);

Z_{3i} = Family size (1when (1-5), 2 when (6-10), 3 when (> 10);

Z_{4i} = Marital status (dummy variable which has the value one married and zero, otherwise);

δ0 and δs coefficients are unknown parameters to be estimated; together with the variance parameters which are expressed in terms of

$$\sigma^2 = \sigma_u^2 + \sigma^2 v \text{ and } \gamma = \sigma u^2 / \sigma^2$$

Where the □□ parameters has value between zero and one. The parameters of the stochastic frontier production function model are estimated by the method of maximum likelihood, using the computer program, FRONTIER Version 4.1.

III. Result and Discussion

3.1 Stochastic Frontier Production Function Results

The maximum likelihood estimate of the parameters of the stochastic frontier production function with inefficiency model is presented in table (1). The mean technical efficiency of groundnut production is 0.65 in the groundnut model, with a minimum of 40% and maximum of 97%. This means that on average, the tenants in the scheme produced 65% of groundnut output that achievable by best practice, given their current level of production input and technology used. This implies that the respondents can increase their groundnut output by 35% from a given mix of production inputs if the tenants are technically efficient. Tenancy location has a positive and not significant. Age years has positive sign and significant at 5% level of significant for groundnut, positively significant parameter of age means that technical efficiency increases with the increase of age of farmers due to accumulate experience and knowledge. The coefficient of education years has a positive sign and significantly different from zero at 10 percent level of significance for groundnut, positively significant parameter of education means that technical efficiency increases with the increase in education of farm operators. The reasons is that the

level of education of tenants are indicators of the farmers awareness and their abilities of taking decisions on how and what to produce, approaching credit, allocating their available resources and adopting new agricultural technologies as argued by [11]. Sowing date is an important factor affected crops yield. The coefficient of the sowing date has a negative sign and highly significant at 1 percent level of significance for groundnut, the negative sign reflects the bad effects of late sowing on production level of groundnut; this result was in conformity with the findings of [12]. The coefficient of farm income had positive sign and significant at 5 % level of significant. The may be reason is that a high percent of income directed toward groundnut crop production in the Gezira scheme. This result was in conformity with the findings of [6] and [13]. Off- farm income most of the tenants in the scheme have an off-farm income from other sources. The estimated coefficient of the part of the off-farm income that is used in agriculture had positive sign and insignificant for groundnut. A possible explanation of this result is that a part of off- farm income is used for other crops in the scheme like (chickpea, onion sorghum and wheat); education fees for students and live expenditures rather than groundnut production. The coefficient of irrigation number had a positive sign and significant at 10% level of significance for groundnut. A positively significant parameter of irrigation means that technical efficiency increases with the increase in irrigation number. That means irrigation is one of the main determinants of groundnut crop production in the Gezira scheme. Coefficient of the weeding number has positive sign and not significant. Labour (in man-days): The coefficient of labour is positive sign and significant at 1% level of significance for groundnut. Labour is required to carry out crop activities timely, particularly weeding and harvesting. That means labour is one of the main determinants of groundnut crop production in the Gezira scheme.

Table (1): Maximum Likelihood Estimate for the Parameters of the Stochastic Frontier Production Function and Technical Inefficiency Effect Model for groundnut.

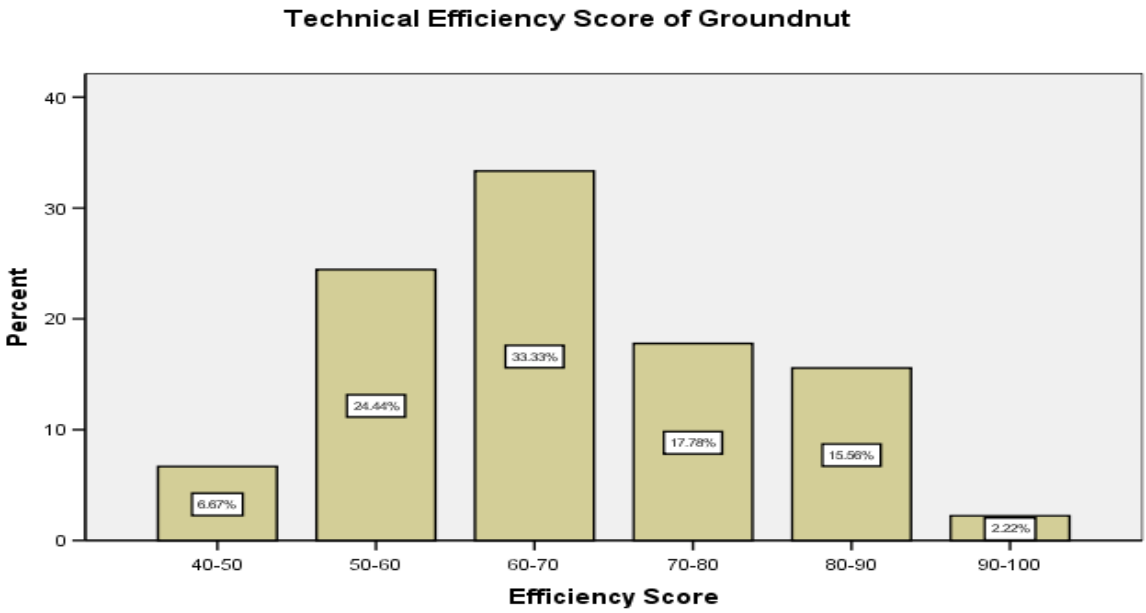
Parameters	Variable	Coefficient	Standard -error	T- ratio
β_0	Constant	-1.038	1.007	-1.030
β_1	Tenancy location (x_1)	0.008	0.360	0.022
β_2	Age (x_2)	0.517	0.219	2.351**
β_3	Education years (x_3)	0.277	0.155	1.789*
β_4	Sowing date (x_4)	-12.393	1.578	-7.851***
β_5	Farm income (x_5)	.922	.045	2.021**
β_6	Off- farm income (x_6)	0.005	0.018	0.323
β_7	Irrigation (x_7)	0.507	0.289	1.749*
β_8	Weeding (x_8)	0.206	0.333	0.618
β_9	Total labour (x_9)	0.683	0.232	2.938***
Inefficiency model				
δ_0	Constant	0.414	0.185	2.519**
δ_1	Education level (z_1)	0.064	0.100	0.645
δ_2	Experience (z_2)	- 0.012	0.009	-1.797**
δ_3	Family size (z_3)	-0.051	0.025	-1.646*
δ_4	Marital status (z_4)	-2.909	3.567	-0.815
Sigma-squared	$\sigma_s^2 = \sigma_v^2 + \sigma^2$	0.162	0.039	2.413**
gamma	$\gamma = \sigma^2 / \sigma_s^2$	0.94	0.05	19.913***
	Mean Efficiency		0.65	
	Maximum Efficiency		0.97	
	Minimum Efficiency		0.40	
	Log likelihood function		17.081	

Source: author calculation

***, ** and * asterisks on the value of the parameters indicate it's significant at 1, 5, and 10 percent level of significance, respectively.

3.1.1 Frequency Distribution of Tenants Technical Efficiency

The tenants in Gezira scheme have wide range of technical efficiency ranging from 40% up to 97% for groundnut crop. The frequency distribution of the efficiency estimates obtained from the stochastic frontier for groundnut (Figure 1) shows that 82.2% of the tenants operate with efficiency ranged between (40-80) and 17.8 % of the farmers operate with efficiency ranged between (80-100).This implies that on average, the tenants producing groundnut in Gezira scheme achieved almost 65 % of the potential stochastic frontier groundnut production level given their current level of production inputs and technology used. 82.2% of groundnut production model for farmers in the Gezira scheme operated below 80% of the maximum groundnut production, obtained by the fully efficient and 17.8% operated above the 80% level of technical efficiency in the groundnut model. The variance parameter, γ, with a value of 0.94 is significant component in explaining the variability of groundnut production level in the Gezira scheme. This relatively high value of the variance parameter implies that substantial proportion, 94%, of the groundnut production total variability is mainly associated with tenants' technical inefficiency of production. The estimate of the variance parameter γ, is significantly different from zero, indicating that the inefficiencies are significant in determining the level of variability of groundnut yield in the Gezira scheme [14]. Tenants low technical efficiencies are consistence with relatively high (γ) variance of tenants' effects which indicate that the stochastic frontier and the average production function are expected to be quite different. The variance of the random effects (v_i) was not a significant component of the groundnut yield variability.



Source: author calculation

Figure (1): Technical Efficiency Score of Groundnut crop in Gezira scheme, 2011/2012.

3.2 Inefficiency model:

The results of the factors affecting tenants' technical inefficiency were presented in table 1. Education level coefficient has not significant. The coefficients of experience had negative sign and significantly different from zero at 5% level of significance for groundnut. A negatively significant parameter of experiences of tenant means that the inefficiency effects decrease with increase in experience years. This result is in conformity with the findings of [11]. He found a negative association between the technical inefficiency and farmer experience. Family size coefficient had negative sign and significant at 10% for groundnut. Family size is negative sign indicate that farmers with large family size tend to have smaller inefficiency effects then farmers with small family size. Family size is assumed to influence technical efficiency positively. It is expected that as the family size increases the number of the members who participate in farming activities increase. Family size has a negative effect on the inefficiency of groundnut crop produced in the Gezira scheme. The marital status has negative sign and insignificant for groundnut.

3.3 Hypotheses Test of Groundnut crop Production Model

Here were testing the coefficients of the farm-specific variables on the technical inefficiency effect models using the generalized likelihood- ratio statistic.LR. [15] suggested that the one-sided generalized likelihood-ratio test should be performed when ML estimation is involved because this test has the correct size (i.e. probability of a type 1 error). This is testing the null hypothesis that the inefficiency effects were not present. In other words, the null hypothesis is that there are no technical inefficiency effects in the model. That is, H_0: $\gamma = \delta_0 = \delta_1 = \ldots = \delta_5 = 0$ [11].

Table (2): Groundnut crop model, test of hypothesis for the parameters of stochastic frontier production function.

MODEL		
	Groundnut	Decision
H_0: $\gamma = \mu = 0$	19.913***	H0: Rejected
LR $H_{0:}$ No technical inefficiency	2.293**	H0: Rejected

Source: Author calculation.
***, ** and * asterisks on the value of the parameters indicate it's significant at 1, 5, and 10 percent level of significance, respectively.

As revealed in table (2), test hypothesis of groundnut likelihood ratio test (LR), which tests the null hypothesis for the technical efficiency effect for groundnut crop production in the Gezira scheme are rejected.

The value of the test is calculated as:
$LR = -2\{\ln[L(H_0) / L(H_1)]\} = -2\{\ln[L(H_0)] - \ln[L(H_1)]\}$
Where L (H_0) and L (H_1) are the values of the likelihood function under the null hypothesis and alternative hypothesis, respectively [11] & [6]. Table 2 reveals that there are significant technical inefficiency effects in groundnut crop production, because the null hypotheses H_0 are fully efficient given the specification of (SPF) in Cobb-Douglas form. Then the (H_0: $\gamma = \mu = 0$): null hypothesis are rejected.

IV. CONCLUSIONS AND RECOMMENDATIONS

The aim of this paper are to measure and evaluate groundnut technical efficiency, identify technical inefficiency determinants and quantify the technical gain from enhancing the technical efficiency of groundnut farmers in Gezira scheme of Sudan. The study used the stochastic frontier analysis model to estimate technical efficiency and inefficiency determinants. The results revealed that the mean technical efficiency was found to be 65% for groundnut production. In other words, groundnut production could have increased by 35% at the same level of inputs had farmers been technically efficient. The results also showed that 94% of groundnut output deviation from normal is due to differences in farmers' level of technical efficiencies as opposite to the conventional random variability. Also, the study found that age farmers, education years, sowing date, farm income, irrigation numbers and total labour is the major factors that are associated with changes in groundnut yield. The experience farmers and family size are the appeared to be the most important socio-economic factors determining farmers' efficiencies in groundnut production in Gezira scheme. The study recommends improving technical efficiency for groundnut production in the Gezira scheme, through improved farmer specific efficiency factors, which include improved farmer education, Gezira Scheme management should improve the extension services and supervision, and supply of credit, agricultural inputs should be at the right time with easy access for tenants.

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