Original Research Article

Economic Efficiency of Grasscutter Production *(Thryonomys swinderianus)* in Osun State, Nigeria: A case of Data Envelopment Approach

ABSTRACT

Aim: The study estimated the technical, allocative and economic efficiency indices and further examined the factors influencing technical efficiency for the sampled grasscutter farms in Osun State.

Study Design: The study made use of only primary data obtained from sampled grasscutter farmers in the three agricultural zones of the State.

Place and Duration of Study: The study was carried out in Osun State, Nigeria during 2017/2018 farming season.

Methodology: Twenty four respondents, each, were randomly selected from the list of grasscutter farmers obtained from Osun State Agricultural Development Project (ADP). Data collected was analyzed using the stochastic frontier model and Tobit regression model. The overall technical efficiency was estimated with no effort of decomposing it into pure and scale efficiencies.

Results: The results showed that the range of efficiency indices varies greatly with minimum of 0.742, 0.263 and 0.168 and maximum of 1.0 for technical, allocative and economic efficiencies, respectively. The mean efficiencies which indicate the average potential therein in grasscutter production in the study area were 0.96, 0.63 and 0.83 for technical, allocative and economic efficiency, respectively. Only one, out of the seventy two grasscutter farmers involved in the analysis was found to be technically, alocatively and economically efficient. Many sampled grasscutter farmers employed the 'wrong' input mix, given input prices, so that, on average, costs were (37%) higher than the cost minimizing level. However, farms have the potential to reduce their physical input, on average, by (4%) and still produce the same level of output.

Conclusion: There was a great potential to improve the output of grasscutter farms and save cost, if variable inputs were adjusted to the optimal level along the short-run isoquant. Education and farming experience significantly influenced technical, allocative and economic efficiencies, respectively, while inefficiency results, in large part, from allocative rather than technical inefficiency.

Keywords: Economic Efficiency, DEA, Grasscutter, Tobit.

1.0. INTRODUCTION

Wildlife has great potentials for meat production and serves as an important source of the highly desired animal protein for both in urban and rural communities [1]. In Nigeria, there is an abundant variety of wildlife resources capable of supporting the protein intake of the populace. However, in recent times, there had been significant short fall between the production and supply of animal protein to feed the ever increasing population [4]. To arrest this unacceptable trend, efforts had been directed towards boosting the micro-livestock sector. Among the micro-livestock species is the grasscutter or cane rat (*Thryonomys swinderianus*) popularly called Nchi by the Igbos, Gegbi in Hausa Language, Oya by the Yorubas, in Nigeria, Akranti/Akrantie in Ghana and simply grasscutter in other West African Countries.

Grasscutter is a hystricomorphic rodent widely distributed in the African sub-region and exploited in most areas as a source of animal protein [9]. It is a heavily built animal with round muzzle, small round ears, short tail and harsh bristly fur. Apart from being the most preferred, it is the most expensive bush meat in most West African countries, Nigeria inclusive [16]. It contributes to both local and foreign earnings in some of these countries. Most rural populations in Nigeria depend on bush meat for their dietary protein supply and most Chinese who are resident in Nigeria cherish grasscutter meat as regular meal and forms delicacy for entertainment for their guest from abroad [14]. The preference for grasscutter is attributable to its high carcass quality and protein that is comparable to that of poultry, especially turkey and other domesticated livestock like rabbit, sheep, goat and cattle [17]. A crude protein content of (22.7%) had been reported for grasscutter meat. This value is higher than the crude protein values of (20.7%) for rabbit meat, (19%) for chicken meat and (18.2%) for beef and (22.2%) for turkey [19]. However, it has been observed that one of the most serious constraints of agricultural growth in Nigeria is the inefficient use of productive resources and that considerable growth can be achieved by simply improving the level of efficiency in resource use [3]. Studies conducted by [20] and [16] revealed that grasscutter production in Southwest, Nigeria, is mainly at subsistence level and output is relatively low despite its relatively competitive prices in both local and international market. It is therefore obvious that with the ever increasing human population and obvious protein shortage in Africa, an understanding of the efficiency of grasscutter production in Nigeria, is most opportune.

Production efficiency means the attainment of production goals without waste. Efficiency is often used synonymously with that of productivity which relates output to input. In agriculture, the analysis of efficiency is generally associated with the possibility of farm production to attain optimal level of output from a given bundle of input at least cost. An underlining premises behind much of this work is that farmers are not making efficient use of existing technology, then efforts designed to improve efficiency would be more cost effective than introducing new technologies as a means of increasing agricultural output. Efficiency of various livestock sub-sectors can be improved through efficient use of the existing technologies, reallocation of resources and adoption of new technologies [20] and [6]. The challenge to policy makers is how to improve efficiency especially of the small farmers so as to attain large gains in agricultural output thus leading to reduction in food insecurity.

There have been several studies on economics of grasscutter production in Nigeria but very few exist on efficiency e.g. [1] revealed the potential and constraints in grasscutter production in Oyo State but falls short of providing the economic values of these potentials; also, [4] attempted to address this using marginal values which we consider inadequate in view of its average value. Despite the fewer studies conducted in grasscutter production in the State, a Data Envelopment Approach has not been applied to determine the production efficiency of grasscutter farmers in the study area. In view of this, the study examined the economic efficiency of grassutter production in Osun State using the Data Envelopment Approach.

1.1   Overview of Literature

Interestingly, there exist a large body of empirical literature on economic efficiency of farmers in developed countries and Asian economics but only a few empirical studies have focused on African agriculture to measure economic efficiency. These have proceeded along two general approaches: non-parametric and parametric. Whereas, the parametric imposes a functional form on the production function and uses the common production functions such as the Cobb-Douglas and trans log production function, the non-parametric do not and uses Linear programming. Most parametric approaches adopt either the two-step or the one-step stochastic frontier approach first developed by Aigner and Chu in 1977 [2].

From the existing studies, a consensus that seems to emerge is that farmers are inefficient in their resource allocation. Between [20 -30%] of agricultural output is lost due to inefficiency but the most common are socio-economic variable such as farmers' age, farming experience, frequency of extension contact, educational level, farm size as well as membership of farmers' cooperative among

others [21]. It has been argued that it is possible to increase agricultural production significantly by simply improving the producer's technical efficiency without additional investment.

Several authors' present strength and weaknesses of various techniques used in the efficiency measurement. For example, [5] among others noted that the stochastic frontier model specification not only addressed the noise problem associated with earlier (deterministic) frontiers, but also permitted the estimation of standard error and test of hypotheses which were not possible with the earlier deterministic models because of the variation of certain maximum likelihood regularity conditions. However, it was further noted that there is a problem of no *a priori* justification for the selection of any particular distributional form. Though the specification of a more general distributional form such as the truncated-normal and the two parameters gamma has partially alleviated this problem but the resulting efficiency measure may still be sensitive to distributional assumption [10]. The need for imposing an explicit parametric form for the underlying technology and an explicit distributional assumption for the inefficiency term are the main weaknesses of the parametric approach.

According to [12], DEA avoids parametric specification of technology as well as distributional assumption for the inefficiency term. By using DEA, one will be able to:

(i) Compare a group of service units to identify relatively inefficient units.
(ii) Measure the magnitude of the inefficiencies.
(iii) Compare the inefficient with the efficient ones.
(iv) Discover ways to reduce the inefficiency.

However, DEA is deterministic and attributes all deviations from the frontier to inefficiency; a frontier estimated by DEA is likely to be sensitive to measurement error or other noise in the data. Various authors have examined the empirical performances of these two approaches. For instance, [13] found out that overall distribution of the technical efficiency scores for the stochastic production frontier (SPF) and DEA models were similar while the efficiency scores for individual boat varied considerably for these two approaches. Also, [3] found the result from the DEA to be more robust than those from the parametric.

This study demonstrates an approach to determining the farm efficiency using DEA technique. DEA is a non-parametric technique that measures the efficiency of Decision Making Units (DMU) relative to production possibility or input requirement set. It was further described by [13] in terms of floating piece-wise linear surface to rest on top of the observations. Specifically, the key constructs of a DEA model are the envelopment surface and the efficient projection path to the envelopment surface

The envelopment surface and the efficient projection path depend on the scale assumption that underlined the model and the optimization assumption respectively. The optimization production process could be output or input-oriented model. The input-oriented model shows how much the input could be proportionally reduced without changing the quantity of the output produced while the output-oriented shows how much the output quantity could be proportionally expanded without altering the

input quantity. Output oriented model gives credence to neo-classical production function defined as the maximum output given input quantity [8].

Most DEA applications to efficiency measurement in the literature are input-based type. The few established applications of output-based efficiency have primarily focused on the technical, scale and congestion efficiency [5]. In this study, the input-oriented model approach was used to estimate various efficiency indices because farmers tend to have greater control over their inputs than over their output. Non-parametric production frontier estimation was used in this study because it de-emphasizes the assumptions that support much of the classical parametric production frontier and has the following merits as listed in the literature, among which are:

(i) It requires less restrictive population assumptions than corresponding parametric methods.
(ii) It generates a single input/output index to characterize efficiency of a firm or decision making unit producing multiple output from a set of inputs [5].
(iii) It avoids parametric specification of technology.

2.0.   MATERIALS AND METHODS

2.1.   Study area

The study was carried out in Osun State. The State has thirty local government areas divided into three agricultural zones (Iwo, Osogbo and Ife-Ijesa) by the Osun State Agricultural Development Programme (OSADEP). The State is located in the South-West geopolitical zone of Nigeria and occupies an area of land of about 14, 875km^2. The ecological conditions are conducive for an impressive diversity of livestock such as cattle, sheep, goat, pig, rabbit, grasscutter and poultry. The State has a population of about 3.5 million [15] and the vegetation is characteristically that of rain forest and derived savannah with a mean annual rainfall that varies between 980mm and 2800mm and a temperature range of 27 - 32°C. Fig. 1 shows the zonal classification of the study area.

Fig. 1: Map of Osun State, Nigeria showing the three agricultural zones.

## 2.2.	Method of Data Collection

The data for the research was collected mainly from primary source. This was obtained through a well-structured questionnaire which was distributed to seventy two grasscutter farmers in the study area. The Data covered 2017/2018 farming season.

## 2.3.	Sampling Technique/Method of Data Analysis

The Resident Agricultural Extension agents and the State Ministry of Agriculture, Osun, were contacted to provide the list of registered grasscutter farmers in the three agricultural zones which forms the sampling frame for the study. From the list provided, the total number of registered farmers in Ife-Ijesha zone was 38, 40 in Iwo zone and 42 in Osogbo zone. Hence, twenty four (24) grasscutter farmers each were randomly selected from each of the agricultural zones to arrive at a total sample size of seventy two (72) respondents. The study made use of descriptive statistics and Data Envelopment Analysis (DEA), a non-parametric frontier, to estimate the efficiency indexes of grasscutter farmers in the study area.

## 2.4	Model Specification

2.4.1. Technical Efficiency Model

TE; $(y_j, x_j) = Q_1$ is independent of input prices and computed by solving the following input oriented DEA model under CRS assumption.

Min Q_1

Q1.

S . t

$$x_{ij} \ Q_1 - \sum_{i=1}^{m} x_{ij} \qquad j \geq 0$$

$$\sum_{j=1}^{m} y_j \ _j - y_j \geq 0$$

$$j \geq 0 \ f \ \sum x_{ij} \qquad j \geq 0$$

$$\sum_{j=1}^{m} y_j \ _j - y_j \geq 0 \qquad \text{...(1)}$$

for v_j ; Q_1 unconstrained

If Q = 1, then the farm is on the frontier and is technically efficient under CRS.

2.4.2. Allocative Efficiency Model

Using [8] decomposition relationship, the AE is computed thus:

$$AE; (y_j, x_{ij}, c_{ij}) = \frac{[EE_j (y_j; x_{ij}, c_{ij})]}{[TE, (y_j; x_{ij})]} \quad \text{................................} (2)$$

2.4.3. Economic Efficiency Model

The overall economic efficiency is derived by first solving the cost minimizing DEA model under the CRS assumption.

$$MC_j (y_j , x^*_{ij}) = \min C_{ij} \cdot x^*_{ij} \text{...}(3)$$

$$S. t. \quad + \sum_{j=1}^{n} y_j \ j - y \geq 0$$

$$X^*_{ij} \ - \ \sum_{j=1}^{n} y_j \ xij \quad j \geq 0 \geq 0$$

$$j \geq 0 \quad f \quad v_j$$

Where MC_j (y_j,x_j, C_{ij}) is the minimum total cost under CRS assumption.

Yj values are the weights to be used as multipliers for the input levels of the jth farm to indicate the input level that the farm aims at to achieve efficiency. EE is then defined as the ratio of minimum to actual observed costs.

$$EE (y_j, x_{ij}, G_j) = \frac{[MC (y_j;x^*_{ij}; c_{ij})]}{(c_{ij}. x. x_{ij})} \text{.....................................}(4)$$

2.5.0. Determinants of Inefficiency Model

A second step regression model was applied to determine the farm specific attributes in explaining inefficiency in some studies such as [3] and [4]. Alternatively, the factors can be incorporated directly into the model. The pros and cons of these approaches are provided in [11]. This study applied a second step approach by using a Tobit regression.

The model assumes

$$y^* = , + _1Z_1 + _2Z_2 + _3Z_3 + _4Z_4 + _5Z_5 + e \text{...........................}(5)$$

$$y = \begin{cases} y^* & if \ y^* < 100 \\ 100 & otherwise \end{cases}$$

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Where y is the DEA efficiency model and used as a dependent variable.

Z_1 = Education

Z_2 = Experience

Z_3 = Age

Z_4 = Extension contact

Z_5 = Household size

β is the unknown parameter vector associated with the farm specific attributes and e is an independently distributed error term assumed to be normally distributed with zero mean and constant variance, δ^2. Therefore, the model assumed that there is underlying, stochastic index equal to (Z β + e) which is observed only when it is less than 100 and qualified as an unobserved latent variable. The dependent variable, that is efficiency invest cannot be normally distributed but censored distribution because it has a value between 0 and 1. OLS will yield an inconsistent estimate, hence, this study used Tobit regression model using maximum likelihood estimate (MLE) approach.

The expected value becomes *E(y/z) = 1 – (b) x 100 + (b) Z - (b)*

Where b = (100 – z)
E(y/z). …………………………………………………………………………….(6)

3.0. Results and Discussion

3.1. Technical, Allocative and Economic Efficiency of the Farms

The Technical, allocative and economic efficiencies of grassutter farmers are presented in Table 1. These efficiencies were grouped into a frequency distribution with class interval of 0.10. The range of efficiency index varies greatly with minimum of 0.742, 0.263 and 0.168 and maximum of 1.0 for technical, allocative and economic efficiencies, respectively. The mean efficiency which indicates the average potential that exists in grasscutter production in the study area is 0.96, 0.63 and 0.827 for technical, allocative and economic efficiencies, respectively. Of the 72 grasscutter farmers involved in the analysis, only one was found to be technically, allocatively and economically efficient. The measures of relative allocative and technical efficiency provide evidence as to the source of deviations from overall cost-minimizing behavior. Many grasscutter farms employed the 'wrong' input mix, given input prices, so that, on average, costs were [37%] higher than the cost minimizing level. Although, effort was not made in this study to decompose the TE into pure TE and scale efficiency (SE). However, farms have the potential to reduce their physical input, on the average, by (4%) and still produce the same level of grasscutter output.

Given the number of grasscutter farmers that are inefficient, this suggests that there is the need to strengthen the existing level of resources used to increase their income at the existing level of available resources rather than a technological change. Table 1 further showed that with the allocative

index of 0.630, it implies that the grasscutter farmers in the study area have about (37%) potential to efficiently combine their resources. It was observed from Table 1 that inefficiency results in large part from allocative inefficiency (37%) rather than technical inefficiency (4%). This suggests that inefficient grasscutter farmers use fewer resources to achieve maximum production but do not combine resources (input) efficiently. This finding is similar to [4] which found out that grasscutter farmers in Oyo State achieve higher TE but poor AE which was attributed to the farmers' decision on the amount of inputs for cultivation was based on their experiences and not using input flexibilities according to the markets.

Table 1: Frequency distribution of efficiency index

	TE	AE	EE
< 0.6	0	5	7
0.60 – 0.70	0	21	9
0.71 - 0.80	8	24	19
0.81 - 0.90	15	6	29
0.91 – 0.99	40	12	5
1	9	4	3
Mean	0.96	0.63	0.827

Source: Data analysis, 2018

3.2. Cost Minimizing Input Quantity of Grasscutter Farms

Summarily, the mean cost minimizing input quantities showed that on the average, the input used can be reduced to 21.5; 54.53; 11.41; 33.33 and 121.71 for X1, X2, X3, X4 and X5, respectively. This indicates that so many saving could be made if the respondents are cost efficient. Table 2 showed that the efficiency scores of the descriptive statistics having the lowest dispersion of 0.02 around the mean.

Table 2: Descriptive Statistics of the Efficiency indices

Efficiency Measure	Mean score	Standard deviation	Minimum	Maximum
Technical efficiency	0.96	0.02	0.742	1
Allocative efficiency	0.63	0.11	0.263	1
Economic efficiency	0.83	0.14	0.168	1

Source: Data analysis, 2018.

3.3. Determinants of Efficiency Differentials among Grasscutter Farmers

Firm specific factors such as age, experience, frequency of extension contact, education and household size were examined to explain the determinants of efficiency differentials among farmers for TE, AE and EE. Applying Tobit regressions to analyze the efficiency parameters as defined in equation (5) and (6). The Tobit regression coefficients are interpreted to analyze the directional relationship between efficiency and covariates. The results in Table 3 showed that the education parameter has a consistent positive relationship with all the three efficiency indexes and significant for TE, AE and EE at 5%, 1% and 10% probability levels, respectively. This implies that the more educated the farmer is, the more likely efficient he is, probably as a result of their better skills and willingness to identify and adopt new innovations. This agrees with the findings of [1] and [16].

Farmers' years of experience in grasscutter farming was positively signed with the three efficiency indexes but only significant for TE at 10% level of probability. This implies that farmers are able to draw on past production experience to suit their farming condition and the technical know-how obtained through experience increases technical efficiency and thus increase productivity. This finding is consistent with the findings of [18] and [16]. Extension visit also was positively signed with all the efficiency indexes and significant for TE, AE and EE at 10%, 5% and 1% probability levels, respectively. This implies that farmers that were visited by extension agents were more likely to be more technically, allocatively and economically efficient than those not visited by extension agents. Since extension services increases the level of farmers' availability to information which in turn plays an important role in increasing farm level efficiency. This also agrees with the finding of [10].

Table 3: Tobit Regression Showing Relationship selected farm specific factors and Efficiencies index

Variable parameter	TE Coef.	t-value	AE Coef.	t-value	EE Coef.	t-value
Constant (βo)	0.731	1.75	0.310	1.820	0.569	4.250
Education	0.370	2.710**	0.407	6.055***	0.357	1.978*
Experience	0.215	1.972*	0.067	1.105	0.002	0.100
Age	0.020	0.011	0.017	0.979	0.033	0.778
Extension	0.340	2.109*	0.340	2.109**	0.451	3.799***
Household size	0.010	0.555	0.040	0.225	0.001	0.111

*10%, **5% and ***1% levels of significance; βi Signifies the parameter estimates*

3.4. Spearman Rank Correlation Depicting Relationship among TE, AE and EE

Table 4 shows the results of the Spearman rank correlations coefficients between the different measures of efficiency. This estimate provides weak but significant estimates between TE and AE with a strong but significant relationship between TE and EE. This finding suggests that a technically efficient farm would not necessarily be allocativelly efficient.

Table 4: Spearman Rank Correlation Depicting Relationship among TE, AE and EE.

	TE	AE	EE
TE	1.00	0.43*	0.89*
AE	0.43*	1.00	0.66*
EE	0.89*	0.67*	1.00

Signifies significance at 1% probability level

4.0. Conclusion and Recommendations

The study examined the economic efficiency of grasscutter production and the various drivers through which the grassccutter farmers' performance can be improved in Osun State using the DEA. It was observed that there exists more potential that remained untapped in grassccutter production in the study area and that the economic inefficiency observed was more as a result of allocative inefficiency rather than the technical inefficiency. The TE and AE were found to be 0.96 and 0.63 respectively. This suggests that an increase in output is possible with a decrease in the cost, if the grasscutter farmer uses the right input mix. Education and frequency of access to extension service were found to significantly impact on both TE and AE. The study therefore recommends, based on the findings, that the extension teaching should focus more on the appropriate combinations of input resources given the price as this was found to contribute more to the economic inefficiency than technical inefficiency. Also, both old and new entries into grasscutter production in the study area should be exposed to educational programmes such as workshops and seminars since education helps to improve economic efficiency.

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