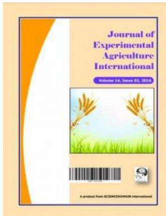

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Economics and Efficiency of Rain-Fed Cabbage Production (*Brassica oleracea Var. Capitata*) in Kaduna State, Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aims: To analyze Economics of Rain-fed Cabbage Production in Kaduna State, Nigeria.
Study Design: Primary data were collected from 130 cabbage farmers with the aid of structured questionnaire.
Place and Duration of Study: This study was carried out in three local government areas (Kudan, Sabon-Gari and Zaria) in Kaduna state during 2015 cropping season.
Methodology: Multistage purposive and random sampling techniques were employed for data collection.
Results: The results of the maximum likelihood estimates (MLEs) of the stochastic frontier production function model revealed that farm size was significant to cabbage output. The technical efficiency scores revealed that the most efficient farmer operated at 98% efficiency, the least efficient farmer was found to operate at 1% efficiency level, while the mean was indicating that rain-fed cabbage farmers still have room to increase the efficiency in their farming activities from the

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optimum (100%) is yet to be attained by a typical farmer in the study area. However, the mean economic efficiency of the rain-fed cabbage farmers was 0.80, implying that output fell by 20% from the maximum possible attainable level due to economic inefficiency of the farmers. The inefficiency model revealed that age squared, family size, extension contact and educational level, increased TE, while credit access and farming experience were the determinant of allocative efficiency of the farmers.

Conclusion: This study carried out an assessment of economic efficiency of rain-fed cabbage farmers in selected local government areas of Kaduna state, Nigeria. The result of the study showed that there is positive and significant relationship between farm size and cabbage output in the study area. The study also identified the determinants of the technical inefficiency of the farmers. The farm specific technical efficiency distribution reveals that none of the farmers achieved the maximum efficiency level. Thus, within the context of efficient agricultural production, output can still be increased by 13 percent using available inputs and technology by reallocating the resources more optimally.

Keywords: Economic efficiency; rain-fed; stochastic production frontier cabbage; production.

1. INTRODUCTION

There has been a rise in the production of vegetables in general, stimulated by high public demand, driven in large part by enhanced consumer awareness of the dietary and health benefits of fresh vegetable consumption [1]. Vegetables are good sources of protein, mineral salts, sugars, vitamins, and essential oils that increase man's resistance to disease [2]. Increase in vegetable production improved food security and offered employment opportunities to many rural women in Nigeria [3]. Vegetables are the most important and extensively cultivated food and income generating crops in many parts of Africa [4].

Agricultural production in Nigeria is dominated by small-scale farmers who produce more than ninety percent of the food consumed in the country. One of the major crops produced are vegetables which represent an essential part of agricultural products. Their production remains entrenched in Nigerian agriculture and forms an important condiment in the national diet [5].

Cabbage (*Brassica oleracea var. capitata L.*) is the most important vegetable commercially of the Cole crops, which include Cabbage, *Cauliflower, Brussels sprouts, Kale, Kohlrabi, Collard, Broccoli,* and many others. It also ranks as one of the most important of all vegetable crops and is universally cultivated as a garden, truck and general farm crop. The market for cabbage, like that for potatoes, is continuous throughout the year, and this tends to make it one of the staple vegetables [6]. Fresh cabbages are sold through fresh produce market, processors, restaurants and retailers.

Cabbages are among the most important vegetables in Africa in general and particularly in Nigeria, especially for lower income groups. It serves as an income source among groups most affected by poverty, including small farmers, youths, and most especially women who play an important role in agricultural production [7].

Despite the involvement of farming families in cabbage production in the study area over the years, the generality of their income and productivity has remained low. There is however scanty research works on efficiency and profitability analysis of cabbage production in the study area. Against the backdrop that cabbage production is not capital intensive and can be undertaken all year-round even by resources poor farmers.

2. MATERIALS AND METHODS

2.1 Area of Study

The study was conducted in Kaduna state, Nigeria. The state occupies an area of approximately 68,000 square kilometers or 7% of Nigeria's land mass. It lies between Latitudes 9°N and 12°N of the equator and between Longitudes 6°E and 9°E of the prime meridian. The state shares boundaries with Katsina and Kano States to the North, Plateau State to the north east, Nasarawa and Abuja to the South, and Niger and Zamfara States to the West. The mean annual rainfall shows a marked decrease from South to North (1,524mm to 635mm). Two distinct seasons, rainy and dry witnessed in the state. The relative humidity is constantly below 40 degrees except in few wet months when it goes up to an average of 60 degrees. The duration of dry season is 5-7 months which normally starts from October.

2.2 Sampling Procedure

This study was carried out in 2015. The study estimated economics of cabbage farmers in Kaduna state for 2015 cropping season. Three local government areas (Sabon-Gari, Kudan and Zaria) were purposively selected because of their high involvement in cabbage farming in the state. Simple random sampling technique was employed for the selection of 130 respondents. This was followed by self-administered of structured questionnaire to the selected farmers.

2.3 Model Specification

Stochastic frontier production function was used in the analysis of the result.

2.3.1 Stochastic frontier production function

The major tool of analysis used in this study was the stochastic frontier model. The stochastic frontier production function model is specified in the implicit form as follows:

$$Y = f(Xa, \beta)\, e^{E} \quad (1)$$

Where;

Y=output of cabbage (kg);

Xa = vector of input quantities;

β = a vector of parameter and

E= Stochastic disturbance term consisting of two independent elements U and V,

Where;

E = V-U

The symmetric component, V is for random variation in output due to the factors outside the farmers' control such as weather and diseases. It is assumed to be normally, independently and identically distributed N~ $(0, \delta^2 v)$. A one–sided component ≤ 0 reflects technical inefficiency relative to the stochastic frontier. Thus, U= 0 for a farm output which is lies on the frontier and U < 0 for output which is below the frontier, hence the distribution of U is half normal as specified for cabbage production in the study area.

The explicit form of the model Cobb-Douglas stochastic frontier production function was specified as:

$$\text{In}Y = \beta_o + \beta_1 \text{In}X_1 + \beta_2 \text{In}X_2 + \beta_3 \text{In}X_3 + \beta_4 \text{In}X_4 + \beta_4 \text{In}X_5 + V_1 - U_i \quad (2)$$

Where:

Y = Output of cabbage (kg);

X_1 = Land (hectares);

X_2 = Fertilizer (kg);

X_3 = Seed (kg);

X_4 = Labour (man-day);

X_5 = Agro-chemicals (litre);

β_o = constant term; and

β_1, β_2, β_3, β_4 and β_5 = coefficients of the inputs with respect to output level. The output was measured in kilogram (kg). The unit price was also measured in kg.

The *a priori* expectation was that the coefficients of the whole inputs X_1 to X_5which are $\beta_{1,}\beta_{2,}\beta_{3,}$ β_4 and β_5 should be positive, respectively (i.e. greater than zero). Therefore, each variable was expected to have positive effect on the dependent variable (cabbage output).

V_1 = random error term and
$-U_i$ = inefficiency component of error term

The inefficiency model was of the form:

$$-U_i = d_o + d_1 Z_i + d_2 Z_2 + d_3 Z_3 + d_4 Z_4 + d_5 Z_5 + d_6 Z_6 \quad (3)$$

Where;

$-U_i$ = technical inefficiency,

d_o= intercept,

d_1-d_4 = respective coefficients of the independent variables,

Z_1 = age of the farmers (years),

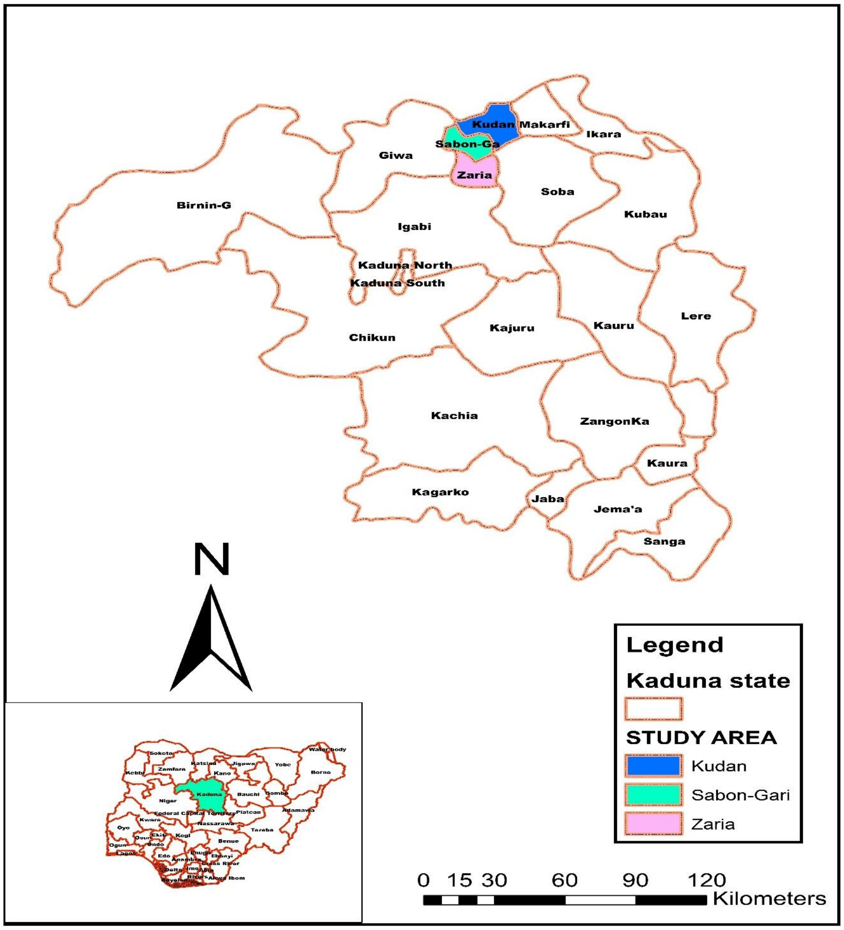
Z_2 = family size,

Z_3 = extension contact (number of contacts),

Z_4 = levels of education,

Z_5 = Credit, and

Z_6 = Experience in cabbage production



Map 1. Map of Kaduna State showing the study area

The specification of the model for the inefficiency effects in equation (3) implies that, if the independent variables of the inefficiency model have a negative sign for an estimated parameter, then the associated variable has a positive effect on efficiency while a positive sign indicates that the reverse is true.

Thus, the *a priori* expectation was that the coefficients of the independent variables of the inefficiency model (i.e. d_1, d_2, d_3, d_4, d_5 and d_6)should be negative, respectively (i.e. less than zero).Therefore, each variable was expected to have positive effect on technical efficiency.

Allocative efficiency was computed as

$$AE_i = \frac{1}{CE_i} \quad (4)$$

Where

AE_i = Allocative efficiency level of the i[th] farmer

CE_i = Cost efficiency level of the i[th] farmer

Economic efficiency was computed as

$$EE_{ij} = TE_i * AE_i \quad (5)$$

Where

TE_i= Technical efficiency level of the i[th] farmer
AE_i = Allocative efficiency level of the i[th] farmer

3. RESULTS AND DISCUSSION

3.1 Technical Efficiency of Cabbage Farmers

The Maximum Likelihood Estimates (MLE) of the parameters of the Cobb-Douglas stochastic frontier production function and inefficiency model was estimated using FRONTIER 4.1 software. The MLEs of the Cobb-Douglass stochastic frontier model with the half-normal distribution assumption made on the efficiency error term are presented in Table 1.The result contain estimate of the parameters of the frontier production function and the variance parameters of the model.

The variance parameters for sigma square (δ^2) and gamma (γ) are 0.23 and0.99, respectively. They are significant at 1% level. The sigma square indicates the goodness of fit and correctness of the distributional form assumed for the composite error term. The gamma (γ) estimate indicates the systematic variance that is unexplained by the production function and is the dominant source of random errors. The estimate of γ= 0.99 or 99% means that the inefficiency effects had significant contribution to the technical inefficiency of cabbage farmers in the study area.

The mean average technical efficiency for the farmers was 0.87 implying that, on the average the farmers are able to obtain 87% of potential output from a given mix of production inputs. Thus, in a short run, there is minimal scope (13%) of increasing the efficiency, by adopting technology and techniques used by the efficient cabbage farmer.

The results show that only the coefficient of land size was positive and statistically significant at 1% level. Labour input also found to be positive. This implies that an increase in the use of this production inputs would bring about increase in cabbage output.

The estimated coefficient for farm size was 0.97 which was positive in line with the *a priori* expectation and statistically significant at 1% level. The magnitude of the coefficient indicates that the output of cabbage crop was inelastic to the changes in the level of cultivated land area. Therefore, this implies that a 1% increase in cultivated land area, *ceteris paribus*, would lead to 0.97 increases in cabbage output, and *vice versa*. This further suggests that land is a significant factor associated with changes in agricultural production. This result is in accord with [8] that identified land as a critical factor in agricultural production. This result is similar to the finding of [9] that showed a positive relationship between land size or farm size and farm level efficiency of smallholder farmer. This also, agrees with the findings of [10], who found that land was a significant factor and positively related to the output of rice farmers in Adamawa state.

Table 1. Maximum likelihood estimates of the production factors for cabbage and the inefficiency factors affecting technical efficiency in Kaduna State, Nigeria

Models	Coefficient	Standard-error	T-ratio
Constant	10.82	0.06	180.40***
Land	0.97	0.002	446.10***
Seed	-0.07	0.08	-0.96
Fertilizer	-0.002	0.01	-0.17
Labour	0.008	0.006	1.43
Pesticide	-0.004	0.005	-0.79
Constant	-2.502	0.936	-2.67***
Age	0.122	0.046	2.66***
Age squared	-0.01	0.001	-4.55***
Marital Status	0.903	0.181	4.99***
Family size	-0.034	0.011	-2.94***
Contact with Extension Agents	-0.39	0.088	-4.43***
Primary Education	-1.752	0.207	-8.45***
Secondary Education	-1.967	0.191	-10.28***
Tertiary Education	-1.5	0.193	-7.78***
Sigma-squared	0.233	0.019	12.56***
Gamma	0.99	0.102	9.71***
Mean Technical Efficiency	0.87		
Number of Observation	130		

*Source: Computed from survey data (2015), Note: ***=Significant 1%*

3.2 Estimated Stochastic Frontier Cost Functions

The MLEs parameter of the stochastic frontier cost function for cabbage farmers is presented in Table 2. The results show that the estimated sigma squared (δ^2) was (0.146) and significant at 1% level of probability. This indicates the goodness of fit and correctness of the specified assumption of the composite error term distribution [11]. The value of gamma (γ) was (0.607) and significant at 1% level, suggesting that 61% of the variation from the frontier output of cabbage farmers was due to the cost inefficiency of the farmers.

The estimated coefficients of the parameters of the cost function were found to be positive. The result revealed that the estimated coefficient of fertilizer was positive and significant at 1% probability level. This implies that an increase in the cost of fertilizer increased the total cost of cabbage production. This agrees with the finding of [12] who reported a positive and significant influence of fertilizer cost on total cost of farm production in Benue and Imo States respectively.

The estimated coefficient of credit was positive and significant at 1% probability level. This implies that increase in credit access increased cost inefficiency of cabbage growers in the study area. The result agreed with the finding of [13] who reported that access to credit had positive and significant effect on the cost efficiency of plantain farmers in Ondo State.

The estimated coefficient of farming experience was negative and significantly affected the cost efficiency of cabbage farmers in the study area at 10% probability level. This implies that increase in farming experience increased cost efficiency of cabbage farmers in the study area. Audu et al. [14] who found farming experience as significant determinant of the cost efficiency of cassava farmers in Kogi State, Nigeria.

3.3 Frequency Distribution of Technical Efficiency (TE) Estimates of Cabbage Farmers

The frequency distribution of the technical efficiency levels for cabbage farmers in the study area as obtained from the stochastic frontier model is presented in Table 3. It was observed from the study that 7% of the farmers operated at a efficiency level of less than 0.26, 3% of the farmers operated at technical efficiency that ranged from 0.26-0.5, while majority, that is 90% of the farmers operated at more than 0.75 efficiency level. The mean technical efficiency for the cabbage farmers in the study area was 0.87.

Table 2. Maximum likelihood estimates results of stochastic frontier cost function of cabbage production in Kaduna State

Characteristics	Coefficients	Standard error	T-value
Cost model			
Constant	1.133	0.989	1.146
Output	0.055	0.259	0.214
Cost of Seed	0.136	0.102	1.334
Cost of Fertilizer	0.748	0.15	4.976***
Cost of Labour	0.113	0.34	0.334
Cost of Land	0.05	0.282	0.178
Inefficiency model			
Constant	-0.032	0.997	-0.032
Age	-0.009	0.118	-0.075
Marital Status	0.15	0.833	0.181
Family Size	-0.002	0.051	-0.048
Extension	0.003	0.963	0.003
Education	0.081	0.931	0.087
Credit	2.5	0.43	5.81***
Experience	-1.3	0.55	2.36**
Sigma-squared	0.146	0.045	3.244***
Gamma	0.607	0.16	3.794***
Likelihood Ratio Test	0.385		

*Source: Survey data (2015), Note: *** and ** =Significant at 1 and 5% Level of probability*

The farmer with the best practice had a technical efficiency of 0.98 while the least efficient farmer operated at 0.01 levels. This implies that cabbage farmers on average are not fully technically efficient. However, only 10% of the farmers operated at a technical efficiency level of less than 0.75, while the remaining farmers operated technical efficiency greater than 0.75. This agreed with the finding of [15] on their study of land management and resources use efficiency in North region of Bangladesh.

3.4 Frequency Distribution of Allocative Efficiency (AE) Estimates of Cabbage Farmers

The frequency distribution of the allocative efficiency estimates of the cabbage farmers as obtained from the stochastic frontier cost function is presented in Table 3. The allocative efficiency estimates ranged from 0.66 to 0.99, with an average of 0.92. The results revealed that the model class (>75%) had a higher allocative efficiency than the lowest class (<26%). However, none of the farmers had a 100% efficiency index. This implies that allocative efficiency among the cabbage farmers could be increased by8% in the study area through better utilization of their farm resources with current state of technology.

3.5 Frequency Distribution of Economic Efficiency Estimates of Cabbage Farmers

The frequency distribution of the economic efficiency estimates for cabbage farmers in the study area as obtained from the stochastic frontier cost function model is presented in Table 3. It was observed from the study that 85% of the farmers had economic efficiency (EE) of 0.75 and above while 15% of the farmers operated at less than 0.75 efficiency level. The mean economic efficiency for the sampled farmers in the study area was 0.80. The farmer with the best practice had an economic efficiency of 0.96 while 0.01 was for the least efficient farmers. This implies that on the average, output fell by 20% from the maximum possible attainable level due to inefficiency.

3.6 Technical Inefficiency Estimates of Cabbage Farmers

The results of the determinants of the technical inefficiency of cabbage farmers are further presented in Table 1. A negative coefficient means an increase in efficiency or a positive effect on technical efficiency, while a positive coefficient means an increase in inefficiency or a negative effect on productivity. The estimates of the inefficiency model revealed that all the variables are statistically significant at 1% level. The result shows that age squared, family size, extension contact and educational levels had a negative signs, and therefore reduced technical inefficiency (increase technical efficiency).

The age variable could have either positive or negative effect on technical efficiency. Older farmers are more experienced and would be more technically efficient than younger farmers. However, with respect to new ideas and techniques of farming, older farmers are less likely to adopt innovations and thus would be less technically efficient than younger farmers [16]. In this study, farmer's age and age squared had positive and negative sign relationships respectively and both had significant effect on

Table 3. Frequency distribution of technical, allocative and economic estimates from the stochastic frontier models

Efficiency level	Technical efficiency		Allocative efficiency		Economic efficiency	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
<0.26	9	6.92	0	0.00	10	7.69
0.26-0.5	4	3.08	0	0.00	3	2.31
0.51-0.75	0	0.00	3	2.31	7	5.38
>0.75	117	90.00	127	97.69	110	84.62
Total	130	100.00	130	100.00	130	100.00
Minimum	0.01		0.66		0.01	
Maximum	0.98		0.99		0.96	
Mean	0.87		0.92		0.8	

Source: Survey Data (2015)

technical efficiency at 1% level. Thus, farmers with more years of experience in farming will have more technical skills in management and thus higher efficiency than younger farmers as the study revealed. Increased experience in cultivation may also enhance critical evaluation of the relevance of better production decisions, including efficient utilization of productive resources. This result is in conformity with the findings of [17] and [18] who found that older farmers had significant effect on technical efficiency of soya beans farmers in Mekong River Delta of Vietnam.

The negative sign on the estimated coefficient for family size (-0.034) indicated that an increase in household size of cabbage farmers reduced technical inefficiency (increase technical efficiency). The effect of household size on farm level technical efficiency of cabbage farming in the study area is traceable to its contribution to the supply of family labour for work on the farm. This finding is in line with [19] who reported that family size was negative and significantly related to technical inefficiency of rice farmers.

The estimated coefficient of extension contact (-0.390) was negative and statistically significant at 1% level, implying that regular contact with experienced cabbage farmers increased technical efficiency.

Education had a negative relationship with technical inefficiency. This implies that an increase in the level of education would decrease technical inefficiency or increase technical efficiency. However, efficiency of the farmers differed at different level of education. This could probably be explained by the fact that high levels of education exposes and it can raise the technical competence of an entrepreneur. Therefore, the farmers probably employed their educational advantage as opportunity to develop their farming experience and capability to adopt innovations and technologies for improved productivity. This agreed with the finding of [20] that identified education as a significant and positive factor on efficiency of vegetable crop farmers.

4. CONCLUSION

This study carried out an assessment of economic efficiency of rain-fed cabbage farmers in selected local government areas of Kaduna state, Nigeria. The result of the study showed that there is positive and significant relationship between farm size and cabbage output in the study area. The study also identified the determinants of the technical inefficiency of the farmers. The farm specific technical efficiency distribution reveals that none of the farmers achieved the maximum efficiency level. Thus, within the context of efficient agricultural production, output can still be increased by 13 percent using available inputs and technology by reallocating the resources more optimally. The overall economic efficiency was 0.8. The implication of the study is that economic efficiency of rain-fed cabbage production could be increased by 20% through better use of available resources given the current state of technology.

5. RECOMMENDATIONS

Despite the relatively high production efficiency of the farmers, there exist opportunity for enhancing their present level of efficiency which would require more efficient resource utilization by the rain-fed cabbage farmers. This could be achieved through technical and micro credit support from Local Government Authorities and non-governmental agencies in the study areas. Extension service should be intensified by the non-governmental organizations and the Local Government Authorities to educate and encourage farmers to adopt modern cultural practices of rain-fed cabbage production in order to reduce the incidence of insects and disease and promote efficient utilization of existing knowledge and skills to increase their yield.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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