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SENSITIVITY ANALYSIS AND EFFICIENCY OF COCOYAM PRODUCERS IN KADUNA STATE: AN APPLICATION OF DATA ENVELOPMENT APPROACH

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ABSTRACT

The study focused on sensitivity analysis and efficiency of cocoyam producers in Kaduna State using data envelopment approach. The technical, allocative and economic efficiencies of cocoyam farmers and the factors influencing economic efficiency of cocoyam producers and sensitivity analysis of the optimum plan of cocoyam production were estimated. Primary data were collected from cocoyam producers through the use of structured questionnaires. This study was carried out in three (Giwa, Ikara and Kudan) Local Government Areas in Kaduna State, Nigeria between August and November 2016 cropping season. Multistage sampling procedure were employed for data collection. It was observed from the study that majority of the respondents (36.29%) operated within a technical efficiency range of 0.81 and less than 1.00, the respondents (27.42%) operated within an allocative efficiency range of 0.2 and less than 0.2. The study also suggests that economic efficiency among the respondents varied widely ranging between 0.029 and 1.00, with a mean economic efficiency of 0.335. The results revealed that none of the sampled cocoyam farms reached the frontier threshold and the low level of overall economic efficiency is the result of higher cost (allocative) inefficiency and scale inefficiency (operating at less than optimal scale size). Also, age, education, extension and amount of credit received were the socio-economic variable responsible for the variation in economic efficiency of the cocoyam producers. The sensitivity analysis showed that resource allocation patterns in the optimum plan were remarkably different from that in the existing plan. However, this result calls for increase in labour supply as well as decrease in fertilizer usage among farmers.

Keywords: Sensitivity analysis; Economic efficiency; Cocoyam; Data envelopment analysis

INTRODUCTION

Nigeria is an agrarian economy with 70% of its people dependent on agriculture. The government of Nigeria has been trying to achieve food security at both household and national level through its mechanized approach (Abdulrahman *et al*., 2015). These agrarian structure of the economy plays a key role in enhancing agricultural productivity and raising economic efficiency of farms.

Cocoyam is an important carbohydrate staple food in Nigeria (World Bank, 2008a) and this crop possesses comparative advantage over cassava and yam. The main nutrient supplied by cocoyam, as with other roots and tubers, is dietary energy provided by its carbohydrate content. Its protein content is low 1-2%, and as in almost all root crop proteins, sulfur-containing amino acids are limiting (Olayiwola *et al.*, 2012). Cocoyam ranks third in importance after cassava and yam among the root and tuber crops that are cultivated and consumed in rural areas in Nigeria. The crop is no longer favoured in urban homes due to poor information about its nutritive values (Olayiwola *et al*., 2012). This widespread ignorance of the nutritive value and diversities of food forms of cocoyam is a major problem for the general acceptability and extensive production of the crop (Olayiwola *et al*., 2012: Okoye *et al*., 2007). Production of cocoyam has been neglected in many countries probably because of its inability to contribute to the GDP through foreign exchange earnings and most of what is produced is consumed locally (Mbanaso and Enyinnaya, 1989; Abdulrahman *et al*., 2015). There is also dearth of information on the economics of cocoyam production in Nigeria.

In addition, most farm management studies in Nigeria uses production function analysis, thereby revealing the marginality conditions of resource use with respect to production of individual or selected enterprises and fails to address as to what would be the optimum combination of enterprises under given restraining conditions. Furthermore, the use of operations researches tools (Linear programming technique) in agricultural activities by farmers and agricultural advisers is limited resulting in decision-making being primarily empirical. The goal of this work is to develop an optimized model for a smallholder cocoyam farmer in Kaduna State. Lack of knowledge about the recommended farm practices also has a direct bearing on the efficient utilization of resources. It could be argued that it is not enough to know about the constraints only. It would be useful to know which of the constraints have had binding and limiting effects on the farm efficiency. Linear Programming (LP) technique using data envelopment analysis methodologies helps in by sorting out the effects of such constraints on economic efficiency of the farms.

The sensitivity analysis of DEA is advanced and important research in the field of operational research and management science. It is important not only because the dataset can be erroneous, and we need to justify the obtained efficiency at least for some change in dataset, but also because some inefficient DMUs may turn out to be efficient after the changes in the dataset. Early work on this topic was started by the paper of (Charnes *et al*, 1984), which examined change in a single output. This was followed by a series of sensitivity analysis articles by Charnes and Neralic (1989; 1990; 1992) in which they determine sufficient condition, for a simultaneous change in all output and (or) all inputs of an efficient DMU, which preserve efficiency. Charnes and Neralic (1990) studied the sensitivity analysis of the additive model given (Charnes *et al*, 1984) in DEA for simultaneous and independent perturbations of multiple inputs and outputs of an efficient DMU.

The early work in this area, which focused on analyses of a single input or output for a single DMU, has now moved to sensitivity analyses directed to evaluating the stability of DEA results when all inputs and outputs are varied simultaneously in all DMUs. Unlike other, looser characterizations of stability (as in the substantive approaches) these analytical approaches have been precise as to the nature of the problems to be treated. They have focused almost exclusively on changes from efficient to inefficient status for the DMUs being analyzed. The sensitivity analysis further enables us to analyze the effects of any change in the constraints on the overall farm activity.

MATERIALS AND METHODS

Study Area

The study was conducted in Kaduna State of Nigeria. Kaduna State occupies almost the entire mid-central portion of the northern part of Nigeria, an altitude of 500–1000m above sea level and annual average of 1,272mm of rain. The relative humidity is constantly below 40 degrees except in few wet months when it goes up to an average of 60 degrees (Kaduna State Agricultural Development Project (KADP), 2012). The duration of dry season in the state is between 5-7 months, which starts from late October to May (World Bank, 2008a). Kaduna is the third most populous state after Kano and Lagos with an estimated population of 6.11 million with an annual increase rate of about 3.2%, the projected population of the state is about 8, 456, 240 million people in 2018 (NPC, 2018). Agriculture is the main stay of the economy of Kaduna State with about 80% of the people actively engaged in farming. The state is well suited for the production of cash and arable crops; the produce includes: cotton, groundnuts, tobacco, maize, yam, beans, guinea corn, millet, ginger, rice, cassava, sugarcane, shea nuts, cowpea, mango, kenaf, cocoyam, cassava, timber, palm kernel, banana, soya bean, corn, onions, sorghum and potatoes. Over 180,000 tons of groundnuts are produced in the state annually. The major cash crops are ginger and cotton which the state has a comparative advantage in as it is the leading producer in the country. During the dry season, a considerable number of people in the state engage in irrigation farming along rivers and near dams, mainly growing vegetables. Another major occupation of the people is animal rearing and poultry farming. The animals reared include cattle, sheep, goats and pigs (World Bank, 2008a).

Sampling Procedure

Three stage sampling procedure were used to select the cocoyam farmers for this study. In the first stage, three Local Government Areas were purposively selection based on the fact they are the major cocoyam producers. In the second stage, 9 villages were also selected purposively from each local government areas based on their intensity in cocoyam production. In the third stage, a Krejcie and Morgan (1970), Slovian (1973) formula (adopted by Abdulrahman *et al.,* 2017) for calculating sample size based on the assumption of 5% expected margins of error, 95% confidence interval and applying the finite population correction factor was used. The formula was expressed as follows:

$$n_0 = \frac{N}{1+N(e^2)} \quad \text{---} (1)$$

Where: n_0 is the sample size without considering the finite population correction factor; e = 0.05; N = total number of observations. Therefore, a simple random sampling was used to select 124 cocoyam farmers for the study.

Data Collection and Analysis

The primary data used for this study were obtained by the use of structured questionnaire administered to cocoyam farmers. The information collected were on labour, fertilizer, seed, farm size, the costs of the variable inputs and farmer's socio-economic characteristics such as age, household size, educational status, amount of credit received, number of extension contacts and years spent on the cooperative were also obtained.

Analytical Framework

In this study, the Data Envelopment Analysis (DEA) method was chosen because of its ability to readily produce rich information on technical and scale efficiency. DEA is a nonparametric mathematical programming technique that presents a particularly suitable way to decompose efficiency into pure technical and scale aspects and therefore facilitates the examination of economies of scale. The DEA technique does not require a specific functional or distributional form, and can accommodate scale issues. A large number of studies have extended and applied the DEA technology in the study of efficiency worldwide. DEA models can be either output or input oriented. The input-oriented model measures the quantities of inputs that can be reduced without any reduction in the output quantity produced. On the other hand, output oriented model measures the degree to which output quantity can be increased without any change in the quantities of inputs used (Abu, 2011). However, the relative range of the efficiency scores remains the same whether input-oriented or output-oriented method is employed. The output oriented models involves constant returns-to scale (CRS) or variable returns-to-scale (VRS) (Abu, 2011). This study used both constant returns to scale (CRS) and variable returns to scale (VRS) models with output orientation to produce maximum output from given quantities of input.

The cost approach data envelopment analysis model has the advantage of allowing simultaneous estimation of the technical efficiency, allocative efficiency and economic efficiency of individuals (Coelli 1996). The use of the variable returns to scale specification permits the calculation of technical efficiency devoid of scale efficiency effects (Coelli, 1996).

Model Specification

The DEA Model

Data Envelopment Analysis (DEA) is an interesting application of linear programming methodology. It has been successfully employed for assessing the relative performance of a set of firms, usually called decision making units (DMUs), which use a variety of identical inputs to produce a variety of identical outputs. Further, the principal advantage of the DEA framework is that it requires neither profit maximization nor cost minimization but only quantity data and that efficiency is measured relative to the highest observed performance rather than some average (Mehta, 1992; Hjalmarsson and Veiderpass 1992). However, because DEA is deterministic and attribute all deviation from the frontier to inefficiencies, a frontier estimated by DEA is likely to be sensitive to measurement errors or other noise in the data.

Given the CRTS assumption, the best way to introduce DEA is via the *ratio* form. For each decision-making unit (DMU) one would like to obtain a measure of the ratio of all outputs over all inputs, such as $u'y_i/v'x_i$, where u is an Mx1 vector of output weights and v is a Kx1 vector of input weights. To select optimal weights, one specifies the mathematical programming problem as used by (Benjamin *et al*., 2011):

Max u,v $(u'y_i/v'x_i)$,

st $u'y_j/v'y_j \leq 1$, j=1,2,…, N,

u, v ≥ 0 -- (2)

This values of u and v, implies efficiency measure of i-th DMU is maximized, subject to the constraint that all efficiency measures must be less than or equal to one. One problem with this particular ratio formulation is that it has an infinite number of solutions. According to (Benjamin et al., 2011). To avoid this, one can impose the constraint $v'x_i = 1$, which provides:

$Max_{i},v(ì'y_i)$,

st $v'x_i = 1$,

$\mu'y_j - v'x_j \leq 0$, j =1,2, …,N,

$\mu, v \geq 0$, --- (3)

Where:

The change in sign from u and v to μ and v reflects the transformation. This is the multiplier form of the linear programming problem. An equivalent envelopment form of this problem can be derived linear programming using duality linear programming problem:

$Min_{\theta,\lambda}\, \theta$,

st $-y_i + Y\lambda \geq 0$,

$\theta x_i - X\lambda \geq 0$,

$\lambda \geq 0$, --- (4)

where θ is a scalar and λ is a N x1 vector of constants. According to This envelopment form involves fewer constraints than the multiplier form (K + M < N+ 1), and hence is generally the preferred form to solve. The value of θ obtained will be the efficiency score of the i-th DMU. It will satisfy $\theta \leq 1$, with a value of 1 indicating a point on the frontier and hence a technically efficient DMU, according to (Farrell, 1957) definition. Note that the linear programming problem must be solved N times, once for each DMU in the sample. A value of é is then obtained for each DMU as adopted by (Benjamin *et al.*, 2011)

The linear programming problem in terms of constant return to scale can be easily modified by adding the convexity constraint to account for variable return to scale: $N1'\lambda=1$ to (3) to provide:

$Min\theta,ë^{\theta}$,

st $-y_i + Y\lambda \geq 0$,

$\theta x_i - X\lambda \geq 0$,

$N1'\lambda=1$

$\lambda \geq 0$, -- (5)

where: θ is a scalar and λ is N x1, θ obtained will represent the efficiency score of the i-th Decision Making Unit.
$\theta \leq 1$, with a value of 1 represent technically efficient DMU and a point on the frontier.

According to Fletschner and Zepeda (2002) and Wu and Prato (2006) Cost minimization Data Envelopment Analysis is thus:

$Min_{\lambda,xi}* W_{i2}X_i*$

st $-y_i + Y\lambda \geq 0$,

$x_i* - Xë \geq 0$,

$N1'\lambda=1$

$\lambda \geq 0$, -- (6)

Where: w_i is the input prices for the i-th DMU and x_i* is the cost minimizing of input quantities for the i-th DMU, given the input prices w_i and the output levels y_i. The economic efficiency of the i-th DMU would be thus:

$CE = w_{i2}\ x_i */ w_{i2}\ x_i$ --- (7)

The allocative efficiency residually can then be calculated as:

AE = CE/TE -- (8)

Note that the overall economic efficiency is the product of technical efficiency and allocative efficiency. Note that economic, technical and allocative efficiencies lie between zero and one (Farrell, 1957).

Tobit Regression Model

Tobit Regression model was used to determine the f factors affecting the economic efficiency of cocoyam farmers. According to Greene (2000), the Tobit model for a continuous dependent variable is thus:

$Y_i^* = \beta_0 + \beta_i X_i + \mu_i$
$Y_i = Y_i^*$ if $\beta_o + \beta_1 X_1 + \beta_{i2} X_{i2} + \beta_{i3} X_{i3} + \beta_{i4} X_{i4} + \beta_{i5} X_{i5} + \beta_{i6} X_{i6} + \mu_i > 0$ -----------------(9)
$Y_i = 0$ if $\beta_0 + \beta_i X_i + \mu_i \leq 0$
Where: Y_i = economic efficiency ratio
Y_i^* = latent variable,
β_i = vector of unknown parameters, and
μ_i = error term which is normally distributed with mean 0 and variance σ^2
X_i = vector of the explanatory variables (i = 1, 2, 3, ...6) such as :
X_1 = Age (in actual number of years)
X_2 = Educational level (number of years spent on formal education)
X_3 = Household size (number of persons in a given household)
X_4 = cooperative membership (number of years spent in cooperative as a member)
X_5 = extension contact (number of extension contact)
X_6 = Amount of credit received (Naira)

RESULTS AND DISCUSSION

Returns to Scale

Table 1 revealed nature of scale with which the sampled cocoyam farms operated. This is important because in addition to knowing the number of efficient cocoyam farms, degree inefficiency and optimal scale of operation, it is also vital to know how many farms are operating under increasing returns to scale (IRS), decreasing returns to scale (DRS) or operating at optimal scale. Using DEA every cocoyam farm was evaluated, given its size level to determine its scale measures. This type of analysis according to (Anderson et al., 2002) would be useful to each farm as they could determine the implications for expansion. The number of farms operating under constant, increasing, and decreasing returns to scale is shown in Table 1.

Table 1: Scale efficiency estimates

Return to scale	Frequency	Percentage
IRS	48	38.71
DRS	63	50.81
CRS	13	10.48
Total	124	100

About 39% of cocoyam farms were found operating with increasing return to scale (IRS) or sub-optimal scale. This implies that production scale of these farms could be increased by decreasing costs, given that they were performing below optimum. On the other hand, about 51% farms were operating with decreasing return to scale (DRS) or supraoptimal scale that is the farms were operating above the optimum scale, suggesting that these farms could increase their technical efficiency by reducing their production levels.

Similarly, only 11% cocoyam farms were found operating at optimal scale. Given that majority of the cocoyam farms were operating under IRS and DRS suggests that cocoyam farms in general were scale inefficient, since scale inefficiency is usually due to the presence of either IRS or DRS. This is in agreement with (Sharma *et al.*, 2003; Nasiru, 2010; Asogwa et al. 2011). Although in the short run, farms may operate with increasing returns to scale (IRS) or decreasing returns to scale (DRS), in the long run however, cocoyam farms must shift towards constant returns to scale (CRS) to be efficient in order to achieve the desired increase in cocoyam production in Nigeria.

Technical Efficiency

The frequency distribution of the technical efficiency estimates of cocoyam farmers is presented in Table 2. It was observed from the study that about 36%) of cocoyam had technical efficiency between 0.81 and less than 1.00. This implies is that reasonable percentage of cocoyam farmers were not technically efficient in the use of production resources. This maximum possible level attainable may be due to inefficiency and hence results to low productivity.

The average technical efficiency for the farmers was 0.619 implying that, on the average, the respondents are able to obtain about 62% of potential output from a given mixture of production inputs. This result suggests that the farmers are not utilizing their production resources efficiently Thus, in a short run, there is minimal scope (38%) of increasing the efficiency level, through better use of available production resources. This finding agrees with (Asogwa *et al*. 2011) that Nigerian rural farmers do not obtain maximum output from their given quantum of inputs.

Table 2: Technical efficiency estimates

Technical efficiency	Frequency	Percentage
<0.2	2	1.61
0.20-0.40	27	21.77
0.41-0.60	32	25.81
0.61-0.80	18	14.52
0.81-1.00	45	36.29
Total	124	100
Min	0.167	
Max	1.00	
Mean	0.619	

Allocative Efficiency

The result presented in Table 3 shows allocative efficiency of cocoyam farmers as obtained from the data envelopment analysis. It was observed from the study that (27.42%) of cocoyam farmers operated within an allocative efficiency of 0.2 to 0.4. This implies that majority of the respondents are not allocatively efficient in the use of production resources. This allocative inefficiency could be as a result of under-utilization of scarce resource and hence, reduced return to capital.

The average allocative efficiency for the farmers was 0.53 implying that, on the average, the respondents are able to obtain about 53% of potential allocative efficiency, It was observed from the study that 19% of the farmers had allocative efficiency (AE) of 0.81 and above while 19% of the farmers operated at less than 0.8 allocative efficiency levels. This result implies that cocoyam farmers are misallocating the resource in wrong proportions. In order words, about 81 percent of the respondents are allocatively inefficient in the study area. Through better utilization of resources in optimal proportions given their respective prices and given the current state of technology, cocoyam farmers could increase their allocative efficiency by 81 percent in the area This finding is in line with (Okoye *et al*., 2009) who observed that the most allocatively inefficient farmer will have an efficiency gain of 89.6 percent in cocoyam production if he or she is to attain the efficiency level of most allocatively efficient farmer in the state. It also agrees with the findings of (Asogwa *et al.*, 2011) that Nigerian rural farmers are not utilizing production inputs in the optimal proportions, given input prices.

Table 3: Allocative efficiency estimates

Allocative efficiency	Frequency	Percentage
<0.2	14	11.29
0.20-0.40	34	27.42
0.41-0.60	30	24.19
0.61-0.80	22	17.74
0.81-1.00	24	19.35
Total	124	100
Min	0.043	
Max	1.00	
Mean	0.503	

Economic Efficiency

Table 4 revealed that (37.9%) of cocoyam farmers had economic efficiency of 0.029 and less than 0.2. This implies that larger proportion of cocoyam farmers are economically inefficient in the use of input (productive) resources. This inefficiency could stem from farmer’s inability to minimize cost or maximizing the potential profit.

Table 4: Economic efficiency estimates

Economic efficiency	Frequency	Percentage
<0.2	47	37.9
0.20-0.40	39	31.46
0.41-0.60	14	11.29
0.61-0.80	8	6.45
0.81-1.00	16	12.90
Total	124	100
Min	0.029	
Max	1.00	
Mean	0.335	

However, the average economic efficiency of the cocoyam farmers was 34%. This indicates that cocoyam farms were economically inefficient. This implies that economic efficiency of cocoyam farmers could be increased by 66% in the area through efficient cost reduction. The study also suggests that for the average farmer in the study area to achieve economic efficiency of his most efficient counterpart, he could realize about 54 percent cost savings. This agrees with the observation of Benjamin *et al*. (2011) that Nigerian rural farmers are economically inefficient.

Factors Affecting Economic Efficiency of Cocoyam Producers

The Tobit regression model was used to estimate the parameters of factors affecting the economic efficiency of cocoyam farmers are showed in Table 5. The DECOMP based fit measure is 0.409, suggesting that the model has a good fit to the data. This indicates that 41% in the variability in economic efficiency of cocoyam farmers is explained by the explanatory variables specified in the model with 95% level of confidence and the maximum likelihood function was -60.478. The factors that had significant influence on economic efficiency of cocoyam farmers in the study area were age, education, extension contact and credit while household size and cooperative membership were not statistically significant.

The coefficient of age (0.005) was directly related to economic efficiency and statistically significant at 10% level of probability influencing the economic efficiency of cocoyam farmers. This implies that holding other factors constant, a unit increase with the age of cocoyam producers will increase their economic efficiency by magnitude of 0.005. This result disagrees with (Begun *et al*., 2009) who found out that age was not a significant determinant of economic efficiency but agrees with (Basanta *et al.*, 2004) who suggest that younger farmers tends to be inefficient than their older counterparts.

The coefficient of Education variable was found to be positive and significant at 1% level. The estimated coefficient of 0.081 implies that the efficiency of the cocoyam producers will increase by a magnitude of 0.081 as their level of education increases by one unit *ceteris paribus*. A plausible explanation for this result is that, increase in educational level of the farmers leads to higher rate of improved technology and techniques of production adoption. Also, educated farmers are likely to be more successful in gathering information and understanding new practices and the use of modern inputs which in turn will improve their economic efficiency. Hence, education is a very important policy tool that can be employed to enhance the economic efficiency of cocoyam production in the study area.

The coefficient of extension contact had the expected positive relationship with the economic efficiency of cocoyam farmers and was statistically significant at 10% level of probability. This implies that holding other factors constant, a unit increase in the Household size of certified cocoyam producers will increase their economic efficiency by magnitude of 0.057. This finding is at variance with the study of Ajani and Olayemi (2001) who observed that extension contact enhances farm productivity and efficiency in his study of resources productivity in food crop farming in Northern area of Oyo State Nigeria.

Table 5: Factors influencing economic efficiency of cocoyam production

Variable	Coefficient	Standard error	t-value
Constant	0.092	0.097	0.953
Age	0.005	0.003	1.889*
Education	0.081	0.026	3.091***
Household size	0.005	0.004	1.474
Membership of cooperative society	-0.009	0.006	-1.458
Extension contact	0.057	0.030	1.933*
Credit	0.003	0.000	2.041**
Sigma	0.1416		
Log likelihood	60.478		
Log likelihood ratio Chi^2	34.61		
Prob> Chi^2	0.00		
Decomp base fit measure	0.409		

****$P<0.01$, **$P<0.05$ and *$P<0.10$*

The coefficient of Credit had the expected positive relationship with the economic efficiency of cocoyam farmers and was significant in at 5% probability level. The estimated coefficient of 0.0003 implies that the economic efficiency of the cocoyam farmers will increase by a magnitude of 7.352E-8 as the amount of credit obtained increases by one unit. This result agrees with that of Adewuyi *et al.* (2013) who reported that access to credit was significant in influencing the efficiency of cocoyam farmers in Ogun State, Nigeria.

Sensitivity Analysis

To get the optimal farm solution, the farmers are expected to expand and reduce some of their resource in cocoyam production. Land is the most important asset for farmers and farming families' livelihood depends mainly on land. Land is a basic source of livelihood; providing employment, the key factor in agricultural activities, and a major determinant of a farmer's access to other productive resources and services. The result in Table 6 shows that land is used optimally, however, Increasing the area under cultivation will not increase the value of output. Further, land is the most limiting factor when compared to other resource available and so the model suggested that more land should be added (with the restrictions on the other resources) for optimal performance.

On the other hand, cocoyam sett (seed) is not a limiting resource and for the optimal farm plan, about 2700kg sett more of it need to be injected into the system. This overutilization of sett could have emanated from lack of improved seed variety and pest and disease. This finding is in line with Abdulrahman et al (2015) who opined that most farmers have little or no access to improved seeds and continues to recycle seeds that have become exhausted after generations of cultivation. And pest and disease such as leaf patches, shrinking of the seed and seed dormancy were responsible for pre-harvest and post-harvest losses by cocoyam producers.

Labour is not a limiting resource and for the optimal farm plan, about 0.075 man-days need to be reduced from the system. The abundant availability of human labour contrary to apriori expectation is relative to the area, given that an average farmer in the area cultivates small farm size per planting season due to nature of the crop. This finding is in line with Igwe and Onyenweaku (2013) and at variance with Abdulrahman *et al.* (2015) who posited that

Family labour was predominant in the study area and that is why there was acute shortage of labour. According to the farmers, during active period of production-every household would have been engaged in his family farm work. The demand for labour is normally very high and expensive during the peak period of land clearing, ridging, harvesting, processing and weeding.

There was an overutilization of fertilizer of about 50Kg in the model out of the average of 100Kg available for cocoyam production. According to the farmers, fertilizer is made available when farmers are far into the production period, sometimes at the middle of the raining season. however, output was not properly optimized due to these limiting resources. The sensitivity analysis of the plans to changes in some production variables was observed. Usually as has been established by many researchers in the past, land and labour are variables of utmost interest in such analysis (Igwe and Onyenweaku, 2013). In the first scenario, land resource was increased by 50 percent, to see its effect on the optimum plan. In the second scenario, labour was increased by 50% for the production to see their effect on the optimum plan; in the third scenario, fertilizer was decreased by 50%. The sensitivity analysis showed that a very small increase in the resources resulted in a very remarkable rise in the cocoyam output.

Table 6: Sensitivity analysis for optimum plan for cocoyam production

Resource	Unit	Original value	Radial movement	Slack movement	Projected value
Land	Ha	1.0	0.00	0.00	1.00
Seed	Kg	3000	0.00	-2700	300
Labour	Man-days	0.4	0.00	-0.075	0.025
Fertilizer	Kg	100	0.00	-50.00	50.00
Output	Kg	1.0	0.00	90.00	91.00

CONCLUSION

On the findings of this study, it could be concluded that cocoyam farmers are economically inefficient. Majority of the farmers were experiencing decreasing returns to scale. By operating on an optimal scale (CRS). Thus, the sensitivity analysis showed that resource allocation patterns in the optimum plan were remarkably different from that in the existing plan. However, input wastage could be reduced through improvement on farmer's education level, access to contact with extension agents and as well as linkage to credit will enhance farmer's productivity through adoption of improved production practices

Since cooperative membership was a significant determinant of economic efficiency, cocoyam farmers should join cooperative societies, to benefit from the government and non-governmental organization through increased credit access, input supply and farm advisory services. Also, the level of economic efficiency of some farmers was very low due to improper management of resources; it is therefore recommended that farmers should be trained and advised on proper and efficient utilization of resources (seed, farm size and labour) in order to improve their economic efficiency.

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