# COST EFFICIENCY OF SORGHUM/COWPEA INTERCROPPING SYSTEM IN KEBBI STATE, NIGERIA

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**Abstract**
Cost efficiency is a state of optimal allocation of factors of production in which any other allocation will result to higher cost. In that case, the selection of farm inputs at minimum cost will help to reduce production cost and hence improve profitability of the farmers This research investigated the optimal allocation of factors of production by sorghum/cowpea intercrop farmers in Kebbi State Nigeria, with the aim of generating reliable information on their determinants. The technique applied in order to achieve the objectives of the study were the data envelopment analysis (DEA) and the ordinary least squares (OLS) regression. The data were obtained mainly from primary sources through a questionnaire survey of 256 monocroppers and intercroppers. Seventy-three sorghum/cowpea intercroppers were used for the cost efficiency analysis. The results show that the average cost efficiency of the sorghum/cowpea farmers in the study area was 0.52 indicating that the farmers were relatively cost inefficient. The result further indicated that years of farming experience and age of the farmer positively affected cost efficiency while access to credit and land fragmentation were found to decrease cost efficiency. Reduction in production cost through accessing support services such as subsidies on farm inputs, provision of credit, extension services and trainings on good agricultural practices by Government agricultural related and non-governmental agencies will also help farmers to apply the recommended farm inputs, which is also likely to influence cost efficiency positively. Farmers should also be sensitized on the benefits of having contiguous farms. This will lead to increase in the benefits from improving cost efficiency of the farmers in Kebbi State.

**Key words:** Cost efficiency, Sorghum/cowpea intercrop, OLS, DEA, Nigeria

## Introduction

Nigeria's agriculture remains largely subsistence based, with about 80% of agricultural output coming from the rural poor (Gain Report, 2011). There has been a reduction in production and productivity has continued to characterize the Nigerian agricultural sector, thereby limiting the ability of the sector to perform its traditional role in economic development. The two main cropping systems practiced in Nigeria are mono and intercropping system. The Kebbi State is characterized by inadequate rainfall which last for less than 90 days and the soils are degraded due to continuous cropping which poses a risk to farming activities in the area. The farmers have over the years, practice intercropping in order to combat the risk in crop production.

Productivity can be enhanced if there is reliable empirical knowledge available on cost efficiency of resources and the factors that determine such efficiencies. Most of the farm efficiency studies carried out in the northern parts of Nigeria has shown that resources are inefficiently utilised (Jirgi, 2002; Baiyegunhi *et al*., 2010). The basic approach to estimate allocative efficiency of farmers from Nigerian studies is through the marginal value product which is calculated from econometrically estimated production functions (Jirgi, 2002; Baiyegunhi *et al*., 2010). Allocative efficiency is determined by the ratio of the marginal value product to the marginal factor cost. Allocative efficiency, however, can also be expressed as the cost efficiency of the farmers. Cost efficiency is given by the ratio of minimum feasible cost to actual cost (Coelli *et al*., 2005). It is possible to estimate cost efficiency when the Decision-Making-Units (DMUs) pay different prices for their inputs and obtain the same prices for their produce (Coelli *et al*., 2005). This makes cost efficiency a more appropriate measure of allocative efficiency. Jordaan, Grové, and Matthews (2013) reported that there are substantial financial gains possible if farmers were to use their production inputs in a cost efficient combination. The knowledge of the extent to which farmers from Kebbi State can reduce the costs with which they produce their crops is limited. It is also important to investigate the influence of risk attitude on the cost efficiency of the intercrop farmers. When exploring the determinants of allocative efficiency, most of the studies (Jordaan, 2012, Ogunniyi and Ojedokun, 2012, Obare *et al*, 2010, Okoye *et al*, 2006) focus on socio-economic variables such as age, farming experience, extension, education and sex as explanatory variables. The researchers have not investigated the influence of risk attitude on efficiency. The fact that risk aversion is associated with the decision making behaviour of an individual, means that it should be incorporated in the determination of factors that influence efficiency. Information on risk attitude as a determinant of allocative efficiency is lacking in the study area.

The goal of this research was to determine the optimal allocation of factors of production by sorghum/cowpea intercrop farmers in Kebbi State Nigeria, and their determinants. The specific objectives of the study are to:

i. estimate the levels of cost efficiency of the sorghum/cowpea farmers
ii. determine the socio-economic determinants of cost efficiency of the farmers.

**Methodology**

Description of The Study Area:
The study was conducted in Kebbi State, located in the north-western part of Nigeria. The State is located between latitudes 10° 8′ N – 13°15′ N, and longitudes 3° 30′ E–6° 02′ E. The population of the State was 3 238 628 in 2006 (NPC, 2006), and projected to be 3 952 766 in 2012 (UNFPA, 2012). The State occupies an area of about 36 229 square kilometres.

The average annual rainfall is 1 020 mm (CBN, 2009). The mean annual temperature of about 27°C is recorded in all locations, but temperature can be as high as 40°C during the months of April to June (Onlinenigeria, 2012). The climate favours both crop and livestock production. Agriculture is the major source of revenue and the backbone of the economy of the State. Over two-thirds of the population are engaged in agricultural production with about 80 – 90 % of the population living in the rural areas (Tanko, 2004).

Intercropping is the predominant type of farming system, especially rain fed, with the use of traditional inefficient hand tools (KARDA, 2009).

Sampling Technique and Instrument of Data Collection
A multi-stage sampling technique was used to select 256 farmers comprising 98 monocrop farmers and 158 intercrop farmers. The reason for the sample size chosen is that there are more intercrop farmers than monocrop farmers in the state. A random selection of two Local Government Areas (LGAs) from each of the four agricultural zones was done. This was followed by random selection of four villages from each of the two LGAs. The last stage involved the random selection of the 98 monocrop farmers and the 158 intercrop farmers. Seventy three sorghum/cowpea intercrop farmers were used for the cost efficiency analysis.

Specification of the DEA model to estimate cost efficiency
Allocative efficiency is defined as the ability of a decision maker to utilise the inputs in optimal proportions given their respective prices and the production technology (Coelli *et al*., 2005). Coelli *et al*. (2005) mentioned that there are three measures of allocative efficiency. They are cost, revenue and profit efficiency. It is possible to estimate cost efficiency when the Decision-Making-Units (DMUs) pay different prices for their inputs and obtain the same prices for their produce (Coelli *et al*., 2005). In this study it is assumed that on average farmers receive the same price for their produce and pay different prices for their inputs.
The cost minimising DEA for the case of variable returns to scale (VRS) using an input-orientated DEA model according to Coelli *et al*. (2005) is given by Equation. 1:

$$\min_{\lambda,x_i^*} W_i^{'} X_i^*, \qquad ...1$$

Subject to $\quad -q_i + Q\lambda \geq 0,$

$x_i^* - X\lambda \geq 0,$

$I1^{'}\lambda = 1$

$\lambda \geq 0,$

Where $W_i$ is a $N \times 1$ vector of input prices for the $i-th$ farm and $x_i^*$ (which is calculated by the linear programming) is the cost minimising vector of input quantities for the $i-th$ farm, given the input prices $W_i$ and the output levels $q_i$. $\lambda$ is a $I \times 1$ vector of weights, $M \times I$ is output matrix $Q$,
The total cost efficiency (CE) of the farm is expressed as:

$$\text{CE} = {W_i^{'} x_i^*} \Big/ {W_i^{'} x_i} \qquad ...2$$

Thus the CE is the ratio of minimum cost calculated from equation 1 1to the observed or actual cost for the $i-th$ farm. The value of CE score lies between zero and one. A value of one indicates that the farm lies on the frontier and is efficient (Begum *et al*., 2011; Jordaan, 2012).

Estimating the Determinants of Cost Efficiency of the Respondents

Recent studies on the determinants of efficiency using DEA approach have applied Tobit regression in the second stage (Begum, 2011; Aman and Haji, 2011). It has been argued that the efficiency scores obtained from DEA are not generated by a censoring process but are fractional data (McDonald, 2009; Simar and Wilson 2007). Therefore, the use of Tobit to estimate the determinants of DEA efficiency scores is not reliable. According to McDonald (2009) ordinary least squares (OLS) is an unbiased and consistent estimator and was therefore used for this study. The OLS model is implicitly specified in equation 3:

$$Y=f(X_1,X_2,X_3,X_4\text{-----}X_{10+}Ui) \qquad ...3$$

Where: Y=Dependent variable
X's= Independent variables
U= error term

Generally OLS estimates of $\beta$ is consistent and asymptotically normal (McDonald, 2009). The OLS regression was used to examine the determinants of cost efficiency of sorghum/cowpea farmers in Kebbi State. The efficiency scores $(y_i)$ which is the dependent variable obtained from equation 2 is logged (McDonald, 2009; Jordaan, 2012). The factors that were hypothesised to influence the cost efficiency of the sorghum/cowpea farmers from Kebbi State, Nigeria, are presented in Table 1.

**Results and Discussion**

Cost Efficiency of the Sorghum/Cowpea Farmers in Kebbi State:

Estimated cost efficiency scores of the sorghum/cowpea farmers in Kebbi State is presented in Figure 1. The results reveal that the cost efficiency levels of the sorghum/cowpea farmers ranges from 0.27 to 1, with an average of 0.52. The cost efficiency score of 0.27 of the farmer who performed the worst in terms of cost efficiency implies that the farmer could have produced his sorghum/cowpea at only 27% of his current cost. The results show that farmers can improve their financial performance if given the necessary support (such as training on good agricultural practices) to use production inputs in a cost effective way. About 8% of the sorghum/cowpea farmers achieved a cost efficiency of 1, meaning that these farmers produce their output at minimum costs and are cost efficient. The remaining 92% of the farmers are cost inefficient. These farmers could have produced their output at lower costs by selecting the least cost combination of farm inputs.

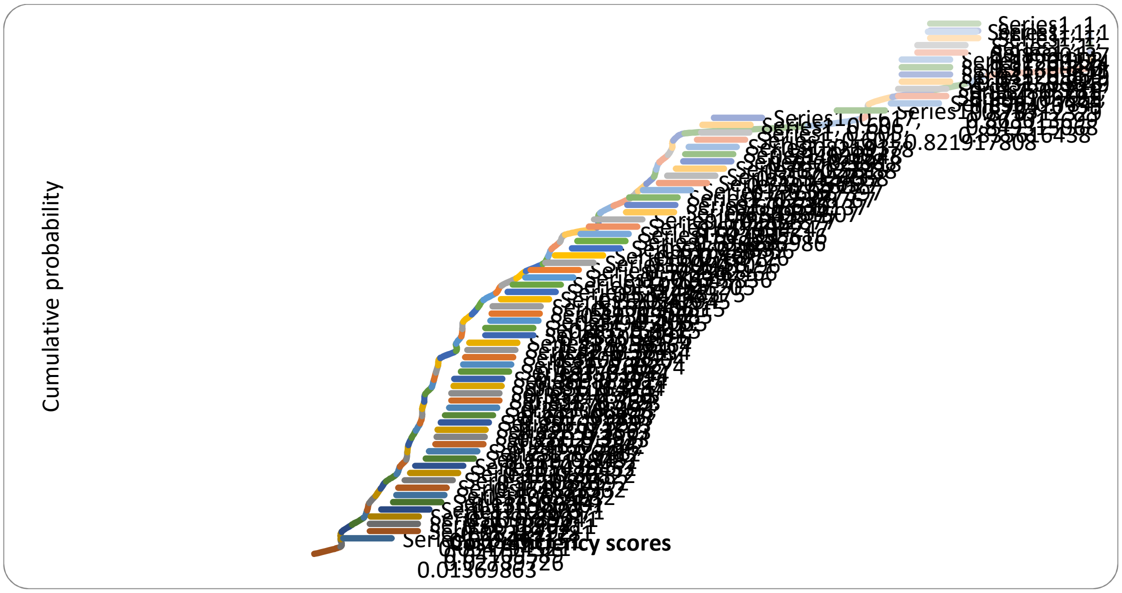


**Figure 1:** Cumulative probability distribution of the cost efficiency scores of the sorghum/cowpea farmers in Kebbi State, January 2012

Determinants of Cost Efficiency of Sorghum/Cowpea Farmers in Kebbi State:

Ordinary Least Square (OLS) regression was used to identify factors influencing cost efficiencies of sorghum/cowpea intercrop farmers. Based on the recommendation of McDonald (2009), the dependent variable (cost efficiency) was logged. It is imperative to know that since the aim is not to predict the cost efficiency of farmers but rather to identify the explanatory variables that are likely to influence cost efficiency levels, a probability of 15% is still considered adequate (Jordaan, 2012). The OLS regression results are presented in Table 2.

The $R^2$ value for the regression is 0.35, implying the independent variables included in the model explain 35% of the variation in the cost efficiency levels of the sorghum/cowpea farmers.

The personal characteristics of the respondents (experience and age) were hypothesized to have a direct relationship with cost efficiency. The results show that experience has a positive statistically significant relationship with cost efficiency ($P<0.05$). The positive relationship between experience and cost efficiency is in accordance with the *a priori* expectation. Farmers who are more experienced are better in terms of planning, managerial ability, adoption of innovation, hence more efficient in terms production efficiency (Anyanwu, 2011). The result is consistent with the findings of Jordaan, (2012) who also reported positive relationship between experience and cost efficiency.

As hypothesized, age has a positive statistically significant relationship with cost efficiency of the sorghum/cowpea farmers ($P<0.1$). Age goes with the farming experience of a farmer, older farmers are likely to be more experienced in the choice of input at minimum cost, and hence they are more cost efficient (Khan and Saeed, 2012).

There is an inverse relationship between wealth generation characteristics (access to agricultural credit) and cost efficiency ($P<0.1$). The reason for the inverse association could be either that the farmers are not getting optimum amounts of loan or the loans are diverted to off-farm activities (Oboh and Ekpebu, 2011). Similar result was reported by Khan and Saeed (2011), Igwe, *et al.,* (2017).

Natural resource capital (land fragmentation) had a negative statistically significant association with cost efficiency ($P<0.01$). The possible reason could be that land fragmentation causes the farmers to travel between parcels of land, wasting time and energy, thus making it impossible for them to enjoy the benefits of economy of scale which is an impediment to efficiency in crop production thus increasing the costs of production. This corroborated the findings of Bizimana *et al* (2004) who reported that land fragmentation measured in terms of number of arable plots cultivated is negatively and significantly related with economic efficiency among farmers in Southern Rwanda. Balogun and Akinyemi (2017) reported similar results for cassava farmers in South-West geo-political Zone, Nigeria.

**Conclusion and Recommendations**

This study investigated the levels of efficiency with which the farmers use their production inputs to produce their crops and determined the relationship between the efficiency scores and characteristics of the farmers.

The results of the cost efficiency of the sorghum/cowpea farmers show that the farmers in Kebbi State are relatively cost inefficient. This implies that the farmers do not produce at minimum cost. The farmers could have produced their output at lower cost by moving closer to the cost minimising combination of farm inputs.. Reduction in production cost will also help farmers to apply the recommended farm inputs, which is also likely to influence technical efficiency positively. This will lead to increase in the benefits from improving cost efficiency of the farmers in Kebbi State.

The results from the determinants of cost efficiency for the sorghum/cowpea farmers reveal that the personal characteristics (experience, age) significantly contributes to efficient management of farm inputs which enhance the ability of farmers to allocate resources more efficiently. Farming experience can be enhanced through training by extension agents. Intervention programmes should have components focused on training to increase the capacity of farmers to plan and execute cost minimizing enterprise plans. Land fragmentation has negative effect on cost efficiency. Relevant governmental and non- governmental agricultural institutions should sensitization farmers on the benefit of having contiguous farms in order to achieve economies of scale. These will go a long way in improving the cost efficiency of the farmers. Policies geared towards training of farmers through extension agents will improve the knowledge of the farmers and thus, enhancing efficiency.

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Table 1: Variables hypothesized to influence cost efficiency of intercrop farmers

| **Variables** | **Description** | **A priori expectations** |
|---|---|---|
| Education (EDU) | Education of the household head in years of schooling | + |
| Farming experience (EXP) | Farming experience of household head in years | + |
| Access to extension (AGX) | Dummy 1: if the farmer had a contact with an extension agent per cropping season 0 if otherwise | + |
| Access to Credit (CRT) | Dummy 1: if the household head benefitted from financial institution or 0 if otherwise | + |
| Asset value (ASV) | The monetary value of assets (e.g. house, oxen, bicycle etc) valued in naira | + |
| Risk attitude (RASTD) | Risk aversion coefficients obtained using experimental gambling approach. | - |
| Membership of Organization (COOP) | Dummy 1 if: the household head belong to any farmers organization or 0 if otherwise | + |
| Access to *fadama* (FDM) | Dummy 1 if the household head is involved in *fadama* cultivation or 0 if otherwise | + |
| Age (AGE) | Age of household head, years | + |
| Land fragmentation (LF) | Dummy: 1 if the farmers land is fragmented into more than two plots or 0 if otherwise | - |

Positive values means that the variable has a positive relationship with cost efficiency
**Note**: The details of the literature to support the *a priori* expectations are in Jirgi, 2013.

Table 2: Ordinary Least Squares (OLS) regressions results of the explanatory variables affecting cost efficiency of sorghum/cowpea farmers

| **Variable** | **Coefficient** | **Std Error** | **t-stat** | **Prob** |
|---|---|---|---|---|
| Intercept | -0.946 | 0.283 | -3.339 | 0.001 |
| **Personal characteristics** | | | | |
| Education | 0.003 | 0.011 | 0.235 | 0.815 |
| Experience | 0.021** | 0.009 | 2.358 | 0.022 |
| Age | 0.015* | 0.008 | 1.775 | 0.081 |
| Risk attitude | -0.044 | 0.044 | -1.015 | 0.314 |
| **Wealth generation characteristics** | | | | |
| Credit | -0.259* | 0.131 | -1.965 | 0.054 |
| Asset value | -1.99E+00 | 6.54E-07 | -0.304 | 0.762 |
| **Human capital development** | | | | |
| Extension | 0.075 | 0.098 | 0.775 | 0.441 |
| **Natural resource capital** | | | | |
| *Fadama* | 0.024 | 0.094 | 0.248 | 0.805 |
| Land Fragmentation | -1.643*** | 0.632 | -2.6 | 0.001 |
| **Social capital** | | | | |
| Cooperatives | -0.127 | 0.121 | -1.046 | 0.299 |
| R-squared | 0.35 | | | |
| Prob(F-statistic) | 2.85 | | | |

The asterisks ***, **and * represents statistical significance at 1%, 5% and 10% probability level respectively.