# Efficiency of Intercropping System under Smallholder Farmers in Osun State, Nigeria

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**Abstract:** Recently, the constant rise in population growth has resulted in increased pressure on available agricultural land. This has given rise to greater land use intensification and crop diversification by smallholder farmers. However, information is scarce about the economic efficiency of the system in the Osun State. The study was carried out to assess the technical and allocative efficiencies of intercropping systems in Osun State of Nigeria. A three-stage random sampling technique was used to select a total of 120 smallholder farmers across six local communities namely Owode, Ologede, Ifewara, Iperindo, Ilerin and Odundun from which responses were solicited with the aid of a questionnaire. The descriptive and stochastic production frontier was used to analyze the data gotten from the smallholders. The results showed that the average technical efficiency index was 67%, while allocative efficiency was 13%. The factors that significantly influenced the production were farm size, quantity of fertilizer used as well as the cost of other inputs. While those that significantly influence the technical and allocative efficiencies of intercropping systems in the study area were the educational status, household size in adult equivalent and membership to cooperatives. It is, therefore, recommended that farmers require training on the appropriate skills required to operate an efficient intercropping system. This can be done through the cooperative societies. This will help the farmers in the efficient allocation of resources available to them.

**Keywords:** Allocative; Efficiency; Intercropping; Land and Technical

## 1 Introduction

One of the current challenges in agriculture is to place crop production systems on a sustainable platform. This demands operating of the systems at high productivity and economic levels even in the face of the negative impact of climate change on agricultural productivity. Sustainable crop production and management lies within land intensification (FAO, 2011; Kassam and Friedrich, 2012). Crop diversification such as intercropping has a potential to improve yield. Moreover, the global food system problems as impacted by climate change, population growth, rapid urbanization, and pressure on land calls for these adaptive approaches to food security (Godfray *et. al.,* 2010). Traditionally, multiple cropping systems such as intercropping have been estimated to provide as much as 15 to 20 percent of the world's food supply (Koohafkan and Altieri, 2016).

Intercropping is the agricultural practice of cultivating two or more crops in the same space at the same time. It is a commonly used cropping practice that aims to match efficiently crop demands to the available growth resources and labor. The most common advantage of intercropping is the production of greater yield on a given piece of land (Dordas and Damalas, 2011). Intercropping also improves soil fertility and increases soil conservation through greater ground cover than sole cropping (Fukai and Trenbath, 1993; Russell, 2002; Hauggard-Nielson *et al,* 2001). Intercropping is also efficient for the conservation of biodiversity by providing habitat for a variety of insects and soil organisms that would not be present in a single-crop environment. This in turn can help to limit the outbreaks of crop pests (Jane, 2006). In Nigeria, intercropping is a common cropping system practiced by almost all small-scale farmers. This is because it is cheaper while playing a significant role in integrated pest management (Sanni *et al.*, 2011). One of the major problems limiting crop production is weed infestation. Weed control is a serious problem for most of the smallholders, particularly in the absence of adequate technologies as well as in the light of the emergence of weeds resistant to herbicides and the concerns about herbicide residues in food, soil, and groundwater-atmosphere (Abouziena and Haggag, 2016). Therefore, weeds limit the production potentials of resource poor farmers and thereby affect the wellbeing of these smallholders (Llewellyn *et al*, 2016). Also, the increasing menace of erosion in recent times has imposed a serious constraint on land availability. The consequence of which are low productivity, increasing soil degradation and agricultural land fragmentation as well as land use intensification which is capable of affecting their level of efficiency in crop productivity (Kumer and Pani, 2015).

According to Dordas and Damalas (2011), global population is projected to rise from the current seven billion to nine billion in few decades. Therefore, almost three quarters increase in land productivity will be needed to meet the future growth in global food demand by 2030, either from yield increases or increases in cropping intensity (Brij and Anil, 2013). It is, therefore, safe to emphasize sustainable crop production through


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efficient land intensification as an innovative strategy capable of feeding the projected nine billion people (Dordas and Damalas, 2011). Although intercropping is an accepted agricultural practice to increase the productivity of scarce land resources, the levels of the efficiency may differ depending on the knowledge and experiences of farmers in practicing it properly. Intercropping is practiced by most smallholders in Nigeria in divers forms (Agbongiahuoyi *et al.*, 2012). However, information is scarce about the economic efficiency of intercropping systems in the Osun state, Nigeria. Therefore, it is necessary to generate information from systematic studies in the state to assess as well as improve the economic efficiency of these intercropping systems. Thus, this research was conducted with the objectives of examining the technical and allocative efficiencies of intercropping systems and also to identify the factors influencing them in Osun State, Nigeria. The intercropping systems commonly practiced in Osun state are maize/Cassava, maize/cassava/yam, cocoa/kolanut and cocoa/kolanut /palm tree.

## 2 Methodology

### 2.1 Study Area

The study area is Osun state located in the south-west geopolitical zone of Nigeria. Osun State is an inland state with its capital in Osogbo city and lies on latitude of $8^0 10'$ N and longitude of $6^0 5'$S on the south. The modern Osun State was created in 1991 from part of the old Oyo State and it is divided into three (3) main agricultural zones namely Iwo, Osogbo and Ife/Ijesha (Osun ADP, 2012). The major types of crops grown in the state are maize, cocoa, plantain, cassava, and the likes.

### 2.2. Sampling Technique and Data Collection

The data was collected through the use of a structured questionnaire from 120 smallholders. A three-stage random sampling technique was employed. The first stage was the random selection of one (1) agricultural zone from the three (3) zones in the state. The second stage was the selection of six (6) communities from the selected agricultural zone and the last stage was the random selection of twenty (20) farmers from each of the selected communities to make a total of 120 smallholders.

Data were collected that could help understand the socioeconomic structure of the smallholders. These include the age (years), farming experience (years), household size, farm income (Naira), grain equivalent of output (kg), and farm size (hectares), among others. Data were also collected that were used as the inefficiency predictors; access to credit facilities, membership of cooperative societies, gender and educational level.

### 2.3 Tools of Analysis

Descriptive statistics was used to assess the socio-economic characteristics of farmers. The stochastic frontier was used to examine the technical and allocative efficiencies of intercropping systems and also the factors influencing the technical and allocative efficiencies of intercropping systems in the study area. The Stochastic production function is defined as:

$$Y = f(X_{i,} a_i) \times e(v_i - u_i)$$

Where

$Y_i$ is the grain equivalent of the outputs of farmer *i*,

$X_i$'s are the input variables,

$a_i$ are production coefficients and

$v_i$ is a symmetric error term associated with random factors not under the control of the farmers and assumed to be independently and identically distributed (i.i.d.) with a random error that is independent of *ui*.

$u_i$ is the non-negative efficiency measured relative to the stochastic frontier, which is also assumed to be i.i.d. distributed as half normal (at zero mean) or truncated half-normal (at mean μ), or with two-parameter gamma distributions.

The farm-specific technical efficiency is defined in terms of observed output (Yi) to the corresponding frontier output (Yi*) using the available technology derived from the result of the equation i above as:

$$TE_i = \frac{Y_i}{Y_i^*} = \frac{E\ (Y\ i|\ u\ i\ , X\ i)}{E\ (Yi|ui\ = 0, Xi)} = E[exp(-U_i/\varepsilon_i)] \ldots\ldots\ldots\ldots\ldots\ldots (ii)$$

TE takes value on the interval (0, 1). The stochastic frontier cost functions model for estimating farm level overall economic efficiency is specified as:

$$C_i = g\ (Y_i, P_i;\ \alpha) + \varepsilon_i = 1, 2, \ldots n \ldots\ldots\ldots\ldots\ldots\ldots (iii)$$

Where;

$C_i$ represents total production cost,

$Y_i$ represents grain equivalent of the output produced,

$P_i$ represents cost of input,

α represents parameters of cost function and

$\varepsilon_i$ represents the error term.

However, because inefficiencies are assumed to always increase costs, error components are preceded by positive signs (Igbal *et al.*, 2007). The farm specific economic efficiency (EE) was defined as the ratio of minimum observed total production cost (C*) to actual total production cost (C).

$$EE = \frac{C^*}{C} = \frac{E\,(Ci|\,u\,i,=0,Y\,i,Pi)}{E\,(Ci|ui,Yi,Pi)} = E\,[exp.(Ui)/\,\varepsilon] \ldots \quad ..(iv)$$

EE took the value between 0 and 1.

Hence a measure of farm specific allocative efficiency (AE) was thus obtained from technical and economic efficiencies estimated as:

$$AE = \frac{EE}{TE} \quad . \qquad (v)$$

The range was from 0 to 1.

For this paper, Y = Grain Equivalent of output (kg)
Where:
$X_1$ = Farm Size (Hectares)
$X_2$ = Family labour (total man-days)
$X_3$ = Hired labour (man-days)
$X_4$ = Seeds (Kg)
$X_5$ = Pesticides (litres)
$X_6$ = Fertilizer (kg)
The inefficiency predictors:
$X_1$ = Farming experience (years)
$X_2$ = Gender (male=1)
$X_3$ = Age (years)
$X_4$ = Households size (AE)
$X_5$ = Members of cooperative societies (Yes =1)
$X_6$ = Access to credit (Yes =1)
$X_7$ = Educational level (Formal =1, Non-formal =0)

## 3. Results and Discussion

### 3.1 Socioeconomic Characteristics

The summary statistics of the socioeconomics characteristics is shown in Table 1. An average farmer in the study area is about 51 years old with a household size of four persons and cultivates a farm size of three hectares. The average farming experience was 23 years and earns an off-farm income of about N21, 180 per month. This implies that most of the respondents in the study area are on the average very agile (that is within their productive years) and thus can still be actively involved in farming. The household size might in turn affect the amount of labour that will be available for farming activities since most smallholders rely on family labour for production activities. These averages are consistent with the reports of NBS (2006) and that of Babatunde and Qaim (2010).

### 3.2 Factors Influencing the Technical Efficiency of Intercropping Systems

The result of the analysis on the determinants of technical efficiency of intercropping system as shown in Table 2 revealed that the farm size had positive coefficient and it was significant at 5%. This indicated that as the farm size increases output also increases. The coefficient of fertilizer was also positive and significant indicating that as the fertilizer usage increases production increases too. For the inefficiency model, the negative coefficient of educational status which was significant at 1% implies that the farmer's level of technical inefficiency decreases with improved educational status. The negative coefficient for membership of cooperative societies implies that the farmers level of technical efficiency increases with their members. This can be attributed to the fact that educated farmers who are members of cooperative group are likely to be exposed to skill acquisition programs that can enhance their capacities. These relationships are in agreement with several literatures such as those of Narala and Kala, 2010 and Mangu *et al*, 2015.

Table 1. Socioeconomic characteristics of farmers.

| Variables | Mean | Standard Deviation |
|---|---|---|
| Age (years) | 50.58 | 10.17 |
| Years of Schooling | 9.38 | 4.83 |
| Household Size (Adult Equivalent) | 4.29 | 1.84 |
| Farm Size (hectares) | 3.32 | 4.10 |
| Farming Experience (years) | 23.95 | 12.19 |
| Frequency of Extension Visit (in the last farming season) | 2.83 | 3.64 |
| Farm Income (₦/month) | 10, 193 | 12, 143 |
| Off-farm Income (₦/month) | 21, 180 | 20, 920 |

Table 2. Stochastic production function estimates of the factors influencing the technical efficiency of intercropping systems.

| Variables | Coefficients | S.E | t-values |
|---|---|---|---|
| **Stochastic Frontier** | | | |
| Constant | 9.423 | 0.493 | 19.120 |
| Farm size (hectares) | 0.414** | 0.180 | 2.304 |
| Family Labour (man-days) | -0.907 | 0.215 | -0.423 |
| Hired Labour (man-days) | 0.097 | 0.180 | 0.540 |
| Seeds (kg) | 0.001 | 0.003 | 0.169 |
| Pesticides (litres) | 0.017 | 0.013 | 1.300 |
| Fertilizers (kg) | 0.021** | 0.009 | 2.206 |
| **Inefficiency Model** | | | |
| Constant | 4.293 | 1.081 | 3.970 |
| Farming Experience (years) | -0.182 | 0.186 | -0.979 |
| Gender (Male =1) | 0.377 | 0.418 | 0.899 |
| Age (years) | 0.070 | 0.213 | 0.416 |
| Household size (AE) | -0.271 | 0.652 | -0.195 |
| Members of cooperatives (Yes =1) | -0.827* | 0.424 | 1.840 |
| Access to credit (Yes =1) | 0.190 | 0.430 | 0.441 |
| Educational status | -0.586*** | 0.126 | -4.633 |
| **Variance parameters** | | | |
| Sigma-squrared ($\sigma^2$) | 1.413 | 0.240 | 5.888 |
| Gamma ($\gamma$) | 4.148 | 0.212 | 0.195 |

Note: ***, **, and * represent 1%, 5% and 10% level of significance

### 3.3 Factors influencing the Allocative Efficiency of intercropping system

The factors that significantly influence the allocative efficiency of intercropping systems in the study area as indicated in Table 3 were the cost of other inputs (this includes the cost of packaging, cost of transporting produce to the farm gate among others) household size, and membership to cooperatives. The estimated coefficient for the cost of other inputs with respect to the allocative efficiency had a positive sign and was significant at the 5%. This implies that cost of other input contributed positively to the allocative efficiency of intercropping systems in the study area. The estimated coefficient for household size and membership of cooperative societies had a negative sign for the allocative inefficiencies, but they were significant at 5%. This implies that as the household size decreases the more allocatively inefficient the production system becomes. This may be as a result of the fact that households with smaller members do not have enough labour to work on the farm and as such resulting in lower reduced output. Also, the result shows that non-members of cooperative societies are more likely to be inefficient. This may be because they do not possess the skills required to efficiently engage in intercropping systems as some of these ideas and skills are taught within the societies. These results are not too different from that of Okoye *et al*, 2006 who also reported the same relationship.

Table 3. Stochastic production function estimates of the factors influencing the allocative efficiency of intercropping systems.

| Variables | Coefficients | S.E | t-values |
|---|---|---|---|
| **Stochastic Frontier** | | | |
| **Efficiency model** | -517810.280 | 1.000 | -517807.63 |
| Land Rent (₦/year) | 2.512 | 2.861 | 0.878 |
| Cost of hire labour (₦/man-day) | 93.787 | 5.185 | 18.083 |
| Cost of seeds (₦/kg) | 7.798 | 0.553 | 14.101 |
| Cost of fertilizers (₦/kg) | 33.591 | 1.903 | 17.647 |
| Cost of pesticide (₦/kg) | 27.105 | 2.739 | 9.894 |
| Farming experience (years) | -94.070 | 1.065 | 88.366 |
| Cost of other inputs (₦) | 15.539** | 6.347 | 2.448 |
| **Inefficiency model** | | | |
| Constant | -2127.296 | 1.000 | -2127.296 |
| Gender (Male =1) | 5.633 | 1.000 | 5.633 |
| Age (years) | 542.402 | 1.000 | 542.402 |
| Household size (AE) | -1.803** | 1.000 | -1.803 |
| Members of cooperative (Yes =1) | 46.192** | 1.000 | -1.083 |
| Access to extension services (Yes =1) | 20.778 | 1.000 | 27.778 |
| Access to credit (Yes =1) | 17.032 | 1.000 | 170.325 |
| Source of land | -27.533 | 1.000 | -27.534 |
| Educational status | -21.739 | 1.000 | -21.729 |
| **Variance parameters** | | | |
| Sigma-squrared ($\sigma^2$) | 2260.000 | 1.000 | 67282.154 |
| Gamma ($\gamma$) | 0.999 | 1486.2 | 672851.540 |

Note: ***, **, and * represent 1%, 5% and 10% level of significance

**3.3 Technical and Allocative Efficiencies of Intercropping systems**

The frequency distribution of the efficiency estimates obtained from the stochastic frontier model is presented in Table 4 and 5 for the technical and allocative efficiencies, respectively. The results in Table 4 indicated that technical efficiency indices varied widely with an average efficiency index of 67%. Majority (38.3%) of the farmer's falls into the modal class (60-70%) while the lowest class (50-60%) was just about 3.3%. This could be because the farmers had relatively bigger farm. They are more experienced with the skills to efficiently engage in intercropping systems. None of the respondent achieved a technical efficiency of 100% which implies that there is still more room for improved efficiency of intercropping system in the study area. This result is not too different from those of Altieri (1999) for National Directorate of Employment (NDE) farmers in Ondo State (Bifarin *et al.,* 2010).

Table 4. Technical efficiencies of intercropping systems.

| Technical efficiency index | Frequency | % |
|---|---|---|
| 0.501 -0 .600 | 4 | 3.3 |
| 0.601 - 0.700 | 46 | 38.3 |
| 0.701 -0 .800 | 40 | 33.3 |
| 0.801 - 0.900 | 23 | 19.2 |
| 0.901+ | 7 | 5.8 |
| Total | 120 | 100 |
| Maximum Technical Efficiency | 0.60 | |
| Minimum Technical Efficiency | 0.50 | |
| Mean Technical Efficiency | 0.67 | |

The frequency distribution of allocative efficiency estimate obtained from the stochastic frontier model is presented in Table 5. This results indicates that majority (95.8%) of the farmers fall into the modal class (lowest class of about 30%) while the highest class (above 50%) were just about 0.8% with an average efficiency index of 13%. This could be because the little money that is being acquired by the farmer is spent on other household expenditures as most were found with relatively large household sizes. Also, only few of them have access to credit. This is in agreement with the findings of Ghosh, 2004.

Table 5. Allocative efficiencies of intercropping systems.

| Allocative Efficiency Index | Frequency | % |
|---|---|---|
| <0.30 | 115 | 95.8 |
| 0.30-0.50 | 4 | 3.3 |
| >0.50 | 1 | 0.8 |
| Total | 120 | 100 |
| Minimum Allocative Efficiency | 0.10 | |
| Maximum Allocative Efficiency | 0.84 | |
| Mean Allocative Efficiency | 0.13 | |

## 4. Conclusion and Recommendations

This study revealed that most of the farmers practicing intercropping were male. Although smallholders were relatively technically efficient, they were not allocatively efficient. The farm size, quantity of fertilizer used and cost of other inputs determined the level of output in the intercropping system in the study. While membership of cooperative societies, household size and educational level were the factors that influence the level of technical inefficiencies of farmers. Therefore, it is recommended that farmers be trained either through cooperative societies or organizing seminars on the advantages of practicing intercropping systems and the technique/skills involved. This may help the farmers to improve their allocative efficiency hence the quantity poduced most especially in the face of current climatic challenges and food security problems.

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