EE
*E u r o E c o n o m i c a*
*Issue 1(42)/2023* *ISSN: 1582-8859*

EE
EuroEconomica

# Effect of Land Fragmentation and Socioeconomic Factors on Food Crop Productivity in Ogun State, Nigeria

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**Abstract:** Land fragmentation has contributed to low productivity with high production costs resulting from scattered farm plots. This study examined the implication of land fragmentation on food crop productivity. Primary data were collected from 118 farmers through a multistage and snowball sampling techniques using structured questionnaire. Descriptive statistics, land fragmentation indices and Cobb-Douglas production function were used to analyse the data. Descriptive results show that an average farmer was 51.7 years old, 61.0% was male, and 75.4% was married with mean of 5 persons per household while 87.3% had formal education. About 86.4% derived major income from farming; a an average farmer cultivated 3.82 ha and had 19 years of experience. Majority (57.6%) of the farms was acquired through inheritance, 24.6% rented/borrowed, 17.8% purchased (17.8) while 69.5% operated two (2) or more parcels. Productivity was promoted by Age (0.471) and education (0.261) at $p<0.01$ while it was reduced by land fragmentation (-0.323) and distance from homestead to farm locations (-0.324) at $p<0.05$ and $p<0.01$ respectively. Therefore, cooperative farming should be promoted with subsidized inputs to enhance farm mechanization and productivity. Land consolidation policy should be used to partially restrict total land inheritance in order to reduce land fragmentation in the area.

**Keyword:** Land fragmentation; Parcel; Simpson index; Productivity

**JEL Classification:** O47

## 1. Introduction

The agriculture sector provides food for the growing population and raw materials for industries. It is a source of foreign exchange and capital formation for the Nigerian economy despite the dominance of the oil sector (Awotide and Agbola, 2010). Evidence has shown that land fragmentation negatively affects agricultural productivity as it reduces access to adequate land, hinders farm mechanization and increase production cost (Manjunatha *et. al.*, 2013; Deininger *et al*., 2017). Agriculture sector is the single largest employer of about 70% of the country's total workforce. The sector is dominated by small-holder farmers who operate scattered farms a consequence of land inheritance practices although Nigeria is endowed with enormous arable land (Ali *et al.*, 2015). According to Demetriou *et al* (2013), those problems that are prevalent with land fragmentation are small farm size, irregular shape and dispersion

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of parcels. Kadigi *et al.* (2017) pointed out that land use for farming is becoming scarce as against what is obtainable in past years. Because most of the lands where inherited from their ancestors and claimed by individual family members sometimes in a violent manner.

Deininger et al, (2017) indicated that land fragmentation is often considered as the source of inefficiencies in crop productivity which is associated with high production costs due to inefficient resource allocation and sub-optimal usage of production inputs. Sklenicka (2016) and Apata et al. (2014) consider land fragmentation as a major threat to efficient production system due to continuous subdivision of farms which lead to small size of farm-holdings that may be economically hard to operate. They accounted the harms of land fragmentation on productivity including increase in transport costs when the plots are located far from home and far from each other. A lot of time is wasted in travelling in-between the plots and home. It is also difficult, costly and time consuming to manage, supervise and secure scattered plots against theft (Latruffe & Piet, 2014).

### 1.1. Literature Review

Land is an indispensable farm input. Rakhshanda, et al. (2020) defined land fragmentation as existence of separate number of plots cultivated by the same farmer at different location and this is a constraint for agricultural mechanization, technological advancement and economic growth. Agricultural productivity and profitability do suffer due to uneven distribution and fragmentation of land. The size of cultivated farmland has been decreasing due to subdivision resulted in farmland holding which did not support 33.0% of farm households (Gashaw et al., 2017).

Reuben *et al*. (2017) affirmed that land holdings in Ihemi cluster were highly fragmented. They observed that parcels that were located closer to homestead were more fragmented than those at distant location. According to Iheke and Amaechi (2015), there is a high degree of land fragmentation which has a negative effect on farm productivity as it increases both travelling time and cost of traveling between plots leading to lower labour and overall farm productivity. The study of Bhola and Narendra (2018) shows that large numbers of households have 2 to 3 land parcels. They stressed that population growth, infrastructure development and inheritance as well as land tenure systems are the main reasons for land fragmentation Land fragmentation poses a challenge to the application of effective sustainable land management practices and can exacerbate land degradation and vulnerability to food insecurity (Tesfaye *et al*., 2018). However, Louwsma *et al*. (2017) suggested that land assembling can be done either by promoting the voluntary exchange of plots between farmers or through cooperatives. Increased access by farmers to training in sustainable land management practices is vital to identifying the land consolidation strategy that promotes sustainable development. Swai (2016) warned that land access and farm fragmentation affect the welfare of farm household and have negative impact on national development.

### 1.2. Problem Statement

Farm fragmentation is a cause of low agricultural development in Nigeria as multiple number of plots negatively affected productivity and technical efficiency of farms (Awotide and Agbola, 2010; Karangwa Mathias, 2010). Olarinre and Omonona (2018) revealed that majority of rice farmers in Osun

State were young between 41-50 years old, and they did not use machineries for farm operations due to small farm holdings. However, land fragmentation poses a great challenge to agricultural mechanization and commercialization in Nigeria because, small farm size does not provide farmers with enough income to satisfy their basic needs (Kakwagh *et al*., 2011). Oyebanjo et al (2022) found that 65.3% of arable crop farmers cultivated below 1.0 ha, 34.7% cultivated above 1.0 ha while the average farm size was 1.4 ha indicating a small level of farm holdings in Southwest Nigeria. They also reported that the largest proportion of the farmland was controlled by indigenous families through inheritance (47.0%), rent/ lease (25.4%), borrowed farmland (12.3%) while only 15.3% of the farmland was owned by purchase.

Therefore, the main objectives of this study were to describe the socio-economic characteristics of the food crop farmers and their farming system, examine the effect of land fragmentation and socioeconomic factors on farm productivity and analyse the factors that influence land fragmentation among the farmers in the study area.

### 1.3. The Study Area

The study was conducted in Ogun State which was created from the old western region in February 1976 with Abeokuta as the State capital. It is one of the 6 States in the Southwest geopolitical zone of Nigeria with land mass of about 1.7million hectares or 1.9% of the total land mass of Nigeria and estimated human population of 4,864,322 (NPC, 2021).

Ogun State lies within latitude 60$^{o}$N and 80$^{o}$N and longitude 2.50$^{o}$E and 50$^{o}$E. There are four Divisions in the State namely; Egba, Ijebu, Remo, and Yewa/Awori with a total of 20 Local Government Areas. The State shares an international boundary with the Republic of Benin to the west and local boundaries with Oyo State to the North, Lagos state to the South, and Ondo State to the East. There are two main types of vegetation namely; tropical rain forest and the guinea savannah as designated by the Ogun State Agricultural Development Programme (OGADEP). The study area is noted to produce arable crops, cash crops and livestock as a result of favourable weather condition. The average rainfall is between 1500mm and 1800mm in the area and the larger percentage of the population are engage in agriculture, agro-processing or agricultural marketing.

## 2. Materials and Methods

### Method of Data Collection and Sampling Technique

Primary data were collected from food crop farmers using well-structured questionnaires. A multistage sampling technique was used to randomly select Ijebu and Yewa Divisions out of the four (4) Divisions in Ogun State. The second stage involved selection of Ijebu-North Local Government Area (LGA) and Yewa North LGA which were the predominant areas of food crop production in Ijebu and Yewa Divisions. Subsequently, ten (10) farming communities were selected from each LGA. The farmers were selected through a snow-ball sampling technique. Thus, complete responses from one hundred and eighteen (118) questionnaires were used in data analyses.

**2.1. Method of Data Analysis**

Descriptive statistics i.e. frequency distribution, percentage, mean and standard deviation were used to analyse the socioeconomic characteristics of the respondents and their farming system. Land fragmentation indices were adapted to examine the land use intensity while the Cobb-Douglass production model was fitted to capture the effect of land fragmentation and socioeconomic characteristics on food crop productivity in the area.

**2.1.1. Land Fragmentation Indices**

Land fragmentation is a situation where a farming household cultivated several plots which is often scattered over a wide area. King and Burton (1982) cited six factors that are relevant in the measure of land fragmentation index. These factors include holding size; number of parcels belonging to the holding; size of each parcel; shape of each parcel; the spatial distribution of parcels; and the size distribution of parcels. Simmons (1964) proposed a land fragmentation index (FI) which considered the number of parcels in a holding ($\boldsymbol{A^2}$), relative sizes of each parcel ($\boldsymbol{a}$)**,** and the number of plot (n). The formula is given as:

$$\boldsymbol{FI} = \frac{\sum_{i=1}^{n} \boldsymbol{a_i^2}}{\boldsymbol{A^2}}$$

The Januszewki index (JI) measures the land fragmentation index within the range of 0 and 1. The smaller the JI value, the higher the degree of land fragmentation. Thus, fragmentation increases when the size of average plot declines. More so, inequality in plot sizes lead to a decrease in fragmentation index. However, the index fails to account for farm size, plot distance, and shape of plots. The number of plots **n** and area of each plot $\boldsymbol{a_i}$ are specified in the formula which is given as;

$$\boldsymbol{JI} = \frac{\sqrt{\sum_{i=1}^{n} \boldsymbol{a_i}}}{\sum_{i=1}^{n} \sqrt{\boldsymbol{a_i}}}$$

The Simpson index (SI) also measures the degree of land fragmentation based on the number of parcels in a holding, ***A,*** and it is ranged between 0 and 1. In contrary to the JI index, a higher SI value corresponds with a higher degree of land fragmentation. The index is given as;

$$\boldsymbol{SI} = \frac{\sum_{j=1}^{J} \boldsymbol{A_i^2}}{\boldsymbol{A^2}}$$

**2.1.2. The Analytical Model**

The Cobb-Douglas production function used in the measure of productivity of food crop in this study is of the following specifications:

$$Q = b_0 X_{1i}^{b1} X_{2i}^{b2} \ldots . X_{ni}^{bn} e \quad (1)$$

When log-linearised, the estimating equation is expressed as;

$$ln Q_i = ln b_0 + bn_1 ln X_{1i} + b_2 ln X_{2i} + \ldots..{}_i + b_n ln X_{ni} + \mu i. \quad (2)$$

i= 1,2,3….n

Where:

Q = Output per hectare (kg/ha)

$X_1$ = Fragmentation Index

$X_2$ = Quantity of farm labour in man-day

$X_3$ = Quantity of seed planted (kg)

$X_4$ = Quantity of fertilizer used in farming (kg)

$X_5$ = Distance between farms and homestead (km)

$X_6$ = Gender of crop farmers where male=1 and female = 0

$X_7$ = Age of crop farmers (years)

$X_8$ = Quantity of chemical applied (liters)

$X_9$ = Years of crop farming experience

$X_{10}$ = Level of education of the farmer in years

$X_{11}$ = Use of machinery (1 if tractor was used on farm and 0 if otherwise)

α = Intercept

β = parameter to be estimated

μ =disturbance term

The isoquant of the Cob-Douglas production function is convex and thus obeys the law of diminishing returns. The coefficient associated with each explanatory variable ($b_i$, i = 1, 2, … , n) are the respective partial input elasticities while the overall production elasticity ($E_p$) is the sum of the $b_i$s ($E_p = \sum b_i$), which is non-negative ($\sum b_i \geq 0$) and measures return to scale. The scale factor is positive (i.e. $b_o > 0$) and its elasticity of substitution is equal to one.

The Double-log functional form of the Cobb-Douglas production model was fitted to further examine the determinants of land fragmentation in the area as follows;

$$\text{In}L = \alpha + \beta_1 lnX_1 + \beta_2 lnX_2 + \beta_3 lnX_3 \ldots . + \beta_9 lnX_9 + \mu i \quad (3)$$

Where:

L= Land Fragmentation index measured by Simons Index

$X_1$ = Gender of crop farmer (1 if male and 0 if otherwise)

$X_2$ = Age of crop farmers in years

$X_3$ = Educational level of crop farmers in years

$X_4$ = Years of crop farming experience

$X_5$ = Household Size (number)

$X_6$ = Number of separate parcel cultivated by farmer

$X_7$ = Total distance from home to farms in kilometers

$X_8$ = Migration status (1 if farmer is an indigene and 0 if otherwise)

$X_9$ = Total farm size cultivated in hectares

$\alpha$ = Intercept

$\beta$ = parameter to be estimated

$\mu$ =disturbance term

## 3. Results and Discussions

### 3.1. The Socioeconomic Characteristics of the Farmers

Table 1 shows the distribution of the respondents by their socioeconomic characteristics. The result revealed that majority (82.2%) was, at most, 60 years-old, 17.8% was above the formal retirement age of 60 years while an average farmer was 51.7 years old. This means that the farmers were still agile and active in food crop production. Age can affect the farm size, number of parcels operated and productivity level particularly where there is high index of land fragmentation. However, majority (61.0%) of the respondents were male while 39.0% were female maybe due to the strength required in cultivating more than one parcel and the distance from homestead to the farms. Majority (75.4%) of the farmers was married while 24.6% was single, divorced or widowed. Marital status could influence the number of members in a household which may determine the availability of family labour and the ability of a rural household to cultivate farms two or more locations.

About 77.9% of the farmers had, at most, six (6) household members, 22.1% had up to 12 members while there was an average of 5 persons in a household. A farmer with higher household size may be able to increase farm size or cultivate more parcels of land in a traditional setting. The result further revealed that 87.3% of the respondents could read and write while 12.7% had no formal education. Education is of great importance in decision making and it promotes cooperative participation among rural dwellers and this could reduce the problems of land fragmentation and land tenure system. More so, 86.4% of the respondents earned their livelihood from farming while non-farm activity was a major source of livelihood for 13.6%.

**Table 1. Distribution of the Respondents by Their Socioeconomic Characteristics**

| Socio economic characteristics | Frequency | Percentage | Mean |
|---|---|---|---|
| Age in years | | | |
| ≤ 30 | 13 | 11.0 | |
| 31-40 | 16 | 13.6 | |
| 41-50 | 25 | 21.2 | |
| 51-60 | 43 | 36.4 | 51.7 |
| Above 60 | 21 | 17.8 | |
| Gender | | | |
| Male | 72 | 61.0 | |
| Female | 46 | 39.0 | |
| Marital Status | | | |
| Widowed/ divorced | 17 | 14.4 | |
| Single | 12 | 10.2 | |
| Married | 89 | 75.4 | |
| Family size | | | |
| 1-3 | 27 | 22.8 | |
| 4-6 | 65 | 55.1 | 5.23 |
| 7-9 | 16 | 13.6 | |
| 10-12 | 10 | 8.5 | |
| Educational Status (years) | | | |
| No formal education | 15 | 12.7 | |
| Primary education | 32 | 27.1 | |
| Secondary education | 48 | 40.7 | |
| Tertiary education | 23 | 19.5 | |
| Major Source of livelihood | | | |
| Farming | 102 | 86.4 | |
| Non-farm activities | 16 | 13.6 | |
| Total | 118 | 100.0 | |

*Source: Field data, 2021*

### 3.2. The Farming System

Table 2 shows the results of descriptive statistics of the farming system in the area. The results revealed that 28.0% had a maximum of 15 years of farming experience, 49.1% had been cultivating up to 30 years while 22.9% were into farming for more than 30 years. The farmer had been cultivating for an average of 19 years. This implies that the farmers had a relatively high level of experience to understand their farm settings towards improved productivity. Farm experience could enhance operation of a larger farm size and adoption of modern farm practices as well as farm commercialization. These could reduce land tenure system.

It was evident that 26.3% cultivated below 2.0 hectares. The majority 45.7% cultivated between 2.0 to 4.0 ha while 28.0% had more than 4.0 ha of food crop farm. The average cultivated farm size was 3.82 ha. Farm size had a positive relationship with productivity, and it was affected by land fragmentation. Majority 57.6% of the farmers inherited the farmland, 24.6% either rented or borrowed while 17.8% owned the land through purchase. The higher proportion of inherited land was an evidence of high

fragmentation index as well as land tenure system among the respondents. About 69.5% operated more than two (2) plots of land while 30.5% cultivated only one (1) plot.

**Table2. Distribution of the Respondents by Characteristics of Farming System**

| Farming characteristics | Frequency | Percentage | Mean |
|---|---|---|---|
| **Farming experience (years)** | | | |
| Below 10 | 12 | 10.2 | |
| 10-15 | 21 | 17.8 | |
| 16-20 | 43 | 36.4 | 19.08 |
| 21-30 | 15 | 12.7 | |
| Above 30 | 27 | 22.9 | |
| **Total Farm Size (ha)** | | | |
| Below 2.0 | 31 | 26.3 | |
| 2.0-< 4.0 | 54 | 45.7 | 3.82 |
| Above 4.0 | 33 | 28.0 | |
| **Mode of land Acquisition** | | | |
| Inherited | 68 | 57.6 | |
| Borrowed | 13 | 11.0 | |
| Rented | 16 | 13.6 | |
| Purchased | 21 | 17.8 | |
| **Number of cultivated parcel** | | | |
| 1 parcel of land | 36 | 30.5 | |
| ≥ 2 parcels of land | 82 | 69.5 | |
| Total | 118 | 100.0 | |

*Source: Field data, 2021*

### 3.3. The Results of Land Fragmentation Indices

The estimated land fragmentation indices were presented in Table 3. The mean Simmons' index was 0.78 implying a high level of scattered farms. The Januszewki (JI) index of 0.58 indicates a moderate level of land fragmentation because; a high JI index means a low land fragmentation. Meanwhile, Simpson index of 0.62 confirmed that majority of the farmer cultivated more than one plot. The results imply that high land fragmentation was evident among the farmers thus restricting farm mechanization in the area.

**Table 3. Estimates of the Land Fragmentation Indices**

| Index | Minimum | Maximum | Mean | Standard Deviation | Remark |
|---|---|---|---|---|---|
| Simmons index | 0.37 | 0.85 | 0.78 | 0.20 | High level of land fragmentation |
| Januszewki index | 0.54 | 0.69 | 0.58 | 0.02 | Moderate land fragmentation |
| Simpson index | 0.42 | 0.79 | 0.62 | 0.05 | High level of land fragmentation |

*Source: Field data, 2021*

### 3.4. Determinants of Food Crop Productivity among the Farmers

Productivity of food crops among the farms was examined by the Double-log form of the Cobb-Douglas production function. The result in Table 6 shows that the F-value of the model (7.322) is significant at $p<0.01$ with Adjusted-$R^2$ (0.618). This implies that the model is relevant to the data and the fitted explanatory variables were 61.8% of the factors affecting food crop productivity in the area. The coefficient of land fragmentation (-0.323) and distance to farms (-0.324) had negative and significant relationships with food crop productivity at $p<0.05$ and $p<0.01$ respectively. This implies that food crop productivity was reduced by cultivation of scattered parcels and distance from homestead to all the farm locations. Perhaps, this contributed body stress and high production cost. Thus, a policy to reduce land fragmentation will lead to increased productivity in the area. However, age had the largest positive and significant impact (0.471) on productivity at $p<0.01$ probably because the farmers were relatively young and active. Education (0.261) had the second largest positive impact at $p<0.01$ significant level. This means that the knowledge of the farmer will enhance the understanding of his farm setting leading to increased productivity.

**Table 6. Determinants of farm productivity in the area**

| Variables | Co-efficient | t-value |
|---|---|---|
| (Constant) | -0.679*** | -3.743 |
| Fragmentation Index | -0.323** | -2.351 |
| Quantity of farm labour | 0.115 | 1.203 |
| Quantity of Seed planted | -0.040 | -0.329 |
| Quantity of fertilizer used | 0.124 | 1.153 |
| Distance between farms and homestead | -0.324*** | 3.203 |
| Gender of crop farmers | 0.247 | 1.590 |
| Age of crop farmers | 0.471*** | 3.062 |
| Chemical applied | 0.239 | 1.378 |
| Years of cropping experience | 0.110 | 0.940 |
| Level of education of the farmer | 0.261*** | 2.524 |
| Use of machineries | -0.083 | -.0764 |
| F-value | 7.322*** | |
| R Square | 0.684 | |
| Adjusted R Square | 0.618 | |

*Source: Field data, 2021. ***Significant at 10% level; **significant at 5% level*

### 3.5. Factors Influencing Land Fragmentation in the Study Area.

In the same vein, the Double-log functional form was further estimated to examine the factors affecting land fragmentation using the Simpson index as dependent variable. The result in Table 4 shows that the F-value of the model (13.172) is significant at $p<0.01$ with Adjusted $R^2$ of 0.530. This indicates that the explanatory variables were responsible for 53.0% of the factors influencing land fragmentation in the study area. Among the variables, the coefficient of age (-0.360) has a negative and significant relationship with land fragmentation at $p<0.01$. Thus, age had a reducing effect on land fragmentation probably due to reduced strength as age increases. This could lead to low farm productivity.

The coefficient of education (-0.237) also had a reducing effect on land fragmentation at p<0.01. This could be attributed to low level of enlightenment among the farmers. Meanwhile, education could promote cooperative participation and collective farm holding as well as farm mechanization or commercialization which has higher benefits. Furthermore, farming experience (-0.578) has a negative coefficient that experience played a significant role in reducing land fragmentation in the area at p<0.01. Appreciable year of farming experience implies long stay in the community and this may promote trust and better relationship with landlords who may agree to allocate a larger farm size to a farmer at one location in spite of family inheritance.

Farm size (0.379) contributed positively to land fragmentation in the area at p<0.01 significance level. This confirms a restriction against farm expansion which hinders productivity since the farmers would continue to operate small farm holdings at the detriment of sufficient food for the growing population. The migration status (0.288) positively and significantly influenced the high index of land fragmentation among the farmers at p<0.01. Perhaps, the indigenous culture i.e. land inheritance restricted the non-indigenes from having adequate access to farm land. This implies a serious impediment against farm productivity.

**Table 5. Determinants of Land Fragmentation in the Farming Area**

| Variables | Coefficient | t-value |
|---|---|---|
| (Constant) | 0.642*** | 5.954 |
| Gender of farmer | -0.056 | -0.469 |
| Age | -0.360*** | -3.199 |
| Educational level | -0.237*** | -2.819 |
| Farming experience | -0.578*** | -4.663 |
| Household Size | 0.105 | 0.770 |
| Farm size | 0.379*** | 3.365 |
| Total distance from home to farms | 0.183 | 1.459 |
| Migration status | 0.288*** | 3.050 |
| Total farm size cultivated | -0.047 | -0.475 |
| F-value | 13.172*** | |
| R Square | 0.574 | |
| Adjusted R Square | 0.530 | |

*Source: Field data, 2021. *** Significant at 1% level*

## 4. Conclusion

The findings show that majority (61.0%) of the farmers were male perhaps due to the strength required to cultivate multiple parcels in different location. About 87.3% of them were educated and could adopt modern farm practices. The majority (72.0%) had been cultivating for 30 years or more with understanding of the farm settings which could enhance farm productivity. However, the average cultivated farm size of 3.82 ha revealed that the respondents were small-scaled farmers possibly due to high fragmentation of farmland as shown by Simpson index (0.62).

The mode of land acquisition also confirmed that majority of the farmers were operating on inherited land (57.6%), rented/ borrowed (24.6%) and purchased land (17.8) while 69.5% of them had two (2) or more parcels in different locations. Productivity of food crops was significantly promoted by education

(0.261) at p<0.01 but reduced by land fragmentation index (-0.323) and distance from homestead to farm locations (-0.324).

The study concluded that food crop productivity was reduced by land fragmentation and total walking distance to farms. Therefore, cooperative farming should be promoted by government through distribution of subsidized inputs to farmer's cooperative associations to enhance farm mechanization in the area. Land consolidation policy and integration programs should be designed by policy makers to reduce land fragmentation and increase farm productivity as well as income among the farmers.

**Acknowledgement**

We appreciate Professor A. O. Otunaiya for his guidance during the presentation of this work for necessary corrections. We are also grateful to Dr. A. O. Idowu for analyzing the study data and Abimbola Patience Balogun for assisting in data collection during her undergraduate programme in the University.

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