



EFFECT OF LAND FRAGMENTATION ON TECHNICAL EFFICIENCY AMONG FARMERS IN SOUTHWEST NIGERIA

*Akintayo, O.I. & Lawal, B.O.

Institute of Agricultural Research and Training, Moor Plantation, Ibadan, Oyo state, Nigeria.

*Corresponding author email: oluremijayakint@gmail.com

ABSTRACT

Using data collected with the aid of structured interview schedule from 102 randomly selected farmers, the study analyses the effect of farm fragmentation on technical efficiency of smallholder farmers in southwest Nigeria. About fifty-two per cent (52.94%) of the farmers were land owners through inheritance, 8.82% were owners through purchase while the remaining 38.24% were tenants who rented the lands for farming activities. Only 26.47% of the farmers cultivated a hundred per cent of their land while 73.53% left some percentage of their land uncultivated for several reasons such as lack of/insufficient farm labour, lack of capital for farm inputs, soil conservation by fallow and by rotation. With a range of 0.28 to 1.00, the average fragmentation index (Simmons' index) was 0.45. Only 8.82% of the farmers had one-block land (non-fragmented land). The technical efficiency estimates for the farms indicated an average efficiency score of 57.05%. The size of rice farm, which is the most important crop to farmers in the study area, percentage of total land cultivated and land fragmentation index all had significant negative effects on technical inefficiency. In other words, the larger the size of rice farm cultivated, the lower will be the level of inefficiency. Furthermore, the higher the proportion of total land that is cultivated, the lower will be the technical inefficiency. Also, the higher Simmons' index is (the less fragmented the land), the lower the inefficiency will be. The role of government cannot be over-emphasized in helping to reduce the level of technical inefficiency in agriculture. For instance, simple farm labour-saving machines can be made available to farmers so that they can cultivate larger land areas. This would eventually lead to higher technical efficiency levels and greater farm output for higher incomes and better livelihoods for the farmers.

KEYWORDS: Simmons' index, stochastic production frontier, Nigeria.

INTRODUCTION

The importance of land to man cannot be over emphasized. It is a finite, non reproducible natural resource that is essential for the survival and upkeep of mankind and maintenance of all global ecosystems. It is also a form of wealth that can be transferred across generations. Land fragmentation is noted to be a worldwide phenomenon (Latruffe and Piet, 2013) while its existence has been noted to be a significant feature in less-developed agricultural systems (Blarel et al, 1992; Van Hung et al, 2007). Land fragmentation has been defined as the existence of a number of spatially separate plots of land which are farmed as single units. Fragmentation of land is also taken to be the spatial dispersion of a farmer's plots over a wide area, intermixed with parcels of land operated by other farmers (King and Burton, 1982). It has been observed that there are two sides to land fragmentation in terms of benefits and detriments to farmers and overall agricultural development. Some of the negative aspects to land fragmentation have been identified to include higher transport costs for inputs and outputs in addition to lower labour productivity as a result of increased travelling time between farm plots (Blarel et al, 1992), inefficiencies in production (Nguyen, 2014) and difficulty to mechanize farm operations due to spatial, size and shape awkwardness of land parcels. On the other hand, some benefits that have been associated with farm fragmentation include the enhancement of household food

security through diversification of crops grown on plots of different soil quality, management of production and price risks through crop scheduling and use of multiple micro-environments (Van Hung et al, 2007; Kakwagh et al, 2011; Nguyen, 2014). The fragmentation of land has been attributed to several causal factors which have generally been classified into two major categories. These are demand-side and supply-side causes (Blarel et al, 1992; Van Hung et al, 2007). Demand-side causes of land fragmentation occur when farmers fragment their land because they assign some benefits (such as risk-spreading, crop diversification and seasonal labour spreading) to land fragmentation. The supply-side causes of land fragmentation indicate that farmers involuntarily use several plots for their agricultural activities due to certain factors which include population pressure, geographical issues and partible inheritance (Hristov, 2009; Van Hung et al, 2007).

Land fragmentation has been expressed using several parameters and combinations of parameters which include farm size, number of parcels, average distance of parcels from home (Lerman, 2005), size of the parcels, size and spatial distributions of the parcels and the shape characteristics of the parcels (King and Burton, 1982). Also, a number of indices have been developed to express land fragmentation, the most popular of which are Simmons' index and Januszewski's index that both take

into consideration the number and size distribution of the land parcels. Simmons' index is expressed as $FI = \frac{\sum a^2}{A^2}$. Where FI is fragmentation index, $\sum a^2$ is the sum of the squares of the plot/parcel sizes and A^2 is the square of the total farm size. Simmons index does not take into account the distances between parcels and it takes value between 0 and 1. Values close to zero indicate high fragmentation while the value of 1 indicates a one-block land holding.

Januszewski's index is expressed as $K = \frac{\sqrt{\sum a}}{\sum \sqrt{a}}$

Where K is consolidation index which takes on values between 0 and 1. Lower values indicate higher fragmentation while higher values indicate lower fragmentation (more consolidated land holdings).

Some studies have been carried out on land fragmentation in various countries. These include studies such as Manjunatha *et al* (2013) which examined the effect of land fragmentation on efficiency in India. The authors analyzed the effect of land fragmentation on farm profit and efficiency in India where they found a positive and significant association between land fragmentation and inefficiency but a negative and significant relationship between farm profit and land fragmentation. Hristov (2009) also found a negative and significant impact of land fragmentation upon the productivity and profitability of vegetable growers in Macedonia. Niroula and Thapa (2005) examined the impacts and causes of land fragmentation in south Asia. Obwona (2006) examined the determinants of technical efficiency differentials among tobacco farmers in Uganda observed a negative impact of land fragmentation on the farmers' technical efficiencies. Studies on land fragmentation that have been carried out in Nigeria include Awotide and Agbola (2010) who with the aid of farm level data examined the relationship between farm fragmentation and productivity of maize farmers in northern Nigeria and found that farmers with several plots of land tended to be more efficient than those with fewer plots. Okezie *et al* (2012) explored the link between land fragmentation and agricultural productivity and observed a negative impact on agricultural productivity in south east Nigeria. Apata *et al* (2016) utilized secondary national data (Nigerian living standard survey and national consumer survey data) to examine the effect of land fragmentation on agricultural productivity in rural Nigeria which was found to be significantly negative.

Nigeria is an agrarian country whose agricultural sector is dominated by smallholder farmers who operate several scattered plots (Kakwagh *et al*, 2011) and produce a high percentage of total food in Nigeria (Awotide and Agbola, 2010). The importance of these smallholder farmers cannot be over-emphasized in Nigeria. However, with the myriad of demerits associated with land fragmentation, this phenomenon is still wide spread in the country. This study therefore analyses the effect of farm fragmentation on technical efficiency of smallholder farmers in southwest Nigeria using farm level data.

MATERIALS AND METHODS

The study was carried out in Ekiti state, a major rice producing state in south west Nigeria. The state is located

between longitudes 4° 51 and 5° 45 east and latitudes 7° 15 and 8° 51 north of the equator. Crops grown in the state include rice, cowpea, maize, yam, cocoa, kola and palm produce. In southwestern Nigeria, Ekiti state has the largest rice land area of between 46,000 and 92,000 hectares.

A multistage random sampling technique was utilized to select one hundred and two farmers from three local government areas in the state. Structured questionnaire was used through interview schedules with farmers to obtain data for the study. The production structure of the farmers is specified with a single output multiple input stochastic production frontier. The Maximum Likelihood Estimation (MLE) procedure was employed in jointly estimating the parameters of the stochastic production frontier and inefficiency effect models. The stochastic model incorporates a one-sided error component (u_i) which reflects inefficiency as well as a two-sided symmetric error component (v_i) which captures measurement errors and other statistical noise. The stochastic frontier function is specified as

$$Y_i = f(X_i; \beta) \exp(v_i - u_i), i = 1, 2, 3 \dots N \quad (1)$$

Where Y is output of i th farm
 X_i is vector of inputs
 β is a vector of parameters to be estimated

The possible production Y_i is bounded above by the stochastic quantity $f(X_i; \beta) \exp(v_i)$. The random errors v_i are assumed to be independently and identically distributed as $N(0, \sigma^2)$ random variables and independent of the u_i 's. The u_i 's are assumed to be non-negative truncations of the $N(0, \sigma^2)$ distribution (that is, half normal distribution) (Stevenson, 1980) or have exponential distribution (Meeusen and van den Broeck, 1977).

The technical efficiency of farm i is given as;
 $TE_i = \exp(-u_i) \quad (2)$
 $TE = Y_i/Y_i^* \quad (3)$
 $= f(X_i; \beta) \exp(v_i - u_i) / f(X_i; \beta) \exp(v_i) \exp(-u_i) \quad (4)$
 $= \exp(-u_i) \quad (5)$

The functional form used is Cobb Douglas frontier production function defined as
 $\ln Y = b_0 + b_1 \ln X_1 + b_2 \ln X_2 + \dots + b_8 \ln X_8 + V_i - U_i \quad (6)$

Where Y is rice paddy output
 X_1 = farmer's age
 X_2 = number of years spent in formal schooling
 X_3 = household size
 X_4 = farming experience in years
 X_5 = quantity of seed planted (kg/ha)
 X_6 = quantity of fertilizer applied (kg/ha)
 X_7 = quantity of agrochemicals applied (liters/ha)
 X_8 = labour used (mandays/ha)

In order to estimate the effect of land fragmentation on technical efficiency, the parameters for land fragmentation were placed in the 'inefficiency effects model' in addition to other variables to explain the underlying causes of deviation from the frontier.

The inefficiency model is represented by U and is defined by

$$U_i = d_0 + d_1Z_1 + d_2Z_2 + \dots + d_5Z_5 \quad (7)$$

Where U_i = technical inefficiency

d_1 = size of rice farm (hectares)

d_2 = average distance between farm and homestead (km)

d_3 = farm ownership (1 = land owner; 0 = tenant)

d_4 = percentage of total land cultivated

d_5 = fragmentation index (Simmons' index)

RESULTS AND DISCUSSION

The average age of the farmers was 48.50 years with an average household size of 7.20 people and average farming experience of 28.15 years. The average number of years spent in formal education by the farmers was 7.25 years. Farmers practiced multiple cropping system where crops such as cassava, maize, yam and cocoyam were

cultivated. However, rice was cultivated as sole crop on the rice plots.

In relation to land ownership, 52.94% of the farmers were land owners through inheritance, 8.82% were owners through purchase while the remaining 38.24% were tenants who rented the lands for farming activities. Only 26.47% of the farmers cultivated a hundred per cent of their land while 73.53% left some percentage of their land uncultivated for several reasons such as lack of/insufficient farm labour, lack of capital for farm inputs, soil conservation by fallow and by rotation. The farmers had lands which were fragmented into an average of three (2.91) plots. Figure 1 illustrates the distribution of the farmers in relation to the total number of plots they owned.

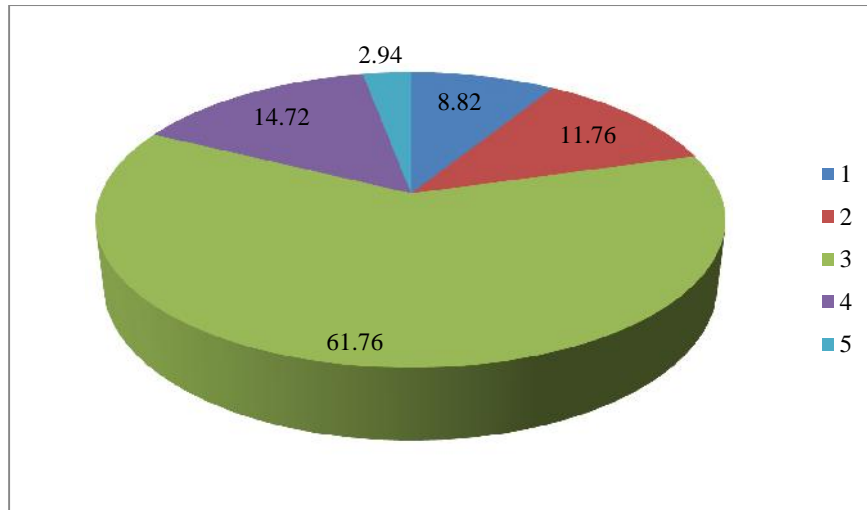


FIGURE 1: Percentage of farmers by number of plots owned

With a range of 0.28 to 1.00, the average fragmentation index (Simmons' index) was 0.45. Only 8.82% of the farmers had one-block land (non-fragmented land). The technical efficiency estimates for the farms indicated an average efficiency score of 57.05%. Figure 2 shows the percentage distribution of the farmers by their technical efficiency scores.

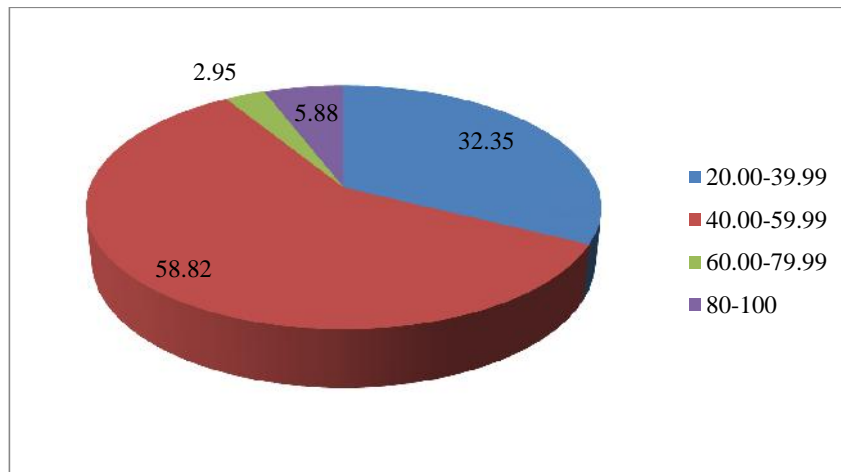


FIGURE 2: Percentage distribution of farmers by TE scores

It is evident from these estimates that there is great room for improvement of rice production in the study area. Several factors were observed to affect farm production by the farmers. These factors are illustrated by the final MLE results on Table 1 below.

TABLE 1: Maximum Likelihood Estimates of the stochastic production frontier function with inefficiency model

Variable	Coefficient
Constant	0.072 (0.83)
X ₁ (age)	0.42 (1.32)
X ₂ (school years)	0.08 (0.91)
X ₃ (household size)	0.56 (5.21)*
X ₄ (farming experience)	0.077 (0.89)
X ₅ (seed)	0.041 (0.43)
X ₆ (fertilizer)	0.22 (2.52)**
X ₇ (agrochemical)	0.013 (3.86)*
X ₈ (labour)	0.035 (0.42)
d ₀ (constant)	-0.052 (-0.96)
d ₁ (size of rice farm)	-0.11 (-1.82)***
d ₂ (farm to home distance)	0.07 (0.55)
d ₃ (farm ownership)	0.084 (0.77)
d ₄ (% land cultivated)	-0.006 (-1.66)***
d ₅ (Simmons' index)	-0.148 (-2.11)**
gamma	0.60 (3.72)

*significant at 1%, **significant at 5%, ***significant at 10%

Household size, fertilizer and agrochemical quantities applied per hectare of land had significant and positive effects on output. The estimated gamma parameter (γ) indicates that about sixty per cent (60.13%) of the variation in the rice output was due to differences in technical efficiencies which ranged between 23.04% and 99.42% with a mean of 57.05%. The size of rice farm (most important crop to farmer), percentage of total land cultivated and land fragmentation index all had significant negative effects on technical inefficiency. In other words, the larger the size of rice farm cultivated, the lower will be the level of inefficiency. Furthermore, the higher the proportion of total land that is cultivated, the lower will be the technical inefficiency. Also, the higher Simmons' index is (the less fragmented the land), the lower the inefficiency will be.

CONCLUSION

The study has shown that about sixty per cent of variations in rice output in the study area are due to technical inefficiency which is significantly affected by land fragmentation. Though widespread, land fragmentation can be considered an obstacle to agricultural development in the study area as it contributes significantly to technical inefficiency. The role of government cannot be over-emphasized in helping to reduce the level of technical efficiency in agriculture. For instance, simple farm labour-saving machines can be made available to farmers so that they can cultivate larger land areas. This would eventually lead to higher technical efficiency levels and greater farm output for increased food security, higher incomes and better livelihoods for the farmers.

REFERENCES

Apata, T., Sanusi, A and V. Olajorin. (2016) Small farms and agricultural productivity in Nigeria: Empirical analysis of the effects of land tenure, fragmentation and property rights. Paper prepared for presentation at the annual world bank conference on land and poverty, Washington DC, March 14-18, 2016.

Awotide, D.O. and Agbola, P.O. (2010) Relationship between land fragmentation and maize farmers' productivity in northern Nigeria. *actaSATECH* 3(2):1-9.

Blarel, B., Hazell, P., Place, F. and Quiggin, J. (1992). The economics of farm fragmentation: Evidence from Ghana and Rwanda. *The world bank economic review* 6(2):233-254.

Hristov, J. (2009). Assessment of the high fragmented land impact over the productivity and profitability of the farms: The case of the Macedonian vegetable growers. Degree thesis in Business Administration, department of economics, Swedish University of Agricultural Sciences, Uppsala, Sweden. 77pp.

Kakwagh, V.V., Aderonmu, J.A and Ikwuba, A. (2011) Land fragmentation and agricultural development in Tivland of Benue state, Nigeria. *Current research journal of social sciences* 3(2):54-58.

King Russell and Burton Steve (1982) Land fragmentation: Notes on a fundamental rural spatial problem. *Progress in human geography* 6(4):475-494.

Latruffe, L. and Piet, L. (2013) Does land fragmentation affect farm performance?. A case study from Brittany. Factor markets working paper no. 40/April 2013. www.factormarkets.eu.

Lerman, Z. (2005) Farm fragmentation and productivity: Evidence from Georgia. Discussion paper no. 8.05, department of agricultural economics and management, center for agricultural economic research, Hebrew university of Jerusalem, Israel.

Manjunatha, A.V., Anik, A.R., Speelman, S. and Nuppenau, E.A (2013) Impact of land fragmentation, farm size, land ownership and crop diversity on profit and efficiency of irrigated farms in India. *Land use policy* 13:397-405.

- Meeusen, W and van den Broeck, J. (1977), Efficiency estimation from Cobb-Douglas production function with Composed error. *International economic review* 18:435-444.
- Nguyen, H. (2014) The effect of land fragmentation on labor allocation and the economic diversity of farm households: The case of Vietnam. MPRA Paper no. 57643 retrieved from <http://mpra.ub.uni-muenchen.de/57643>.
- Niroula, G.S and Thapa, G.B. (2005) Impacts and causes of land fragmentation, and lessons learned from land consolidation in South Asia. *Land use policy* 22:358-372
- Obwona, M. (2006) Determinants of technical efficiency differentials amongst small and medium-scale farmers in Uganda: A case of tobacco growers. *AERC Research paper* 152, African Economic Research Consortium, Nairobi.
- Okezie, C.A., Ahuchuogu, C.U and S. Jamalludin (2012). Exploring the link between land fragmentation and agricultural productivity. *International journal of agriculture and forestry* 2(1):30-34.
- Van Hung, P., MacAulay, T.G and Marsh, S.P. (2007) The economics of land fragmentation in the north of Vietnam. *The Australian journal of agricultural and resource economics* 51:195-211