EFFECT OF LAND FRAGMENTATION ON INPUT USE, YIELD AND PRODUCTION EFFICIENCY OF ARABLE CROP FARMERS IN IHIALA LOCAL GOVERNMENT AREA OF ANAMBRA STATE, NIGERIA

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ABSTRACT

This study analyzed impact of land fragmentation on the input use, yield and production efficiency of arable crop farmers in Ihiala local Government area, Anambra State, Nigeria. A multi-stage sampling procedure was used to select 90 respondents for the study. Data collected using well-structured questionnaire were analyzed using means, standard deviation, Simpson's index, stochastic frontier profit function and Ordinary Least Squares (OLS) regression analysis. Result showed that the Simpson index measuring the level of fragmentation was 0.54. The average farm size cultivated by the arable crop farmers was 2.33 ha. The mean cost of labour, seed, cuttings, fertilizer, pesticides and herbicides were ₦35987.01, ₦8020.77, ₦14044.44, ₦16198.04, ₦10500.00, and ₦7400.00 respectively; while the mean capital consumption allowance was ₦11348.06 and the mean value of output was ₦249601.2. The significant variables influencing farm profit were farm size (P < 0.001), normalized prices of labour (P < 0.001), planting materials (P < 0.010), and fertilizer (P < 0.001), and capital (P < 0.001). The significant determinants of the economics efficiency of the arable crop farmers were years of education (P < 0.001), household size (P < 0.005), farming experience (P < 0.001), extension contact (P < 0.001), and degree of land fragmentation (P < 0.001). The result showed that the individual economic efficiency indices range from 0.41to1.00 with mean of 0.778. The coefficient of fragmentation had negative and significant effect on output at 5% level of significance, farm size (at 1% level of significance level) and economic efficiency (at 1% level of significance level). For increased productivity and efficiency, farm consolidation programmes was therefore advocated as land fragmentation increases capital costs, labour demand and restrictions on the possibilities of agricultural mechanization.

KEYWORDS: Land, Fragmentation, Input Use, Yield, Production, Efficiency

1. INTRODUCTION

Land is an important resource for food, shelter and clothes. It is an essential natural resource, both for the survival and prosperity of humanity and for the maintenance of all global ecosystems (FAO, 2014). It is a basic resource for agricultural production. Majority of the population in sub-Saharan African countries like Nigeria live in rural areas and they depend on arable crop production as their major source of livelihoods. Arable farming entails the production of wide range of food crops or annual crops. This entails crops in which the life cycle is within one year; from germination to seed production and maturity. Arable crops included yam, maize, cocoyam, cassava, among others. The increase in food prices and food insecurity in various homes is not unconnected with the challenges facing arable crop production in the rural areas (Enete and Ubokudom, 2011).

Arable crop farming is subjected to various challenges ranging from scarcity of land and poor soil fertility, natural hazards, soil degradation, pests and diseases infestation, variations in rainfall and temperature, among others. Land fragmentation has been observed to have serious direct impact on agricultural production, because of the land-dependent nature of agricultural production systems (Enete and Ubokudom, 2011). They noted that the impact is particularly significant in developing countries like Nigeria where agriculture is the main source of income, employment and livelihoods for majority of the population.

Land fragmentation is the practice of farming a number of spatially separated plots of owned or rented land by the same farmer. It is a phenomenon which exists when a household operates a number of owned or rented non-contiguous plots at the same time as a single production unit (McPherson, 2014; Dovring and Dovring, 2009; Wu *et al*. 2005; Bentley, 1987). The existence of fragmented landholdings is regarded as an important feature of less developed agricultural systems. It can be a major obstacle to agricultural mechanization, causing inefficiencies in production of arable crop and involves large cost to alleviate its effects (Niroula and Thapa, 2007). Rahman and Rahman (2009) reported that land fragmentation has a significant detrimental effect on productivity and efficiency. According to Shuhao (2010) and Jha *et al.*, (2005), land fragmentation leads to increased travelling time between fields, hence lower labour productivity and higher transport cost for inputs and outputs. They noted that fragmentation also involves negative externalities such as reduced scope for irrigation, soil conservation investments and loss of land for boundaries and access routes.

Land fragmentation could result basically from either voluntary or involuntary choices by the farmer. According to Olarinre and Omonona (2018), voluntary choices which are demand driven are conditions or forces from outside or circumstances that may force the farmer to scatter or sub-divide his parcels. This can be done in order to acquire some financial gain majorly due to poverty index and need to go for specialized crop production on fragmented plot due to soils with different soil quality or fertility.

Involuntary choices are internal factors that the farmer has very little or no control over and yet they lead to land fragmentation. This is exemplified by inheritance and customary practices that forces people to divide their holdings or purchase additional holdings in attempt to achieve equitable distribution of properties among their heir as customs demands, increasing population densities across the world that puts a lot of pressure on the available land leading to land scarcity (Olarinre and Omonona, 2018; World Bank, 2015; Wadud and White, 2010).

Failure of land markets and state laws can also be a major cause for land fragmentation, where the transaction on land is restricted by law. This can have negative effect on the land consolidation policy. Obonyo (2015) noted that the nature of the landscape is one of the reasons for land fragmentation on the supply-side. Specifically, the boundaries such as waterways and wastelands allow the acquisition of separate pieces of land on either side of the natural boundaries leading to land fragmentation.

Customary tenure in cultures, where it is the responsibility of a father to divide his holdings equally among his sons, the problem of sub-division might become so severe and promote excessive fragmentation which is a drawback to land reform policy and impediment to agricultural development because of inefficiencies involved in owning a small unit vis-a-vis the

modem agricultural techniques (Obonyo, 2015).

Results from research on the negative effects imposed by land fragmentation on productivity and efficiency in agriculture are mixed, (Rahman and Rahman, 2009). Blakie and Sadeque (2000) argue that land fragmentation is becoming a serious limit in increasing wheat productivity in Nepal, India and other nearby regions. On the contrary, in Malaysia and Philippines high land fragmentation is not considered an impediment in paddy farming (Niroula and Thapa, 2005, cited in Obonyo, 2015). This goes long way to prove that as much as land fragmentation affects the food security, it is entirely not a negative factor hence should be considered on both sides by authorities when making decisions over the land.

Land fragmentation is more often believed to be one major problem existing in rural land management, especially in developing countries (Balogun and Akinyemi, 2017). Land fragmentation besides the positive effects causes many negative effects including inefficiencies and higher costs i.e. extra labour costs, more fuel inputs for travelling between one plot to another plot, more wastages due to increased leakages and evaporation of fertilizers, water, pesticides, when applied to smaller parcels of land as compared to when used on one single holding (Balogun and Akinyemi, 2017). Increased negative externality such as reduced scope for irrigation and soil conserving investments, access routes, loss of land due borders and greater possibilities for disputes between neighbouring farmers (Balogun and Akinyemi, 2017).

Africa with a huge potential to feed itself requires sustainable and efficient utilization of resources in order to increase agricultural productivity thus addressing persistent food security threat in the region. It is argued that that there are only two possible options left to increase food production; either increase yield per hectare or expand the amount of land to be cultivated or both (Hofstrand, 2012). Expansion of agricultural land area is, however, not feasible technically since arable land is limited; the latter remains the only viable option. Increasing productivity could, however, further pose a major environmental threat since most technologies adopted often involve intensive input application, including fertilizers and agro-chemicals, which may impact negatively on the environment.

According to Iheke (2010), the concept of efficiency is concerned with the relative performance of the processes used in transforming given inputs into output. The analysis of efficiency is generally associated with the possibility of farms producing a certain optimal level of output from a given bundle of resources at least cost. Efficiency is achieved either by maximizing output from given resources or by minimizing the resources required for producing a given output (Varian, 2014). Production efficiency is the product of technical and allocative efficiencies. Technical efficiency is the ability of a farm to maximize output for a given set of resource inputs while allocative efficiency refers to the choice of optimum combination of inputs consistent with the relative factor prices (Iheke and Nwanyanwu, 2017).

Efficiency is the ability of a firm to achieve potential maximum profit, given the level of fixed factors and prices faced by the firm (Ambali1, *et al.,* 2012). Aigner *et al*. (1977) however, showed that profit function models do not provide a numerical measurement of firm-specific efficiency and popularised the use of the translog production frontier approach. The stochastic frontier approach has gained popularity in firm- specific efficiency studies (Ambali1 *et al.,* 2012).

Example of recent application includes (Ali *et al*., 1994; Ambali1, *et al.*, 2012, Iheke and Nwanyanwu, 2017; Iheke, 2010; Iheke *et al.*, 2013; Iheke and Onyendi, 2017).

From the foregoing therefore, it has become necessary and indeed pertinent to evaluate the effect of land fragmentation on input use and production efficiency among arable crop farmers in Ihiala Local Government Area of Anambra State, Nigeria. The study is justified by the fact that despite the plethora of works on land fragmentation and efficiency, none has dwelt on the subject matter in the study area. This information generated would aid the policy makers, governmental and non -governmental organization to design and develop effective sustainable land management strategies and policies for improved agricultural productivity and efficiency. This study specifically estimated the degree of land fragmentation, examined the input use of the farmers and their level of output, determined the production efficiency of the farmers and the factors influencing it, and examined the effect of land fragmentation and other factors on input use and yield.

2. METHODOLOGY

This study was conducted in Ihiala Local Government Area (LGA) of Anambra State, Nigeria. Ihiala is located between Longitude $6^{o}70^{1}$ and $6^{o}65^{1}$ North of the Equator and Latitude $6^{o}20^{1}$ and $6^{o}30^{1}$ east of the Greenwich Meridian (Microsoft Encarta, 2009). The population of the state according to the National Population Commission (NPC, 2006) was 188,060 and an estimate of 400, 000 persons (NBS, 2016). The annual relative humidity is 75% reaching 85% in the rainy season. The vegetation of the area is rainforest type with annual rainfall ranging from 2000 mm – 3000 mm and temperature ranging from 22^{o}C and 35^{o}C. The majority of the inhabitants of the town are farmers mainly of subsistent type while others were civil servants, traders, and other professionals. Arable and cash crops are cultivated, with livestock kept on small scale basis.

All arable crop farmers in Ihiala Local Government Area of Anambra State, Nigeria comprised the sampling frame for the study. Multi-stage random sampling techniques was adopted in selecting a sample of 90 respondents. In the first stage, 3 communities from Ihiala L.G.A (Uli, Okija, Azia) were purposively selected. These communities were selected based on the population of arable crop farmers in the area, as gotten from the State Agricultural Development Programme. In the second stage, 3 villages were randomly selected from each of the three (3) communities, making a total of nine (9) villages. Ten (10) arable crop farmers were randomly selected from each of the nine (9) selected villages in the final stage, giving total 90 arable crop farmers for the study.

Primary data were used for this study. A well-structured questionnaire was used to obtain information from the selected respondents. Of the 90 questionnaire distributed, 86 were retrieved and used for the analysis. Data collected included those of age, sex, marital status, household size, education level, farming as primary occupation, years of farming experience, method of land acquisition, number of farm plots, average plot size, distance of farmland, extension visit, cooperation, problems encountered in farm operations, amount of credit and farm input such as cost of seeds, labour, fertilizer, agrochemicals, rent, farm implements and their number and costs, etc. and prices of farm output.

The analytical tools employed for this study were descriptive statistics, Simpson's index, net farm income formula, multiple regression analysis and stochastic frontier production function. With respect to measuring the degree of fragmentation, the Simmons Index of Simmons (1964), the Januszewski Index of Januszewski (1968) and the Simpson Index of Blarel *et al* (1992) are among the most commonly used fragmentation indices in the literature. None of these indices is superior to one another; they are essentially similar to each other and incorporate the same three parameters desirable in assessing the degree of fragmentation: farm size; number of plots; and the size of plots. The choice of index for this study is the Simpson Index. The Simpson Index is defined as the sum of the squares of the plot sizes, divided by the square of the farm size.

$$SI = \frac{\sum_{i=1}^{n} a_i^2}{A^2} \quad (1)$$

Where SI is the fragmentation index, n is the number of parcels belong to a holding, a is the size of a parcel and A is the total holding size. An SI value of 1 means that a holding consists of only one parcel and values closer to zero mean higher fragmentation.

The production efficiency of the farmers it in the study area will be analysed using economic (profit) efficiency. The economic efficiency was analyzed using the Cobb-Douglas profit function. It is given by:

$$\ln\Pi^* = In\beta_0 + \beta_1 InP^*_1 + \beta_2 InP^*_2 + \beta_3 InX_3 + \beta_4 InX_4 + V_1 - U_1 \quad (2)$$

Where ln = the natural logarithm, Π^* = normalized profit, βo = constant term, β_1 - β_4 = regression coefficients, P^*_1 = normalized price of fertilizers; P^*_2 = normalized price of labour; X_3 = farm size (ha); X_4 = capital inputs in naira; V_i is a symmetric error accounting for the effect of random variations in output due to factors beyond the control of the farmer e.g., weather, diseases outbreaks, measurement errors, etc. Vi is assumed to be independently and identically distributed as N (O, δv_2) random variables independent of the U_is which is a non-negative random variable representing inefficiency in production relative to the stochastic frontier. The U_is are assumed to be non-negative truncations of the N (O, δv_2) distribution (i.e., half normal distribution) or have exponential distribution.

In order to determine the factors contributing to economic efficiency, the following model was formulated and estimated jointly with the stochastic frontier profit model in a single stage maximum likelihood estimation procedure using the computer software frontier version 4.1:

$$EE_i = [\exp(-U_i)] = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \delta_5 Z_5 + \delta_6 Z_6 + \delta_7 Z_7 + \delta_8 Z_8 + \delta_9 Z_9 + \delta_{10} Z_{10} + \delta_{11} Z_{11} \quad (3)$$

Where EE_i= economic inefficiency effect of the ith farm; Z_1 = educational level of farmer in years of formal education completed; Z_2 = household size; Z_3 = sex of farmer (dummy; 1 = male, 0 female); Z_4 = age of farmer in years; Z_5 = primary occupation; Z_6 = years of farming experience; Z_7 = farm size (ha); Z_8 = credit access (dummy: 1 for access and 0 if otherwise);

Z_9 = Membership of association (dummy: 1 for membership and 0 if otherwise); Z_{10} = extension contact (numbers of contacts); Z_{11} = land fragmentation index; and δ_i = parameters to be estimated.

The effect of land fragmentation and other factors on input use and yield were analysed using the Ordinary Least Square regression model (OLS). The model is specified in the implicit form as:

$$Y= f (X_1, X_2, X_3, X_4, X_5.....X_8) \quad (4)$$

Where Y = amount of inputs used (naira); X_1= land fragmentation index (number measured by Simpson index); X_2 = income (naira); X_3 = access to credit (amount of credit accessed in naira) X_4 = extension contact (dummy: contact = 1, 0 otherwise); X_5 = membership of co-operative (dummy: member = 1,0 otherwise); capital (depreciation, rent etc. in naira); X_6 = farming experience (years); X_7 = education attainment (years); and X_8 = farm size (ha^2)

$$Y= f (X_1, X_2, X_3, X_4, X_5.....X_9) \quad (5)$$

Where Y = value of output (naira); X_1= land fragmentation index X_2 = farm size (ha^2); X_3 = labor cost (naira); X_4 = fertilizer (kg); X_5=capital (depreciation, rent etc. in naira); X_6 = extension contact (dummy: contact = 1, 0 otherwise); X_7 = membership of co-operative (dummy: member = 1,0 otherwise); X_8 = farming experience (years); and X_9 = education attainment (years).

Four functional forms of equations (4) and (5) namely: linear, exponential; semi long and double log function were fitted and the best fit model chosen for further analysis. The choice of the best fit model was based on the magnitude of the coefficient of multiple determination (R^2); the number of significant variables and the conformity of the signs borne by the coefficients of the variables to a priori expectations; and the significance of the F ratio.

3. RESULTS AND DISCUSSION

3.1 Degree of Fragmentation

The Simpson index (SI) was used to determine the degree of land fragmentation in the study area. The result showed an index of 0.54. This implies that there is still high level of fragmentation in the study area; a measure which if reversed by granting farmers access to contiguous farm holdings would lead to improved level of efficiency and productivity.

3.2 Input Use and Level of Output

The level of use of farm inputs and output produced are summarized and presented in Table 1

Table 1. Level of inputs and output

Variable	Mean	Standard deviation	Minimum	Maximum
Average plot size (ha)	2.33	1.81	0.4	4.5
Total labour (₦)	35987.01	95053.2	2000	53500
Seed (₦)	8020.77	1345.07	5750	15000
Cassava cuttings (₦)	14044.44	4474.55	9550	45000
Fertilizer (₦)	16198.04	3068.52	0	45000
Pesticide (₦)	10500.00	2543.63	0	31000
Herbicide (₦)	7400.00	9478.80	0	20000
Capital (₦)	11348.06	13271.19	710	16450
Output (₦)	249601.2	327139.9	75500	3150000

Source: Field Survey, 2019.

Table 1 showed that the average farm size cultivated by the arable crop farmers was 2.33 ha and the minimum and maximum were 0.4 and 4.5 hectares respectively, with a standard deviation of 1.81. Iheke (2010) reported a mean farm size of 2.73 and 1.98 hectares respectively for remittance receiving and non-receiving households. These farms despite being small were not contiguous farm holdings but fragmented, increasing the cost and time of moving from one plot to the other. This makes the drive towards farm mechanization difficult.

Table 1 further showed that the average amount spent on labour, seed, cassava cuttings, fertilizer, pesticides and herbicides were ₦35987.01, ₦8020.77, ₦14044.44, ₦16198.04, ₦10500.00, and ₦7400.00 respectively. These inputs are critical in agricultural production. According to Dome *et al. (*2015), higher input prices will increase total cost and as a result, farmers receive little output per hectare because of their inability to manage input costs. According to Mvodo-Meyo and Mbey-Egoh (2020), labour cost represents an integral part of production costs; production will be greatly affected by its variability. They asserted that in many instances, higher increase in labour cost has resulted in the inability of producers to cover functioning expenses.

Table 1 showed that there is increased used of fertilizer by the farmers as shown by the amount spent on fertilizer although there are farmers who did not use fertilizer. With declining soil fertility due to soil degradation and nutrient depletion, use of fertilizer and manure has been on the increase. The Food and Agriculture Organisation of the United Nations (FAO, 2005) reported that better fertilizer application implies an upwards shift in production and according to Byerlee *et al.* (1994), its low applicability results in low production, declining soil fertility and increase soil degradation through nutrient mining. Mvodo-Meyo and Mbey-Egoh (2020) reported that prices of variable inputs (fertilizers, labour and herbicides) are negatively correlated to maize production.

The mean capital cost (capital consumption allowance) was ₦11348.06 and the mean value of output was ₦249601.20. The average input cost was ₦103498.32. This implies that the farmers made a profit of ₦146102.88 (value of output less cost). The farmer operates at a profit if the value of output (total revenue) exceeds the total cost of production (sum of total variable and fixed costs).

3.3 Efficiency

3.3.1 Estimated profit function of the arable crop farmers

The maximum likelihood (ML) estimate of the stochastic frontier Cobb-Douglas profit function parameters for the arable crop farmers is presented in Table 2.

The estimated variance (δ^2) was statistically significant at 1 percent indicating the goodness of fit and correctness of the specified distribution assumptions of the composite error. Gamma (γ) was 0.869 and statistically significant at 1 percent. This implies that 86.9%percent of the variations in profit of the respondents are due to economic inefficiency.

Table 2. Estimated profit function of the arable crop farmers

Variable	Coefficient	Standard error	T-ratio
Intercept	11.698	1.092	10.716***
Farm size (X_1)	0.623	0.172	3.624***
Price of Labour (X_2)	-0.419	0.169	-2.477**
Price of planting material (X_3)	-0.329	0.204	-1.612*
Price of Fertilizer (X_4)	-0.055	0.016	-3.109***
Price of other agrochemical(X_5)	0.064	0.058	1.103
Capital (X_6)	0.392	0.036	10.782***
Diagnostic statistics			
Sigma squared	0.459	0.196	2.432**
Gamma	.869	0.321	2.7077***
Log likelihood function	-88.861		

Source: computed from Frontier 4.1/ Survey data, 2019.

The coefficients of the normalized prices of labour, planting materials, and fertilizer have the theoretically expected negative signs indicating that profit decreases with increase in the price of these variables, *ceteris paribus* for the arable crop farmers. This result conforms with the results of Mvodo-Meyo and Mbey-Egoh (2020), Iheke and Onyendi (2017) and Iheke (2010). Mvodo-Meyo and Mbey-Egoh (2020) noted that increase in input prices will reduce the quantity of inputs used production which ultimately results to low agricultural production; and this would lead to a concomitant decrease in farm profit. Similarly, high cost of inputs would lead to a reduction in profit since profit is the difference between value of output (revenue) and total cost of production.

The coefficients of farm size and capital were positively signed and significant indicating that increase in these variables would lead to increase in profit, *ceteris paribus.* Increase in farm size would lead to application of superior technology such as farm mechanization leading to increase output per unit of input and capital enables the farmer to purchase improved farm inputs and adoption of farm innovations for increased productivity. These would lead to increase in farm profits. These results are consistent with the findings of Iheke and Nwanyanwu (2017) who reported a positive and significant relationship between farm size, capital with profit.

3.3.2 Determinants of economic efficiency

Table 3 shows the result of the factors influencing the economic efficiency of the farmers. According to the Table, the significant determinants of the economics efficiency of the arable

crop farmers were years of education, household size, farming experience, extension contact, and degree of land fragmentation.

Table 3. Determinant of economic efficiency

Variable	Coefficient	Standard error	t-ratio
Intercept	2.611	1.601	1.631*
Age (Z_1)	-0.011	0.101	-0.111
Education (Z_2)	0.123	0.043	2.860***
Household size(Z_3)	0.041	0.019	2.195**
Farming experience (Z_4)	0.330	0.103	3.199***
Cooperative (Z_5)	0.628	0.898	0.699
Extension contact (Z_6)	0.536	0.137	3.912***
Credit (Z_7)	-0.258	0.268	-0.964
Fragmentation (Z_8)	-0.411	0.182	-2.258**

Source: Computed from survey data, 2019.

***= significant at 1%; **= significant at 5%; and *= significant at 10%.

The coefficient of education had a positive coefficient and was significant at 1% level of significance. This implies that economic efficiency increases with increase educational attainment. Education enable farmers to be able understand new and adopt improved agricultural innovations and how best to combine the farm resources for improved productivity and efficiency. This result corroborates the findings of Iheke and Onyendi (2017), Iheke and Nwaru (2014), Iheke *et al.* (2013), and Nnadozie and Nwaru (2002).

The coefficient of household size was positively related to the economic efficiency of the arable crop farmers and significant at 5% level of significance. The result agrees with Oyetunde-Usman and Olagunju (2019) and Dipeolu and Akinbode (2008) and implies that the larger the household size, the more economic efficient the household would be, *ceteris paribus.* Large household size eases labour constraints at critical production period thereby leading to increase in productivity. Iheke (2010) reported that large household size provide cheap source of labour for farm work as farmers rely more on members of their households for labour which more predictable than hired labour.

The coefficient of farming experience was significant at 1% level of significance and positively related to economic efficiency. This implies that the more experience the farmer in farming, the more economically efficient he becomes. This conforms to *a priori* expectations. This result is consistent with the reports of Onubuogu *et al.* (2014), Nurudeen (2012), Onaiwu (2011) and Oluwataya *et al.* (2008) that farmers with more experience would be more efficient, have better knowledge of climatic conditions and market situation and are thus, expected to run a more efficient and profitable enterprise. According to Iheke and Nwankwo (2016) and Nwaru (2004), the number of years a farmer has spent in the farming business may give an indication of the practical knowledge he has acquired on how he can overcome certain inherent farm production problems and challenges.

The coefficient of extension contact was significant at 1% level of significance and positively related to economic efficiency. This implies that the higher the contacts with extension agents,

the more economically efficient the farmer becomes. According to Nwaru *et al.* (2011), extension services provide informal training that helps to unlock the natural talents and inherent enterprising qualities of the farmer, enhancing his ability to understand and evaluate new production techniques leading to increased farm productivity and incomes with concomitant increase in the welfare of the farmer.

The coefficient of fragmentation was significant at 5% level of significance and negatively related to economic efficiency. This implies that he higher the fragmentation of farmland, the lower the economic efficiency. This result agrees with Dao (2013) who also reported a negative relationship between land fragmentation and efficiency but differs from the results of Balogun and Akinyemi (2017), Sherlund, *et al.* (2002), and Tan *et al.* (2010) that technical efficiency is higher for farmers who cultivate more plots than few. Gashaw *et al.* (2017), Deininger *et al.* (2014), and Kakwagh (2011) indicated that land fragmentation is often considered as the source of inefficiencies in crop productivity which is associated with production costs due to inefficient resource allocation; suboptimal usage of factor inputs that lowers overall returns to land due to losses on extra travel time, wasted space along borders, inadequate monitoring, and the inability to use certain types of machinery; hindering agricultural modernization and making it costly to modify adverse effects by consolidation schemes; and so forth. Empirically, they estimated that land fragmentation constitutes 60% of the total cash cost of production.

3.3.3 Distribution of efficiency

The efficiency distribution of the respondents is summarized and presented in Table 4.

Table 4. Distribution of economic efficiency of the arable crop farmers

Level of efficiency	**Frequency**	**Percentage**
0.41-0.60	14	16.28
0.61-0.80	27	31.40
0.81-1.00	45	52.33
Total	86	100.00
Mean	0.778	
Minimum	0.484	
Maximum	1.000	

Source: Computed from survey data, 2019.

Table 4 showed that the individual economic efficiency indices range from 0.41 to 1.00 with mean of 0.778. About 83.72% of the farmers have an economic index above 60 percent. The level of efficiency implies that ample opportunities exist for farmers to increase their efficiency for increased productivity.

3.4 Effect of Fragmentation on Output, Input use, and Efficiency

The effect of fragmentation on output and other variables is presented in Table 5. The result showed that the coefficients of multiple determination (R^2) were 0.7601. 0.8737, 0.7828, 0.8015, 0.4393, 0.2701, 0.6538, and 0.6716 for the output, farm size, labour, fertilizer, planting material, other agrochemical, capital, and efficiency functions, respectively. This showed that 76.01%, 87.375, 78.28%, 80.15%, 43.93%, 27.01%, 65.38% and 67.165 of the variations in output, farm size, labour, fertilizer, planting material, other agrochemical, capital, and efficiency of the

farmers respectively, was explained by land fragmentation. The F ratios were all statistically significant indicating the goodness-of-fit of the model.

The coefficient of fragmentation had negative and significant effect on output at 5% level of significance, farm size (at 1% level of significance level) and economic efficiency (at 1% level of significance level). This result implies that increase in land fragmentation would lead to decrease in output, farm size and economic efficiency of the arable crop farmers. This result is consistent with Gashaw *et al.* (2017), Balogun and Akinyemi (2017), Iheke ans Amaechi (2015), Austin *et al.* (2012), and Kakwagh *et al.* (2011). They reported a negative relationship between fragmentation and output, farm size, and efficiency. However, this result is in contrast with Paul and wa Gĩthĩnji (2018) who reported a positive relationship between fragmentation and output.

On the other hand, the coefficient of fragmentation was significant and positively related to labour, fertilizer, and agrochemicals. This implies that increase in the degree of fragmentation would, ceteris paribus, lead to increase in the use of labour, fertilizer and agrochemicals. This implies that fragmentation hinders the efficiency of resource use. This conforms with the reports of Gashaw *et al.* (2017), Deininger *et al.* (2014), and Kakwagh (2011).

Table 5. Estimated effects of fragmentation of output and other variables

Output	**Coefficient**	**t-ratio**	**R^2**	**R^{-2}**	**F-ratio**
Intercept	525149.9	4.19***			
Fragmentation	-92186.11	-2.32**	0.7601	0.7089	9.28***
Farm size					
Intercept	1.286	-19.85***			
Fragmentation	-0.864	-4.20***	0.8737	0.8138	17.65***
Labour					
Intercept	29.2111	9.82***			
Fragmentation	46.36326	4.89***	0.7828	0.7290	10.99***
Planting material					
Intercept	7384.947	2.51***			
Fragmentation	333.8759	0.36	0.8015	0.7504	12.81***
Fertilizer					
Intercept	25037.02	3.46***			
Fragmentation	4254.354	1.85*	0.4393	0.3579	3.44***
Agro-chemical					
Intercept	9234.613	1.83*			
Fragmentation	157.8978	0.10	0.2701	0.2118	2.01**
Capital					
Intercept	17042.48	3.56***			
Fragmentation	2177.599	1.43	0.6538	0.6122	6.05**
Efficiency					
Intercept	0.8645442	17.65***			
Fragmentation	-0.756565	4.87***	0.6716	0.6103	8.88

Source: Computed from survey data, 2019.

4. RECOMMENDATIONS

Based on the findings of this study, it was recommended that land reform policies that will grant farmers access to large and consolidated farm holdings for improved productivity and efficiency should be implemented. Also, there is the need for agricultural input subsidy policies as this would enhance farmers' accessibility to production inputs, leading to increased productivity and access to food. There is equally the need to strengthen the extension delivery system in Nigeria as improved extension contact by farmers enhances their efficiency.

5. CONCLUSION

It could be concluded that land fragmentation reduces farm productivity and efficiency. Also, the level of efficiency recorded indicated that ample opportunities exist for the arable farmers to improve on their efficiency and productivity. It could equally be deduced from the study that land fragmentation increases capital costs, labour demand and restrictions on the possibilities of agricultural mechanization.

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