



**ORIGINAL ARTICLE**

# Assessment of Effects of Land Degradation on Productivity of Arable Crop Farmers in Selected Local Government Areas of Ogun State, Nigeria

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DOI: <http://doi.org/10.4038/sljae.v4i1.82>

**Abstract**

The study assessed the farmers' level of awareness of land degradation (LD), determinant of LD, effect of LD on total factor productivity and, the mitigating measures adopted against LD. The study employed cross-sectional research design. Primary data were retrieved from 180 arable crop farmers while descriptive statistics were employed to assess the level of awareness and mitigating measures. Land degradation indices, total factor productivity and fractional and ordinary least square regression techniques were modelled to analyse the determinants and effects of LD on their productivity, respectively. The results showed that the level of awareness of LD problem was high among the farmers. The major determinants of land degradation in the area included bush burning, cropping system, system of land usage, soil structure, tillage and topography. In addition, the severity scale of bush burning was the lowest while that of topography was the highest. Moreover, LD, age of farmers, amount of credit accessed, agro-chemicals and labour-use tend to reduce the productivity of the farmers in the area. The arable crop farmers mitigated the effect of LD in the area mostly through terracing and avoidance of bush burning. Based on these findings, it is recommended that the government of Nigeria should focus on policies that can enhance sustainable land management and hence, increase productivity of the farmers in the area.

**Keywords:** Arable land, Land degradation, Nigeria, Productivity

## 1. Introduction

Globally, the importance of land for agricultural production cannot be over emphasized because without it, provision of food, fibre and other terrestrial ecosystem goods for the ever-growing world's population will be a mirage. Thus, poses serious threat to human existence which further hinders the sustainable development goals. Global Environment Facility (GEF) (2015) and, International Food Policy Research Institute and Center for Development Research (IFPRI and CDR) (2016) reported that about 25-30 percent of the global total land area has been degraded and that about three billion people reside in these degraded lands. The annual global cost of land degradation due to land use/cover change and the use of land degrading management practices on static cropland and grazing land was reported to be about 300 billion USD. It was further reported that if this trend continues, 95% of the Earth's land areas could become degraded by 2050. Out of this global cost, sub-Saharan Africa (SSA) accounted for the largest share of 22% (IFPRI and CDR 2016).

Land degradation can be described as an environmental phenomenon affecting dry lands, leading to loss of economic and biological quality of an agricultural land (Mantel & Engelen 1997; Debtanu et al. 2013). The ever-increasing population of the country coupled with the environmental changes due to climate change and poor land-use patterns has resulted an exertion of significant pressure on land for both agricultural and non-agricultural uses

(Sop & Oldeland 2011; Dardel et al. 2014). According to Debtanu et al. (2013) and Nigeria Land Degradation Neutrality (LDN) & the Global Mechanism of the United Nations Convention to Combat Desertification (UNCCD) (2018), land clearing, poor and unsustainable land management practices, overgrazing, mining, flooding, uncontrolled irrigation, illegal sand excavation, deforestation, bush burning, road grading, poor waste disposals, quarrying, infrastructure, transportation, and energy are some of these human activities that directly or indirectly enhance land degradation.

The resultant impact of land degradation includes loss of productive capacity of the soils for present and future usage, food shortage, increase in food prices, loss of farmlands, decrease in farm income, threatened livelihood of the rural poor who heavily depend on farming for survival, low yield of crops, increased salinity of the soil, food, and nutritional insecurity, decrease in fallow period of land, increased intensification in land use and rapid soil losses, destruction of economic trees and eventual deforestation of our forests and forest reserves (Onyerika 2016; Nigeria LDN and UNCCD 2018).

The practice of farming on viable land is known as arable farming and it has been ongoing for centuries both locally and globally. According to Nigeria LDN and UNCCD (2018), land degradation constitutes a serious problem on arable land across the various ecological zones of Nigeria though it varies from place to place in terms of the types, duration, severity, and socio-

economic impact. Tropical soils, such as what is obtainable in Nigeria, are less stable than those of the temperate climates. Therefore, these soils are usually severely threatened due to their fragile properties and the very aggressive climatic conditions. Moreover, the use to which the land is put is not often related to the land potential capacity of the use type (Senjobi 2001; Senjobi and Ogunkunle 2010). This is largely because the decision on land use rests virtually with landowners/users, who are mostly peasant farmers and are less concerned on the professional land evaluation outcome (Senjobi & Ogununle 2010). This had rendered some of the previously agriculturally rich lands, progressively unfit for agricultural production with low productivity of arable crops. This has impacted negatively on productivity of arable crops globally.

In addition to low productivity, land degradation also results in loss of productive capacity of the soils, loss of farmlands, threatened livelihood of the rural poor, increase in food prices, and decrease in farm income. Furthermore, it also leads to increased salinity of the soil, rapid soil losses, food and nutritional insecurity and deforestation of our forests and forest reserves.

Few studies have been carried out on land degradation in Nigeria, but none has assessed the effects of land degradation on the arable crop farmers' productivity in the study area. Hence, the study was carried out to advance body of knowledge on the extent and effect of land degradation on the total factor

productivity of arable crop farmers in the area by addressing the following specific objectives viz,

1. ascertain the arable crop farmers' level of awareness of land degradation (LD) problems
2. analyse the determinants of LD in the area
3. determine the effect of LD on total factor productivity of the arable crop farmers' productivity
4. identify mitigating measures adopted against LD problems in the study area.

The knowledge of these objectives will provide useful information for policy makers as basis for the formulation and execution of policies that will enhance sustainable land management practices among the vulnerable in the rural areas. This will help in increasing the arable farmers' productivity, *ceteris paribus*, thereby improve their living standards as well as promote their food and nutritional security.

## **2. Theoretical Review**

### ***Measurement of land degradation***

Land (Soil) degradation describes ongoing processes that generally limit agronomic productivity, result in undesirable or deteriorating physical, chemical, or biological properties, enhance soil displacement due to wind or water driven erosion, and require reassignment of land resources. Soil degradation often interacts with terrain and climatic factors defining an ecosystem to reduce sustainable land productivity; which, eventually, threatens food security (Oldeman

1992; Baumhardt et al. 2015). To analyse land degradation, many methods could be used as discussed thus:

### **Direct field measurement**

Direct measurement and observation at individual sites are the most accurate methods of detection of land degradation (Torrion 2002). The information on the temporal and spatial distribution of long-term soil loss in drainage basins and on the rates of soil erosion generated by these techniques are used to calibrate and test various background models. However classical methodologies for soil erosion measurement are capital and labour intensive as well as time consuming. They fail to produce detailed outputs due to budget constraint, inaccessible area, insufficient standardisation, and repeatability (Loughran 1989).

### **Geospatial remote sensing technique**

The geo-spatial remote sensing techniques is handy in mapping land degradation. Remote sensing techniques have large area coverage with varying temporal, spatial and spectral resolutions making it possible to monitor temporal and spatial land degradation patterns (Vrieling 2007). Satellite imagery is increasingly being used for regional land degradation studies (Vrieling 2007).

### **Severity method**

This method is used to measure land degradation by classifying the intensity of the land degradation in terms of how severe the land has been degraded. This method was used by Adewuyi & Baduku (2012). Extent of land degradation is Likert scaled into severe and not severe levels. The weakness of this method is that the measurement is more qualitative than quantitative. With this method the actual land degradation level is difficult to ascertain.

### **Land degradation perception index**

This method is used to measure the intensity of land degradation in a particular place. It was used in a study conducted by Yisa (2019) to classify the intensity of land degradation in the study area. The perception index is computed using the following formula:

$$PI = \sum_{N=1} \frac{PS}{N}$$

Where, PI = Perception index, N = Number of observations, PS = Perception score

The cumulative logistic probability function is expressed as:

$$P_i = F(Z_i) = F\left[\alpha + \sum_{i=1}^n \beta_i x_i\right] = \left[\frac{1}{1 + e^{-(\alpha + \sum \beta_i x_i)}}\right]$$

Where,  $\sum$  = summation sign,  $P_i$  = probability that  $i$ th farm is degraded given  $X_i$ ,  $X_i$  =  $i$ th farmers explanatory variables,  $i = 1, 2, 3, \dots, n$ ,  $Z_i$  = linear function of  $n$  explanatory variables ( $X_i$ ),  $e$  represent the base of logarithms,  $\alpha$  and  $\beta_i$  = regression parameters to be estimated in the

model, where  $\alpha$  = intercept and  $\beta_1, \beta_2, \dots, \beta_n$  = slope coefficient of the equation.

For the purpose of this study, land degradation perception index was chosen due to ease of analysis. It is less cumbersome and cheaper than direct measurement and geo-spatial remote sensing technique.

### ***Productivity measurement***

Total factor productivity (TFP) is a measure of the relationship between output (goods and services) and all inputs used in their production, such as labour, land, and capital. It is typically expressed as a ratio of outputs to inputs. An improvement in productivity means that more output can be obtained for a given input, or alternatively, that the same level of output can be obtained with fewer inputs (Hauver et al. 2003). Conventionally, productivity is measured by an index of output divided by inputs. Two measures of productivity are frequently used: the partial factor productivity (PFP) and total factor productivity (TFP). PFP is simply the ratio of output and any one of the inputs, typically labour or land. In notation form this can be expressed as:

$$PFP = Y/X_i$$

Where; Y is output, and X is input i.

Although commonly used, the partial factor productivity measure has one important weakness in that it does not control for the level of other inputs employed. Total factor

productivity on the other hand measures output per unit of total factor inputs. Therefore, total factor productivity is a generalization of single factor productivity measures such as land productivity or labour productivity (Odhiambo & Nyangito 2003).

Since productivity measures describe how the transformation of inputs into products is affected by efficiency and technological change, it follows that productivity measures are often volume based. However, in some cases, efficiency and technological change may not be factors behind increased productivity. One example would be if production were to double in response to a doubling of output prices caused by an external shock. Most farms produce multiple commodities with many inputs. While it is technically possible to define multi-product output in terms of physical measure (kilogrammes or joules, for example), it is simpler to convert volumes to monetary values to perform the aggregation (FAO 2017). Based on this premise, TFP will be measured in monetary terms in this study.

### ***Land degradation and mitigating measures***

Land degradation is largely a society-driven problem which can be effectively managed only through a thorough understanding of the principal ecological, socio-cultural, and economic driving forces associated with land use and climate change, and their impacts (Bartman et al. 2007). The mitigating

measures and problems can be interrelated, e.g., grazing by animals can help reduce the risk for forest fire (Conacher & Sala 1998) but at the same time may lead to overgrazing problems if not controlled properly. According to Baartman et al. 2007, there are two main approaches to solving/mitigating LD. These are biophysical solutions and, political and socioeconomic solutions.

**Biophysical solutions:** This involves the application of physical and biological methods to solving LD problems. It can be subdivided into four different measures. These include first, agronomic measures (such as, minimum tillage, crop rotation, optimum soil cover, manuring/composting, mixed cropping, contour cultivation and mulching). These measures are of short duration, are independent of slope and usually associated with annual crops. However, these do not lead to changes in slope profile but are repeated routinely or in a rotational sequence. Second, vegetative measures (such as grass strips, hedge barriers, wind breaks or agroforestry). They involve the use of perennial grasses, shrubs, or trees. They are of long duration and often leads to changes in slope profile. In addition, they are often aligned along the contour or against the wind. Third, management measures (such as land use change, drainage channels, rotational grazing, and area closure). This involves fundamental change in land use and often results in improved vegetative cover. They do not and finally, structural measures (such as terraces,

bunds, and construction palisades) which are of long duration and often require substantial inputs of labour and capital when first installed. It usually involves major earth movements and/or construction with wood, stone, and concrete. They are carried out primarily to control runoff, wind velocity and erosion. Combination of all these measures is most versatile and has proven to enhance the effectiveness of the various measures in tackling LD.

**Political and socio-economic solutions:** This includes a variety of factors such as training and extension, markets, socio-cultural issues, participation, credit facilities, legislative and political issues. Perhaps even more than with bio-physical measures, these “approaches” consist most often of a combination of different measures and are often framed in a project or programme strategy. It is therefore difficult to highlight specific single solutions in this respect. but a few important elements can be highlighted:

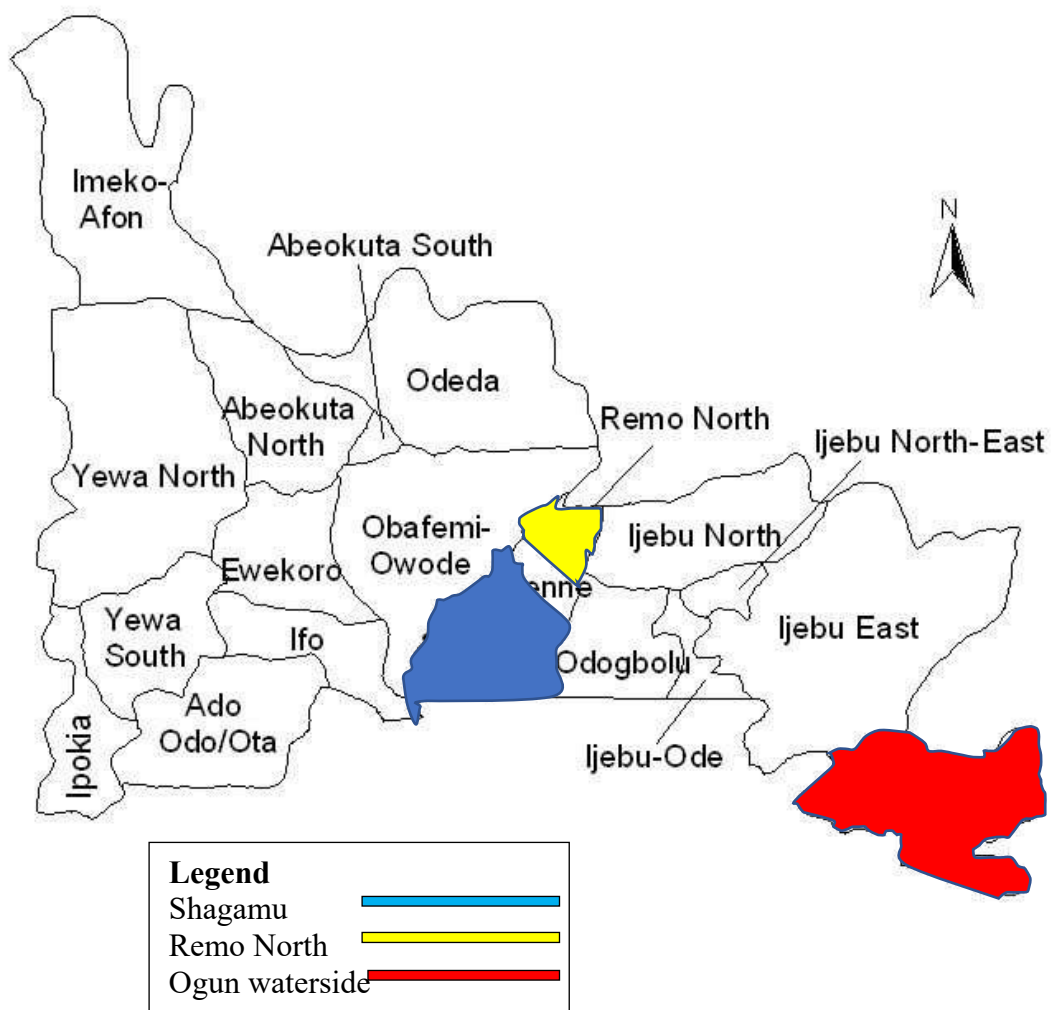
### 3. Materials and Methods

#### ***Sampling procedure and data description***

The study covered three Local Government Areas (LGAs) of *Ogun* State, Nigeria namely, Sagamu. *Ogun* waterside and *Remo* North LGA of *Ogun* State Nigeria (Fig 1). The State is located in the South-Western part of Nigeria. It is bounded in the west by the Republic of Benin, in the east by *Ondo* State, in the south by Lagos State and in the north by *Osun* and *Oyo* States. It

lies within latitude 6 °N and 8 °N and longitude 2 °E and 5 °E. It has a land area of about 16,980 km<sup>2</sup> and a population of about 3,751,140 (National Population Commission (NPC) 2006) which is approximately 2.7% of Nigeria's population. Farming is the major occupation of the people, particularly those living in the rural areas. The average temperature is 27.1 °C. August is the coldest month with a mean temperature of 25.0 °C. Average annual precipitation is 1,514 mm which favours the production of arable crops such as maize, yam, cassava, rice, cocoyam and tree crops like kola nuts, cashew, and oil-palm. *Sagamu*, which comprises of 15 wards, is the main town in the LGA and has an area of 614 km<sup>2</sup> and an estimated population of 355,900 as at 2016 (NPC 2020). *Ogun* waterside with 10 wards, has an area of 1,000 km<sup>2</sup> and an estimated population of 103,200 as at 2016 (NPC 2020) while Remo North with 10 wards also, has an area of 199 km<sup>2</sup> and an estimated population of 83,100 as at 2016 (NPC, 2020). These three LGAs were purposive selected because land degradation menace was prevalent in the area. This was followed by stage two where three towns/villages were randomly selected from each of the three LGAs. The third stage involved a random selection of twenty farmers from the selected towns/villages using a simple random selection technique giving a total of 180 sampled arable crop farmers in the area. Simple random sampling procedure used in the second and third stages was to give each of the arable crop farmers equal opportunity of being selected. Data for this study were collected from

cross-sectional survey of arable crop farmers in the area during the 2018/2019 cropping season to have interaction with the farmers and to gather useful information on the effects of land degradation on the TFP of their arable farming. Trained enumerators from Agricultural Development Programme (ADP) offices in the area who were conversant with the terrain of the study area and dialect of the respondents were used to administer the interview schedule. Data were collected on arable farmers' socio-economic factors, level of awareness of land degradation, land degradation drivers, source of information on land degradation, production variables as well as their mitigating measures against land degradation.



**Figure 1:** Map of Ogun State showing selected Local Government Areas

Source: Gbadebo et al. (2012)



### **Analytical Techniques**

Inferential statistics and econometric techniques were employed for the analysis of study objectives. To ascertain arable crop farmers' level of awareness of land degradation and the mitigating measures adopted against land degradation in the study area, 5-point Likert scale was employed. The categorizations for the farmers' opinions were strongly aware (5), aware (4), undecided (3), unaware (2) and strongly unaware (1). These scales were aggregated together to get a mean of 3.0. Any weighted mean score of  $\geq 3.0$  was considered as high level of awareness of land degradation and vice-versa for any weighted mean of  $< 3.0$ . For the latter, the categorization was strongly agree (5), agree (4), undecided (3), disagree (2) and strongly disagree (1). Any weighted mean score of  $\geq 3.0$  was considered as major mitigating measure against land degradation and vice-versa for any weighted mean of  $< 3.0$ .

Fractional regression was then used to analyse the determinant of land degradation in the study area. It is a well-developed alternative for modelling bounded dependent variables and its similar to ordered logit regression in many respects but is more flexible because the dependent variable can be measured as continuous over a defined bounded range. Thus, fractional regression will not lead to misleading findings (in comparison to OLS) when modelling bounded dependent variables (Oberhofer & Pfaffermayr 2012).

Land degradation index (LDI) was measured in terms of degradation dimensions caused by bush burning, cropping system, soil, tillage, topography, source of information and water, having different sub-indicators. The value of the index ranges from 0–1 means a 'complete' and 'no degradation'. For further explanation of the findings, this study used an extent of a severity scale for the description of the land degradation index, that is, 0–0.20 (very severe), 0.21–0.40 (severe), 0.41–0.60 (moderate), 0.61–0.80 (light) and 0.81–1 (no degradation). The following specific methodology was used for aforementioned different land degradation indicators as used by different researchers (Baumhardt et al. 2015; Beniston and Mercer 2015; Adeniyi et al. 2017, Sione et al. 2017; Israr et al. 2018) in different parts of the world.

### **Bush burning degradation index**

To measure the effect of bush burning on land degradation, four indicators as used by different researchers (Schwaab et al. 2017; Corstanje et al. 2017) were used by constructing the following formula viz:

$$IBBD = \frac{X_{LMC} + X_{LV} + X_{LMI} + X_{CC}}{4} = \left( \sum_{i=1}^4 X_i \right) / 4 \dots \dots \dots (1)$$

Where, IBBD = Index of bush burning;  $X_{LMC}$  = loss of moisture retaining capacity of the soil (1 if yes, otherwise 0);  $X_{LV}$  = loss of vegetation (1 if yes, otherwise 0);  $X_{LMI}$  = loss of microbes in the soil (1 if yes, otherwise 0);  $X_{CC}$  = colour change (1 if yes, otherwise 0).

### **Index of cropping system degradation**

The cropping system of land degradation was measured by taking the following five indicators.

$$ICSD = \frac{X_{MC} + X_{CR} + X_{SC} + X_{IC}}{4} = \left( \sum_{i=1}^4 X_i \right) / 4 \dots \dots (2)$$

Where, ICSD = Index of cropping system degradation;  $X_{MC}$  = mono-cropping (1 if yes, otherwise 0);  $X_{CR}$  = crop rotation (1 if yes, otherwise 0);  $X_{SC}$  = sequential cropping (1 if yes, otherwise 0);  $X_{IC}$  = inter-cropping (1 if yes, otherwise 0)

### **Soil structure degradation index**

The effect of soil structure degradation was measured using the following five indicators.

$$ISSD = \frac{X_{RT} + X_{ES} + X_{CG} + X_{PP} + X_{LM}}{5} = \left( \sum_{i=1}^5 X_i \right) / 5 \dots \dots (3)$$

Where, ISSD = Index of soil structure degradation;  $X_{RT}$  = Removal of the topsoil (1 if reported yes, otherwise 0);  $X_{ES}$  = Exposure of the subsoil (1 if reported yes, otherwise 0);  $X_{CG}$  = Colour change (1 if reported yes, otherwise 0);  $X_{PP}$  = Problems of ploughing (1 if reported yes, otherwise 0);  $X_{LM}$  = Low moisture retaining capacity (1 if reported yes, otherwise 0).

### **Land ownership degradation index**

Land ownership was measured by taking the following four indicators.

$$ILOD = \frac{X_I + X_P + X_G + X_L}{4} = \left( \sum_{i=1}^4 X_i \right) / 4 \dots \dots (4)$$

Where, ILOD = Index of land ownership degradation;  $X_I$  = Inherited (1 if yes, otherwise 0);  $X_P$  = purchased (1 if yes, otherwise 0);  $X_G$  = Gift (1 if yes, otherwise 0);  $X_L$  = Leased (1 if yes, otherwise 0)

### **Tillage degradation index**

The effect of tillage was measured by taking the following four indicators.

$$ITD = \frac{X_{RO} + X_{RS} + X_{RT} + X_{DS}}{4} = \left( \sum_{i=1}^4 X_i \right) / 4 \dots \dots (5)$$

Where, ITD = Index of tillage degradation;  $X_{RO}$  = Reducing organic matter content of soil (1 if yes, otherwise 0);  $X_{RS}$  = Reduced slope gradient of soil (1 if yes, otherwise 0);  $X_{RT}$  = Reducing terracing for land management practice (1 if yes, otherwise 0);  $X_{DS}$  = Destruction of soil structure (1 if yes, otherwise 0).

### **Information degradation index**

Source of information on land degradation was measured by taking the following seven indicators.

$$IFD = \frac{X_{RO} + X_{TV} + X_{NP} + X_{FR} + X_{TC} + X_{EA} + X_{SG}}{7} = \left( \sum_{i=1}^7 X_{i=1} \right) / 7 \dots \dots (6)$$

Where, IFD = Index of information;  $X_{RO}$  = Radio (1 if yes, otherwise 0);  $X_{TV}$  = Television (1 if yes, otherwise 0);  $X_{NP}$  = Newspaper (1 if yes, otherwise 0);  $X_{FR}$  = Friends (1 if yes, otherwise 0);  $X_{TC}$  = Town crier (1 if yes, otherwise 0);

XEA = Extension agent (1 if yes, otherwise 0);  
 XSG = Social group (1 if yes, otherwise 0).

**Water degradation index**

To measure water degradation, six indicators were used.

$$IWD = \frac{X_{LS} + X_{RD} + X_{RS} + X_{RR} + X_{IC} + X_{IF}}{6} = \left( \sum_{i=1}^6 X_i \right) / 6 \dots \dots \dots (7)$$

Where, IWD = Index of water degradation; XLS = Loss of vegetation (1 if yes, otherwise 0); XRD = Reduced the drainage density of water runoff (1 if yes, otherwise 0); XRS = Reduced the slope gradient (1 if yes, otherwise 0); XRR = Reduced runoff water storage (1 if yes, otherwise 0); XIC = Increased climate change (1 if yes, otherwise 0); XIF = Increase land fragmentation (1 if yes, otherwise 0).

**Topography degradation index**

To measure topography degradation index, four indicators were used:

$$ITP = \frac{X_{SS} + X_{GS} + X_{ES} + X_{FS}}{4} = \left( \sum_{i=1}^4 X_i \right) / 4 \dots \dots \dots (8)$$

Where, ITP = Index of topography XSS = Steep slope (1 if yes, otherwise 0); XGS = Gentle slope (1 if yes, otherwise 0); XES = Even slope (1 if yes, otherwise 0); XFL = Flat slope (1 if yes, otherwise 0).

**Overall land degradation index**

The overall land degradation index was calculated by summing the degradation indices of bush burning, cropping system, soil

structure, land ownership, tillage, information, and water as expressed in equation 8.

$$IOLD = \frac{X_{IBD} + X_{ICD} + X_{ISD} + X_{ITD} + X_{IWD} + X_{IFD} + X_{ITPD}}{8} = \left( \sum_{i=1}^8 X_i \right) / 8 \dots \dots (8)$$

Where, IOLD= Index of Overall land degradation; XIBD = Index of bush burning degradation; XICD = Index of cropping system degradation; XISD = Index of soil structure degradation; XITD = Index of tillage degradation; XIWD = Index of water degradation; XIFD = Index of information; XITPD

Fractional regression was used to achieve the determinants of land degradation in the study area.

The model is implicitly specified as follows:

$$E(y_i/x_i) = G(x_i \beta), i = 1, \dots, N \dots \dots \dots (9)$$

Where,  $0 \leq y_i \leq 1$  denotes the dependent variable, LDI, and (the 1 x k vector)  $x_i$  refers to the explanatory variables of observations,  $G(.)$  is a distribution function

$\beta$  = Regression parameter and  $N$  = Number of observations

Simply put,  $Y = (X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, X_9, X_{10}, X_{11}, X_{12}) \dots \dots \dots (10)$

Where,

LDI = Land degradation index

BBGX<sub>1</sub> = Bush burning (Yes = 1; 0 otherwise)

AGFX<sub>2</sub> = Age of farmers (Years)

TCSX<sub>3</sub> = Types of cropping system (Sole = 1; 0 otherwise)

LUIX<sub>4</sub> = Land use intensity (No of years the land is allowed to rest before re-cultivated)

LOPX<sub>5</sub> = Land ownership (ownership = 1; 0 otherwise)

TOSX6 = Types of soil (Sandy = 1; 0 otherwise)  
 FWGX7 = Frequency of weeding (No)  
 NECX8 = Number of Extension contact (No)  
 EDLX9 = Educational level (Years)  
 HHSX10 = Household size (No)  
 SOIX11 = Source of information (Media = 1; 0 otherwise)  
 FMSX12 = Farm size (Ha)  
 TILX13 = Tillage (Complete = 1; 0 otherwise)  
 TPYX14 = Topography (Sloppy = 1; 0 otherwise)  
 UOFX15 = Use of organic fertilizer (kg)  
 WTRX16 = Water (1 if yes; 0 otherwise)  
 $\mu$  = Error

The analysis of the effect of land degradation on the productivity of arable crop farmers in the study area also involved a two-stage procedure as used by Ojo et al. (2020). The first stage involved generating the Productivity Index while the second stage involved the use of ordinary least square regression analysis to determine the effect of land degradation on the productivity of arable crop farmers in the study area. The most common causes of land degradation in the area were deforestation, bush burning, water erosion and acid sulphate formation. All these resulted from poor land use of human activities and if these activities are not curtailed on time, the land may be permanently unfit for agricultural production with underlying effect on productivity of the farmers and it can also impact negatively on the health and socio-economic well-being of the vulnerable in the area. This result is consistent with previous studies which affirmed that there

were natural and man-made causes of land degradation. The former included earthquakes, tsunamis, droughts, avalanche, landslides, mud flow, volcanic eruptions, flood tornado and wildfire, while the latter resulted from land clearance, deforestation, overgrazing by livestock, inappropriate irrigation and over drafting, urban sprawl, and commercial development and, pollution from industries, quarrying, and mining activities. (Okezie and Amaefula 2006; Etuonovbe 2009; Debtanu et al. 2013; Onyerika 2016; Okorafor et al. 2017).

### **Total factor productivity (TFP)**

The TFP of the arable crop farmers in the study area was expressed as follows:

$$TFPI = \frac{VOP}{VIE} = \frac{VOP}{TVC} \dots\dots\dots (11)$$

Where,

Total Factor Productivity Index

VOP= Value of output (₦)

TVC = Total Variable Cost (₦)

VIE = Value of inputs employed (VIE) (₦)

The scores generated were fitted into fractional regression model as the dependent variable, Y.

The model is implicitly specified as follows:

$$Y = (X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, X_9, X_{10}, X_{11}, X_{12}) \dots\dots\dots (12)$$

$$TFPI = \beta_0 + \sum \beta_n X_n + \dots + \mu \dots\dots\dots (13)$$

TFPI = Total factor productivity index

ASX1 = Amount of seed used (kg)

FSX2 = Farm size (Ha)

LRX3 = Labour (Man-day)

ACX4 = Agro-chemicals (Litres)

FZX5 = Fertiliser (kg)

CIX6 = Capital input (Naira)

AGX7 = Age (Years)

SXX8 = Gender (Male = 1, female = 0)

EDX9 = Education (Years)

FEX10 = Farmer's experience in farming  
(Years)

CAX11 = Amount of Credit accessed (Naira)

FCX12 = Extension visits (No.)

LDIX13 = Land degradation index

### 3. Results and Discussion

#### ***Farmers' level of awareness of land degradation problem***

The result in Table 1 revealed the level of awareness of causes and effects of land degradation by arable farmers in the study area. Accordingly, the level of awareness about different types and causes of land degradation in the area was very high because all the weighted mean scores were greater than 3.0. In addition, it was revealed that deforestation, bush burning and water erosion which ranked 1<sup>st</sup>, 2<sup>nd</sup>, and 3<sup>rd</sup> respectively, were prominent among the causes of land degradation in the area. However, climate change and urban/industrial encroachment ranked least among the causes of land degradation in the area. Further, acid sulphate formation and soil fertility decline ranked 1<sup>st</sup> and 2<sup>nd</sup>, respectively while salinisation was the least among the itemized effects of LD in the area. All these resulted from poor land use of human activities and if these activities are not curtailed on time, the land may be permanently unfit for agricultural production with underlying effect on productivity of the farmers and it can also

impact negatively on the health and socio-economic well-being of the vulnerable in the area. This result is consistent with previous studies which affirmed that there were natural and man-made causes of land degradation. The former included earthquakes, tsunamis, droughts, avalanche, landslides, mud flow, volcanic eruptions, flood tornado and wildfire while the latter resulted from land clearance, deforestation, overgrazing by livestock, inappropriate irrigation and over drafting, urban sprawl and commercial development and, pollution from industries, quarrying, and mining activities (Okezie & Amaefula 2006; Etuonovbe 2009; Debtanu et al. 2013; Onyerika 2016; Okorafor et al. 2017).

**Table 1:** Level of awareness of causes and effects of land degradation

Causes and effects of land degradation	Weighted Sum	Weighted Mean Sum	Rank	Remark
<b>Causes of LD</b>				
Deforestation	748	4.20	1st	HLA
Bush burning	712	4.00	2nd	HLA
Water erosion	697	3.87	3rd	HLA
Mining	660	3.67	4th	HLA
Wind erosion	647	3.59	5th	HLA
Waterlogging	638	3.54	6th	HLA
Soil pollution	625	3.47	7th	HLA
Climate change	584	3.24	8th	HLA
Urban & industrial encroachment	545	3.03	9th	HLA
<b>Effects of LD</b>				
Acid sulphate formation	693	3.85	1st	HLA
Soil fertility decline	690	3.83	2nd	HLA
Lowering of water table	651	3.62	3rd	HLA
Salinisation	607	3.37	4th	HLA

HLA= High Level of Awareness

Source: Field survey, 2019

**Table:** Determinants of land degradation in the study area

Variable	Robust		
	Coefficient	standard Error	z-value
Constant	-1.627***	0.079	-20.57
Bush burning	0.401***	0.062	6.52
Age of farmers	0.001	0.001	0.98
Cropping system	0.488***	0.099	4.92
Land use intensity	-0.009*	0.005	-1.94
Land ownership	0.404***	0.025	15.91
Soil structure	0.317***	0.037	8.50
Frequency of weeding	-0.004	0.008	-0.47
Extension contacts	0.079**	0.036	2.18
Educational level	0.003*	0.002	1.92
Household size	0.003	0.003	0.91
Source of information	0.441***	0.045	9.79
Farm size	-0.011***	0.003	-3.62
Tillage	0.262***	0.043	6.12
Topography	0.355***	0.022	15.94
Fertilizer	0.002	0.001	1.08
Water	0.432***	0.044	9.88
Pseudo R <sup>2</sup>	13.79		

Prob > chi<sup>2</sup> = 0.0000, \*\*\*=significant at 1%, log pseudo-Likelihood = -103.8605

Source: Field survey, 2019

### ***Determinants of land degradation in the study area***

Using fractional regression analysis, Table 2 shows the various determinants of land degradation in the area. The Prob > chi-square value showed that the whole model was statistically significant at  $P < 0.01$ . The result revealed that bush burning (6.52), cropping system (4.92), land ownership (15.91), soil structure (8.50), extension contact (2.18), educational level (1.92), source of information (9.79), tillage (6.12), topography (15.94) and water (9.88) were all positive and significant at  $P < 0.01$  probability level, respectively while land use intensity (-0.94) and farm size (-3.62) were both negative but significant at  $P < 0.10$  and  $P < 0.01$ , respectively. However, the result can better be interpreted by running the marginal effect and the elasticity of these significant variables as shown in Table 3.

### ***Estimation of marginal effects and partial/quasi elasticity***

Analysis of marginal effect and partial elasticity were carried out on the significant variables of the fractional regression analysis of the determinants of land degradation in the area. The estimates of the marginal effect showed that, out of all the variables, cropping system, source of information on LD and water had more effect on land degradation as one percent increase in each of the variables led to 16.0%, 14.4% and 14.1% increase in the probability of the land being degraded, respectively. These were followed closely by land ownership, bush

burning, topography, soil structure and tillage, as one percent increase in each of the variables led to 13.2%, 13.1%, 11.6%, 10.4% and 8.6%, increase in the probability of the land being degraded. However, extension contact, and educational level of the farmers had negligible positive effect of LD tendency in the area as one percent increase in the variables led to 2.6% and 0.1% in the probability of the land being degraded, respectively.

The type of cropping system adopted could enhance the loss of the biological diversity of soil and hence, LD when practiced alongside unsustainable farming techniques. Also, land ownership could also have the possibility of increasing LD because, decision on land use rests virtually on landowners/users who are mostly peasant farmers and are less concerned on the professional land evaluation outcomes. Besides, the source of information is also very paramount in decision making. Access to right information keeps farmers abreast with the cause and effect of activities that can influence LD. Farmers who obtain information from the right sources can adopt farming practices that are sustainable and could prevent/reduce LD and vice versa.

In contrast, land use intensity and farm size had little or no effect on LD in the area as, one percent increase in these variables led to only 0.3% and 0.4% decrease in probability of LD in the area. The more frequent a land is put into usage, the more the tendency of the farmers to adopt practices that will reduce the impact of environmental factors on their land and hence

reduce LD problem. In addition, small farm size could easily be managed than big farm sizes. A well-managed farm would reduce the exposure of such farms to LD problems. The findings of this research have shown that environmental factors were the main determinants of LD in the area. The finding disagrees with the findings of Assemu and Mekuriaw (2014) who reported that small farm size, land tenurial problems and land redistribution can hinder the adoption of land management practice

**Table 3:** Marginal effects and elasticity of the significant variable

Variable	Robust	
	Marginal Effect	Elasticity
Bush burning	0.131	0.159
Cropping system	0.160	0.149
Land use intensity	-0.003	-0.020
Land ownership	0.132	0.121
Soil structure	0.104	0.106
Extension contacts	0.026	0.006
Educational level	0.001	0.026
Source of information	0.144	0.148
Farm size	-0.004	-0.022
Tillage	0.086	0.093
Topography	0.116	0.093
Water	0.141	0.148

Source: Field survey, 2019

### ***Severity of the determinants of land degradation***

The severity of the determinants of land degradation is shown in Table 4 with severity scale ranging from 0 to 1. The result revealed

that land degradation existed in the area though it was not very severe. Land degradation intensity (severity scale) ranged from moderate to light degradation. Bush burning was lowest with severity scale of 0.72 while topography was highest with severity scale of 0.52. Issues on topography, cropping system, land ownership and sources of information needed to be addressed early before downturn to severe land degradation in the area. The result revealed that land degradation existed in the area though it was not very severe. Land degradation intensity (severity scale) ranged from moderate to light degradation. Severity of bush burning was lowest with severity scale of 0.72 while severity of topography was highest with severity scale of 0.52. Severity of land degradation in the area resulted from inappropriate land use. Therefore, sustainable land management practices should be adopted to reclaim degraded land and to forestall re-occurrence in the future. This result corroborates the findings of some of the past research in southwest zone of Nigeria and other parts of the continent. For instance, Adeniyi et al. (2017) conducted research on development of a composite soil degradation assessment index for cocoa agroecosystems in southwestern Nigeria. It was reported that 65 % of the selected cocoa farms in the study area were moderately degraded, while 18 % had a high degradation status. The finding also agrees with the study conducted by Senjobi & Ogunkunle (2010) who reported that the degradation level in Ogun State in



Southwestern Nigeria ranked from moderate to high due to inappropriate land uses.

Going beyond Nigeria to Pakistan in south Asia, Israr et al. (2018) conducted a study on the land degradation process in northern irrigated plains of Pakistan. They reported that the result of extent of severity scale revealed that land degradation sub-indicators ranged from light to moderate and high severity in the area. However, the result is at variance with the study of Sonneveld et al. (2016) that reported severe land degradation tendencies in Senegal.

### ***Effect of land degradation on total factor productivity of arable crop farmers***

The result of the econometric analysis of effect of land degradation on the productivity of the arable crop farmers using Ordinary Least Square regression analysis was presented in Table 5. The whole model was significant at  $P < 0.01$  probability level. The result revealed that the coefficient of farming experience and extension visit were both positive and significant at  $P < 0.01$ , respectively which showed that an increase in years of farming experience and frequency of extension visit to the farmers led to increased productivity of the farmers. The engagement of farmers in regular farming operation activities/practices help the farmers to monitor and evaluate the effects of his practices and decisions on his production output and productivity level. This aids constant adjustment in his farming practices which could improve the farmers' productivity.

Moreso, extension agents, through their visits, help in the dissemination of relevant information on better farming practices and sustainable soil management practices that will mitigate the problem of land degradation. On the contrary, age of farmers ( $P < 0.01$ ), access to credit ( $P < 0.01$ ), labour ( $P < 0.05$ ) and agrochemicals ( $P < 0.05$ ) all had negative coefficients which showed that an increase in each of the variables led to decrease in the productivity of the arable crop farmers. This implied that as the farmers became advanced in age, the likelihood of being productive reduced. In addition, excessive use of labour and agrochemicals also reduced the likelihood of the farmers' being productive. Access to credit did not follow the *a priori* expectation of positively influencing the productivity of the farmers. This could occur partly because of late disbursement of credit facilities and relevant production inputs to farmers. Since arable crop production is time bound, this could distort the planting operations on the farm. Secondly, there could be diversion of accessed credit to other unproductive activities or unintended purposes. The finding of this research also revealed that land degradation had negative effect on the productivity of arable crop farmers in the area. Wherever and whenever, there is existence of land degradation whether, light, moderate or highly severe, it usually impacts negatively on the soil structure and texture, ecosystems, the livelihood of the farmers as well as the economy as a whole. Moreover, due to competing uses of

land for both agricultural and non-agricultural activities, land degradation further poses a restriction on land available for agricultural production thereby undermining agricultural productivity, sustainability and management for food and nutritional security in the area. Thus, inducing high food prices with low returns to the farmers. Different research outputs are in agreement with these findings. Okpala-okaka (2009) and Onyerika (2016) reported that reduction in crop yield, loss of farm labour due to forced migration, reduction in land productivity, decrease in farm income and destruction of markets and other infrastructure, were the major perceived effects of land degradation on agricultural production. In line with this, Lal (1997) conducted a study on degradation and resilience of soils affirmed that soil degradation results in decrease productivity, reduction in biomass and, decline in environmental quality. The finding is also in consonance with Sonneveld et al. (2016) who reported that yield reduction is associated with higher levels of land degradation.

**Table 4:** Severity of the determinants of land degradation.

<b>Type/causes of land degradation</b>	<b>Severity Scale</b>	<b>Remarks</b>
Bush burning	0.72	Light
Tillage	0.66	Light
Water	0.64	Light
Soil structure	0.61	Light
Sources of information on degradation	0.60	Moderate
Land ownership	0.58	Moderate
Cropping system	0.57	Moderate
Topography	0.52	Moderate

Source: Field survey, 2019

**Table 5:** Effect of land degradation on arable crop farmers' productivity.

Variable	Coefficient	t-value
Constant	29227.920	3.23
Amount of seed	7.782	0.65
Total farm size	664.500	1.61
Labour	-319.279	-2.72**
Agro chemicals	-75.501	-2.77**
Fertilizer	181.932	1.12
Capital input	0.024	0.95
Age of farmers	-326.496	-4.07***
Gender	2244.500	1.14
Educational level	64.310	0.25
Farmers' experience	236.572	3.02***
Credit accessed	-31545.550	-6.40***
Extension visits	25683.760	7.38***
Land degradation index	-3486.895	-2.66**

F-Ratio = 8.58\*\*\*,  $R^2 = 0.429$ , \*=significant at  $P < 0.10$  probability level, \*\*=significant at  $P < 0.05$  probability level, \*\*\*=significant at  $P < 0.01$  probability level. Log likelihood = -1800.365

### ***Mitigating measures against land degradation by arable crop farmers in the area***

In Nigeria, farmers often result in self helps when government intervention is inadequate or delayed in order to salvage or reduce the resultant impact of production related challenges. The result in Table 6 revealed that farmers in the area devised various measures on how to mitigate the effect of land degradation on their livelihood in the area. The methods ranged from agronomic to mechanical. The major measures were ranked from 1st to 10th, respectively. These included terracing ( $\bar{X} = 3.98$ ), avoidance of bush burning ( $\bar{X} = 3.82$ ), mulching of farmland ( $\bar{X} = 3.77$ ) and use of cover crops ( $\bar{X} = 3.71$ ). Others were zero

tillage, use of organic manure, afforestation, agroforestry, and bush fallowing. The farmers hardly use alley cropping and planting of grasses as a mitigating measure in the area. The arable crop farmers in the area devised various measures on how to mitigate the effect of land degradation on their livelihood in the area. Since government interventions may be delayed or inadequate, they usually result in self-help as palliative measures against land degradation problems through the adoption of both agronomic and mechanical measures in reducing the impact of the menace. This result is in line with the findings of Akinbile & Odebode (2007), Oyakale (2008), Onyerika (2016) and Okorafor et al. (2017).

**Table 6:** Mitigating measures against land degradation

Measures	Weighted Score	Weighted Mean Score	Rank	Remarks
Terracing	716	3.98	1 <sup>st</sup>	Major measure
Avoidance of bush burning	688	3.82	2 <sup>nd</sup>	Major measure
Mulching of farmland	678	3.77	3 <sup>rd</sup>	Major measure
Use of cover crop	667	3.71	4 <sup>th</sup>	Major measure
Zero/minimum tillage	652	3.62	5 <sup>th</sup>	Major measure
Use of organic manure	647	3.59	6 <sup>th</sup>	Major measure
Afforestation	638	3.54	7 <sup>th</sup>	Major measure
Agroforestry	620	3.44	8 <sup>th</sup>	Major measure
Bush fallowing	587	3.26	9 <sup>th</sup>	Major measure
Alley cropping	538	2.99	10 <sup>th</sup>	Minor Measure
Planting of grasses	529	2.94	11 <sup>th</sup>	Minor Measure

#### 4. Conclusions

The level of awareness of land degradation problems, among the arable crop farmers, was high which showed that land degradation was common phenomena in the area. The result further revealed that the major determinants of land degradation in the area were bush burning, cropping system, land ownership, soil structure, tillage, and topography. In addition, land degradation had negatively affected the productivity of arable crop farmers in area. The severity of the determinants of land degradation showed that land degradation existed in the area though it was not very severe. Amongst all the factors, bush burning was the least problem while topography was the highest. The arable crop farmers mitigated the effect of land degradation in the area mostly

through terracing, avoidance of bush burning, mulching and use of cover crops.

These findings are expected to assist policy makers to formulate and execute sustainable land management policies that would curb the menace for improved productivity of arable farmers in the area. Based on the findings of the study, the following recommendations were made:

1. Bush burning on the farmland should be restricted by a law enacted by government to control land degradation in the area.
2. Since the severity of land degradation in the area was moderate, government of Nigeria should focus on policies that enhance sustainable land management and hence, increased productivity of the farmers in the area.

3. Stakeholders should embark on reforestation programmes to reclaim the degraded land before the problem escalates.

**Conflicts of Interest:** The authors have no conflicts of interest as regards this publication.

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