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Contributive Effect of Land Management Indicators to Farmers Farmland Conservation in Oyo State, Nigeria

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Abstract. Major problem facing tropical agriculture is the inherent low fertility status of most of the soils because of the predominant low-activity. The study explained the contributive effect of sustainable land management indicators to land use on farmers' productivity in Oyo State Nigeria. A two-stage sampling technique was employed in selecting 330 farmers from the four agricultural zones in Oyo State. Structured questionnaire was used to obtain primary data. The data collected were analysed using descriptive and Fuzzy logic analysis (Fuzzy set theory). The result revealed that the result of Fuzzy Logic which was used to compute the composite indicators of unsustainable land use (IULU) showed that the total IULU of 0.26 obtained indicated that farmers' land management practices in the study area are generally sustainable. Residue cover, land fallowing, compaction and rooting, salinity and crop rotations among others have the highest relative contributions of 3.2%, 3.2%, 3.2%, 3.2% and 3.2% respectively to land farmers land conservation, while other indicators contribute lower percentage to land conservation been unsustainable in the study with relative contributions of 2.1%, 2.3%, 2.3%, 2.0, 2.5% and 2.4% respectively also majority of the farmer (60%) are sustainable and contributed larger percentage (96.4%) to sustainability and had between 0.1-0.2 with minimum of 0.00004 and maximum of 0.95650 sustainable land index in the study. The study recommended among others that cultural practices for erosion prevention should be encouraged by planting of cover crops and planting of trees and other agronomic best practices which enhance soil conservation and improve more on their level of sustainable land use indicators.

Keywords: Sustainable, Land, Conservation, Indicators, Aggregation, Fuzzy, Nigeria

1. Introduction

According to Fabiyi (1990) land was defined as an important factor of production in agricultural sector on the whole. Land serve as a social security function to most Nigerians because after all else have failed they could still return to their villages to stake a claim on a portion of the family land and raise crops on this for subsistence. However, the land is faced with many environmental problems especially the ones resulting from human activities; for instance, land destruction through agricultural practices unsuitable to the climate, slope and soil, extinction of animals and plant species through hunting, fishing and disturbance of habitats, prevention of forest regeneration through unplanned deforestation practices and through periodic burning, spoliation of scenic and other aesthetic values through open pit mining, road construction and other farmland management practices. Nigerian farmers embarked upon various farming activities at farm level in other to keep up their farmland for long time use. Such farming activities include fertilizer application, addition of organic manure, mulching, land fallowing, pesticide, herbicides, vigour of crop growth and are known as farm indicator. Indicators at different levels of the system related to environmental impacts include those measuring farmer production practices (requiring means-based indicators such as water use or nitrogen use) and emissions and wastes released into the environment (requiring effect-based indicators) (Aimee *et al.*, 2009). A simple understanding of an indicator is as a proxy or measure of something in which one has an interest, but which is difficult to monitor exactly (Dan *et al.*, 2001). However, Gameda, *et al*., (2002) used frame work of sustainable land management (FESLM) (Table 1) as identified by farmers through questionnaire responses and in-depth interviews to examined sustainable land management indicators at farm level; this was also adopted by this study as it was used in Oyewo *et al*., 2020 in their study on sustainable land management.

Marginal lands such as slopes and gravelly soils which under normal circumstances should be left under cover are now being exposed through farming activities. In the humid and sub-humid tropics, the traditional farming system, which is shifting cultivation, was adequate many years back as far as soil conservation is concerned. As a result of low population, small pieces of land were required for farming to obtain equilibrium of food production (Is-haq, 2008). Presently, the population is increasing and this necessitates sustainable land management practices in other to enhance crop yield.

Table 1: Framework for Evaluation of Sustainable Land Management Indicators in Oyo State

Maintenance of production (productivity)	Reduction of production risk (security)	Protects potentials of natural resources (protection)	Economically viable (viability)	Socially acceptable (acceptability)
Application of fertilizer Addition of organic manure Vigour of crop growth	Drainage infiltration of water Water holding capacity Aggregation of soil Irrigation water level Irrigation water quality Salinity	Trends of vegetative covers Plant residue cover Wind or water erosion Planting of cover crops Mulching of soil Fallowing of land Earthworm soil life Tilth/ workability Compaction and rooting Crusting/emergency Organic matter Contents	Land use intensity Labour use intensity Crop yield Profit per hectares Labour productivity Seed use intensity	Type of seeds Use of pesticides Use of herbicides Use of chemical poison in rivers Industrial discharges

Management issue cannot be taken for granted, given that these resources constitute the productive base for the Nigerian agriculture, upon which the livelihoods of many rural and urban household depend (Oyekale, 2012). The understanding of the quality use and management interaction of land as well as socio-economic factors and farmers' attitudes towards land management is also a key indicator of the sustainability of the resource. Moreover, poor incentives for natural resource conservation, together with among other socio-economic problems, have subjected the soils nutrients to serious exploitation and depletion. However, studies which had been conducted by various authors such as Rahji (2005), Adeola (2010), Raufu and Adetunji (2012), Ikechukwu *et al.,* (2013), Oladeebo *et al.*, (2013), Adedokun and Ogunyemi (2013), Amao *et al.*, (2013) Ademola and Olujide (2014) and Akinola *et al.*, (2015) on land management, soil conservation, adoption, degradation, awareness and sustainable agricultural practices had not examined the issue of farm level indicators indices, hence necessitating this study.

1.1 Objectives

The study explained the contributive effect of sustainable land management indicators to land use on farmers productivity in Oyo State Nigeria, which the following objectives which are to: construct index of sustainable land use indicators, assess the contributions of sustainable land management indicators to land use and identified individual farmers contributions to sustainable land management in the study area.

2. Methodology

2.1 The Study Area

This study was carried out in Oyo State, Nigeria. The State is located in the Southwestern part of the country. Oyo State consists of thirty three (33) Local Government Areas grouped under four (4) agricultural zones. The zones are: Ibadan-Ibarapa, Oyo, Saki and Ogbomoso Zones. Oyo State covers a total land area of about 27,249,000 square kilometers with a total population of about 5.6million (National Population Commission, 2006). It is situated between Latitude 7^{o} N and 19^{o}N and Longitude 2.5^{o}E and 5^{o}E of the meridian and it is bounded in the south by Ogun State, in the north by Kwara State, in the west it is partly bounded by Ogun State and partly by the Republic of Benin, while in the East by Osun State. (www.oyostate.gov.ng,http://oduainvestment.com.ng/portfolio-item/oyo-state/ 2014). Retrieved on February 16, 2023.

2.2 Sampling Frame

A two-stage sampling technique was employed in selecting 330 farmers from the four agricultural zones in Oyo State. Structured questionnaire was used to obtain primary data. The data collected were analysed with the use of Fuzzy logic analysis.

Table 2: Sampling Frame and Size for the Study

Agricultural zones	Population of respondents	Sample size used
Ibadan-Ibarapa	138	80
Oyo	156	90
Saki	119	70
Ogbomoso	167	90
4	580	330

Source: *Author computation, 2018*

2.3 Data Collection

The study used data mainly from primary source. The data (primary source) were obtained from the farmers' during the 2018 agricultural season with the use of structured questionnaire and interview schedule. These were administered and interpreted by the researcher and trained enumerators to the local language which the farmers understood.

2.4 Data Analysis

Fuzzy Sets Theory (FST) was used to compute the composite indicators of sustainable land management from selected farm level indicators, and individual farmers sustainable land use indices while descriptive statistics was used analyse the relative contributions of sustainable land use Indices (SLUI) among the farmers (table 3)

Table 3: Analysis of Objectives

Objectives	Meaning	Data required	Sources of data	Method of data analysis
To construct index of sustainable land use indicators (IULU)	To study the farm level indicators that are responsible for land being sustainable	Factors such as, vigour of crop growth, erosion runoff, pesticides, crop yield.	Primary	Fuzzy Logic
Analyse the relative contributions of sustainable land use Indices (SLUI) among the farmers.	To describe the decomposed indicators of land sustainability and their implications.	Mulching of crop, cover crop, land fallowing, herbicides use, pesticides.	Primary	Descriptive statistics
Analyse the individual farmers' contributions of (SLMI) to sustainable land use.	To examine the individual farmers level of sustainable land use.	Factors such as, vigour of crop growth, erosion runoff, pesticides, crop yield.	Primary	Fuzzy Logic

2.5 Model Specification

2.5.1 Fuzzy Logic Analysis

Using fuzzy set theory, a set of composite farm level indicators was constructed in order to analyze different dimensions of sustainable land management using (FESLM) in Table 3.3. Each indicator was calculated as one-dimensional sustainability ratio, thus allowing a comparison among indicators on the dimensions of sustainable land management. According to Oyekale (2012) farm level indicators of sustainable land use often take the form of simple 'yes/no' dichotomies. In this case Xij is 0 or 1. However, some indicators may involve more than two ordered categories (for example, discrete categorical variables and continuous categorical variables), reflecting different degree of deprivation. Consider the general case of c = 1 to C ordered categories of some deprivation indicator, with c = 1 representing the most deprived and c = C the least deprived situation. Let ci be the category to which individual *i* belongs. Cerioli and Zani (1990), assuming that the rank of the categories represents an equally-spaced metric variable, assigned to the individual a deprivation score as:

Xij=(C-ci)/(C 1)……………………………(1)

where 1 < ci < C, by summarizing the key notions about sustainable land management based on the theory of fuzzy sets and in particular on the work of Dagum and Costa (2004).

Sustainable land management in the given space (a_i)

Therefore, Xij needs not to be compulsorily 0 or 1, but 0 ≤ Xij ≤ 1 when there are many categories of the jth indicator and the household possesses the attribute with intensity.

The sustainable land management index of a household, U_β(ai), is defined as the weighted average of Xij,

$U\beta(ai) = \sum_{j=1}^{m} Xij\ wj / \sum_{j=1}^{m} wj$ …………………………… (2)

The function of the i-th farmer (i = 1.........n) belonging to the fuzzy subset β in relation to the j-th attribute (j = 1......m) is defined as follows

$X_{ij}=U_\beta(X_1(a_i)),0\leq 1$..(3)

In this case:

Xij = 1, if the i-th farmer does not have the j-th attribute;

Xij = 0, if the i-th farmer possesses the j-th attribute;

0 < Xij < 1, if the i-th farmer has the j-th attribute with an intensity between (0, 1).

U_β (ai) = equation U_β (ai) measures the ratio of the sustainable land management of the i-th farmer, where w_i is the weight attached to the j-th attribute and where;

$0 \leq U_\beta (ai) \leq 1$

The behaviour of the function of belonging (to a fuzzy subset) is the following;

Uβ (ai) = 0, if ai possesses the m attributes;

Uβ (ai)= 1, if ai is totally deprived of the m attributes;

0 < Uβ (ai) < 1. If ai is partially or totally deprived of some attributes, but not completely deprived of all attributes.

Weight wj represents the intensity of deprivation linked to attribute Xj. It is an inverse function of the degree of deprivation of this attribute for the farmer population. The smaller the number of households with attribute Xj is, the bigger the weight wj will be. Cerioli and Zani (1990) defined a weight that verifies this property, namely;

$Wj = \log [\sum_{j=1}^{n} g(a_i) / \sum_{j=1}^{n} x_n g(a_i)]$ .... (4)

$\sum_{j=1}^{n} x_n g(a_i) > 0$

Where $g(a_i)$ refers to the frequency (weight) with which respondent a_i of the population was observed;

$g(a_i) \sum_{j=1}^{n} x_n g(a_i)$ is the relative frequency with which sample a_i of the population observed, g(ai) is equal to n times the relative frequency of farmers in the total population.

Therefore, $\sum_{j=1}^{n} x_n g(a_i) = n$, However, if nighters of the farmer posses an attribute, it has to be removed because it has no relevant to the sustainable land use.

In equation (5), the denominator of the logarithm is always positive. If the value Xij = 0, was part of the possible sets, that would mean that there would be no deprivation in Xj. The fuzzy index of sustainability of set A is a weighted mean of $\mu_B(a_i)$ given by equation (4)

In addition to determining the multidimensional sustainable land management for i-th farmer and that for the overall population, the use of the theory of fuzzy sets makes it possible to calculate a uni-dimensional index for each one of the j attributes considered.

$U\beta\ (X_j) = \sum_{j=1}^{n} x_n g(a_i) / \sum_{j=1}^{n} g(a_i)$ j = 1, 2, ...m... (5)

$U\beta\ (X_j)$ defines the degree of deprivation of the jth attribute for the population of the respondent. The overall fuzzy index of sustainable land management can also be defined as a weighted average of uni-dimensional indices for each attribute;

$U\beta = \sum_{j=1}^{n} x_n g(a_i) / \sum_{j=1}^{n} g(a_i) = \sum_{i=1}^{m} \mu_\beta(X_i) W_i / \sum_{i=1}^{m} w_i$ = 1, 2,..........m................(6)

3. Results and Discussion

3.1 Contributive effects of Land Indicators Aggregation to Farmers Land use

From the result in Table 4 using the fuzzy logic model as specified in equation (1) to (6) of the fuzzy set theory, the contribution of SLM indicators to sustainable land us were identified.

Application of fuzzy set theory was due to its attempts to standardize all the variables that have different predictor, variables with different units of measurement and allows the decomposition of the sustainability land use indices based on the contributions of each indicator or attributes, it also determining the multidimensional sustainable land management for each farmer and that for the overall population, the use of this theory of fuzzy sets makes it possible to calculate a uni-dimensional index for each one of the attributes considered.

It was therefore revealed that land fallowing contributes absolute value of 0.009 and relatively 3.20% to sustainability because same pieces of farm land were used periodically for agricultural activities which may cause soil nutrients depletion and degradation (Oyekale, 2012). Compaction and rooting has absolute contribution of 0.009 with 3.20% relative contribution to sustainability because this may affects the sustaining power of the crop root to penetrate soil due to the hardness of the nature of the soil. Residue cover has absolute contribution of 0.009 with relative contribution of 3.20% to sustainability, this shows that surface residue though present, were not properly covering the soil which could give room for wind or water erosion with absolute contribution of 0.009 and relatively contributes 3.20% to sustainability, to wash or blow away the top soil and affect the soil water holding capacity thereby exposing the top soil surface to depletion which may in turn have a negative effect on small scale cassava farmers' production and sustainability, plot level of fertilizer application had absolute contribution of 0.007 with 2.7% relative contribution, this shows that fertilizer was applied in the right quantity and up to specification, this is in line with Rahman, (2013). This could be due to the number of year of farming experience and majority of them who had one form of formal education which however, could enhance productivity, sustaining agricultural production and maintenance of soil nutrients lost.

Stem use intensity, profit per hectare, labour use intensity, vigour of crop growth, this enhance the maintenance of soil covers because the crops were found to be healthy and had uniform growth which could be due to the use of improved stem cuttings and increases crop stocking density and hereby increased farmers profit per hectare, land use intensity, proper use of chemical poison, proper management of industrial discharge from water been polluted and avoid environmental pollution which may be hazardous to animals even the farmers themselves and enhance increased labour productivity among others contribute absolutely 0.006, 0.006, 0.007, 0.007, 0.007 and 0.007 with relative contribution of 2.1%, 2.0%, 2.3%, 2.3%, 2.3% and 2.3% respectively to sustainable land management in the study. This implies that these indicators among others may influence sustainability and crop output positively; an increase, better management and adoption of these indicators could bring an increase in crop production, prevent soil erosion and land degradation, maintenance of production, reduction of production risk, protects potentials of natural resources as well as environmental pollution in the study area.

The result further revealed that the computed average of sustainable land indices (SLI) of 0.26 obtained indicated that farmers' land management practices in the study area are generally sustainable because the farther away the index value from 1 and the closer the index value is to 0 the better the sustainability. This is in line with Kayode *et al*., (2017), Oyewo *et al*., 2020 and conforms to the findings of Oyekale (2012). However, the SLI value which is 26% indicated that the aggregated indicator contributed 74 % to land conservation and sustainability in the study area.

Table 4: Contributive effects of SL Indicators to Farmers Land Use

+ SLM Indicators	*Absolute contribution	**Relative contribution (%)
Vigour of crop growth	0.0064	2.317233483
Trend of vegetative covers	0.0087	3.172457796
Residue cover	0.0088	3.204165584
Crop yield	0.0082	2.980865299
Labour productivity	0.0072	2.626626269
Profit per hectare	0.0056	2.026445528
Organic matter contents	0.0078	2.840350661
Drainage/infiltration of water	0.0087	3.162153270
Water holding capacity	0.0088	3.189395739
Aggregation of soil	0.0087	3.154559936
Earthworm/ soil life	0.0083	3.024332006
Compaction and rooting	0.0088	3.202386116
Crusting/emergency	0.0088	3.184818606
Tilth/ workability	0.0086	3.118113701
Wind or water erosion	0.0087	3.150813599
Salinity	0.0088	3.209217214
Plot level application fertilizer	0.0074	2.695404096
Addition of organic manure	0.0075	2.706514029
Mulching of crops	0.0088	3.183196149
Minimum tillage	0.0088	3.189936159
Cover crops	0.0087	3.175581225
Rotation of crops	0.0088	3.207030646
Land fallowing	0.0088	3.190824110
Irrigation Water level	0.0082	2.981777222
Irrigation Water quality	0.0087	3.171362817
Use of Pesticide	0.0088	3.190824110
Use of Herbicide	0.0076	2.758734516
Use of chemical poison	0.0067	2.447056059
Industrial discharges	0.0069	2.495042768
Land use intensity	0.0069	2.518237365
Labour use intensity	0.0065	2.358827751
Type of stem cuttings	0.0077	2.800804515
Stem use intensity	0.0059	2.125136962
Total Computed (SLUI)	0.2637	100

Author computation 2016

Note: (*): Absolute contribution and (**): Relative contribution

(*): This is the raw index score of the fuzzified indicators analysed by fuzzy logic.

(**): This is the value of the fuzzified index score in percentage.

(+): as defined in the data collection instrument

3.2 Individual Famers' Contributions to Land Use Sustainability in the Study Area

From Table 5, the individual famers contributions to land sustainability using fuzzy logic model in equation (1) to (6) and Table 1 using the framework for evaluating sustainable land management (FESLM) were analysed by the application of fuzzy set theory due to its attempts to standardize all the variables that have different predictor and different units of measurement and allows the decomposition of the sustainability land use indices based on the contributions of each indicator or attributes, it also determining the multidimensional sustainable land management for each farmer which ranges between 1 and 0, it was therefore revealed that farmers showed varied level of contributions sustainability ranging from the lowest 0.00004 to the highest 0.95650 with mean of 0.264 and frequency of occurrence of the decomposed predicted SLMI in decile range showed that 5.2% had less than 0.1, majority (60%) of the famers had SLMI of between 0.1-0.2, 31.2% had SLMI of between 0.3-0.4, 3.0% had between 0.5-0.6 while 0.6% had between 0.9-1.0 sustainable land management index with Minimum index of 0.00004 and Maximum index of 0.95650 and overall mean index of the farmers was 0.264 (26.4%) indicating that the farmers are sustainable at 73.6% level. However, according to fuzzy set theory used, the closer the decomposed value is to zero the better the individual farmers' contributions to sustainability in the study area.

Majority (96.4%) of the famers adopt sustainable land management practices with the proper combination and use of the farm level management indicators which enhanced farmers' productivity, soil conservation and reduce land degradation in the study area. This therefore shows that there is a wider distribution to sustainability among the farmers and there is a considerable room for effecting improvements in the SLM and conservation practices as reflected in Table 5

Table 5: Range and Distribution of Individual Farmer's Sustainable Land Use Indices

+ Sustainable land use Index	Frequency	Percentage
0.0-0.1	17	5.2
0.1-0.2	198	60.0
0.3-0.4	103	31.2
0.5-0.6	10	3.0
0.7-0.8	0	0.0
0.9-1.0	2	0.6
Total	330	100
Maximum SLUI	0.95650	
Minimum SLUI	0.00004	
Total Mean SLUI	0.26372	

Source: *Author computation 2016*

Note: (+) Fuzzified values generated from the decomposed multidimensional sustainable land management indicators for each farmer which ranges between 0 and 1

4. Conclusion

It considered different production objectives in farmers land use system using fuzzy sets theory. This allows integration of different properties of a particular land into a composite index that captures the extent of degradation to the farm land and therefore concluded that:

- Majority (96.4%) of the famers adopt sustainable land management practices with the proper combination and use of the farm level management indicators which enhanced farmers' productivity, soil conservation and reduce land degradation in the study area
- Majority (60%) of the famers had SLI of between 0.1-0.2 sustainable land management index with minimum index of 0.00004 and maximum index of 0.95650 and overall mean index of the farmers was 26.4% indicating that farmers aggregated indicator contributed 74 % to land conservation and sustainable at 73.6% level.

5. Recommendations

Based on the result and findings of the study the following are therefore recommended that:

- Farmers should be encouraged on the intensive use of environmentally friendly hybrids cassava stems and fertilizer application for increase production and better land sustainability in the study area.
- Cultural practices for erosion prevention should be encouraged by planting of cover crops and planting of trees and other agronomic best practices in the study area
- There is room for farmer's improvement on their level of contribution to sustainability with 26% better adoption of better land and soil conservation practices.

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