Journal of Forestry Research and Management. Vol. 17(2).68-74; 2020, ISSN 0189-8418

www.jfrm.org.ng

Sustainable Land Management Practices among Agroforestry Farmers in Oyo State, Nigeria

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ABSTRACT

Soil and land degradation has been a problem of agricultural sustainability among agroforestry farmers. This study used fuzzy logic to compute the composite farm level indicators to examine sustainable land management practices and its contributive effects to agroforestry farmer's sustainability. A well structured questionnaire was used to collect data from one hundred and seventy six respondents. Tobit and fuzzy logic analysis were used to analyse the data collected for this study. The result revealed that the estimated parameters with Tobit regression shows that farm size (ß= 0.0193, p<0.05), organic manure (ß= 0.0347, p<0.10), fertilizer application (ß= 0.1707, p<0.01), continuous cropping (ß= -0.0494, p<0.05), pesticide application (ß= 0.0807, p<0.01), income (ß= 0.0094, p<0.05) and mode of cultivation (ß= -0.0524, p<0.05) were the significant determinants of sustainable land management while the fuzzy results revealed that the total sustainable land use index (SLUI) was 0.2761 showing that agroforestry farmers were generally sustainable, seed use intensity (0.0049), labour used intensity (0.0051), land used intensity (0.0065), minimum tillage (0.0075) and profit per hectare (0.0064) had a better and higher absolute contribution to sustainable land use in the study area. It was revealed that farmer's income, farm size, organic manure, fertilizer and pesticide application and mode of cultivation were the major determinants of sustainable land management though continuous cropping and mode of cultivation

Keywords: Agroforestry, Determinant, Sustainable, Tobit Regression, Fuzzy.

Introduction

A general understanding among sustainable agricultural farmers is that 'healthy' soil is a key component of farm sustainability; that is a healthy soil will produce healthy crop plants. Traditionally through time, agroforestry farmers have developed different soil conservation and land management practices of their own, with these practices, they have been able to sustain their production for centuries thus the effects of resource exploitation has become widespread, there has been growing awareness that productive lands are getting scarce, land resources are not unlimited, and that the land already in use needs more care. As a result of the increase in world population, other non-agricultural activities are demanding for land space, hence there is progressive loss of land for food production. However, Ogunkunle (2004) affirmed that over time, demand for food and other agricultural products is increasing, requiring for more land which is not available since the earth's land area is finite.

The extent of land degradation in Nigeria is presently alarming, thus 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 depends (Oyekale, 2012). Dumanski and Smyth (1994) defined

Sustainable Land Management (SLM) as a system that combines technologies, policies and activities aimed at integrating socioeconomic principles with environmental concerns so as to simultaneously: maintain or enhance production/services (productivity);reduce the level of production risk (security);protect the potential of natural resources (protection);be economically viable (viability);be socially acceptable (acceptability).

The diminishing worldwide availability of productive land is such that continued degradation of such land is a clear threat to the survival of human race. However, continuous loss of farm land to land degradation and soil erosion will have negative effects on agricultural sustainability. Therefore, there is need for an average farmer to operate various farm land management practices in other to enhance sustainable agriculture trough soil and land conservation. Hence, this raises the research objectives which are to: examine the determinants of sustainable land management practiced by farmers, determine the status of SLMP among agroforestry farmers and analyses the contributions of sustainable land management indicators to land use among the agroforestry farmers in the study area

Methodology

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 consist of thirty three (33) Local Government Areas grouped under four (4) agricultural zones of Oyo State Agricultural Development Programme (OYSADEP).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 5.6 million (National Population Commission, 2016). Presently, the population of Oyo State has hit 7,840, 864 million as of 2016, latest demographic estimates released by the National Bureau of Statistics in 2017. 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. The State is predominantly agrarian, annual mean rainfall is above 1000mm and the rainy season in the State average eight months in a year. Rain starts in Oyo State during the first week of March with storms. Mean temperature varies from daily minimum of 18.9^{0}C to a daily maximum of 35^{0}C. Humidity is quite high in Oyo State; relative humidity in the State is 70 percent with a maximum of about 60 percent in the evening and a maximum of around 80 percent in the morning.

Sampling technique and sampling size

Multi-stage method sampling technique was used to select sampled population while a well structured questionnaire was used to collect data. The first stage was selection of existing four Agricultural zones in the State, namely, Ibadan-Ibarapa, Oyo, Saki and Ogbomoso zones due to the existence of agroforestry farmers. Second stage involved purposive selection of one Local Government from each of the zone where the agroforestry farmers are concentrated. Third stage: was the proportionate selection of the agroforestry farmers from the selected local governments, this comprises of 50, 46,40 and 40 respondents from Oyo, Ogbomoso, Ibadan / Ibarapa and Saki zones respectively making a total of 176 agroforestry farmers. Lastly: well structured questionnaire were distributed to collect data from one hundred and seventy six sampled agroforestry farmers from the agricultural zones.

Analytical techniques

Tobit regression analysis was used to identify the determinants of sustainable land use

management practices by the agro forest farmers while fuzzy set theory was used to construct the index of sustainable land use practices.

Model specification

Tobit regression method was used to analyze the determinants of sustainable land management index in the study.

The model used for the estimation was given as:

$SLMIi = A + ßi \sum_{j=1}^{12} Zi + \mu$ ……. (1)

$LMIi = (ßo + ß1Z1 + ß2Z2 + ß3Z3 + ß4Z4 + ß5Z5 \ldots . ß12Z12 + \mu i)$…… (2)

Where; SLMI = (Sustainable Land Management Index)

Z_1= Age (Years), Z_2 = Farming experience (years), Z_3 = Income (Naira), Z_4 = Farm size (ha),

Z_5 = Organic manure application (dummy), Z_6 = Fertilizer application (dummy),

Z_7 = Continuous cropping (dummy), Z_8 = Erosion runoff (dummy), Z_9 = Pesticide application (litre), Z_{10} = Organic matter (dummy), Z_{11} = Mode of cultivation (dummy), Z_{12} = Educational level (years), μ = Error term, ß = Parameter estimated, $ß_o$= Constant

Fuzzy Logic Model

According to Betti *et al*., (2005) putting together categorical indicators of deprivation for individual items to construct composite indices requires decisions about assigning numerical values to the ordered categories and the weighting and scaling of the measures. Indicators of sustainable land use often take the form of simple 'yes/no' dichotomies. In this case Xij is 0≤ 1 as used by Dagum and Costa, (2004)

A = (a1 .....ai .....); and..... (1)

A: X = (X1 .....Xj ..... Xm)..... (2)

$X_{ij} = U_ß (X_1(a_1))$, 0 = 1..... (3)

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

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

$\mu_ß = \sum_{j=1}^{m} \mu_\beta(X_j) W_j / \sum_{j=1}^{m} w_j$ = 1, 2,..... m..... (6)

Results and Discussion

Tobit regression of determinants of sustainable land management

The result in Table 1 shows the marginal effect of the variables used on the determinants of sustainable land management which revealed that farm size is positively related to sustainable land management (SLM) ($p<0.05$). This implies that there is probability of increasing SLM with an increase in the application of this variable (farm size). Farm size is one of the factor influencing land use intensity, a unit increase in hectare of farm land marginally increase land use, Yusuf *et al.*, (2011). Farmers gross income is positively significant ($p<0.05$) to (SLM). This implies that as agroforestry farmer's income increases there is likelihood that SLM will be enhanced. This is in line with the *apriori* expectation because increase in farmers income will encourage the farmers in the adoption of sustainable land management practices, this may however be due to the fact that farmer's gross farm income will encourage the farmer to operate an extensive land management system which may enhance farmland sustainability, this agrees with the work of Ogbonna *et al.*, (2007) and Ikechukwu and Nwakwo (2013) that increase in income will lead to increase in the use of sustainable Farmland Management Practices and that higher income will give the farmers more money for possible adoption of farmland management practices, also supported by Agboola *et al*., (2015) that farm

income suggests that the larger the income earned, the greater the level of use of a particular technology and ease the capital constraint needed for soil-conservation investments. Mode of cultivation and continuous cropping have negative relationship and significant ($p<0.05$) to sustainable land management. This implies that as the mode of cultivation (manually) by the farmers is continually practiced there is likelihood that sustainable land management may not be enhanced. This may due to the cultural practices that the farmers are used to and unable to adopt mechanized mode of cultivation which will enhance sustainable farming. Continuous cropping will also have negative effect on agroforestry farmer's sustainability because continuous cropping on the same portion of land without allowing the land to rest may lead to soil nutrient loss and thereby reduce sustainable management and affect the crop grown. Fertilizer and pesticide are significant ($p<0.01$) respectively while organic manure is also significant ($p<0.10$). This implies that increase in any of these variables will increase the level of sustainable land management of the agroforestry farmers as these have positive relationship to SLM and enhance agroforestry farmer's sustainability. Chi^2 value of 61.99 was significant ($p<0.01$) indicating a good fit of the model used for the study.

Table 1: Determinants of Sustainable Land Management

Variable	Coefficient	dy/dx	Standard error	T-statistic
Constant	0.2022		0.0614	3.29
Z_1= Age	0.0009	0.0009	0.0092	0.10
Z_2 = Farming experience	0.0009	0.0009	0.0012	0.77
Z_3 = Income	0.0094**	00094**	0.0038	2.48
Z_4 = Farm size	0.0193**	0.0193**	0.0079	2.45
Z_5 = Organic manure	0.0347*	0.0347*	0.0208	1.67
Z_6 = Fertilizer application	0.1707***	0.1707***	0.0273	6.25
Z_7 = Continuous cropping	-0.0494**	-0.0494**	0.0222	-2.22
Z_8 = Erosion runoff	0.0188	0.0188	0.0220	0.85
Z_9 = Pesticide application	0.0807***	0.0807***	0.0253	3.20
Z_{10} = Organic matter	0.0473	0.0473	0.0319	1.48
Z_{11} = Mode of cultivation	-0.0524**	-0.0524**	0.0217	-2.41
Z_{12} = Educational level	0.0033	0.0033	0.0116	0.28
Sigma	0.1223			
Chi^2 (12)	61.99***			

Source: Authors Data Analysis. * implies, $p<0.10$; ** implies, $p<0.05$; *** implies $p<0.01$.

Contribution of SLM indicators to agroforestry farmers sustainable land use

The result presented in Table 2 reveals that Land fallowing contributes relatively 3.51% to SLMP sustainability index because same pieces of farm land were used periodically for agricultural activities without allowing the land to rest which causes soil nutrients loss and degradation. Compaction and rooting has relative contributions of 3.47% to sustainability because it affects the sustaining power of the crop root to penetrate soil because of the hardness of the nature of the soil due to surface land exposure. Relative contribution of addition of organic manure (3.0%) is higher than that of plot level application of fertilizer 2.9% this is because most of the farmers were able to sustain their

production through the use of organic manure than fertilizer because it is readily available at the farmer disposal and were applied in the right manner and given quantity. Residue cover has a relative contribution of 3.47% to land sustainability which shows that surface residue though present, were not properly covering the soil. This gives room for wind or water erosion which also contributes relatively (3.48%) to sustainable land management which may wash or blown away the top soil and hereby affect the soil fertility. Seed use intensity, labour used intensity, land used intensity, minimum tillage and profit per hectare had better and higher absolute contribution to sustainable land use with 0.0049, 0.0051, 0.0065, 0.0075, and 0.0064 and relative contributions of 1.7%, 1.8%, 2.3%, 2.6% and 2.3% respectively. This shows that the agroforestry farmers combination of these indicators contribute positively to land sustainability and could influence farmer's output positively and encouraged soil conservation except for residue cover, wind or water erosion, compaction and rooting among others contributes to land been unsustainable. This conforms to the work of Agboola *et al*., (2015) that factors influencing the use of land management and conservation practices by the farming household head were determined by combination of parcel/ plot level factor, human, physical and financial capitals as well as institutional factors

However, the total computed sustainable land use index (SLUI) 0.2761and mean computed (SLUI) of 0.0084 indicated that the agroforestry farmers were generally sustainable with the present combination of these farm level indices because the closer the index value is to zero the better the farmers sustainability.

Table 2: Contribution of SLM indicators to agro forest farmers Productivity

SLM Indicators	Absolute contribution	Relative contribution (%)
Vigor of crop yield	0.0072	2.607750815
Trend of vegetative covers	0.0093	3.368344803
Residue cover	0.0096	3.477001087
Crop yield	0.0081	2.933719667
Labour productivity	0.0074	2.680188338
Profit per hectares	0.0064	2.318000724
Organic matter contents	0.0089	3.223469757
Drainage/infiltration of water	0.0095	3.440782325
Water holding capacity	0.0093	3.368344803
Aggregation of soil	0.0095	3.440782325
Earthworm/ soil life	0.0081	2.933719667
Compaction and rooting	0.0096	3.477001087
Crusting/emergency	0.0090	3.259688519
Tilth/ workability	0.0094	3.404563564
Wind or water erosion	0.0096	3.477001087
Salinity	0.0086	3.114813473
Plot level application fertilizer	0.0082	2.969938428
Addition of organic manure	0.0083	3.006157189
Mulching of crops	0.0095	3.440782325
Minimum tillage	0.0075	2.716407099

Cover crops	0.0088	3.187250996
Rotation of crops	0.0085	3.078594712
Land fallowing	0.0097	3.513219848
Irrigation Water level	0.0079	2.861282144
Irrigation Water quality	0.0085	3.078594712
Use of Pesticide	0.0096	3.477001087
Use of Herbicide	0.0079	2.861282144
Use of chemical poison	0.0075	2.716407099
Industrial discharges	0.0089	3.223469757
Land use intensity	0.0065	2.354219486
Labour use intensity	0.0051	1.847156827
Type of seeds	0.0089	3.223469757
Seed use intensity	0.0049	1.774719305
Mean Computed (SLUI)	0.0084	3.042375951
Total Computed (SLUI)	0.2761	100

Author computation

Conclusion

The study considered different objectives in farmers land use system using fuzzy sets theory to compute the composite indicators of sustainable land use (ISLU) from selected farm level indicators and Tobit regression was used to analyze the determinants of sustainable land management index in the study. It was therefore concluded that the total sustainable land use index (SLUI) was 0.2761 indicating that agroforestry farmers were generally sustainable in their land use system considering the combinations of all the indicators because the closer the index value is to zero (0) and far away from one (1) the sustainable the farmers are; also, contribution of SLM indicators shows that seed use intensity, labour use intensity, land use intensity, minimum tillage, profit per hectare have a better absolute contributions to sustainable land use management and enhance the sustainability of the agroforestry farmers except for land fallowing, residue cover, wind or water erosion, compaction and rooting among others contributes to land been unsustainable. Tobit analysis shows that farmer's income, farm size, organic manure, fertilizer and pesticide application and mode of cultivation were the major determinants of sustainable land management though continuous cropping and mode of cultivation were negatively signed which may have negative effect on agroforestry farming in the study area.

Recommendations

It was therefore recommended that agroforestry farmers should be encouraged on the adoption of organic fertilizer application; farmers should be sensitized on the need to be discouraged on their manual mode of cultivation and embrace mechanized mode of cultivation which may enhance farmers sustainable land management, also continuous cropping should be discouraged and better agronomic practices should be enhanced to conserve the soil from erosion, by the agroforestry farmers in the study.

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