Original Research Article

INCOME DIVERSIFICATION AND SUSTAINABLE LAND MANAGEMENT PRACTICES AMONG RURAL CASSAVA-BASED FARMERS IN IMO STATE

ABSTRACT

Aims: To examine the income diversification activities and sustainable land management practices among rural cassava-based farmers in Imo State, Nigeria.

Study Design: Primary data collection.

Place and Duration of Study: Michael Okpara University of Agriculture, Umudike, Pre-requisite study, Post-Graduation in Agricultural Resource and Environmental Economics, between August 2017 and January 2018.

Methodology: Data were collected using well-structured questionnaire, administered to rural cassava-based farmers. Multi-stage and purposive sampling techniques were employed, and one hundred and twenty (120) farmers were randomly selected for the study. Data collected were analyzed using descriptive statistics, Sustainable Land Management Index, Probit model and Inverse Herfindahl–Hirschman Diversity Index. The sustainable land management index (SLMI) was constructed from twelve (12) different sustainable land management indicators based on the sustainable practices prevalent in the study area.

Results:

Results showed that cassava-based production was dominated by female farmers (63.33%) with mean age of 46, married (70.00%) with mean household size of 6 persons. The Inverse Herfindahl-Hirschman Diversity (IHHD) results showed that 87.50% of rural cassava-based farmers diversified their income base into other income-generating activities namely, off-farm and/or non-farm activities. The mean on-farm income was ₦ 130,646.2k, while that of off-farm and non-farm were ₦ 20,554.17k and ₦ 78,333.33k, respectively. Cassava-based farmers diversified mostly into non-farm activities together with their on-farm activities, with a mean annual income of ₦244,333.60k. The ~~probit~~profit estimates showed that off-farm and non-farm activities have positive and significant effects on sustainable land management practices. The off-farm and non-farm activities encouraged the rural cassava-based farmers to adapt sustainable land management practices. However, doubling farmer's engagement to off-farm activities (off-farm^2) had a negative effect on sustainable land management, indicating that doubling their engagement to off-farm activities empowers farmers to adapt unsustainable labour-saving practices such over use of agrochemicals (herbicides, inorganic fertilizers and insecticides), due to drudgery and exhaustion as they allocate more of their labour services to another farmer's farm.

Conclusion: In order to improve the adoption and adaption of sustainable land management practices, and reduce the drudgery in cassava production as farmers diversify more into off-farm activities, sustainable labour-saving technologies and practices such as conservation tillage and simple tools that reduce labour requirement in cassava production, save time and energy, were recommended. More lands should be allocated to cassava farmers, as farm land diversity will facilitate the adoption and adaption of sustainable land management practices such as fallowing and crop rotation that increase productivity by replacing fallow periods with growing different crops that replenish soil nutrients.

Comment [F1]: It is recommended to use a suitable symbol for the mean.

Keywords: *sustainable land management, income diversification, non-farm, off-farm, on-farm, cassava-based*

1. INTRODUCTION

Agriculture serves as a reliable source of food for the rural poor (Ojiako, Tarawali, Okechukwu & Chianu, 2016), and a critical component of income-generating activities. As a result of the high-risk in agriculture, low agricultural productivity and low rural farm income, Frelat *et al.*, (2016) call for measures beyond agricultural production and diversification of employment sources. Rural farmers diversify into other income sources due to limited resources to provide a sufficient means of livelihood (Minot *et al.,* 2006). Diversification is the scope and combination of activities and choices (Liu & Liu, 2016), and increases the chances of economic growth and survival of individuals (Mphande, 2016). It refers to income generating activities of rural individuals regardless of the sector or location (Brandth & Haugen, 2011; Loison & Loison, 2016; Martin & Lorenzen, 2016). There are three broad categories of farm income-generating activities, namely, on-farm, off-farm and non-farm activities (Ellis & Freeman, 2004; Sherren, Loik & Debner, 2016). The diversification activities are also classified by sector as farm or non-farm or by location as on-farm or off-farm (Bowen & De Master, 2011; Loison & Loison, 2016), representing important diversification activities of farmers to cope with the changing economic framework conditions (Weltin *et al.,* 2017). Diversification activities are undertaken by farmers to generate additional income to that of the farmer's main agricultural activities (Assan & Beyene, 2013). On-farm income-generating activities involve commitment to farming (crop and livestock production), off-farm income involves income from agricultural activities that take place outside the farmer's own farm, such as local daily wage labour in return for cash payment or the agricultural work at another farmer's farm. Non-farm income-generating activities take place outside the agricultural sector, such as handicraft activities (carpentry, house mudding, weaving, etc), petty trading and remittance transfers. In Nigeria, off-farm and non-farm activities have become an important component of income diversification activities among rural farmers (Adepoju & Obayelu, 2013), especially rural cassava-based farmers in the Southeast zone of Nigeria.

Cassava (*Manihot esculenta* Crantz), a starchy root crop, is a source of income-generating activities in Nigeria. The country is the world's leading cassava producer, with about 21 percent share in the global market (Food and Agriculture Organization, 2013). Rural cassava-based farmers engaged in off-farm and non-farm activities for additional income. Income from working off the farm can facilitate the acquisition of farm inputs or the adaption of new technologies (Anang, 2017). Income from off-farm and on-farm sources affects farmer's decision to adapt sustainable land management practices (Kassie, 2017). Sustainable land management refers to the adoption of land-use systems that through appropriate management practices enable land users to maximize the economic and social benefits from the land while maintaining or enhancing the ecological support functions of the land resources (Liniger *et al.,* 2011). Sustainable land management refers to practices that do not degrade the soil or contaminate the environment while providing support to human life (Greenland, 1994), sustaining ecosystem services and livelihoods (World Bank, 2006), and restoring soil fertility (International Fund for Agricultural Development, 2011). Sustainable land management practices contribute to improving soil fertility and structure, adding high amounts of biomass to the soil, causing minimal soil disturbance, conserving soil and water, enhancing activity and diversity of soil fauna, and strengthening mechanisms of elemental cycling (Woodfine, 2008). This in turn translates into better plant nutrient content, increased water retention capacity and better soil structure, potentially leading to higher yields and greater resilience, thus contributing to enhancing food security and rural livelihoods (Food and Agriculture Organization, 2009). Unsustainable management of agricultural soils depletes soil organic carbon (Barua & Haque, 2013; Rinivasarao *et al.,* 2014), and triggering land degradation (Cerdà *et al.,* 2009; Borelli *et al.,* 2013; Haregeweyn *et al.,* 2013; Jones *et al.,* 2014; Zdruli, 2014).

Intergovernmental Panel on Climate Change (IPCC, 2007) categorized sustainable land management practices into agronomic practices which include, use of cover crops, improved crop or fallow rotations, improved crop varieties, use of legumes in crop rotations; integrated nutrient management involving increased efficiency of nitrogen fertilizer, organic fertilization (use of compost, animal and green manure); tillage and residue management which include incorporation of crop residues, reduced/minimum/zero tillage; water management practices which include irrigation, bunds/ ridge system, terraces, contour farming, water harvesting; and agroforestry practices which include live barriers, fences, crops on tree-land and trees on cropland. Crop rotations and intercropping designed to ensure differential nutrient uptake and use enhance soil fertility, reduce reliance on chemical

Formatted: Font: Not Italic

fertilizers, and enrich nutrient supply to subsequent crops (Conant, 2010). Cassava can be grown successfully under no-till (zero-tillage) to give the optimum growth and yield required of the crop, while conserving the soil physical properties (Fasinmirin & Reichert, 2011). Organic fertilization (compost and animal manure) is widely found to have positive effects on the yields. It enhances inputs of nitrogen through nitrogen-fixing plants that are not harvested (green manure), and is the key to maximizing production and ensuring long term sustainability of agricultural systems (Fageria, 2007; Hansen *et al.,* 2007).

Farmland is a valuable asset for the rural poor, and diversifying to off-farm and/or non-farm activities reduces the intensity of agricultural land cultivation. Off-farm employment reduces environmental stress, which is beneficial for keeping sustainable achievements (~~Ito, Bao & Ni~~,Ito *et al.,* 2016). Continuous cultivation of the same land without appropriate and sufficient management lead to soil degradation (Kebede *et al*., 2013). Garibaldi *et al*. (2016) argued that farmers with higher non-farm income are greater adapters of better land management practices. On the contrary, Imfeld and Vuilleumier (2012) asserted that high non-farm income increases the probability to adapt unsustainable practices such as purchase and over use of agro-chemicals. Unsustainable land management practices and low farm income are the major problems of agricultural sector in Nigeria (Daudu *et al*., 2016), and the type of income-generating activities engaged by rural farmers affect the rural land management system. Therefore, this paper examined the income diversification activities and sustainable land management practices among rural cassava-based farmers in Imo state. The specific objectives were to:

i. examine the socioeconomic characteristics of rural cassava-based farmers in the study area,
ii. identify the sustainable land management practices adopted and adapted by farmers in the area,
iii. determine the extent of farmer's income diversification and the corresponding income levels,
iv. determine the effects of income diversification activities on sustainable land management practices in the area,
v. identify the factors constraining farmers from adapting sustainable land management practices in the area

Hypothesis of the Study

The null hypothesis tested was that:

i. Income diversification activities of rural cassava-based farmers have no significant effect on sustainable land management practices in the area.

2. METHODOLOGY

2.1 Study Area

Imo State is in the ~~southeast~~ South-East zone of Nigeria. The state is made up of twenty-seven Local Government Areas. Imo State lies between Latitude 5°12' and 5°56' North of the Equator and between Longitudes 6°38' and 7°25' east of the Greenwich meridian. The state is bordered by Abia State on the east, by the River Niger on the West, by Anambra State to the north and River State to the south (Imo State Government, 2001). Imo State occupies a land mass of about 5,530 km^2 with a total population of approximately 3.93 million persons (NPC, 2006). The State has two dominant seasons, that is, rainy and dry seasons. Rainfall is between April and October, while the dry season starts from November to early March. Agriculture is assumed to be one of the major sources of income of most of rural dwellers. The major food produce include cassava, yam, cocoyam, maize, and melon.

2.2 Analytical Techniques

Well-structured questionnaire were administered to rural cassava-based farmers in the area. Multi-stage and purposive sampling techniques were employed, and one hundred and twenty (120) farmers were randomly selected for the study. Data collected were analyzed using descriptive statistics, Sustainable Land Management Index (SLMI), Probit model and Inverse Herfindahl–Hirschman Diversity (IHHD) Index. The sustainable land management index (SLMI) was constructed from twelve (12) different sustainable land management indicators based on the sustainable practices prevalent in the study area. The indicators were contour bund, mixed and intercropping, mulching, use of cover crops, use of legume crops in rotation, crop rotation, incorporation of crop residues, compost and farm manure, minimum tillage, terracing, crops cultivation on tree-land, and fallowing and fallow rotation. The levels to which the farmers adapt these sustainable land management practices were measured. These were then added and divided by twelve (12) to determine the Sustainable Land Management Index (SLMI) for each farmer. The SLMI is stated as (Kassie, 2017):

$$SLMI_i = \left(\sum_{i=1}^{k} \frac{S_i}{12}\right) \quad (1)$$

Comment [F2]: The equation appears as an image and has no clarity. It was probably edited in docx format. It is recommended to re-edited with Equation Editor in doc format, in order to have the necessary clarity.
This observation and recommendation is valid for all equations in the paper.

Where,
$SLMI_i$ = Sustainable land management index for the ith farmer
S_i = Sustainable land management practices adapted by the i[th] farmer.
A cutoff point was derived to specifically classify farmers that adapt up to 50% or above of the sustainable land management practices. That is, $SLMI_i < 0.5$ is an indication that the i[th] farmer adapted other land management technique that are not sustainable, while $SLMI_i \geq 0.5$ implies that the i[th] farmer adapted sustainable land management practices. This then forms the dependent variable (dichotomous variable) coded as:

$$SLMI_i < 0.5 \implies 0\ (unsustainable\ practices)$$

$$SLMI_i \geq 0.5 \implies 1\ (sustainable\ practices)$$

Considering the fact that the income diversification activities may affect the land management system of the farmer, a rational farmer chooses among the mutually exclusive income diversification activities that could offer the maximum utility (Yizengaw~~, Okoyo & Beyene,~~ et al., 2015). The income diversification activities were grouped into three major activities which include on-farm, non-farm, and off-farm activities. On-farm activities involve income derived from cassava-based production. Off-farm activities involve income derived from agricultural activities that take place outside the farmer's own farm or the agricultural work at another farmer's farm; while non-farm activities involve income derived from activities that take place outside the agricultural sector. The extent of income diversification was determined using the Inverse Herfindahl-Hirschman Diversity (IHHD) index, stated as (Ellis & Freeman, 2004):
.

$$IHHD_i = \left[\frac{1}{\left(\sum \frac{a_{ij}}{y_i}\right)^2}\right] \quad 5$$

Where,
$IHHD_i$ = Inverse Herfindahl-Hirschman Diversity index of the i[th] farmer
a_i = Income from the i[th] activity of the j[th] farmer (Naira)
y_j = Total income of the j[th] farmer (Naira)
The i[th] cassava-based farmer is considered to be diversified in its income sources if *IHHD >1*, and if *IHHD =1*, the farmer is not diversified in its income sources. The overall extent (in percentage) of cassava-based farmers' diversification was measured as:

$$EID = \left(\frac{n}{N}\right)100 \quad 6$$

Where,
EID = Overall extent of income diversification by cassava-based farmers (percentage).
n = Number of farmers with IHHD ~~inderx~~index > 1
N = sample size.
However, the effect of income diversification activities on sustainable land management practices was determined using the Probit model. Given the sustainable land management index, the cassava-based farmer is observed adapting sustainable land management practices if y_i^* crosses the threshold value 0. That is,

$y_i = 1\ if\ y_i^* \geq 0, if\ the\ i^{th}\ farmer\ adapts\ SLMP$,

$y_i = 0\ if\ y_i^* < 0, if\ the\ i^{th}\ farmer\ do\ not\ adapt\ SLMP$.

This is stated as:

$$y_i = \begin{cases} 1\ if\ y_i^* \geq 0 \\ 0\ if\ y_i^* < 0 \end{cases} \quad (2)$$

The probit model is specified as:

$$y_i^* = \beta x_i + U_i \quad (3)$$

The marginal probability for a non-dichotomous variable, is defined by the partial derivatives of the probability that $y_i = 1$ with respect to that variable. For the j^{th} explanatory variable, the marginal probability is stated as:

$$\frac{\partial P}{\partial X_{ij}} = \varphi(X_i\beta)\beta_j \qquad (4)$$

Where,

y_i = Observed dichotomous dependent variable (1, when i^{th} farmer adapts SLMP and 0, otherwise);

y_i^* = Underlying latent variable;

β_j = Vector parameter estimate of j^{th} variable;

X_i = Vector exogenous variables, which are the on-farm, off-farm and non-farm activities.

$\varphi(.)$ = Distribution function for the standard normal random variable

X_1 = Income derived from on-farm activities (naira)

X_2 = Income derived from off-farm activities (naira)

X_3 = Income derived from non-farm activities (naira)

X_4 = income from on-farm^2 activities (naira)

X_5 = income from off-farm^2 activities (naira)

X_6 = Income derived from non-farm^2 activities (naira)

U_i = Standard normally distributed error term,

Formatted: Superscript

3. RESULTS AND DISCUSSION

3.1 Socioeconomic Characteristics of cassava-based farmers

Table 1 shows the socioeconomic characteristics of cassava-based farmers in the area. Results showed that the mean age of farmers was 46 years. This is an indication that cassava-based farmers in the state are at their younger and active age. This implication is that at this youthful age, farmers can easily diversify into other income sources. This is in line with Ohen~~, Ene and Umeze~~ et al. (2014) who reported that farmers within the age range of 41 to 50 years are active, more receptive to innovation and could withstand the stress and strain involved in crop production. Results also showed that majority (68.33%) were female farmers. This implies that cassava production is mostly dominated by female farmers in the state, as asserted by Forsythe~~, Posthumus and Martin~~ et al. (2016) that cassava is a women's crop. Results showed that majority (70.00%) of the farmers were married, with mean household size of 6 persons. This implies that most married female-headed farmers in cassava production have more family labour to enhance production and reduce the cost of hired labour. Majority of the farmers (55.83%) had secondary education. This is an indication that cassava-based farmers had training in formal education. The implication is that increase in literacy level of these farmers exposes them to sustainable techniques in cassava production, and increases the opportunity to engage in activities other income generating activities as reported by Seng (2015). Results showed that the mean experience in cassava production was 23 years. It implies that farmers have more years of experience in cassava production. Increase in experience of farmers improves their technical know-how in crop production and income earning activities. More experienced farmers adapt sustainable land management techniques to improve soil fertility, minimize the use of highly expensive practices and labour intensive techniques. Majority (64.17%) had no access to credit, and only 43% belonged to a cooperative society. Results showed that majority (89.17%) had no contact with extension agents.

Table 1: Socioeconomic characteristics of cassava-based farmers in the Area

Variables	freq	%	$\bar{X}$
Age (years)			46
a. 21-30	7	5.83	
b. 31-40	22	18.33	
c. 41-50	57	47.50	
d. 51-60	26	21.57	
e. 61-70	8	6.67	

Sex			
a. Male	38	31.67	
b. Female	82	68.33	
Marital Status			
a. Married	84	70.00	
b. Single	36	30.00	
Household Size			**6**
a. 1-4	22	18.33	
b. 5-8	86	71.67	
c. 9-12	12	10.00	
Education			
a. primary	38	31.67	
b. secondary	67	55.83	
c. tertiary	6	5.00	
d. none	9	7.50	
Years of Experience			**23**
a. 1-10	11	9.17	
b. 11-20	31	25.83	
c. 21-30	57	47.50	
d. 31-40	21	17.50	
Access to Credit			
a. Yes	37	30.83	
b. No	83	69.17	
Cooperative Membership			
a. Yes	43	35.83	
b. No	77	64.17	
Extension Contact			
a. Yes	13	10.83	
b. No	107	89.17	

freq(frequency); $\bar{X}$ (mean)

Source: Field Survey Data, 2018

3.2 Sustainable Land Management Practices Adapted by Cassava-Based Farmers

Table 2 shows the multiple response and percentage distribution of respondents by sustainable land management practices adapted in the area. Results showed that majority of the respondents adapted mixed and intercropping (96.67%), mulching (86.67%), incorporation of crop residues (95.00%), compost and farm manure (98.33%) and crop cultivation on tree-land (74.17%). This implies that cassava-based farmers adapted mixed and intercropping, mulching, compost and farm manure, incorporation of crop residues, and crop cultivation on tree-land in the study area. This is in agreement with Onubuogu~~, Esiobu, Nwosu and Okereke~~ et al. (2014) who asserted that cassava producers adapt mixed and intercropping system to ensure food security/food availability all year round, increase income and reduce incidence of pests and diseases. According to Branca~~, McCarthy, Lipper and Jolejole~~ et al. (2011), intercropping is designed to ensure differential nutrient uptake and use between crops, nitrogen-fixing and enhance soil fertility, reduce reliance on chemical fertilizers, and enrich nutrient supply to subsequent crops.

Table 2: Percentage Distribution of Respondents by Sustainable Land Management Practices Adapted.

Sustainable Land Management Practices	Freq	% Distribution

a.	Contour bund	7	5.83
b.	Mixed and intercropping	116	96.67
c.	Mulching	104	86.67
d.	Use of cover crops	26	21.67
e.	Use of legume crops in rotation	12	10.00
f.	Crop rotation	7	5.83
g.	Incorporation of crop residues	114	95.00
h.	Compost and farm manure	118	98.33
i.	Minimum tillage	34	28.33
j.	Terracing	11	9.17
k.	Crops cultivation on tree-land	89	74.17
l.	Fallowing and fallow rotation	17	14.17

*major practices (Multiple response)
Source: Field Survey Data, 2018.

3.3 Income Diversification Activities of Cassava-based farmers

Table 3 shows the income generated from various diversification activities by cassava-based farmers. Results showed that the mean on-farm income was ₦ 130,646.2k, while that of off-farm and non-farm were ₦ 20,554.17k and ₦ 78,333.33k, respectively. Results also showed that majority of the respondents (60.00%) engaged in on-farm, together with non-farm activities, with a mean annual income of ₦244,333.60k. This implies that cassava-based farmers mostly diversify into non-farm activities in order to widen their income earning opportunities. The need for more income could be attributed to the decline in on-farm income and responsibilities outside farm needs such as home chores and taking care of a large household. As opined by Anang (2017) that the decline in farm wages and emerging opportunities for work outside the farm sector can promote farmers' engagement in rural non-farm work. On the other hand, additional income from non-farm activities influences farmer's decision to adapt sustainable practices, as reported by Garibaldi *et al.* (2016) that farmers with higher non-farm income are greater adapters of sustainable land management practices. The more income farmers earn from different sources, the more they adapt sustainable practices. According to Hainmueller~~, Michael, Hiscox and Maja~~ et al. (2011) low farm income (on-farm income) affects farmers' ability to improve the soil fertility that has been depleted due to unsustainable practices. Results also showed that cassava-based farmers who engaged in on-farm and non-farm together with off-farm activities earned higher income of ₦271,061.43k. This increase results from the additional earnings from off-farm activities.

Comment [F3]: A correct symbol for the mean is recommended.
Review the entire paper.

Table 3: Income Generated from Various Diversification Activities by Cassava-based farmers

Activities	freq	%	Mean Income (₦)
a. On-farm only	15	12.50	121,803.33
b. On farm + off farm	7	7.50	151,500.17
c. On farm + non farm	74	60.00	244,333.60
d. On farm + off farm + non farm	24	20.00	271,061.43

Mean on-farm income ₦ 130,646.2k
Mean off-farm income ₦ 20554.17k
Mean non-farm income ₦ 78333.33k

Source: Field Survey Data, 2018

Comment [F4]: A correct symbol for the mean is recommended.
Review the entire paper

Table 4 shows the percentage distribution of respondents by extent of income diversification in the area. Results showed that majority (87.50%) of the respondents had Inverse Herfindahl-Hirschman Diversity (IHHD) index greater than one. This implies that cassava-based farmers in the study area diversified their income base into other income-generating activities. This is an indication that cassava-based farmers diversified their income into off-farm and non-farm activities in order to maximize their income and livelihood sources. Rural farmers diversify their income-generating activities to better cope with adverse factors and events that affect agriculture (Ellis & Freeman, 2004; Rahman & Akter, 2014). Diversifying to non-farm income encourages land management practices that are environmentally friendly and sustainable, and reduces the continuous cultivation of the land without adequate fertilization and fallowing (Okalebo *et al.* 2006; Njeru *et al.* 2011).

Table 4: Percentage Distribution of Respondents by Extent of Income Diversification

Income Diversification	Frequency	% Distribution
$IHHD = 1$	15	12.50
$IHHD > 1$	105	87.50
Total	**120**	**100.00**

Source: Field Survey Data, 2018

3.4 Effects of Income Diversification Activities on Sustainable Land Management Practices adapted by Cassava-Based farmers

Table 5 shows probit estimates of the effects of income diversification activities on sustainable land management practices adapted by cassava-based farmers. It shows the coefficient and marginal effects of the Probit model. The Pseudo R^2 value was 0.5176. This is an indication that the income diversification activities of cassava-based farmers included in the ~~probit~~ Probit models explained about 51.76% of the variations in farmer's decision to adapt sustainable land management practices. The statistically significant coefficients showed the income diversification activities that influence farmer's decision to adapt sustainable land management practices in the study area. Results showed that the coefficients of off-farm income, non-farm income and off-farm^2 income were statistically significant at 1%. However, since the Probit model is non-linear, the estimated coefficients cannot give the correct measure of the effect of the explanatory variables on the dependent variable. Therefore, the most fitting method is to use marginal effects rather than their coefficients.

The coefficient of off-farm income was positive and significant at 1%, and the marginal value was 0.0000187. This is an indication that off-farm income has a positive effect on sustainable land management. The implication is that increase in off-farm income by 1%, increases the probability of cassava-based farmers to adapt sustainable land management practices by 0.0019%. The off-farm income compensates for any additional financial resource needs especially those associated with sustainable land management such as purchase of animal droppings. Availability of off-farm income encourages farmer's investment in sustainable soil management practices and decreases investment in agrochemicals as reported by Alabi~~, Lawal, Coker and Awoyinka~~ et al. (2012). According to Kassie (2017) farmers allocate their labour to off farm activities in order to supplement their daily consumption expenditure, and reduce the intensity of on-farm agricultural practices.

The coefficient of non-farm income was positive and significant at 1%, and the marginal value was 0.0000086. This implies that non-farm income has a positive effect on sustainable land management. The implication is that increase in non-farm income by 1%, increases the probability of cassava-based farmers to adapt sustainable land management practices by 0.00086%. Wage from non-farm income sources has a positive effect on sustainable land management practices. This could be stem from the fact that as cassava-based farmer gets employed in non-farm activities, the intensity of on-farm activities decreases thereby encouraging sustainable land management practices such as fallowing and minimum tillage. This is also in line with the findings of Nkonya et al. (2008); Bhandari & Grant, 2007; Robalino, 2007; and Kassie (2017). This contradicts the findings of Holden *et al.* (2004) who reported that participation in non-farm diversification activities decreased the farmers' motivation to invest their resources and time in suitable land management and conservation activities.

The coefficient of off-farm^2 income was negative and significant at 1%, and the marginal value was -0.0000127. This implies that more than 1% increase in farmer's diversification into off-farm activities decreases the probability to adapt sustainable land management practices by 0.0013%. This is an indication that doubling farmer's engagement to off-farm activities will have a negative effect on sustainable land management. This implies that doubling farmer's engagement to off-farm activities empowers cassava-based farmers to adapt unsustainable labour-saving practices such use of agrochemicals (herbicides, inorganic fertilizers and insecticides). This could be linked to farmer's drudgery and exhaustion as they allocate more of their labour services to another farmer's farm, and for this reason adopts unsustainable labour-saving practices such as overuse of agrochemicals. The arrival of chemical fertilizers drastically modified the function and structure of microbial communities, altering the terrestrial ecosystems, which has important implications for soil quality (Imfeld & Vuilleumier, 2012). Unbalanced use of chemical fertilizers can degrade soil quality and deplete soil organic contents (SOC) (Lal, 2015). Good soil structure is important for the sustainable production of agricultural lands (van Leeuwen *et al.,* 2015), and sustainable land management is one of the key factors in soil structure quality and aggregate stability (Wick *et al.,* 2015). Unsuitable land management can lead to a loss in soil fertility (García-Orenes *et al.*, 2010) and is the main reason for land degradation (Cerdà *et al.,* 2009; Barbera *et al.,* 2013).

Table 5: Probit Estimates of the Effects of Income Diversification Activities on Sustainable Land Management Practices adapted by Rural Cassava-Based Farmers

Activities	Coefficients	Marginal Effects $\left(\frac{dy}{dx}\right)$
On-farm	0.0020738 (0.2350358)	0.0003909 (0.0443035)
Off-farm	0.000099* (0.0000196)	0.0000187* (2.61e-06)
Non farm	0.0000458* (8.73e-06)	8.63e-06* (1.06e-06)
On-farm^2	-0.0002185 (0.0087095)	-0.0000412 (0.0016417)
Off-farm^2	-0.0000674* (0.000015)	-0.0000127* (1.98e-06)
Non-farm^2	0.0001254 (0.0344693)	0.0000236 (0.0064974)
LR chi2(6)	84.38	
Prob > chi^2	0.0000	
Pseudo R^2	0.5176	
Log likelihood	-39.314776*	

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

3.5 Factors Constraining Farmers from Adapting Sustainable Land Management Practices

Table 6 shows multiple response and percentage distribution of respondents by factors constraining farmers from adapting sustainable land management practices in the study area. Results showed that the major factors were high labour requirement (80.00%), insufficient land (64.17%) inadequate organic manure (69.17%); high labour cost (53.33%) and need for more output (65.83%). This is an indication that high labour requirement, insufficient land, inadequate organic manure, high labour cost and the need for more output are the factors limiting cassava-based farmers from adapting sustainable land management practices in the area. The finding is in agreement with Rahman~~, Wiederholt and Chen~~ et al. (2009) who also reported that organic manure application is highly challenged by unavailability of manure resource in the required amount particularly in areas where there is no large number of livestock population. According to Waithaka *et al.* (2006), manure and compost require much labour to carry and spread on the field. Adequate manure application enriches the soil and improves yield. Organic manure is an excellent source of nutrient and can improve soil structure and water holding capacity. On the other hand, high labour cost or requirement poses a serious challenge in food crop production. Sanginga (2015) reported that cassava farming is highly labour intensive especially in applying sustainable land management practices, as this increases the total production costs.

Table 6: Multiple Response and Percentage Distribution of Respondents by factors constraining farmers from adapting sustainable land management practices

Constraining factors	frequency	%
a) Low farm income	44	36.67
b) High labour requirement	96	80.00*
c) Insufficient land	77	64.17*
d) Soil erosion	37	30.83
e) Low productivity	9	7.50
f) Inadequate organic manure	83	69.17*
g) Unsuitable agricultural landscape	21	17.50
h) Non-availability of Credit	19	15.83
i) Inadequate Knowledge of SLMP	20	16.67
j) High labour Cost	64	53.33*
k) Need for more output	79	65.83*
l) High pest and disease infestation	19	15.83
m) Insufficient Extension Services	14	11.67

*major factors (≥ 50%)
Source: Field Survey Data, 2018

3.6 Test of Hypotheses

Table 5 shows that the likelihood ratio chi-square statistics (84.38) of the ~~probit~~ Probit model was statistically significant at 1% level. Therefore the null hypothesis that income diversification activities of cassava-based farmers have no effect on sustainable land management practices in the area was rejected. The study however accepted the alternative and concluded that income diversification activities of cassava-based farmers have significant effects on sustainable land management practices in the area.

3.7 Conclusion and Recommendations

This paper examined the income diversification activities and sustainable land management practices among rural cassava-based farmers in Imo state, Nigeria. Cassava-based farmers in the study area are mostly female producers at their younger and active age, married with a mean household size of six persons. The farmers had training in formal education, with 23 years experience in cassava production. Most rural farmers have no access to credit and contact with extension agents, and do not belong to a cooperative society. Sustainable land management practices adopted and adapted by rural cassava-based farmers are mixed and intercropping, mulching, compost and farm manure, incorporation of crop residues, and crop cultivation on tree-land. Farmers diversified their income base into other income-generating activities such as off-farm and non-farm activities, in order to maximize their income and livelihood sources. The mean on-farm income of rural cassava-based farmers per production cycle is ₦ 130,646.2k, while that of off-farm and non-farm are ₦ 20,554.17k and ₦ 78,333.33k, respectively. Rural farmers engage mostly in on-farm activities, together with non-farm activities, with a mean annual income of ₦244,333.60k. The off-farm and non-farm activities have positive and significant effects on sustainable land management. The off-farm and non-farm activities facilitate the adoption and adaption of sustainable land management practices by rural cassava-based farmers. However, doubling farmer's engagement to off-farm activities (off-farm^2) empowers rural cassava-based farmers to adapt unsustainable labour-saving practices such as overuse of agrochemicals (herbicides, inorganic fertilizers and insecticides) due to drudgery and exhaustion as they allocate more of their labour services to another farmer's farm. High labour requirement, insufficient land, inadequate organic manure, high labour cost and the need for more output are the factors limiting cassava-based farmers from adapting sustainable land management practices in the area. We therefore recommend labour-saving practices and technologies such as conservation tillage and simple mechanized tools that reduce labour requirement in cassava production, and save time and energy. This will not only reduce the drudgery in cassava production as farmers diversify more into off-farm activities, but will improve the adoption and adaption of sustainable land management practices such as minimum tillage, and thereby increase income from off-farm activities. In addition, more lands should be allocated to cassava farmers, as farm land diversity will facilitate the adoption and adaption of sustainable land management practices such as fallowing and crop rotation that increase productivity by replacing fallow periods with growing different crops that replenish soil nutrients.

REFERENCES

Adepoju, AO; Obayelu,OA.. Livelihood diversification and welfare of Rural households `in Ondo State, Nigeria. Journal of Development and Agricultural Economics. 2013:5(12):482-489

Anang, BT. Effect of non-farm work on agricultural productivity: Empirical evidence from northern Ghana, WIDER Working Paper, No. 2017/38, ISBN 978-92-9256-262-5, UNU-WIDER, Helsinki, 2017

Assan, JK, Beyene FR. Livelihood Impacts of Environmental Conservation Programmes in the `Amhara Region of Ethiopia. *Journal of Sustainable Development,* 2013:6(10);87-105

Comment [F5]: Some journals titles are written in italic, and other in regular format.
Some journals titles are written in abbreviated form, and other with full text.
The entire References chapter requires revision and correction.

Formatted: Font: Not Italic

Barbera, V; Poma, I; Gristina, L; Novara, A, Egli, M. Long-term cropping systems and tillage management effects on soil organic carbon stock and steady state level of C sequestration rates in a semiarid environment, Land Degrad. Dev., 2013: 23, 82–91, *doi:10.1002/ldr.1055.*

Barua, SK, Haque, SMS. Soil characteristics and carbon sequestration potentials of vegetation in degraded hills of Chittagong, Bangladesh, Land Degrad. Dev., 2013: 24, 63–71, doi:10.1002/ldr.1107,.

Bhandari, BS, Grant, MÃ. Analysis of livelihood security: A case study in the Kali-Khola watershed of Nepal. Journal of Environmental Management, 2007: 85, 17–26. doi:10.1016/j.jenvman.2006.07.010

Borrelli, P., Märker, M., Schütt, B. Modelling post-tree-haversting soil erosion and sediment deposition potential in the Turano River Basin (Italian Central Apennine). Land Degradation and Development,2013: DOI 432 10.1002/ldr.2214.

Bowen, S, De Master, K. De. New rural livelihoods or museums of production? Quality food initiatives in practice. Journal of Rural Studies, 2011: 27, 73–82.

Branca, G., McCarthy, N., Lipper, L. Jolejole, M. *Climate-Smart Agriculture: A Synthesis of Empirical Evidence of Food Security and Mitigation Benefits from Improved Cropland Management.* Food and Agriculture Organization of the United Nations, Rome, Italy. 2011: 43pp.

Brandth, B., Haugen, MS. Farm diversification into tourism – Implications for social identity? `Journal of Rural Studies, 2011:27, 35–44. doi:10.1016/j.jrurstud.2010.09.002

Cerdà, A., Flanagan, DC., le Bissonnais, Y, Boardman, J. Soil erosion and agriculture `*Soil Till. Res., 2009:106, 107–108, doi:10.1016/j.still.2009.10.006.*

Conant, R T. Rebuilding resilience: Sustainable land management for climate mitigation and adaptation, Technical Report on Land and Climate Change for the Natural Resources Management and Environment Department. Rome, Food and Agriculture Organization of the United Nations, 2009.

Ellis, F, Freeman, HA. *Rural Livelihoods and Poverty Reduction Policies*. Routledge Studies in Development Economics. ISBN 1134296282, 9781134296286.2004:1-440

Fageria, NK. "Green manuring in crop production." J. Plant Nutr. 2007:30(4-6): 691-719.

Fasinmirin, JT, Reichert, JM. Conservation tillage for cassava (Manihot esculenta crantz) `production in the tropics. Soil & Tillage Research 2011:113 (2011) 1–10

Food and Agriculture Organization. Food Security and Agricultural Mitigation in Developing Countries: Options for Capturing Synergies. Rome, Food and Agriculture Organization of the United Nations,2009.

Forsythe, L; Posthumus, H, Martin, A . A crop of one's own? Women's experiences of cassava commercialization in Nigeria and Malawi. Journal of Gender, Agriculture and Food Security 2016: 1(2): 110-128.

Frelat, R; Santiago Lopez-Ridaura; Giller, KE; Herrero, M; Douxchamps, S; Djurfeldt, AA; Erenstein, O; Henderson, B; Kassie, M; Paul, B.K; Rigolot, C; Ritzema, R. S; Rodriguez, D; Piet J. A. van Asteni, van Wijk, M T. Drivers of household food availability in sub-Saharan Africa based on big data from small farms', *Proc Natl Acad Sci USA 2016:113(2): 458–463*

García-Orenes, F., Guerrero, C., Roldán, A., Mataix-Solera, J., Cerdá, A., Campoy, M., Zornoza, R., Barcenas, G., Caravaca, F. Soil microbial biomass and activity under di_erent agricultural management systems in a semiarid Mediterranean agroecosystem, Soil Till. Res.,2010:109, 110–115

Garibaldi, L A., Gemmill-herren, B., Annolfo, RD., Graeub, BE., Cunningham, SA, Breeze, TD. Farming approaches for greater biodiversity, livelihoods, and food security. Trends in Ecology & Evolution,2016: *xx*, 1–13. doi:10.1016/j.tree.2016.10.001

Greenland, DJ. Soil science and sustainable land management. In: J.K. Syers and D.L. Rimmer (Editors), Soil science and sustainable land management in the tropics. CAB International, Wallingford, 1994: 1-15.

Hainmueller, J., Michael J. Hiscox, MJ, Maja T. *Sustainable Development for Cocoa Farmers in `Ghana*. Cambirdge (MA): MIT and Harvard University, 2011.

Hansen, E, Eriksen, J, Vinther, FP. Catch crop strategy and nitrate leaching following grazed grassclover. *Soil Use Manag 2007:23(4): 348-358*

Haregeweyn, N; Poesen, J; Verstraeten, G; Govers, G; de Vente, J; Nyssen, J; Deckers, J, Moeyersons, J. Assessing the performance of a spatially distributed soil erosion and sediment delivery model (WATEM/SEDEM) in Northern Ethiopia. *Land Degradation and Development* 2013:*24, 188-204.*

Holden, S., Shiferaw, B., Pender, J. Non-farm income, household welfare, and sustainable land management in a less-favoured area in the Ethiopian highlands. *Food Policy, 2004:29*, 369–392. doi:10.1016/j.foodpol.2004.07.007

Imfeld, G, Vuilleumier, S. Measuring the effects of pesticides on bacterial communities in soil: a critical review, Eur. J Soil Biol., 2012:49, 22–30

Imo State Government (IMSG). Examination Ethics Commission, Imo State Government, Ministry of Education, Owerri, Imo State, 2001.

Intergovernmental Panel on Climate Change (IPCC). Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Chapter 8-Agriculture. Climate Change 2007:Mitigation. Cambridge, United Kingdom and New York, NY, USA Cambridge University Press, 2007.

International Fund for Agricultural Development**.** *Rural poverty report. New realities, new challenges: new opportunities for tomorrow's generation*. Rome, International Fund for Agricultural Development, 2011.

Ito, J., Bao, Z, Ni, J. Land rental development via institutional innovation in rural Jiangsu,China. `*Food Policy, 2016: 59*, 1–11. doi:10.1016/j.foodpol.2015.12.005

Jones, N; de Graaff, J; Duarte, F; Rodrigo, I, Poortinga, A. Farming systems in two less favoured areas in Portugal: their development from 1989 to 2009 and the implication for sustainable land management, *Land Degrad. Dev., 2014:25, 29-44, doi:10.1002/ldr.2257*.

Kassie, G. W. The Nexus between livelihood diversification and farmland management strategies in rural Ethiopia. *Cogent Economics & Finance* 5: 1275087. http://dx.doi.org/10.1080/23322039.2016.1275087.

Kebede W, Awdenegest M, Fantaw Y. Farmers perception of the effects of soil and water conservation structures on crop production: The case of Bokole watershed, Southern Ethiopia, 2013.

Lal, R. Restoring Soil Quality to Mitigate Soil Degradation. *Sustainability*, 2015:*7*, 5875-5895; doi:10.3390/su7055875

Formatted: Font: Not Italic

Liniger, H.P., R. Mekdaschi Studer, C. Hauert, Gurtner, M. Sustainable Land Management in Practice – Guidelines and Best Practices for Sub-Saharan Africa. TerrAfrica, World Overview of Conservation Approaches and Technologies (WOCAT) and `Food and Agriculture Organization of the United Nations (FAO), 2011.

Liu, Z., Liu, L. Characteristics and driving factors of rural livelihood transition in the east coastal region of China: A case study of suburban Shanghai. *Journal of Rural Studies, 2016:43*, 145–158. doi:10.1016/j.jrurstud.2015.12.008

Loison, SA., Loison, SA. Rural livelihood diversification in Sub-Saharan Africa: A literature review rural livelihood diversification in Sub-Saharan Africa: A literature review. *The Journal of Development Studies, 2016:51*, 1125–1138. doi:10.1080/00220388.2015.1046445

Martin, SM., Lorenzen, KAI. Livelihood diversification in rural laos. *World Development, 2016:83*, 231–243. doi:10.1016/j.worlddev.2016.01.018

Minot M, Epprecht M, Anh T, Trung L. Income diversification and poverty in the Northern uplands of Vietnam, International Food Policy Research Institute, Wishington, DC; 2006.

Mphande, F. A. *Infectious Diseases and Rural Livelihood in Developing Countries*. Science+Business Media, Singapore, Springer, 2006:XV, 187: DOI 10.1007/978-981-10-0428-5_2

National Population Commission. National Population Commission, Provisional Population Result Figures 2006, Abuja, Nigeria.

Njeru, P.N.M; Maina I; Miruka M *et al*. Soil fertility characterization of smallholder farms under group and individual management in Central Kenya. Proceedings on held at Maputo, Mozambique on 10th to 13th October. African Crop Science Conference Proceedings 2011:10: 1– 4

Nkonya, E; Pender, J; Kaizzi, K. C; Kato, E; Mugarura, S; Ssali, H, Muwonge, J. Linkages between Land Management, Land Degradation, and Poverty in Sub-Saharan Africa *The Case of Uganda. Research Report 159.* International Food Policy Research Institute. 2008: DOI: 10.2499/9780896291683RR159

Ohen, S B; D.E Ene, Umeze, G.E. Resource Use Efficiency of Cassava farmers in Akwa Ibom State, Nigeria**;** J. Bio. Agric. and Healthcare 2014:4(2),(Online), ISSN 2224-3208 (Paper) ISSN `2225-093X

Ojiako, I.A; Tarawali, G; Okechukwu, R.U, Chianu, JN. Household Characteristics and Market Participation Competence of Smallholder Farmers Supplying Cassava to Starch Processors In Nigeria. *Int. J. Agril. Res. Innov. & Tech. 2016:6 (2): 42-56.*

Okalebo, J. R; Othieno, C. O; Woomer, P. L *et al*.. Available technologies to replenish soil fertility in East Africa. Nutrient Cycling in Agro-ecosystems 2006:76:153–170.

Onubuogu, G. C; Esiobu, N.S; Nwosu, C. S, Okereke, C. N. Resource use efficiency of smallholder cassava farmers in Owerri Agricultural zone, Imo State, Nigeria. *Scholarly Journal of Agricultural Science 2014:4(6):306-318*

Rahman, S, Akter, S.Determinants of livelihood choices: an empirical analysis from rural Bangladesh. *Journal of South Asian Development, 2014:9(3): 287-308*

Rahman, S. Wiederholt, R, Chen, Y. Land Application of Manure and Environmental Concerns. `North Dakota State University press, 2009.

Rinivasarao, C., Venkateswarlu, B., Lal, R., Singh, A. K., Kundu, S., Vittal, K. P. R., Patel, J. J., Patel, M. M. Long-term manuring and fertilizer effects on depletion of soil organic carbon stocks under pearl millet-cluster bean-castor rotation in Western India, *Land Degrad. Dev., 2014:25, 173–183.*

Robalino, JA. Land conservation policies and income distribution: who bears the burden of our environmental efforts? *Environment and Development Economics, 2007:12*, 521–533.doi:10.1017/S1355770X07003671

Sanginga, N. Roots and tuber crops (Cassava, yam, potato and sweet potato). In Proceedings of the An Action Plan for African Agricultural Transformation Conference, Dakar, Senegal, 21–23 October 2015.

Seng, K.'The Effects of Nonfarm Activities of Farm Households' Food Consumption in Rural Cambodia'. *Development Studies Research*, 2015:2(1): 77–89.

Sherren, K., Loik, L, Debner, J. A. Climate adaptation in "new world" cultural landscapes: The case of Bay of Fundy agricultural dykelands (Nova Scotia, Canada). *Land Use Policy, 2016:51*, 267–280. doi:10.1016/j.landusepol.2015.11.018

Tadele, Z. Raising Crop Productivity in Africa through Intensification. Agronomy 2017, 7, 22; doi:10.3390/agronomy7010022

Vanlauwe, B., Descheemaeker, K., Giller, K.E., Huising, J.,Merckx, R., Nziguheba, G.,Wendt, J, Zingore, S. Integrated soil fertility management in sub-Saharan Africa: unravelling local adaptation. Soil 2015:1, 491–508.

Waithaka, M., P. K. Thornton, Shepherd, K. Bio-economic evaluation of farmers' perceptions of viable farms in western Kenya. *Agricultural Systems, 2006:*90**,** 243-271.

Weltin, M; Zasada,I; Franke, C; Piorr, A; Raggi, M, Viaggi, D. Analysing Behavioural Differences of Farm Households: An Example of Income Diversification Strategies Based on European Farm Survey Data*. Land Use Policy 2017:62, 172–184*

Wick, A.F., Daniels, W.L., Nash, WL, Burger, JA. Aggregate recovery in reclaimed coal mine soils of SW Virginia. Land Degrad. Dev.2015: http://dx.doi.org/10.1002/ldr.2309.

Woodfine, A. The Potential of Sustainable Land Management Practices for Climate Change Mitigation and Adaptation in Sub-Saharan Africa. Rome, Food and Agriculture Organization of the United Nations, 2008.

World Bank. Sustainable Land Management: Challenges, Opportunities and Trade-Offs. The World Bank: Washington, DC, 2006.

Yizengaw, S. Y; Okoyo, E. N, Beyene, F. Determinants of livelihood diversification strategies: The case of smallholder rural farm households in Debre Elias Woreda, East Gojjam Zone, Ethiopia. *African Journal of Agricultural Research, 2015:10(19):1998-2013*

Zdruli, P. Land resources of the Mediterranean: Status, pressures, trends and impacts on future regional development. Land Degradation and Development, 2014:25 (4):373-384. DOI: http://dx.doi.org/10.1002/ldr.2150