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Analysis of the Factors Affecting the Adoption of Soil Management Practices by Smallholder Crop Farmers in Ondo State, Nigeria

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ABSTRACT: Land is one the major economic resources that plays a critical role in the production of goods and services. It exhibits distinct characteristics which makes it different from the other factors of production. Some of these features include being subject to the law of diminishing returns, immobile, a free gift of nature, varies in quality and limited in area. Based on this, land required to be carefully nurtured. Therefore, the aim of this study was to identify factors affecting the adoption of soil management practices by smallholder crop farmers in Ondo State of Nigeria, using binary logistic regression model. A multi-stage sampling technique was used for the collection of data from smallholder food crops farmers in the study area. In the first stage, four Local Government Areas were purposively selected because of large concentration of food crops farmers in the areas. The Local Government Areas selected for this study were Odigbo, Okitipupa, Irele and Ile-Oluji/Oke-Igbo. In the second stage, five villages were randomly chosen from each of the Local Government Area. In the third stage, six farmers producing food crops in the area were randomly selected from each of the five villages. Thirty farmers were interviewed in each of the Local Government Area selected such that a total of 120 farmers were sampled and interviewed for this study. The socio-economic characteristics of the farmers showed that 70.9% of the farmers were between the ages of 30-59 years while 75.8% of the farmers had married. The married farmers have more responsibility than unmarried and this would spur them to adopt soil management practices. More than half of the farmers were educated with household size between 5 and 9 people. This implies that many of the farmers adopt soil management practices. The percentage correct classifications for the maintenance of vegetation cover model, non-tillage with herbicide and fallow model were all as high as 76.3, 69.5 and 72.9 respectively. Results also showed that farmers were constrained by poor market prices (29.2%), absence of information (25%) and shortage of land (20.8%).The variables used in the study were statistically significant at 1%, 5% and 10% levels respectively.

Keywords: Adoption, Smallholders, Soil Erosion, Soil Management, Logistic Regression Models

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INTRODUCTION

Prior to the discovery crude oil in Nigeria, the contribution of agriculture to the Nation's gross domestic product was significant with about 60% of earnings being derived from her exports. The contribution of agriculture to Nigerian economy through its major export-oriented crops could not be over-emphasized. Some of these crops are cocoa, kola, groundnut, coffee, rubber, palm kernel, cashew nut and so on. The structure of agricultural production in Nigeria shows the

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dominance of crop production which accounted for 80% of the total production in agriculture. Agriculture is by far the most important sector in Nigerian economy providing employment for about 70% of the labour force (UNDP, 2012).

In recent years, Nigerian agriculture contributed 40% to the total Gross Domestic Product (GDP) in 2013 with a growth rate of 4.15%, (CBN, 2013). However, in 2013 and 2014 the percentage contributions of agriculture to GDP have been consistently fallen. The trend of agricultural contributions to the Nation's GDP is recorded in Table 1 between 2010 and 2014.

Nigeria's physical environment is promising for the development of prosperous agricultural economy because both natural and economic resources are adequately present. Despite this enormous promise Nigeria holds to increase agricultural production, the contribution of agricultural sector to the total Gross Domestic Product is dwindling and has suffered serious neglect as a result of misplaced priorities, inconsistent policies, and lack of proper implementation of agricultural policies with respect to conservation of natural resources of agricultural land. The production of food in Nigeria can best be described by Malthusian's proposition in which he foresaw the growth of food production in arithmetical manner while population grew in geometrical progression. The supply of food does not longer match the demand for it in Nigeria. According to (CBN, 2004) the production of food increases at the rate of 2.5%, while demand for food is increasing at the rate of more than 3.5% due to high population growth

The economic development in Nigeria which resulted in large part from the proceeds realised from petroleum had impacted positively and negatively on the environment. Positively, we can say it brought about rapid infrastructural development in term of buildings and construction of roads and aggressive industrial revolution. However, this has also reduced the frontier of agricultural land in term of deforestation of which eventually led to soil erosion. The per capita land area (ha) in 1960, 1990, and 2025, respectively is 0.68, 0.34, and 0.14 for Nigeria (Junge, *et al*., 2008). The economic activities of most developing countries like Nigeria in the past was so much wound around agriculture and diversification was almost impossible before the discovery of crude oil in Nigeria, so the natural resource base, which is land, became the major source upon which individuals and the nation relied to generate their incomes. Soil erosion poses serious environmental threats to agricultural land. Erosion degrades soil ecosystems and thus leads to crop yield reduction, threatening food security and farmers' incomes (Borrelli, *et al*., 2016). There are basically two causes that are responsible for soil erosion which include natural and anthropogenic factors.

In West Africa, Nigeria inclusive, human-induced soil degradation is a common phenomenon. The severity is light for 37.5% of the area (342,917 km2), moderate for 4.3% (39,440 km2), high for 26.3% (240,495 km2), and very high for 27.9% (255,167 km2) (FAO, 2005). Some human-induced soil erosion include over-fertilization, careless use of biocide; bush

Table 1: The Contribution of Agriculture to Nigeria's GDP, 2010-2014

Year	Percentage	Growth Rate
2010	40.00	5.60
2011	40.21	5.54
2012	22.07	4.00
2013	23.33	2.94
2014	22.90	4.27

Source: NBS, 2014

burning and deforestation over the years and they all have negative impacts on crop yields. Soil erosion is an ecological plague and reduces soil quality. Soil erosion occurs when the rate of soil formation is less than the rate at which soil is lost through physical, chemical and biological process. According to Troel *et al.,* (1999) erosion is normal when the rate of natural vegetation is approximately equal to the rate of soil formation. However, problem arises when the natural process of soil erosion is accelerated by human interference which results in its disequilibrium. Other factor can be linked to careless deforestation of forest trees for fuel wood. It was reported that 80% of Nigerian households make use of firewood as an alternative source of cooking to fossil fuel due to poverty (NPC, 2006). Approximated 25% of the world's degraded land is found in Africa, Nigeria inclusive, where overgrazing, deforestation and wood harvest for firewood accounts for most of the human induced erosion (Barbier, 1995).

LITERATURE REVIEW

Many studies have investigated factors influencing the adoption of soil management practices that can prevent erosion. Oloyede*, et al*., (2014) focussed and investigated soil management practices in cereal based production systems among small scale farmers in Kwara State of Nigeria. The study used logistic regression ' to identify socio-economic factors affecting the cereal based production farmers in its study area. The results of the study reveal that age, farm size, number of contact with extension agents, total labour employed and total number of plots cultivated influence the use of soil management practices by farmers. The dependent variables in the study include ridging, crop rotation, fertilizer, zero tillage, bush fallow and cover cropping. Junge *et al*. (2009) study focussed and investigated farmers' attitudes towards erosion and adoption of soil conservation technologies in Nigeria. In their study, low labour demand, common access, low cost and simplicity of operation and compatibility with existing agricultural systems were the factors that influenced the adoption. In the study of Demeke (2003) factors influencing the adoption of soil conservation practices introduced in North West of Ethiopia was investigated. The results revealed that variables like farm size and awareness of the conservation methods have a positive influence on farmers' decisions to adopt conservation structures. Torshizi and Salami (2007) study was based on factors affecting soil conservation practices for a group of farmers in Khorasan Razavi Province, using the Logit model. The results revealed that awareness of the effects of soil conservation index, education, land price, ratio of sloping land under cultivation compared to the total cultivated area, family labour force employed in agriculture, and percentage of farming income are significantly related to probability of adoption.

Calatrava *et al*., (2007) carried out the analysis of the adoption of soil conservation practices in olive groves in the mountainous area of Southern Spain. The major objectives of their study was focused on determining the adoption level of soil conservation practices and to address the socio economic and institutional factors determine such adoption. The study examined the use of agronomic conservation strategies s and mechanical methods to control erosion. In the study, three probit models were estimated with three different soil conservation practices, namely tillage following contour lines, maintenance of terraces with stonewalls and non-tillage with weedicides as dependent variables. The result of their study showed that variables like farm profitability, young farmers, and continuity of the farming by relatives and the use of family labour were found to be significantly and positively related to adoption in the area.

Haghjou *et al*., (2014) in their study used ordered logit model to identify factors affecting the adoption of soil conservation practices by some rainfed farmers in Iran. The study sampled 178 farmers of Izeh County in Khuzestan Province, Iran, during 2010 crop season. The results showed that farmers' perception of soil erosion and their knowledge about soil conservation practices, farms size, and grant funding have a positive effect, while farmers' levels of education and number of plots have negative effects on farmers' adoption. The study, therefore, concluded that award granting and use of training/extension would increase knowledge of the farmers on soil erosion conservation. However, factors like farms distance, access to off-farm job, and insecurity of tenure can have a negative effect on their decision.

Given the above situation, if the supply of food must be greater than demand for it, this situation must be reversed. From the previous literature, factors affecting adoption of innovation is of three categories. They are farm and farmers' associated attributes, attributes associated with the technology and farming objective (CIMMYT, 1988., Adesina *et al*, 1992). First, human capital is related to the level of education of the farmer (Rahm and Huffman, 1985), the risk and risk management strategies (Saha and Love 1994), the institutional support system, such as marketing facilities, research and extension services and transportation (Feder *et al*., 1985). However, the second and third categories depend on the type of technology and are important when farmers have access to different types of technical innovation. There are three major divisions for controlling erosion and these include agronomic practices, soil management practices and mechanical practices (El- swaify, 1982).

Many of the available studies on soil management practices focused on soil fertility while only few studies talked about soil erosion in Nigeria. Another important observation was that none of these studies used logistic regression model in their data analysis. Some of the past studies on soil erosion control include that of Ifenkwe, *et al.,* (2013), Onweremadu *et al.,* (2007), Titilola, *et al*., (1990), Babalola and Olayemi, (2013), Awoyinka (2009) and Adeoti and Adewusi, (2005) The current study is committed to filling this gap in order to provide relevant information to policy makers on soil erosion control in the study area in particular and Nigeria in general. It is, therefore, justified to investigate factors influencing the adoption of soil management practices by smallholder crop farmers in Ondo State, Nigeria. Specifically, the study

- examined the socio-economic characteristics of the farmers,
- identified constraints to the adoption of soil management practices by farmers, and
- analysed probability of adoption of soil management practices.

Hypothesis

H_0 = There is no significant relationship between farmers' socio-economic variables and adoption of soil management practices.

H_A = There is significant relationship between farmers' socio-economic variables and adoption of soil management practices.

METHODOLOGY

Study Area

The study was carried out in Ondo State, Nigeria. Ondo State is located in the South- West of Nigeria. It shares boundaries with Osun and Ogun States in the West and Ekiti and Kogi States in the North. Ondo State also shares boundaries with Edo and Delta States in the East and the South by Atlantic Ocean. Ondo State is blessed abundantly with both human and natural resources. It covers an area of 15,500km^2 of the total land area of South-West. Ondo State has eighteen (18) Local Government Areas with a

total population of 3,441,024 (NPC, 2006). The State lies between latitude $5^0 45^{'}$ and $7^0 52^{'}$ of the equator and longitude $4^0 30^{'}$ and $6^0 05^{'}$E (UNAAB-IFSERA). The study area is located in the tropical rainforest zone of Nigeria with two distinct seasons which include the wet and dry seasons and they usually occur between April and October and November – March respectively. The low rainfall is marked by the period of August break in August. A moderate temperature of about 25^0C with an annual rainfall that varies between 1150mm in the North and 2000mm in the South of the State.

Ondo State is composed of lowlands and rugged hills with granitic outcrops in several places. The soils are well drained with a medium texture. In the northeast, the soils are skeletal in nature and comparatively recent origin. In the southern part of the state, the soil is reported to be brown and orange sandy in nature while the one close to the coastal area of the State is light grey sandy soils (UNAAB-IFSERAR, 2010).

Sequel to this favourable climatic condition and good soil in the State, the people in the areas engage in the production of both food and cash crops. The soil is good for the cultivation of crops like yam, cocoyam, plantain, maize, oil palm, cocoa, rubber, cassava,

pepper to mention but a few. In the riverine area of the State, inhabitants engage in lumbering, building of canoes, basketry and weaving with a major occupation in fishing.

Sampling Techniques and Sample Size

A multi-stage sampling technique was used for the collection of data from smallholder food crops farmers in the study area. In the first stage, four Local Government Areas were purposively selected because of large concentration of foods crops farmers in the areas. The Local Government Areas selected for this study were Odigbo, Okitipupa, Irele, and Ile-Oluji/Okeigbo.

In the second stage, five villages were randomly chosen from each of the Local Government Area. In the third stage, six farmers producing food crops in the area were randomly selected from each of the five villages. The number of farmers interviewed in each Local Government Area was thirty (30). Finally, a total sum of 120 farmers were sampled and interviewed for this study.

Sources of Data

This study used primary data collected through a well-structured questionnaire. Other relevant information used in the study was obtained from published articles, textbooks, journals and other relevant papers sourced from Internet.

Method of Data Analysis

This study used descriptive statistics such as percentage frequency and tables to examine the socio-economic characteristics and soil management constraints of the respondents in the area. The inferential statistics employed was binary logistic regression. This was used to determine factors influencing the probability of adoption of soil management practices in the study area. The analysis of the data was done using Statistical Package for Social Sciences (SPSS 17.0) software.

Analytical Framework

In adoption studies, a number of response models which include logit, probit, tobit, multinomial logit and probit models, are normally employed to identify factors influencing behavioural responses in agriculture. Basically, logit, probit and linear probability models appear to be common in econometric literature for estimating binary choice models. Probit and logit usually give similar results when estimates are compared. Though, the difference between the two models is that probit assumes that the dependent variable follows cumulative normal distribution while logit is logistically distributed.

Binary logistic regression is a response model with dichotomous dependent variable. With the

knowledge of logit model, models whose dependent and explanatory variables are dummies can be conveniently, handled (Gujarati, 2006). It is commonly employed because of its computational simplicity (Maddala, 1989, Green, 2003,). Therefore, binary logistic regression was employed in this study to identify farm and farm-household level (socio-economic) and technology specific variable factors influencing adoption of maintenance of vegetation cover, non-tillage with herbicide and fallow to reduce soil erosion.

The logistic regression model is based on the cumulative logistic function. The parameters of this decision are not usually observable but we can defined as latent variable Y*, which is an unobservable index of the willingness of each farmer to adopt soil management practices to curb soil erosion and as well can be related to a set of explanatory variables $X_{i.}$.

The factors affecting the adoption of soil management practice will therefore be specified as:

$$Y^* = \beta X_i + U_i \quad (1)$$

The observed pattern of adoption can be described by a dummy variable, y, such that Y_i = 1 if farmer has adopted, otherwise 0, if he has. These observed values of Y are related to Y* as follows:

$Y^* = 1$, if $Y_i > 0$

$Y_i = 0$ if otherwise (2)

$Pr\ (yi=1)\ Pr\ (Yi^* > 0) = Pr\ (U > \beta_2 X_i = 1 - F(-\beta_2 X_i)$ (3)

Where F is the cumulative distribution function for U, if a symmetric distribution is assumed

$Pr\ (U_i - \beta X_i) = Pr\ (Ui < \beta_2 X_i) = F\ (\beta_2 x\ X_i)$ (4)

For N independent observations and assuming a symmetric distribution for U, a likelihood function can be obtained. Assumptions about the functional form of F result in different models. Here we focus on logistic model, which is based on the logistic distribution.

$$Pi = Pr\ (y_i e^{\beta X}) = (\beta X)/1 + e^{\beta 2X} \quad (5)$$

The odds ratio, which defines the probability of adoption relative to non-adoption, is given as:

$$Ln\ [\frac{P_i}{1-P_i}] = e^{\beta X} \quad (6)$$

Model Specification

Following Kalineza *et al.*, (1999), three logit models such as maintenance of vegetation cover, non-tillage with herbicide and fallow were specified as

$$Y_i = Ln\ [\frac{P_i}{1-P_i}] = \beta_0 + \sum_{i=1}^{n} \beta_i X_i + \varepsilon_i \quad (7)$$

Where Y_i= dichotomous dependent variable (if adopts =1, otherwise = 0)

β_i = vector of unknown parameters to be estimated,

β_0=constant,

X_i = vector of explanatory variables

ε_i = error term

Table 2: Definition of Variables and its Measurement

Variable	Definition and Measurements	Expected Signs
Age	Age of Household head in Years (continuous)	±
Sex	Male 1, 0 otherwise	±
Educational Status	Years spent in schooling (continuous)	±
Extension Services	Access to soil erosion control (Dummy)	±
Household Size	Number of household member (continuous)	±
Income level	The amount realised in Naira (continuous)	±
Experience	Years of experience of the household head (continuous)	±
Output Prices	Average price of products sold in Naira (continuous)	±
Input Prices	Average prices of input employed in Naira (continuous)	±
Farm size (Ha)	Measured in hectares (continuous)	±
Land man Ratio	Total land area/household size	±
Land Tenancy	Dummy, if a farmer owns 1, 0 otherwise	±
Productivity of the practices	If management practices leads to increases in yield 1,0 otherwise	±

RESULTS AND DISCUSSION

Socio Economic Characteristics of the Farmer

Table 3 showed that farmers in the study area were still young in age with a pool of 91.7%. The marital status of the farmers also showed that 75.8% of them were married. More than half (68.3%) of the farmers were educated while about 40.8% of the farmers had put in 10 years in terms of farming experience. The modal class of the household size was between 5 and 9.

Distribution of Farmers by Soil Management Constraints

Table 4 showed responses of soil management constraint as 20.8% of the farmers complained of shortage of land, 25.0% lack of information. Others said high cost of inputs (8.3%), low market prices for their product (29.2%) while 4.5% said they were too old to reap the benefits of soil management practices. The implications of these findings showed that in the study area, land was scarce; the farmers were not having adequacy of information on soil erosion. Also low returns to farmers' efforts could lead to non- adoption of erosion control.

Binary Logistic Regression of the Factors Affecting the Adoption of Soil Management Practices by Smallholder Crop farmers

The result in Table 5 showed the estimated coefficients for the adoption of maintenance of

Table 3: Distribution of Farmers by Socio economic Characteristics

Characteristics	Frequency	%
Age in year		
30-39	47	39.2
41-49	38	31.7
50-59	25	20.8
>60	10	8.3
Total	120	100
Marital status		
Single	20	16.7
Married	91	75.8
Divorced	4	3.3
Widowed	5	4.2
Total	120	100
Educational Status		
Non-formal	38.0	31.7
Primary	30.0	25.0
Secondary	32.0	26.7
Tertiary	20.0	16.6
Total	120	100
Experience in year		
0-10	49.0	40.8
11-20	30.0	25.0
>20	41.0	34.2
Total	120	100
Household size		
0-4	5	4.2
5-9	67	56.0
>9	48	40.0
Total	120	100

Source: Survey Field, 2014

Table 4: Distribution of Farmers by Soil Management Constraints

Constraints	Frequency	%
Shortage of land	25	20.8
Absence of soil erosion information	30	25.0
High cost of inputs	10	8.3
High cost of fossil fuel	15	12.5
Low market values of products	35	29.2
Farmers are too old	5	4.2
Total	120	100

Source: Survey Field, 2014

Table 5: Estimated coefficients of Binary Logistic Regression of the Factors Affecting the Adoption of Soil Management Practices by Smallholder Crop farmers

Variable	Maintenance of vegetation cover	Non Tillage with Herbicide	Fallow Practices
constant	-28.420(14.420)	-21.048(7.182)	-23.528(7.350)***
Age>50yrs	-1.889(0.670)***	-3.092(1.257)	-2.910(0.952)***
sex	1.427(0.661)	-2.750(1.261)	1.520(0.761)**
Education>14yrs	1.438(0.667)	0.763(0.062)	1.338(0.643)**
Extension serv.	1.468(0.780)*	0.749(0.542)	-1.52990.635)
Household >6	-1.837(0.680)	1.154(0.649)	-1.789(0.635)**
Income>50,000	-2.409(1.085)	-0.819(0.660)	-2.276(0.705)***
Experience	1.817(0.609)***	1.017(0.064)	1.513(0.815)**
Output pr>3001	0.926(0.745)	1.808(0.036)	4.036(1.612)
Input prices	1.365(0.067)	1.789(0.722)	1.770(0.065)
Farm size<2.1ha	-1.39790.662)	1.347(0.651)	-1.529(0.063)***
Land-man Ratio	-22.059(2.842)***	-23.277(2.480)	1.367(0.054)
Land tenancy	2.037(0.064)	-1.997(0.887)	1.367(0.054)
Productivity	1.378(1.248)	1.245(0.0340)	1.037(0.055)***
Pseudo R^2	0.42	0.25	0.40
%correct pred.	76.3	69.5	72.9
Sample size	120	120	120
-log likelihood	104.600	135.187	114.203

*Source: Field Survey, 2014. Level of Significance ***=1%, **= 5%, * =10%*
Figure in Parentheses are standard errors

vegetation cover, non-tillage with herbicide and fallow models to prevent soil erosion on farm plots. The results indicate that the log of the likelihoods were high and overall percentage correct classification are 76.3%, 69.5% and 72.9% respectively which indicates that the model fits the data well. The pseudo R squared were fairly good. For instant, the pseudo R squared implied that about 40%, 25% and 40% of the variations in the dependent variables were explained by the explanatory variables included in the models, respectively.

Firstly, the probability of adopting maintenance of vegetation cover by the farmer to prevent soil erosion increases with the following variables: education of the household head above 14 years, extension service and input prices. Farmers' access to extension service in the area was also statistically significant at the 5% level and positively related with the probability of adopting maintenance of vegetation. On the other hand, the adoption of maintenance of vegetation cover had negative relationship with age of the household head, household size, income level,

output prices and land man-ratio. This implies that a unit increase in any of these variables, holding others constant would lead reduction in the probability of adopting soil erosion control using maintenance of vegetation cover in the study area. The negative sign assumed by income level of the farmers might have arisen from the small-sized farms cultivated by the farmers and the likelihood of using this method of controlling erosion is less.

Secondly, the probability of adopting non-tillage with herbicide was also positively and statistically measured by age of household head, income level, and experience of household head, productivity and farm size. The positive and negative signs showed the marginal effects of the exogenous variables on the adoption of non-tillage with herbicide.

Thirdly, the probability of adopting fallow model were also measured by the following variables namely Sex, land tenancy, experience of the household head in years and input prices. All but land tenancy were statistically significant at the 5% level. The marginal effects of these variables would mean a unit increase in any of these variables would also increase the likelihood of adopting fallow technique in the study area.

CONCLUSION AND RECOMMENDATIONS

The results of the data analysed in this study showed that farmers were constrained by a number of factors that can encourage to adopt techniques in soil management. Also, the binary regression of maintenance of vegetation cover non-tillage with herbicide and fallow mode analysed showed that as farmer's age increases, so his interest reduces towards adoption of soil management packages. The following factors that positively measure adoption of soil management in this study are input prices, extension services, while others carried negative signs but are significant at 1%, 5% and 10% levels respectively.

Sequel to these findings, it is therefore concluded that farmers and technology-specific attributes determine the probability of adoption of soil management. It would be recommended that appropriate agricultural policies be formulated and implemented accordingly. It was noted that farmers were constrained by shortage of land and absence of relevant information on soil management. Farmer can maintain minimum vegetation covers; adopt careful use of herbicide instead of tilling the land as well as fallow would go a long to reduce farmland erosion. Therefore, Land Act of 1978 should be looked into and any conflicting areas should be addressed and tailored towards making soil management practices economically and environmentally attractive to the land users.

Surveys of agricultural areas susceptible to soil erosion in the country should be periodically undertaken with a view to finding a lasting solution to soil erosion in the Nigeria.

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