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DOES LAND TENURE SECURITY MATTER FOR ADOPTION OF SUSTAINABLE AGRICULTURAL TECHNOLOGY? EVIDENCE FROM AGROFORESTRY IN NIGERIA

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ABSTRACT

Land tenure constitutes a major factor militating against land use and its management practices for sustainable agricultural production in Nigeria. The study was therefore conducted to investigate the effects of land tenure security and other factors on agroforestry technology adoption decision in the study area. A multi-stage sampling procedure was employed to select respondents for the study. Data collected were analysed using descriptive statistics and probit regression model. Farmers' decision to adopt agroforestry technology in the study area is explained by land tenure security (risk measures) and other factors. The decision to adopt agroforestry technology is influenced by land ownership, plot age, land certification, farmers' income and land conflicts. The study suggests land use and distribution policy that would enhance ownership, certification and address conflicts as well as enhance farmers' income sources be put in place for the adoption of sustainable agricultural technologies for the purposes of sustainable production and development.

Keywords: Land Tenure Security, Agroforestry, Adoption, Agricultural Technology

INTRODUCTION

Land degradation constitutes a major problem facing sustainable agriculture in developing countries, Nigeria inclusive. The problem of unsustainable agricultural practices has threatened farmers' productivity resulting in food insecurity and poverty among the rural household (Kabwe, Bigsby and Cullen, 2009). The low farmers' productivity and the consequent food insecurity have increased government spending on food importation with its attendant effects on the economy. To solve the problem of land degradation, various methods are usually adopted by farmers in different countries depending on the available and affordable technologies.

In Nigeria, the main land use practices and farming systems commonly adopted as land management technologies are crop rotation, natural fallow and shifting cultivation (Neef, 1999). Another land management system adopted by some farmers to address the problem of poor soil fertility caused by unsustainable land use in some parts of the country is agroforestry. Agroforestry is an ecologically-based land management system, which has the potential of enhancing soil fertility as well as providing fuel wood and fodder for animal consumption and employment (Alavalapati and Thangata, 2003). It is a land use option in which the trees planted within the farm land provide both products and environmental services (Alao and Shuaibu, 2013).

The incorporation of trees in agroforestry system helps to enrich the soil for sustainable crop production which in turn brings about improved fuel wood supply, enhanced better livelihood of farm families as well as food security (Otegbeye, 2002). However, the rapid population increase and insecure land tenure in the country have threatened this technology and has driven the farmers to the cultivation of marginal land (Bifarin, Folayan and Omoniyi, 2013; Adekola, Adereti, Koledoye and Owombo, 2013). One major advantage of agroforestry technology is that it saves the smallholder farmers from a wide use of inorganic fertilizers which may be beyond most of the rural farmers' budgets (Kabwe *et al*., 2009). Therefore, agroforestry technology adoption and utilization become imperative in order to harness their potential benefits for the farmers.

The adoption of agroforestry technology among smallholder farmers is generally influenced by socioeconomic, environmental and institutional factors which include the land tenure system (Kabubo-Mariara, 2007). Land tenure system has been discussed in literature as a major determinant of agricultural technology adoption because technology adoption involves investment which may require a fairly long period before the returns on investment (Kabubo–Mariara, Linderhof and Kruseman, 2010). Property rights and tenure security play prominent roles in agricultural technology adoption because returns on investment may not be accrued in the short (Kabubo-Mariara *et al*., 2010). A right or tenure is secure if the land owner is capable of using a parcel of land for a long period of time such that whatever investment made could be reaped.
Tenure refers to the terms and condition or arrangement under which a parcel of land is held (Neef, 1999). Tenure is secure if the farm operator or owner is sure of using a parcel of land for a long period such that the operators could reap the benefits of investment made (Bekele and Mekonen, 2010). Land tenure security influences decisions on farm technology adoption, especially the extent to which farmers are prepared to invest in improvements in production, sustainable management, and adoption of new technologies and promising innovations (IFAD, 2008).

The effects of tenure security on agricultural technology adoption have been variously discussed in literature with diverse views. For example, while Migot-Adholla, Place and Oluoch-Kosura (1994) and Pinckney and Kimuyu (1994) posited that tenure security is not important for technology adoption, Gebremedhin and Swinton (2003) and Kabubo-Mariara *et al*. (2010) emphasized the positive effects of highly individualized rights and secured tenure on long-term than short-term investments.

Despite the identified positive effects of agroforestry on land management as well as the socioeconomic characteristics of the practicing farmers, the adoption rate is still low (Bifarin *et al*., 2013). The low adoption rate is traceable to tenure factors (Neef, 1999) and socioeconomic factors (Bifarin *et al*., 2013). Few studies have been conducted to highlight the importance and prospect of agroforestry in land use management in Nigeria. These include Bifarin *et al*. (2013) who conducted an assessment of agroforestry practices as a land use option for sustainable agricultural production in Osun State and found that level of education is a determinant of agroforestry technology adoption and Akinbile, Salimonu and Yekinni (2007) that investigated farmers' participation in agroforestry practices in Ondo State, Nigeria and found that awareness has a positive relationship with agroforestry participation.

However, no known studies have been conducted to investigate whether or not tenure security has effects on agroforestry technology adoption in the study area. The paucity of information on the effects of tenure security on agroforestry technology adoption necessitates the study. Therefore, the objectives of the study are to investigate the effects of tenure security and other characteristics on agroforestry technology adoption in the study area as well as examine the constraints militating against the technology utilization.

CONCEPTUAL FRAMEWORK

Farmers' decision to adopt a particular agricultural technology is influenced by various factors ranging from tenure related, socioeconomic, institutional as well as the financial implications among smallholder holder farmers. Agroforestry technology adoption involves farmers expenditure and input uses. The associated expenditure may consume a significant proportion of their overall expenditure the return of which may not come in the short run. The expenditure and input uses imply that the farmers have forgone other and/or investment opportunities either in the short or long run (Bekele and Mekonnen, 2010). Expectedly, farmers decision on the utilisation or otherwise of a particular is dependent mainly on several factors among which are profitability of the technology, affordability of the technology and simplicity of the technology as well as whether or not the technology will bring returns to investment in the short run. However, the ability of the investment to give return in the short run on or before the forfeiture of the land by farmers will be a motivator for adoption decision. Therefore, tenure security and other factors such as financial incentives, affordability of the technology, socioeconomic, institutional and resource-based factors influence agroforestry technology adoption (Alavalapati and Thangata, 2003). This study is interested in determining whether or not tenure security, socio-economic and resources-based characteristics of the farmers do have influence on agroforestry technology adoption in Nigeria. The relationship between agroforestry technology adoption and the assumed determining variable is depicted in Figure 1.

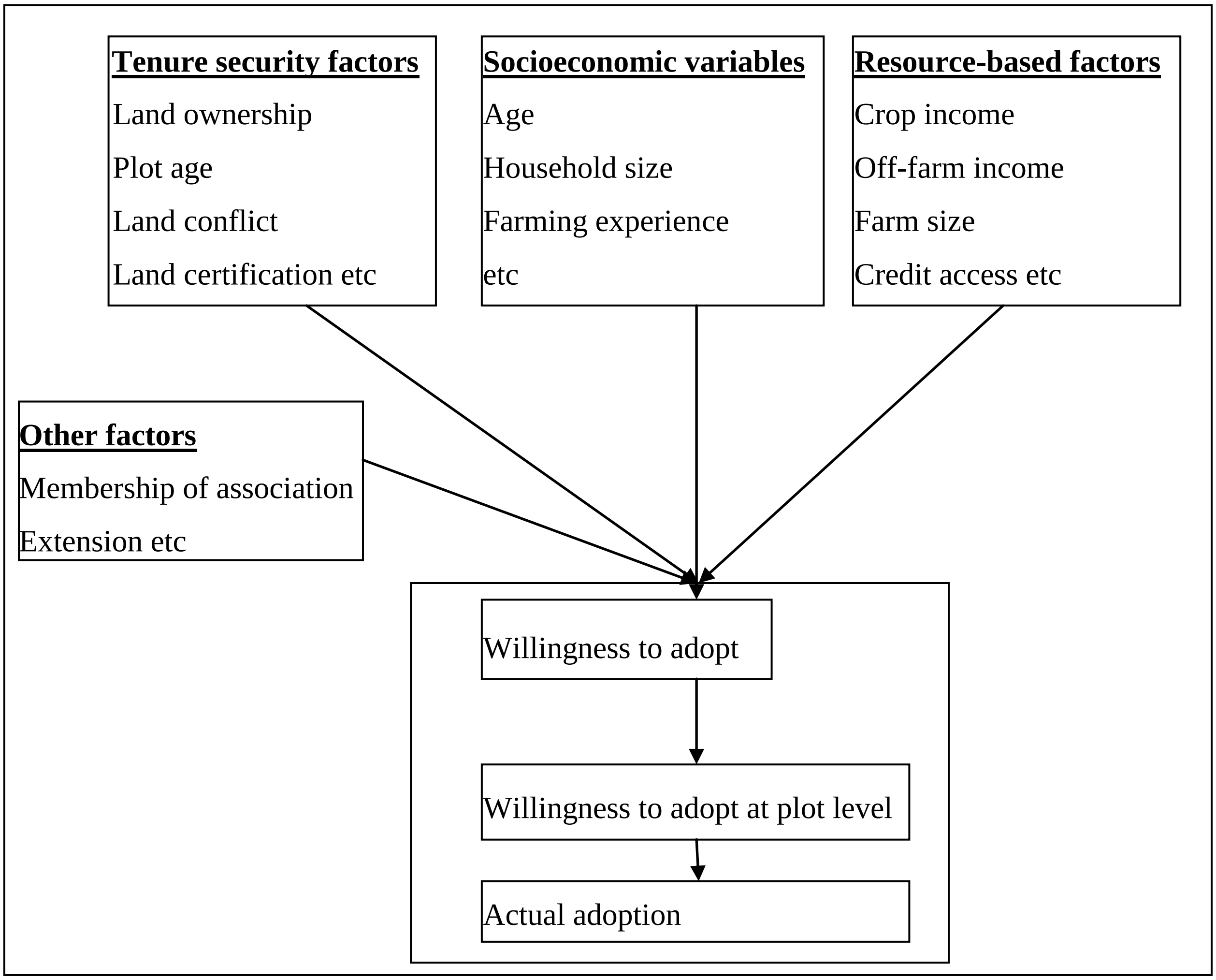

Figure 1: Link between agroforestry technology and determinants of adoption

RESEARCH METHODOLOGY

Study site

The study was conducted in Ondo State, which is located in the Southwestern part of Nigeria. The state was purposively selected for the study owing to closeness, accessibility, subsistence nature of agricultural production and relative incidence of land degradation. The state was created out of the defunct western region, Nigeria on February 3, 1976 and lies between Longitude $4^{0}30^{1}$ and $6^{0}00$ east of the Greenwich Meridian and Latitude $4^{0}45^{1}$ and $8^{0}15^{1}$ north of equator. The state is a tropical coastal wetland with mean annual rainfall approaching 2800mm, and mean number of rainy days of between 160 and 180. Mean relative humidity is between 70-80%, mean annual temperature is about 27.8°C, mean daily temperature is 26°C, mean daily minimum temperature is 22°C, and mean daily maximum temperature is 26.7°C.The land area is about 13,595 square kilometres with varying physical features like hills, lowland, rivers, creeks and lagoons. The people are predominantly smallholder farmers cultivating both cash and food (such as yam, cassava, maize and cocoyam) crops for family consumption, market and cash. Farming activities are usually carried out using simple farm tools with limited application of modern implements. The map of the study area is shown below.

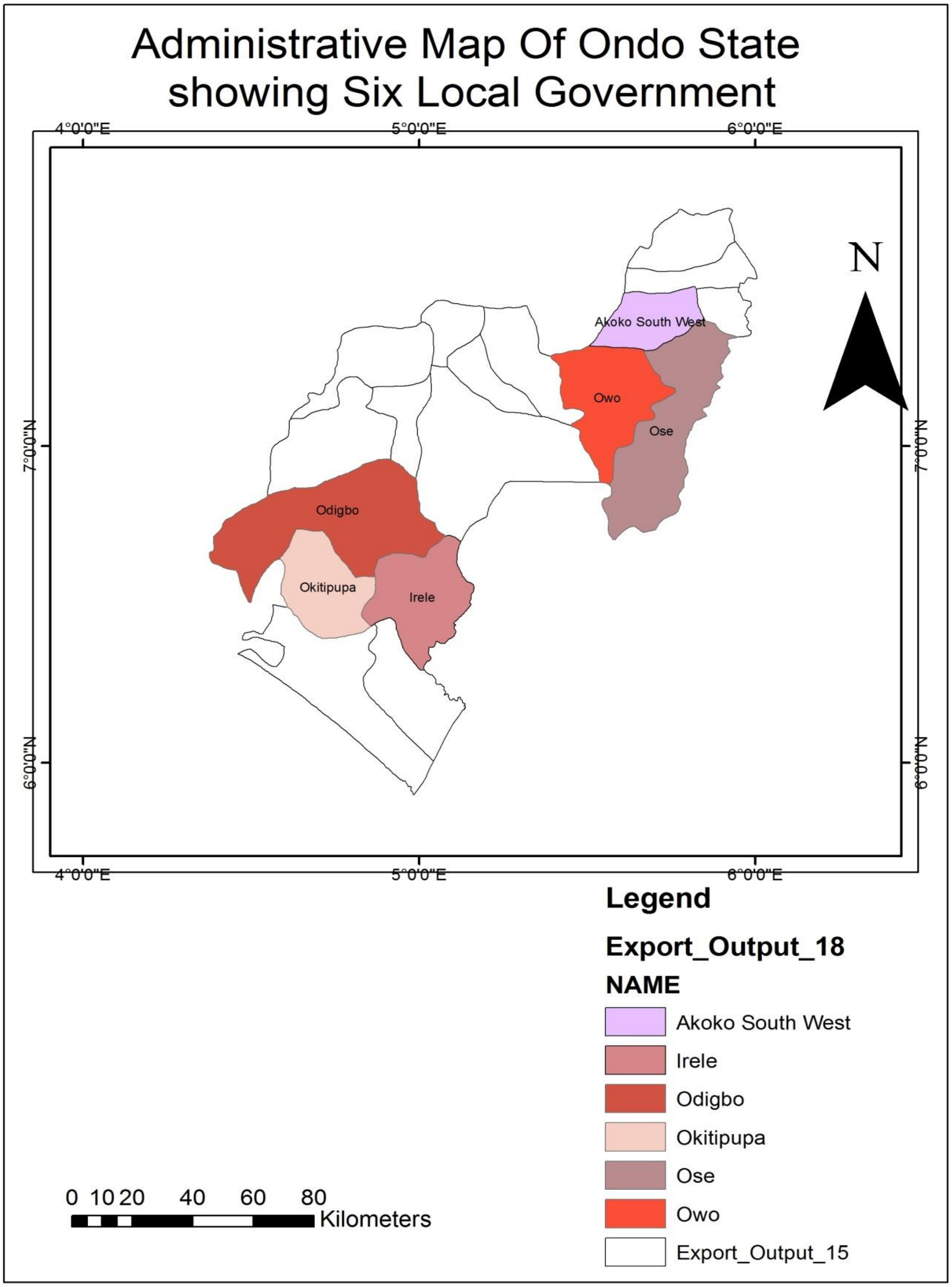

Fig. 2: Administrative map of the study area

SAMPLING PROCEDURE AND DATA

Multi-stage sampling technique was used in selecting respondents for the study. In the first stage, Ondo state was stratified into two agro-ecological zones based on the state's Agricultural Development Programme (ADP) classification. These are Ondo and Owo zones. The second stage involved the purposive selection of three local government areas (LGAs) from each of the zones based on the past records of land degradation. These are Irele, Odigbo and Okitipupa in the Ondo zone and Akoko South West, Ose and Owo in Owo zone. The third stage involved a random selection of 2 villages from each of the LGAs. In the fourth stage, 20 respondents per village were randomly selected making a total of 240 respondents. Primary data were used for the study. The data were collected using a well structured questionnaire. Data were collected on the socioeconomic characteristics of respondents such as age, household size, sex, farm income, off farm income; tenure factors such as land ownership and plot age; resource-based factors such as crop income, livestock income, non-crop income; institutional factors such as access to extension, membership of association and level of education.

ESTIMATION TECHNIQUES

Descriptive characteristics and Probit regression model were employed in the analyses. The socioeconomic and institutional characteristics of the respondents were described using descriptive statistics such as means, simple percentage and standard deviation.

THE PROBIT MODEL

Theoretically, adoption decision is estimated using binary choice models. The appropriateness of a model is dependence on the nature of the dependent variable (Barungi, Ng'ong'ola, Mugisha, Waithaka and Tukahirwa, 2013; Owombo, Akinola, Ayodele and Koledoye, 2012; Akinola *et al*., 2007). However, limited dependent variable models such as the linear probability model (LPM), Logit and Probit are used when the dependent variable is dichotomous (i.e. takes 0 or 1 values). LPM is estimated by ordinary least squares (OLS) technique, estimates of which are interpreted as changes in the probability of changes in dependent variable caused by a unit change in the independent variables (Barungi *et al*., 2013; Wooldridge, 2009). They added that the LPM is limited in fitting probabilities that can be less than zero or greater than one. Overcoming these limitations calls for the application of either Logit or Probit model. Probit or logit has the potentials to determine the effects of independent variables on the utilization or otherwise of a particular technology. Probit and logit are structurally, methodologically and statistically similar (Barungi *et al*., 2013; Amemiya, 1981), except that the Probit model uses the cumulative distribution function (CDF) to explain the behaviour of a dichotomous dependent variable (thus has fatter tails) while the Logit model uses a logistic distribution approach. There is tendency that the parameter estimates will be varied in the two models because of the varying scales. Having variations in the two models according to Amemiya (1981), Agresti (2002) and Barungi *et al*. (2013) would require enormous sample sizes. Hence, Barungi *et al*. (2013) posited that the use of either model is thus discretionary. Therefore, in this study, the probit regression model was used based on its utilisation of cumulative distribution function (CDF) to explain the behaviour of a dichotomous dependent variable.

Given the assumption of normality, the probability that I^*_i is less than or equal to I_i can be computed from the normal CDF as

$$P_i = P\left(Y = {}^{1}/_{X}\right)$$

$= P\ (I_i^* < I_i\ )$

$=P\ (Z_i < \beta_{1\ +}\ \beta_2 X_i)$

$=F\ (\beta_1 + \beta_2 Xi)$

Where I* represents the critical or threshold level of the index, such that if I_i exceeds I*, the farmer will adopt agroforestry technology, otherwise he will not. P (Y=1/X) is the probability that an event occurs given the values of X, or explanatory variable(s) and where Z_i represents the normal variable i.e Z~N(0, Q2).

The term "probit" was coined in the 1930's by Chester Bliss and stands for probability unit. The probit model is defined as

$Pr(y = 1/X) = \Phi\ (xb)$

Where Φ is the standard cumulative normal probability distribution and xb is the probit score or index.

Since xb has a normal distribution, probit coefficients can be interpreted in the Z(normal quantile) metric using probability. It can be interpreted such that a unit increase in the predictor leads to a corresponding increase in the probit score by b standard deviations. The study used a number of tools developed by Long and Freese to aid in the interpretation of the results because the Z metric may be confusing.

The log- likelihood function for probit is

$In\ L=\sum_{Wj} In\theta(x_j b) + \sum_{wj} In(1-\theta(x_j b)$

Where w_j denotes optional weights.

EMPIRICAL STRATEGY

The selected explanatory variables used in the study were based on various related empirical works (Kabubo-Mariara *et al*., 2010; Bekele and Mekonne, 2010) and theoretical literature on farm-level technology adoption (e.g., Bamire, Fabiyi and Manyong, 2002; Akinola *et al*., 2007). Therefore, adoption decision of agroforestry technology is viewed as a function of four vectors of variables (socioeconomic characteristics, land tenure security, resource-based factors and other factors).
The general empirical model of the study is:

$$A_a = \beta_0 + (Socioeconomic)\beta_1 + (Land\ tenure\ security)\beta_2 + (Resource - based\ factor)\beta_3 + (Other\ factor)\beta_4 + \varepsilon_i$$

Where

A_a = Adoption decision of respondents; β_0 = Constant term; vector socioeconomic characteristics include age of respondents, farming experience and household size; β_1 represents the coefficients of socioeconomic characteristics; vectors of land tenure security include land ownership, plot age, land conflicts and land certification while β_2 represents coefficients of land tenure security. Resource-based factors include crop income, off-farm income, farm size and credit access while β_3 represents coefficients of resource-based factors. Vectors of institutional factors include extension contact, level of education and membership of association while β_4 represents the coefficients of institutional factors and ε_i is the error term

The specific model relating to agroforestry technology adoption is specified as follows:

$$A_a = \beta_0 + \beta_1 AGERES + \beta_2 HHSIZE + \beta_3 FARMEXP + \beta_4 LANDOWSH + \beta_5 PLOTAGE + \beta_6 LANDCONF + \beta_7 LANDCERT + \beta_8 CROPINCM + \beta_9 OFFFARMINCM + \beta_{10} FARMSZ + \beta_{11} CREDITACC + \beta_{12} MEMASS + \beta_{13} EXTNVIST + \beta_{14} EDULEV + \varepsilon_i$$

Where

A_a = Agroforestry technology adoption

AGERES = Age of respondents in year

HHSIZE = Household size

FARMEXP = Farming experience in year

LANDOWSH = Land ownership

PLOTAGE = Years since land is being used by the farmer in year

LANDCONF = Conflicts on land (dummy: 1 = land under conflict, 0=otherwise)

LANDCERT = Land certification (dummy: 1= land is certified, 0=otherwise)

CROPINCM = Crop income (₦)

OFFFARMINCM = Off-farm income (₦)

FARMSZ = Farm size in hectare
CREDITACC = Credit access (dummy: 1=has access, 0=otherwise)
MEMASS = Membership of association (dummy: 1 = member, 0 = none)
EXTNVIST = Extension visit (dummy: 1= visited, 0 = otherwise)
EDULEV = Level of education in years

RESULTS AND DISCUSSION

Tables 1a and 1b reveal the socioeconomic, personal and land characteristics of the respondents in the area. Table 1 shows that the mean age of the adopters and the non-adopters were 49±8.2 years and 52±8.9 years, respectively. The results in the table also showed that the mean level of education among the adopters and non-adopters were 11±5 years and 6±3.3 years, respectively. The t-test statistics shows that there were no significant difference between the means of the age and level of education of the adopters and non-adopter in the study area. The mean household size among the adopters and non-adopters were 9±4.6 and 10±5.2 while the mean farm sizes among them were 3.7±2.2 hectare and 2.1±1.3 hectare, respectively. The mean off-farm income among the adopters and non-adopters were ₦108, 223.4±63,883 and ₦28, 002.88±13,022.3, respectively. The off-farm income values among the adopters and non-adopters imply that both the adopters and non-adopters engage in economic activities other than farming. The mean crop income among the adopters and non-adopters were ₦454, 988.9±107,002.2 and ₦299, 775.01±89,645.9, respectively. The higher crop income recorded among the agroforestry users might be due to agroforestry technology adopted which is capable of managing the land. The t-test statistics shows statistical significant differences ($p \leq 0.05$) between the means of household size, farm size, off-farm income and crop income among the adopters and non-adopters, respectively.

The results in table revealed that 64 percent and 36 percent of the adopters were male and female while 47 percent and 53 percent of the non-adopters were male and female, respectively. This implies that greater proportion of the adopters were male in the study area. This might be due to gender discrimination in land access in the area which suggests that female farmers are not given full allowance to own land (Adekola *et al*., 2013). This might be the reason for the low adoption of the technology among the respondents. The results also showed that 6 percent, 76 percent and 18 percent of the respondents were singles, married and others, respectively. This implies that majority of the adopters were married. The others were the divorced, widows and widowers, respectively. However, 18 percent, 59 percent and 23 percent of the non-adopters were single, married and others respectively. It could be inferred from the above that majority of farmers of both categories were married. The results further revealed that 64 percent of the adopters own the plots on which they operate while just 36 percent of them indicated otherwise. Also, while just 47 percent of the non-adopters own plot, 53 percent of them do not own the plot on which they operate. The ownership of plot among the majority of the adopters may be the responsible factor for agroforestry technology adoption in the area. This is in agreement with previous studies (Kabubo-Mariara *et al*., 2010; Bekele and Mekonnen, 2010) that land ownership is a determinant of long term investment decision in land management. Also, while just 12 percent of the adopters operate on land with conflicts, majority (88%) of them operate on lands without conflicts. However, majority of the non-adopters (54%) operate on land with conflict while 46 percent of them indicated otherwise. The higher proportion of the adopters who operate on conflict free lands may be the responsible factor the adoption of the technology. Credit access in the area is low; just 38 percent and 11 percent of the adopters and non-adopters of the technology had access to credit. However, 62 percent and 89 percent of adopters and non-adopters indicated none access to credit. The low access of the respondents to credit in the area has implications on their purchasing power.

DETERMINANTS OF AGROFORESTRY TECHNOLOGY ADOPTION

Table 2 reveals the determinants of agroforestry technology adoption in the study area.

Socioeconomic factors

The results revealed that the coefficient of household size of the respondents was negative and significantly influenced agroforestry technology adoption in the area. The result revealed that an increase in the household size by a unit will decrease the probability of adoption by 2 percent. The inverse relationship between agroforestry technology adoption and household size implies that the higher the household size, the more the farmers' spending on household consumption and hence less will be spent on agricultural technology adoption. The age and farming experience of respondents though were not significant but had negative relationship with the agroforestry technology adoption in the area. It implies that the older a farmer is the less the likelihood that he will adopt new technology. This is in agreement with several studies (Bamire *et al*., 2002; Akinola *et al*., 2007) that farmers' technology adoption and age are inversely related. Similarly, farming experience is inversely related to technology adoption. It implies that the more the experience of the farmers, the greater the likelihood that he will be conservative and will be less interest in new innovations.

Land tenure security factors

Land tenure security factors are risk factors militating against long term innovation adoption among smallholder farmers in developing countries. The results in table 2 also showed that while land ownership, plot age and land certification were positive and significantly influenced agroforestry technology adoption, land conflict was negative and significantly influenced agroforestry technology adoption in the area. Land ownership, plot age, land conflict and land certification were positive at 1 percent, 1 percent, 1 percent and 5 percent levels of probability, respectively. An increase in the hectarage of land owned by a unit will increase the probability of adoption by 41.15 percent. Also, an increase in the hectarage of land certified by a unit will increase the probability of adoption by 2 percent. Similarly, increase in plot age will increase the probability of agroforestry technology adoption. This is in agreement with Neef (1999). However, increase in the hectarage of land under conflicts will reduce the probability of adopting agroforestry technology adoption.

Resource-based factors

Resource-based factors are measures of the respondents' wealth or holdings. The results in the showed that crop income, off-farm income, farm size and credit access had positive and significant influence on agroforestry technology adoption in the area. While both crop income and farm size were significant at 1 percent, off-farm income and credit access were significant at 5 % and 10 %, respectively. This implies that the higher the crop and off-farm income, the higher the likelihood that the farmers will adopt agroforestry technology adoption. The implication is that the farmers will have access to investment fund. Similarly, an increase in the farm size by an hectare will increase the probability of adoption by 36.1 percent while an increase in the credit accessed by the respondents by ₦1 will increase the probability of adoption by 4.4 percent. The positive and direct relationship between agroforestry technology adoption and farm size implies that the larger the hectarage of land owned by respondents, the greater the likelihood that he will have enough to practice agricultural innovations. Similarly, the higher the amount of credit accessed by a farmer, the more such a farmer can access investment in agricultural innovation.

Other factors

Extension visit was the only institutional factors that influenced agroforestry technology adoption in the area. This is in agreement with several studies (Bamire *et al*., 2002; Akinola and Owombo, 2012; Akinola et al., 2007) that extension visit is a determinant of agricultural innovation adoption. The extension visit was significant at 1 percent. The results revealed that an increase in the number of extension visit by 1 unit will increase the probability of adoption 29.12 percent. Membership of association and level of education though were not significant but had positive relationship with the technology adoption. This is in agreement with the expectation of the study that education and membership of the association would have positive relationship with technology adoption.

CONCLUSION

Agroforestry is a sustainable agricultural practice that enhances sustainable agricultural production and hence development. This paper investigates the effects of land tenure security and other factors on the adoption of agroforestry technology as a sustainable farming practice. The analysis was based on cross-sectional data collected from a sample of 240 farmers from Ondo State, Nigeria. Probit model was estimated for the adoption of agroforestry technology. The results in this study demonstrated that the decision to adopt agroforestry technology is explained by different characteristic bundles. Agroforestry technology adoption is positively influenced by plot age, land ownership, land certification and reduced by land conflicts. Analysis also revealed that adoption decision is positively influenced by resources-based factors such as crop income, off-farm income, farm size and credit access. Also, while extension contact positively influenced adoption decision, household size was negative and significantly influenced adoption decision. The study suggests land use and distribution policy that would enhance ownership, certification and address conflicts as well as enhance farmers' income sources. The introduction of such policy will enhance a wide adoption of the technology for sustainable agricultural practice and by extension development.

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Table1a: Socioeconomics of respondents

Variable	Adopters (N=102)	Non-Adopters (N=138)	t-value
Age (year)	49±8.2	52±8.9	0.32
Level of education (year)	11±5	6±3.3	0.44
Household size (year)	9±4.6	10±5.2	1.89*
Farm size (ha)	3.7±2.2	2.1±1.3	2.1**
Off-farm income (₦)	108, 223.4±63,883	28,002.88±13,022.3	5.57***
Crop income (₦)	454,988.9±107,002.2	299,775.01±89,645.9	21.14***

Source: Data analysis, 2015

Note: *significant at 10 percent

**Significant at 5 percent

***Significant at 1 percent

Number of respondents = 240

₦ = Nigerian currency

₦ = $0.0051

Table1b: Personal and land characteristics of respondents

Variable	Adopters (N=102)	Non-Adopters (N=138)
	%	
Sex		
Male	64	47
Female	36	53
Total	**100**	**100**
Marital status		
Single	6	18
Married	76	59
Others	18	23
Total	**100**	**100**
Land ownership		
Own land	64	47
Otherwise	36	53
Total	**100**	**100**
Land conflicts		
Land under conflict	12	54
Otherwise	88	46
Total	**100**	**100**
Access to credit		
Yes	38	11
Otherwise	62	89
Total	**100**	**100**

Source: Data analysis, 2015

Table2: Results of probit model

Variable	Coefficients	p-value	Marginal effects
Social characteristics			
AGERES	-0.7348	0.5111	-0.0327
HHSIZE	-0.1100***	0.0000	-0.0222
FARMEXP	-0.0362	0.1370	-0.0027
Land tenure security factors			
LANDOWSH	0.5537***	0.0000	0.4115
PLOTAGE	0.0946***	0.0000	0.0012
LANDCONF	-0.6944***	0.0000	-0.0133
LANDCERT	0.2643**	0.0114	0.0201
Resource-based factors			
CROPINCM	0.0003***	0.0026	0.0000
OFFFARMINCM	0.0001**	0.0145	0.0000
FARMSZ	0.6596***	0.0000	0.3606
CREDITACC	0.1989*	0.0881	0.0439
Institutional factors			
MEMASS	0.2912	0.1459	0.0168
EXTNVIST	1.8865***	0.0012	0.2912
EDULEV	0.2164	0.1253	0.2164
Log Likelihood	-63.5986		
Pseudo-R^2	0.6127		
Chi-squared value/p-value	201.23/0.0000		

Source: Data analysis, 2015

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