Determinants of Agroforestry Innovations Adoption among Small-Scale Farmers in Nigeria: An Agricultural Innovation System Approach

Oloyede, Adeola Oreoluwa
University of Ilorin, Ilorin, Nigeria, Nigeria

Abstract

Agroforestry innovations are said to be induced innovations developed in a bid to address problems associated with reckless land use practices and climate change. Agroforestry innovations are among the land-based economic development strategies with potentials of enhanced rural livelihoods. Using a logistic regression model in a cross-sectional data collected from a sample of 110 households, this study explores the influence of factors affecting the adoption of agroforestry innovations. The study finds that access to credit, access to extension services, membership in farmers groups and organizations, and distance to input and output markets are the variables which significantly affect the adoption of agroforestry innovations in the study areas. It is recommended that government policies that would facilitate financial credit services and incentive scheme be put in place which will bring about improvements in the agricultural system of the country.

Keywords: Adoption, Agroforestry, Innovation, Institutions, Logit model

Jel codes: N57, O13, O33, Q15

Introduction

Agriculture has been the mainstay of the economy in Nigeria. The Nigerian agricultural sector contributes about 40 percent of GDP and accounts for about 60 percent of employment, both formal and informal, in Nigeria (Ajibade, et al. 2013). The sector plays a significant role in the economic development of the country. Although, agriculture in Nigeria is characterized by small-scale farmers with small holdings, it is still the main source of livelihood for the rural poor. In addition, agriculture in Nigeria like in most part of Africa is faced with many challenges. Land degradation and declining productivity of agricultural soils in the country occurs at a high rate and farm land is being extended into marginal areas. Deforestation and climate change are some of the other serious challenges facing the country today.

To solve the challenges, introduction of new technologies and improving risk management capacity through investments amongst others is required (World Agroforestry center, 2012). More so, to ensure environmental sustainability while addressing constraints encountered by

resource-poor farmers brought about the idea of sustainable agriculture which has emerged as an alternative agricultural system (Zerihun, et al. 2014). Sustainable agricultural practices are said to promote increased agricultural productivity for smallholder farmers in developing countries. They are considered a remedy to the smallholder's farming activities problems and helps in addressing issues on food security and poverty reduction while reducing environmental degradation. Agroforestry is a sustainable agricultural practice which is identified as a way of repairing the degraded lands of the world. It stands as an option to halt the effect of deforestation, land degradation, soil erosion, and other environmental problems across the ecological zones (Merem, 2005). Agroforestry is targeted at tackling land degradation and effects of climate change for a sustainable environment. The efficacy of agroforestry to address the needs of the present generations inclusive of the future ones most efficiently makes it the most viable land use system to meet the aim of sustainable environmental and agricultural development (World Agroforestry Centre 2009).

Adoption of Innovations and technologies is crucial to advancement in science and agriculture. (Sagar, 2013). Ntsama and Epo (2009) noted that to ensure a dynamic economic development through increased productivity requires re-enforcing agricultural innovation adoption. However, most small-scale farmers in Nigeria and sub-Saharan Africa as a whole, being characterized by a rain-fed agriculture, have most times rarely adopted technologies in-spite of the substantial interventions through research (Röling, 2009). Although agroforestry innovations were introduced to Nigeria in the early nineties (90s) (Nair, 1993), the practice of agroforestry has not been well developed (Zerihun et al, 2014). Poor adoption rate has been recorded among the targeted farmers (small-scale farmers). These problems are directly linked to weak institutional support and poor incentive mechanisms towards the development of the practice and agricultural sector as a whole.

Pyburn & Woodhill (2014) indicated that over the last two decades, innovation systems thinking has gradually evolved as a response to the limitations of the technology transfer model. More recently, one of the most comprehensive systems approach, is the agricultural innovation systems (AIS) approach which is a shift from technologically-oriented approaches to a systems-oriented approach for agricultural innovation (Schut et al 2015). The AIS approach, perceives innovation to be a process of combined technological (e.g. cultivars, agronomic practices) and non-

technological (e.g. institutional settings and policies) changes (Hounkonnou et al., 2012; Leeuwis, 2004). Schut et al (2015) indicated that these changes occur across diverse levels and are influenced by interactions between stakeholder from within and outside the agricultural system. This study therefore assesses the factors (socio economic, institutional and incentive mechanism) influencing adoption of agroforestry innovations in the study area.

Literature Review

Innovation is defined as the process through which new or traditional technologies are developed and brought into widespread use in a place or by people where they have not been used before (Sagar, 2013; Nabradi, 2009). Agroforestry innovation is been seen to go with the theory of induced innovation. The theory of induced innovation by Boserup (1965) indicated that the demand for agricultural products rise, as population densities increases and the resulting land pressures induce adoption of technological and institutional innovations. Basically, land degradation increase due to the increasing population since more people will consume more food. This will consequently induce investment in additional inputs (technological) to maintain or increase agricultural production and productivity. As a result, Agroforestry innovations are considered as induced innovations being developed to address the deteriorating environmental conditions exacerbated by land use pressures in most parts as common to innovation decision process in any sector (Rogers, 1995; Reed et al, 2007). In an attempt to meet the challenges of a changing natural world and climate change, many institutional and technical natural resources management practices have been introduced. A number of successful agroforestry innovation, has been developed by ICRAF such as fertilizer trees to improve soil fertility and replace expensive fertilizers, fast-growing trees for fuel wood, fruit trees to provide additional nutrition and income, and the introduction of medicinal plants (Moule 2003). According to Alavalapati et al. 2004, agroforestry innovations range from traditional to recent practices and the nature, complexity, and objectives are also varied greatly between the agroforestry practices in tropics and temperate zones.

Technological Innovations are said to increase economic development and human productivity throughout history (Amankwah et al 2015). However, it has been indicated that the innovation challenge is not only for the usual researcher extension worker-farmer trio. It extends to other actors in the agricultural value chain, policy-makers and more (Pyburn & Woodhill, 2014). The

actors include the farmers, processors, input suppliers traders, researchers, extensionists, government officials among others. The Agricultural innovation system perspective which was partially derived from innovation systems provides a framework for analyzing interactions and innovative processes that occur among the multiple actors, enabling institutions, and internally generated technological and institutional opportunities (Aerni et al, 2015). Agricultural innovation system is defined as "*network of individuals, organizations and enterprises focused on bringing new products, processes and forms of organization into social and economic use, together with the institutions and policies that affect their behavior and performance, to achieve food and nutrition security, economic development and sustainable natural resource management*" (Rajalahti, 2012). The framework provided by the agricultural innovation system aid policies and incentives to stimulate innovation towards increased food productivity while ensuring a sustainable environment. The agricultural innovation systems approach recognizes the dynamic nature of learning and innovation, and stresses a stronger relationship of knowledge systems (research, extension, education) with markets and other actors in the supply chains, as well as institutional contexts within which they interact and the larger policy environment (Ragasa et al 2010). In contrast to the theory of linear knowledge flows in which innovations and knowledge generated by public knowledge generators passed down to adopting farmers, AIS approach considers the role of networking, social and interactive learning among the actors in the adoption of innovations. Among the network of actors, farmers are important as well as organizational and institutional issues for effective adoption of innovations. As such it is important to focus on "farmers" while emphasizing both the technological and organizational aspects (Kannan, 2011). Therefore, it is important to understand farmers decision making process related to their adoption of innovation in their agricultural activity in light of being central in the agricultural innovation system.

Ragasa et al (2010) further stated that agricultural innovation system shifts the focus from research outputs towards research being a part of the whole process of innovation. This also include the use and adoption of technologies being generated by research, as well as to how those technologies are addressing the problems of farmers and to assuage the constraints of supply chain actors. However only a few empirical studies (Rasaga, et al 2010; Zerihun, et al, 2014; Schut et al 2015) have looked at these issues within the innovation system perspective.

Moule (2003) stated that agroforestry innovations are rapidly advancing, with the main challenge of ensuring sustained farm-level adoption and implementation of these innovations. Nevertheless, the institutional aspects of these practices are not considered by policy makers and end users (Torquebiau and Taylor, 2009). In addition, studies on agroforestry (Oeba, et al, 2013; Thangata and Alavalapati, 2003; Obasi, et al 2014; Okunlola, 2010) has focused on the adopter (farmers) to identify factors that contributes to adopting or rejecting an innovation however the interactions among institutional factors and incentive mechanisms in agroforestry adoption have not been given emphasis (Zerihun, et al 2012, Ragasa, 2010). This study therefore fills these gaps by analyzing these two groups of variables using the agricultural innovation system perspective in the study area.

Data and Methodology

The data for this study were collected in Kwara state, Nigeria through the use of well-structured questionnaire. Kwara State is located between longitude $8^{o}30'$N and latitude $5^{o}00'$E. The vegetation consists of a mix of savannah to its north and the thick forest in its southern parts is now mainly wooded guinea savannah. The sampling procedure comprised the use of purposive and random selections. This is due to the presence of tree-rich savannah in the area. A total of one hundred and ten households (110) were used for the study.

Logit Model

The logit model, is used to model dichotomous outcome variables. The model was used to analyze the determinant of adoption agroforestry innovations among farmers. The regression model fits a linear model to describe the relationship between the dichotomous characteristics of interest (dependent variable) and a set of independent (explanatory) variables. The model also generates the coefficients (and its standard errors and significance levels) to predict a logit transformation of the probability of presence of the characteristic of interest.

The logistic function written implicitly as inverse of the logit function is then:

$$\operatorname{logit}(\mathbb{E}[Y_i \mid x_{1,i}, \ldots, x_{m,i}]) = \operatorname{logit}(p_i) = \ln\left(\frac{p_i}{1-p_i}\right) = \beta_0 + \beta_1 x_{1,i} + \cdots + \beta_m x_{m,i} \quad (1)$$

This is written explicitly as

$$\text{logit}(P_i) = Y_i = \beta_0 + \beta_1 X_1 + \mathcal{E} \quad (2)$$

Where: Y_i= adoption of agroforestry innovation (dummy 1= Yes, 0=otherwise)

$\frac{P\text{i}}{1-P\text{i}}$= ratio of the probability that a farmer adopt agroforestry innovation to the probability that a farmer does not adopt.

X= explanatory variables and

$\mathcal{E}$ = error term

Result and Discussions

Table 1 summarizes the descriptive statistics of the farmers' characteristics, farm characteristics, institutional variable, incentive mechanism and other variables of the household. The result shows that 80 percent of the household head are male with an average household size of seven members and average farm size of 2 hectares. This implies that the farmers are small scale farmers. The result also shows that 50% of the farmers are land owners. 53% of the farmers are members of farmers association and 57% of the farmers share information on agricultural practices with their fellow farmers. The farmers cover an average distance 9.35 kilometer to their input market and about 5.1 kilometer to their output market. Most (70%) of the farmers had no access to credit which implies that the farmers may not have enough funds to carry out their desired farming activities. 88% of the farmers had access to extension services and an average of 9 contacts with the extension agent over the last farming period. This implies that the farmers received frequent visit from the extension agents. About 69% of the farmers had adopted 2 to 3 innovations over the last 20 years with an average of 3 innovations being adopted. The farmers (79%) had no participation in on farm demonstration of agroforestry innovations. However, only 11% farmers had no prior exposure to agricultural technologies. This implies that although the farmers had frequent visit, the visit may have been to train the farmers on other agricultural technologies aside from agroforestry innovations.

Descriptive Statistics

Table 1: Descriptive Statistics of Variables

Variables	**Percentage**	**Mean**	**Standard Deviation**
Farmer characteristics			
Gender	80 (male)		
Household size	71 (3-8 members)	7 (members)	3.21335
Farmers innovativeness	69.1 (between 2-5 innovations)	3	2.21084
Farm characteristics			
Land ownership	50		
Farm size	66.3 (1-2hectares)	2 (hectares)	1.22933
Institutional variables			
Membership of farmers group	53.6 (members)		
Farmer to farmer information exchange	57.3		
Incentive mechanism			
Access to credit	70.9 (No access)		
Access to extension services	88.2 (extension access)		
Extension contacts	13.6 (no visits)	9 (Visits)	5.17491
Participation in on-farm experimentation	79.1 (no experimentation)		
Prior exposure to agricultural technologies	11.8 (no exposure)		
Distance to input market		9.345	19.91884
Distance to output market		5.1000	7.29735

Land Ownership status of the farmers

Agroforestry is classified as a long term investment because it involves tree planting and requires tenure security. The argument is that farmers may be reluctant to invest in agroforestry innovations if they do not have right to use the land. Table 3 reveals the result of the land ownership status among the farmers in the study area. The result shows that 44% of the farmers acquired their land through inheritance, while 20% of the farmers were making used of their family land. This suggests that the farmers have the capacity to engage in long term project like agroforestry.

Table 2: Land Ownership status

Land Ownership status	Frequency	Percent
Borrowed	1	0.9
Communal	14	12.7
Family Land	22	20.0
Gift	6	5.5
Government	1	0.9
Inherited	49	44.5
Purchased	6	5.5
Rented	11	10.0
Total	110	100.0

Information sources

The information sources on agroforestry practices among the farmers are described in table 3. The result shows that most (23 %) of the farmers depended on farmer to farmer information exchange in addition to their local knowledge. About 19 percent of the farmers rely solely on extension agents for information on agroforestry innovations while 12 percent of the farmers rely sole on their local knowledge. Only 39 percent of the farmers depended on a single soruce of information, while the rest made use of more than one source of information.

Table 3: Information Sources among Farmers in the study area.

Information sources	Frequency	Percentage
Extension Agents	21	19.1
Extension Agents + Farmer to farmer	7	6.4
Extension Agents + Farmer to farmer + Local Knowledge	21	19.1
Extension Agents + Farmer associations + Local Knowledge	1	0.9
Extension Agents + Local Knowledge	11	10.0
Farmer to farmer	7	6.4
Farmer to farmer + Local Knowledge	25	22.7
Private organization	1	0.9
Farmer to farmer + Local Knowledge	2	1.8
Local Knowledge	14	12.7
Total	110	100.0

Determinants of Adoption of Agroforestry Innovations

The explanatory variables like: farmers innovativeness, distance to input market, distance to output market, membership in farmers associations, information and technical knowledge exchange among farmers, are the variables selected for use. As shown in Table 4 information exchange among farmers significantly reduces the likelihood of agroforestry innovation adoption at 5 percent level of significance. This can be because of the fact that the farmers value information on short term investment rather than the long term ones. The other two variables in this model; namely, the distance to input market, distance to output market increase the likelihood of agroforestry innovation adoption by higher odds ratios i.e. by more than one times than the rest of the variables in the model. These values imply that these variables have a positive effect on the adoption of agroforestry innovation in the study areas.

Table 4: Logistic regression results on the effects of institutional factors on the adoption of agroforestry innovations.

Variables	**Coefficient**	**Sig.**	**Exp(B)**
Membership in farmers association	0.067	.353	.935
Land ownership	-1.124	.119	.325
Farmers innovativeness	0.281	.110	1.325
Information exchange from farmer to farmer	-1.687**	.034	.185
Distance to output market	0.292*	.068	1.339
Distance to output market	0.537***	.006	1.711
Constant	0.765	.392	2.148

-2 Log likelihood =73.288[a] Cox & Snell R Square= 0.284 Nagelkerke R Square= 0.450 Sig = *** at 1%; ** at 5% and * at 10% level of significance.

Logistic Regression Result on Incentive Mechanisms

In most cases existing incentive mechanisms is assumed to promote the adoption of agroforestry innovations. The variables used to assess the impact of the incentive mechanism on agroforestry adoption are qualitative variables represented by dummy variables for the purpose of logistic

regression. The overall model has 83.6% correct predictions with significant Chi-square value. Two variables have maximum odds ratios with the negative and positive significant effect on the agroforestry adoption both at 1% and 5% level of significance respectively. These variables are: access to extension services and access to credit. This implies that the farmers have the likelihood of not adopting agroforestry innovations as they have increased access to extension services. This confirms earlier result that the farmers had frequent visit, the visit may have been to train the farmers on other agricultural technologies aside from agroforestry innovation. However, with increased access to credit, farmers have the likelihood to adopt agroforestry innovations.

Table 5: Logistic regression results on the effect of household incentive mechanism on the adoption of AF innovations

Variables	**B**	**Sig.**	**Exp(B)**
Access to credit	1.548**	0.068	0.213
Access to Extension services	-3.408***	0.011	0.033
Extension Contact	-0.063	0.346	0.939
Prior exposure to agricultural technologies	21.946	0.998	3397662660.167
Participation in on farm experimentation of agroforestry practices	0.018	0.981	1.018
Constant	3.328***	0.004	27.895

-2 Log likelihood=87.704[a] Cox & Snell R Square= 0.184 Nagelkerke R Square= 0.291

Conclusion and Recommendations

Previous studies in the adoption of agroforestry innovations propose, among others, the need for additional research for better understanding of the role of incentive mechanisms and institutional factors. This study found that the farmers received frequent visit from the extension agents and had adopted an average of 3 innovations over the last 20 years. However, most of the farmers had no participation in on farm demonstration of agroforestry innovations. Only a few farmers had no prior exposure to agricultural technologies. This implies that although the farmers had frequent visit, the visit may have been to train the farmers on other agricultural technologies aside from agroforestry practices. Among institutional variables included in this study;

information and technical knowledge exchange among farmers significantly reduces the likelihood of agroforestry innovation adoption. This can be as a result of the fact that the farmers value information on short term investment rather than the long term ones. Frequency of extension services negatively influenced agroforestry adoption in the study area. However increased access to credit increased farmers likelihood of adopting of agroforestry innovations. However, improved collaboration between stakeholders in the agricultural sector across the country will bring about improvements and strengthening of the innovation capacity of the Nigerian agricultural system as well as improvements in the agricultural environment of the country. Therefore it is recommended that

The extension agents should provide more training on agroforestry through on farm experimentation/demonstration for farmers. This should involve the researchers, extension agents and the farmers' participation to enhance faster adoption.

Agricultural inputs (such as seedlings, exotic tree species and others) should be made available to the farmers at their localities to enhance easier adoption. This should involve establishing input outlets in the farmers' village. Consequently it will bring about improved access to markets for farmers and timely access to high quality agricultural inputs.

The government policies that would facilitate financial credit services and incentive scheme should be made. This will be done through the provision of funds specifically for tree planting on farm and establishment of forests/ plantation to promote agroforestry practices in the study area and across the country.

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