Int. j. adv. multidisc. res. stud. 2022; 2(3):538-543

Received: 03-05-2022
Accepted: 13-06-2022

International Journal of Advanced Multidisciplinary Research and Studies

ISSN: 2583-049X

Agroforestry-based technology's adoption: A case study of small-scale farmers in Oyo State, Nigeria

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Abstract
The study examined the adoption of agroforestry-based technology among small-scale farmers in Oyo State, Nigeria. A cross-sectional data of 200 respondents were randomly selected with the aid of a well-structured questionnaire. Descriptive statistics and Tobit regression model were used in the analysis. Results showed that the mean age of the farmers was 49years and that majority (87%) was male. The main occupation (92%) of the respondents was farming, and only 12% of them had not received any form of formal education. The majority (73%) of the farmers cultivated farmland that was less than 2ha. Apart from the farmers' age, farm size, household size, income, and off-farm income, all socioeconomic variables of the farmers are positively associated to adoption decisions. Adoption demonstrated inelastic responses to changes in the socio-economic factors studied, according to the estimated elasticity estimates. The most important factor influencing adoption and use intensity is financing availability. Farmers' adoption behaviour was also positively influenced by cultivated farm size, loan availability, extension contact, cooperative membership, product distance to market, and tenurial status, according to Tobit analysis. Except for the age of the farmers, minor changes in their socio-economic variables enhance the chance of adopting agroforestry practices more than they increase use intensities, according to the estimates from the computed elasticities. The study, therefore, recommends that effort should be intensified in identifying preferred agroforestry-based technology by the farmers to boost participation as well as evaluate the cost of effective potentials of such technology.

Keywords: Adoption, Technology, Farmers, Forestry, Tobit Model, Nigeria

1. Introduction

More than 70% of Nigeria population density are rural dwellers rely solely on Agriculture as a means of sustainable livelihood. Most especially, small-scale farmers are always at the losing end as a result of constraints they encounter from low yield, scarcity of rain, heavy dependence on rain-fed agriculture, loss of plant nutrients, problem of tenure system, insecurity arising from farmers-herders crisis, lack of information as regards agroforestry-based technology, deforestation due to unpleasant Agricultural practices. These constraints thereby led many farmers to be unproductive vis-à-vis low income and poverty severity. The best way to address this is introduction of agroforestry-based technology and the only way by which small-scale farmers can flow with this is through "*Adoption*' [1, 2].

Adoption according to [3] has been viewed as a process, efforts or an attempt of utilizing new findings, innovations in a persistent manner. [4] defined technology as the synchronization of knowledge in science to use practically and this includes techniques, methodologies, designs and innovations. [5, 6] opined that upon much availability of technologies, the rate of adoption might still be low as a result of people's belief: personal, social or cultural.

The World Agroforestry Centre defines agroforestry as a vital relationship incorporated into care of the natural resources through which nexus between farm trees and agricultural topography changes with prolong productivity thereby leading to improvement in social, economic and environment boon to land users at all spheres [7].

Agroforestry is also seen as a means of optimal usage of land to provide for man's needs while the soil is maintained by being sheltered from the sun and use of animal wastes to enrich it. Hence, agroforestry is a land management concept where woody perennial plant species are cropped to protect the land on long term basis [8]. The role of extension services in adoption of agroforestry-based technology by farmers cannot be overemphasized in establishment of demonstration of this agroforestry-based technologies to farmers both on-farm and off-farm, knowledge transfer, information dissemination, among others [9].

There has been rising concern among stakeholders in Oyo state about adoption of agroforestry-based technology and despite many interventions from government and NGOs, small-scale farmers in Oyo State, Nigeria are still adopting agroforestry-based technology at a relatively low rate. There have been relatively few economic studies on the adoption of agroforestry practices in Africa (especially in Nigeria). Scholars such as [10, 11, 8, 12, 13] focused adoption on improved food production technology but little attention is given to extent in which the various agroforestry-based technologies have been adopted by the farmers and identification of constraints impeding the participation of farmers. Again, the study area has experienced drastic change noticeable in its vegetation, decline in agricultural productivity and other environmental consequences that have been attributed to deforestation. Introduction of Agroforestry in this area has however not recorded much participation from the farmers and thus is representative of the situation all over Nigeria. Findings in Oyo State will be relevant for some other States in the region. The presence of the International Institute of Tropical Agriculture (IITA)-an agricultural organization that has been active in alley cropping since the early 1980s-and the volume of extension work carried out in the area for Taungya further influenced the research area selection. International livestock Centre for Africa's (ILCA's) introduction of alley farming in the area has made the technology popular as shown by the high adoption and spontaneous spread of the practice among traditional farmers. These are the key factors for choosing the study area. In this context, the objectives of this study were to determine the extent of adoption of various agroforestry-based technologies and to empirically determine the factors influencing adoption of the agroforestry-based technologies among the respondents in the research area.

2. Materials and methods

2.1 Study area

The research area was Oyo-State, and this is located in the Southwestern Nigeria. The study area, Oyo State, contains two of the eight ecological zones of crop production in Nigeria. The State lies between latitudes 7ºN and 9º30N and longitude 2ºE and 4ºE, and bound in the south by Ogun State, east by Osun and Ondo State, North by Kwara and West by the Republic of Benin. The total land area is about 42862 sqkm. Two climatic seasons can be distinguished in the study area namely: The dry season between November and March and the rainy season between April and October (There have been some distortion of these ranges).

2.2 Sampling technique

A cross-sectional sample survey was used in this study with the aid of a well-structured questionnaire which was administered on the sampled farmers. Due to the necessity to balance probability and non-probability samples, a two-stage sampling approach was adopted. To avoid the exclusion of representative samples, the first stage entailed the purposive sampling of four (4) Local Government Areas (LGAs) where IITA had previously worked on agroforestry. The second stage involved a random selection of fifty (50) respondents from each LGA, therefore, making a total of 200 farmers used for the study.

2.3 Analytical method

The respondents' socioeconomic characteristics were determined using descriptive statistics such as frequency and percentages, while the probability of adoption was calculated using the Tobit model. Below is a design model of the Tobit regression framework utilizing an index function technique.

$$I_i^* = \beta T X_i + e_i$$
$$Y_i = O \text{ if } I_i^* < T$$
$$Y_i = I_i^* \text{ if } I_i^* > T$$

Where Yi = Limited dependent variable

I_i^* = Latent variable that indexes adoption

T = Observed threshold level

X_i = Vector of independent variable

$X_1, X_2 \ldots\ldots.. X_{12}$

β = Vector parameter to be estimated

e_i = Error term

The impacts of changes in socioeconomic factors on adoption probability and use intensities can be derived using the Tobit decomposition approach. Let E(P) represent the expected value of the dependent variable probability of adoption and intensity of usage over all observations, with the expected value of the dependent variable conditional farmers adoption being greater than the threshold limit (i.e., already an adopter and thus now concerned about use intensities) be given as E(p), and the probability of the farmer being above the limit (i.e., the probability of adoption) be represented as F(z), where $z = X\beta/\sigma$.

The relationship between these variables can be shown as:

$$E(P) = F(z) * E(p) \quad (1)$$

The effects on farmer adoption behaviour can be split down into two portions for a given change in the degree of socioeconomic features in the adoption of agroforestry-based technologies by differentiating equation with respect to the socioeconomic characteristics.

$$\delta E(P)/ \delta Xi = F(z) [\delta E(p)/ \delta Xi] + E(p) [\delta F(z)/ \delta Xi] \quad (2)$$

Multiplying through by Xi/E(P), the relation in equation (2) can be converted into elasticity forms:

$$[\delta E(P)/ \delta Xi]Xi/E(P) = F(z) [\delta E(p)/ \delta Xi] Xi/E(P) + E(p) [\delta F(z)/ \delta Xi]Xi/E(P) \quad (3)$$

Re-arranging equation (3) by using equation (1):

$$[\delta E(P)/ \delta Xi]Xi/E(P) = [\delta E(p)/ \delta Xi] Xi/E(p) + [\delta F(z)/ \delta Xi]Xi/F(z) \quad (4)$$

Total elasticity of a change in the level of the characteristics, consists of two effects namely; the change in the elasticity of the use intensities of agroforestry-based technologies and the change in the elasticity of the probability of being an adopter. The explanatory variables are age (year), farm size (ha), household size (numbers), distance to input source (km), credit availability (1 = access and 0, otherwise), extension contact (1 = access and 0, otherwise), cooperative membership (1 = access and 0, otherwise), distance in product market (km), farm income (Naira), off farm income (Naira), farmer's education (years spent in school), and tenurial status (1 = access and 0, otherwise).

3. Results and discussion

3.1 Socio-Economic characteristics of the respondents

This category of characteristics relates to age, farmers' educational status or number of years spent receiving instructions, occupation(s), household size and farming experience as presented in Table 1.

Table 1: Socio-Economic characteristics of the respondents

Variables	Freq.	Percentage
Age of Respondents		
< 20	9	45
21 – 30	3	1.5
31 – 40	42	21
41 – 50	70	35
51 – 60	46	23
61 – 70	28	14
> 71	2	1
Gender		
Male	174	87.0
Female	26	13.0
Years of Experience		
1 – 10	63	31.5
11 – 20	51	25.5
21 – 30	34	17.0
31 – 40	31	15.5
41 – 50	16	81.0
51 – 60	4	2.0
`61 – 70	1	0.5
Level of Education		
No formal Education	24	12.0
Primary Education	107	53.5
Secondary Education	54	27.0
Tertiary Education	15	7.5
Farming Status		
Full-Time Farming	32	16
Part-Time Farming	168	84

The age of the farmers ranged between 20 and 78 years, with the average age being 49 years. The data showed that majority (35%) of the farmers are between the age of 41 and 50 years. Only 1% of the farmers are over 71years of age. This is in agreement with earlier studies that age of the farmer is related to adoption decisions. Younger farmers have been found to be more knowledgeable about new practices and may be more willing to bear risk due to their longer planning horizons. This is in line with earlier empirical findings; the maintained hypothesis is that age is negatively related to adoption [8]. About 87% of the respondents are male while the remaining 13% of the respondents are female farmers. The data showed that 92% of the sampled farmers were actually engaged in farming as their major occupation. Only 16% of them were not combining any other occupation with farming, while the remaining farmers were engaged in occupations such as trading, carpentry, tailoring etc. Level of education reflects that 12% of the respondents have not received any formal education, while 53%, 27% and 7.5% had primary education, secondary education and tertiary education respectively. It was also observed that the average size of farming household was approximately eight people per household. This is consistent with the fact that majority of the farming population are illiterate and polygamous. Farmers' wives are engaged in off-farm occupations like trading, etc., and children go to school. The meaning of this is that larger household size no longer translates into more family labour for farming operations but more responsibilities for the household. Farmers with higher level of education possess higher allocative ability and are easier to convince to adopt. The study further noted that education is important when extension is less intense, as is usually the case in developing countries like Nigeria. This study buttresses an earlier finding by [14] that education enhances one's ability to receive, decode and understand information which implies that the more educated a farmer is, the quicker he will be to adopt.

3.2 Economic factors

These are factors that reflect the level of affluence and economic well-being of the farmers. They include factors like farm size, farm income, off-farm income and credit availability (Table 2). The means of these factors are expected to be low because of the socio-economic status of the majority of the farmers sampled. About 73% of the sampled farmers cultivated farm sizes which were less than 2.0 hectares of farmland. On the basis of cultivated area, such farmers were referred to as small farmers. These farms are usually in small plots and scattered in locations. This latter factor was responsible for higher number of holdings (ranging between 2 and 8 per farmers) but with a low total farm size. Reasons given by farmers for the observed pattern of holdings included land tenure problems, risk aversion strategies and edaphic/topographic factors. This is in agreement with the findings of [15].

Table 2: Economic factors

Variables	Freq.	Percentage
Farm size		
< 1.00	78	39
1.01 – 2.00	68	34
2.01 – 5.00	35	17.5
5.00 and above	19	9.5
Source of Credit		
Private money lender	18	9
Cooperative Society	41	21
Bank	2	1
Others (friends, other business)	58	29
No credit	80	40
Off-Farm Income		
490000 and below	191	95.5
500,000 – 999,999	5	2.5
1,000,000 – 1,499,999	2	1.0
1,500, 000 – 1,999,999	1	0.5
2,000,000 – 2,499,999	-	-
2,500,000 and above	1	0.5
On-Farm Income		
490000 and below	157	78
500,000 – 999,999	24	12.5
1,000,000 – 1,499,999	11	5.5
1,500, 000 – 1,999,999	5	2.5
2,000,000 – 2,499,999	-	-
2,500,000 and above	3	1.5

The result also shows that distribution of farmers by sources of credit available to them. The amount of credit available to a farmer is a financial indicator of his or her worth. Credit restrictions are cited by the majority of farmers as a major factor in their adoption decisions. They obviously cannot adopt when their purchasing power is ineffective. Also, nearly 40% of the farmers sampled did not access credit, claiming not to have access to any form of credit sources. Only 9% of them took loan from private money lenders, only 1% had secured bank loans, 21% had taken loan from cooperative societies. The remaining 29% farmers had raised their loans from friends, relatives, etc.

3.3 Adoption of agroforestry-based technology

Only the availability of financing to farmers is significant at the 0.05 (5%) level of significance, according to the study. However, distance of input source from farm, membership in cooperative organization, and farmer's educational status are relevant in explaining adoption decision and use intensities at a 10% significant level. Aside from the farmers' age, farm size, household size, farmers' income, and off farm income, all of the farmers' socioeconomic factors (farm and farmer specific variables) were found to be positively connected to adoption decisions. The variables are connected to the likelihood of acceptance and the intensity with which agroforestry-based technologies are used. This finding is consistent with [16], who claimed that while some of the farm and farmer-specific factors discussed in the adoption literature are important in explaining adoption decisions for modern mangrove rice varieties, the technology-specific attributes of the varieties are the most important factors determining adoption and use intensities.

These findings support the hypothesis that some farmers' socioeconomic characteristics influence their adoption decisions. Thus, information from this study supports a previous finding widely stated in the adoption and diffusion literature concerning how farmers' socioeconomic qualities greatly affect adoption of agricultural innovations. The inelastic responses of adoption to changes in the socioeconomic parameters investigated are shown in Table 3 by the computed elasticity estimates. The most important factor influencing adoption and use intensity is financing availability. The total elasticity value is 0.33, which is broken into 0.1669 for adoption probability elasticity and 0.1651 for use intensity elasticity. For input distance, the total elasticity value is 0.25. The elasticity of the probability of adoption was divided into 0.1243 and the elasticity of the expected use of intensity was decomposed into 0.1229. The model's socioeconomic characteristics for farmers are based on innovation diffusion theory and previous research. According to studies, the age of the farmer influences adoption decisions. Due to their wider planning horizons, younger farmers have been found to be more aware about new practices and may be more prepared to take risks [13]. The maintained hypothesis is that age is negatively connected to adoption, based on previous empirical evidence.

Table 3 shows that the size of the cultivated farm has been demonstrated to have a favourable impact on adoption decisions [17, 18, 15, 19]. As a result, the empirical model's sign on this variable is assumed to be positive. However, the size of the farmed farm was found to be a negative factor in this study. In the study area, there is no significant association between the size of cultivated farms and the use of agroforestry-based technologies.

According to [14], the household size should have a positive sign, but the coefficient showed a negative sign, indicating that the household size, which includes all people living under the same roof and also includes the number of family workers, is negatively related to adoption. This aspect has no meaningful correlation with the adoption of agroforestry-based technologies.

The input source distance was predicted to be negative, but it turned out to be positive. This means that the assumption that farmers will be discouraged from adopting owing to increased adoption costs due to travel is incorrect. At a 10% level of significance, the study found a significant association between input source distance and adoption of agroforestry-based technologies.

As expected, credit availability yielded a beneficial result. As a result, credit availability has a favourable impact on farmers' adoption behaviour in the research area. The amount of credit available to a farmer is a financial indicator of his or her worth. Credit restrictions are cited by the majority of farmers as a major factor in their adoption decisions. They can't adapt if their purchasing power isn't strong enough. At a 5% level of significance, loan availability is significant in determining adoption decisions and use intensities of agroforestry-based technologies. Farmers' access to credit, according to [20], influenced agricultural investment and policy alternatives for farmers.

According to the innovation – diffusion theory, contact with extension agents has a beneficial effect on adoption. By exposing farmers to the availability of information, such encounters are likely to encourage adoption. This tendency, however, is in line with the findings of [18], who found that increasing extension contact with farmers is critical in encouraging adoption. Farmers should be exposed to the availability of knowledge through interactions with extension personnel, which should encourage adoption. In the study area, there is no significant association between this factor and the adoption of agroforestry-based technologies.

Cooperative membership yielded a favourable result. Farmers' participation in cooperatives has a favourable impact on their adoption behaviour. As expected, some experience sharing must have been included in these variables, which will influence the adoption behaviour of individual farmers as well as the entire group. At a 10% level of significance, there is a substantial association between this characteristic and the adoption of agroforestry-based technologies in the research area.

The distance between the farm and the product market was projected to have a detrimental impact on adoption. The variable returned a positive sign, contrary to the hypothesis. Either most farmers prefer to sell their products in distant markets because they fetch a higher price, or most farmers are unconcerned about the product's distance from the market. In the study area, there is no significant association between this factor and the adoption of agroforestry-based technologies. Farmers' income and off-farm income, which were thought to have a favourable impact on adoption, showed a negative trend. This contradicts the belief that income is a powerful motivator since it provides farmers with liquid capital to invest in productivity-enhancing inputs like the new [21]. A high off-farm income could indicate that farming is less profitable, implying that the farmer is farming as a hobby or to meet subsistence needs. On the other hand, the farm income may not be sufficient to motivate the farmer to take a 'risk' and adopt. As a result, the negative sign is used.

The farmer's ability to receive, process, and utilise information relevant to the adoption of agroforestry-based technologies is likely to be related to his or her educational level. This variable is thought to have a favourable link with adoption. As expected, this variable showed a positive indication. At a 10% level of significance, the study found that a farmer's degree of education has a substantial impact on his adoption of agroforestry-based technology.

Tenant farmers may have been told not to grow any permanent crops, although landowners are free to do so. Landowners will find it easier to embrace agroforestry-based technology. As expected, this variable showed a positive indication. Though the study found that tenurial status has a beneficial effect on agroforestry-based technology adoption, there is no significant association between this feature and agroforestry-based technology adoption in the study area.

Table 3: Estimated Results for Farmers' Adoption Model Using Socioeconomic (Farm and Farmer Specific) Variables

Variable	Normalized coefficient	Asymptotic		Regression Coefficient
		Standard Error	T-Ratio	
Age	$-0.83741E^{-3}$	$0.57880E^{-2}$	-0.14468	$-0.55789E^{-3}$
Farm size	$-0.10549E^{-1}$	$0.25591E^{-1}$	-0.4123	$-0.70281E^{-2}$
Household size	$-0.11906E^{-1}$	$0.20195E^{-1}$	-0.58952	$-0.79316E^{-2}$
Distance to input	$0.72918E^{-1}$	$0.53802E^{-1}$	1.3553*	$0.48579E^{-1}$
Credit	0.22507	0.11105	2.0268**	0.14994
Extension	$0.26229E^{-1}$	0.16609	0.15792	$0.17474E^{-1}$
Cooperative	0.16116	0.11847	1.3604*	0.10737
Distance market	$0.10237E^{-1}$	$0.50470E^{-1}$	0.20284	$0.68203E^{-2}$
Farm income	$-0.20110E^{-6}$	$0.51254E^{-6}$	-0.39236	$-0.13398E^{-6}$
Off-farm income	$-0.15419E^{-6}$	$0.85662E^{-6}$	-0.18000	$-0.10272E^{-6}$
Education	$0.66641E^{-1}$	$0.55003E^{-1}$	1.2116*	$0.44397E^{-1}$
Tenural status	$0.24726E^{-1}$	0.10453	0.23654	$0.16473E^{-1}$
CONSTANT	1.0789	0.52222	2.0661**	0.71881
Y	1.5010	$0.81393E^{-1}$	18.442	

The predicted probability of Y > Limit given average x (I) = 0.9744

The observed frequency of Y > Limit IS = 0.9050

At mean values of all X(I), E(Y); E(Y) = 1.3053

Log – Likelihood function = -208.47465

Mean – square error = 0.37265066

Mean error = -0.17136042E-01

Squared correlation between observed and expected values = 0.91052E-01

** = Significant at 5%

* = Significant at 10%

Cooperative membership and farmer education have nearly identical effects on total adoption elasticity and its components. A total elasticity of 0.19 was found in membership cooperative groups. The elasticity of the probability of adoption was 0.0964, and the elasticity of the expected utilization of intensity was 0.0954. Farmers' education has a total elasticity of 0.13, which is split into 0.0632 for adoption probability elasticity and 0.0625 for use intensity elasticity.

The total adoption elasticities are influenced by tenurial status and the participation of extension agents. The elasticity value of the tenurial state is 0.07, divided into 0.035 for elasticity adoption likelihood and 0.035 for elasticity use intensity. Extension agents' role has a total elasticity of 0.05. For the elasticity of the probability of adoption and expected use of intensity, this was decomposed to 0.0266 and 0.0263, respectively.

The total elasticity of the distance between the product and the market is 0.03, with 0.0128 attributable to the elasticity of adoption and 0.0126 owing to the elasticity of expected use intensities. The distance between the farm and the product market was projected to have a detrimental impact on adoption. The variable returned a positive sign, contrary to the hypothesis. Either most farmers prefer to sell their products in distant markets because they fetch a higher price, or most farmers are unconcerned about the product's distance from the market.

Except for the age of the farmers, marginal changes in the socioeconomic characteristics of farmers increase the probability of adoption of agroforestry practices in the study area more than they increase the use intensities, according to the estimates from the computed elasticities reported in Table 4. The elasticity estimates, on the other hand, reveal inelastic reactions to changes in these parameters.

Table 4: Tobit Total Elasticity Decompositions for Changes in Socio-Economic Characteristics

Variable	Elasticity of Adoption Probability	Expected use intensity (Elasticity of E(Y))	Total Elasticity	Approximate Total Elasticity
X_1 (AGE)	-0.199	-0.0197	-0.2187	-0.22
X_2 (FM SZ)	-0.0164	-0.0162	-0.0326	-0.03
X_3 (HD SZ)	-0.406	-0.0402	-0.4462	-0.45
X_4 (DT IMP)	0.1243	0.1229	0.2472	0.25
X_5 (CRDT)	0.1669	0.1651	0.3320	0.33
X_6 (EXT)	0.0266	0.0263	0.0529	0.05
X_7 (COOP)	0.0964	0.0954	0.1918	0.19
X_8 (DT PRD)	0.0128	0.0126	0.0254	0.03
X_9 (FM IN)	-0.0088	-0.0087	-0.0175	-0.02
X_{10} (OFF FM)	-0.0021	-0.0021	-0.0042	-0.00
X_{11} (FM ED)	0.0632	0.0625	0.1257	0.13
X_{12} (TEN STAT)	0.0354	0.0350	0.0704	0.07

4. Conclusion

The total adoption elasticities are influenced by tenurial status and the participation of extension agents. According to the results of the computed elasticities, little changes in farmers' socioeconomic parameters boost the likelihood of them adopting agroforestry practices in Oyo State. As a result, it is suggested that more focused and particular research efforts be devoted toward identifying preferable agroforestry-based technologies and analysing their cost-effective potentials. The economic impact of agroforestry-based technologies that have been adopted can also be assessed and compared.

5. Conflict of interest

There is no conflict of interest

6. References

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