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Analysis of Farmers' Perception and Adoption of Agroforestry Technology as Climate Change Mitigation Strategy in Edo State, Nigeria

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ABSTRACT

Climate change constitutes a major threat to environment and agriculture in developing countries. The study was, therefore, conducted to assess the socioeconomic characteristics of farmers' perception of agroforestry as climate change mitigation strategy, and to determine the factors influencing agroforestry adoption as climate change mitigation strategy in the study area. A multi-stage sampling procedure was used to select 300 respondents, out of which information from 299 respondents were suitable for analysis. Data were collected by means of a structured questionnaire, and were analysed with the aid of descriptive statistics and probit modeling. Data were collected on socioeconomic characteristics of respondents and farmers' perception of climate elements and agroforestry techniques in mitigating climate change. Results of analysis showed that farmers were in their active ages and are mostly married. Farmers also perceived that temperature and sunshine hour were on the increase, while they also perceived that agroforestry is soil fertility enhancing. Probit analysis showed that perceived soil fertility enhancement of the technology ($p \leq 0.10$), perceived drought controlling capacity of the technology ($p \leq 0.05$), farm size ($p \leq 0.01$) and membership of association ($p \leq 0.10$) were positive determinants of farmers' adoption of agroforestry as climate change mitigation strategy in the area. The paper concludes that farmers should be encouraged to belong to farming associations, and should be educated on the importance of agroforestry in fertility enhancement and drought control.

Keywords: Farmers' perception, adoption, agroforestry, technology, climate change

1. INTRODUCTION

Climate change is a global problem that constitutes threats to agriculture generally. Global climate variability and shocks put growing pressure on the livelihoods, health, food production capabilities, and other aspects of lives of the rural poor (Siwar *et al.*, 2013). The adverse impacts of climate change have already been observed on natural resources, food security, human health, the environment, economic activity and physical infrastructures (Deschenes and Greenstone, 2007).

Africa and Asia are considered the two continents most vulnerable to climate change, with sub-Saharan Africa having the highest levels of chronic poverty in the world, and South Asia containing the majority of the world's chronically poor people (Chronic Poverty Research Centre, 2008). Agriculturists are particularly affected since they are heavily weather-dependent in the part of the world (Roudier *et al.*, 2011). The effects may be more in Africa. Knox *et al.* (2012) posited in its estimates that by 2020 between 75 and 250 million people are likely to be exposed to increased water stress and that rain fed agricultural yields could be reduced by up to 50% in Africa if production practices remain unchanged. Nevertheless, those countries contributing least to global climate change suffer most from its adverse consequences, which are often magnified due to their dependence on rain fed agriculture (Oluwasusi, 2013).

The case in Nigeria is not different since farmers employ similar techniques of production and are weather dependent. In addressing the threats posed by change in climate, farmers were encouraged to mitigate or adapt to it. Mitigation refers to all activities aimed at reducing the vulnerability of farmers to change in climate (Ongoro and Ogara, 2012) while adaptation practices mostly introduced to farmers in Nigeria included land conservation, agroforestry (Owombo *et al.*, 2015), irrigation, improved varieties and varying planting time, among others (Sofoluwe *et al.*, 2011; Owombo *et al.*, 2013).

Agroforestry is one of the mostly encouraged since it has multiple advantages of mitigating change in climate, enhancing soil fertility as well as enhancing farmers' revenue through income from fuel wood (Bifarin *et al.*, 2013). The adoption of this technology may be influenced by several factors ranging from perception of the technology to personal and socio-economic characteristic of farmers. Farmers' perception of a technology plays prominent roles in technology decision (Adesina and Baidu-Forson, 1995). Sofoluwe *et al.* (2011) in their study posited that farmers' perception of a strategy as well as the change in the climate variables are also important variables in climate change mitigation and adaptation.

Adoption of an innovation is influenced by farmers' perception and their socioeconomic characteristics (Adesina and Baidu-Forson, 1995). Farmers' ability to perceive the effectiveness of a technology as a potential solution to a problem is a key precondition for decision to adopt such technology (Adesina and Baidu-Forson, 1995).

They added that this is reflected in the respondents' subjective preference for a particular technology. Just like economists' position on the effects of consumers' preference for a commodity as a determinants of its consumption, farmers' decision about a particular technology is also dependent on their subjective preference of the technology in terms of perceived impacts on output.

The paucity of empirical evidence on this subject justifies the study. The objective of the study is therefore to determine the effects of farmers' perception and other characteristics on adoption decision of agroforestry.

2. METHODOLOGY

2. 1. Study area

This study was carried out in Edo state, Nigeria. Edo state is located between latitude 5°51'N -7°33'N and longitudes 5°E - 6°40'E. It shares common boundary with Ondo state in the west, Delta State in the east and Kogi state in the north. The vegetation of the state is moist rain forest in the south and derived savanna in the north. The people of the area are mostly farmers who engaged in trading. The primary data were obtained using well-structured questionnaire. The land in the area is characterized by varying physical features like lowland, rivers and creeks. The people are predominantly smallholder farmers cultivating both permanent plantation crops like cocoa, cola, oil palm, etc. for cash and arable crops like yam, cassava, maize and cocoyam, etc. for the dual purposes of consumption and cash. These crops are planted with some trees like *Tectona grandis* (teak) *Gmelina arborea*, *Terminalia ivorensis*, *Khaya ivorensis* etc for agroforestry practices. Farming activities are usually carried out using simple farm tools with limited application of modern implements.

2. 2. Sampling techniques and data collection

A multi-stage sampling procedure was employed to select respondents for the study. In the first stage, one local government area (LGA) per agro-ecological zones was selected in the State. In the second stage, 5 villages per LGA were selected using simple random selection. In the final stage, 20 respondents per village were sampled. A total of 300 respondents were sampled for the study. Out of the 300 questionnaires administered for the study, a total of 299 were retrieved for analysis and suitable for analysis. Primary data were used for the study. Data were collected on socioeconomic characteristics of respondents, farmers' perception of climate elements and agroforestry.

2. 3. Analytical technique

Descriptive statistics and probit model were employed for analysis.

2. 4. Descriptive statistics

The descriptive statistics was employed to describe the socio-economic characteristics of respondents, their perception and farm characteristics.

2. 5. 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 (Owombo *et al.*, 2012). However, limited dependent variable model such as the linear probability model (LPM), Logit and Probit are mostly used when the dependent variable is dichotomous (i.e. takes 0 or 1 values). The LPM is different from the probit and logit models because is estimated by ordinary least squares (OLS) technique, which allows for a binary response using regression analysis. The LPM has the limitations of fitted probabilities that can be less than zero or greater than one and that the partial effect of any explanatory variable is constant. Addressing these limitations calls for the employment of either Logit or Probit model. Probit or logit has the potentials to determine the effects of dependent variables (regressors) on the utilization or otherwise of a particular technology. Probit and logit are structurally, methodologically and

statistically similar (Amemiya, 1981). However, the Probit model uses the cumulative distribution function (CDF) to explain the behaviour of a dichotomous dependent variable while the Logit model uses a logistic distribution of the dependent variable. There is tendency that the parameter estimates will be varied in the two models because of the varying scales. Hence, the use of either model is thus discretionary. Therefore, in this study, the probit regression model is 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

$$\begin{aligned} P_i &= P(Y = 1/X) \dots\dots\dots (1) \\ &= P(I_i^* < I_i) \\ &= P(Z_i < \beta_1 + \beta_2 X_i) \\ &= F(\beta_1 + \beta_2 X_i) \end{aligned}$$

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 $Z \sim N(0, Q2)$.

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

$$\ln L = \sum w_j \ln \theta(x_j b) + \sum w_j \ln (1 - \theta(x_j b))$$

where w_j denotes optional weights.

Equation 1 above can be specified empirically as follows:

$$Y = \beta_0 + \beta_1 YIELD + \beta_2 SOILPERF + \beta_3 DROUGHT + \beta_4 AGERESPN + \beta_5 EXTENVST + \beta_6 OFFFINCM + \beta_7 FARMSIZE + \beta_8 HHLDSIZE + \beta_9 LEVEDUCA + \beta_{10} MEMBASS + \beta_{11} CREDTACC + \beta_{12} INFOSOUR + \beta_{13} FARMEXP + \epsilon_i \dots\dots\dots (2)$$

$Y^* = 1$ = adoption

0 = No adoption

β_0 = Intercept

$\beta_1 - \beta_{15}$ = Coefficients of independent variables

YIELD = Perceived yield

SOILFERT = Perceived impact on soil fertility

DROUGHT = Perceived effects on drought

AGERESPN = Age of respondents

EXTENVST = Number of contacts a farmer had with extension agents

OFFFINCM = Off-farm income

FARMSIZE = Farm size

HHLDSIZE = Household size

LEVEDUCA = level of education

MEMBASSO = membership of association

CREDITACC = Credit access (1= access, 0=no access)

INFOSOUR = Source of information (1= friends, 2= radio, 3= news papers/fliers, 4 extension agents)

FARMEXP = Farming experience (years)

ε_i = error term.

2. 6. Socio-economic characteristics of respondents

Table 1 shows the socio-economic characteristics of respondents. The results in the table showed that 181 (60.5%) of respondents were males while 118 (39.5%) of them were females. It can be seen from the above that farming in the area is male dominant. The results in the Table further showed that 5 (1.7%) of respondents were less or equal 30 years of age while 51 (17.1%), 145 (48.5%), 74 (24.7%), and 28 (8%) fell in the age brackets of 31-40 years, 41-50 years, 51-60 years and greater or equal 61 years, respectively. The mean age of respondents in the area was 48.6 ± 11.5 years. It can be inferred from the above that farmers in the area were in their active ages. The majority, 248 (82.9%), of respondents had formal education while 51 (17.1%) of them did not have any formal education. Household size constitutes a major source of labour in peasant agriculture. About 2 (0.6%) of respondents had household size of less or equal 2 while 26 (8.7%), 139 (46.5%), and 132 (44%) had household sizes 3-4, 5-6, and greater or equal 7, respectively. The mean household size in the area was 7 ± 3.35 . It can be seen from the above that family labour may play significant roles in farm labour supply. Off-farm income constitutes the wheel with which innovations and technology are purchased by farmers. The results show that 3 (1%) of respondents had off-farm income of less or equal ₦20,000:00 while 47 (15.7%), 60 (20.1%), and 189 (63.2%) had off-farm income ₦20001-40000, ₦40001-60000 and greater or equal ₦60,001, respectively. The mean off-farm income in the area was ₦156,020.7 \pm 149,933. This implied that farmers in the area engaged in activities other than farming. Also, 65 (21.7%) of respondents had access to credit while majority, 234 (78.3%) of them had no access. This implied that access to credit in the area was low. The mean farm size

in the area was 4 ± 3.3 hectare. The results further showed that while 28 (9.4%) of respondents had farm size of less or equal 1 hectare, 58 (19.4%), 86 (28.8%), and 127 (42.5%) had farm sizes 1.1-2.0 hectares, 2.1-3.0 hectares and greater or equal 3.1 hectares, respectively. It could be inferred from the above that farmers in the area are smallholder farmers.

Table 1. Socio-economic characteristics of respondents

Variable	Frequency	Percentage	Mean	Std. Dev.
Sex				
Male	181	60.5		
Female	118	39.5		
Total	299			
Age				
≤30	5	1.7		
31-40	51	17.1		
41-50	145	48.5	48.6	11.5
51-60	74	24.7		
≥61	24	8.0		
Total	299	100		
Formal education				
Yes	248	82.9		
No	51	17.1		
Total	299	100		
Household size				
≤2	2	0.6		
3-4	26	8.7		
5-6	139	46.5		
≥7	132	44		
Total	299	100		
Off-farm income				
≤20000	3	1.0		
20001-40000	47	15.7		
40001-60000	60	20.1	156020.7	149933
≥60001	189	63.2		
Total	299	100		
Access to credit				
Yes	65	21.7		
No	234	78.3		
Total	299	100		
Farm size				
≤1	28	9.4		
1.1-2.0	58	19.4		

2.1-3.0	86	28.8
≥3.1	127	42.5
Total	299	100

Source: Field survey, 2016

2. 7. Climate change awareness and perception of climate factors

Table 2 shows the results of climate change awareness and perception of the state of climate elements. The results in the Table showed that majority, 250 (83.6%) of respondents indicated that they were aware of climate change while just 49 (16.4%) indicated non-awareness. This implies that majority of respondents were aware of change in climate. The results in the table further showed that majority of respondents, 205 (68.6%) perceived that temperature was increasing while 41 (13.7%) and 53 (17.7%) of them perceived that temperature was decreasing and unchanged, respectively. This implied that majority of farmers in the area perceived that temperature was increasing. Also, 141 (47.2%) perceived that length of rainfall was increasing while 106 (35.5%) and 52 (17.4%) perceived that rainfall was decreasing and unchanged, respectively. The majority of respondents, 134 (44.8%) also perceived that humidity was decreasing while 59 (19.7%) and 106 (35.5%) of them perceived that humidity was increasing and unchanged, respectively. Similarly, majority, 181 (60.5%) of respondents perceived that sunshine hour was increasing while 42 (14%) and 25 (25.5%) of them perceived that sunshine hour was decreasing and unchanged, respectively. It can be inferred from the above that farmers in the area perceived that climatic variables are incessantly increasing which had in no small measure affected their yields.

Table 2. Climate change awareness and perception of climate variables

Item	Frequency	Percentage
Awareness of climate change		
Yes	250	83.6
No	49	16.4
Total	299	100
Perceived state of temperature		
Increasing	205	68.6
Decreasing	41	13.7
Unchanged	53	17.7
Total	299	100
Length of rainfall		
Increasing	141	47.2
Decreasing	106	35.5
Unchanged	52	17.4
Total	299	100
Perceived state of humidity		
Increasing	134	44.8
Decreasing	59	19.7
Unchanged	106	35.5

Total	299	100
Perceived state of sunshine hour		
Increasing	181	60.5
Decreasing	42	14.0
Unchanged	76	25.5
Total	299	100

Source: Field survey, 2016

2. 8. Perception of agroforestry as climate change mitigation technique

Table 3 shows the results of the perception of agroforestry as climate change mitigation technique in the study area. The results in the table showed that majority, 240 (80.3%) of respondents showed that agroforestry mitigates climate change while just 59 (19.7%) of them indicated otherwise. It can be seen from the analysis that majority of respondents in the area indicated that agroforestry mitigate climate. The results in the Table also showed that 97 (32.4%) of respondents got information from extension agents while 7 (2.3%), 4 (1.3%), 82 (27.4%), and 109 (36.5%) of them indicated mass media, local NGOs, friends and family and Forestry Research Institute of Nigeria (FRIN) as their major sources information. This implied that FRIN plays significant roles in extending agroforestry systems to rural farmers in the study area. The results further showed that while 102 (34.1%) of respondents indicated complete disagreement that agroforestry is effective in mitigating climate change, 22 (7.4%), 69 (23.1%), 64 (21.4%), and 37 (12.4%) were slightly disagreed, slightly agreed, agreed and completely agreed that agroforestry mitigate climate change. This might be the reason for the wide utilisation of the technique among the respondents. On fertility enhancing, 100 (33.4%) of respondents completely disagreed that agroforestry is a fertility enhancing technique while 45 (15.1%), 68 (22.7%), 43 (14.4%), and 43 (14.4%) were slightly disagreed, slightly agreed, agreed and completely agreed that agroforestry is a fertility enhancing technique. Similarly, 95 (31.8%) of respondents were completely disagreed that agroforestry is good for the future while 31 (10.4%), 62 (20.7%), 64 (21.4%), and 47 (15.7%) were slightly disagreed, slightly agreed, agreed and completely agreed that agroforestry is good for the future. In the same vein, 68 (22.7%) of respondents were completely disagreed that agroforestry technique is very complex while 44 (14.7%), 26 (8.7%), 40 (13.4%), and 121 (40.5%) of respondents were slightly disagreed, slightly agreed, agreed and completely agreed that agroforestry technique is very complex. It can be inferred from the above that a good number of farmers in the area saw agroforestry as a complex farming technique.

Table 3. Perception of agroforestry as climate change mitigation technique

Item	Frequency	Percentage
Agroforestry mitigate climate change		
Yes	240	80.3
No	59	19.7
Total	299	100
Source of information		
Mass media	7	2.3

Extension	97	32.4
Local NGOs	4	1.3
Friends and family	82	27.4
Research institute (FRIN)	109	36.5
Total	299	100
Agroforestry is very effective		
Completely disagree	102	34.1
Slightly disagree	22	7.4
Slightly agree	69	23.1
Agree	64	21.4
Completely agree	37	12.4
Total	299	100
Agroforestry is fertility enhancing		
Completely disagree	100	33.4
Slightly disagree	45	15.1
Slightly disagree	68	22.7
Agree	43	14.4
Completely agree	43	14.4
Total	299	100
Agroforestry is good for future		
Completely disagree	95	31.8
Slightly disagree	31	10.4
Slightly agree	62	20.7
Agree	64	21.4
Completely	47	15.7
Total	299	100
Agroforestry is very complex		
Completely disagree	68	22.7
Slightly disagree	44	14.7
Slightly agree	26	8.7
Agree	40	13.4
Completely agree	121	40.5
Total	299	100

Source: Field Survey, 2016

3. RESULTS OF PROBIT REGRESSION FOR THE INFLUENCE OF PERCEPTION AND OTHER VARIABLES ON AGROFORESTRY ADOPTION AS A CLIMATE CHANGE MITIGATION TECHNIQUE

Table 4 shows the results of probit regression for the influence of perception and other variables on adoption of agroforestry as climate change mitigation technique. The results in the table showed that the log-likelihood was -183.46 . The results further showed that perceived effect of agroforestry on soil fertility, perceived effect of agroforestry on drought control, farm size, and membership of association were the positive determinants of agroforestry technique adoption among respondents in the study area. The results showed that perceived effect on

fertility, perceived effect on drought control, farm size and membership of association were significant 10 percent, 5 percent, 1 percent and 10 percent alpha levels, respectively. This implied that the more a farmer perceives agroforestry in fertility enhancement and drought control, the more the likelihood that the farmers will use the technique. More so, the higher the size of farm a farmer owned, the greater the likelihood that he would engage the technology. Also, membership of association enhances information about the potential benefit of a technology and the higher the number of association a farmer belongs, the higher the likelihood that he would adopt agroforestry. However, age was a negative determinant of agroforestry adoption in the area. Age was significant at 10 percent alpha level. This implied that the older a farmers is, the less the likelihood that he would adopt agroforestry. This is in agreement with Adesina and Baidu-Forson, 1995) that age and technology adoption are inversely related.

Table 4. Results of probit regression

Variable	Marginal effect	Std. Error	P-value
Perceived yield	0.086	0.545	0.123
Perceived fertility	0.400*	0.151	0.081
Perceived effect on drought	0.509**	0.189	0.043
Age	-0.059*	0.029	0.097
Extension	0.081	0.145	0.602
Off-farm income	0.105	0.111	0.386
Farm size	0.035***	0.010	0.001
Household size	0.052	0.066	0.459
Education	0.006	0.041	0.885
Association	0.082*	0.848	0.061
Credit access	0.800	0.335	0.061
Information source	-0.001	0.055	0.981
Farming experience	0.081	0.145	0.602
Log-likelihood function	-183.46		

Source: Field survey, 2016

4. CONCLUSIONS

The study concluded that farmers in the area were in their active ages and mostly males. Majority of them did not have formal education. The farmers engaged in activities other than farming and majority had not access to credit. Majority were aware of climate change and perceived that temperature and sunshine hours were on the increase. Majority indicated that agroforestry was an effective climate change mitigation strategy. Agroforestry adoption as climate change mitigation strategy was positively influenced by perceived fertility enhancing capacity of agroforestry, perceived drought controlling characteristics of the technology, membership of association and farm size. Farmers in the area should therefore be educated on the importance of agroforestry in fertility management and drought control.

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