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Determinants of Smallholder Farmers Adaptation Strategy to Climate Change in Nigeria

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Abstract. This study was carried out to determine the factors influencing decisions of smallholders on adaptation strategy to climate change in Nigeria and this is necessary as part of efforts to achieve the Sustainable Development Goals.The study used primary data with objectives that include assessment of the perception level of farmers to climate change; identify climate change adaptation strategies and to determine the factors influencing their choice of adaptation strategy using Multivariate Probit model. Results revealed that adaptation strategy options adopted by the smallholders were planting new crop variety, drought tolerant variety, participation in non-farm activities, land management practices, adoption of other coping strategies while some farmers did not use any adaptation strategy. These strategies were subsequently used as the dependent variables in the Multivariate Probit Model. The study found that household farmers adopt various adaptation strategies in order to cushion from the negative effects of climatic variability and extreme events such as drought and floods. There is therefore need to put in place policies and programs that will make the smallholder farmers to be proactive in adapting to climate change through extension information provided by the government.

Keywords: Adaptation, Strategies, Climate change, smallholders, Nigeria

1. Introduction

Subsistence agriculture is a major source of income and livelihood for large numbers of people living in rural area that subsequently provide food directly for household consumption for majority of people in Nigeria (World Bank, 2012). Climate change is already affecting people, their livelihoods and ecosystems and presents a great development challenge for the global community in general and for the poor people in developing countries in particular (Khanal, 2009). This also presents major challenges to scientists and policymakers. Scientific evidence indicates that the earth's climate is rapidly changing, owing to increases in greenhouse gas emissions (Havlik *et al.,* 2015; Chakravarty *et al.,* 2012) The increased concentration of greenhouse gases has raised the average temperature and altered the amount and distribution of rainfall globally. In Sub-Saharan Africa for example, warming is expected to be greater than the global average and in parts of the region, rainfall will decline (Chakravarty *et al.,* 2012, Garibaldi *et al.,* 2017) There is growing evidence that extreme events, such as droughts and floods, have been common incidences Chakravarty *et al.,* 2012) These have affected smallholder farmers in developing countries who heavily depend on rain fed

agriculture for their livelihoods (Terdoo and Adekola, 2014; Olsson *et al.,* 2014). In Africa, climate change has affected both the natural and social systems (*Olsson et al.,* 2014). Impacts of climate change are felt more severely in semi-arid and arid areas (McCarthy and Brubaker 2014, Teklewold *et al.,* 2013; Aslan *et al.,* 2013; Boko *et al.,* 2007). Limiting the damage due to climate change has become a challenge for the global community now. In this regard, there are two central ideas crucial for dealing with climate change, namely, mitigation and adaptation. Mitigation is a response strategy to global climate change, and can be explained as measures that reduce the amount of emissions (abatement) or enhance the absorption capacity of greenhouse gases (sequestration). Adaptation to climate change is an adjustment made to human, ecological or physical system in response to vulnerability (Adger *et al.,* 2007). The climate is changing and mitigation efforts to reduce sources or enhance the sinks of greenhouse gases will take time. Adaptation is therefore critical and of concern in developing countries, particularly Africa (including Nigeria) where vulnerability is high because the ability to adapt is low. Adaptation can manage the impacts but cannot by itself solve the problem of climate change. Even with adaptation, there will be residual costs. Smallholder farmers, for instance, can switch to more adapted crop varieties, but they may have lower productivity (Adger *et al.,* 2007). In developing countries, adaptation of the agricultural sector to the changing climate is important for ensuring livelihoods of the poor communities (Olsson *et al.,* 2014). Adaptation will require the involvement of multiple stakeholders, including policymakers, extension agents, NGOs, researchers, communities, and farmers. Climate change adaptation is mostly location-specific, and its effectiveness depends on local institutions and socioeconomic setting (Morton, 2007). A better understanding of how smallholder farmers perceive climate change and the adaptation strategies they practice is needed to make policies and design programs aimed at promoting successful adaptation in the agricultural sector. A combination of factors influences the farmers' perception about climate variability and the decision to use the selected adaptation strategies (Deressa, 2008; Hassan and Nhemachena 2007). The study focused on smallholder farmers because they have been identified as one of the groups most vulnerable to the adverse effect of climate change especially in Sub-Saharan region (Morton, 2007). This research helped to determine the factors that influence the decisions of smallholder farmers on adaptation strategy to climate change in Nigeria. This is necessary as part of efforts to achieve the Sustainable Development Goals (SDGs), and take urgent action to combat climate change and its impacts (goal 13) among other goals. The study objectives include assessment of the perception level of farmers to climate change; identify climate change adaptation strategies used by smallholder farmers in the Nigeria; and to determine the factors influencing their choice of adaptation strategy in Nigeria.

2. Research Methodology

2.1 Study Area, Sampling and Data Collection

The study was carried out in Nigeria. Primary data was collected using structured interview schedule and questionnaire. The data collection instrument focused on socio economic factors, status of awareness of climate change, climate change adaptation strategy used by the farmers and other relative information. The respondents were drawn in a multi-stage sampling process as follows, the first stage was a purposive selection of three States (Cross river, Ebonyi and Ondo States) in the rain forest zone and two States (Ogun and Oyo States) in the derived savannah zone. The second stage was by purposive selection of three Agricultural Blocks per crop and two Extension Cells per block - that is, 12 Cells across six Blocks - among those that are located in the main area where each of Rice and Maize are produced in the State. The final stage was by random selection of 5 – 10 members of the Rice/Maize farmers' groups in each of the selected cells. This process yielded a total of 521 farm households and 1338 rice and maize farmers from Southern

2.3 Data Analysis

Data from the study was analyzed using both descriptive and inferential statistics. This study used a multivariate probit (MVP) econometric technique, which simultaneously models the influence of the set of explanatory variables on each of the adaptation strategies, while allowing the unobserved factors (error terms) to be freely correlated (Belderbos, 2004). The source of correlation may be complementarities (positive correlation) and substitutability's (negative correlation) between different adaptation strategies (Belderbos, 2004). The study follows (Afolami *et al.,* 2015) in formulating the multivariate model; the dependent variables were six dummy variables: did nothing, planting of new crop, drought tolerance, nonfarm activities, land management and other coping strategies equals to one if the household adopts the adaptation strategy option and zero if otherwise.

$$Y_{ik}^{*} = \beta_{IK} X_{ik} + \alpha_k A_{ik} + \varepsilon_k$$

Where,

$Y_{ik}^{*}is$ a latent variable which captures the observed and unobserved preferences is associated with k^{th} climate change adaptation strategies and Y_{ik} denotes the binary dependent variables,

(k =1,...,m) represents the various adaptation strategies used by the farmers. Farmers who practice adaptation strategies are adopters and non-adopters are those who did not. The adopters of these adaptation strategies take value 1 and 0 otherwise.

X_{ik} is a vector of the explanatory variables which denotes the observed household and farm-specific characteristics, as well as institutional variables

β_k and α_k are conformable vectors to be estimated.

3. Results and Discussion

Socioeconomic Characteristics of Farmers

This section presents a description of the socio-economic characteristics of farmers in Nigeria. Table1 shows that the mean age of the farmers was 46.6years. Also, majority (55.6%) of the farmers fell within the age range of 31-60 years, which constitute the modal age group with the highest frequency of 462. The result showed that majority of the respondents were still within economically active age group. The average age reported in this study is higher than 43.4 years in Ogun State reported in (Ogunnaike *et al.,* 2019) and also agrees with the report of (Amigun, 2011) that most Nigerian farmers (women inclusive) are between 41-50 years of age and are still active. Majority (89.5%) of the respondents are married, this contributed widely to the use of family labour by the households as the wives and children constituted part of the labour force. The study further revealed the mean years of formal education to be 8 years.

Also, 22.7% of the total respondents sampled had no formal education, while 77.3% of the farmers had at least primary education qualification. This implies that majority of the farmers had at least first leaving school certificate (primary education). The result of the finding thus supports that of other studies have revealed that the level of education (years of schooling) helps farmers to use production information efficiently, as a more educated person acquires more information and, to that extent, is a better producer (Wang, 1996). The level of farmers' education is believed to influence the use of improved technology in agriculture and, hence, farm productivity. The level of education determines the level of opportunities available to improve livelihood strategies and enhance food security. It affects the level of exposure to new ideas and managerial capacity in production and the perception of the household members on how to adopt and integrate innovations into the household's survival strategies. The mean farm size is 1.7ha for the total respondents in Nigeria this implies that the larger the farm size, the higher the tendency of diversification of crop production thus leading to more production for home consumption and for sale (Minot, 2006). Majority (65.6%) of the sampled farmers produced their cereals from the upland. Majority (40.8%) of the farmers cultivated leased or rented land. With respect to their tenure duration, 53.6% of farmers had a long term tenure duration on their cultivated lands. This may be attributed to the fact that majority of their cultivated plots are leased thereby giving them more rights to invest in long term farming activities in addition, majority (89.7%) of the farmers do not have registered rights on their cultivated lands.

Table 1: Socioeconomic Characteristics of Farmers

Characteristics	Frequency	Percent
Age(Years)		
<30	134	10
31-40	359	26.8
41-50	401	30
51-60	290	21.7
>60	154	11.5
Mean	**46.6(12.8)**	
Marital Status		
Married	1176	87.9
Single	118	8.8
Widow	44	3.3
Educational status		

No formal education	262	19.6
Primary education	315	23.5
Secondary education	458	34.2
Tertiary education	303	22.6
Mean	8.9(5.4)	
Farm size (ha)		
<2	1083	80.9
2-4ha	172	12.9
>4	83	6.2
Mean	1.68(2.7)	
Land type		
Upland	921	68.8
Lowland	417	31.2
Mode of land acquisition		
Inherited	475	35.6
Purchased	147	11
Leased/Rented	545	40.8
Family land	90	6.7
Community land	66	4.9
Others	12	0.9
Tenure duration		
Short term use	389	29.1
Medium term use	232	17.3
Long term use	717	53.6
Right registration		
Not registered	1200	89.7
Registered	138	10.3

Source: *Computed from Field Survey 2018*

Perception of Farmers to Climate Variables

All of the respondents were asked question about whether or not they had experienced changes to regional climate within the past 25years, they were asked about their perceived experience in relation to a series of climatic events commonly associated within the global climate change effects in Nigeria. To these they could respond that the changes they experienced declined substantially, declined slightly, remain the same, increased slightly or increased substantially. The results on Table 2 report the response of respondents. It revealed that most of the respondents (65%) perceived that average day time temperature increased substantially. In addition, 47.6% of the respondents perceived an increase in the length of dry season or prevalence of droughts in the last 25 years. This is in accordance with the findings of (Adebayo *et al.*, 2012) who reported that 82% of respondents perceived an increase in day time temperature in Nigeria. Furthermore 26.1% of the respondents perceived a substantial decline in the average volume of rainfall while 33.8% perceived slight decline in the rainy season length, which however implies that an average respondent felt that the volume of rainfall and the rainy season length had decreased relative to the last twenty-five years.

The results as presented also show that majority of the respondents do not perceive any change in relation to incidence of flood (32.7%), intensity of storms (36.8%) and intensity of harmattan (26.1%) which implies that on the average, respondents in the study area perceived that incidences of flood and river overflow beyond its bank, frequency and intensity of storms and intensity of harmattan had increased compared to the last twenty-five years. Furthermore, 28.4% of the respondents perceived a

substantial decline in the prediction of rainfall which implies that an average respondent in the study area perceived a decrease in the prediction of rainfall compared to the last twenty-five years.

Lastly, while 37.8% of farmers perceived a substantial increase in the dryness of soil. The perception of the respondents towards the incidences of unusually high rainfall and thunderstorm remain the same (33.8%) in the study area. This imply that an average respondent in the study area felt an increase in the dryness of soil while the perception to the incidences of unusually high rainfall and thunderstorms remains the same relative to the last twenty-five years.

Table 2: Perception of farmers to climate variables

	Increased substantially	Increased slightly	Remain the same	Declined slightly	Declined substantially
Daytime temp	346(65)	109(20.5)	46(8.6)	19(3.6)	12(2.3)
Dry season length	253(47.6)	163(30.6)	67(12.6)	40(7.5)	9(1.7)
Volume of rainfall	86(16.2)	80(15)	79(14.8)	148(27.8)	139(26.1)
Rainy season length	66(12.4)	74(13.9)	64(12)	180(33.8)	148(27.8)
Incidence of flood	92(17.3)	111(20.9)	174(32.7)	96(18)	59(11.1)
Intensity of storms	115(21.6)	105(19.7)	196(36.8)	73(13.7)	43(8.1)
Intensity of harmattan	90(16.9)	111(20.9)	139(26.1)	108(20.3)	84(15.8)
Prediction of rainfall	51(9.6)	66(12.4)	134(25.2)	130(24.4)	151(28.4)
Dryness of the soil	201(37.8)	136(25.6)	111(20.9)	37(7)	47(8.8)
Unusually high rainfall	79(14.8)	123(23.1)	180(33.8)	67(12.6)	83(15.6)

Source: *Computed from Field Survey 2018*

Climate Adaptation Strategies Used

This section deals with the farm-level climate change adaptation strategies used by the sampled smallholder farmers during the last cropping year. 29.4% of the sampled smallholder farmers used other coping strategy such as mulching, multiple crop types, and multiple planting date as a coping mechanism to adapt to climate change. 23.9% of the respondents used new crop variety as an adaptation strategy while 6.7% of the respondents used drought tolerant variety. Some farmers diversified into Nonfarm activities (5.6%) and land management such as land fragmentation was used by 8.3% of the respondents. 26.1% of the respondents (smallholder farmers) did not adopt any strategy to mitigate climate change. This result partly agrees with the finding of (Hassan and Nhemachena 2007) that noted different varieties, crop diversification and different planting dates as main farm-level adaptation strategies in Southern Africa.

Table 3: Distribution of Respondents by their Main Farm-level Climate Change Adaptation Strategies used

Adaptation strategy	Percentage
Did nothing	**26.1**
New crop variety	**23.9**
Drought tolerant variety	**6.7**
Nonfarm activities	**5.6**
Land management	**8.3**
Other coping strategy	**29.4**

Source: *Computed from field survey 2018*

Multivariate Probit Model

The MVP regression results revealed the Wald chi-square test statistics($X^2(126) = 351.11$) shows that the hypothesis that all regression coefficients in each equation are jointly equal to zero is rejected at 1% ($prob>X^2=0.00$), thus indicating the fitness of the model with the data, and the relevance of the chosen explanatory variables in explaining the model. Furthermore, the likelihood ratio test($X^2(15) = 78.582$), which test the hypothesis that the correlations between error terms of the equations are all equal to zero is also rejected at 1%($prob>X^2=0.00$), thus confirming the

fitness of the multivariate probit model over the six distinct univariate probit models which ignore the potential correlation between the adoption decision of the different adaptation strategies by the farmers. The multivariate probit (MVP) models are presented in Table 4 and 5.

Table 4 shows the relationship existing between the adaptation strategies used by the smallholder farmers. The relationship is either complementary when they have a positive coefficient that is the strategies can be used together or substitute when they have a negative coefficient. The strategies that are complements are rho31(Drought tolerant variety & Did nothing), rho42(Non-farm activities & new crop variety), rho52(Land management practices & New crop variety), rho62 (Other coping strategies & New crop variety), rho54 (Land management practices & Non-farm activities), rho64 (Other coping strategies & Non-farm activities) and rho65 (Other coping strategies & Land management practices). Rho53 (Land management practices & Drought tolerant variety) are substitutes.

Table 4: Relationship between the Adaptation Strategy used by the Smallholder Farmers

	Coefficients	**Standard error**
Rho21	-0.0142	0.1259
Rho31	0.5160***	0.1473
Rho41	0.0978	0.1422
Rho51	-0.0085	0.1248
Rho61	0.0706	0.1207
Rho32	0.0710	0.1723
Rho42	0.5629***	0.1264
Rho52	0.3663***	0.1350
Rho62	0.7753***	0.0882
Rho43	0.3372	0.2294
Rho53	-0.3915*	0.2188
Rho63	-0.0881	0.1727
Rho54	0.5027***	0.1814
Rho64	0.5623***	0.1318
Rho65	0.5931***	0.1117

Source: *Computed from field survey 2018 *significant at 10% ***significant at 1%*

Results on Table 5 revealed that age is significant and positively correlated to the probability of not adopting any strategy to mitigate climate change while age squared has a negative influence on the adoption of the same practice. This implies that as majority of the farmers are above 40, they have a short planning horizon and do not have the ability to cope with the changing climate and climate variability risk. This is in line with the result reported in literature that the age of farmers has a negative influence on adoption of technology (Awotide *et al.,* 2016). Male headed household has a higher probability of adopting land management practices than female headed households. Correspondingly, the following previous studies found that male household heads have a positive relationship in adoption of manure and intensity of its use and fertilizer adoption and intensity of its use of farm technology adoption in Kenya (Ogada *et al.,* 2010) on multiple crops under irrigation and multiple crop-livestock under irrigation as African farmers' strategies for adapting to climate change (Hassan and Nhemachena 2007); and on adoption of fallow and terracing as land management technologies in Uganda (Birungi and Hassan, 2010). Male-headed households are more likely to get information about new technologies and undertake risky businesses than female-headed households (Asfaw *et al.,* 2016).

Married small holder farmers have increased likelihood of adopting new crop variety and other coping strategies, while farmers that does not belong to a farmers group has increased likelihood to move to non-farm activities The result further showed that there increase in household size increases the probability of adopting new crop variety, land management practices and other coping strategies. However, household size has a negative effect on the probability of adopting non-farm activities. This result agrees with literature which found out that household size is negatively related to adoption of fallow as land management technology in Uganda (Birungi and Hassan, 2010).

Furthermore, increase in farm size increases the likelihood of adopting non-farm activities, this implies that farmers with large farm size tends to diversify into non-farm activities. Farm size also has a negative effect on the probability of choosing land management practices. This implies that small farm size owners decrease the likelihood of adopting land management practices. This is attributed to the fact that adaptation is plot specific (Amigun *et al.,* 2011). It is not the size of the farm but the specific characteristics of the farm that dictate the need for a specific adaptation method to climate change. Access to basic amenities such as road, water and electricity increases the likelihood of adopting drought tolerant variety, non-farm activities, land management and other coping strategy. Also Increase in total farm income increases the likelihood of adopting other coping strategies.

Table 5: Factors that Influence the Choice of Adaptation Strategy Used.

	Did Nothing		**New Crop variety**		**Drought Tolerant**		**Nonfarm act.**		**Land practices**	**Mgt.**	**Other Strategies**	**Coping**
	Coefficient	**Z**	**Coefficient**	**Z**	**Coefficient**	**Z**	**Coefficient**	**Z**	**Coefficient**	**Z**	**Coefficient**	**Z**
Age	0.284**	2.03	0.096	0.9	-0.1667	-1.11	0.2056	0.93	0.1932	1.23	0.0516	0.45
Age Squared	-0.0024*	-1.67	-0.001	-1.03	0.0023	1.44	-0.0024	-1.03	-0.0023	-1.3	-0.0007	-0.54
Sex	0.1030	0.38	0.386	1.52	-0.2830	-0.75	0.1144	0.31	0.6256*	1.9	0.2187	0.84
Marital status	0.0389	0.09	-0.725*	-1.94	-0.2248	-0.47	-0.0529	-0.09	0.0574	0.11	-0.6841*	-1.88
Years of education	0.0159	0.55	0.0169	0.58	0.0189	0.52	0.0106	0.25	-0.0132	-0.39	0.0063	0.22
Farmers association	-0.3437	-1.31	0.2081	0.85	-0.3920	-0.94	-0.8528**	-2.13	0.1765	0.51	0.0779	0.27
Household Size	-0.0016	-0.03	0.0985*	1.94	-0.0135	-0.27	-0.1034*	-1.8	0.1542***	3.64	0.0961**	2.01
Nativity	-0.1891	-0.81	0.1361	0.63	-0.3710	-1.12	0.3441	0.99	0.0819	0.32	0.0196	0.09
Farm size_ Ha	0.0342	0.33	-0.0379	-0.36	-0.182	-1.09	0.2284*	1.82	-0.2886**	-2.21	-0.0982	-0.9
Amount borrowed	1.06E-06	1.26	1.17E-06	0.89	-1.11E-06	-1.17	-1.1E-05**	-2.32	6.72E-07	0.67	2.02E-07	0.15
Access to water	0.053	0.22	0.306	1.37	0.442	1.24	0.028	0.1	0.163	0.62	0.567**	2.33
Access to road	4.925***	16.05	-0.106	-0.14	3.849***	6.39	3.949***	8.15	2.819**	2.48	2.665***	4.81
Access to Electricity	-0.0405	-0.08	-0.4706	-0.99	4.0102***	5.81	-0.1064	-0.17	-1.523***	-2.92	-1.156***	-2.94
Total income	7.08E-07	0.32	5.01E-07	0.23	3.47E-06	1.4	3.48E-06	1.49	1.86E-06	0.98	9.36E-06***	3.31
Constant	-14.270	-4.07	-2.8581	-1.11	-6.3355	-1.62	-13.3463	-2.57	-7.9406	-1.77	-3.9626	-1.37
Log pseudo likelihood	-353.11											

Likelihood ratio test of rho21=rho31=rho41=rho51=rh061=rho32=rho42rho52rho62rho43rho53rho63rho54>rho64=rho65=0.00

chi2(15)=78.582 Probability>chi2=0

Source: *Computed from field survey, 2018. *, **,***significant at 10%, 5% and 1% respectively*

4. Conclusions

The study found that household farmers adopt various adaptation strategies in order to cushion from the negative effects of climatic/weather variability and extreme events such as drought and floods. Although majority of the farmers did not adapt any measures to mitigate the changes in climate because of lack of information and financial constraint, the study found that sex, age, income, access to road, farm size, farmers' association have significant impact on adaptation of climate change. Policy and decision makers would find these findings very important in making decision towards adaptation to changes in climate. There is therefore need for putting in place policies and programs that will make the smallholder farmers to be proactive in adapting to climate change. Based on the finding, the study concluded that:

Government, policy makers and NGOs should facilitate the availability of credit for smallholders' farmers in order to improve their adaptation strategy.

Government, policy makers and NGOs should sensitize farmers through extension agents on the effect of climate change and the need to mitigate in other to cushion the effect.

Farmers should be encouraged to join farmer's groups as it helps to give farmers a common front in negotiating input and output prices as well as an avenue for informal education and sharing of information about new technologies.

Youths and young adults should be encouraged to engage in agricultural production because they are still economically active in this age as it increases the probability of adopting new technologies.

Government should invest more in providing basic amenities to the rural populace as access to road and other needs tends to increase the likelihood of adoption of adaptation strategies.

There is a need for new institutions such as Public-Private Partnership organized which can take research findings to the field and help smallholder farmers adapt to a changing climate.

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