Nigerian Agricultural Policy Research Journal (NAPReJ) Agricultural Policy Research Network
Vol. 3. Iss. 1. Website: http:// www.aprnetworkng.org ©2017

NAPReJ

ISSN 2536-6084 (Print) & ISSN 2545-5745 (Online)

Determinants of adaptation strategies to climate change in Nigerian forest communities

NwaJesus Anthony Onyekuru[1] and Rob Marchant[2]

[1]Department of Agricultural Economics
University of Nigeria
Nsukka, Enugu State, Nigeria
E-Mail: anthony.onyekuru@unn.edu.ng

[2]York Institute for Tropical Ecosystem (KITE), Environment Department
University of York, University Road, York, UK, YO10 5DD.
Environment Department, University of York, York, UK

A R T I C L E I N F O

Key Words

Agroforestry

Logit model

Resilience

Vulnerability

Climate change

ABSTRACT

The impacts of climate change are increasingly being felt by forest communities of Nigeria. Based on this, the determinants of adaptation strategies were assessed across five broad ecological regions within Nigeria using a random sample of 400 rural households from forest communities. Data were collected using structured questionnaire and analyzed using the logit model. The major adaptation strategies identified using were agroforestry, erosion control, changed timing of operations, use of improved cook stoves, changed cultural practices, irrigation and migration. The determinants of adaptation strategies were: level of education, mode of transportation (use of motorized vehicle) to access markets, detection of climate change, household size, access to electricity, number of years of forest use, number of extension visits and net revenue made from the forest, which were significant at $p \leq 0.05$. Primary occupation (farming) and age of the household head were shown to be negatively associated with the adoption of different adaptation options. Seasonal rainfall and temperature were shown to impact on the use of different adaptation options. These findings could be used to incorporate adaptation strategies into national development planning in forestry and the agricultural sector to build resilience among forest communities in Nigeria, and the wider West African region.

1.0 Introduction

Although the nature of recent global climate changes is unprecedented, both in magnitude and impact, through geological history, local farmers and forest dwellers have traditionally survived and coped with climate shifts over time (Odero, 2011). In the tropics climate change is making weather less predictable, rains more uncertain and thunderstorms more likely (IPCC, 2014). Communities in West Africa have developed indigenous mechanisms and strategies over the years to cope with these changes (Nyong *et al*., 2007). Adapting to climate change is a human response to actual or expected climatic stimuli or their effects, which moderates harm or exploit beneficial opportunities and includes all activities that help people and ecosystems reduce their vulnerability to the impact of climate change (Intergovernmental Panel on Climate Change (IPCC), 2007). Adaptation helps farmers achieve food, income and livelihood security in the face of changing climatic and socioeconomic conditions, including climate variability, extreme weather conditions such as droughts, floods and volatile short-term changes in local and large-scale markets (Kandlinkar and Risbey, 2000; Hassan and Nhemachena, 2008). Farmers choose the levels of inputs, the kind of management, the desired number of animals/crops, management strategies and the species that will yield the highest net profit subject to exogenous socio-economic and environmental factors (Seo and Mendelsohn, 2008), sometimes reducing the negative impacts of climate change on crop yields by up to 50% (Reilly *et al*., 1996). With the increasing frequency and magnitude of climate change, it has become critical to understand how local people perceive and are adapting to these changes, and what factors influence their adoption of different strategies. Such information may enable practitioners, policy makers and individuals to better make informed decisions, and design incentives and policies that help to build resilience and enhance adaptive capacity against impacts of climate change (Hassan and Nhemachena, 2008; Seo and Mendelsohn, 2008).

Increasing system resilience is directly related to increasing the adaptive capacity of farmers (Verchot *et al*., 2007) and an effective adaptation policy must be built on a wide variety of economic, social, political and environmental information (Spittlehouse and Stewart, 2003).

Different models have been used to analyze the determinants of climate change adaptation strategies on crop (Deressa *et al.*, 2009; Kurukulasuriya and Mendelsohn, 2008; Hassan and Nhemachena, 2008) and livestock (Seo and Mendelsohn, 2008) production. Farmers' adaptation to climate change in Nigeria have also been estimated (Enete *et al.*, 2011; Nzeadibe *et al.*, 2011; Sofoluwe *et al.*, 2011; Ibrahim *et al.*, 2011; Ajao and Ogunniyi, 2011; Okereke, 2012), although all of these studies have been localized in either a single state or one of the six agro ecological regions of Nigeria; with no single common national assessment.

The broad objective of this study was to assess the socio economic, agronomic and climatic factors that influence the use of different climate change adaption strategies among forest communities in Nigeria. Thus, the null hypothesis that 'socioeconomic, agronomic and climatic factors do not influence the use of different adaption practices' was tested.

2.0 Materials and methods

The study was conducted in Nigeria. Nigeria is in West Africa. The country is bounded in the west by Respublic of Benin, Chad and Cameroun in the East and Niger in the North. Its coast lies in the Gulf of Guinea in the south, boardering Lake Chad in the north east (Fig.1), Multistage random sampling was used to collect 450 rural households from five broad ecological regions of Nigeria (Fig.1).

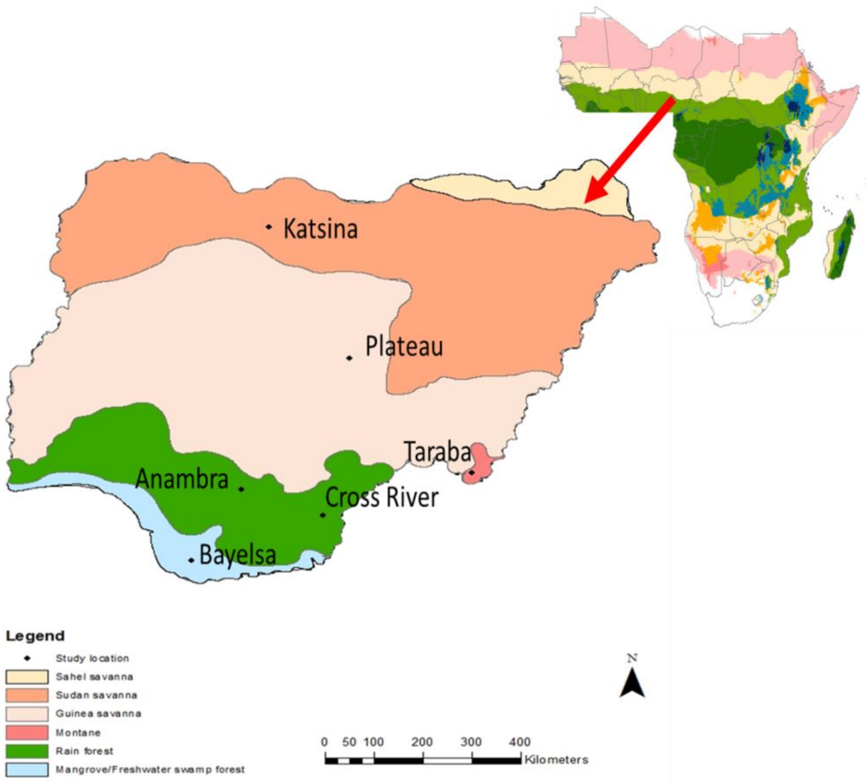

Figure 1. Agro ecological map of Nigeria showing locations where communities were assessed.

In Nigeria, agriculture is mostly dominated by smallholder farmers (John et al, 2013). These set of farmers contribute as much as 70% of the food production in the region, mostly for household consumption (FAO, 2009). Agriculture in Nigeria has been shown to be greatly impacted upon b climate change due to the heavy dependence on climate sensitive variables; rainfall and temperature. Particularly, climate change in Nigeria has led to increased bite of hunger and poverty, decline in agricultural yields, loss of livelihood, civil unrest and unemployment. This has even worsened with the current downturn in the petroleum sector of the economy. Efforts are now being made to fall back to agriculture.

Sampling procedure and data collection
Data was collected using structured questionnaire. The questionnaire was validated by three experts in the Technical Advisory Committee of the Environment Department, University of York, UK. A total of 450farm households were selected from five ecological regions of the country (Fig. 1) using multistage random sampling technique. Interviews focused on assessing the socio economic attributes of respondents, how they have been impacted upon by climate change and what their adaptation strategies were.

2.2. Theoretical model

Several models have been employed to measure the determinants of farmers' choice of adaption option to climate change (e.g binary and multinomial logistic models). In this study, due to the dichotomous nature of the dependent variables, a binomial logit model was used to explore associations between the socioeconomic and climatic attributes and climate change adaptation strategies as was employed by Silvestri *et al.* (2012), Bubeck*et al.* (2013), Panda *et al.* (2013) and Wood *et al.* (2014).The choice of the logit model for the individual adaptation options as against one single model, like Multinomial Logit Model (MNL), was due to the large number of factorial combinations which would be hard to analyze within one empirical model; as there were several simultaneous adaptation options reported by the respondents. This problem was also encountered by Silvestri *et al.* (2012), thus they opted for logit model. The logit model is thus specified as follows:

$$Y^* = \sum x\beta + \varepsilon,\ \varepsilon \sim N(0, 1)$$

If $y^* > 0$, $y = 1$
If $y^* < 0$, $y = 0$

Where"Y" is the dependent variable that can take only two values one (y = 1 for the use of the adaptation option) and zero,(y = 0, for the non use of the adaptation option). thus depicting a binary outcome, 'x' is a set of explanatory variables and ε, is error term.

2.2.1 Definition of the variables
The dependent variables in this estimation are defined to have two possible values: 1, denotes the use of the adaptation option and 0 for non-use. The type of adaptation option used may be related to: household size; gender; age; number of years of forest use; level of education; occupation of household head; household net income from the forest; temperature; rainfall; individual observation of climatic change; distance to the market; access to extension services and electricity (Table 1), these variables are as obtained in the works of Silvestri *et al.* (2012), Bubeck*et al.* (2013), Panda *et al.* (2013) and Wood *et al.* (2014).The sign and size of the association between each adaptation option and the explanatory variables could vary from negative to positive and 0 to 100% respectively (Table 1), depending on the nature of the explanatory variables, economic theory and prevailing environmental conditions.

Table 1. Description of variables used in the logit model analysis

Variable	Definition	Values/measure	Expected sign
Temperature	Winter, spring, summer and autumn temperature	^oC	±
Precipitation	Amount of rainfall in the winter, spring, summer and autumn seasons	mm	±
Noticed climate Change	Noticed changes in climate	1 = yes and 0 = no	±
Gender	Sex of household head	1 = male and 0 = female	±
Household size	Size of household	Number of members	+
Head age	Age of household head	Number of years	±
Experience	Number of years of forest use	Number of year	+
Level edu	Level of education of household head	Years	+
Majorocu	Major occupation	1 = farmer, 0 = others	±
Income	Net household income from the forest	₦	+
Distance	Time taken to get to the market	minutes	-
Extension	Access to extension services	Number of visits	+
Electricity	Access to electricity	1 = yes and 0 = no	+

Source: Field Survey (2013).

2.2.2 Application of the model

In Nigeria most of the practices reported by researchers as adaptation options are actually agronomic practices driven by economic, traditional/cultural concerns and not necessarily specifically adapting to climate change. To address this issue, respondents were asked to state *the actual adaptation practices used specifically to cope with perceived impacts of climate change, aside from their usual agronomic practices*. Several adaptations options were reported, but were aggregated to merge similar options or those with same / similar outcomes, resulting in the following broad categories: agroforestry. erosion control, changing dates of operations, use of improved / energy saving cook stove, cultural practices, irrigation/Drainage/use of wetland and migration. Thus, options like agroforestry includes water shade management, tree planting in different forms and reduction of tree cutting, while crops are integrated into existing trees. Irrigation includes all forms of water saving and supply, ranging from use of local drip irrigation, water harvesting, use of wetland, water channeling to more sophisticated drip irrigation. While cultural practices includes pruning, mulching, increased weeding, increased use of fertilizer/chemicals, use of resistant varieties and building of shades.

2.3 Analytical procedure

In this analysis the explanatory variables were regressed against each of the adaptation options (dependent variables) to estimate how each of the explanatory variables influence adaptation to climate change; the level and direction of association. Furthermore, the marginal effect analysis was performed to determine the likelihood (percent) of each explanatory variable influencing the use of each of the adaptation strategies.

3.0 Results

3.1 Socioeconomic characteristics of the households

At the end of data screening, 50 questionnaires from the different regions were discarded for having incomplete information with a total of 400 used for the analysis. Most (53%) respondents have used the forest for between 11 and 20 years

(Figure 2) indicating that they have good understanding of changes occurring in their forests and thus could provide up to date account of climate change impact and adaptation information as required. Over 88% have detected climate change in one form or the other. The adaptation options identified to be of importance by the forest communities were different cultural practices (76%), agroforestry (66%), erosion control (52%), changing time of operation (46%), energy cook stove (10.6%), migration (8.3%) and irrigation (24%) (Fig. 2).

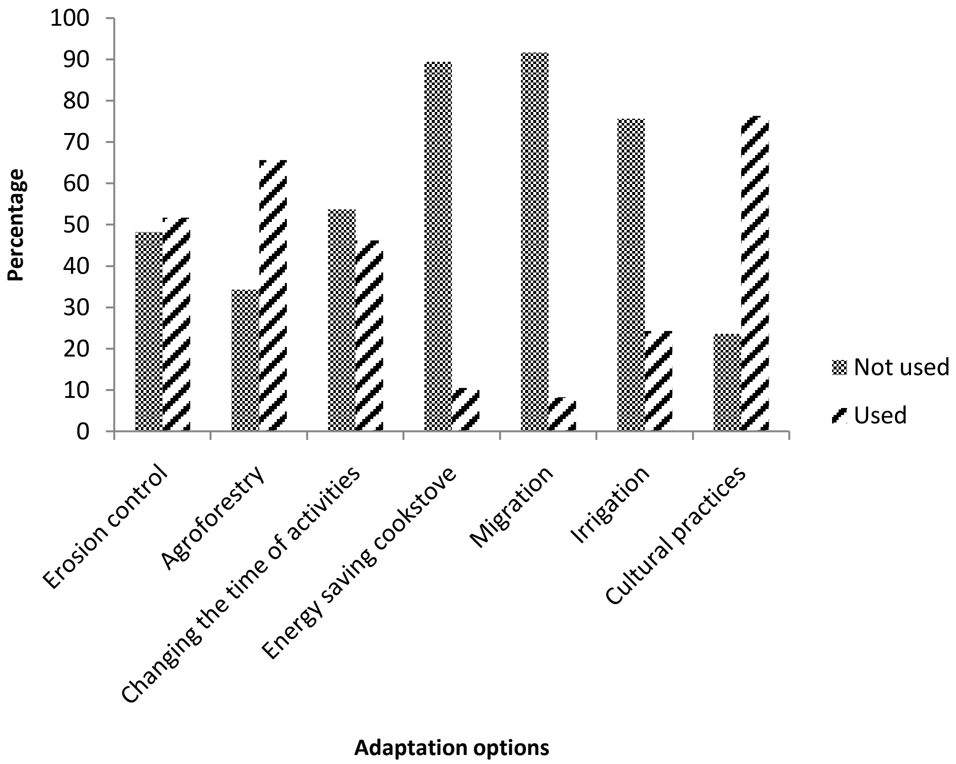

Figure 2. Adaptation strategies identified and their levels of importance

The majority of the household heads involved in forest resource use and management were between the ages of 40 and 60;over 70% were male and most of them (46%) had only primary school education.(Tables 1 and 2). The predominant family size was between 3 and 6, the majority net income from the forest (34%) was between 51,000 ($320) and 100,000 Naira ($625), the average income from the forest was over 300,000 Naira ($2000)yr^{-1}. This income is often in combination with other activities like agriculture (64%) and artisan jobs. About 59% of the households have access to electricity, 53% have used the forest for between 11 and 20 years, about 50% take between 30 to 60 minutes to get to their markets and over 65% use motorized transport to go to the market, while about 95% of them have no access to extension agents (Table 2).

Table 2. Descriptive statistics of explanatory variables used in the logit analysis.

	N	Min	Max	Mean	Std Deviation
Household size	400	1	9	4.21	2.551
Gender of Household head	400	0	1	0.73	0.443
Age of household head	400	8	86	48.55	13.981
Level of education of household head	400	0	25	9.39	5.27
Access to electricity	400	0	1	0.59	0.49
Primary occupation	400	0	10	0.75	1.05
Number of years of forest use	400	1	60	19.9	10.73
Distance to the input market (minutes)	400	5	90	39.58	22.75
Mode of transportation to the market	400	0	1	0.66	0.48
Net revenue from forest products	400	5000	5500000	307893	532373
Number of visits from extension officers	400	0	24	0.51	2.65
Notice if climate change by the farmer	400	0	1	0.88	0.32
Spring precipitation	400	21.43	222.98	138.97	67.23
Summer precipitation	400	164.38	419.94	283.21	97.59
Fall precipitation	400	37.05	285.13	179.45	88.75
Winter precipitation	400	0	40.98	19.30	18.55
Spring temperature	400	29.89	37.92	33.30	2.41
Summer temperature	400	25.12	32.87	29.34	2.06
Falltemperature	400	27.31	33.51	30.68	1.76
Winter temperature	400	28.26	35.51	32.53	2.23

3.2 Determinants of adaptation strategies

The forest communities are engaged in several adaptive activities in response to the negative impacts of climate change. Depending on the socioeconomic and prevailing environmental attributes, their likelihood of using different adaptation options was either positive or negative (Tables 3 and 4). Level of education of the household head was positively associated with the use of agroforestry and the use of erosion control as an adaptation option. A unit increase in education results in an increase in the likelihood of using agroforestry and erosion control respectively. The age of the household head was positively associated with the use of erosion control and irrigation and a disincentive to the use of changing of time of activities, improved cook stove and migration. A unit change in the age of the household head increases the likelihood of the use of erosion control and irrigation by 0.3% and 56% respectively, while it decreases that of changing of timing of activities, use of improved cook stove and migration by 0.6%, 40.5% and 1.2% respectively. Primary occupation (farming) was negatively associated with the use of agroforestry as an adaptation option and decreases the likelihood of its use by 7.3%.

The mode of transportation to the market was positively associated with the use of agroforestry, changing of the time of operations, use of improved cook stove, migration and negatively associated with the use of erosion control. The use of motorized means of transportation results in 18.3%, 22.7%, 46% and 11.3% increases in the likelihood of the use of agroforestry, change of time of activities, migration and use of improved cook stove respectively, while it decreases that of the use of erosion control and irrigation by 22.6% and 9.7% respectively.

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Vol. 3. Iss. 1. Website: http:// www.aprnetworkng.org ©2017
NAPReJ
ISSN 2536-6084 (Print) & ISSN 2545-5745 (Online)

Table 3. Summary of logistic regression analysis

Variables	Adaptation options													
	Agroforestry		Erosion control		Changing of time of activities		Use of improved cook stove		migration		irrigation		Cultural practices	
	coef.	Sig.	coef.	Sig.	coef.	Sig.	coef	Sig.	coef.	Sig.	coef.	Sig.	coef.	Sig.
Spring prec.	-0.023	0.222	0.067	0.888	-0.022	0.028	0.437	0.998	0.008	1	-0.076	0.8841	0.023	0.282
Summer prec.	0.003	0.733	-0.033	0.001	0.004	0.08	-0.474	0.996	-0.05	1	-0.122	0.008	-0.01	0.039
Fall prec.	-0.018	0.117	0.002	0.853	0.011	0.215	0.142	0.999	0.183	0.999	0.173	0.034	-0.001	0.922
Winter prec.	0.149	0	-0.023	0.464	0.006	0.81	-0.043	1	-0.999	0.997	-0.133	0.998	0.011	0.793
Spring temp.	-2.547	0.057	1.089	0.414	-0.454	0.692	-47.506	0.995	-1.929	1	-0.48	1	-3.929	0.023
Summer temp.	-2.189	0.261	3.493	0.068	0.191	0.908	-74.328	0.996	-19.762	0.999	13.02	0.998	-4.479	0.058
Fall temp.	6.87	0.109	-6.327	0.136	0.635	0.862	158.96	0.996	2.700	0.999	17.67	0.997	10.96	0.041
Winter temp.	-1.005	0.025	1.216	0	-0.19	0.614	-11.463	0.997	0.389	1	5.199	0.995	-0.873	0.1
Hhold size	-0.017	0.734	0.08	0.1	-0.055	0.214	-0.103	0.269	-0.017	0.853	-0.037	0.573	0.035	0.472
Gender	-0.019	0.952	-0.415	0.196	0.211	0.453	-0.052	0.919	17.433	0.995	0.07	0.832	-0.294	0.419
Age of hh head	-0.007	0.466	0.019	0.066	-0.027	0.003	-0.021	0.037	-0.061	0.083	0.032	0.011	0.01	0.323
Level of edu	0.043	0.1	0.051	0.042	-0.027	0.231	0.033	0.461	-0.071	0.148	-0.013	0.668	0.008	0.76
Has electricity	-1.255	0.004	0.958	0.032	-0.14	0.694	0.285	0.767	-14.673	0.994	1.906	0	0.45	0.254
Pri. occupation	-0.41	0.094	-0.065	0.562	-0.068	0.537	0.047	0.759	-0.084	0.554	0.106	0.435	-0.059	0.581
Forest use yrs	-0.011	0.338	0.002	0.89	0.026	0.02	-0.058	0.005	-0.001	0.979	0.008	0.537	0.025	0.1
Dist to mkt	0.007	0.207	0.003	0.562	-0.003	0.584	0.024	0.008	-0.01	0.253	-0.001	0.822	-0.003	0.637
Mode of trans.	1.029	0.004	-1.278	0	1.028	0	1.051	0.107	2.421	0.027	-0.369	0.284	-0.533	0.121
Net rev (forest)	0	0.961	0	0.452	0	0.458	0	0.062	0	0.927	0	0.834	0	0.69
Extension visit	-0.138	0.205	0.061	0.414	-0.092	0.1	-12.349	0.993	-12.987	0.993	-0.054	0.241	0.059	0.433
Notice cc	2.823	0	-0.24	0.523	0.961	0.01	19.247	0.997	-4.90	0.937	0.433	0.346	0.484	0.208
Constant	-31.99	0.053	14.65	0.366	-4.022	0.775	-770.20	0.995	-236.38	0.999	-1.747	1	-45.44	0.03
Chi-square	46.71	0	128.7	0	96.15	0	114.45	0	127.5	0	118.9	0	48.34	0

Access to electricity encourages the use of erosion control and irrigation and was negatively associated with the use of agroforestry as an adaptation option. A unit increase in electricity access increases the likelihood of the use of erosion control and irrigation by 17% and 35.1% respectively and decreases that of agroforestry by 22.2%. Net revenue from the forest has a positive association with the use of improved cook stove (ICS) and a unit increase in revenue increases the likelihood of its use by 6.4%. While the number of years of forest use (experience) was positively associated with changing the time of operations and the use of cultural practices, but it was negatively associated with the use of ICS. A unit increase in the number of years of experience in forest resource use increases the likelihood of the use of changing of the time of operations and cultural practices by 0.6% and 0.4% respectively, while it decreases the use of ICS by 10.7%. The number of extension visits was positively associated with the changing of the time of operations, increase sing the likelihood by 2% and decreased the use of agroforestry by 2.4%. Distance to the market was positively associated with the use of improved cook stove and negatively associated with the use of irrigation. A unit increase in the distance to the market increases the likelihood of the use of ICS by 28% and decreases that of

Table 4. Marginal effects from the logit climate change adaptation model

Variables	Agroforestry		Erosion control		Changing time of activities		Use of improved cookstove		Migration		Irrigation		Cultural Practices	
	dy/dx	P>|z|	dy/dx	P>|z|	dy/dx	P>|z|	dy/dx	P>|z|	dy/dx	P>|z|	dy/dx	P>|z|	dy/dx	P>|z|
Hhsize	-0.003	0.731	0.014	0.095	-0.003	0.850	-0.067	0.461	0.006	0.469	-0.012	0.198	-0.151	0.050
Gender	-0.003	0.951	-0.073	0.185	(omitted)		-0.012	0.808	-0.047	0.412	0.047	0.441	-0.008	0.881
Age	-0.001	0.463	0.003	0.091	-0.0120	0.035	0.580	0.004	0.002	0.333	-0.006	0.003	-0.405	0.030
educ1	0.008	0.082	0.009	0.031	-0.0140	0.115	0.082	0.516	0.001	0.761	-0.006	0.221	-0.063	0.509
Electric	-0.222	0.005	0.170	0.035	(omitted)		0.351	0	0.072	0.243	-0.031	0.705	0.031	0.681
Priocupation	-0.073	0.050	-0.011	0.521	-0.016	0.492	0.029	0.248	-0.009	0.596	-0.015	0.526	0.004	0.733
Foruseyrs	-0.002	0.334	0.000	0.893	-0.000	0.982	-0.036	0.619	0.004	0.123	0.006	0.022	-0.107	0.026
Distmktmin	0.001	0.211	0.001	0.551	-0.002	0.285	-0.165	0.025	-0.001	0.638	-0.001	0.576	0.279	0.003
Mkttrans	0.182	0.003	-0.226	0	0.458	0.027	-0.097	0.075	-0.085	0.116	0.227	0	0.113	0.114
Nrforest	0.000	0.961	3.290	0.383	-0.000	0.891	0.033	0.494	0.000	0.625	-3.820	0.436	-0.064	0.089
Extcvisit	-0.025	0.008	0.011	0.309	(omitted)		-0.008	0.243	0.009	0.335	-0.020	0.084	omitted	omitted
Noticecc	0.500	0	-0.043	0.481	-0.009	0.934	0.077	0.318	0.077	0.194	0.212	0.006	omitted	omitted
Springp	-0.007	0.003	0.001	0.604	0.000	0	-0.402	0	0.002	0.321	-0.004	0.131	-1.943	0
summerp	0.002	0.064	-0.003	0.009	0.000	0.913	-1.036	0.015	-0.003	0.013	0.001	0.257	-2.091	0
Fallp	0.001	0.536	0.005	0.001	0.000	0	2.508	0	-0.000	0.964	0.001	0.503	0.717	0
winterp	0.012	0.012	-0.007	0.127	0.101	0	-0.141	0.301	0.010	0.059	0.004	0.380	0.521	0
Springt	0.008	0	-0.006	0	0.001	0	-0.511	0	-0.005	0	0.006	0	1.091	0.261
summert	0.014	0	-0.006	0	0.001	0	0.003	0	-0.007	0	0.010	0	1.447	0
Fallt	0.004	0	-0.004	0	0.001	0	-0.405	0	-0.003	0	0.003	0	1.187	0
Winter	-0.019	0.007	0.011	0.098	(omitted)		0.153	0.895	0.011	0.099	-0.012	0.108	1.504	0

irrigation by 16.5%. Detecting climate change positively influences the changing of the time of operations and the use of agroforestry. A unit increase in the farmers' detecting climate change increases the use of agroforestry and change of time of activities by 50% and 21.2% respectively.

Average rainfall was shown to be prominent in influencing agronomic practices (agro-forestry and erosion control). Dry seasons (winter) rainfall encourages the practice of agroforestry; the establishment of nursery, planting and establishment of the trees after planting are rainfall dependent.

A unit increase in dry season rainfall increases the likelihood of the practice of agroforestry by 1.2%. During the dry seasons there is usually little rain, thus having water supply at this period increases agroforestry practice. Rainfall during this period is usually not too heavy to affect planting operations, cause water logging, inhibit fruit ripening or affect harvesting process. On the other hand, winter and spring temperature are negatively associated with agroforestry; unit increase results in a corresponding 1.9% and 0.8% decreases in the likelihood of agroforestry practice respectively.

The beginning of the spring period (March and April) is too dry to plant tree crops and in most parts of Nigeria is the peak of dry season. In addition the harvesting of most fruits would have been completed before then and fruit trees have shed their leaves, waiting for the next rainy season. This result also conforms with that of cultural practices which shows

Table 4. Marginal effects from the logit climate change adaptation model (continued)

Variables	Migration		Irrigation		Cultural Practices	
	dy/dx	P>|z|	dy/dx	P>|z|	dy/dx	P>|z|
Hhsize	-0.003	0.850	-0.067	0.461	0.006	0.469
Sex	(omitted)		-0.012	0.808	-0.047	0.412
Age	-0.0120	0.035	0.580	0.004	0.002	0.333
educ1	-0.0140	0.115	0.082	0.516	0.001	0.761
electric	(omitted)		0.351	0	0.072	0.243
priocupation	-0.016	0.492	0.029	0.248	-0.009	0.596
foruseyrs	-0.000	0.982	-0.036	0.619	0.004	0.123
distpmktkm~s	-0.002	0.285	-0.165	0.025	-0.001	0.638
mkttrans	0.458	0.027	-0.097	0.075	-0.085	0.116
nrforest	-0.000	0.891	0.033	0.494	0.000	0.625
extcvisit	(omitted)		-0.008	0.243	0.009	0.335
noticecc	-0.009	0.934	0.077	0.318	0.077	0.194
springp	0.000	0	-0.402	0	0.002	0.321
summerp	0.000	0.913	-1.036	0.015	-0.003	0.013
fallp	0.000	0	2.508	0	-0.000	0.964
winterp	0.101	0	-0.141	0.301	0.010	0.059
springt	0.001	0	-0.511	0	-0.005	0
summert	0.001	0	0.003	0	-0.007	0
fallt	0.001	0	-0.405	0	-0.003	0
wintert	(omitted)		0.153	0.895	0.011	0.099

that autumn (September – November) temperature favours agronomic practices in agroforestry system; planting, fertilizer application, weeding, pruning, budding and grafting. This is because of the reduced rainy season and relatively drier environment for these practices, which are done before the onset of the dry season that starts at the later part of the winter and peaks at the early part of the spring. In the case of the summer temperature and rainfall, they both negatively affect cultural practices. A unit increase in both results in a corresponding decrerase in the likelihood of use of cultural practices by 0.7% and 0.3% respectively. The period is too damp for any meaningful activity in the forest / farm, it inhibits the collection of forest products and causes fruits to rot, fuelwood is damp and most people are forced indoors, especially during the peak of summer rainy season when it rains for several days non-stop. In addition a higher temperature in the damp environment encourages fruit putrefaction, pest / insect multiplication and disease outbreak, thereby reducing output. There is no doubt that spring rainfall positively influences erosion control as the later part of the spring season is usually the beginning of the rainy season which often is characterized by floods, farmers are kept busy channeling water out of their farms and clearing water ways.During the peak of the rainy season (summer) the reverse is the case as excessive rain makes it difficult for any meaningful activity. Subsequently, when the rain subsides (autumn) season major works are done by farmers and communities on gullies formed during the rainy season before the onset of dry season when the soil is too hard to work.

Nigerian Agricultural Policy Research Journal (NAPReJ) Agricultural Policy Research Network
Vol. 3. Iss. 1. Website: http:// www.aprnetworkng.org ©2017
NAPReJ
ISSN 2536-6084 (Print) & ISSN 2545-5745 (Online)

4.0 Discussion

The main adaptation strategies identified in this study are agroforestry, erosion control, changing date of operations, use of ICS, cultural practices, irrigation and migration. These adaptation options are in resonance with adjusted planting dates and new varieties in Greece (Kapetanaki and Rosenzweig,1997), new hybrids and changes in sowing dates in Spain (Iglesias and Minguez, 1997), altered crop mix, crop varieties, sowing times, harvesting dates, and water saving technologies in the United States (Kaiser *et al*., 1993; Kaiser *et al*., 1993); varying planting dates, using different crop varieties, different cultural practices, soil and water conservation in sub-Saharan Africa (Hassan and Nhemachena, 2008; Wehaa *et al*., 2013). Among these, the use of different cultural practices and the practice of agroforestry appear most important among adaptation strategies of forest communities to climate change. Cultural practices are an amalgam of different agronomic practices like pruning, mulching, use of fertilizer, weeding, fallowing, building of shades and use of resistant varieties. Agroforestry is a win-win adaptation options available to the forest communities in the face of climate change, especially with respect to incentives accruable via the nascent carbon market. It is also widely recognized that forests play an important role in the global carbon cycle by sequestering and storing carbon (IPCC, 2000; 2014; Karjalainen *et al.,* 1994; Stainback and Alavalapati, 2002; Nyong *et al.,* 2007). According to Verchot *et al.* (2007) agroforestry can enhance productivity, contribute to climate change mitigation and strengthen the system’s ability to cope with adverse impacts of changing climate conditions. Thus, the agroforestry component of the REDD+ initiative should be fast tracked as a win-win option for carbon climate change mitigation and building of resilience among the forest poor (Minang, 2013). Agroforestry tries to find some balance in the raising of food crops and forests (Adesina *et al.*, 1999) and makes important contributions to rural livelihoods (Sivakumar *et al.* 2005). According to Verchot *et al.* (2007) agroforestry contributes to reducing farmers’ vulnerability to mid-season droughts and offers opportunities for improving rural livelihoods by turning unproductive land into productive ones. Due to being able to tolerate inter-annual variability in rainfall, deep rooted tree-based systems have some obvious advantages for maintaining production during wetter and drier years; Charles *et al.* (2013) found that agroforestry practitioners were richer than non-practitioners with an extra US$618 income annually as economic yields from marketable tree products compensate for the loss of crop yield. Integrated forest agro systems are common in southern Nigeria where shade tolerant crops such as *Dioscorea spp.* and Cocoyam are incorporated within permanent forest settings (Adesina, 1988).

Those whose primary occupation was farming were shown to be averse to practicing agroforestry. This could be due to the technicalities involved; the subsistent nature of agriculture in rural Nigerian communities where the priority is given to arable crops for families’ consumption. In addition, the practice of agroforestry requires large areas of land, contrary to the fragmented small pieces of land holdings by the farmers in most of the rural communities of Nigeria. This is also made more complex with the lease system of farming where most farmers crop on other peoples’ lands and therefore are not allowed or lack the incentivesto invest in more permanent ventures.

Most of the household heads identified in this study were middle aged males with primary school education; this is in line with the findings of Chhetri (2005) that community forest income to the male headed and illiterate household in Nepal was higher than those of female headed and literate households. In this regard there is the concern that the problem of traditional male dominance in the realm of forestry limits the degree to which forest departments around the developing world are motivated and capable of initiating and implementing gender equality agenda (Gurung and Lama, undated). Thus, there is a need to develop more appropriate options for women, like socially conditioned inequities in access, use and control of forest resources in order to reduce the gender gap in the system (Adesina *et al.,* 2000).

The negative association of summer rainfall (peak of rainy season) to different adaptation strategies, and consequently output, was due to excessive wetness that makes it difficult for farmers to get into their farms, cause some vegetables products to rot and encourages mould and fungus which damage crops, especially those that have fruits close to or in the ground (Sosnowski, 2013). Problems of excess rainfall also cause fruit to crack or split (Marshall *et al.*, 2002; NeSmith, 2005) and causes diseases, delays ripening, destroy or reduces flowering and reduces yields (Johnson, 2013).The positive association between age and different adaptation strategies resonates with those of Deressa *et al.* (2009) in Ethiopia and Baffoe-Asare *et al.* (2013) in Ghana. The result may also reflect that older farmers have more money over the years to implement long lasting investments in their farms, have more equity to enable them to borrow from commercial institution and also have more grown up members of their families, with older children to assist in on-farm activities. This finding also resonates with the that of Cassidy and Barnes (2012) that ages of the household head was positively correlated with social connectivity and resilience and the older the children the freer are the parents for economic activities that build resilience (Andersen and Cardona, 2013). This finding also relates to the positive relationship between household size and erosion control; because the family has more labour force for these operations. The fact that innovation take-up and social resilience are positively associated with household size has also been demonstrated in the work of Baffoe-Asare *et al.* (2013) and Cassidy and Barnes (2012).

Furthermore, older farmers are more reluctant to migrate in the face of adverse climate change effects; considering their land assets and longtime investments on the farm, they are not easily able to change their activities (Hutton and Haque, 2004; McLeman and Smit, 2006; Johnson *et al.*, 2013). There is the tendency for one to remain even in the face of adversaries, due to deep social ties to relatives, friends and associates. Households in the rural areas use migration as a risk management strategy when faced with rainfall variability and food and livelihood insecurity (Warner, 2012). Migration as an adaptation strategy is not a new phenomenon; it has also been reported in the Sahel and Sudan (Afolayan and Adelekan, 1998; Hammer, 2004), Papua New Guinea (Barnet and Webber, 2010), Tanzania (Charnley, 1997) and Ethiopia (Meze-Hausken, 2000).

The number of years of experience individuals have been involved in forest activities was positively associated with the use of diverse cultural practices and also changes in their activities with emerging climate change impacts. This is in agreement with the finding of Negash (2011) in a study of farmers' preference for adaptation strategies in Ethiopia, Rana *et al.* (2012) in India and Baffoe-Asare *et al.* (2013) in Ghana. Age is adversely associated with the adoption of changing of activities as an adaption option; this was also found by Ekwe and Onunka (2006) in Nigeria and Rana *et al.* (2012) in India. These findings are not unconnected with the reluctance to innovate by the older people, due to the fear of uncertainty and the quest for food security and not 'profit' in subsistence agriculture. Age of the household head was also negatively associated with the use of ICS. El Tayeb and Mukhtar (2003) also found out that age of wives, had negative significant effect on the adoption of ICS in Sudan; possibly the long time users of open fire cooking are more reluctant to adopt ICS due to cultural beliefs and inertia associated with long time practices. For the cost implication associated with the change, Ergeneman (2003), Jagadish (2004), Rai and McDonald (2009), Holme (2010), Inayat (2011) and Mobaraka *et al.* (2012) observe that an obvious disadvantage and barrier to adoption of improved cook stoves is that they cost money. For most low-income consumers, ICS are simply not affordable with disposable income (Rai and McDonald, 2009; Slaski and Thurber, 2009), and the economic situation of subsistence populations is such that they do not see the long-term benefits for the short-term cost of the ICS (Manuel, 2003). The amount of income from a system is usually a positive incentive to invest in strategies to protect the system from adverse climate change impact, and the forest sector is not an exception. Thus, there is the need for targeted intervention by government agencies and development practitioners to subsidize the price of ICS in order to make them more affordable, or provide credit and financing for the poor (Rai and McDonald, 2009). It was expected that the closer a person is to the market the more likely the adoption of ICS,
but the reverse was the case: it could be that the markets where the ICS are procured are further from the rural areas as shown in Appendix 1. In the same vain, mode of transportation to the market was positively related to the use of ICS, showing that those that use motor and transport to the market, who are more probably richer are more likely to use ICS.

More widely the mode of transportation was also positively related to agroforestry, changing the time of activities and migration. In all of these situations it shows that those that have access to motorized forms of mobility are more versatile and adaptive to

Nigerian Agricultural Policy Research Journal (NAPReJ) Agricultural Policy Research Network
Vol. 3. Iss. 1. Website: http:// www.aprnetworkng.org ©2017
NAPReJ
ISSN 2536-6084 (Print) & ISSN 2545-5745 (Online)

changing environmental conditions than those that have not. In the case of agroforestry, the use of vehicles help in the evacuation of products to the market for sale, it helps to make migration easy and makes the work of the farmers easier especially when they need to reschedule operations in the farm, as it is more convenient to adjust operation times when there is a motorized form of transport than when there is none. Education was positively associated with the practice of agroforestry as against the traditional arable crop agriculture. Deressa *et al*. (2009), Baffoe-Asare *et al.* (2013) and Hassan and Nhemachena (2008) also found that education was positively related to the use of adaptation options in their analysis of the determents of farmers' strategies for adapting to climate change: those with better level of education have also been found to exhibit greater level of resilience against adverse climate change impact (Tesso *et al.*, 2012). Educated farmers have greater understanding of the importance of tree planting and the incorporation of trees as part of farming practices, especially appreciating the concept of carbon storage and Nitrogen fixation in the case of the use of leguminous trees.

Those that have access to electricity were shown to be more likely to invest in irrigation on the farms. This result is in agreement with that of Hassan and Nhemachena (2008). This is because electricity is very essential in the powering of most on-tarm irrigation facilities. As in Ethiopia (Deressa, *et al.*, 2008), age of the household head also has a positive association with irrigation; due to the long period of involvement in agro-forestry activities by the older farmers which has predisposed them to invest in irrigation infrastructure with their accumulated capital and experience compared to the young entrants. Thus, it is most likely that the positive association between education and erosion control is linked to the need to protect irrigation facilities, crops, farm assets and other investments in the farm.

Awareness of climate change was reflected in the findings on the number of extension visits and notice of climate change which were positively related to changing the time of activities. Rana *et al.* (2012) and Fatuase and Ajibefun (2013) also found that the more the farmers have access to extension services, the more the chances of adopting different adaptation measures, including changing the dates of farm activities in India and parts of South Western, Nigeria respectively. Nhemachena and Hassan (2007) and Deressa *et al*. (2011) found access to extension agent to influence the adoption of different agronomic practices in Southern Africa and Ethiopia respectively. Detection of climate change (change in rainfall) was also reported by Debalke (2011) as a major determinant of farmers' change of their time of operations in Ethiopia. Farmers' detection of climate change was also positively related to the practice of agroforestry; resonanating with the findings of Advancing Capacity to Support Climate Change Adaptation (2010) in Ethipia. The higher the level of awareness of climate change either via the extension officers or individuals' personal experiences, the more likelihood that they will adjust their operations in the face of climate change, due to superior information. Thus, the need to increase public awareness and personal contact with the extension officers to update farmers with the latest issues in climate change adaption cannot be over emphasised, not only in Nigeria, but across Africa.

5.0 Conclusion

The impact of climate change is one of the serious threats facing rural forest and farm communities, not only in Nigeria but across the developing world. Many forest communities in Nigeria are implementing coping strategies that include, agroforestry, erosion control, changing dates of operations, use of ICS, cultural practices, irrigation/drainage/use of wetland and migration. Agroforestry stands out as the prominent strategy for its obvious win-win benefits; it has a particular role to play in mitigation of atmospheric accumulation of GHGs, increase in the amount of organic matter in the soil which help to improving agricultural productivity. There are many adaptation options, which, if adequately designed and applied in response to specific local contexts and realities, can limit the negative effects of climate change and land degradation not only in Nigeria but across West Africa. Many of these options combine land conservation and productivity enhancement practices to build resilience among rural forest communities and are already familiar to most of the local communities, but their effectiveness now depends on careful incubation, selection and application, so that they are implemented in the right place and at the right time and combined with an enabling policy environment for the adaptation options to be practiced in a sustainable manner (UNDP, 2009). Communities already have a long record of successful adaptation to climate variability, however, if we are to meet the goal of agricultural transformation we must help poor rural people cope with climate change.

Acknowledgement:
Authors wish to express our gratitude to the Commonwealth Scholarship Commission in the United Kingdom for sponsoring my PhD study and this research in the Environment Department of the University of York, UK. Also thanks to my employer, the University of Nigeria, Nsukka for all their support. Specially, I express my profound gratitude to the Centre for Environmental Economics and Policy in Africa (CEEPA), University of Pretoria, South Africa, for their numerous trainings and expert advice that have made this work a success.

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