DETERMINANTS OF CLIMATE CHANGE ADAPTATION STRATEGIES OF YAM PRODUCERS IN NIGER STATE, NIGERIA

J. N. Nmadu*, A.A.A. Coker, and E. Adams
Department of Agricultural Economics and Extension, Federal University of Technology, Minna, Nigeria

*CORRESPONDENCE E-MAIL: job.nmadu@gmail.com , Telephone: 08035861170

ABSTRACT
The associated impacts of climate change affects availability of soil water, plant growth and productivity. Thus, understanding farmers' response and the factors influencing adaptation measures used will help in designing more appropriate coping strategies to the effect of climate change which was why this study was undertaken. Data for the study were obtained from primary source with the aid of structured questionnaire administered to 120 yam farmers from across Shiroro, Lapai and Wushishi LGAs in Niger State. The data were analysed using descriptive statistics and multivariate probit regression model. The results indicate that crop rotation, early planting of yam and mixed cropping were the most important adaptation measure used by the respondents with a mean adaptive capacity of 0.60. The most important variables affecting the choice of adaptation strategies are age, gender, household size, major occupation, farm size, educational level, farming experience, method of land ownership, farm income, membership of cooperatives/association, extension contact, access to climate change information, amount of credit access and farmers perception of climate change while it was found that some of the adaptation strategies were complementary and others were substitutive. It is recommended that continuous education and effective advisory services aimed at empowering the farmers and enhancing their capacity to choose appropriate climate change adaptation measures be instituted.
KEYWORDS: Climate change, yam farmers, adaptation strategies, multivariate regression, Nigeria

INTRODUCTION
Agriculture in Nigeria is mostly rain-fed as well as in sub-Saharan Africa, in terms of total cropped land and its exposes agricultural production to high seasonal rainfall variability. About 90% of the total population depends on rain-fed agriculture for food production. The effect of climate on agriculture is related to variability in local climates rather than in global climate patterns and therefore any change in climate will have an impact on its productivity and other socio-economic activities in the country. The impact could however be measured in terms of effects on crop growth, availability of soil water, soil erosion, incidents of pests and diseases, and decrease in soil fertility (Alvaro et. al., 2009; Adejuwon, 2004; IFAD, 2011; Fraser, 2008).
Climate change is the most severe problem that the world is facing today. It has been suggested that it is a more serious threat than global terrorism (King, 2004). Rough estimates suggest that over the 50 years, climate change may likely have a serious threat to meeting global food needs than other constraints on agricultural systems, as climate change has brought about possibly permanent alterations to our planet's geological, biological and ecological systems (IPCC, 2007; Building Nigerian's Response to Climate Change, 2008). This worrisome trend indicates that rising demand for food over the next century due to population and real income growth will lead to increasing global food scarcity and a worsening of hunger and malnutrition problems particularly in developing countries (Wolfe

et al., 2005). Climate change leads to the emergence of large-scale environmental hazards to human health such as extreme weather, ozone depletion, increased danger of wild land fires, loss of biodiversity, stresses to food producing systems and the global spread of infectious diseases (McMichael, 2003; Sahney, Benton and Falcon-lang, 2010). WHO estimates that 160,000 death since 1950 are directly attributable to climate change (McMichael, Woodruff and Hales, 2006).

According to IPCC (2007), adaptation to climate change is the adjustment in natural or human systems in response to actual or expected climate stimuli or their effects with moderated harm or exploits beneficial opportunities. Adaptation is usually a long term livelihood activity and a continuous process where results are sustained; it uses resources efficiently and sustainably, involves planning and combining of new and old strategies, knowledge focused on finding alternatives and includes all activities that help people and ecosystems reduce their vulnerability to the impact of climate change and minimize the costs of natural disasters (Federal Ministry of Environment, 2011). Adaptation to climate change is a complex multi-dimensional and multi-scale process (Bryant, *et al.,* 2000). Adger, *et al.,* (2005) validated this finding by reporting that, the ways towards adaptation are diverse and can be integrated together so as to guarantee the sustainability and resilience of agriculture in the context of an uncertain future challenge by climate change. Heltberg, Siegel and Jorgensen (2009) used a social risk management framework to group adaptation strategies into three categories according to their timing and effect; those that prevent or reduce risk, those that mitigate risk, and those that compensate for risk. Adaptation to climate stress is a local process that is rooted in socialization and learning (Adger and Kelly, 1999; Locatelli, 2011). It is not possible to implement an adaptation policy without considering the social context in which local knowledge is developed (Kapadonou, Adegbola and Tovignan, 2012). The perspectives of the indigenous people, the way they behave and think in relation to climate changes, as well as their values and aspirations have a significant role to play in addressing climate change (Doss and Morris, 2001, Easton, 2004). The consensus in scientific literature indicates that in the coming decades, the world will witness change in precipitation levels and higher temperatures and the effect of these changes will lead to low or poor agricultural production (Kurukulasuriya and Mendelsohn, 2006; Lobell *et. al.*, 2008). Evidence has also shown that changing climate is already affecting crop yields in many countries, including Nigeria where majority of the population are farmers (IPCC, 2007; Deressa *et. al.*, 2008; BNRCC, 2008; Nwaiwu *et al.*, 2014; Orebiyi *et al.*, 2014). This is particularly true in low income countries where climate is the primary determinant of agricultural productivity and adaptive capacities are low (Spore, 2008; Apata, *et al.*, 2009). Most African countries which have their economies largely based on weather-sensitive agricultural production systems like Nigeria are particularly vulnerable to climate change (Dinar *et al.*, 2006). This vulnerability has been demonstrated by the devastating effects of recent flooding in the Niger delta in Nigeria and the various prolonged droughts that are currently witnessed in some parts of Northern region (Apata *et. al.*, 2010). In all this studies, the methodology of determining the impacts seem to have an in-built bias in the correlation among the various options is not considered.

Yam production is a major source of livelihood and food security to the producers (International Institute of Tropical Agriculture, 2013). Its cultivation and yield patterns are of economic importance to the livelihood of an average farmer, as they have link to food security in rural communities (Babaleye, 2003; National Bureau of Statistics, 2012). Climate variability is the resultant effect in the alterations of ecosystem structures to satisfy human land use and livelihood potentials of the populace. Climate variability poses significant impacts on agricultural sector and its direct impacts causes vulnerability to the natural and social systems (IPCC, 2013). The setbacks are attributed to low and poor scientific development, as most development innovations are not built on indigenous knowledge of the farmers to provide for sustainability of new practices. Consequently, the associated impacts of climate variation is predominantly negative with the most severe impacts being experienced in vulnerable communities made up of the bulk of Nigerian farmers, particularly, yam farmers practicing farming at subsistent levels. The production of yam is a very profitable venture and that more producers can still enter and make profit.

In Nigeria, a strong relationship was observed between land improvement techniques and net returns in yams output by the farmers (Ennin, Otoo and Telleh, 2009). Climate change adaptation has significant impact on both farm productivity and farm net revenues (Di-Falco, Yusuf, Kohlin and Ringler, 2011). It was found that farmers who adopted climate change adaptation strategies had higher output and net revenues than those who did not, which implied that, if households undertake adaptation measures they are likely to be able to produce more food and obtain higher revenues in the face of climate change. This is consistent with the argument in the literature that climate change adaptation partially offsets the impact of climate change on food production and exclusion of climate change adaptation in the analysis would overstate the impact of climate change on agricultural production (Dinar, Rashid, Robert and James, 2008). In investigating the methods used by farmers to mitigate the negative impact of climate change in Osun State Nigeria, Adesoji and Ayinde (2013) found that age, household size, income, source of information and farm size are the main determinants of the choice of adaptation strategies implemented by farmers. Nhemachena and Hassan (2007) also identified the important determinants of adaptation in South Africa, Zambia and Zimbabwe as access to credit, extension, and awareness. Their study suggests enhancing access to credit and information about climate and agronomy so as to boost adaptation. Findings by Okoh (2004) revealed that, mulching materials improve the soil condition for well-developed roots. Halugalle, Lal and Gichuru (1990); Inyang (2005); Gbadebo (2006) also revealed that mulching materials improve soil physio-chemical properties, reduce soil temperature, reduce evaporation and increase the soil moisture, thereby creating enabling soil micro-climatic condition for early sprouting of yams. Other studies indicated that agricultural adaptation measures such as the use of crop varieties, planting of trees, soil conservation, changing of planting dates, diverging from crops production to livestock keeping and irrigation are the most used adaptation methods in African countries (Deressa *et al.*, 2009; Kabubo-Mariara 2008; Mideksa 2009; Ajao and Ogunniyi 2011; Bryan *et al.*, 2009, Easterling, 1996; Alexandrov *et al.*, 2002, Foresight, 2011, IPCC, 2012, Ike and Ezeafulkwe, 2015, Apata, 2015). Wilcock *et al.*, 2008) reported that adaptive strategies are needed in order to protect local food supplies, assets and livelihoods, avoid damage to farmers' output and protect the ecosystems. (Füssel and Klein, 2006). Most studies have pointed out several socioeconomic, environmental and institutional factors, as well as the economic structure as key drivers influencing farmers' choice to specific adaptive strategies. In view of all the foregoing, there is need to comprehensively determine the factors influencing climate change adaptation decision for a given adaptation option by yam producers in Niger State. Therefore, the objectives of this study are to describe the socio-economic status of yam farmers in the study area and determine factors affecting climate change adaptation strategies adopted by yam farmers in the study area using multivariate regression model.

ANALYTICAL FRAMEWORK

Multivariate regression is an econometric model for estimating an equation in which there is more than one dependent variable, thus incorporating the interdependence among them. Where the dependent variables are categorical or quantitative, then the model is known as multivariate multiple regression (MMR) model whereas, in a case where the dependent variables are binary, then it is known as multivariate multiple probit (MMP) regression model. This system of equations recognizes the correlation in the error terms of the dependent variables and it estimates the set of models simultaneously. These models are more efficient than the univariate multiple models as it analyzes each of dependent variables independently. The univariate modeling (the estimates of separate dependent variables) ignores the potential correlation among the unobserved disturbances in the variables. In addition, one dependent variable may be conditioned on the other-complementary (positive correlation in the error terms) or substitutable (negative correlation). Failure to capture interdependence of the variables among themselves may lead to bias and inefficient coefficient estimates (Dorfamn, 1996; Kassie *et al.*, 2013; Teklewold *et al.*, 2013a; Yu *et al.*, 2012, Khanna, 2001; Belderbos *et al.*, 2004). In general, the Multivariate probit model is given as,

$$Y_i = (Y_1, \ldots, Y_k) \quad (1),$$

$i = 1, \ldots, n$ is sample size

k is the number of dependent variables, the probability of observing choice yi is given as

$$\Pr(y_i|X_i\ \beta, \Sigma) = \int_{AJ} \cdots \int_{A1} \int N(y_i^*|X_i\beta\Sigma)dy_1^* \ldots dd_j^* \quad (2)$$

$$\Pr(y_i|X_i\ \beta, \Sigma) = \int 1_{y*} \epsilon A f N(y_i^*|X_i\beta\Sigma)dy_1^* \quad (3)$$

Where; $A = A_1 \times \ldots \times A_J$ and

$$A_j = \begin{cases} (-\&\infty, 0)y_i^* = 0 \\ (0, \infty)y_i^* = 1 \end{cases} \quad (4)$$

The model can be represented by two systems of equations. First, a system of equations with latent (unobservable) dependent variables are described by a linear function of a set of observed household (h) and plot (p) characteristics (X_{hp}) and a multivariate normally distributed stochastic terms (ϵ_{hp}). Each equation in the system can be written as:

$$T^*_{hpk} = X_{hp}\beta_k + \epsilon_{hp} \quad (5)$$

Where T_{hpk} denotes the latent dependent variables which can be represented by the level of each sub-dependent variable

$$T_{hpk} = \begin{cases} 1 \text{ if } T^*_{hpk} > 0 \\ 0 \text{ otherwise} \end{cases} \quad (6)$$

The off-diagonal elements of the variance–covariance matrix represent pairwise error terms correlation rho (ρ) for any two dependent variables in the model. In the presence of error terms correlation (ρ), the off-diagonal elements in the variance–covariance matrix of adoption options become non-zero. A positive correlation is interpreted as a complementary relationship, while a negative correlation is interpreted as a substitute relationship.

METHODOLOGY

The study was carried out in Niger State which lies between Latitudes $8^0 20'$N and $11^0 30'$N and Longitudes $3^0 30'$E and $7^0 20'$E. The state is bordered to the North by Zamfara state, North West by Kebbi state, South by Kogi state, South West by Kwara state, while Kaduna state and federal capital territory bordered the State from North East and South East respectively. Furthermore, the state shares a common international boundary with the republic of Benin at Babanna in Borgu Local Government Area of the state. The state has a projected population of 5,062,443 as at 2016, premised on 2.5% population growth rate (World Bank, 2013, Niger State Bureau of Statistics, 2014).

Niger State has twenty-five Local Government Areas (LGAs) and a total land mass covering about 76,363km^2 (representing about 10% of the total land area of Nigeria). It is mainly grassland, with scanty trees all year round. The state has two types of soil - Ku soil and Ya soil. The Ku soil has little erosion hazards, while the Ya soil has better water holding capacity. Niger State experiences distinct dry and wet seasons, with annual rainfall varying

between 1,100mm in the Northern parts to 1,600mm in the Southern parts, which last between 120 and 150 days in the Southern and Northern parts of the state respectively with an average temperature between 26° C and 36° C and relative humidity of 42°c.
Agriculture is the major occupation in the state with about 85% of the population engaged in farming, while the remaining15% are involved in other vocations such as white collar jobs, business, craft and arts. Generally, the fertile soil and hydrology of the state permits the cultivation of most of Nigeria's staple crops and still allows sufficient opportunities for grazing, fresh water fishing and forestry development. Major crops grown in the state are; yam, maize, beans, millet, rice, groundnut, sorghum cassava and sugar cane (NSBS, 2012). The availability of wide varieties of minerals and agricultural resources attest to the economic potentials of the state. Mineral resources available in the state include: Talc, Gold, Ball Clay, Silica, Sand, Marble, Copper, Iron, Feldspar, Lead, Kaolin, Casserole, Columbite, Mica, Quartzite, and Limestone. The three Hydro Electric Power Stations in the country (located at Kainji, Jebba and Shiroro) are all in the state (NSBS, 2012).
Multi-stage sampling technique was used for selecting respondents in the study area. The first stage involved random selection of one Local Government Area (LGA) each from the three Agricultural Zones (Zone I, II and III) in Niger State. This was followed by random selection of three wards eaoh from the selected LGAs in the Zones. The third stage was the random selection of one community each from the selected wards, giving a total of nine (9) communities. The fourth stage involved the use of sampling fraction of 20% of the total population of registered yam farmers in the study area. This was adopted from Zubairu and Jibrin (2014). The sample size of 120 was computed proportionately to the total population of yam farmers in each of the selected communities.
The data for this study was collected from primary source. Primary data were obtained using a structured questionnaire which was administered to yam farmers in the study area. Data were collected by the researcher and via the help of trained enumerators. The primary data collected include the socio-economic characteristics of farmers such as age, gender, household size, major occupation, farm size, education, farming experience, membership of cooperation/association, extension contact/visit, annual income, access to credit, farmer adaptation strategies and climate change related variables.
Data collected for this study were analyzed using descriptive and inferential statistical tools. Descriptive statistics such as mean, mean scores, frequency distribution tables and percentage were used to analyze data while inferential statistics i.e. multivariate regression (probit) model was used to determine the factors determining choice of adaptation strategies to climate change.

The Multivariate Probit Model (MVP) was used to estimate the determinants of adaptation strategies to climate change variation. The empirical Multivariate regression model is specified in equation (7).

$$Y_{ik} = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6 + \beta_7X_7 + \beta_8X_8 + \beta_9X_9 + \beta_{10}X_{10} + \beta_{11}X_{11} + \beta_{12}X_{12} + \beta_{13}X_{13} + \beta_{14}X_{14} + e \quad (7)$$

Where k= number of dependent variables gives as 1=Change of crop varieties (CCV); 2=Change of planting/harvesting dates/calendar (CPHD); 3=Crop diversification (CD); 4=Soil and water conservation measures (SWCM); 5=Diversification to off-farm income (DOI); 6=Change of cultural practice/farm operations (CCP). The independent variables are X_1 = Age, X_2 = Gender, X_3 = Household size, X_4 = Major occupation, X_5= Farm size, X_6= Education level, X_7= Farming experience, X_8= Land ownership, X_9= Farm income,

X_{10}=Membership of cooperative/association, X_{11}=Extension contact/visit, X_{12}=Access to climate change information, X_{13}= Amount of credit accessed, X_{14}=Farmers perception of climate change.

RESULTS AND DISCUSSION

The description of the socio-economic characteristics of the respondents is presented in Table 1; the perception of the respondents on climate change is presented on Table 2. The sources of climate change information expressed by the respondents are presented in Table 3 and the various adaptation strategies are presented on Table 4. The estimates of the coefficients of the multivariate probit regression model are presented on Table 5 and the correlation between of error terms of the adaptations choices is presented on Table 6. In addition, the educational status of the respondents is presented in Fig. 1 and the distribution of their incomes is presented in Fig. 2.

The socio-economic characteristics of the respondents (Table 1) shows that the mean age for the overall sampled farmers was 44 years with minimum age of 20 years and maximum 72

Table 1 Description of farmers' socio-economic characteristics

Socio-economic characteristics	Freq.	%
Age		
≤ 30	15	13
31-40	41	33
41-50	36	30
51-60	14	12
≥ 61	14	12
		44
Gender		
Male	101	84
Female	19	16
Household size		
1-5	41	34
6-10	50	42
11-15	26	22
16-20	3	2
		9
Major occupation		
Farming	82	68
Trading	20	17
Civil servants	14	12
Artisans	4	3
Marital status		
Single	18	15
Married	88	73
Divorced	4	3
Widowed	7	6
Separated	3	3
Farm size		
≤1	10	8
2-4	70	58
5-7	35	29
≥8	5	4
		3.60
≤10	8	7
11-20	23	19
21-30	21	18
31-40	31	26
41-50	18	15
≥51	19	16
		34
Total	**120**	**100**

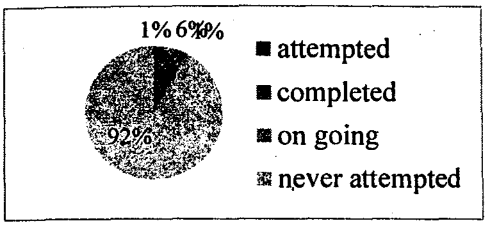

Fig. 1 Yam farmers' educational level

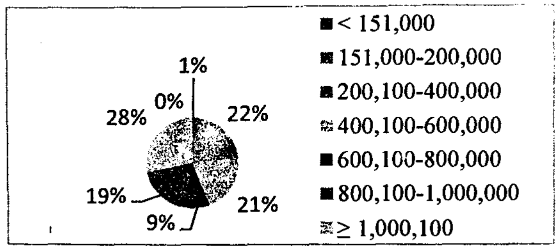

Fig. 4.2 Yam farmers' annual income

Table 2 Distribution of farmers' according to their perception of climate change

Farmers Perceived Climate Change	*5 (%)	4 (%)	3 (%)	2 (%)	1 (%)	MS	RK
Increased/high temperature	41	30	11	10	8	3.85	1st
Increased sunshine hours	24	42	15	8	11	3.60	2nd
Low rainfall	33	31	13	6	18	3.55	3rd
Soil erosion	34	28	14	4	19	3.54	4th
Soil infertility	28	37	13	6	17	3.53	5th
Disappearance of wildlife	23	38	17	8	15	3.46	6th
Disappearance of plant /vegetation	26	32	19	8	16	3.44	7th
Shorter raining season	28	30	15	11	17	3.41	8th
Decreased in incident pest & diseases	26	22	24	17	12	3.33	9th
Increased in incident drought	27	22	24	10	18	3.30	10th
Increase in incident of pest & diseases	24	23	21	10	22	3.18	11th
Increase in Incident of Flood	22	28	18	8	25	3.14	12th
Longer raining season	17	28	23	14	18	3.13	13th
Decrease in Incident of Flood	21	20	15	20	24	2.93	14th
Decreased Sunshine hours	23	14	21	16	27	2.90	15th
High rainfall	18	23	15	19	26	2.87	16th
Decreased in incident of drought	18	17	19	25	21	2.87	16th
Decreased/low temperature	14	20	23	21	23	2.83	18th

*5=Very frequent, 4=Frequent, 3=Not sure, 2=Not frequent, 1=Not very frequent, MS= Mean scores, RK= Rank. Decision: Mean scores ≥ 3= highly perceived climate change and Mean scores < 3= Lowly perceived climate change.

Table3 Distribution of respondents' sources of climate change information

Source of Climate Change Information	* 5 (%)	4 (%)	3 (%)	2 (%)	1 (%)	MS	RK
Radio	14	27	25	22	13	3.08	1st
Farmers Association/ Cooperatives	1	15	27	35	23	2.38	2nd
Agricultural Development project	3	12	21	45	20	2.37	3rd
Television	5	13	13	40	28	2.32	4th
Non-governmental Organizations	1	4	21	41	33	1.98	5th
Metrological agency	3	8	16	25	48	1.92	6th
News paper	0	7	15	38	41	1.88	7th
Internets	4	5	13	23	55	1.80	8th

* 5=Always, 4=Sometimes, 3=Neutral, 2= Rarely, 1=Never, MS= Mean scores, RK= Rank. Decision: Mean scores ≥ 3= Always available, Mean scores < 3= Not always available.

Table 4 Distribution of respondents according to adaptation measures used and their degrees of adaptive capacities

Farmers Adaptation Strategies	*1 (%)	2 (%)	3 (%)	4 (%)	MC	RK
Crop rotation	6	8	38	48	0.65	1st
Early planting of yam	4	8	46	43	0.64	2nd
Mixed cropping	7	8	40	45	0.64	3rd
Mulching/planting of cover crops	7	9	41	43	0.64	4th
Early maturing variety	10	6	44	40	0.63	5th
Late planting of yam	5	11	39	45	0.63	5th
Application of farm yard manure/fertilizer	10	9	42	39	0.62	7th
Livestock production/animal fattening	8	8	43	41	0.62	7th
Late maturing variety	8	12	38	42	0.61	9th
Early harvesting of yam	12	4	41	43	0.61	9th
Bush fallowing/relocation to different site	12	13	35	40	0.61	9th
Late harvesting of yam	9	16	39	36	0.60	12th
Mono /sole cropping	8	13	49	30	0.60	12th
Mining/quarrying activity	11	10	44	35	0.60	12th
Diseases resistant variety	16	10	43	31	0.59	15th
Forest/ tree planting for shed	44	7	18	31	0.59	15th
Okada service	14	13	40	33	0.59	15th
Change of weeding pattern	19	10	33	38	0.59	15th
Drought resistant variety	11	13	50	26	0.58	19th
Construction of bond across flood plain	40	17	14	29	0.58	19th
Small scale business/ agro-business	13	11	48	28	0.58	19th
Artisan	51	4	18	26	0.58	19th
Alteration of heap/mound size	17	17	36	30	0.58	19th
Change in land preparation pattern/minimum tillage	20	9	44	27	0.58	19th
Change of mulching material	13	20	36	31	0.58	19th

*1=Low adaptive capacity, 2=Neutral adaptive capacity, 3=Moderate adaptive capacity, 4=high adaptive capacity, MC= Mean capacity. Decision: Farmers with Average mean capacity 0.5 ≤AdapCapij < 0.75 = Moderate adopters

Table 5 Determinants of climate change adaptation strategies

Variables	CCV	CPHD	CD	SWCM	DOI	CCP
Age	0.0591 (5.95)***	0.0315 (3.61)***	0.0076 (0.93)	0.0076 (0.90)	0.0122 (1.58)	0.0324 (3.88)***
Gender	-1.086 (-3.35)***	0.0366 (0.12)	-0.1310 (-0.49)	0.2090 (0.62)	-0.5537 (-1.91)*	0.4233 (1.57)
Household size	0.0157 (0.40)	-0.0784 (-2.17)**	-0.0714 (-1.99)**	-0.1364 (-3.35)***	-0.0335 (-0.97)	-0.1188 (-3.47)***
Major occupation	0.9241 (3.66)***	-0.0708 (-0.31)	0.1890 (0.88)	-0.8515 (-3.45)***	0.1307 (0.59)	-0.0673 (-0.30)
Farm size	-0.1925 (-2.62)***	0.0213 (0.31)	0.2150 (3.24)***	0.2800 (3.51)***	-0.1452 (-2.33)**	0.0427 (0.73)
Educational level	0.0821 (4.86)***	0.0016 (0.12)	0.0113 (0.84)	0.0271 (1.72)*	-0.0298 (-2.18)**	-0.0089 (-0.68)
Farming experience	-0.0202 (-2.09)**	-0.0157 (-1.83)*	0.0006 (0.08)	0.0480 (5.08)***	-0.0140 (-1.75)*	0.0223 (2.68)***
Method of land ownership	0.2360 (1.17)	-0.3237 (-1.65)*	-0.2520 (-1.29)	-0.0331 (-0.16)	0.0114 (0.06)	-0.2720 (-1.44)
Log of farm income	0.0752 (0.36)	0.868 (3.86)***	-0.1665 (-0.93)	0.2012 (1.05)	0.5821 (2.71)***	-0.0585 (-0.34)
Membership of cooperation/ association	0.1840 (0.92)	-0.4210 (-2.41)**	-0.3360 (-1.93)*	-0.4961 (-2.52)**	-0.2801 (-1.60)	-0.0305 (-0.17)
Extension contact	0.5347 (2.87)***	-0.2770 (-1.64)	-0.0468 (-0.29)	0.5388 (2.69)***	0.2940 (1.83)*	-0.4630 (-2.84)***
Access to climate change information	-0.8868 (-2.64)***	0.2960 (1.00)	0.5232 (1.92)*	0.9142 (2.98)***	0.1958 (0.67)	0.0024 (0.01)
Log of amount of credit accessed	-0.0045 (-0.21)	0.0849 (4.28)***	0.0301 (1.61)	-0.0444 (-2.19)**	0.0231 (1.27)	0.0176 (0.97)
Farmers perception of climate change	-0.3649 (-1.91)*	0.0181 (0.10)	-0.0361 (-0.21)	-0.2580 (-1.38)	0.3140 (1.87)*	-0.2211 (-1.34)
Constant	-2.3350 (-0.89)	-11.446 (-4.03)***	2.2800 (1.00)	-3.2450 (-1.35)	-6.7411 (-2.50)**	-0.3690 (-0.16)
Model Wald Chi^2 (84)	343.10					
Log pseudo likelihood	-1119.0614					
Prob>Chi^2	0.0000					
Plot observation	343					

T-values are in parentheses. *** P<0.01, ** P<0.05, and * P<0.10. CCV= Change of crop variety, CPHD= Change of planting/harvesting dates/calendar, CD= Crop diversification, SWCM= Soil and water conservation measures, DOI= Diversification to off-farm income and CCP= Change of cultural practice/farm operations. Numbers of observations=120.

Table 6 Correlation coefficient of error terms obtained from the MVP estimation

Binary correlation	Correlation coefficient	Standard error	t-value
rho21	0.1244	0.0968	(1.28)
rho31	-0.2147	0.0962	(-2.23)**
rho41	-0.1468	0.1012	(-1.45)
rho51	-0.1143	0.0947	(-1.21)
rho61	-0.0929	0.0988	(-0.94)
rho32	0.2439	0.0869	(2.81)***
rho42	0.0668	0.0980	(0.68)
rho52	-0.0149	0.0876	(-0.17)
rho62	0.0587	0.0889	(0.66)
rho43	0.4071	0.0862	(4.72)***
rho53	0.2275	0.0847	(2.68)***
rho63	0.2251	0.0837	(2.69)***
rho54	0.1304	0.0882	(1.48)
rho64	0.3891	0.0850	(4.58)***
rho65	0.4678	0.0750	(6.24)***

Likelihood ratio testof overall error terms correlation: rho21 = rho31= rho41 = rho51= rho61 = rho32= rho42 = rho52 = rho62 = rho43 = rho53 = rho63= rho54 = rho64 = rho65 = 0: Chi square (15) = 90.2436, Prob. Chi square = 0.0000. The numbers in rho refers to: 1=Change of crop variety; 2=change in planting/harvesting date/calendar; 3=crop diversification; 4=soil and water conservation measures; 5=diversification into off-farm incomes and 6=change in cultural practices/farm operations.

years. Majority (84%) of the farmers were male. Major occupation was farming with (68%) of the farmers engaged in farming as main occupation. The households had a size of 9 with a standard deviation of 4. The average farm size of farmers was 3.6ha. Mean farming experience of farmers was 34 years. Farmers with more than ten years of farming experience were likely to understand the effect of climate change and might be willing to adopt adaptation measures against climate change. Most (91.7%) of the sampled farmers never attempted any form of education (Fig.1) in spite of the relevance it has to the ability to adapt to climate change (Manyatsi *et al.,* 2010). This study reveals that, mean annual income of farmers was N946, 050 (Fig. 2). A number of the respondents (28%) had annual income above one million naira and (1%) had annual income between N151, 000 and N200, 000. This is an indication that yam farming is profitable as earlier investigated in previous researches (Izokor and Olumese, 2010; Odinwa *et al.,* 2011; Ibetoye and Onomisi, 2013).

The perception of climate change by the respondents (Table 3) reveals that increased/high temperature, increased sunshine hours, low rainfall, soil erosion and soil infertility are the most important indicators of climate change. The finding agree with Brussel (2009) and Zubairu and Jibril (2014) who reported that higher temperatures, changes in precipitation patterns and the frequency of extreme events affect the volume, quality, quantity, stability of food production and the natural environment in which agricultural activities takes place and disagree with the findings of Gourdji *et al.* (2015), who reported that, change in rainy season (precipitation) and frequency of extreme events in Nicaragua had no significant changes in the past years.

The findings in Table 3 reveal radio, farmers' association/cooperatives and the Agricultural Development Project (ADP) were the most important sources of climate change information. It therefore seems that more official sources like NIMET were not accessible to the farmers. The finding agrees with Oluwasusi and Sangotegbe (2012), who reported that the most accessible sources of information on climate change to farmers' were radio and disagrees with Yohanna *et al.* (2014) who reported that, farmers' sources of information on climate change were mostly from fellow farmers, friends and relations.

The results in Table 4 show that, out of the twenty five (25) adaptation strategies most of the farmers were highly adaptive to nine (9) strategies, moderately adaptive to thirteen (13) strategies and lowly adaptive to three (3) of the adaptation strategies identified in the study area. This study further reveals that, the mean capacity of majority of the farmers falls within the range $0.5 \leq AdapCapij < 0.75$, indicating that farmers were moderately adaptive to climate change variation. The average adaptive capacity of farmers was 0.60, also indicating that, farmers were generally moderate adopters to climate change adaptation measures in the study area. This result agrees with the findings of Bradshaw *et al.*, (2004); Maddison (2006); Hassan and Nhemachea (2008), who reported that, common strategies adopted in agriculture to cope with climate change effect include the use of new crop varieties, mixed cropping, livestock farming, change of planting dates and diversification to off-farm activities. Oluwasusi, (2013) also reported that, adaptation strategies employed by yam farmers to mitigate the impact of climate change were planting of cover crops, mulching, planting of early maturing yam seed and movement to different site. Apata (2015) also reported that crop rotation, planting disease resistant variety and mixed cropping were strategies adopted by arable farmer.

The result of estimated Multivariate Probit (MVP) regression (Table 5) shows that the Log pseudo likelihood = -1119.0614, associated Wald Chi square value was= 343.10 and significant at 1% probability levels, this suggest a good-fit for the model. For CCV, age, major occupation, educational level and extension contact were positively significant ($P<0.01$), while gender, farm size and access to climate change information were negatively significant ($P<0.01$). Farming experience and farmers perception of climate change were negatively significant ($P<0.05$) and ($P<0.10$) respectively. This implies that, a unit increase in age, major occupation, educational level and extension contact will increase the probability of farmers choosing change in crop variety adaptation measure by (5.95%), (3.66%), (4.86%) and (2.87%) respectively, while a unit increase in farm size, access to climate change information, farming experience and farmers perception of climate change will decrease the probability of yam farmers choosing change in crop variety adaptation measure by (3.35%), (2.62%), (2.64%), (2.09%) and (1.91%) respectively. The result corroborate the findings of Phindile *et al.*, (2014), who reported that, occupation and perceptions of the household head towards climate change significantly influence their choice of adaptation to climate change using conservation agriculture and drought tolerant varieties. Gebre *et al.*, (2015), also opined that, levels of education, age and extension services of household head positively influence climate change adaptation strategies. Sipho, *et al.*, (2015) in his findings, reported that, perceived climate change variation observed by farmers forms the basis for their response or adaptation to climate change.

For CPHD; the results shows that, age, farm income and amount of credit access were positively significant ($P<0.01$). However, household size and membership of cooperatives/association was negatively significant ($P<0.05$), while farming experience and method of land ownership were negatively significant ($P<0.10$). This implies that, a unit increase in age, farm income and amount of credit access will increase the probability of farmers choosing change of planting/harvesting date/calendar adaptation measures by (3.61%), (3.86%) and (4.28%) respectively. While a unit increase in household size, membership of cooperatives/association, farming experience and method of land ownership will decrease the probability of yam farmers choosing change of planting/harvesting dates/calendar adaptation measures by (2.17%), (2.41%), (1.83%) and (1.65%) respectively. This result corroborate the findings of Obayelu *et al.*, (2014), who opined that, access to credit is an important variable which has positive effect on adaptation behaviour. Mulatu (2013) also opined that, increase in farm income of household increases the likelihood of adapting to climate change. Deressa *et* *al.*, (2009); Tesso *et al.*, (2012), reported that, increase in credit access significantly influenced farmers' choice of climate change adaptation strategies.

For CD; the coefficient of farm size was positively significant (P<0.01), while access to climate change information was positively significant (P<0.10). However, household size was negatively significant (P<0.05), while membership of cooperatives/association was negatively significant (P<0.10). This implies that, a unit increase in farm size and access to climate change information will increase the probability of farmers choosing crop diversification adaptation measures by (3.24%) and (1.92%)respectively, while a unit increase in household size and membership of cooperatives/association will decrease the probability of farmers choosing crop diversification adaptation measures by (1.99%) and (1.93%) respectively. This suggests that, farmers with more access to information on climate change, increased farm size and belongs to membership of association adopted crop diversification adaptation measures to cope with climate change. This result conform with the findings of Maddison, (2006); Nhemachena and Hassan, (2007), who reported that access to information through extension services increased the likelihood of farmers adapting to climate change. Adesoji and Ayinde (2013) also reported that access to information and farm size are the main determinants of the choice of adaptation strategies implemented by farmers. Apata (2015) reported that crop rotation, intercropping and mixed-cropping were adaptation strategies adopted by arable crop farmers.

For SWCM; farm size, farming experience, extension contact and access to climate change information were positively significant (P<0.01), while educational level was positively significant (P<0.10). Household size and major occupation were negatively significant (P<0.01), while membership of cooperatives/association and amount of credit access were negatively significant (P<0.05). This implies that, a unit increase in farm size, farming experience, extension contact, access to climate change information and educational level will increase the probability of farmers choosing soil and water conservation measures by (3.51%), (5.08%), (2.69%), (2.98%) and (1.72%) respectively, while a unit increase in household size, major occupation membership of cooperative/association and amount of credit accessed will decrease the probability of farmers choosing soil and water conservation measures to cope with climate change by (3.35%), (3.45%), (2.52%) and (2.19%) respectively. The result corroborates with findings of Legesse *et al.*, (2013) opined that increase in extension contact increases the probability of household to adopt soil and water conservation strategy. Tessema *et al.*, (2013) also reported that, credit access negatively influence the probability of farmers using planting of trees as adaptation strategy to climate change. In contrast Phindile *et al.*, (2014) reported that, farming as main occupation of household head increase farmers' probability of adapting to climate change.

For DOI; farm income was positively significant (p<0.01), while extension contact and farmers' perception of climate change were positively significant (p<0.10). Farm size and educational status were negatively significant (P<0.05), while gender and farming experience were negatively significant (P<0.10). This implies that, a unit increase in farm income, extension contact and farmers' perception of climate change will increase the probability of farmers choosing diversification to off-farm income by (2.71%), (1.83%), and (1.87%) respectively, While a unit increase in gender, farm size and educational level, farming experience will decrease the probability of farmers' adapting diversification to off-farm income by (1.91%), (2.33%), (2.18%) and (1.75%) respectively. This result corroborate the findings of Mohammed *et al.*, (2014) who reported that positive and significant relationship exist between faming income and adaptation strategies to climate change. Mulatu (2013) also reported that, increase in farm income of household increases the likelihood of adapting to climate change.

For CCP; the coefficient of age and farming experience were positively significant ($P<0.01$), while household size and extension contact were negatively significant ($P>0.01$). This implies that a unit increase in age and farming experience will increase the probability of farmers' choosing change in cultural practice/farm operation adaptation measures by (3.88%) and (2.68%) respectively, while a unit increase in household size and extension contact will decrease the probability of farmers choosing change in cultural practice/farm operation adaptation measures by (3.47%) and (2.84%) respectively. This is in view of the fact that, older farmers are able to access available technology and gain more knowledge which could strongly influence their choice of adaptation to change in cultural practice/farm operation. This result conform to the findings of Gebre *et al.,* (2015), who reported that gender of household head negatively influence the adoption of climate change adaptation strategies.

The Multivariate Probit (MVP) results shows that the likelihood ratio test for overall error terms correlation (Table 6) rejected the null hypothesis that there is no significant relationship between socio-economic characteristics and climate change adaptation strategies (Chi square (21) = 90.2436, Prob > Chi square = 0.0000). This indicates the correlated binary responses between different adaptation options and supports the choice of the MVP model for this data. The result shows the interdependence of different adaptation options such that the probability of adopting one adaptation measure is conditioned by whether another measure in the subset has been adopted or not. This is supported by the significance of some of the pairwise correlation coefficients between error terms of the adaptation measures showed in Table 4.9. A positive correlation implies a complementary relationship, while a negative correlation implies a substitute relationship. In addition, crop diversification and change of crop variety adaptation measures were close substitute for farmers to cope with climate change in the study area while the complimentary relationship exists between crop diversification and change of planting/harvesting date; soil and water conservation measures; and, crop diversification and change in cultural practice/farm operations and soil and water conservation measures on the other.

CONCLUSION

This paper attempts to investigate the determinants of climate change adaptation strategies in in Niger State, Nigeria. To achieve its objectives, this study randomly selected 120 yam farmers across three Local Government area of Niger State. The data generated through the use of structured questionnaire were analyzed using descriptive statistics and multivariate probit regression model. The results indicated that choices of adaptation strategies were determined by a variety of socio-economic and other variables. Particularly, it was found that age, gender, household size, major occupation, farm size, educational level, farming experience, method of land ownership, farm income, membership of cooperatives/association, extension contact, access to climate change information, amount of credit access and farmers perception of climate change are the most important variables that could influence policies towards ensuring that yam farmers are able to manage climate change information effectively as well as reducing the risks associated with climate change, thus maintain and enhanced income base from yam production. It is recommended that continuous education and effective advisory services aimed at empowering the farmers and enhancing their capacity to choose appropriate climate change adaptation measures be instituted. Also, deliberate effort aimed at organizing training for farmers on early warnings signs and interpretations of meteorological data to promote the use of adaptation options and indigenous knowledge systems to reduce the negative impact of climate change, and evolution of appropriate risk reduction production strategies in response to perceived climate change to improve their well-being should be intensified.

REFERENCES

Adejuwon, S. A. (2004). Impacts of climate variability and climate change on crop yield in Nigeria. Lead Paper presented at the stakeholders workshop on assessment of impacts and adaptation to climate change, conference centre, Obafemi Awolowo University, Ile Ife. 20th-21st September.

Adesoji, S. A. & Ayinde, J. O. (2013). Ethno-Practices and adaptation strategies for the mitigation of climate change by arable crop farmers in Osun State:

Adger, W. N. & Kelly, P. M. (1999). Social vulnerability to climate change and the architecture of entitlements. *Mitigation and Adaptation Strategies for Global Change,* 4(99), 253-266.

Adger, W. N., Arnell N. W. & Tompkins, E. L. (2005). Successful adaptation to climate change across scales. *Global Environment Change,* 15, 77-86.

Ajao, A. O. & Ogunniyi, L. T. (2011). Farmers' strategies for adapting to climate change in Ogbomoso agricultural zone of Oyo State. *Agris On-line Papers in Economics and Informatics,* 3(3), 3-13.

Alexandrov, V., Eitzinger, J., Cajic, V. & Oberforster, M. (2002). Potential impact of climate change on selected agricultural crops in Northeastern Austria. *Global Change Biology,* 8(4), 372-389.

Alvaro, C., Tingju, Z., Katrin, R., Richard, S. J. & Claudia, R. (2009). Economy-wide impact of climate change on agriculture in sub-Saharan Africa International Food Policy Research Institute (IFPRI). *Discussion Paper,* 008731.

Apata, T. G., Samuel, K. D. & Adeola, A.O. (2009). Analysis of climate change perception and adaption among arable food crop farmers in South Western Nigeria, paper presented at the conference of International Association of Agricultural Economics. Pp. 2-9.

Apata, T. G. Ogunyinka, A. I. Sanusi, R. A. & Ogunwande, S. (2010). Effects of Global Climate Change on Nigerian Agriculture: An Empirical Analysis. Paper presented at the 84th Annual Conference of the Agricultural Economics Society, Edinburgh 29th - 31st March, 2010.

Apata, O. M. (2015). Adaptation strategies to effects of climate change on arable crops production in South western Nigeria. *Bristish Journal of Applied Science and Technology,* 12 (5), 1-7.

Babaleye, T. (2003). Improving yam production technology in West Africa. Supplement issues/edition. Pp. 463.

Belderbos, R., Carree, M., Diederen, B., Lokshin, B. & Veugelers, R. (2004). Heterogeneityin R & D cooperation strategies. *International Journal of Industrial Organization* 22, 1237–1263.

Bradshaw, B., Dolan, H. & Smith, B. (2004). Farm level adaptation to climatic variability & change crop diversification in the Canadian prairies. *Climate change,* 67, 119 - 141.

Bryan, E., T., Deressa, T., Gbetibouo, G. A. & Ringler, C. (2009). Adaptation to climate change in Ethiopia and South Africa: Options and Constraints. *Environmental Science and Policy,* 12, 413 426.

Bryant, C. R., Smit, B., Brklacich, M., Johnston, T. R., Smithers, J. Chjotti, Q. & Singh, B. (2000). Adaptation in Canadian agriculture to climatic variability and change. *Climatic Change,* 45(1), 181-201.

Building Nigeria's Response to Climate Change (BNRCC), (2008). The recent global and local action on climate change paper presented at annual workshop of Nigerian Environmental Study Team (NEST) held at Hotel Millennium, Abuja, Nigeria. 2008:2-4.

Deressa, T., Hassen, R., Alemu, T., Yesuf, M. & Ringler, C. (2008). Analyzing the determinants of Farmers choice of adaptation measures and perceptions of climate change in the Nile Basin of Ethiopia. *International Food Policy Research Institute (IFPRI)* Discussion Paper No. 00798. Washington, D.C: IFPRI.

Deressa, T. T., Hassan, R. M., Ringler, C., Alemu, T. & Yesuf, M. (2009). Determinants of farmer's choice of adaptation methods to climate change in the Nile Basin of Ethiopia. *Global Environmental Change,* 19, 248-255.

Di-falco, S., Yusuf, M., Kohlin, G. & Ringler, C. (2011). Estimating the impact of climate change on agriculture in low income countries: House hold level: Evidence from the Nile Basin, Ethopia. *Environmental Resource Economics.* doi.10.1007/S10640-011-9538-y.

Dinar, A., Hassan, R., Kurukulasuriya., P., Benhin, J. & Mendelsohn, R. (2006). The policy next between agriculture and climate change in Africa. A synthesis of the investigation under the GEF/WB Project: Regional climate, water and agriculture: Impacts on and adaptation of agro ecological systems in Africa. CEEPA Discussion Paper No. 39. Centre for Environmental Economics and Policy in Africa, University of Pretoria.

Dorfamn, D. J. (1996). Modeling multiple adoption decisions in a joint framework. American Journal of Agricultural Economics 78 (3), 547–557.

Doss, C. & Morris, M. (2001). How does gender affect the adoption of agricultural innovations? The case study of improved maize technology in Ghana. *Journal* of *Agricultural Economics,* 25, 27-39.

Easterling, W. E. (1996). Adapting North American agriculture to climate change in review. *Agricultural and Forest Meteorology,* 80(1), 1-53.

Easton, P. B. (2004). Education and indigenous knowledge: In indigenous knowledge. Local pathways to global development. Marking five years of the World Bank Indigenous Knowledge for Development Programme (eds). Woytek, R., Shroff-Mehta, P., and Mohan, P. C. Knowledge and Learning Group Africa Region: The World Bank. Retrieved from *http://worldbank.org/afr/ik/default.htm.*

Ennin, S. A., Otoo, E. & Telleh, F. M. (2009). Ridging a mechanized alternative to mounding for yam and cassava production. *West African Journal of Applied Ecology*, 15, 2-3.

Federal Ministry of Environment (FME). (2011). Federal Ministry of Environment, Abuja. Retrieved from: *www.nigeria.com.ngcichng.org./ccinfo.php.*

Foresight, (2011). The future of food and farming. *Final project report.* The government office for science. London.

Fraser, E. (2008). Crop yield and Climate change *International Institute of Tropical Agriculture.* Annual report 2001. Pp. 24-30. Retrieved: *http//www.fao/org/waicent/fao/agricult/wrpurNigeribright.htm.*

Füssel, H. M. & Klein, R. J. T. (2006). Climate change vulnerability assessments: An evolution of conceptual thinking. *Climate Change,* 75, 301-329.

Gebre, H., Kindie, T., Girma, M. & Belay, K. (2015). Farmer's climate change adaptation options and their determinants in Tigray Region, Northern Ethiopia. African Journal of Agricultural Research, 10(9), 956-964. doi.10.5897AJR2014.9146.

Gourdji, S., Läderach, P., Martinez, A., Zelaya, C. and Lobell, D. (2015), Historical climate trends, deforestation, and maize and bean yields in Nicaragua, *Agricultural and Forest Meteorology*, 200, 270-281.

Halugalle , N. R., Lal, R. & Gichuru, M. (1990). Effects of five years of no tillage and mulch on soil properties and cassava tuber yield on an acid ultisol in South-eastern Nigeria. *Experimental Agriculture*, 21, 235-240.

Heltberg, R., Siegel, P. B. & Jorgensen, S. L. (2009). Addressing human vulnerability to climate change: Toward a 'no-regrets' approach. Global Environmental Change, 19 (1), 88-99.

Ibitoye, S. J. & Onimisi, J.A. (2013). Economic assessment of yam production in Kabba-Bunu local government area of Kogi State, Nigeria. *Journal of Development and Agricultural Economics,* 5(11), 470-475.

Ike, P. C. & Ezeafulukwe, L.C. (2015). Analysis of coping strategies adopted against climate change by small-scale farmers in Delta State, Nigeria. *Journal of Natural Science Research,* 5(4), 15-22. ISSN: 2224-3186.

Intergovernmental Panel on Climate Change (IPCC). (2007). *Climate change*. Impacts, adaptation and vulnerability Report of working group II to the fourth assessment report of the IPCC. Cambridge University Press, Cambridge, United Kingdom and New York.

Intergovernmental Panel on Climate Change (IPCC), (2012). Managing the risks of extreme events and disasters to advance climate change adaptation (SREX). Special Report of the Intergovernmental Panel on Climate Change. Geneva, IPCC Secretariat.

Intergovernmental Panel on Climate Change (IPCC), (2013). Climate Change: the physical science basis. Contribution of Working Group I (WGI) to the fifth Assessment Report of the Intergovernmental Panel on Change, Stocker, T. T., D. Qin, G.K., Plattner, M. Tignor, S. K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex & P. M. Midgley (eds.). Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, Pp.1535. doi.10.1017/CB09781107415324.

International Fund for Agricultural Development (IFAD), (2011). Proceedings, IFAD Conference on New Directions for Smallholder Agriculture, 24-25 January, 2011.IFAD, WFP, and FAO, 2012: The State of Food Insecurity in the World 2012. Economic growth is necessary but not sufficient to accelerate reduction of hunger and malnutrition. Food and Agriculture Organization of the United Nations (FAO), Rome, Italy, pp. 61.

International Institute of Tropical Agriculture (IITA). (2013). Healthy yam seed production. IITA Publications. *http.//www.iita.org.* Accessed: November 2, 2016.

Inyang, E. U. (2005). An evaluation of tillage and storage systems applied by traditional root crop farmers Cameroon. *Agriculture and Environmental Journal,* 7(2), 15-22.

Izekor, O. B. & Olumese, M. I. (2010). Determinants of yam production and profitability in Edo State, Nigeria. *African Journal of General Agriculture,* 6(4), 30-35.

Kabubo-Mariara, J. (2008). Global warming and livestock husbandry in Kenya: Impacts and adaptations. *Ecological Economics,* 68, 1915-1924.

Kapadonou, R. A. B. Adegbola, P. Y. & Tovignan, S. D. (2012). Local knowledge and adaptation to climate change in Oueme Valley Benin. *African Crop Science Journal,* 20(2), 181-192.

Kassie, M., Jaleta, M., Shiferaw, B., Mmbando, F. & Mekuria, M. (2013). Adoption of interrelated sustainable agricultural practices in smallholder systems: evidence from rural Tanzania. *Technological Forecast and Social Changes,* 80 (3), 525–540.

Khanna, M. (2001). Sequential adoption of site-specific technologies and its implications for nitrogen productivity: a double selectivity model. *American Journal of Agricultural Economic,* 83, 35–51.

King, D. (2004). Climate change science: Adaptation, mitigate or ignore? *Science,* 303, 176-177.

Kurukulasuriya, P. & Mendelsohn, R. (2006). A Ricardian analysis of the impact of climate change on African cropland. CEEPA Discussion Paper No. 8 Centre for Environmental Economics and Policy in Africa, University of Pretoria.

Legesse, B., Ayele, Y. & Bewket, W. (2013). Smallhold farmers' perceptions and adaptation to climate variability and climate change in Doba district, west Hararghe, Ethiopia. *Asian Journal Empirical Research, 3(3), 251-265.*

Lobell, D. B., Burke, M. B., Tebaldi, C., Mastrandrea, M. D., Falcon, W.P. & Naylor, R.L. (2008). Prioritizing climate change adaptation needs for food security in 2030. *Science,* 319 (5863), 607–10.

Locatelli, B. (2011). Climate change and forests in the Congo Basin: Synergies between adaptation and mitigation. COBAM Project Brochure.

Maddison, D. (2006). The perception of an adaptation to climate change in Africa (EEPA): Discussion paper No. 10. Centre for Environmental Economics and Policy in Africa. University of Pretoria, South Africa. Pp. 9.

Manyatsi, A. M., Mhazo, N. & Masarirambi, M. T. (2010). Climate Variability and Change as Perceived by Rural Communities in Swaziland. *Research Journal of Environmental and Earth Sciences, 2*(3), 165-170.

McMichael, A. J. (2003). Global climate change and health: An old story Writ large. World Health Organization Geneva. Retrieved 15 July 2016.

McMichael, A. J., Woodruff, R. & Hales, S. (2006). Climate change and human health: Present and future risks. Lancet 367 (9513): 859–69. Doi: 10.1016/S0140-6736(06)680793.PMID 16530580.

Mideksa, T. K. (2009). Economic and distributional impacts of climate change: The Case of Ethiopia. *Global Environmental Change,* 20, 278-286.

Mulatu, N. D. (2013). Determinants of farmers' preference for adaptation strategies to climate change: evidence from north shoa zone of Amhara region Ethiopia. MPRA (Munich personal RePEc Archive) Paper No. 48753 posted 1. August 2013 11:07 UTC available at http://mpra.ub.uni-muenchen.de/48753/, accessed on 3rd July, 2017.

National Bureau of Statistics (NBS), (2012). Living Standards Measurement Study: Integrated surveys on agriculture and general household survey panel 2010/2011. *https://agriknowledge.org.*

Nhemachena, C. & Hassan, R. (2007). Micro-level analysis of farmers' adaptation to climate change in Southern Africa, *IFPRI Discussion Paper*, No. 00714. International Food Policy Research institute, Washington, D.C. Pp. 62.

Niger State Bureau of Statistics (NSBS), (2012). Niger State agricultural statistics: Fact and figures about Niger State. Retrieved from: *www.nigerstats.ni.gov.ng.*

Nwaiwu, I. U. O., Ohajianya, D. O., Orebiyi, J. S., Ibekwe, U. C., Lemchi, J. I., Onyeagocha, S. U. O., Odoemena, B., Utazi, C. O., Osuagwu, C. O. & Tasie, C. M. (2014). Climate Change Trend and Appropriate Mitigation and Adaptation Strategies in Southeast Nigeria. *Global Journal of Biology, Agriculture and Health Sciences,* 3(1), 120 – 125.

Obayelu, A. O., Adepoju, O. A. & Idowu, T. (2014). Factors influencing farmers choice of adaptation to climate change in Ekiti State, Nigeria. *Journal of Agriculture and Environmental Development (JAEID),* 108(1), 3-16. Doi: 10.12895/jaeid.20141.140.

Odinwa, A. B., Ali, N., Abali, I., Ahiskwo, A. A. & Odinwa, A. N. (2011). Economic viability of yam mini-sett production and the problems affecting mini-sett enterprise in Northern River State, Nigeria. *Mediterranean Journal of Social Science,* 2(4), 67-62.

Okoh, C. A. (2004). The effect of mulching on soil physico-chemical properties and the yield of White Yam. *Tropical Journal Root Tuber Crops,* 4(2), 24-31.

Oluwasusi, J. O. & Sangotegbe, N. S. (2012). Awareness and perception of climate variation among yam farmers' in Ekiti State, Nigeria, *Research Gate* (www.researchgate.net/publication/280114827) accessed 7th August, 2017

Oluwasusi, A. J. (2013). Farmers' adaptation strategies to the effect of climate variation on yam production in Ekiti State, Nigeria. *Journal of Food, Agriculture and Environment,* 11(2), 724-728.

Orebiyi, J. S., Tasie, C. M., Onyemauwa C. S., & Emeya, S. (2014). Mitigating climate change effects on agriculture in Nigeria. Proceedings of the 2014 Annual Conference of the Nigerian Association of Agricultural Econimists (NAAE), held at the CCE Hilltop Auditorium, Federal University of Technology, Akure, Nigeria, 24th - 27th February. Pp. 328 – 337.

Phindile, S., Micah, B. M. & Absalom, M. M. (2014). Factors influencing the choice of climate change adaptation strategies in households: A case of Mpolongeni Area Development Programme (ADP) in Swaziland.

Sahney, S., Benton, M. J. & Falcon-Lang, H. J. (2010). Rainforest collapse triggered Pennsylvanian tetrapod diversification in Euramerica. *Geology,* 38(12), 1079–1082. Bibcode: 2010Geo.38.1079S. doi :10.1130/G31182.1.

Sipho, F. M., Abulsalam, G. P. (2015). Farmers perception of climate change a case study in Swaziland. Journal of Food Security, 3(2), 47-61. Doi.10.12691/Jfs-3-2-3.

Spore, (2008). *Climate Change*, Spore Special Issue-August, 2008 redo referencing.

Tessema, Y. A., Aweke, C. S. & Endris, G. S. (2013). Understanding the process of adaptation to climate change by small-holder farmers: the case of east Hararghe zone, Ethiopia. *Agricultural Food Economics*. 1:13.

Tesso, G., Emana, B. & Ketema, M. (2012). Econometric analysis of local level perception, adaptation and coping strategies to climate change induced shocks in North Shewa, Ethiopia. *International Research Journal of Agricultural Science and Soil Science,* 2(8), 347-363.

Teklewold, H., Kassie, M. & Shiferaw, B. (2013a). Adoption of multiple sustainable agricultural practices in rural Ethiopia. *Journal of Agricultural Economics,* 64 (3), 597–623.

Wilcock, R., Elliott, S., Hudson, N., Parkyn, S. & Quinn, J. (2008). Climate change mitigation for Agriculture: water quality benefits and costs. *Water Science & Technology,* 58(11), 2093-2099.

Wolfe, D. W., Schwartz, M. D., Lakso, A. N., Otsuki, Y., Pool, R. M. & Shaulis, N. J. (2005). Climate change and shifts in spring phenology of three horticultural woody perennials in Northeastern United State of America, Meteorological Organization, Geneva. *International Journal of Biometeorology,* 49, 303-309.

World Bank, (2003). *World Development Report 20004:* making service work for poor people. Washington, D.C: Oxford University Press, New York.

Yohanna, I. Ndagbu, A. A & Barnaba, B. P. (2014). Sources of information on climate change among arable crop farmers in Adamawa State, Nigeria, Journal of Agriculture and Veterinary Science, 7(8), 32-36.

Yu, L., Hurley, T., Kliebenstein, J. & Orazem, P. (2012). A test for complementarities among multiple technologies that avoids the curse of dimensionality. *Economics Letter,* 116, 354–357.

Zubairu, S. U. & Jibril, H. M. (2014). Yam (*Dioscorea spp)* farmers' adaptation to climate change in some selected Local government areas in Niger State, Nigeria. *Journal of Applied Biological Research,* 6(2), 46-55.