CLIMATE CHANGE PERCEPTION AND ADAPTATION IN NIGERIA'S GUINEA SAVANNA: EMPIRICAL EVIDENCE FROM FARMERS IN NASARAWA STATE, NIGERIA

TARFA, P. Y.[1] – AYUBA, H. K.[2] – ONYENEKE, R. U.[3*] – IDRIS, N.[2] – NWAJIUBA, C. A.[4] – IGBERI, C. O.[3]

[1]*Department of Climate Change, Federal Ministry of Environment, Abuja, Nigeria*

[2]*Department of Geography, Nasarawa State University, Keffi, Nigeria*

[3]*Department of Agriculture (Agricultural Economics and Extension Programme) Alex Ekwueme Federal University Ndufu-Alike, Ebonyi State, Nigeria*

[4]*Department of Educational Foundations Alex Ekwueme Federal University Ndufu-Alike, Ebonyi State, Nigeria*

[*]*Corresponding author*
e-mail: robertonyeneke@yahoo.com, robert.onyeneke@funai.edu.ng

(Received 23rd Feb 2019; accepted 10th Apr 2019)

Abstract. Nigeria's guinea savanna produces the bulk of the food consumed in the country and climate change is adversely affecting agriculture in the area. Farmers in the area respond differently to climate change based on their perception. Yet, studies that systematically link farmers' perception on climate change to scientific data from meteorological stations are rare in Nigeria's guinea savanna. Much rarer are studies that consider the simultaneity in the adaptation decisions of the farmers. This study therefore aimed at analysing farmers' perception in comparison with meteorological data and the determinants of adaptation efforts of crop farmers in the areas with data from Nasarawa State of Nigeria. To achieve this aim, the study combined time-series data on climatic variables obtained from a weather station and cross-sectional data from 160 smallholder farmers selected from the area. The study applied descriptive statistics, trend analysis, and multivariate probit model in analysing data collected. The study showed reduction in volume of rainfall and significant increase in surface temperature with the farmers having firm perception of these changes. The farmers responded to the changes in temperature and rainfall by choosing adaptation strategies such as use of improved crop varieties, soil and water conservation, tree planting, changing dates of sowing and tillage options, irrigation, diversifying their means of livelihood, and farmland management. Interestingly, these strategies were complementary and farmers' socioeconomic and institutional characteristics significantly determined adaptation in the area. Therefore, considering farmers' socioeconomic characteristics and improving the institutions will help in future and planned adaptation efforts of governments.
Keywords: *crop farmers, climate risk management, determinants, multivariate probit model*

Introduction

Climate change, which can be described at various scales – regional, national, or global – is a non-random change in the average weather conditions of a place overtime (Adejuwon, 2004; BNRCC, 2007; Nigerian Meteorological Agency, 2017). Empirical evidence confirms that the Earth has experienced a significant rise in temperature – between 0.65°C and 1.06°C – over the past 100 years (IPCC, 2013, 2014). The warming is real and significant but has varied across time and space with greenhouse gases, emanating from anthropogenic activities, being the major cause (Crosson, 1997; IPCC, 2014).

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1703_70857112

Climate change can retard/impede efforts being made by nations to achieve the sustainable development goals. The region that will suffer most of the impacts of climate change is Africa because it is the most vulnerable among other regions of the world and has the lowest capacity to adapt (Niang et al., 2014). Niang et al. (2014) documented dramatic and widespread evidence of global warming and other climate changes. Some of these impacts include threats to global food supply citing a decrease of up to 2 percent each decade in yields of staple crops like maize, wheat and rice; freshwater and marine species; ecosystem shift and species extinction; negative impact on agriculture; migration and security; heat waves, flood; shortage of water resources; destruction of homes and infrastructure; increased food insecurity; and violent conflict that lead to the destruction of infrastructure, livelihood opportunities and natural resources. Scientific evidence suggests that climate change may decline the output of major staple crops - wheat, maize, and rice (Niang et al., 2014; Olsson et al., 2014; Magrin et al., 2014; Hijioka et al., 2014; IPCC, 2015).

In Africa, the African Union adopted an African Climate Change Strategy in 2011, while, in the West African sub-region, ECOWAS has developed and adopted Climate Change Policy and Strategy Plan (2011). These policy documents provide priority actions in the region, which shape national climate change policies and strategies in member countries. The present research has been informed by the global, regional and national commitments and obligations.

In Nigeria's guinea savanna, the frequency and severity of heat waves, drought and intense rainfall is increasing and this is changing the vulnerability and exposure of economic sectors, livelihoods, people and assets. Agriculture is perhaps the most sensitive of all the sectors as most of the farmers depend on rain-fed agriculture. Reduced growing seasons and higher temperatures will affect agriculture (IPCC, 2007; Babatunde et al., 2011; Federal Ministry of Environment, 2014).

The guinea savanna area of Nigeria is known as the 'food basket' of Nigeria. Therefore, climate change will increase the challenge of food insecurity, compound or worsen the degree of seasonal hunger that pervades in many parts of Nigeria, especially Nasarawa State (Babatunde et al., 2011; DCC, 2013, 2014; Ethan, 2015). Dry-spell occurring any time during the growing season often exposes crops to moisture stress, hence farmers usually face problems of both too much and little moisture (Babatunde et al., 2011; Osabo et al., 2014). These have brought about changes in the way smallholder farmers make decision to adapt to their environment (Ajetomobi et al., 2010).

Lazkano et al. (2016) describe adaptation as any activity that reduces climate change-induced damages. The literature captures well some adaptation practices used by farmers in different parts of Nigeria. These include use of improved crop varieties, conservation practices, planting different crops, farmland management, agroforestry and irrigation (NEST and Woodley, 2011; BNRCC, 2011; Women Farmers Advancement Network, 2014; Onyeneke et al., 2017). Even though there are several studies on crop production and climate change (NEST, 2011; BNRCC, 2011; NEST and Woodley, 2011; Onyeneke et al., 2012; Falaki et al., 2013; Ezeaku et al., 2014; Ibrahim et al., 2014; Women Farmers Advancement Network, 2014; Odiana and Ibrahim, 2015; Tiamiyu et al., 2015; Tsojon, 2017), still little is known regarding the farmers' perceptions and adaptations in smallholder agricultural production systems in Nasarawa State in Nigeria's guinea savanna. In spite of the efforts of researchers in documenting climate risk management measures in agriculture in Nigeria, there is scanty empirical evidence on the determinants of the choice of adaptation strategies

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1703_70857112

used by crop farmers in Nigeria. Furthermore, farmers by nature adopt multiple strategies to manage climate risks and such decisions are made simultaneously. Much rarer are research works accounting for the possibility of simultaneously or sequentially adopting multiple climate change adaptation strategies by farmers in Nigeria in particular and sub-Saharan Africa at large. Previous studies on climate change adaptation of farmers in sub-Saharan Africa mainly treated adaptation strategies singly without considering the joint and simultaneous adaptation decisions of farmers. Our study filled this gap in research by analysing the determinants of sequential adoption of climate risk management of farmers. Understanding farmers' perception, adaptation strategies and the complementarity or substitutability of the chosen strategies and their determinants is important for the determination of the effectiveness of farmers' adaptation efforts. Such knowledge will enhance policies and programmes directed towards enhancing the resilience of the agricultural sector of Nasarawa State and Nigeria. This study therefore aims to assess climate change perception and adaptation practices of farmers in Nasarawa State, Nigeria. In specific terms, the study:

i) described crop farmers' socioeconomic characteristics in Nasarawa State;
ii) compared trend of climatic data from the meteorological station with farmers' perception on the changes observed;
iii) identified and classified farmers' chosen adaptation strategies to deal with climate change; and
iv) analysed the effect of farmers' characteristics on adaptation choices.

Materials and Methods

Study Area

Nasarawa State is located in north-central Nigeria (*Figure 1*). The State lies within the guinea savanna and has a tropical climate. Two major seasons characterise the State – the rainy and dry seasons. The vegetation of Nasarawa is characterised by tall grasses and scattered trees. The population of Nasarawa State is 1,863,275 persons (National Population Commission, 2006). The State has thirteen (13) Local Government Areas namely. The inhabitants of the State depend mainly on agriculture with the production of varieties of cash crops throughout the year.

Sampling Technique

In selecting respondents for this study, the researchers employed purposive and random sampling methods. Firstly, two Local Government Areas (LGAs), Lafia and Toto LGAs, from the thirteen (13) Local Government Areas of Nasarawa State (*Figure 1*), that have high concentration of smallholder farmers and visible impacts of climate change LGAs, were selected. Since Lafia and Toto LGAs have high concentration of smallholder farmers and are affected by climate change, the researchers focused on these LGAs and randomly selected four communities in each of the LGAs. Finally, the researchers selected twenty (20) farmers randomly without replacement in each selected community making the sample size of the study 160 farmers. The sampling frames were provided by the extension agents working in the selected communities. Subjective judgment of ten officials of the Ministries of Agriculture and Environment in the State revealed that about 12 percent of farmers in the LGAs have been adversely affected by climate change hazards. The researchers

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1703_70857112

used this proportion with a z-value of 1.96 for 95% confidence level and 5% error margin to compute the final sample size which gave about 161 farmers. The formula for calculating the final sample size is given in *Equation 1* as:

$$n = p(1 - p)\,(z/E)^2 \quad \text{(Eq.1)}$$

where:
n = Final sample size;
p = Proportion farmers adversely affected by climate change (12% or 0.12);
z = Z-value at 95% confidence level (1.96);
E = error margin (5% or 0.05).

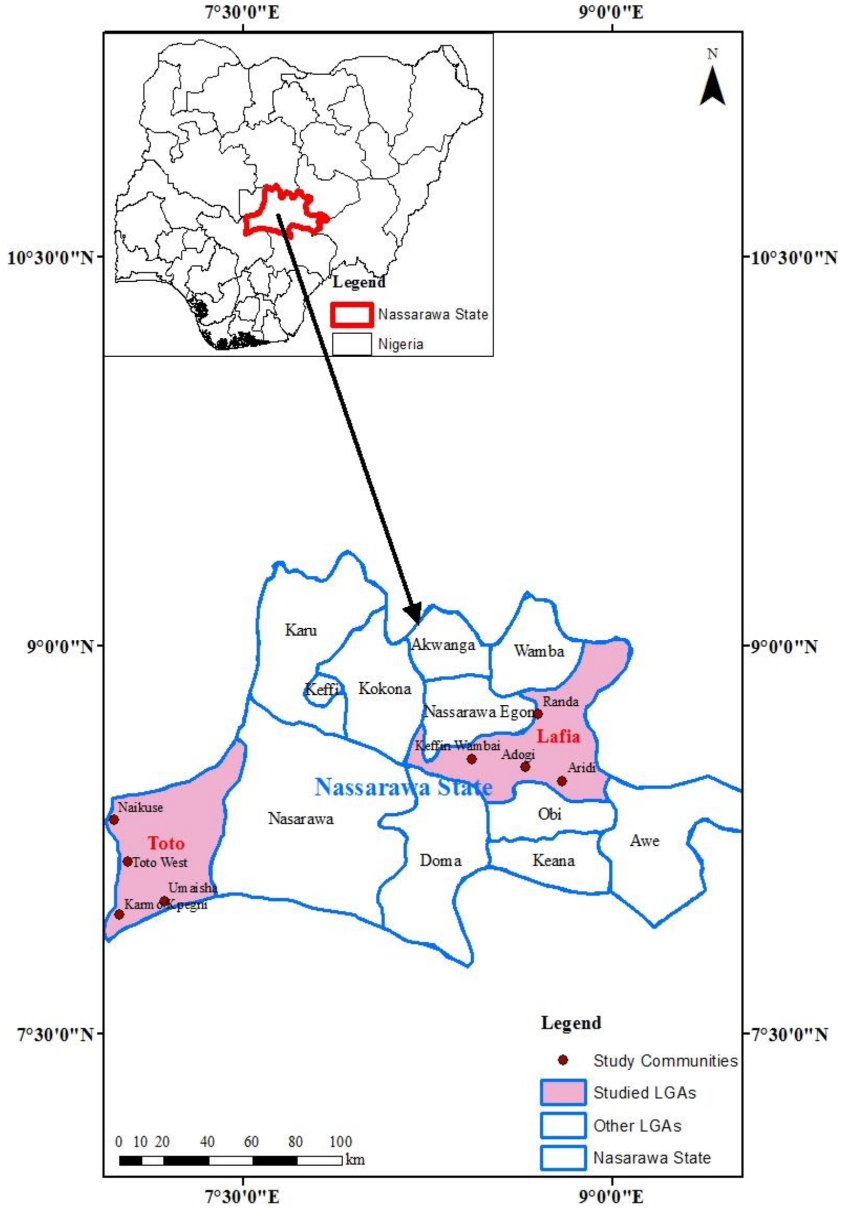

***Figure 1.** Nasarawa State showing the two selected Local Government Areas and Study Communities*

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1703_70857112

Types and Sources of Data

The study collected primary and secondary data. Interview schedule developed by the researchers was used to collect primary data from the farmers. The information contained in the interview schedule consisted of household characteristics of the farmers, institutional factors, perception, and adaptation measures. The researchers hired eight enumerators to assist in data collection in the eight communities. That is one enumerator per community. In order to ensure uniform and accurate data collection by all enumerators, one-day training was held for the enumerators. The researchers supervised the data collection as the study progressed. The survey was conducted between January and June 2014. The secondary data collected included climatic data such as annual temperature means, and annual aggregate rainfall. The climatic data were annual time-series data obtained in 2014 from the Nigerian Meteorological Agency for at least a period of thirty years. Due to data availability, the temperature data covered a period of thirty-three years (1981 – 2013) while rainfall covered a period of fifty-three years (1961 – 2013).

Method of Data Analysis

Descriptive statistics, trend analysis and multivariate probit analysis were statistical tools adopted for data analysis. Specific objectives i and iii were achieved with descriptive statistics. To compare farmers' perception on climate change and scientific data from meteorological station, a trend analysis was used to present the change observed in climate variables in the area and then link that to the anecdotal accounts from the farmers to check whether there is convergence or divergence. Many researchers have applied this method to model climate change trend and people's perception (Vedwan and Rhoades, 2001; Maddison, 2006; Gbetibouo, 2009). Multivariate probit regression was used to analyse the determinants of climate change adaptation decisions of farmers.

Multivariate Probit Model (MVP)

Multivariate probit technique was used to determine the interdependency of the adaptation practices and the socioeconomic factors influencing adaptation decisions. Lin et al. (2005) used similar model in their study. The adaptation practices are nominal variables and the researchers constructed a dichotomous dependent variable to capture whether such practice was adopted by a farmer or not. If a farmer used such practice, the researchers coded it as one and coded 0 for farmers who did not use such practice, and this makes the dependent variables binary taking only two values – 0 or 1 – (Gujarati, 1995; Greene, 2003). The study adopted the multivariate probit approach to model the factors influencing adaptation decisions of the farmers. An important advantage of the multivariate probit (MVP) framework is its strength in modeling the simultaneous or sequential decisions farmers make in climate risk management and this informed the choice of the MVP for this study. Farmers usually make complementary or substitutive decisions in choosing climate risk management strategies and the multivariate probit model makes interpretation of such simultaneous adaptation decisions possible and less difficult. The study has a set of eight binary dependent variables representing adaptation choices made by farmers, $Y_1, \ldots, Y_8$ such that:

$$Y_i = 1 \; if \; \beta i X' + \varepsilon i > 0 \qquad \text{(Eq.2)}$$

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1703_70857112

and

$$Y_i = 0 \; if \; \beta i X' + \varepsilon i \leq 0, \; i = 1,2, \ldots ,8 \qquad \text{(Eq.3)}$$

where
$i = 1,2, \ldots ,8$ are the chosen climate risk management practices/adaptation options; X represents the vector of the predictors; β_i is the parameter estimates of the predictors; and εi, random error vectors having a zero mean, unitary standard deviation, and an 8×8 correlation matrix. *Equations 2 and 3* represent the multivariate probit framework of this study.

Dependent variables of the MVP

The adaptation strategies identified in this study as dependent variables are planting improved varieties of crops, portfolio diversification, soil and water conservation practices, adjusting the time of planting, changing soil tillage options, tree planting, irrigation, and farmland management. These are defined as follows:

1. Use of improved crop varieties: The adaptation options in this category are use of short gestation crops, use of flood tolerant crop, planting drought-tolerant crops, cultivating disease/pest-resistant crop cultivars, and planting different varieties of crops. These strategies have been documented as climate-resilient practices in the agricultural sector in sub-Saharan Africa (Napier, 1991; Nhemachena and Hassan, 2007; Yegbemey et al., 2014; Wondimagegn and Lemma, 2016; Mulwa et al., 2017). Any farmer who adopted at least fifty percent of the options under this category was considered an adopter of improved crop varieties and was coded 1 while any farmer who adopted less than fifty percent of the options under this category was coded 0.

2. Portfolio diversification: Piya et al. (2012), Gbetibouo (2009) and Deressa et al. (2008) classified portfolio diversification as an important climate risk management measure. The adaptation options in this category include diversifying from agriculture to non-agricultural activities, crop farming to livestock farming and mixed farming. Any farmer who adopted at least fifty percent of the options under this category was considered an adopter of portfolio diversification and was coded 1 while any farmer who adopted less than fifty percent of the options under this category was coded 0.

3. Soil and water conservation practices: These are very important measures in managing climate change because they aid in maintaining soil fertility, increasing yield and improving resilience. The adaptation options here include terracing, mulching, planting of cover crops, crop rotation and water harvesting. Any farmer who adopted at least fifty percent of the options under this category was considered an adopter of soil and water conservation practices and was coded 1 while any farmer who adopted less than fifty percent of the options under this category was coded 0.

4. Adjusting planting dates: This is a straightforward farm-level climate change adaptation strategy in Nigeria. The options here cover adjusting planting dates and shortening the length of growing period. Any farmer who adopted at least fifty percent of the options under this category was considered an adopter of adjusting planting dates and was coded 1 while any farmer who adopted less than fifty percent of the options under this category was coded 0.

5. Changing tillage operations: Changing tillage operations is also very important in climate change adaptation management in Nigeria. This involves planting on mounds and/or ridges. Any farmer who adopted this option/category was considered an adopter

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1703_70857112

of changing tillage operations and was coded 1 while any farmer who adopted less than fifty percent of the options under this category was coded 0.

6. Planting trees: This covers tree planting on the farms for protection against scorching of crops. Any farmer who adopted this option/category was considered an adopter of planting trees on farms and was coded 1 while any farmer who did not adopt it was considered non-adopter and was coded 0.

7. Irrigation: This category includes irrigation and drainage. Any farmer who adopted at least fifty percent of the options under this category was considered an adopter of irrigation and was coded 1 while any farmer who adopted less than fifty percent of the options under this category was coded 0.

8. Farmland management: This involves adjustments in land use and land management. The main option here is changing land area cultivated. Any farmer who adopted this option/category was considered an adopter of farmland management and was coded 1 while any farmer who did not adopt it was considered non-adopter and was coded 0.

Independent variables of the MVP

The independent variables are:
X_1= Education of household head (years spent in school)
X_2= Age of household head (years)
X_3= Household size (number of persons)
X_4= Income (Naira)
X_5= Livestock ownership (number owned)
X_6= Extension contact
X_7= Farming experience (years)
X_8= Availability of credit (Naira)
X_9= Farm size (hectares)
X_{10}= Distance to markets (kilometres)
X_{11}= Distance to water sources (minutes)
X_{12}= Disposed to take crop farming risks (Dummy variable; yes = 1, no = 0)
X_{13}= Membership to farmer groups (Dummy variable; 1=member or 0 =not member)

Results and Discussion

Farmers' Characteristics

Table 1 presents the demographic characteristics of the farmers. Analysing the demographic properties of farmers is very important in understanding the type of farmers studied, which has implications on the adaptive capacity, choice and degree of climate resilient agricultural practices chosen and implemented. *Table 1* showed that the farmers' average age was 45.66 years which is an indication that they are mainly young adults. Younger farmers are more experimental and productive than older farmers and would be more disposed to adopt strategies that build their resilience than their older counterparts. This result is not far from the findings of other researchers in different parts of Nigeria. Onyegbula and Oladeji (2017) noted that the average age of rice farmers in three rice-producing States in Nigeria was 45.3 years while Ifeanyi-Obi et al. (2017) averred that the average age of cocoyam farmers in Southeast Nigeria was 51

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1703_70857112

years. Also, similar findings abound in other parts of Africa. For example, Mulwa et al. (2017), in their study on farmers' response to climate risks in Malawi, found that the average of the farmers was 50 years, Feleke et al. (2016) recorded an average age of 43.4 years among Ethiopian farmers while Nhemachena et al. (2014) found the average age of Southern African farmers to be 47.41 years.

Table 1. *Socio-economic characteristics of the farmers (n = 160)*

Variable	Frequency	Percentage	Average
Age (Years)			
Less than 40	50	31.25	45.66 years
41-50	70	43.75	
51-60	22	13.75	
Above 61	18	11.25	
Total	**160**	**100.00**	
Sex			
Female	3	1.88	
Male	157	98.12	
Total	**160**	**100.00**	
Marital Status			
Married	150	93.75	
Single	6	3.75	
Widowed	3	1.88	
Divorced	1	0.62	
Total	**160**	**100.00**	
Educational level (Years)			
No Formal Education (0)	23	14.38	10.1 years
Primary Education (1-6)	34	21.25	
Secondary Education (7-12)	48	30.00	
Tertiary Education (12-18)	53	33.12	
Total	**160**	**100.00**	
Farm size (Ha)			
0.1-1.9	94	58.75	4.31Ha
1.91-2.9	44	27.50	
2.91-5	22	13.75	
Total	**160**	**100.00**	
Household size (Number of Persons)			
1-5	34	21.25	10 persons
6-10	70	43.75	
11-15	56	35.00	
Total	**160**	**100.00**	

Majority (98.12%) of the farmers were males. Thus, male-headed households are predominantly involved in agriculture in the area than the female-headed households. This may be connected to ownership of agricultural production resources in the area as men have more access to the resources than females, and hence will adapt more readily to climate change than females. Mulwa et al. (2017), Wondimagegn and Lemma (2016), Asfaw and Admassie (2004), Tenge et al. (2004) documented male dominance in agriculture across sub-Saharan Africa. The majority of the farmers (93.75%) were married with both partners alive which is similar to the percentage (92.00%) recorded by Ifeanyi-Obi et al. (2017) among farmers in Southeast Nigeria. In many rural

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1703_70857112

agricultural communities, husbands, wives and children work in the farm which usually compensates farm labour needs of the household and increases agricultural production.

The level of education of farmers showed that majority of the farmers (85%) received a formal education suggesting that the farmers are literates. Similar level of literacy was recorded by Okpe and Aye (2015) among farmers in Makurdi, Benue State of Nigeria. With this level of education, farmers in the area would be readily disposed to adopting strategies that will help them manage climate change. The result of household size indicates that the farmers have large families with an average of 10 persons per family. The farmers were smallholders because they operated an average farm size of 4.31 ha. This may support or discourage adaptation depending on the farm management options and decisions pursued by the farm household.

Comparison between Farmers' Perception of Climate Change and Meteorological Station's Recorded Data

The study also analysed trend of climate data recorded for a long period. The trends in recorded climate data were then linked to farmers' perception of the changes. Climatic variables (temperature and rainfall) were explained to smallholder farmers using their knowledge of local weather conditions and the researchers sought their perception on changes in the climatic variables for at least for the past twenty years.

Temperature

Perception on changes in temperature is classified into three categories- "decreased", "unchanged" and "increased" (*Table 2*). The result indicates that most farmers (76.25%) perceived that long-term temperature is increasing.

Table 2. *Farmers perception on change in temperature (n = 160)*

Perception	Frequency	Percentage
Decreased	23	14.38
Unchanged	15	9.38
Increased	122	76.25
Total	**160**	**100.0**

Temperature data from the weather station showed an increasing and statistically significant trend and correlation with time (*Figure 2*). Time is therefore, a major determinant of temperature changes observed in Nasarawa State. This confirms that global warming is real and significant in Nasarawa State. Babatunde et al. (2011) and Anuforom (2010) reported significant and steady increase in the temperature of the savanna region of Nigeria where Nasarawa is located. Scientists in different parts of Africa and Asia have documented similar evidence. For example, Fosu-Mensah et al. (2010), Akponikpe et al. (2010), Nwajiuba and Onyeneke (2010), Acquah-de Graft and Onumah (2011), Enete and Onyekuru (2011), Acquah-de Graft (2011), Fosu-Mensah et al. (2012), Falaki et al. (2013), Umeh and Chukwu (2015), Biola et al. (2015), Olujobi (2015), Nkwusi et al. (2015), Ndamani and Watanabe (2016), and Ehiakpor et al. (2016) documented evidence of increasing temperature across different countries in West Africa. Maddison (2006), Kurukulasuriya and Mendelson (2006), Nyanga et al. (2011), Mandleni and Anim (2011), Gandure et al. (2013), Hitayezu et al. (2017) recorded steady increase in surface and atmospheric temperature across Southern Africa while in

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1703_70857112

East Africa, Gbegbelegbe et al. (2018), Mkonda and He (2017), Mutunga et al. (2017), Kebede and Gizachew (2017), Mwalusepo et al. (2015) found that most agroecological zones in East Africa are experiencing rising temperature. Shrestha (2014) recorded changing temperature in Nepal.

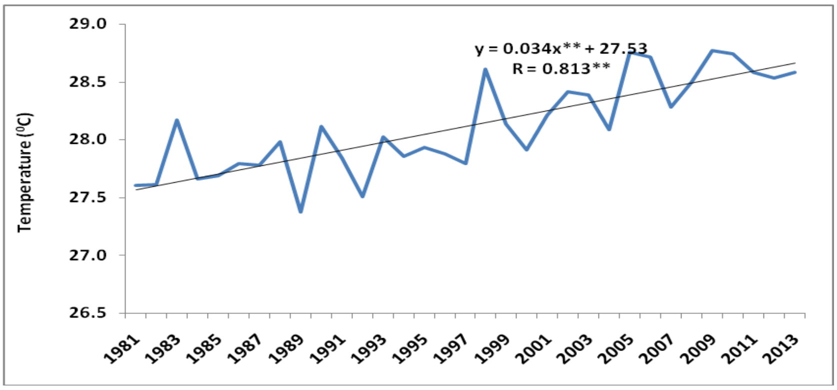

Figure 2. *Trend of average temperature in Nasarawa State from 1981 to 2013. Nb: ** Significant at 1% level of probability*

There is convergence in temperature data from the meteorological station and anecdotal accounts from the local crop farmers. Consequently, farmers' perception of climate change through observation of temperature increase could affect the climate change adaptation decisions they make. This corroborates the findings of Rakgase and Norris (2015), Ugwoke et al. (2012), Onumadu and Okore (2012), Nwosu et al. (2014) in Nigeria; Boansia et al. (2017) in Ghana and Burkina Faso; Ogalleh et al. (2012), Mwalusepo et al. (2015), Mutunga et al. (2017) in Kenya; and Jiri et al. (2015) in Zimbabwe. These scientists showed that farmers perceived increasing temperature in their respective study areas.

Aggregate Rainfall Volume

Most of the farmers (77.50%) averred that rainfall in the area is reducing in aggregate volume (*Table 3*).

Table 3. *Farmers' perception on change in total rainfall volume (n = 160)*

Perception	Frequency	Percentage
Decreased	124	77.50
Unchanged	2	1.25
Increased	34	21.25
Total	**160**	**100.0**

The result of the trend analysis on volume of rainfall in the area shows a high inter-annual variability in volume of rainfall which also resulted in a negative and very low correlation between rainfall volume and time (*Figure 3*). The result implies that aggregate rainfall volume shows a slight but insignificant reduction while surface temperature is getting hotter in Nasarawa State. If this trend continues Nasarawa and the Guinea Savanna may experience increasing challenges of climate change in the nearest future. This may aggravate the risks of floods and droughts as observed by Babatunde et

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1703_70857112

al. (2011) and Anuforom (2010). Farmers' perceptions on aggregate volume of rainfall in other savanna regions across Africa recorded declining aggregate rainfall volume and change in the pattern of rainfall (Maddison, 2006; Nhemachema and Hassan, 2007; Yesuf et al., 2008; Mandleni and Amin, 2011; Sofoluwe et al., 2011; Fosu-Mensah et al., 2012; Tessema et al., 2013; Olujobi, 2015; Mwalusepo et al., 2015; Ehiakpor et al., 2016; Ndamani and Watanabe, 2016; Hitayezu et al., 2017; Mkonda and He, 2017; Mutunga et al., 2017; Kebede and Gizachew, 2017; Boansia et al., 2017; Gbegbelegbe et al., 2018).

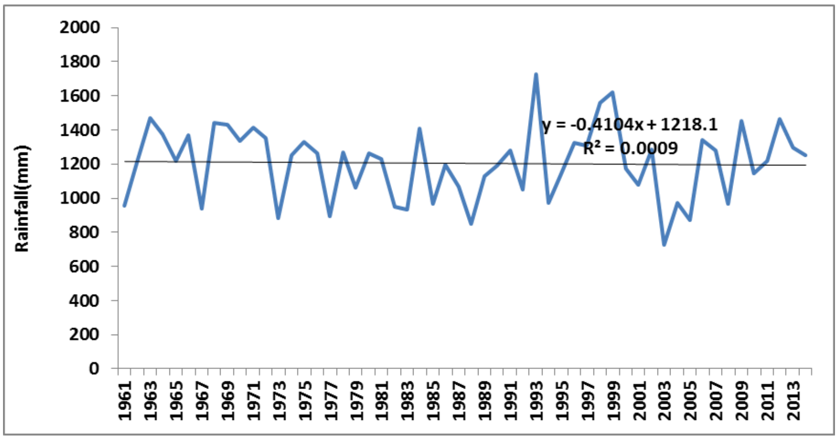

Figure 3. *Trend of total annual rainfall in Nasarawa State from 1961 to 2013*

Adaptation Strategies

The various climate change adaptation measures farmers adopt were classified into eight broad categories as shown in *Table 4* and they include cultivating improved crop varieties, portfolio diversification, practicing soil and water conservation, adjusting time of sowing, changing tillage operations, planting trees, irrigation, and farmland management. These are considered important climate change adaptation strategies in Nigeria (BNRCC, 2011; Okpe and Age, 2015; Onyegbula and Oladeji, 2017; Onyeneke, 2018).

Crop diversification – cultivating different crops – was adopted by majority of the farmers (95.00%). The dominant practice under crop diversification is intercropping of sorghum, maize with sweet potatoes and cowpea or melon (Agboire, 2017). This option is not expensive to practice and farmers have various crops at their disposal to plant. This may be the reason for greater adoption of this option. Furthermore, Bradshaw et al. (2004), Smit and Wandel (2006), Speranza (2006) noted that planting different crop varieties is an important farm-level climate change adaptation strategy. The increasing unpredictable nature of Africa's climate predisposes farmers to risk and shock associated with climate change, hence, makes them to grow different crop varieties. Planting short gestation crop varieties was also commonly practiced by farmers (73.75%) in the area. Farmers living in low rainfall and warm climates switch to short gestation crop varieties in managing climate risks (Wondimagegn and Lemma, 2016).

Mixed farming was the commonly used (68.75%) practice under portfolio diversification by the farmers followed by diversifying from farm to non-farm livelihood activities. Mixed farming is not new to farmers in the area. Farmers who *ab initio* combined livestock production and crop production are gradually intensifying

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1703_70857112

on crop production only because of increasing scarcity of fodder for livestock like cattle, sheep and goat. Farmers in the area whose animals are affected seriously by climate change are resorting to only crop production, especially farmers living in the low-lying plains of the area. This may be connected to the fact that, some farm household members who rear livestock in the area move around in search of pasture, and the rangelands in the State are becoming drier, thereby making fodder unavailable for the farmers and their livestock. Instead of the continuous search of pasture everywhere and the resultant conflicts that follow, the original livestock farmers are now settling near watersheds and low-lying plains where water is almost available all year round, and are cultivating crops and grasses in such areas in order to survive. Another related practice is farmland management which 78.13% of the farmers adopted. This was not far from the adoption level of farmland management reported in the study of Onyeneke et al. (2018).

Table 4. *Distribution of farmers according to climate change adaptation strategies adopted (n = 160)*

Adaptation Strategy	**Frequency**	**Percentage**
1.Use of improved varieties		
Use of short gestation crops	118	73.75
Use of flood tolerant crop	93	58.13
Use of drought tolerant crops	91	56.88
Use of disease/pest resistant varieties	94	58.75
Planting different varieties of crops	152	95.00
2. Portfolio diversification		
Diversifying from farm to non-farm activities	109	68.13
Changing from crop farming to livestock farming	106	66.25
Mixed farming	110	68.75
3. Soil and water conservation		
Terracing	77	48.13
Mulching	112	70.00
Planting of cover crops	112	70.00
Crop rotation	113	70.63
Water harvesting	99	61.88
4. Changing planting dates		
Adjusting planting dates	126	78.75
Shortening the length of growing period	122	76.25
5. Changing tillage operations		
Planting on mounds and planting on ridges	126	78.75
6. Planting Trees		
Planting Trees	112	70.00
7. Irrigation and drainage		
Irrigation/watering	70	43.75
Drainage	79	49.38
8. Farmland management		
Changing land area cultivated	125	78.13

The commonly practised conservation strategies were crop rotation, cover cropping and mulching. Mulching was practised due to its benefit in soil moisture conservation and soil fertility management which often increases farmers' yield. These are similar to

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1703_70857112

the reasons adduced by Agele et al. (2000) and Onyeneke (2016a) for the high adoption rates of mulching in their research works. The reasons for embarking on cover cropping lies in the fact that cover crops suppress weeds, conserve soil moisture, and add nutrient to the soil. These are in line with the explanations given by Sanginga and Woomer (2009), Olaitan and Omomia (2006) and Egbule et al. (2012). Crop rotation is also a common adaptation strategy by farmers in the area and the probable reason for its adoption by about 70.63% of the farmers is because it enhances production, controls pest and diseases, conserves soil moisture and is less expensive. Sorghum, maize and soybean are very important crops cultivated by many farmers in the State and a very important crop rotation practice in the State observed in the course of data collection of this study was planting of *Striga* suppressive soybean varieties in rotation with sorghum and maize.

Furthermore, about 79.00% of the farming households reported that because of the erratic rainfall pattern in the area, they now change the time of planting to match the current distribution and pattern of rainfall. Also, 76.25% of the farmers reported that the growing periods have been shortened. This is now a common practice that farmers across sub-Saharan Africa use in managing vagaries of rainfall that characterise the region. Tadross and Hewitson (2005) have documented the frequency at which farmers change the time of planting in Zimbabwe.

Changing tillage operations was another common (78.75%) practice because of its characteristic benefit of controlling farm erosion and soil moisture conservation. It can also contribute to soil carbon sequestration (Niggli et al., 2009).

Also, 70.00% of the farmers opted for planting trees on farms to serve as shade and help in protecting crops from scorching and controlling farm erosion. Farmers also opted for this strategy because it contributes to mitigation of carbon and increases their income through sales of the products of the trees planted. This can also be considered as a climate-smart agricultural practice because it brings "triple wins" of increased productivity and adaptation (reducing/eliminating scorching of crops and fertilizes the soil), serving as a sink for carbon dioxide (mitigation of carbon) and increased income and ecosystem resilience (resilience) (Nwajiuba et al., 2015; Fadina and Barjolle, 2018).

Terracing (48.13%) was not common in the area and may be as a result of constraining factors such as high labour requirement, frequent inspection, large expanse of farmland needed, and the huge construction material required (Igbokwe, 1996). Also, irrigation (43.75%) and drainage (49.38%) were not commonly practiced by the farmers, perhaps because these options are capital intensive.

The researchers classified the adaptation options into eight broad categories. For categories having more than one specific adaptation option, the authors summed such adaptation options and divided by the number of specific adaptation practices identified/mentioned under such category as presented in *Table 4*. The quotient was further converted to percentage by multiplying by 100 and any farmer with a percentage score of 50 and above was considered as an adopter of such category while those with a percentage score of less than 50 were considered as non-adopters. These categories were used as the dependent variables in the multivariate probit model of this study reported in *Table 8*.

The result in *Table 5* indicates that the level of adoption of the different categories of climate change adaptation was quite high. Adjusting planting dates and changing tillage operations were the most common in the list of the categories of climate change adaptation while irrigation and drainage was the least common.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1703_70857112

Table 5. *Distribution of farmers according to adaptation categories adopted (n = 160)*

Adaptation Category	Frequency	Percentage
Improved varieties	103	64.40
Portfolio diversification	103	64.40
Soil and water conservation	110	68.80
Changing planting dates	133	83.10
Changing tillage operations	126	78.80
Planting trees on farms	112	70.00
Irrigation and drainage	90	56.30
Farmland management	125	78.10

The number of adaptation categories adopted by the farmers was presented in *Table 6*. It could be deduced from the table that in managing climate risks farmers adopted various adaptation strategies. The average number of strategies adopted by the farmers was approximately 6 reflecting the adoption of multiple strategies by farmers in climate risk management. Therefore, farmers' decision in climate risk management in the Guinea savanna is simultaneous and the choice is not mutually exclusive. Hence, analysis of the determinants of farmers' adaptation decisions should account for the simultaneity in the choice of climate risk management strategies. This informed the choice of the multivariate probit regression which models the sequential decisions farmers make in climate change adaptation.

Table 6. *Distribution of farmers according to number of adaptation categories adopted (n = 160)*

Adaptation Category	Frequency	Percentage
One	23	14.38
Two	3	1.88
Three	4	2.50
Four	17	10.63
Five	17	10.63
Six	20	12.50
Seven	20	12.50
Eight	56	35.00
Total	**160**	**100.00**
Average	**5.64**	

Factors determining Choice of Adaptation Category

The multivariate probit model results on the factors determining choices of adaptation options are presented in *Tables 7 and 8*. The model is very fit considering the significance of the likelihood ratio result ($Chi^2 = 202.68$, $p < 0.01$) (*Table 8*). This led to the rejection of the hypothesis of independence of the random errors of the different adaptation models and acceptance of the alternative hypothesis of interdependence of the adaptation practices.

The test of complementarity and/or substitutability of the adaptation measures was done using the pairwise coefficients of the multivariate probit result and is presented in *Table 7*. Two adaptation measures are considered to be complementary when the pairwise coefficient is positive while they are substitutes when the resultant pairwise coefficient has a negative sign. The analysis yielded positive correlations across all the pairs of adaptation categories in this study except between adjusting planting dates and

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1703_70857112

changing tillage operations, which yielded a negative but insignificant correlation. This implies that the strategies were mainly interdependent and complementary.

The analysis indicated that there was positive and significant interdependence between household decisions to cultivate improved crop varieties and conserving the soil, cultivating improved crop varieties and portfolio diversification, adjusting planting dates and cultivation of improved crop varieties, planting improved crop varieties and trees on farms, farmland management and cultivating improved crop varieties, planting improved crop varieties and changing tillage operations and irrigation with cultivation of improved crops. The model results also suggested that there was positive and significant interdependence between household decisions to adopt use of irrigation and farmland management, irrigation and soil conservation, use of irrigation and portfolio diversification, adjusting planting dates and portfolio diversification, portfolio diversification and farmland management, portfolio diversification and planting trees on farms, portfolio diversification and changing tillage operations, soil conservation and changing tillage operations, soil conservation and adjusting planting dates, soil conservation and planting trees on farms, and portfolio diversification and soil conservation. It also suggested that there was positive and significant interdependence between household decisions to adopt use of planting trees on farm and adjusting planting date, planting trees on farms and changing tillage operations, and using improved varieties of crops and adjusting planting date.

Table 7. *Correlation coefficients of the adaptation categories (from the MVP) (n=160)*

Adaptation Category	Improved varieties	Portfolio diversification	Soil and water conservation	Changing planting dates	Changing tillage operations	Planting trees	Irrigation and drainage	Farmland management
Improved varieties	1.000							
Portfolio diversification	0.346**	1.000						
Soil and water conservation	0.428**	0.343**	1.000					
Changing planting dates	0.606**	0.431**	0.632**	1.000				
Changing tillage operations	0.060	0.092	0.210**	-0.071	1.000			
Planting trees	0.424**	0.310**	0.677**	0.688**	0.127	1.000		
Irrigation and drainage	0.475**	0.475**	0.465**	0.376**	0.281**	0.467**	1.000	
Farmland management	0.427**	0.522**	0.654**	0.650**	0.021	0.577**	0.356**	1.000

**$p < 0.01$

The result of the parameter estimates of the multivariate probit model is presented in *Table 8*. Education significantly increased adaptation to climate change through cultivating improved crop varieties, soil conservation, adjusting planting dates, planting of trees, irrigation and farmland management. More educated farmers understand and appreciate the benefits associated with cultivating improved crop varieties, soil conservation, adjusting planting dates, planting of trees, irrigation and farmland management and possess higher managerial ability in farm businesses than the less educated ones. This result is in consonance with the research findings of Onyeneke (2016b) and Nhemachena and Hassan (2007).

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1703_70857112

Table 8. *Multivariate probit estimates of the determinants of farmers' adaptation options to climate change in Nasarawa State (n = 160)*

Variable	Use of improved varieties	Portfolio Diversification	Soil Conservation	Adjusting planting dates	Change Tillage Operations	Planting Trees	Irrigation	Farmland management
Education	0.008 (2.44)**	0.0003 (0.27)	0.016 (2.29)**	0.007 (2.23)**	0.003 (0.54)	0.008 (1.80)*	0.011 (1.69)*	0.014 (1.97)***
Age	-0.008 (-2.08)**	-0.010 (-1.65)*	0.005 (2.55)**	-0.001 (-2.31)**	0.00006 (0.70)	0.006 (1.87)*	-0.015 (-2.88)***	-0.002 (-0.40)
Household size	0.008 (1.29)	-0.001 (-0.10)	0.018 (2.53)**	-0.006 (-1.94)*	0.011 (1.68)*	0.015 (2.55)**	0. 019 (2.12)**	-0.007 (-3.49)***
Income	5.43e-07 (2.46)**	4.10e-07 (1.68)*	9.69e-07 (1.44)	7.05e-08 (0.34)	1.22e-06 (2.01)**	6.59e-07 (1.44)	1.06e-06 (2.50)**	1.91e-07 (0.42)
Livestock ownership	0.0018 (2.24)**	0.010 (3.11)***	0.003 (1.98)*	0.004 (2.39)**	0.001 (2.77)***	0.005 (3.25)***	0.007 (3.17)***	0.005 (2.58)**
Extension Contact	0.076 (2.92)***	0.025 (1.64)*	0.018 (2.15)**	0.017 (2.34)**	0.057 (2.07)**	0.015 (1.51)	0.013 (1.76)*	0.029 (1.85)*
Farming experience	0.005 (1.74)*	0. 018 (3.33)***	0.009 (2.74)***	0.001 (3.84)***	0.004 (1.34)	0.005 (1.81)*	0.019 (4.16)***	0.004 (2.66)***
Credit	1.11e-06 (2.10)**	3.87e-07 (2.43)**	1.06e-07 (0.18)	3.99e-07 (1.25)	5.47e-08 (0.10)	1.19e-06 (1.69)*	7.32e-07 (1.71)*	5.14e-07 (0.88)
Farm size	0.019 (1.98)*	-0. 003 (-0.20)	0.00001 (2.19)**	0.008 (1.89)*	0.011 (1.19)	0.005 (0.52)	0.009 (1.88)*	0.007 (1.71)*
Distance to market	-0.017 (-3.79)***	-0. 002 (-2.51)**	-0.014 (-2.92)***	0.002 (0.96)	-0.002 (-1.65)*	-0.011 (-2.87)***	-0.018 (-3.42)***	0.0063 (1.52)
Distance to water source	-0.003 (-2.24)**	-0. 003 (-1.41)	-0.0006 (-1.76)*	-0.0005 (-0.87)	-0.0001 (-0.11)	-0.0001 (-0.15)	-0.0008 (-0.67)	-0.004 (-2.85)***
Risk orientation	0.007 (1.83)*	0.170 (1.70)*	0.169 (2.37)**	0.182 (3.23)***	0.061 (1.73)*	0.213 (3.29)***	0.147 (1.77)*	0.295 (3.54)***
Member of farmer group	0.016 (1.68)*	-0.071 (-0.66)	0.021 (0.34)	0.005 (0.20)	-0.061 (-1.04)	-0.045 (-0.85)	0.165 (2.21)**	-0.053 (-0.80)
Likelihood Chi square	202.68***							

Note: values in parenthesis are z-values
^{xxx} Significant at 1% level, ^{xx} Significant at 5% level

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1703_70857112

Age and adoption of improved crop varieties, portfolio diversification, irrigation and adjusting planting dates yielded significant negative associations while age and soil and water conservation and planting trees yielded positive relationship. The effect of age on soil and water conservation as well as planting trees on farms were surprising in the light of the theory of adoption of technologies. One key reason for this surprising result could be that soil and water conservation practices identified in this study as well as tree planting on farms are relatively old practices in the Guinea savanna and the older farmers are better positioned to adopt such strategies than their younger counterparts because they understand and appreciate the benefits more. The effect of age and climate change adaptation is well captured by research results (Boansi et al., 2017; Gbetibouo, 2009; Deressa et al., 2008).

Farmers' household size significantly increased the likelihood of using soil conservation, changing tillage operations (digging ridges and mounds), planting trees and irrigation. These strategies require additional labour from the farmer, which the household members can provide. Teklewold et al. (2006) also found household size significant in determining the adoption of poultry technologies. However, household size diminished the probability of uptake of adjusting planting dates and farmland management. As the land area cultivated by each farmer reduces, the farm labour needed by such farmers also reduces which in turn frees some members of the family to pursue other income-generating activities (Tizale, 2007).

Income increased the probability of adoption of improved crop varieties, portfolio diversification, changing tillage operations and irrigation. Adaptation to climate change needs financial capital and information and wealthier farmers would adapt more readily than their poorer counterparts (CIMMYT, 1993; Franzel, 1999; Knowler and Bradshaw, 2007; Kassie, 2017).

Livestock ownership significantly increased uptake of all the options. Livestock is an asset to the farmer and could be sold anytime to purchase other farm inputs needed by farmers and could be responsible for the positive and significant impact recorded across all the adaptation options. Moreover, livestock dungs and dropping are used in soil fertility management. Tizale (2007) documented the benefits of livestock in storing wealth and maintaining soil fertility.

Government extension services significantly increased adoption of all the strategies. Most of the practices are an integral part of the packages disseminated to farmers across Nigeria by extension agents. This may be related to the positive and significant impact of extension services on all the climate change adaptation strategies. This confirms the increasing role of extension in climate risk management which supports better and effective agricultural management decisions (Gbetibouo, 2009; Umar et al., 2014; Duniya and Rekwot, 2015). Tripathi and Mishra (2017) and Mulwa et al. (2017) noted that extension services help farmers in adopting climate change management strategies.

Another important determinant of climate change adaptation strategies is experience (Gbetibouo, 2009) and it significantly increased the adoption of improved crop varieties, portfolio diversification, soil and water conservation practices, adjusting planting dates, planting trees, irrigation, and farmland management. Fadina and Barjolle (2018) also found that experience increased uptake of climate change adaptation strategies in Southern Benin.

Credit access enhanced adoption of improved crop varieties, portfolio diversification, irrigation and planting trees. Availability of credit reduces financial challenges of farmers and allows them to buy agrochemicals, seedlings and other inputs. Access to

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1703_70857112

credit enhances the adoption of climate change adaptation strategies (Nhemachena and Hassan, 2007). In rural El Salvador, Saín and Barreto (1996) found access to credit to have positive impact on adoption of soil conservation technology while Hansen et al. (1987) reported same result in the Dominican Republic. In Rondônia area of Brazil in South America, Caviglia-Harris (2002) noted that credit is a significant predictor of adoption of sustainable agricultural practices.

Farm size significantly increased uptake of improved crop varieties, soil conservation practices, adjusting planting dates, and irrigation and farmland management. Most of the climate change adaptation measures are optimally practised in large farms because farmers who have large farm sizes at their disposal and are more likely to adopt soil conservation techniques, irrigation, farmland management for the purpose of increasing soil fertility and efficiency of their farms (Negash, 2013; Erhabor and Ahmadu, 2013; Wondimagegn and Lemma, 2016) and improved crop varieties for incremental yield.

There was a negative and significant relationship between distance to the market and the uptake of improved crop varieties, portfolio diversification, soil conservation practices, changing tillage operations, planting trees, and irrigation. Nearness and availability of input in the market facilitate the adoption and intensive use of adaptation technologies. Also, transportation cost of agricultural inputs increases with market distance which may discourage farmers from purchasing agricultural inputs and selling their outputs too (Ulimwengu et al., 2009; Kiprono and Matsumoto, 2014).

Distance to water source also emerged as a significant predictor climate change adaptation choices of the farmers. This variable was inversely related to the likelihood of adopting improved crop varieties, soil conservation practices, and farmland management. The distance from the water source to the home and farm of the farmer negatively impacts on the quality and volume of water used for farm and domestic consumption.

Risk orientation demonstrated positive and significant association on adoption of all the climate risk management strategies - improved crop varieties, portfolio diversification, soil and water conservation, adjusting planting dates, changing tillage options, planting trees on farms, irrigation, and farmland management. Adaptation to climate change requires adoption of technology which involves risk-taking and farmers who are willing to take the risk of experimenting the technologies will adapt more readily to climate risks. Farmers who are more disposed to risk-taking were significantly more likely to increase the adoption of improved crop varieties, portfolio diversification, soil and water conservation, adjusting planting dates, changing tillage operations, planting trees, irrigation, and farmland management than their counterparts who are less risk-oriented.

Membership of farmer groups positively impacted the adoption of improved crop varieties and irrigation. Farmers get information about innovations from their associations. Membership to such groups increased the uptake of improved crop varieties and irrigation. Targeting farmers who are members of farmer groups will be important in increasing farmers' adaptive capacity. This result is in line with Mulwa et al. (2017) finding in Malawi. They found that membership of farmer groups significantly increased the adoption of disease/pest-tolerant crop varieties in Malawi.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1703_70857112

Conclusion

The research matched perception survey with scientific data from meteorological agency. We distinguished scientific data and local peoples' accounts of climate change and matched both datasets to find convergence or divergence and see to what extent perceptions data reflects true empirical reality. Farmers' perception reflects empirical reality and they have adopted some strategies to respond to the observed vagaries in climate.

There is interrelationship in the adaptation strategies employed by the smallholder farmers. Most farming households used improved crop varieties (especially growing different varieties of crops and those with short gestation period), portfolio diversification (especially practicing mixed farming and diversifying to non-farm activities), soil and water conservation (crop rotation, mulching, cover cropping and water harvesting), adjusting planting dates, and changing tillage operations. Demographic and farm characteristics and institutions determined climate change management decisions.

Scientific data and farmers' experience point to changing patterns of temperature and rainfall in the region. Therefore, adaptation measures need to focus more on these climate elements to reduce the impact on farmers by boosting access to the livelihood assets. Support to farmers should strengthen their capacity and ability to cultivate improved crop varieties, adopt portfolio diversification, practice water and soil conservation, and use irrigation. Strengthening public extension services and credit institutions such as microfinance and commercial banks as well as cooperative societies should be the priority of government if climate risk management in agricultural production must be achieved. This will support the achievement of food security and poverty reduction objectives of the Nigerian government. Local responses and the adaptive capacity of the farmers cannot be enough but they are very important in shaping government and development partners' planned adaptation interventions. The adaptation practices identified should be integrated into governments' overall strategies and policies.

Conflict of Interests. The authors declared that they have no conflict of interests.

REFERENCES

[1] Acquah-de Graft, H. (2011): Farmers' perception and adaptation to climate change: A willingness to pay analysis. – Journal of Sustainable Development in Africa 13(5): 150-161.

[2] Acquah-de Graft, H., Onumah, E. E. (2011): Farmers' perception and adaptation to climate change: an estimation of willingness to pay. – Agris-on-line Papers in Economics and Informatics 3(4): 31-39.

[3] 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 Center, Obafemi Awolowo University, Ile-Ife 20-21 September, 2004.

[4] Agboire, S. (2017): Research and Development Activities of the National Cereals Research Institute Badeggi in Promoting a Shift to Climate Smart Agriculture in Nigeria. – A Paper presented at the National Stakeholders Workshop on Building Resilience to

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1703_70857112

Climate Change among smallholders in Nigeria holding at Postgraduate School Auditorium, Abeokuta; October 19th -20th, 2017.
[5] Agele, S. O., Iremiren, G. O., Ojeniye, S. O. (2000): Effects of Tillage and Mulching on the Growth, Development and Yield of Late-Season Tomato (Lycopersicon esculentum L.) in the Humid South of Nigeria. – Journal of Agricultural Science 134(1): 55-59. https://doi.org/10.1017/S0021859699007273.
[6] Ajetomobi, J. O., Abiodun, A., Hassan, R. (2010): Economic Impact of Climate Change on Irrigated Rice Agriculture in Nigeria. – Contributed Paper presented at the Joint 3rd African Association of Agricultural Economists (AAAE) and 48th Agricultural Economists Association of South Africa (AEASA) Conference, Cape Town, South Africa, September 19-23, 2010. http://ageconsearch.tind.io//bitstream/95778/1/19.%20Climate%20change%20Nigerian%20rice.pdf. Accessed 29th April, 2017.
[7] Akponikpe, P., Johnston, P., Agbossou, E. K. (2010): Farmers' perceptions of climate change and adaptation strategies in sub-Sahara West Africa. – 2nd International Conference on Climate, Sustainability and Development in Arid Regions, Fartaleza-Ceara, Brazil.
[8] Anuforom, A. C. (2010): Demonstration and Assessment of Climate Change in Nigeria and Development of Adaptation Strategies in the key Socio-economic Sectors: Meteorological Approach. – Paper presented at the National Stakeholders Workshop on Developing National Adaptation Strategies and Plan of Action for Nigeria, held on 22nd, March, Abuja, Nigeria.
[9] Asfaw, A., Admassie, A. (2004): The Role of Education on the Adoption of Chemical Fertilizer under different Socioeconomic Environments in Ethiopia. – Agricultural Economics 30(3): 215-228. https://doi.org/10.1111/j.1574-0862.2004.tb00190.x.
[10] Babatunde, J. A., Salami, A. T., Tadross, M. (2011): Climate Change Scenarios for Nigeria: Understanding Biophysical Impacts. – Climate Systems Analysis Group, Cape Town, for Building Nigeria's Response to Climate Change Project. Ibadan, Nigeria: Nigerian Environmental Study/Action Team (NEST).
[11] Biola, K. B., Villamor, G. B., Agodzo, S. K., Odai, S. N. (2015): Heterogeneous farm household perceptions about climate change: a case study of a semi-arid region of Ghana. – The International Journal of Climate Change: Impacts and Responses 7(3): 67-79.
[12] Boansia, D., Tamboa, J. A., Müller, M. (2017): Analysis of farmers' adaptation to weather extremes in West African Sudan Savanna. – Weather and Climate Extremes 16: 1-13. http://dx.doi.org/10.1016/j.wace.2017.03.001.
[13] Bradshaw, B., Dolan, H., Smit, B. (2004): Farm-level adaptation to climatic variability and change: Crop diversification in the Canadian prairies. – Climatic Change 67: 119-141. https://doi.org/10.1007/s10584-004-0710-z.
[14] Building Nigeria's Response to Climate Change (BNRCC) (2007): Background to Building Nigeria's Response to Climate Change Project. – www.nestinteractive.org, www.nigeriaclimatechange.org. Accessed 20th June, 2009.
[15] Building Nigeria's Response to Climate Change (BNRCC) (2011): National Adaptation Strategy and Plan of Action on Climate Change for Nigeria (NASPA-CCN).
[16] Caviglia-Harris, J. (2002): Sustainable Agricultural Practices in Rondônia, Brazil: Do Local Farmer Organizations Impact Adoption Rates? – Department of Economics and Finance, Salisbury University.
[17] CIMMYT (International Maize and Wheat Improvement Center) (1993): The Adoption of Agricultural Technology: A Guide for Survey Design. – Economics Program. Mexico City, Mexico.
[18] Crosson, P. (1997): Impacts of Climate Change on Agriculture. – Climate Issues Brief No.4. Washington D.C., Resources for the Future.
[19] Department of Climate Change (2013): National Policy on Climate Change, Department of Climate Change of the Federal Ministry of Environment, Abuja, Nigeria.

[20] Department of Climate Change (2014): National Strategic Roadmap for Responding to Climate Change in Nigeria, Department of Climate Change of the Federal Ministry of Environment, Abuja, Nigeria
[21] Deressa, T., Hassan, R., Ringler, C., Alemu, T., Yesuf, M. (2008): Analysis of the determinants of farmers' choice of adaptation methods and perceptions of climate change in the Nile basin of Ethiopia. – IFPRI Discussion Papers No. 798, International Food Policy Research Institute, Washington DC.
[22] Duniya, K. P., Rekwot, G. Z. (2015): Determinants of Poverty among Groundnut Farming Households in Jigawa State, Nigeria. – Asian Journal of Agricultural Extension, Economics and Sociology 4(3): 224-230.
[23] Egbule, C. L., Agwu, A. E., Nwadike, F. U. (2012): Climate change adaptive strategies used by arable crop farmers in Umuahia North Local Government Area (LGA) of Abia State, Nigeria. – Proceedings of the 17th Annual National Conference of Agricultural Extension Society of Nigeria (AESON) held at the Princess Alexandra Unity Hall, University of Nigeria, Nsukka, Enugu State, Nigeria from the 11st – 14th March, 2012.
[24] Ehiakpor, D. S., Danso-Abbeam, G., Baah, J. E. (2016): Cocoa farmer's perception on climate variability and its effects on adaptation strategies in the Suaman district of western region, Ghana. – Cogent Food & Agriculture 2, http://dx.doi.org/ 10.1080/23311932.2016.1210557.
[25] Enete, A., Onyekuru, A. (2011): Challenges of agricultural adaptation to climate change: empirical evidence from South-east Nigeria. – Tropicultura 29(4): 243-49.
[26] Erhabor, P. O., Ahmadu, J. (2013): Technical Efficiency of Small-Scale Rice Farmers in Nigeria. – Research and Reviews: Journal of Agriculture and Allied Sciences 2(3): 14-22.
[27] Ethan, S. (2015): Impact of climate change on agriculture and food security in Nigeria: challenges and adaptation. – Global Advanced Research Journal of Medicinal Plant 3(1): 001-009.
[28] Ezeaku, I. E., Okechukwu, E. C., Aba, C. (2014): Climate Change Effects on Maize (Zea mays) Production in Nigeria and Strategies for Mitigation. – Asian Journal of Science and Technology 5(12): 862-871.
[29] Fadina, A. M. R., Barjolle, D. (2018): Farmers' Adaptation Strategies to Climate Change and their Implications in the Zou Department of South Benin. – Environments 5(1): 15. doi:10.3390/environments5010015.
[30] Falaki, A. A., Akangbe, J. A., Ayinde, O. E. (2013): Analysis of Climate Change and Rural Farmers' Perception in North Central Nigeria. – Journal of Human Ecology 43(2): 133-140. https://doi.org/10.1080/09709274.2013.11906619.
[31] Federal Ministry of Environment (2014): Nigeria's Second National Communication under the United Nations Framework Convention on Climate Change, Federal Republic of Nigeria. – http://unfccc.int/resource/docs/natc/nganc2.pdf. Accessed 4th May, 2014.
[32] Feleke, F. B., Berhe, M., Gebru, G., Hoag, D. (2016): Determinants of adaptation choices to climate change by sheep and goat farmers in Northern Ethiopia: the case of Southern and Central Tigray, Ethiopia. – SpringerPlus (2016) 5:1692. DOI 10.1186/s40064-016-3042-3.
[33] Fosu-Mensah, B., Vlek, P., Manschadi, M. (2010): Farmers' perceptions and adaptations to climate change: a case study of sekyedumase district in Ghana. – A Contributed paper presented at World Food Systems Conference in Tropentag, Zurich: 14th -16th September, 2010.
[34] Fosu-Mensah, B., Vlek, P., MacCarthy, D. (2012): Farmers' perception and adaptation to climate change: A case study of Sekyedumase district in Ghana. – Environment, Development and Sustainability 14(4): 495-505. https://doi.org/10.1007/s10668-012-9339-7.
[35] Franzel, S. (1999): Socioeconomic Factors affecting the Adoption Potential of Improved Tree Fallows in Africa. – Agroforestry Systems 47(1-3): 305-321. https://doi.org/10.1023/A:1006292119954.

[36] Gandure, S., Walker, S., Botha, J. J. (2013): Farmers' perceptions of adaptation to climate change and water in a South African rural community. – Environment Development 5: 39-53. http://dx.doi.org/10.1016/j.endev.2012.11.004.
[37] Gbegbelegbe, S., Serem, J., Stirling, C., Kyazze, F., Radeny, M., Misiko, M., Tongruksawattana, S., Nafula, L., Gakii, M., Sonder, K. (2018): Smallholder farmers in eastern Africa and climate change: a review of risks and adaptation options with implications for future adaptation programmes. – Climate and Development 10(4): 289-306. https://doi.org/10.1080/17565529.2017.1374236.
[38] Gbetibouo, G. A. (2009): Understanding Farmers' Perception and Adaptations to Climate Change and Variability: The Case of the Limpopo Basin, South Africa. – International Food Policy Research Institute (IFPRI) Discussion Paper 00849, February 2009. Environment and Production Technology Division, IFPRI.
[39] Greene, W. H. (2003): Econometric Analysis, 5th edition. – Prentice Hall, Upper Saddle River, New Jersey.
[40] Gujarati, D. N. (1995): Basic Econometrics, 3rd edition. – McGraw-Hill, Inc., New York.
[41] Hansen, D., Erbaugh, J., Napier, T. (1987): Factors Related to Adoption of Soil Conservation Practices in the Dominican Republic. – Journal of Soil and Water Conservation 42: 367-369.
[42] Hijioka, Y., Lin, E., Pereira, J. J., Corlett, R. T., Cui, X., Insarov, G. E., Lasco, R. D., Lindgren, E., Surjan, A. (2014): Asia. – In: Barros, V. R., Field, C. B., Dokken, D. J., Mastrandrea, M. D., Mach, K. J., Bilir, T. E., Chatterjee, M., Ebi, K. L., Estrada, Y. O., Genova, R. C., Girma, B., Kissel, E. S., Levy, A. N., MacCracken, S., Mastrandrea, P. R., White, L. L. (eds.) Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1327-1370.
[43] Hitayezu, P., Wale, E., Ortmann, G. (2017): Assessing farmers' perceptions about climate change: A double-hurdle approach. – Climate Risk Management 17: 123-138. http://dx.doi.org/10.1016/j.crm.2017.07.001.
[44] Ibrahim, K., Shamsudin, M. N., Yacob, R., Radam, A. (2014): Economic Impact of Climate Change on Maize Production in Northern Nigeria. – Trends in Applied Sciences Research 9: 522-533. https://doi.org/10.3923/tasr.2014.522.533.
[45] Ifeanyi-Obi, C. C., Togun, A. O., Lamboll, R., Adesope, O. M., Arokoyu, S. B. (2017): Challenges faced by cocoyam farmers in adapting to climate change in Southeast Nigeria. – Climate Risk Management 17: 155-164. https://doi.org/10.1016/j.crm.2017.04.002.
[46] Igbokwe, E. M. (1996): A Soil and Water Conservation System under Threat: A Visit to Maku, Nigeria. – In: Scoones, I. R., Toulmin, I. C. (eds) Sustaining the Soil - Indigenous soil and Water Conservation in Africa, Earthscan Publication, London.
[47] Intergovernmental Panel on Climate Change (IPCC) (2007): Climate Change 2007: Impacts, Adaptation and Vulnerability. – In: Parry, M. L., Canziani, O. F., Palutikof, J. P., van der Linden, P. J., Hanson, C. E. (eds.) Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK. https://www.ipcc.ch/pdf/assessment-report/ar4/wg2/ar4-wg2-intro.pdf. Accessed April 29th, 2017.
[48] Intergovernmental Panel on Climate Change IPCC (2013): Summary for Policymakers. – In: Stocker, T. F., Qin, D., Plattner, G.-K., Tignor, M., Allen, S. K., Boschung, J., Nauels, A., Xia, Y., Bex, V., Midgley, P. M. (eds.) Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. http://www.ipcc.ch/pdf/assessment-report/ar5/wg1/WG1AR5_SPM_FINAL.pdf. Accessed 4th May, 2017.
[49] Intergovernmental Panel on Climate Change IPCC (2014): Climate Change 2014: Synthesis Report. – In: Core Writing Team, Pachauri, R. K., Meyer, L. A. (eds.)

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1703_70857112

Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. IPCC, Geneva, Switzerland.

[50] Intergovernmental Panel on Climate Change IPCC (2015): Meeting Report of the Intergovernmental Panel on Climate Change Expert Meeting on Climate Change, Food, and Agriculture. – In: Mastrandrea, M. D., Mach, K. J., Barros, V. R., Bilir, T. E., Dokken, D. J., Edenhofer, O., Field, C. B., Hiraishi, T., Kadner, S., Krug, T., Minx, J. C., PichsMadruga, R., Plattner, G.-K., Qin, D., Sokona, Y., Stocker, T. F., Tignor, M. (eds.) World Meteorological Organization, Geneva, Switzerland. https://www.ipcc.ch/pdf/supporting-material/Food-EM_MeetingReport_ FINAL.pdf. Accessed 4th May, 2017.

[51] Jiri, O., Mafongoya, P., Chivenge, P. (2015): Smallholder farmer perceptions on climate change and variability: a predisposition for their subsequent adaptation strategies. – Journal of Earth Science and Climate Change 6(5): 1-7. https://doi.org/10.4172/2157-7617.1000277.

[52] Kassie, G. W. (2017): Agroforestry and farm income diversification: synergy or trade-off? The case of Ethiopia. – Environmental Systems Research 6:8. https://doi.org/10.1186/s40068-017-0085-6.

[53] Kebede, W., Gizachew, Z. (2017): Understanding Farmers' Perception on Climate Change and Adaptation Strategies in Karetha Watershed, Omo-gibe Basin, Ethiopia. – Asian Journal of Earth Sciences 10: 22-32. https://doi.org/10.3923/ajes.2017.22.32.

[54] Kiprono, P., Matsumoto, T. (2014): Roads and farming: The effect of infrastructure improvement on agricultural input use, farm productivity and market participation in Kenya. – Paper Presented at Center for Study of African Economies Conference, St. Catherine's College, Oxford, 23rd-25th March, 2014.

[55] Knowler, D., Bradshaw, B. (2007): Farmers' Adoption of Conservation Agriculture: A Review and Synthesis of Recent Research. – Food Policy 32(1): 25-48. https://doi.org/10.1007/s10584-004-0710-z.

[56] Kurukulasuriya, P., Mendelsohn, R. (2006): Crop selection: adapting to climate change in Africa. – Centre for Environmental Economics and Policy in Africa (CEEPA), University of Pretoria, Pretoria, South Africa.

[57] Lazkano, I., Marrouch, W., Nkuiya, B. (2016): Adaptation to Climate Change: How Does Heterogeneity in Adaptation Costs affect Climate Coalitions? – Environment and Development Economics 21: 812-838. https://doi.org/10.1017/S1355770X16000097.

[58] Lin, C-T. J., Jensen, K. L.,Yen, S. T. (2005): Awareness of foodborne pathogens among US consumers. – Food Quality and Preference 16(5): 401-412. https://doi.org/10.1016/j.foodqual.2004.07.001.

[59] Maddison, D. (2006): The Perception of and Adaptation to Climate Change in Africa. – CEEPA. Discussion Paper No.10. Centre for Environmental Economics and Policy in Africa. Pretoria, South Africa: University of Pretoria.

[60] Magrin, G. O., Marengo, J. A., Boulanger, J.-P., Buckeridge, M. S., Castellanos, E., Poveda, G., Scarano, F. R., Vicuña, S. (2014): Central and South America. – In: Barros, V. R., Field, C. B., Dokken, D. J., Mastrandrea, M. D., Mach, K. J., Bilir, T. E., Chatterjee, M., Ebi, K. L., Estrada, Y. O., Genova, R. C., Girma, B., Kissel, E. S., Levy, A. N., MacCracken, S., Mastrandrea, P. R., White, L. L. (eds.) Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1499-1566.

[61] Mandleni, B., Anim, F. (2011): Perceptions of Cattle and Sheep Framers on Climate Change and Adaptations in the Eastern Cape Province of South Africa. – Journal of Human Ecology 34(2): 107-112. https://doi.org/10.1080/09709274.2011.11906375.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1703_70857112

[62] Mkonda, M. Y., He, X. (2017): Are Rainfall and Temperature Really Changing? Farmer's Perceptions, Meteorological Data, and Policy Implications in the Tanzanian Semi-Arid Zone. – Sustainability 9: 1412. https://doi.org/10.3390/su9081412.

[63] Mulwa, C., Marenya, P., Rahut, D. B., Kassie, M. (2017): Response to climate risks among smallholder farmers in Malawi: A multivariate probit assessment of the role of information, household demographics, and farm characteristics. – Climate Risk Management 16: 208-221. https://doi.org/10.1016/j.crm.2017.01.002.

[64] Mutunga, E. J., Ndungu, C. K., Muendo, P. (2017): Smallholder Farmers' Perceptions and Adaptations to Climate Change and Variability in Kitui County, Kenya. – Journal of Earth Science & Climatic Change 8: 389. https://doi.org/10.4172/2157-7617.1000389.

[65] Mwalusepo, S., Massawe, E. S., Affognon, H., Okuku, G. O., Kingori, S., Mburu, P. D. M., Ong'amo, G. O., Muchugu, E., Calatayud, P., Landmann, T., Muli, E., Raina, S. K., Johansson, T., Ru, B. P. L. (2015): Smallholder Farmers' Perspectives on Climatic Variability and Adaptation Strategies in East Africa: The Case of Mount Kilimanjaro in Tanzania, Taita and Machakos Hills in Kenya. – Journal of Earth Science & Climatic Change 6: 313. doi:10.4172/2157- 7617.1000313.

[66] Napier, T. (1991): Factors Affecting Acceptance and Continued Use of Soil Conservation Practices in Developing Societies: A Diffusion Perspective. – Agriculture, Ecosystems and Environment 36: 127-140. https://doi.org/10.1016/0167-8809(91)90010-U.

[67] National Population Commission (NPC) (2006): Provisional of State and Local Government Totals of the 2006 Population Census of the Federal Republic of Nigeria. – http://www.nigerianstat.gov.ng. Accessed 23rd April 2011.

[68] Ndamani, F., Watanabe, T. (2016): Determinants of farmers' adaptation to climate change: a micro-level analysis in Ghana. – Scientia Agricola 73(3): 201-208. http://dx.doi.org/10.1590/0103-9016-2015-0163.

[69] Negash, M. (2013): Determinants of farmers' preference for adaptation strategies to climate change: evidence from north Shoa zone of Amhara region Ethiopia. – MPRA Paper No. 48753.

[70] Nhemachena, C., Hassan, R. (2007): Micro-level Analysis of Farmers' Adaptation to climate change in Southern Africa. – International Food Policy Research Institute (IFPRI), Discussion Paper 714.

[71] Nhemachena, C., Hassan, R., Chakwizira, J. (2014): Analysis of determinants of farm-level adaptation measures to climate change in Southern Africa. – Journal of Development and Agricultural Economics 6(5): 232-241. http://dx.doi.org/10.5897/JDAE12.0441.

[72] Niang, I., Ruppel, O. C., Abdrabo, M. A., Essel, A., Lennard, C., Padgham, J., Urquhart, P. (2014): Africa. – In: Barros, V. R., Field, C. B., Dokken, D. J., Mastrandrea, M. D., Mach, K. J., Bilir, T. E., Chatterjee, M., Ebi, K. L., Estrada, Y. O., Genova, R. C., Girma, B., Kissel, E. S., Levy, A. N., MacCracken, S., Mastrandrea, P. R., White, L. L. (eds.) Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1199-1265. https://www.ipcc.ch/pdf/assessment-report/ar5/wg2/WGIIAR5-Chap22_FINAL.pdf. Accessed 29th April, 2017.

[73] Nigerian Environmental Study Action Team (NEST) (2011): Reports of Research Projects on Impacts and Adaptation. Building Nigeria's Response to Climate Change (BNRCC). – Ibadan, Nigeria: Nigerian Environmental Study/Action Team (NEST).

[74] Nigerian Environmental Study Action Team NEST, Woodley, E. (2011): Reports of Pilot Projects in Community-based Adaptation - Climate Change in Nigeria. – Building Nigeria's Response to Climate Change (BNRCC). Ibadan, Nigeria. Nigerian Environmental Study/Action Team (NEST).

[75] Nigerian Meteorological Agency (2017): 2017 Seasonal Rainfall Prediction. – Nigerian Meteorological Agency, Abuja.
[76] Niggli, U., Fließbach, A., Hepperly, P., Scialabba, N. (2009): Low Greenhouse Gas Agriculture: Mitigation and Adaptation Potential of Sustainable Farming Systems. – FAO, April 2009, Revised Version 2 – 2009. http://orgprints.org/15690/1/niggli-etal-2009-lowgreenhouse.pdf. Accessed 29th April, 2017.
[77] Nkwusi, G., Adeaga, S., Ayejuyo, S., Annuk, A. (2015): Climate change; farmers' awareness, perceptions and responses in Lagos State. – Applied Ecology and Environmental Sciences 3(4): 95-99.
[78] Nwajiuba, C., Onyeneke, R. (2010): Economic Effects of Climate on the Agriculture of sub-Saharan Africa: Lessons from Nigeria. – Proceedings of the 10th Global Conference on Business and Economics, St. Hugh's College, Oxford University, June 28-29, 2010.
[79] Nwajiuba, C., Tambi, E. N., Bangali, S. (2015): State of Knowledge on CSA in Africa: Case Studies from Nigeria, Cameroon and Democratic Republic of Congo. – Forum for Agricultural Research in Africa, Accra, Ghana.
[80] Nwosu, C. S., Onyeneke, R. U., Joshua, B. N., Mmagu, C. J., Nwaodu, K. T. (2014): Perception on and Adaptation to Climate Change by Farming Households in Etim Ekpo Local Government Area of Akwa Ibom State, Nigeria. – Proceedings the 14th Annual National Conference of the Nigerian Association of Agricultural Economists, Federal University of Technology, Akure, 24th – 27th February, 2014.
[81] Nyanga, P., Johnsen, F., Aune, J., Kahinda, T. (2011): Smallholder farmers' perceptions of climate change and conservation agriculture: evidence from Zambia. – Journal of Sustainable Development 4(4): 73-85. http://dx.doi.org/10.5539/jsd.v4n4p73.
[82] Odiana, S., Ibrahim, A. (2015): An Assessment of the evidence of Climate change in Bauchi, Nigeria. – Journal of Applied Sciences and Environmental Management 19(3): 375-381. https://doi.org/10.4314/jasem.v19i3.5.
[83] Ogalleh, S. A., Christian, R., Vogl, C. R., Eitzinger, J., Hauser, M. (2012): Local perceptions and responses to climate change and variability: The case of Laikipia District, Kenya. – Sustainability 4: 3302-3325. https://doi.org/10.3390/su4123302.
[84] Okpe, B. E., Aye, G. C. (2015): Adaptation to Climate Change by Farmers in Makurdi, Nigeria. – Journal of Agriculture and Ecology Research International 2(1): 46-57. http://dx.doi.org/10.9734/JAERI/2015/12169.
[85] Olaitan, S. O., Omomia, O. A. (2006): Round-up Agricultural Science: A Complete Guide. – Longman Nigerian PLC, Lagos.
[86] Olsson, L., Opondo, M., Tschakert, P., Agrawal, A., Eriksen, S. H., Ma, S., Perch, L. N., Zakieldeen, S. A. (2014): Livelihoods and poverty. – In: Field, C. B., Barros, V. R., Dokken, D. J., Mach, K. J., Mastrandrea, M. D., Bilir, T. E., Chatterjee, M., Ebi, K. L., Estrada, Y. O., Genova, R. C., Girma, B., Kissel, E. S., Levy, A. N., MacCracken, S., Mastrandrea, P. R., White, L. L. (eds.) Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
[87] Olujobi, O. J. (2015): Perception and adaptation strategies of agroforestry farmers to climate change in Ekiti State. – American Journal of Human Ecology 4(1): 1-8.
[88] Onumadu, F. N., Okore, H. O. (2012): Assessment of the effects of climate change and its adaptation measures on agricultural production in Arochukwu Local Government Area, Abia State. – International Journal of Applied Research and Technology 1(2): 260-269.
[89] Onyegbula, C. B., Oladeji, J. O. (2017): Utilization of climate change adaptation strategies among rice farmers in three states of Nigeria. – Journal of Agricultural Extension and Rural Development 9(10): 223-229. http://dx.doi.org/10.5897/JAERD2017.0895.
[90] Onyeneke, R. U., Iruo, F. A., Ogoko, I. M. (2012): Micro-level Analysis of Determinants of Farmers' Adaptation Measures to Climate Change in the Niger Delta Region of

Nigeria: Lessons from Bayelsa State. – Nigerian Journal of Agricultural Economics 3(1): 9-18.
[91] Onyeneke, R. U. (2016a): Effects of Livelihood Strategies on Sustainable Land Management Practices among Arable Crop Farmers in Imo State, Nigeria. – Nigerian Journal of Agriculture, Food and Environment 12(3): 230-235.
[92] Onyeneke, R. U. (2016b): Effects and Coping Measures of the 2012 Flood among Farming Households in Oguta Local Government Area of Imo State, Nigeria. – Nigerian Journal of Agriculture, Food and Environment 12(3): 225-229.
[93] Onyeneke, R. U., Mmagu, C. J., Aligbe, J. O. (2017): Crop Farmers' Understanding of Climate Change and Adaptation Practices in southeast Nigeria. – World Review of Science, Technology and Sustainable Development 13(4): 299-318. https://doi.org/10.1504/WRSTSD.2017.10010650.
[94] Onyeneke, R. U. (2018): Challenges of Adaptation to Climate Change by Farmers Anambra State, Nigeria. – International Journal of BioSciences, Agriculture and Technology 9(1): 1-7.
[95] Onyeneke, R. U., Igberi, C. O., Uwadoka, C. O., Aligbe, J. O. (2018): Status of climate-smart agriculture in southeast Nigeria. – GeoJournal 83(2): 333-346. https://doi.org/10.1007/s10708-017-9773-z.
[96] Osabo, P., Bello, D., Agwale, A. O., Zaknayiba, D. B., Sunday, D. P. (2014): Analysis of Climate Impacts on Crop Production in Savannah Region of Nigeria. – Production Agriculture and Technology 10(2): 91-102.
[97] Piya, L., Maharjan, K. L., Joshi, N. P. (2012): Comparison of Adaptive Capacity and Adaptation Practices in Response to Climate Change and Extremes among the Chepang Households in Rural Mid-Hills of Nepal. – Journal of International Development and Cooperation 18(4): 55-75.
[98] Rakgase, M. A., Norris, D. (2015): Determinants of livestock farmers' perception of future droughts and adoption of mitigating plans. – International Journal of Climate Change Strategies and Management 7(2): 191-205. https://doi.org/10.1108/IJCCSM-01-2014-0011.
[99] Saín, G., Barreto, H. J. (1996): The Adoption of Soil Conservation Technology in El Salvador: Linking Productivity and Conservation. – Journal of Soil and Water Conservation 51: 313-321.
[100] Sanginga, N., Woomer, P. L. (2009): Integrated Soil Fertility Management Practices in Africa: Principles, Practices and Developmental Processes. – Tropical Soil Biology and Fertility Institute of the International Centre for Tropical Agriculture, Nairobi, Kenya.
[101] Shrestha, S. L. (2014): Climate Change Resilience and Vulnerability of Farmers in Nepal. – Doctoral Dissertation, Graduate School for International Development and Cooperation, Hiroshima University.
[102] Smit, B., Wandel, J. (2006): Adaptation, adaptive capacity and vulnerability. – Global Environmental Change 16(3): 282-292. https://doi.org/10.1016/j.gloenvcha.2006.03.008.
[103] Sofoluwe, N. A., Tijani, A. A., Baruwa, O. I. (2011): Farmers' perception and adaptation to climate change in Osun State Nigeria. – African Journal of Agricultural Research 6(20): 4789-4794.
[104] Speranza, C. I. (2006): Drought Vulnerability and Risk in Agro-Pastoral Areas – An Integrative Approach and Its Application in Kenya. – Centre for Development and Environment-CDE, Bern.
[105] Tadross, M. A., Hewitson, B. C. (2005): The interannual variability of the onset of the maize growing season over South Africa and Zimbabwe. – Journal of Climate 18(16): 3356-3372. https://doi.org/10.1175/JCLI3423.1.
[106] Teklewold, H., Dadi, L., Yami, A., Dana, N. (2006): Determinants of adoption of poultry technology: A double-hurdle approach. – Livestock Research for Rural Development 18(3). Retrieved March 26, 2018, from http://www.lrrd.org/lrrd18/3/tekl18040.htm.

[107] Tenge, A. J., De Graaff, J., Hella, J. P. (2004): Social and Economic Factors affecting the Adoption of Soil and Water Conservation in West Usambara Highlands, Tanzania. – Land Degradation and Development 15(2): 99-114. https://doi.org/10.1002/ldr.606.
[108] 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 and Food Economics 1(13): 1-17. https://doi.org/10.1186/2193-7532-1-13.
[109] Tiamiyu, S. A., Eze, J. N., Yusuf, T. M., Maji, A. T., Bakare, S. O. (2015): Rainfall Variability and Its Effect on Yield of Rice in Nigeria. – International Letters of Natural Sciences 49: 63-68. https://doi.org/10.18052/www.scipress.com/ILNS.49.63.
[110] Tizale, C. Y. (2007): The dynamics of soil degradation and incentives for optimal management in the Central Highlands of Ethiopia. – PhD thesis. Faculty of Natural and Agricultural Sciences, University of Pretoria; Pretoria, South Africa.
[111] Tripathi, A., Mishra, A. K. (2017): Knowledge and passive adaptation to climate change: An example from Indian farmers. – Climate Risk Management 16: 195-207.
[112] Tsojon, J. D. (2017): Impact of Climate Change on Agricultural Production by Farmers in Taraba State, Nigeria. – International Journal of Entrepreneurial Development, Education and Science Research 4(1): 178-190.
[113] Ugwoke, F. O., Nnadi, F. N., Anaeto, C. F., Aja, O. O., Nwakwasi, R. N. (2012): Crop farmers' perception of and adaptation to climate change in Orlu Agricultural Zone of Imo State, Nigeria. – Journal of Agricultural Extension 16(2): 212-223.
[114] Ulimwengu, J., Funes, J., Headey, D., You, L. (2009): Paving the way for development: The impact of road infrastructure on agricultural production and household wealth in the Democratic Republic of Congo. – Paper presented at the 2009 Annual Meeting of the Agricultural and Applied Economics Association, Milwaukee, Wisconsin, July 26–28.
[115] Umar, S., Musa, M. W., Kamsang, L. (2014): Determinants of Adoption of Improved Maize Varieties among Resource-Poor Households in Kano and Katsina States, Nigeria. – Journal of Agricultural Extension 18(2): 196-205. https://doi.org/10.4314/jae.v18i2.20.
[116] Umeh, G. N., Chukwu, V. A. (2015): Farmers' perception and adaptive initiative to the effect of climate change on food production in Abakaliki Local Government Area of Ebonyi State, Nigeria. – International Journal of Science and Research 4(12): 417-422.
[117] Vedwan, N., Rhoades, R. (2001): Climate change in the Western Himalayas of India: A study of local perception and response. – Climate Research 9: 109-117. https://doi.org/10.3354/cr019109.
[118] Women Farmers Advancement Network (2014): Report of Focus Groups Discussions (FGD) Conducted With Farmers in Eight Villages from Four Northern States of Nigeria on Adaptation to Climate Change and Radio Listening Habits. – Report submitted to African Radio Drama Association. http://www.ardaradio.net/wp-content/uploads/2014/03/WOFAN-FGD-report-FINAL.pdf. Accessed 4th May, 2017.
[119] Wondimagegn, T., Lemma, S. (2016): Climate change perception and choice of adaptation strategies: Empirical evidence from smallholder farmers in east Ethiopia. – International Journal of Climate Change Strategies and Management 8(2): 253-270. https://doi.org/10.1108/IJCCSM-01-2014-0017.
[120] Yegbemey, R. N., Yabi, J. A., Aïhounton, G. D. B., Kokoye, S. E. H. (2014): Economic valuation of maize farming profitability under climate change adaptation in Benin, West Africa. – International Journal of Agricultural Resources Governance and Ecology 10(3): 269-280. https://doi.org/10.1504/IJARGE.2014.064006.
[121] Yesuf, M., Di Falco, S., Deressa, T., Ringler, C., Kohlin, G. (2008): The impact of climate change and adaptation on food production in low-income countries: evidence from the Nile Basin, Ethiopia. – International Food Policy Research Institute Discussion (IFPRI) Paper No. 00828. Environment and Production Technology Division, IFPRI, Washington D.C.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1703_70857112