# Gombe Journal of Geography and Environmental Studies (GOJGES)

**Vol. 2 N0.2 Dec. 2021**

**e-ISSN: 2714-321X**

**p-ISSN: 2714-3201**

http://www.gojgesjournal.com

Gombe Journal of Geography and Environmental Studies (GOJGES) Vol. 2 N0.2 Dec. 2021, e-ISSN: 2714-321X; p-ISSN: 2714-3201

# DETERMINANTS OF CLIMATE CHANGE ADAPTATION STRATEGIES AMONG SELECTED GRAIN FARMERS IN SOKOTO STATE, NIGERIA

**Ikpe Elisha**

[1]NECIT Nigeria Limited, Ogun State, Nigeria
**Author's email/phone**: elishabethy@gmail.com, +2348065665954

## Abstract

This study examined the determinant of climate change adaptation strategies among selected grain farmers in Sokoto State, Nigeria. The aim of the study was to find out what determines the choice of adaptation strategies among grain farmers in the study area. A systematic multi-stage sampling technique was used to select 6 Local Government Areas in Sokoto State. Seven hundred and eighty-three (783) grain farmers were purposively selected. Structured questionnaire and Focussed Group Discussion were used to obtain the required information from the selected grain farmers. Frequency, percentages, Relative Importance Index Technique and ordered logistic regression were used for data analysis and presentation. The results showed that 97% stated that it is possible to adapt to climate change. Multiple cropping, use of early maturing crop varieties and the use of organic manure are the most effective adaptation strategies in the study area among others. The logistic regression model analysis showed that age, gender, marital status, household size, educational level and years of climate change awareness of the farmers have no significant relationship with the choice of adaptation strategies in the study area. The study recommended that the various government agencies and Non-Governmental Organizations should embark upon continuous raising of awareness on climate change to the farmers; introduction of other emerging strategies; grain farmers should be encouraged to participate in agricultural extension services which will educate them on the effects of climate change and viable adaptation strategies.

**Key words:** Adaptation Strategies, Climate Change, Determinant, Multiple-cropping and Farmers

## 1. Introduction

Climate change can no longer be avoided. In fact, it is here. So far, the global mean temperature has increased by 0.3 to 0.6 degrees Celsius (°C) since late 19th century, and by about 0.2° to 0.3°C over the last 40 years, though the warming is not uniform globally (Climate Ark, 2007). Although it is still uncertain which effects climate change will have in different localities, most models indicate that they will be stronger near the equator and hence in Sub-Sahara Africa than in most other major regions on earth. Climate change refers to some observable variations in the climate system that are attributable to human (anthropogenic) activities, especially those that alter the atmospheric composition of the earth and ultimately lead to global warming (Ozor, 2009). IPCC (2007) defined climate change as a change in the state of the climate that can be identified (e.g. by using statistical tests) by changes in the mean and/or the variability of its properties, which persists for an extended period typically decades or longer. Climate change implies a new mean climatic state or climatic normal. An important point about climate change is the degree of variability that the change is

subjected to, as well as the duration and impact of such variability on man and the ecosystem (Udeh and Ikpe, 2022).
Adaptation to climate change has received a wide set of definitions, both by the scientific and the policy environments. Adapting to climate change entails taking the right measures to reduce the negative effects of climate change (or exploit the positive ones) by making the appropriate adjustments and changes. Adaptation is how we respond to (or prepare for) climate change, in order to reduce the negative impacts and take advantage of positive impacts. According to Oladipo (2010), adaptation, technically, is the appropriate way to deal with the unavoidable impacts of climate change. It is a mechanism to manage risks, adjust economic activity to reduce vulnerability and to improve business certainty. IPCC Third Assessment Report (TAR) (2000) defined adaptation as any adjustment in ecological, social, or economic systems in response to actual or expected climatic stimuli, and their effects or impacts.

Adaptation Strategies refers to the practice of identifying options or methods to adapt to climate change and evaluating them in terms of criteria such as availability, benefits, costs, effectiveness, efficiency and feasibility (IPCC 2001). To deal with the negative effects of climate change, there are a number of adaptation strategies that can be adopted in different situations. In general, the more adaptation there is, the less will be the impacts to which we will have to adjust, and the less the risk for which we will have to try and prepare. Adaptation has three possible objectives: to reduce exposure to the risk of damage; to develop the capacity to cope with unavoidable damages; and to take advantage of new opportunities (Akinnagbe and Irohibe, 2014). Conversely, the greater the degree of preparatory adaptation, the less may be the impacts associated with any given degree of climate change. Adaptation strategies present a complementary approach to mitigation. One important issue in agricultural adaptation to climate change is the manner in which farmers update their expectations of the climate in response to unusual weather patterns. Our reactions to the effect of climate change are measured in terms of adaptation strategies (Ikpe, 2014).

Climate change has affected the supply of sufficient food for the increasing population and has already altered the climatic characteristics which have led to a shift in crops cultivated in northern Nigeria (Odjugo, 2010b). As a result, the production of the principal crops like millet, maize, and sorghum in the past few decades have continued to decline while the population increases (Adamgbe and Ujoh, 2013). This scenario increases the risk of hunger and food insecurity thereby placing a heavy reliance on food aid at the national and household levels. Meeting this challenge requires drastic increase in the productivity of the principal staples crops especially millet, maize and sorghum which are very important staple food crop in Nigeria, and northern Nigeria in particular where these crops constitute the largest volume of grains produced and consumed. However, the yield of millet, maize and sorghum has continued to be very low particularly in Sokoto State which has a lot of potentials for grain production (Iheanacho, 2000).

Adaptation strategies may be completely new to a community or they may simply be an improvement on what the community is already familiar with. Adeshina and Odekunle (2011) suggested relevant adaptation strategies that can be adopted in addressing crop failures in the semi-arid region of Nigeria as follows: provision of accurate and timely weather forecasting; enhancing agricultural extension services; Adoption of drought-tolerant and early maturing varieties of crops; diversifying livelihoods to improve income; increasing and upgrading crop storage facilities; expanding and optimizing existing irrigation infrastructures; helping farmers to secure agricultural insurance and access to loan; multiple cropping system; planting of trees (afforestation) and agroforestry; control of pests - insects and birds; growing more cover crops like potatoes and melon to protect soils from erosion; stabilizing gullies and erosion sites. According to Ikpe (2021) grain farmers in Sokoto uses various adaptation strategies such as adaptation strategies such as planting of early maturing varieties, multiple cropping, use of organic and inorganic manure amongst others.

Sokoto State is located in the semi-arid region, where desertification is intensifying and rainfall is unreliable for crop production (Odjugo and Ikhuoria, 2003). Ojo (1991) reported that rainfall in Sokoto State as in other parts of the Sudan-Sahelian savannah ecological belt is very erratic and characterized by late onset and early cessation which could have adverse effect on effective crop cultivation if no viable adaptation strategies are put in place. Odjugo (2010) observed that this erratic rainfall pattern which lasts for only four months (June – September) and the climatic characteristics of Sokoto State favour the cultivation of grain crops. This short growing season affect crop yield and makes it difficult to cultivate crops that require longer growing season and high amount of rainfall; but favours grains like millet, sorghum and maize which have short growing season and require low amount of rainfall. However, the degree to which crop production is affected by climate change depends on the farmers' adaptation strategies (Rosenzwerig and Parry 1994). Therefore, adaptation strategies are very important in crop production in Sokoto State. Therefore, what informed the choice of adaptation strategies in Sokoto is the focus of this research.

The scope of the study in terms of content is to examine the most effective adaptation strategies adopted by the grain farmers and assess the factors that determine the choice of adaptation strategies in the study area. The selected grain crops are maize, millet and sorghum. These crops were selected because previous researches have shown that they constitute the major food base of Sokoto State. The study covered a period of forty-eight (48) years, from 1970 to 2017, since literature (Odjugo, 2010a) revealed that the impacts of climate change became evident in the study area from the early 1970s. This study will considerably improve the farmers' understanding of climate change and will significantly improve the farmers' adaptation strategies. The findings and recommendations of this research will go a long way to assist the grain farmers in understanding the climatic characteristics of the study area and how to respond to the current upsurge in climate change.

## 2. Study Area

Sokoto State is located in the North-West Sudano-Sahelian Savannah ecological belt of Nigeria between Latitudes 11° 03' and 13° 50' N of the Equator and Longitudes 4° 14' and 6° 40' E of the Greenwich Meridian (Abubakar, 2006). Its headquarters is at Sokoto. It has an area of 25,973 $Km^2$. It is bounded by Niger Republic to the north, Zamfara State to the east and south and Kebbi State to the west. Presently, the State has twenty-three (23) Local Government Areas (LGAs) (see Figure 1).

The climate of Sokoto is tropical continental and is dominated by two opposing air masses: tropical maritime and tropical continental. The tropical maritime is moist and blows from the Atlantic, while the tropical continental air mass, is dry and blows from the Sahara Desert. The rainy seasons are usually short, which is often within the ranges of four to five months (May/June to September/October). Owing to seasonal fluctuations, it could even drop to less than four months. Hence, evapotranspiration is usually high most especially in the dry season (Desanker and Magardza, 2001). The annual rainfall is between 500mm in the north and 800mm to the south. The showers rarely last long and are far from the regular torrential rain known in wet tropical regions. According to Odjugo (2010b), this short growing season affect crop yield and makes it difficult to cultivate crops that require longer growing season and high amount of rainfall; but favours grains like millet, sorghum and maize which have short growing season and require low amount of rainfall. On the whole, Sokoto is located in the semi–arid zone of Nigeria.

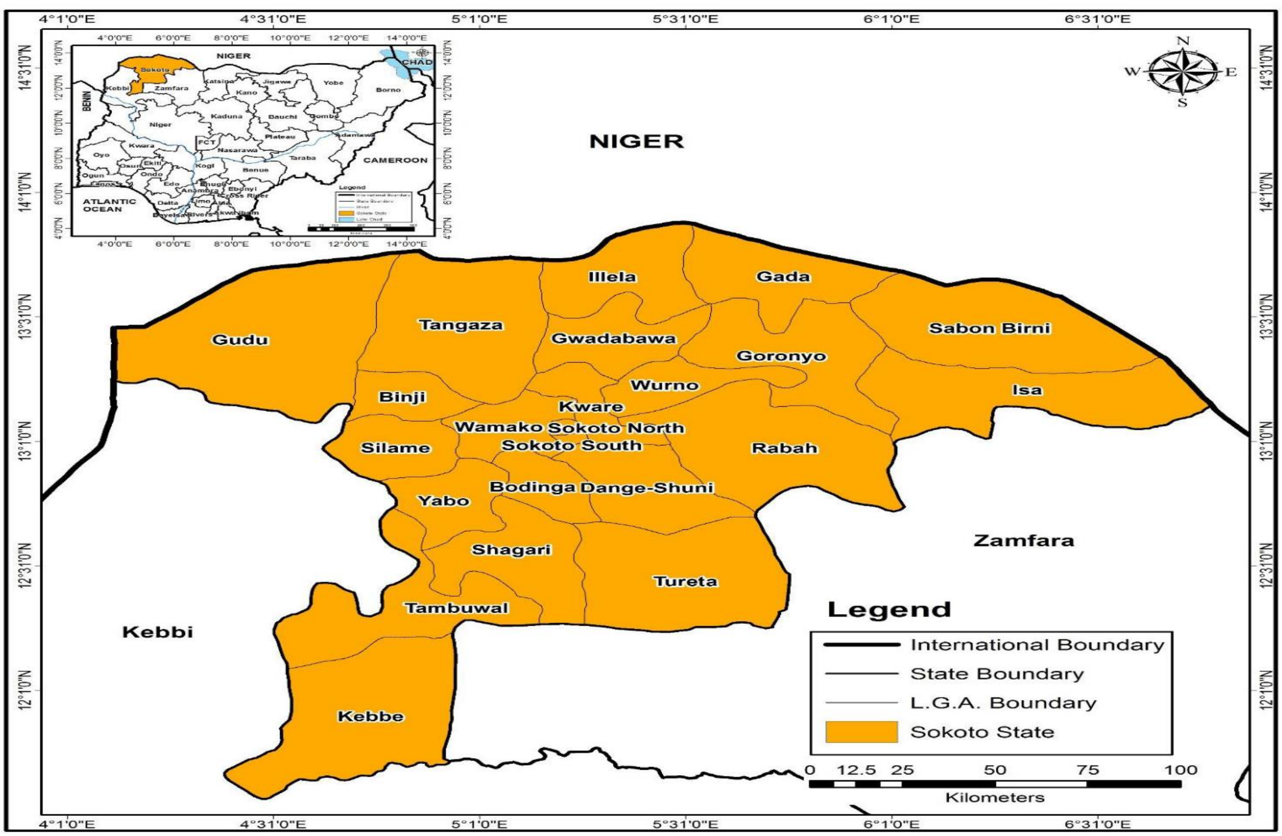


**Figure: 1. Sokoto State (Study Area)**
**Source**: Administrative Map of Sokoto State (2020).

The average temperature during the dry season is about 40.6ºC. However, maximum daytime temperatures are for most of the year generally under 40°C. The hottest months are February to April when daytime temperatures can exceed 45°C. Dwyer, Ghannoum, Nicotra and Caemmerer (2006) reported that high temperature affects C4 plants such as maize through its effects on the availability of water which is very important in the process of photosynthesis. From late October to February, during the dry season, the climate is dominated by the Harmattan wind blowing Sahara dust over the land. The dust dims the sunlight thereby lowering temperatures significantly and also leading to the inconvenience of dust everywhere in houses (Abubakar, 2006).

According to the 2006 census, Sokoto State has a population of 3,702,676 (NPC, 2009). It has a population density of 169.1 $Km^2$. Sokoto is mainly populated by Hausa, Fulani and the Zabarmawa people. A greater proportion of the inhabitants are rural dwellers (80 per cent) with only 20 per cent dwelling in the urban settlements (Abubakar, 2006). The people are mainly farmers and traders. Some inhabitants of the area also engage in artisanal fishing along rivers Sokoto and Rima as well as along some seasonal streams and ponds. In the more recent time, declining agricultural productivities and dwindling income from both agriculture, animal husbandry and fishing has compelled many people in the state to pursue some off-farm activities as a means of income diversification both during the wet and dry seasons (Iliya 1999).

## 3. Methodology

A multi-stage sampling technique was used for the study. In the first stage, the LGAs in the state were clustered into the three senatorial zones of Sokoto East, North and South.

In the second stage, systematic sampling technique was used to select the LGAs from the three senatorial zones of the State. For proper representation, the LGAs in each senatorial zone were arranged in alphabetical order and every third LGA was selected as a sampled LGA. Thus, the selected LGAs were Gwadabawa, Rabah, Kware, Tangaza, Kebbe and Tureta. The selected LGAs and their 1991 population figures are given in Table 1. The 1991 census figures were used for the reason that the population of the LGA were disaggregated into localities compared to the 2006 population census which was on LGAs and state levels.

Sample size was based on Krejcie and Morgan's (1970) sample size determination. It stated that where a population range is between 500,000 and 10,000,000 the sample size is 783 at 95% confidence level and 3.5% margin of error. 3.5% margin of error was chosen in order to minimise the margin of error as smaller sample sizes will yield larger margins of error. Therefore, since the 2018 projected total population of the study area falls within this range (1,179,980), the sample size of 783 was adequate and used for this research. Seven hundred and sixty-two (762) questionnaires were successfully returned. The farmers' responses to questions on adaptation strategies in form of Likert scale (3 = Always, 2= Rarely and 1= Not at all) were analysed using Relative Importance Index Technique (RII).

**Table 1: Selected Local Government Areas and their 1991 Population**

| Senatorial Zones | LGAs | 1991 Population Figures | Selected LGAs Population | 2018 Projected Population |
|---|---|---|---|---|
| | Gada | 147,915 | | |
| | Goronyo | 106,666 | | |
| | **Gwadabawa** | **142,996** | **142,996** | **321,441** |
| | Illela | 131,930 | | |
| **Sokoto East** | Isa | 182,224 | | |
| | **Rabah** | **91,119** | **91,119** | **204, 827** |
| | Sabon Birni | 152,994 | | |
| | Wurno | 100,964 | | |
| | Binji | 54,239 | | |
| | Gudu | 98,161 | | |
| | **Kware** | **116,139** | **116,139** | **261,069** |
| | Silame | 65,139 | | |
| **Sokoto North** | Sokoto North & South | 276,962 | | |
| | **Tangaza** | **128,119** | **128,119** | **287,999** |
| | Wammako | 140,137 | | |
| | Bodinga | 114,067 | | |
| | Dange Shuni | 152,446 | | |
| | **Kebbe** | **32,437** | **32,437** | **72,915** |
| **Sokoto South** | Shagari | 101,231 | | |
| | Tambuwal | 146,976 | | |
| | **Tureta** | **14,115** | **14,115** | **31,725** |
| | Yabo | 167,551 | | |
| **TOTAL** | **23** | **2,664,527** | **524,925** | **1,179,980** |

**Source:** Sokoto State Census Office, June 2018

In the third stage, systematic sampling technique was used to select wards from the six selected LGAs. For proper representation of the six (6) selected LGAs, the wards in each of the LGAs were arranged in alphabetical order and every third ward was picked from each LGA. A total of nineteen (19) wards were selected from the six sampled LGAs (three wards each from Gwadabawa, Rabah, Tangaza, Kebbe, Tureta and four wards from Kware LGAs).

The fourth stage involved the use of purposive sampling technique to determine the actual settlements from which respondents were drawn. Settlements already identified during the reconnaissance survey to have the highest number of grain farmers were chosen; one from each ward to make a total of nineteen (19) settlements.

In the fifth stage, purposive sampling technique was used to select the respondents from the sampled settlements. Grain farmers above thirty (30) years of age and who must have lived in the study area for at least twenty (20) years were identified through the "Sarkin Noma" (Head of the Farmers) and the village Heads. The reason for this decision was that those within the age bracket had the information needed about climate change in the area. Questionnaire was administered proportionately among the selected settlements.

Ordered logistic regression model was used to analyse the determinants of climate change adaptation strategies among the grain farmers in the study area. Age, gender, marital status, household size, education and years of residency of the farmers were used to show whether there is a significant relationship with the choice of adaptation strategies used in the study area.

## 4. Results and Discussion

### 4.1 Demographic characteristics of the grain farmers

The demographic characteristics of the grain farmers in the selected LGAs were identified, analyzed and presented in Table 2.

**Table 2: Demographic characteristics of the grain farmers (n=762)**

| Distribution of Grain Farmers by Sex | | |
|---|---|---|
| Variable | Respondents | Percentage |
| Male | 724 | 95 |
| Female | 38 | 5 |
| Distribution of the Grain Farmers by Age | | |
| Age | Respondents | Percentage |
| 30 – 39 | 200 | 26 |
| 40 – 49 | 215 | 28 |
| 50 – 59 | 206 | 27 |
| 60 – 69 | 137 | 18 |
| 70 & above | 4 | 1 |
| Religious Belief of the Grain Framers | | |
| Religion | Respondents | Percentage |
| Islam | 737 | 97 |
| Christianity | 25 | 3 |
| Marital Status of the Grain Farmers | | |
| Marital Status | Respondents | Percentage |
| Married | 685 | 90 |
| Divorced | 15 | 2 |
| Single | 42 | 5.5 |
| Widowed | 20 | 2.5 |
| Level of Education of the grain farmers | | |
| Level of Education | Respondents | Percentage |
| Primary | 122 | 16 |
| Secondary | 175 | 23 |
| Tertiary | 153 | 20 |
| No Formal Education at all | 312 | 41 |
| Household Size of the Grain Farmers | | |
| Household Size | Respondents | Percentage |
| 1 – 5 | 54 | 7 |
| 6 – 10 | 245 | 32 |
| 11 – 15 | 174 | 23 |
| 16 – 20 | 144 | 19 |
| 21 – 25 | 103 | 13.5 |
| 26 & above | 42 | 5.5 |
| Grain Farmers' Years of Residency | | |
| Years of Residency | Years of Residency | Years of Residency |
| 20 – 30 | 20 – 30 | 20 – 30 |
| 31 – 40 | 31 – 40 | 31 – 40 |
| 41 & above | 41 & above | 41 & above |

**Fieldwork, 2020**

A majority (95 per cent) of the sampled grain farmers were male, while 5 per cent were female. That majority of the farmers were male might be because, male have a dominant role to play in the family as household heads in providing the households basic needs such as food. It has been generally observed that in some parts of Africa, including Nigeria, womenfolk are often deprived of property rights owing to social barriers. As a result, they tend to have lesser capabilities and resources than men (Gbegeh and Akubuilo, 2013). This result agrees with the findings of Umar, Isah, Bello and Abubakar (2015) which reported that males dominate the agricultural workforce in Sokoto State with 99.1 per cent. According to Umar, Isah, Bello and Abubakar (2015), the high proportion of males to females in Sokoto State may be because religion and custom play crucial roles in the livelihoods of the people of the state.

The age distribution of the grain farmers as presented in Table 2, shows that 26 per cent fell within 30 – 39 years; 28 per cent fell within 41 – 49 years; 27 per cent fell within 51 - 59 years; 18 per cent fell within 61 – 69 years and 1 per cent fell within 70 years and above. Majority (74 per cent) of the grain farmers fell within the age of 41 and above. The average age of the farmers was 49 years.

Grain farmers who were above 30 years of age were purposively selected for the study which agrees with the study of Deressa, Hassan, Alemu, Yesuf and Ringler (2008), who argued that the age of the respondents represent experience on climate change. The older the respondent, the more experienced he was in knowledge of climate change and the more exposed to past and present climatic conditions over a longer horizon of his lifespan. These results imply that the sampled grain farmers in the study area were above the dependent age.

Contrary to this view, Adesina and Forson (1995) posited that older farmers could be more reluctant in taking risk and more resistant to changes than younger farmers. This may probably decrease the probability of undertaking new technologies as farmers will adopt and adapt new adaptation practices and technologies only when the switch from the old to new strategies offers additional gains in terms of either higher yield in production or lower risks, or both. Similarly, Marenya and Barrett (2007) noted that since younger farmers have inadequate experience, the cost of changing to new farming practices would be greatly minimized.
Table 2 further indicates that 97 per cent of the grain farmers are Muslims, while 3 per cent are Christians. The religious belief/faith of the respondents plays a major role on their perception of climate change and adaptation measures, especially on what causes climate change. According to Constable (2016), the influence of religion, especially the Christian principles was evident in her study area (Jamaica) in the assertion that climate change is an act of God, a punishment for man’s disobedience and a sign to end of the world.

Tucker and Grim (2001) proposed that nature is an integral component in many religious doctrines. They stated that religion provides explanations as to how the world was created, why; what humans’ role is within it and even when natural disasters occur. They further explained that religion serves to bridge humans to their environment by using rituals to mark the rhythm of seasonal changes, expressing gratitude for bountiful harvests and praying to keep away destructive natural forces. However, other studies e.g. Feder, Ahmad, Lee, Morgan, Singh, Smit and Charney, (2013) also note that there may be instances in which religious belief hinder adaptation to natural disaster

The result shows that 90 per cent of the sampled grain farmers were married, about 2 per cent were divorced, while 5.5 per cent were single and 2.5 per cent were widowed. These indicate that majority of the farming household members were married. This suggests that married household members have many mouths to feed, therefore, engage more in farming activities in order to provide food and income for the family than singled and divorced household members.

Table 2 presented that 16 per cent of the grain farmers attended primary school; 23 per cent attended secondary school; 20 per cent attended higher institution at various levels; 41 per cent had no formal education at all. The results further indicates that most of the respondents received various forms of education in the study area. This might have probably helped them in their farming activities. According to Enete, Madu, Mojekwu, Onyekuru, Onwubuya and Eze (2011), education has a positive and highly significant relationship between the farmers' level of education with the level of investment in indigenous and emerging climate change adaptation practices. This is to be expected as educated farmers may better understand and process information provided by different sources regarding new farm technologies, thereby increasing their allocation and technical efficiency.

Family labour is recognized as a major source of labour supply in smallholder grain crop production in most parts of Africa, including Nigeria. This comprises the labour of all males, females including children in a household, who contribute their mental and physical efforts to the household holdings. More so, Table 2 shows the family size distribution of respondents. The result show that majority (32 per cent) of the grain farmers are within the household size of 6 - 10, followed by 23 per cent which fell within the household size of 11 to 15; 19 per cent are within the range of 16 to 20 household size; 13.5 per cent fell within the range of 21 to 25 household size, while 7 per cent fell within the household size of 1 to 5 and 5.6 per cent fell within the household size of 26 household members and above.

The result further shows that the average household size was 14 persons. This indicates that most of the respondents have larger household size which enables them to receive various forms of assistance from both their wives and children on the farm. This large family size to some extent translate to higher use of family labour in the farming activities in the study area. According to Iheanacho (2000), household size is an important factor in traditional agriculture and affects farm labour sources and supply in northern Nigeria.

### 4.2 Adapting to Climate Change

The results of the possibility of farmers' adapting to climate change are presented in Fig. 2.

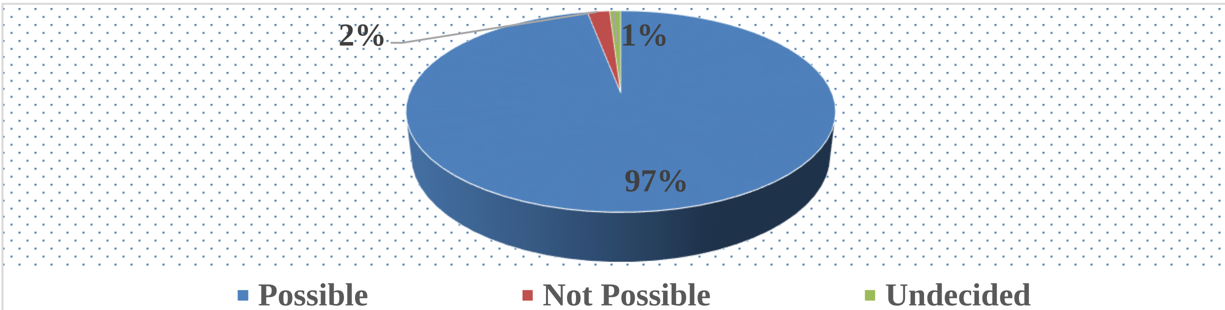


**Figure 2: Possibility of Adapting to Climate Change**

Figure 2 shows that 97 per cent of the farmers stated that it is possible to adapt to climate change, 2 per cent stated that it is not possible to adapt to climate change in the study area, while 1 per cent were undecided. This result corroborated the findings of Adeshina and Odekunle (2011) which stated that through adaptation strategies it is possible for farmers to adapt to the effect of climate change in the semi-arid regions of Nigeria. Ikpe (2014) further stated that through viable adaptation strategies, farmers have been able to effectively cultivate grains in Goronyo, Sokoto State. The results also agree with the findings of Ejeh (2014) which reported that farmers in Kano State are coping with the effects of climate change through various adaptation strategies.

Table 4 shows twenty-five indigenous and emerging strategies for climate change adaptation used by farmers in the study area. The farmers' responses to questions on adaptation strategies in form of Likert scale (3 = Always, 2= Rarely and 1= Not at all) were analysed using Relative Importance Index Technique (RII). The contribution of each of the adaptation strategies used by the farmers was examined; and the ranking of the attributes in terms of their effectiveness as perceived by the respondents was done by the use of Relative Importance Index (RII) (Idoma, 2016, Muhwezi and Otim, 2014). The higher the value of RII, the more important or effective was the adaptation strategy to climate change in the study area.

**Table 3: Adaptation Strategies used by Grain Farmers in the Study Area**

| S/N | Adaptation Strategies | Always | Rarely | Not at all | RII | Rank |
|---|---|---|---|---|---|---|
| 1 | Early and late planting | 615 | 125 | 22 | 0.9 | 2 |
| 2 | Soil conservation and water | 114 | 322 | 326 | 0.6 | 16 |
| 3 | Use of organic manure | 644 | 78 | 40 | 0.9 | 2 |
| 4 | Use of inorganic fertilizer | 547 | 145 | 70 | 0.9 | 2 |
| 5 | Planting pest and disease resistant crop | 535 | 172 | 55 | 0.9 | 2 |
| 6 | Crop varieties that are well acclimatized | 612 | 136 | 14 | 0.9 | 2 |
| 7 | Draining of wetland for crop cultivation | 43 | 45 | 674 | 0.4 | 23 |
| 8 | Contour ploughing around farmland | 133 | 102 | 527 | 0.5 | 18 |
| 9 | Planting of cover crops | 565 | 156 | 41 | 0.9 | 2 |
| 10 | Use of irrigation system/water storage | 125 | 174 | 463 | 0.5 | 18 |
| 11 | Reforestation/Afforestation | 18 | 70 | 674 | 0.4 | 23 |
| 12 | Use of herbicide, insecticide etc. | 590 | 98 | 74 | 0.9 | 2 |
| 13 | Increase in number of weeding | 344 | 262 | 156 | 0.7 | 12 |
| 14 | Use of early maturing crop varieties | 678 | 80 | 4 | 0.9 | 2 |
| 15 | Preservation of seedlings for planting | 600 | 123 | 39 | 0.9 | 2 |
| 16 | Use of weather-resistant variety | 590 | 156 | 16 | 0.9 | 2 |
| 17 | Reducing access to erosion prone area | 72 | 180 | 510 | 0.5 | 18 |
| 18 | Mixed farming practices | 281 | 289 | 192 | 0.7 | 12 |
| 19 | Use of recommended planting distance | 165 | 97 | 500 | 0.5 | 18 |
| 20 | Changing the timing of land preparation | 266 | 289 | 207 | 0.7 | 12 |
| 21 | Changing harvesting dates | 223 | 252 | 287 | 0.6 | 16 |
| 22 | Out migration from climate risk areas | 53 | 121 | 588 | 0.4 | 23 |
| 23 | Use of windbreaks/shelter belts | 39 | 211 | 512 | 0.5 | 18 |
| 24 | Loans, grants and subsidies | 246 | 307 | 209 | 0.7 | 12 |
| 25 | Mixed cropping | 744 | 16 | 2 | 1.0 | 1 |

**Source:** Field work 2018

The result revealed that out of the 25 adaptive strategies, 11 were "highly adopted" by the farmers as reflected in their RII scores of 0.9 and 1.0. These strategies for climate change adaptation included early and late planting, use of organic manure, use of chemical fertilizer, planting of pest and disease resistant crop that are well acclimatized, planting of cover crops, use of early maturing seeds, preservation of seeds; use of weather resistant varieties and mixed cropping systems (Table 3). Soil conservation and water, contour ploughing around farmland, use of irrigation system, use of chemicals like herbicide, increase in number of weeding, use of recommended planting distance, changing harvest dates, and access to loans, grants and subsidies were "rarely adopted". The RII ranked adaptation strategies shows that mixed cropping was ranked first among the 25 adaptation strategies in the study area. According to Iheanacho (2000), multiple cropping is the dominant cropping system used by small-holder farmers in the drought prone, semi-arid tropics of West Africa. The system is commonly practiced in northern

Nigeria where cereals (maize, millet, and sorghum), legumes (beans) and nuts (groundnuts) are grown together. The advantages of mixing crops with varying attributes are in terms of maturity periods (e.g. maize and beans), drought tolerance (maize, millet and sorghum), input requirements (cereals and legumes) and the end users of the product (e.g. maize as food and sunflower for cash).

**Table 4: Multiple Cropping Adaptation and Socio-economic Activities of the Farmers**

| Multiple Cropping | | B | Std. Error | Wald | Df | Sig. |
|---|---|---|---|---|---|---|
| **Socio-economic characteristics** | Intercept | -49.978 | 4695.370 | .000 | 1 | .992 |
| | 30 – 40 years | 15.862 | 1374.952 | .000 | 1 | .991 |
| | 41 – 50 years | 15.829 | 1374.952 | .000 | 1 | .991 |
| **Age of the Farmers** | 51 – 60 years | 15.822 | 1374.952 | .000 | 1 | .991 |
| | 61 – 70 years | 15.623 | 1374.950 | .000 | 1 | .991 |
| **Gender** | Male | 16.355 | .000 | . | 1 | .991 |
| **Marital Status** | Married | 15.782 | 4489.544 | .000 | 1 | .997 |
| | Divorced | 17.461 | 4489.544 | .000 | 1 | .997 |
| | Single | 17.077 | 4489.544 | .000 | 1 | .997 |
| **Size of Household** | 1 – 5 | .318 | 1.489 | .046 | 1 | .831 |
| | 6 – 10 | .452 | 1.149 | .155 | 1 | .694 |
| | 11 – 15 | -1.534 | 1.453 | 1.115 | 1 | .291 |
| | 16 – 20 | -.934 | 1.268 | .543 | 1 | .461 |
| | 21 – 25 | -.416 | 1.202 | .120 | 1 | .730 |
| **Educational Qualification** | Primary | -16.306 | 1706.885 | .000 | 1 | .992 |
| | Secondary | -.487 | 1.234 | .156 | 1 | .693 |
| | Tertiary | -16.783 | 1908.564 | .000 | 1 | .993 |
| | Koranic | -.061 | 1.162 | .003 | 1 | .958 |
| **Years of Residency** | 20 – 30 years | .076 | 1.236 | .004 | 1 | .951 |
| | 31 – 40 years | -.608 | 1.254 | .235 | 1 | .628 |

**Source:** Field Work 2018

**Table 5: Use of Early Maturing Varieties and Socio-economic Activities of the Farmers**

| Early Maturing Crop Varieties | | B | Std. Error | Wald | df | Sig. |
|---|---|---|---|---|---|---|
| **Socio-economic characteristics** | **Intercept** | -48.332 | 5379.932 | .000 | 1 | .993 |
| | 31 – 40 years | 16.034 | 1332.336 | .000 | 1 | .990 |
| | 41 – 50 years | 15.911 | 1332.336 | .000 | 1 | .990 |
| **Age** | 51 – 60 years | 15.712 | 1332.338 | .000 | 1 | .990 |
| | 61 – 70 years | 14.912 | 1332.336 | .000 | 1 | .990 |
| **Gender** | Male | 15.672 | .000 | . | 1 | 990 |
| | Female | $0^c$ | . | . | 0 | . |
| **Marital Status** | Married | 15.526 | 5212.346 | .000 | 1 | .998 |
| | Divorced | 17.015 | 5212.346 | .000 | 1 | .997 |
| | Single | 16.538 | 5212.346 | .000 | 1 | .997 |
| | 1 – 5 | .154 | 1.520 | .010 | 1 | .919 |
| | 6 – 10 | .297 | 1.175 | .064 | 1 | .800 |
| **Household Size** | 11 – 15 | -2.043 | 1.470 | 1.931 | 1 | .165 |
| | 16 – 20 | -1.122 | 1.291 | .756 | 1 | .385 |
| | 20 – 25 | -.847 | 1.223 | .480 | 1 | .489 |
| **Educational Qualification** | Primary | -16.706 | 1643.535 | .000 | 1 | .992 |
| | Secondary | -.789 | 1.261 | .392 | 1 | .531 |
| | Tertiary | -17.464 | 1479.028 | .000 | 1 | .991 |
| | Koranic | -.474 | 1.192 | .158 | 1 | .691 |
| **Years of Residency** | 20 – 30 years | -.244 | 1.241 | .039 | 1 | .844 |
| | 31 – 40 years | -.821 | 1.260 | .424 | 1 | .515 |

**Source:** Field Work 2018

**Table 6: Use of Organic Manure and Socio-economic Activities of the Farmers**

| Use of Organic Manure | | B | Std. Error | Wald | Df | Sig. |
|---|---|---|---|---|---|---|
| **Socio-economic characteristics** | Intercept | -49.223 | 5069.039 | .000 | 1 | .992 |
| | 31 – 40 years | 15.781 | 1391.580 | .000 | 1 | .991 |
| | 41 – 50 years | 15.589 | 1391.580 | .000 | 1 | .991 |
| **Age:** | 51 – 60 years | 15.673 | 1391.580 | .000 | 1 | .991 |
| | 61 – 70 years | 15.588 | 1391.578 | .000 | 1 | .991 |
| **Gender** | Male | 15.909 | .000 | . | 1 | . |
| | Female | $0^c$ | . | . | 0 | . |
| **Marital Status** | Married | 15.705 | 4874.285 | .000 | 1 | .997 |
| | Divorced | 17.443 | 4874.285 | .000 | 1 | .997 |
| | Single | 16.685 | 4874.285 | .000 | 1 | .997 |
| **Size of Household** | 1 – 5 | -.201 | 1.484 | .018 | 1 | .892 |
| | 6 – 10 | .310 | 1.158 | .072 | 1 | .789 |
| | 11 – 15 | -1.930 | 1.459 | 1.751 | 1 | .186 |
| | 16 – 20 | -1.022 | 1.277 | .640 | 1 | .424 |
| | 21 – 25 | -.465 | 1.211 | .148 | 1 | .701 |
| **Educational Qualifications** | Primary education | -15.947 | 1634.236 | .000 | 1 | .992 |
| | Secondary education | -.256 | 1.227 | .044 | 1 | .835 |
| | Tertiary education | -16.971 | 1492.662 | .000 | 1 | .991 |
| | Koranic education | .042 | 1.156 | .001 | 1 | .971 |
| **Years of Residency** | 20 – 30 years | -.192 | 1.233 | .024 | 1 | .876 |
| | 31 – 40 years | -.864 | 1.254 | .475 | 1 | .491 |

**Source:** Field Work 2018

## 4.3 Age of the Grain Farmers and Adaptation Strategies

As to whether age was a factor that determined the choice of multiple cropping, use of early maturing crop varieties and the use of organic manure as adaptation strategies in the study area, the result revealed that age did not play a significant role in the choice of adaptation strategies. Findings from Tables 5,6 and 7 revealed that a farmer who was between 30 to 40 years were 15.862 times more likely to adopt multiple cropping system, 16.034 times more likely to adopt the use of early maturing crop varieties and 15.781 times more likely to adopt the use of organic manure than a farmer who was over 60 years; and farmers who were 41 – 50 years were 15.829, 15.911 and 15.589 times as likely to adopt multiple cropping, use of early maturing crop varieties and the use of organic manure respectively as adaptation strategies than farmers who were over 61 years of age (Tables 4,5and 6).

That age is negatively correlated to the probability of choosing and using multiple cropping, use of early maturing crop varieties and the use of organic manure as adaptation strategies to climate change in Sokoto State shows that young grain farmers have a longer planning horizon and have ability to cope with climate change and climate variability risks in grain crop production than the older counterparts. This result agrees with the findings of Alexander and Mellor (2005) which found that GM corn adoption increased with age for younger farmers as they gain experience and increase their stock of human capital but declines with age for those farmers closer to retirement. Also, the work of Hassan and Nhemachena (2008) found that age is inversely related to the probability of choosing and using mono crop-livestock under irrigation in Southern Africa. Similar result was discovered by Bayard, Jolly and Shannon (2006) that the age of farmers has a negative influence on adoption of rock walls as soil management practice in Fort- Jacques in Haiti and on adoption of rbST in Connecticut Dairy Farms (Foltz and Chang, 2001). From this, it seems experience is measured by whether the grain farmer is a specialist grain farmer and not basically on age. It is assumed that the younger the farmer, the more likely he/she is to adopt innovations early in his/her respective life cycle (Rogers, 1995). According to Enete, Madu, Mojekwu, Onyekuru, Onwubuya and Eze (2011), older farmers are more likely to be risk averse, especially regarding climate change matters, than younger ones as age may likely endow the farmers with the requisite experience that will enable them make better assessment of the risks involved in climate change adaptation investment decisions. They further noted that older farmers have more experience and are able to take healthier production decisions than younger ones. Older farmers may have a shorter time horizon and be less likely to invest in novel technologies.

### 4.4 Gender of the Grain Farmers and Adaptation Strategies

Result on gender revealed that though insignificant (0.991, 0.990 and 0.991 for multiple cropping, use of early maturing crop varieties and the use of organic manure respectively) as presented in Tables 5,6 and 7 in influencing adoption of climate change adaptation in Sokoto State, the male farmers were 16.355, 15.672 and 15.909 times as likely to adopt multiple cropping, use of early maturing crop varieties and the use of organic manure adaptation strategies respectively as their female counterparts. This indicated that male grain farmers in the study area were more likely to adopt climate change adaptation.

The result agrees with Otitoju (2013) which reported that male farmers have a higher probability of choosing, using and intensifying multiple cropping, use of early maturing crop varieties and the use of organic manure, than their female counterparts among the whole sampled grain farmers in the study area. The result further disagreed with the study of Gbetibouo (2009) which reported that female farmers in South Africa are more likely to take up climate adaptation measures than their male counterpart.

Correspondingly, the following previous studies found that male household heads have a positive relationship in adoption of manure and intensity of its use and fertilizer adoption and intensity of its use of farm technology adoption in Kenya (Ogada, Nyangena and Yesuf, 2010).

### 4.5 Marital Status of the Grain Farmers and Adaptation Strategies

On marital status of the grain farmers, findings revealed that marital status did not play a significant role in adopting multiple cropping, use of early maturing crop varieties and the use of organic manure as adaptation strategies (0.997, 0.998 and 0.997 respectively). The result as presented in Table 4 means that a farmer who was single increases his/her likelihood of adopting either multiple cropping, use of early maturing crop varieties and the use of organic manure 15.782, 15.526 and 15.705 times respectively than a married grain farmer. This indicates that a single farmer was more likely to adopt multiple cropping, uses of early maturing crop varieties and the use of organic manure as adaptation strategies than a farmer who had divorced. More so, a farmer who was single was more likely to adopt multiple cropping, use of early maturing crop varieties and the use of organic manure 17.077, 16.538 and 16.685 times respectively than a farmer that was widowed.

**4.6 Household Size of the Grain Farmers and Adaptation Strategies**

The result shows that there was a negative relationship between household size and the probability of choosing multiple cropping, uses of early maturing crop varieties and the use of organic manure as adaptation strategies among grain farmers in Sokoto State (Tables 4, 5 and 6).. That there is a negative relationship between household size and the probability of choosing multiple cropping, uses of early maturing crop varieties and the use of organic manure as adaptation strategies as adaptation strategies among grain farmers in Sokoto State implies that the larger grain farmers' families are able to choose these main climate change adaptation strategies than the smaller families. This result agrees with the finding of Birungi and Hassan (2010) which found out that household size is negatively related to adoption of fallow as land management technology in Uganda. The result disagrees with the findings of Mabe, Sienso and Donkoh (2014) which reported a significant relationship between the household size of the farmers and their adoption of adaptation strategies. They reiterated that farmers with large household sizes have enough family labour to complete planting of crops within a very short period to prevent the possibility of planting late which might be affected by the changing climatic condition.

**4.7 Education Level of the Grain Farmers and Adaptation Strategies**

Education of the grain farmers has an inverse relationship with the probability of a farmer choosing and using multiple cropping, use of early maturing crop varieties and the use of organic manure as adaptation strategies in the study area (Table 4.)

The inverse relationship between education and these adaptation strategies is contrary to expectations that better educated grain farmers are more likely to choose and use climate change adaptation strategies in the study area. It could be probably deduced that the education acquired by these farmers is not formal agricultural education; it is assumed that a farmer with formal agricultural education will be more likely to innovate due to the higher associated skill level. This result agrees with the finding of Birungi and Hassan (2010) that found out that education was negatively related to adoption of terracing and inorganic fertilizer as land management practices in Uganda; and also, the study of Bayard et al. (2006) that found that education is inversely related to adoption of rock walls as soil conservation practice in Forte-Jacques.

That there is no significant relationship between education and adaptation strategies disagrees with the findings of Enete et. al. (2011) which reported a positive and highly significant relationship between the farmers' level of education with the level of investment in indigenous climate change adaptation practices. This is to be expected as educated farmers may better understand and process information provided by different sources regarding new farm technologies, thereby increasing their allocation and technical efficiency.

**4.9 Level of Climate Change Awareness and Adaptation Strategies**

Level of climate change awareness has a negative relationship with the probability of choosing and using multiple crop varieties, use of early maturing crop varieties and the use of organic manure among the grain farmers in the study area (Tables 4, 5 and 6). This result is contrary to the findings of Enete et. al. (2011) which reported that there is a positive and significant relationship between the farmers' level of awareness of climate change effects with the adoption and investment in indigenous climate change adaptation practices. This underscores the importance of awareness in adaptation measures. The awareness of climate problems and the potential benefits of taking action is an important determinant of adoption of agricultural technologies (Hassan and Nhemachena, 2008). Maddison (2006) argued that farmer's awareness of change in climate attributes (temperature and precipitation) is important to adaptation decision making. For example, Araya and Adjaye (2001) reported that farmers awareness and perceptions of soil erosion problem as a result of changes in climate, positively and significantly affect their decisions to adopt soil conservation measures.

## 5. Conclusion

This study has examined the determinant of climate change adaptation strategies among selected grain farmers in Sokoto State, Nigeria. The research established that mixed cropping, use of improved seed varieties and use of organic manure are perceived to be the most effective adaptation strategies in the study area. Results showed that farmers in the study area are aware of climate change. The study also revealed that age, gender, marital status, household size and the educational level of the farmers do not influence the choice of adaptation strategies.

## 6. Recommendations

In view of the above there is the need for the government and NGOs to continue supporting the grain farmers to increase their adaptation capacities by providing credit/loan through micro finance institutions as lack of capitals is a serious constrain to adaptation sustainability. Succour could also come by provision of grants, subsidies and agricultural inputs to the farmers; use of farm extension workers for agricultural education and updates; provision of improved seed varieties and the development of sustainable irrigation project to complement rainfall and for dry season farming in the study area.

## References

Abubakar, M. G. (2006). An Investigation of Ground Water Potential of Gada Town, Sokoto State using Vertical Electrical Sounding. An unpublished Msc. thesis, Department of Geography, Ahmadu Bello University, Zaria, Nigeria.

Adamgbe, E. M. and Ujoh, F. (2013). Effect of Variability in Rainfall Characteristics on Maize Yield in Gboko, Nigeria, *Journal of Environmental Protection*, 4: 881 –

887. Available at: http://dx.doi.org/10.4236/jep.2013.49103.

Adeshina, F. A. and Odekunle, T. O. (2011). Climate Change and Adaptation in Nigeria: Some Background to Nigeria's Response – III. International Conference on Environmental and Agriculture Engineering (IPCBEE) 15, 146-154.

Akinnagbe, O. M. and Irohibe, I. J. (2014). Agricultural Adaptation Strategies to Climate Change Impacts in Africa: A Review. *Bangladesh Journal of Agricultural Resources*, 39(3): 407-418.

Alexander, C. and Mellor, T. V. (2005). Determinants of Corn Rootworm Resistant Corn Adoption in Indiana, Journal of Agricultural BioForum, 8(4), 197-204.

Araya, B. and Adjaye, J. A. (2001). Adoption for Farm Level Soil Conservation Practices in Eritrea. *Indian Journal of Agricultural Economics*, 56: 239-252.

Ayoade, J. O. (2003). Climate Change. Ibadan: Vantage Publishers, 45-66.

Bayard, B., Jolly, C. M. and Shannon, D. A. (2006). The Adoption and Management of Soil Conservation Practices in Haiti: the case of rock walls. Agricultural Economics Review, 7(2), 28- 39

Birungi, P. and Hassan, R. (2010). Poverty, Property Rights and Land Management in Uganda. *African Journal of Agricultural and Resource Economics*, 4(1), 48-69.

Climate Ark (2007). Climate Change and Global Warming Portal. The Original Bio-centric Climate Science, Policy & Advocacy Search Engine. Ecological Internet, Retrieved from http://www.climateark.org/overview/14.asp. Accessed on January 20th 2017

Constable, A. (2016). A Gender Analysis of Climate Change Perceptions and Adaptation in Sherwood Content, Jamaica. An unpublished M.sc Thesis submitted to the Department of Geography and Geology, Faculty of Science and Technology, University of the West Indies, Jamaica.

Deressa, T., Hassan, R. M., Alemu, T., Yesuf, M., and Ringler, C. (2008). Analysing the Determinants of Farmers' Choice of Adaptation Methods and Perceptions of Climate Change in the Nile Basin of Ethiopia, IFPRI Discussion Paper 00798. International Food Policy Research Institute.

Desanker, P. and Magadza, C. (2001). *Climate Change 2001 Impacts, Adaptation, and Vulnerability.* IPCC, Cambridge University Press. Contribution of working group II. 494-499, 517-524.

Dwyer, S. A., Ghannoum, O., Nicotra, A., and Caemmerer, S. V. (2006). High Temperature Acclimation of C4 Photosynthesis. Research School of Biological Sciences and School of Botany and Zoology, Australian

National University, Western Sydney, South Penrith DC; Australia

Ejeh, U. L. (2014). Assessment of Farmers' Perception and Adaptation Strategies to Climate Change in Kano State, Nigeria. An unpublished PhD Dissertation, Department of Geography, Ahmadu Bello University, Zaria, Nigeria.

Enete, A. A., Madu, I. I., Mojekwu, J. C., Onyekuru, A. N., Onwubuya, E. A. and Eze, F. (2011). Indigenous Agricultural Adaptation to Climate Change: Study of Southeast Nigeria. Published by African Technology Policy Studies Network, Nairobi, Kenya.

Feder, A., Ahmad, S., Lee, E. J., Morgan, J. E., Singh, R., Smith, B. W. and Charney, D. S. (2013). Coping and PTSD Symptoms in Pakistani Earthquake Survivors: Purpose in Life, Religious Coping and Social Support. *Journal of Affective Disorders*, *147*(1–3), 156–163.

Foltz, J. and Chang, H. (2001). The Adoption and Profitability of rbST on Connecticut Dairy farms (Research Report No. 55). Connecticut: University of Connecticut, Food Marketing Policy Center, Department of Agricultural and Resource Economics.

Gbegeh, B. and Akubuilo, C. (2013). Socioeconomic Determinants of Adoption of yam Minisett by Farmers in Rivers State, Nigeria. Wudpecker Journal of Agricultural Research, 2(1):033 - 038,

Gbetibouo, G. A. (2009). Understanding Farmers Perceptions and Adaptations to Climate Change and Variability: the case of the Limpopo Basin, South Africa (IFPRI discussion paper No. 00849) retrieved from http://www.ifpri.org/pubs/dp/IFPRIDP00849.pdf.

Hassan, R. M. and Nhemachena, C. (2008). Determinants of African Farmers' Strategies for Adapting to Climate Change: Multinomial Choice Analysis, African Journal of Agricultural and Resource Economics 2(1): 83-104.

Idoma, K. (2016). Analysis of Nomadic Pastoralists' Coping Strategies to Climate Variability in Katsina and Zamfara States, Nigeria. An unpublished PhD Thesis, Department of Geography and Environmental Sciences, Ahmadu Bello University, Zaria, Nigeria.

Iheanacho, A. C. (2000). Economics of Millet Production under differnet Cropping Systems in Borno State of Nigeria. An unpublished PhD thesis, Department of agricultural Economics and Rural Sociology, Ahmadu Bello University, Zaria.

Ikpe, E. (2014). Adaptation Strategies to Climate Change among Grain Farmers in Goronyo Local Government Area of Sokoto State, Nigeria. An unpublished M.Sc Thesis, Department of Geography, Ahmadu Bello University, Zaria, Nigeria.

Intergovernmental Panel on Climate Change (IPCC) (2000). Emissions Scenarios. Special Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA

Intergovernmental Panel on Climate Change (IPCC) (2001). Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the International Panel on Climate Change IPCC Cambridge. Cambridge University Press.

Intergovernmental Panel on Climate Change (IPCC) (2007). Climate Change 2007: Impacts, Adaptation, and Vulnerability. Contribution of working Group II to the fourth Assessment report of the Intergovernmental Panel on Climate Change (Parry, Martin L., Canziani, Osvaldo F., Palutikof, Jean P., Vander Linden, Paul J., and Hanson, Clair E.) (eds.) Cambridge University Press, Cambridge, U.K.

Krejcie, R. V. and Morgan, D. W. (1970). Determining Sample Size for Research Activities. Journal of Educational and Psychological Measurement. 30(2), 607-610.

Mabe, F. N., Sienso, G. and Donkoh, S. (2014). Determinants of Choice of Climate Change Adaptation Strategies in Northern Ghana, *Journal of Research in Applied Economics*, 6(4): 75-94.

Marenya, P. and Barrett, C. (2007). Household-level Determinants of Adoption of Improved Natural Resources Management Practices among Smallholder Farmers in Western Kenya. *Food Policy*, 32(2), 515–536.

National Population Commission, NPC. (1991). National Population Commission Census Report, Federal Republic of Nigeria.

National Population Commission, NPC. (2009). National Population Commission Census Report, Federal Republic of Nigeria.

Odjugo, P. A. O. (2010). General Overview of Climate Change Impacts in Nigeria, Journal of Human Ecology, 29(1), 47-55.

Odjugo, P. A. O. (2010b). Adaptation to Climate Change in the Agricultural Sector in the Semi-Arid Region of Nigeria. Paper presented at the 2nd International Conference: Climate Sustainability and Development in Semi-Arid Regions, Fortaleza-Ceara, Brazil.

Odjugo, P. A. O. and Ikhuoria, A. I. (2003). The Impacts of Climate Change and Anthropogenic Factors on Desertification in the Semi-arid region of Nigeria, Global Journal of Environmental Science, 2(2): 118-126.

Ogada, M. J., Nyangena, W. and Yesuf, M. (2010). Production Risk and Farm Technology Adoption in the Rain-fed Semi-Arid Lands of Kenya, African

Journal of Agricultural and Resource Economics, 4(2), 159-174.

Ojo, O. (1991). Overcoming Hunger: The Challenges in Meteorological Hazards and Agricultural Development. In Oguntoyinbo, J. S., Omotosho, J. B. and Ekuwem, E. E. (Eds.) Meteorological Hazards and Development, Lagos, Kola Okanlawon Publishers, 22-36.

Oladipo, E. O. (2010). Climate Change and Sustainable Livelihoods: Greening Options of Nigeria; In Report of the First National Environment; Sustainable Greening the Environment for Sustainable Economic Development (20th-21st Oct.), Lagos.

Otitoju, M. A (2013). The Effects of Climate Change Adaptation Strategies on Food Crop Production Efficiency in Southwestern Nigeria. A PhD unpublished Dissertation, Department of Agricultural Economics, University of Nigeria, Nsukka.

Ozor, N. (2009). Understanding Climate Change: Implications for Nigerian Agriculture, Policy and Extension. Paper presented at the National Conference on Climate Change and the Nigeria Environment. Organized by the Department of Geography, University of Nigeria, Nsukka, 29 June-2nd July.

Rogers, E. (1995). Diffusion of Innovations (4th ed.). New York: The Free Press.

Rosezwerig, C. and Parry, M. C. (1994). Potential Impact of Climate Change on World Food Supply, Journal of Nature, 307: 133-138.

Tucker, M. E., and Grim, J. A. (2001). Introduction: The Emerging Alliance of World Religions and Ecology. Daedalus, 130(4), 1–22.

Udeh, E. L. and Ikpe Elisha (2022). Relationship Between Rainfall Variability and Sorghum Yield in Potiskum Local Government Area of Yobe State, Nigeria. Journal of Geography and Regional Planning, Vol. 15(1), 10 - 17.

Umar, I., Isah, A. D., Bello A. G. and Abubakar, B. Z. (2015). Farmers' Perception on Climate Change in Sokoto State, Nigeria, African Journal of Agricultural Research, 10(11), 1288-1294.