



## Climate Change and Global Warming Effects: Implications for Agriculture and Food Security In Nigeria

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### ABSTRACT

This paper examines the economic impact of climate change on food security and agricultural productivity in Nigeria. It examines the impact on the basic components of food security; availability, accessibility, affordability, preference, utilization and nutritional value and food system stability. Climate change is an adverse environmental phenomenon that is causing enormous concern all over the world. It refers to some anomalies in the climate system that is a result of human activities. These anomalies include increase in the concentration of GHGs, HFCs and CFCs in earth's atmosphere, which will ultimately lead to global warming. In fact, global warming has already begun, as earth's temperature has risen between 0.4 and 0.8°C in the last 100 years. Nigeria is one of the world's most densely populated countries with a population of 180 million people, half of which are considered to be in abject poverty. Nigeria is recognized as being vulnerable to climate change. Climate change and global warming if left unchecked will cause adverse effects on livelihoods in Nigeria, such as crop production, livestock production, fisheries, forestry and post-harvest activities, because the rainfall regimes and patterns will be altered, floods which devastate farmlands would occur, increase in temperature and humidity which increases pest and disease would occur and other natural disasters like floods, ocean and storm surges, which not only damage Nigerians' livelihood but also cause harm to life and property, would occur.

**Keywords:** Nigeria, Climate change, Agriculture, Food Security.

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### **ISTEAMS Cross-Border Conference Proceedings Paper Citation Format**

Akoso, C., Oshinubi, K. & Okunoye, A. (2017): Climate Change and Global Warming Effects: Implications for Agriculture and Food Security In Nigeria. Proceedings of the 9th iSTEAMS Multidisciplinary Conference, University of Ghana, Legon, Accra Ghana. Pp 241-254

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### 1. INTRODUCTION -

Climate change has been described as the most significant environmental threat of the 21st century. Wetter climates and more floods are predicted for parts of East Africa and Latin America. Agricultural productivity in Africa, Asia and Latin America is expected to decrease by as much as 20%. In 2004, agriculture directly contributed about 14% of global anthropogenic greenhouse gas (GHG) emissions, according to the Intergovernmental Panel on Climate Change (IPCC). Agriculture is particularly vulnerable to climate change. Projections to 2050 suggest both an increase in global mean temperatures and increased weather variability, with implications for the type and distribution of agricultural production worldwide. One successful path to tread is to boost agricultural production. Projections based on population growth and food consumption patterns indicate that agricultural production will need to increase by at least 70 percent to meet demands by 2050



In the developing countries like Nigeria, agriculture is the mainstay of the economy not only providing employment to a very large percentage of the population but also providing a source of food, raw materials and item of trade and commerce. The agricultural sector contributes some percentage of the Nigerian Gross National Product (GNP) and majority of the rural populace are employed in this sector. It is thus the main basis of the livelihood of the vast majority of the population as they engage in agriculture for their daily food supply, source of income and employment.

Agriculture is a major form of human activity, through cultivating the soil, producing crops and raising livestock, that depends on natural conditions; that is, it is largely controlled solely by physical conditions such as temperature, precipitation and water supply, soil (edaphic factors), wind, altitude, angle of slope and aspect (Waugh, 1995). This is the situation in developing countries where agriculture is highly dependent on the climate elements such as temperature, precipitation and water supply. The dominant role of agriculture makes it obvious that even minor climate deteriorations can cause devastating socioeconomic consequences.

Today despite advances in science and technology agriculture is still depended on climate. It is based on this that global climate change affects agricultural products in the following ways. More extreme temperature and precipitation prevents crops from growing well. Extreme especially floods and drought harm crops and reduces yields. For example in 2008, the Mississippi River flooded just before the harvest period for many crops, causing an estimated loss of 8 billion USD for farmers (USEPA, 2014). Heat waves which have started to increase with climate change have directly threatened livestock production. A number of States in the United States have each reported losses of more than 5,000 animals from just one heat wave. The heat waves affect animals both directly and indirectly. Over time heat wave increases vulnerability to diseases, reduces fertility and reduces milk production (USEPA, 2014). The changes in temperatures and seasons affect the timing of reproduction and migration of fish and other aquatic animals. Many stages within an aquatic animal's life cycle are controlled by temperature and the changing of the seasons. For example in North West Europe warmer water temperatures affects the life cycle of salmon fish and increases the likelihood of diseases. This combined with other climatic impacts are projected to lead to decline in salmon fish production in the region (USEPA, 2014). Increase in atmospheric carbon dioxide (CO<sub>2</sub>) is gradually making the world's oceans to become more acidic and this increasing acidity harms shell fish which are created from calcium and are vulnerable to increasing acidity. Ocean acidification can also threaten the structure of sensitive ecosystems which some fish and shell fish depend upon.

Nigeria is practically a monoculture economy: about 80% of the government income, 90-95% of the export earnings and more than 90% of the foreign exchange revenues evolve from the oil sector. However, during the last years the government of Nigeria tried to diversify. Special attention is nowadays paid to gas which emerges in the joint-production of oil. So far the gas has mainly been flared (75%), simply due to the lack of technical facilities to make use of it. As the eighth largest oil supplier in the world and the ninth largest deposits of gas, the Nigerian national economy would evidently be massively affected by a sustainable reduction of fossil energy consumption. Policies to curb the climate change by reducing the consumption of fossil fuels like oil, gas or carbon, have significant economic impacts on the producers or rather the suppliers of these fuels. President Muhammadu Buhari at the summit meeting on climate change New York on 27<sup>th</sup> September 2015 expressed Nigeria's commitment to work together with other nations to address climate change and its impacts which is an undeniable issue of concern to the international community; the increase in global warming is an indication that we face a crisis of global proportions.

In his statement, the President vowed that:

*"the world is experiencing new and unusual climate variability due to increased emissions of greenhouse gases. Even though Africa contributes very little to global warming, the socio-economic consequences of climate change spare no nation. The burden is just as overwhelming for developing countries. In Nigeria, we have seen extreme weather variations, rising sea levels, encroaching desertification, excessive rainfall, erosion and floods, land degradation - all of which threaten the ecosystem. These developments have devastating human costs and are affecting food security, livelihoods and the very survival of our people".*



To address these negative effects, Nigeria has developed a National Policy to guide Nigeria's response to climate change. Nigeria's response is broadly based on the twin strategy of mitigation and adaptation. As a party to the climate change convention and its protocol, Nigeria is strongly committed to the adoption of a legally binding universal agreement to mitigate climate change. An urgent attention or something needs to be done about global warming and climate change. First, there is a need to suggest a mechanism for tackling climate change and global warming, the idea of using carbon sinks to soak up carbon dioxide. For instance reforestation or planting of new forests, this is a popular strategy for the logging industry and nations with large forests interests like Nigeria. Climate change is a global phenomenon, and is evident in Nigeria.

The negative impacts of climate change such as temperature rise, erratic rainfall, sand storms, desertification, low agricultural yield; drying up of water bodies and flooding are real in the desert prone eleven front line states of Nigeria. Environmental degradation and attendant desertification are major threats to the livelihoods of the inhabitants of the frontline states of Nigeria. This leads to increasing population pressure, intensive agricultural land use, overgrazing, bush burning, extraction of fuel wood and other biotic resources. In the arid zones, droughts are getting worse and climate uncertainty is growing, Climate change is an unprecedented threat to food security. Arid and semi-arid areas in northern Nigeria are becoming drier, while the southern part of the country is getting wetter.

Global warming means that many dry areas are going to get drier and wet areas are going to get wetter. They are going to be caught between the devil of drought and the deep blue seas of floods. Persistent droughts and flooding, off season rains and dry spells have sent growing seasons out of orbit, on a country dependent on a rain fed agriculture. Alarm bells are ringing with lakes drying up and a reduction in river flow in the arid and semiarid region. The result is fewer water supplies for use in agriculture, hydro power generation and other users. The main suspect for all this havoc is climate change. Scientific studies show snows are disappearing rapidly.

Climate change has been confirmed following release of the 4<sup>th</sup> IPCC Assessment report. Africa will be worst hit by the effects of Climate Change which Nigeria is part of it. However, "great tragedy" as Nigeria had played virtually no role in global warming; a problem caused by economic activity of the rich, industrial countries. Unless climate change was tackled, all the "best efforts" to help this great country could come to nothing. One of the biggest threats is growing climate unpredictability, which makes subsistence farming difficult, but a better planning to reduce the risk from disasters, together with developing agricultural practices that can withstand changing climates, have been shown to work and could help mitigate the impact if used more widely. Climate change refers to an increase in average global temperatures. Natural events and human activities are believed to be contributing to an increase in average global temperatures. This is caused primarily by increases in greenhouse gases such as carbon dioxide (CO<sub>2</sub>). Nigeria is experiencing adverse climate conditions with negative impacts on the welfare of millions of people.

The primary greenhouse gases (heat-trapping gases) in the Earth's atmosphere are water vapor, carbon dioxide, methane, nitrous oxide and ozone. Other greenhouse gases are three fluorinated industrial gases: hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride. If the world doesn't cut pollution of heat-trapping gases, the already noticeable harms of global warming could spiral out of control. Top 5 most polluting countries in the World are China, United States, Brazil, Indonesia and Japan. Anthropogenic greenhouse gas emissions are the main cause of climate change. Its effects on global warming and climate change are devastating, and it is becoming increasingly urgent to reduce these emissions and curb the pressure that humans exert on the planet. The situation is so critical that, by the International Energy Agency's assessment, if we continue not to remedy it emissions will be up 130% by 2050. Other countries with high emission rates are Russia, India, Germany, Australia and Canada. Most of the emissions that reach the atmosphere come from Coal (43%), followed by Oil (33%). It has been warned that countries must rapidly direct their development toward clean and renewable energy, to curb emissions and avoid the dark forecast for 2050. Global warming and climate change is a global problem, and need to be addressed globally but individual Nation can address this issue separately and responsibly.



Climate change is evidently linked to human actions and in particular from the burning of fossil fuels and changes in global patterns of land use (Salami, 2010). The United Nations Environmental Programme (UNEP) defines climate change as extreme reactions of the weather phenomenon which creates negative impacts on agriculture, water resources, human health, depletion of ozone layer, vegetations, soil and doubling of carbon dioxide in the ecosphere (Ezra, 2010). According to the Nigerian climates reports 490, climate change is any long term change in the statistics to averages, extreme or other measures, and may occur in a specific region or the earth as a whole (Ali, 2011). Climate change has the potential of affecting all natural and human systems and maybe a threat to human development and survival socially, politically and economically (Ali, 2011). A study commissioned by the World Bank in 2007 Nigeria accounts for roughly one-sixth of the world-wide gas flaring which in turn spews some 400 million tons of carbon dioxide into the atmosphere. This would be a catastrophe for the Nigerian development plan. Climate change is really of great concern to our Nation. Government should improve their financial status towards the solution of findings on this issue. Inadequate funds hamper progress in achieving Nigeria's objectives on climate change.

The Nigerian Government and all the stakeholders involves in the global phenomenon needs to increase public awareness, promote research and establish a commission or an agency that will handle issues related to global warming and climate change. The Federal, State and Local Government, International agencies and other development partners are required to funds climate change projects in Nigeria for sustainable solution.

Global warming and climate change refer to an increase in average global temperatures. Natural events and human activities are believed to be contributing to an increase in average global temperatures. Global warming, as stated in many publications and journals, is the increase in the average temperature of Earth's near-surface air and oceans since the mid-20th century and it is projected to continue. Most of the observed temperature increase since the middle of the 20th century was caused by increasing concentrations of Greenhouse Gases, which results from human activity such as deforestation and the burning of fossil fuel, for example, gas flaring. Greenhouse gases are gases in an atmosphere that absorb and emit radiation within the thermal infrared range.

The impact of the change will be difficult to handle and it will be potentially very long lasting. The disproportionate impact on Nigeria will be for a combination of reasons. Global warming will be greater over land than over sea because land retains heat more than water. There is also increasing evidence that it will be particularly hit by the effect of vertical rises and falls in air currents. Climate change often appears very esoteric but in Nigeria, it is real. We already have an increasing incidence of disease, declining agricultural productivity, and a rising number of heat waves. There is glaring evidence that climate change is not only happening but it's changing our lives. Declining rainfall in already desert-prone areas in northern Nigeria is causing increasing desertification, the former food basket in central Nigeria is now empty, and people in the coastal areas who used to depend on fishing have seen their livelihoods destroyed by the rising waters. Women and children are particularly the most vulnerable to the impacts of climate change. Adapting to climate variability and mitigating its impacts is something that we do in our everyday lives, but we have to understand what climate change is, that we contribute to it, and how we can adapt and reduce our vulnerabilities.

The countries politics and public discussions are barely addressing the mentioned problems. Furthermore, the climate change and its problems and solution strategies do not generate great publicity effects as they are too complex for rather superficial political talks. Nigeria's development plan does not recognize the economic threat caused by the climate change nor the menace of declining oil prices which could result from a reduced consumption of fossil fuels.

### 1.1 Objectives of the Study

1. To ascertain how climate change affect agriculture and food security in Nigeria;
2. To determine if climate change dimensions can improve food security in Nigeria;
3. To examine the relationship between climate change vulnerability and the livelihood of Nigerians.



## 2. METHODOLOGY

This study is totally based on existing literature. The main purpose of this paper is to integrate the viewpoints of different researcher and to make a conclusion on the basis of the literature. Initially the research is conducted by the use of Google scholar search engine with the keywords of “Climate change and global warming”, “Agriculture and food security”, “Sustainable development”, “poverty reduction”, as well as “Climate change adaptation strategies” to understand the basic information about terminologies. Furthermore, different research papers are searched and collected by using same key words from Emerald, science direct, Jstore and Ebscohost and did a detail review of each paper. Secondly, information is also gathered by analysing books of different researcher especially (REF) book of five principles. Total number of articles which were considered for this study was 34 and then we short listed most appropriate and relevant articles, which were used for the study.

## 3. AGRICULTURE AND FOOD SECURITY

Agriculture used to be the principal foreign exchange earner of Nigeria from independence in 1960 up to the mid 1970s; at that time Nigeria was the world’s largest of groundnuts, cocoa and palm oil and a significant producer of cocoanuts, citrus fruits, maize, pearl millet, cassava, yam and sugar cane. About 60% of Nigerians work in the agricultural sector and Nigeria has vast areas of underutilized arable land (Wikipedia, 2013c). In Nigeria today agriculture is the main source of food and employer of labour employing about 60 – 70 percent of the population. It is a significant sector of the economy and source of raw materials used in processing industries as well as source of foreign exchange earnings for the country (Ayinde et al., 2011).

Agriculture in Nigeria is mostly rain fed. In the north where rainfall is seasonal farmers clear their land and await the commencement of the rains mostly in May/June. Food crops produced are mainly grains and cereals such as millet, guinea-corn, maize, rice, wheat, beans and cash crops include cotton, groundnut, sugar cane. The occurrences of droughts since the 1970s have necessitated the building of dams to supply water for irrigation agriculture. Examples include Tiga and Kadawa dams in Kano and Jigawa States, Zobe and Jibia in Katsina State, Goronyo and Bakalori dams in Sokoto State.

In the Middle Belt food crops produced are mainly root crops like yams, cassava, cocoyam, potatoes, and beniseed. There are also highland temperate mixed crops produced on the high Plateaux of Jos and Adamawa and examples are Irish potatoes, tea, temperate fruits like apple etc. In the southern part the main crops are roots and tree crops such as yams, cocoa yams, plantations, cocoa, rubber, palm produce, kola nuts etc. There is doublemaxima rainfall in the south which favours the growth of these crops. Some of these crops are grown for commercial purposes in plantations. Shifting cultivation remains the major farming system among the peasant/ local farmers who produce a large percentage of the total food supplies in the country (Akor, 2012).

Forestry is another major activity in Nigeria. In 2005 forestry production shows that 86.7% of the wood is used as fuel while the remaining 18.3% of the wood is used for producing sawn wood, veneer, railways sleepers, pulp and other products (Macmillan, 2007). These are products mainly from the southern forest region and some from the Middle belt and the north where there are forest reserves, communal forest areas within the savannah vegetation zones. Deforestation is however severe in the northern and southern parts and moderate within the north central and middle belt areas of Nigeria. Desertification is severe along the extreme north and moderate in the surrounding areas.



A cattle rearing is predominantly practiced in the northern part by the Fulani herdsmen who are nomadic in nature. They move in search of pasture grass and water for their cattle from the north to the middle belt up to the southern parts of Nigeria. There are also mixed farmers who rear cattle and sedentary rearers found in different parts especially in the northern parts. The main livestock reared are sheep, goats, pigs, cattle and poultry and the products include lamb and mutton, goat meat, pork, beef, milk and eggs (Macmillan, 2006). Fishing is carried out on inland rivers, fish farms lakes and dams and along coastal waters. Fish production for the year 2005 shows that fishing on fish farms account for 8.6%; inland rivers and lakes, 40.78%; coastal waters, 44.7%; shrimps, 2.8%; and fish, 3.2% (Macmillan, 2007). Fish production for the year 2006 was 620,000 tonnes. Fishing is a major source of income and occupation to many people along inland rivers, riverine areas of the Niger Delta and the coastal areas of Nigeria. Conventionally, there are some models that have been widely used to assess the economic impacts of climate change on agriculture, these are; the production function approach, the agronomic-economic models (AEM), agro-ecological zone models (AEZM), and the Ricardian cross-sectional model (RM). In the production function approach, the production function is specified and the yields of different species of crops are examined under different climatic conditions (Reinsborough, 2003). The model assumes that the different species of crop do not have any means of adapting to the changing climate condition. It also assumes that land used in a giving year for a specific crop will be used for that same crop in other years. This makes the model to underestimate the agricultural benefits of the changing climatic conditions.

The AEM employs a combination of: (i) controlled experiments on specific crops grown in field or laboratory settings under different climate scenarios such as temperatures, precipitations, and or carbon-dioxide; (ii) agronomic modeling; and, (iii) economic modeling, to predict climate impacts (Adams & McCarl, 2001). The estimated changes in the experimental crops from the agronomic models are then entered into an economic model to predict crop choice, production, and market prices (Seo et al., 2005). One major advantage of the AEM is that it directly predicts the way climate change affects crop yields since it requires carefully calibrated controlled experiments. However, disadvantages which limits its applicability to the developing countries include amongst others; (i) agronomic estimates do not control for adaptation to changing climates (Mendelsohn & Dinar, 1999); and, (ii) lack of sufficient controlled experiments to determine agronomic responses in several developing countries

The AEZM on the contrary, assigns crops to agro-ecological zones as implicit in the name and their crop yields predicted (FAO, 1996). Underlying this model is the simple fact as climate changes, the agro-ecological zones and the crops changes, which makes it possible to predict the effects of alternative climate scenarios on crop yields (Mendelsohn & Dinar, 1999). However, just like the AEZM, changes in the experimental crops derived from the different agro-ecological zones are fed into an economic model to predict rather overall supply and market effects (Darwin et al., 1995). The greatest strength of this model is that it can easily be applied to the developing countries because the geographical distribution of zones in this region is available (Mendelsohn, 2000). Disadvantages include: (i) it is not clear how tightly climate zones can predict which crops should be grown or what their yields would be (Mendelsohn, 2000); and, (ii) estimates do not control for adaptation to changing climates as the case with the AEZM.

For the RM, its theoretical basis is deeply rooted in the famous theory of economic rents by David Ricardo (1815) however, much of its application to climate-land value analysis, draws extensively from the work of Mendelsohn et al. (1994). The RM simply examines how climate in different places affects the net revenue or value of land. As Seo et al. (2005) note, by doing so, the RM accounts for the direct impacts of climate on yields of different crops as well as the indirect substitution of different inputs, introduction of different activities, and other potential adaptation by farmers to different climates. Thus, the greatest strength of the model is its ability to incorporate the changes that farmers would make to tailor their operations to climate change (Mendelsohn & Dinar, 1999). However, despite this major advantage that the RM has over the AEM and AEZM, it has been criticize on grounds that (i) crops are not subject to controlled experiments across farms as the case with the AEM and AEZM, (ii) it does not account for future change in technology, policies and institutions, (iii) assumes constant prices which is rarely the case with agricultural commodities since other factor determine prices; and, (iv) also fails to account for the effect of factors that do not



vary across space such as CO<sub>2</sub> concentrations that can be beneficial to crops (Hassan, 2008; Fonta et. al., 2010). Despite its major shortcomings, the RM has been extensively applied in both the developed and developing countries with remarkable success

#### 4. CLIMATE CHANGE INDICES IN NIGERIA

Climate change is now widely recognised as the major environmental problem facing the globe (UNEP, 2013). It is due to this fact that climate change is the most topical issue worldwide because of its impacts that are threatening the sustenance of man and his environment. Human activities are largely responsible for climate change experienced in different parts of the globe today. These activities have led to increase in concentration of some gases called greenhouse gases (GHGs) into the atmosphere. These GHGs are carbon dioxide (CO<sub>2</sub>), Methane (CH<sub>4</sub>), Nitrous oxide (N<sub>2</sub>O) and Chloroflouro carbons (CFCs) (Cunningham and Cunningham, 2006). These four GHGs result in the increase in temperature of the globe otherwise referred to as global warming. Presently there are concerns on climate change chief of which is the increase in CO<sub>2</sub> levels due to emissions from fossil fuel combustion, followed by aerosols and cement manufacture. Other factors include land use, ozone depletion, animal agriculture and deforestation. Also of concern is the role they play both separately and in conjunction with other factors in affecting climate, microclimate, and measures of climate variables (Wikipedia, 2013b).

Since the beginning of the industrial revolution in the 1750s, atmospheric concentration of carbon dioxide has increased by nearly 30%, methane concentrations has doubled and nitrous oxide concentration has risen by about 15%. These increases have enhanced the heat trapping capacity of the earth's atmosphere. Increased concentrations of greenhouse gases are likely to accelerate the rate of climate change (Ayuba, 2005). It is these atmospheric emissions and subsequent concentrations of GHGs over the years that have now reached optimum level leading to disruptions in the atmospheric patterns that have caused climate change (Ladan, 2012). African countries in general contribute the least to the emissions that caused climate change. Nigeria like other developing countries contributes insignificantly to the greenhouse emissions. The areas of contribution are in gas flaring, animal agriculture and deforestation which constitute small percentage in comparison to other countries (Ladan, 2012). Climate change is a global problem and many countries are experiencing different aspects of it. In Nigeria, both temporal and spatial variations were observed in air temperature distribution. The temporal air temperature trend has remained generally on the increase since 1901 and within 105 years, temperatures increased by 1.2 °C in the coastal cities of the Niger Delta and 2°C in the Northern extreme of Nigeria (Ojugbo, 2010). A mean air temperature of increase of 1.7 °C was observed in Nigeria for the last 105 years. The lowest mean annual temperature was recorded on the Mambilla, Obudu and Jos Plateau because they experience semi-temperate climatic condition. A further support of the evidence of climate change in Nigeria is the increase in rainfall in the coastal areas since the 1970s and a constant decline in rainfall amount and duration in the continental interiors of the semi-arid region of Nigeria. The increase in rainfall in the coastal cities is partially responsible for the increasing floods devastating the coastal cities like Calabar, Port Harcourt, Warri and Lagos as observed by Ojugbo (2010). The increasing temperatures and decreasing rainfall in the semi-arid regions of Sokoto, Katsina, Kano, Nguru and Maiduguri have resulted in increasing evaporation, drought and desertification in Nigeria which have resulted in either reduction in water levels or total dry up of some rivers in Northern Nigeria; while Lake Chad is reported to be shrinking in size at an alarming rate since the 1970s (Ayuba, 2005).

Dami et al. (2011) in their study on "Adaptation Strategies to Climate Change in Nigeria's Section of the Chad Basin" observed that the reduction in the size of the lake is associated with climate change and human demand for water. The climatic factors are the declining frequency and volume of rainfall received within and outside the basin. The human factors are mainly related to land use and are driven by an increasing demand for water even as its supply is decreasing (Dami et al., 2011). Another study by Sawa (2010), using daily rainfall records of 30 years (1996-2005) for 15 selected meteorological stations in Northern Nigeria concluded that places in the Sudano-Sahelian region of Northern Nigeria are already experiencing the impact of global climate change in form of increasing number of dry spells during the rainy season from May to September of the years under study.



This increasing dry spells result in that little vegetation growth which leads to drought and desertification as the vegetation gets degraded or completely removed due to human activities particularly fuel wood extraction and grazing by animals. The occurrence of extreme weather events is one of the manifestations of climate change in Nigeria. Floods due to heavy rains have been experienced in parts of the country particularly in the southern parts and the Middle Belt in the years 2011 and 2012. In Ibadan, for example on August 28<sup>th</sup> 2011 heavy down pour in more than five decades wreaked havoc across the city. The rains that fell on that day hit an all time height of 187.50 mm accompanied by wind gust reaching 65 km/hr. The previous highest recorded was 178.30 mm in September 1987 (IITA, 2011). The worst flooding in decades was witnessed in the months of July to September 2012 which affected several states close to the major rivers, Niger and Benue that burst their banks due to hours of incessant rains. The floods led to the death of 140 people, hundreds and thousands were displaced, schools and businesses were closed and thousands of hectares of farmlands were submerged. Thousands of people lost properties and lived in displacement camps for three to four months in Benue, Niger, Kogi, Edo and Rivers States. The President of Nigeria while visiting some of the affected States called the floods a national disaster (Daily Herald, 2012).

Rising sea level and ocean surge as a result of global warming are evidences of climate change in Nigeria. Awosika and Folorunsho (2005) reveal that Victoria Island is one of the fastest eroding beaches as it loses about 30 meters to the ocean annually. Ugborodo /Escavors loses around 24 metres yearly and by the end of the 21<sup>st</sup> Century Lekki and Victoria Island will lose 602 and 584 square kilometres. The Niger Delta will be worse with about 15,000 square kilometers under the sea. Lagos in recent times has suffered from ocean surges and the degradation of beaches such as Alpha, Kurama and Lekki with properties destroyed and lives lost. For example, in early August 2012 the people of Lekki were displaced from their homes when the Atlantic Ocean water surged into their residences. The Lekki Beach was totally wiped off as it remained under water for some days.

The weather condition in the Niger Delta region has presently changed primarily as a result of the activities of crude oil extraction companies that operate there. Gas flaring is the singular and most common source of global warming and contributes to the emission of carbon monoxide, nitrogen (II) oxide and methane which cause environmental pollution and ecological disturbances (Ubani & Onyejekwe, 2013). Gas flaring contaminates the atmosphere and produces emissions that cause thermal pollution as the immediate impact of gas flaring is experienced in high and rising temperature in the communities close to the flare sites and beyond, acidification of rain water and deposit of black powder cover (Alaba et al., 2013).

### **Climate Change and Its Impact On Agriculture In Nigeria**

**Increase in temperature:** Increase in temperature especially in the semi-arid region has resulted in the less farm work as farmers and other farm workers get tired easily due to dehydration and constant sweating. This was supported by Bello *et al.* (2012) who indicate that sudden increase in air temperature in Nigeria was observed as from the early 1970s until 2005 which is linked to the effect of climate change and its associated global warming which was previously reported by several studies. The mean air temperature from 1901-1970 was 26.3 °C and increases to 27.8 °C from 1971-2005 (Bello et al., 2012). Also farmers continue to complain that agricultural produce has been very poor these days as they are facing declining crop yields due to weather fluctuations and other environmental threats. The result is that some farmers in Nigeria are abandoning farming for non-farming activities.

**Drought:** Due to drought in the north east, the Lake Chad is receding at a very fast rate so much so that the quantity of water is one third of its original volume. This has affected farming activities around the lake particularly dry season farming. According to Dami et al. (2011), the reduction in the size of the lake is associated with two main factors: climate change and human demand for water. The climate factors include declining frequency and volume of rainfall received within and outside the basin from rivers that drain into the Lake Chad such as Hadejia-Jamaare and Chari. The human factors are mainly related to land use and the increasing demand for water even as the supply is decreasing from the lake due to the climatic factors. The problem of drought had





remarkably impacted the socio-economic life of the people in the region as the major activities in the basin are fisheries, rain-fed and irrigated farming which solely depend on the prevailing climatic conditions (Dami et al., 2011). A study by Joshua and Ekwe (2013) state that field interaction and discussion with the farmers on the farm reveal that many farmers are willing to do dry season farming but the available water is not enough for any meaningful production.

**Serious and severe floods:** In 2010, there was serious flooding due to heavy rains in different parts of the country which destroyed vast fertile farmlands at that time and subsequently resulted in higher food prices, increasing the fear of food insecurity and aggravating rural poverty. The problem of incessant floods and erosion continue to expose peasant farmers to the hazards of climate change. In 2011, there were severe floods in different parts of the country which directly affected agriculture. For example a heavy down pour that lasted six hours on 26<sup>th</sup> August, 2011 in Ibadan, Oyo state swept away poultry farms and fish ponds filled with chicken and fishes worth millions of Naira (Sunday Tribune, 2011). Again in 2012, the worst floods in over five decades submerged and destroyed farmlands of rice, yams cassava, maize, melon as well as plantain and banana in the State around River Niger, Benue and Cross River as the rivers were filled to capacity by heavy rains and thus over flow from their banks. This has also occurred in the far northern states of Katsina, Jigawa and Kano where farmlands of millet, guinea corn, maize etc were destroyed by the floods (Ibekwe, 2012).

Global climate change has brought heavy rainfall where rains that are to fall in different days in one month fall within one or two days leading to massive flooding as witnessed presently in 2014 in parts of India, Pakistan, USA, United Kingdom and Japan. The average temperature in regions across the globe goes up, as more rain has fallen. This happens because warm air holds more moisture and when warm air holding moisture meets cooler air, the moisture condenses into tiny droplets that float in the air. If the droplets gets bigger and become heavy enough, they fall as rain (UCS, 2010). In Nigeria, this is the case where heavy seasonal rains fall particularly in the month of July to September were experienced in 2010, 2011, 2012 and 2013 which causes massive flooding that results in the bursting of rivers, collapse of earth dams, release of water from large dams which displace people especially farmers in rural areas, submerging of farmlands and destroying crops, poultry and fish farms, contaminating water sources and sanitation facilities (IFRC, 2013).

**Weather fluctuations:** Fluctuation of the weather arising from climate change causes resurgence of infectious diseases such as malaria, cholera and meningitis particularly among rural dwellers thereby affecting their output in farming activities. This affects the health of farmers and market transactions, reducing their quality of life and agricultural output. Indeed many prevalent infections including malaria, dengue fever and cholera are climate sensitive as they are transmitted by mosquitoes which cannot survive if temperatures are too low and thus thrive when the weather conditions are warmer with global warming. According to Akingbade (2010), investigations revealed that in the year 2009 that over 200 people were killed by meningitis in Nigeria and Niger Republic in one week. There were 25,000 suspected cases and 1,500 deaths in the first quarter of 2009. Experts have found a correlation between weather and meningitis which affects people in periods of erratic and unpredictable weather (Akingbade, 2010). In many areas in northern Nigeria fluctuating weather does not only cause diseases which affect the health of the farmers, but also confuse farmers about the start of the planting season.

**Gas flaring and crude oil pollution:** The flaring of gas in the Niger Delta area has over the years raised the heat level in many host communities (e.g Ode in Edo State) which creates environmental hazards that destroy the environment and makes it difficult for agricultural activities such as fishing and farming to thrive due to increase in heat arising from thermal pollution. Empirical studies carried out on the impact of gas flaring on agriculture showed a direct relationship between gas flaring and productivity that tends to decrease for farmlands close to the flare sites. One of such studies was by Ubani and Onyejeke (2013), whose results obtained show that gas flaring is responsible for the contamination of water bodies which affects the survival of fishes and other aquatic animals. Acid rain has eliminated insect life and some fish species over the years due to the gas flaring and dangerous gaseous emissions. The acid nature of the soils has attendant effect



on the soil usually used in agricultural purpose. Farmers and fishermen have for decades being con-fronted with difficulties arising from gas flaring. Crude oil pollution includes oil spillages on farmlands, oil flow sites, gas flaring sites, burrow pits, pipelines and other oil and gas activities which affect crop production in the Niger Delta. Ojimba and Iyagba (2012) in their study on the effects of crude oil pollution on horticultural crops in Rivers State reveal that the output of fruits, banana, pepper, okra and leafy vegetables in non- polluted farms were considerably higher than the output in crude oil polluted farms. The average output per horticultural crop farm produced in crude oil polluted farms was 384.58 and 550.94 kg in non-polluted farms, which indicate that crude oil pollution had a negative effect on the quantity of output (Ojimba and Iyagba, 2012).

**Extreme weather events:** Besides floods and drought, there is another extreme weather event as hailstones that accompanied heavy rains caused widespread destruction of houses of rural farmers, farmlands and agricultural products in some local government areas of Jigawa and Katsina States in September 2012. According to the residents of the areas the hailstorms and the destructions they cause were not seen by the people in their entire life time (Ibrahim, 2012). In June 2013 a late night heavy downpour showered large ice pellets on maturing plants destroying most of the crops which include okra, maize, vegetables and sugar cane on some irrigated farms in Mairuwa near Funtua in Katsina State. Most of the farmers have to bear the loss as the okra and the maize were not ready for harvest and cannot be sold (Abubakar, 2013). Also in the same State, Katsina and in the same month of June 2013 hailstorm consisting of ice pellets destroyed okra, maize and other vegetables in farmland whose cost is worth N10 million in villages of Faskari Local Government area. About 2,000 farmers were affected as most of their crops planted were completely damaged by the hailstorm which occurred when the crops were not ready for harvesting. Some of the farmers interviewed said that unless the Government helps the affected farmers, most of them will not be able to farm in the next planting season because they have lost all they have in the disaster (Ibrahim, 2013). In Nigeria's tropical weather, hailstorm was not normal but presently has been occurring frequently and in different locations in the country due to climate change.

**Drought conditions:** Drought condition created by climate change especially in the north eastern part leads to decrease in pasture grass and water availability in the region. This leads to decrease in livestock production resulting in an impaired availability of milk, meat, egg and animal products such as hides and skin. The decrease in pasture grass can cause migration of herdsmen further down South and can increase the rate of Farmers-Fulani clashes as was recently witnessed in May 2013 near Abuja, the federal capital territory. The persistent drought conditions and desertification in the North East have been identified as the primary cause of reduction of the inflow of water into the Lake Chad, causing shrinking of the lake and resulting in conflicts between farmers, fishermen and pastoralists living along the border of the lake.

The shrinking of the lake led to a reduction of land for cultivation and grazing (Fagbohun, 2010). According to Akingbade (2010) agriculture in northern Nigeria in general has been affected by drought as the dryness has led to dry farmlands, water beds and movement of people and their livestock to the southern region thus causing tension and conflict between the original inhabitants and the newcomers.

**Increasing Number of Environmental Refugees:** Increase in the number of environmental refugees has drastically increased as people were forced to leave their homes in search of relief from harsh environmental conditions. These include floods, drought, oil spillage/ crude oil pollution, hailstorm/windstorm, pest incidence etc (Gwaram *et al.*, 2004). For example many victims of 2012 devastating floods who were farmers were still living in displacement camps as at January 2013 which is bound to affect food security as many farmlands are idle and unprepared for the coming planting season. Drought conditions in the North east has led to the reduction in the size of the lake Chad apart from intensifying the conflict between pastoralists, farmers and fishermen had also led to the emergence of environmental refugees (Fagbohun, 2010). Oil spillage and crude oil pollution has created climate refugees as flare motivates change in climatic conditions making large part of the Niger Delta land uncultivable and water resources economically unviable which has pushed people to migrate in order to seek alternative source of livelihood (Alaba *et al.*, 2013). Furthermore



on the occasion of World Environment Day 2014 with the theme : "Raise Your Voice not the Sea Level", the Minister of Environment warned that about 32 million Nigerians living along the coastlines of the Niger Delta might be displaced by rise in the sea level and thus become environmental refugees. An accelerated sea level rise of 0.5 meters, 35 per cent of the Niger Delta land mass would be lost, with an accelerated rise of 1.0 meters, 7.5 per cent of the Niger Delta gone under the sea (Blueprint, 2014).

## 5. CLIMATE CHANGE, AGRICULTURE AND FOOD SECURITY IN NIGERIA

Climate change, agriculture and food security is now a subject of global concern. This is evident from the number of empirical literature that is currently available on the subject matter. However, most seem to focus on the industrial countries where the economic impacts are likely to be less harmful because of better adaptation techniques and technology than the developing nations. Notwithstanding, these studies laid the foundation for the increasing number of developing countries studies that are emerging.

Mano and Nhemachena (2006) finds that when farm revenue in Zimbabwe is regressed against various climates, soil, hydrological and socio-economic variables in a Ricardian framework, the net effect of climate change on agriculture in Zimbabwe is quite significant. Sensitivity analysis of alternative climatic scenarios that is, 2.5<sup>0</sup> C and 5<sup>0</sup> C increases in temperature resulted to decrease in net farm revenues of approximately US\$0.3 and US\$0.3 billions respectively. In Kenya the results were not much different. Mariara and Karanja (2006) find that climate change also affects agricultural productivity using a seasonal Ricardian analysis. The results showed that increased winter temperatures are associated with higher crop revenue, but increased summer temperatures have a negative impact. Increased precipitation is positively correlated with net crop yield. The result further suggests that there is a non-linear relationship between temperature and revenue on the one hand and between precipitation and revenue on the other.

For Cameroon, Molua and Lambi, (2006) finds that a 3.5 per cent increase in temperature associated with a 4.5 per cent increase in precipitation in the absence of irrigation facilities would be detrimental to Cameroon's agriculture, leading to a loss of almost 46.7 per cent in output value. This would negatively affect the economy as a whole, since close to 30 per cent of Cameroon's national GDP comes from agriculture. In Egypt, empirical results from four variants of the standard Ricardian model showed that a rise in temperature would have negative effects on farm net revenue in Egypt (Model 1). In the second, third, and fourth models, adding the linear term of hydrology, the linear and quadratic terms of hydrology, and the hydrology term and heavy machinery to the analysis improved the adaptability of farm net revenue to high temperature. Marginal analysis indicated that the harmful effect of temperature was reduced by adding the hydrology term and heavy machinery to the analysis. Also, estimates from two climate change scenarios showed that high temperatures will constrain agricultural production in Egypt (Eid et al., 2006).

Other studies in this series include (Sene et al. 2006), who assessed the impacts of CC on the revenues and adaptation of farmers in Senegal and finds that farmers have several ways of adapting to climatic constraints in Senegal. These include amongst others diversifying crops, choosing crops with a short growing cycle, weeding early in the north and late in the south, and praying etc. For Seo and Mendelsohn, (2006), using two variants of the standard Ricardian model, results suggest that the livestock net revenues of large farms in Africa fall as temperatures rise but that small farms are not temperature sensitive (Model 1), while in the second model the authors find that higher temperatures reduce both the size of the stock and the net revenue per value of stock for large farms. In Kurukulasuriya and Mendelsohn, (2006), assessing the impact of climate change on African cropland from 11 countries involving over 9000 farmers, the authors find that net farm revenues fall as precipitation falls or as temperatures warm across all the surveyed farms.

In Burkina Faso, Ouedraogo et al. (2006) find that if temperature increases by 1°C, farm revenue will fall by 19.9 US\$/ha, while if precipitation increases by 1 mm/month, net revenue increases by 2.7 US\$/h using a standard Ricardian model. The elasticity shows that agriculture is very sensitive to precipitation in Burkina Faso. In Ethiopia, the results were not much different, Deressa (2006),



also finds that net farm revenue would fall in summer and winter if temperature increases whereas increase in precipitation during spring will increase net farm revenue. Simulation of uniform scenarios that is increasing temperature by 2.5<sup>0</sup>C and 5<sup>0</sup>C; and decreasing precipitation by 7 per cent and 14 per cent suggest that increasing temperature and decreasing precipitation are both damaging to Ethiopian agriculture. However, the author concludes that decreasing precipitation appeared to be more damaging than increasing temperature. Also in Zambia, Jain (2006), finds that an increase in the November–December mean temperature and a decrease in the January–February mean rainfall have negative impacts on net farm revenue in Zambia, whereas an increase in the January–February mean temperature and mean annual runoff has a positive impact.

It is however; surprising, that despite the vastness, population, and position of Nigeria in the Sub-Saharan region coupled with its different climatic conditions, she was left out of the multi-country studies. Some individual research efforts have however been geared toward ascertaining the impact of CC on Agricultural productivity and profitability in Nigeria. For example, Davis and Sadiq, (2010) carried out a research on the effect of climate change on cocoa yield. The study revealed that there is a weak inverse correlation in rainfall (0.0073), meaning that increase in rainfall result in decrease in yield. While positive weak correlation (0.2196) was established for temperature on yield. The study also revealed a strong positive correlation between yields/pods and temperature. They concluded that a combination of optimal temperature (29<sup>o</sup>c) and minimal rainfall (900 to 1000mm) will give a better yield and improve production and the economy of both Cocoa farmers and Nigeria at large. Lawal and Emaku, (2007) during their own study on the effect of climate change on cocoa production in Nigeria found out that there is a weak negative correlation for both rainfall and relative humidity on cocoa yield over the years while they established positive correlation for temperature on yield. On the same study, they found out that the incidence of black pod disease has a positive correlation with temperature and relative humidity but a negative correlation with rainfall. Just like Davis and Sadiq, they concluded that a better yield and reduced incidence of black pod disease on cocoa in Nigeria require an optimal temperature of 29<sup>o</sup>c and minimal rainfall of 1,125mm and relative humidity of about 74%. . In line with the above findings, Ajayi et al, (2010) revealed that rainfall has a constraining ability on cocoa yield in the core cocoa production areas of Ondo state, Nigeria. They found that Cocoa yield was also shown to be the inverse of annual rainfall level as cocoa yield increased in the early and latter months of the year when the rains are yet to fully come, and suffered in the mid year at the heart of rain season.

Contrary to the negative correlation between rainfall and cocoa yield, Omolaja et al, (2009) found that high rainfall and favourable temperature promote flowering intensity of cacao in Nigeria. Also, Ladan (2014) carried out “An appraisal of climate change and agriculture in Nigeria”. Climate change is a phenomenon that has the potential of affecting all natural and human systems and may be a threat to human development. This is particularly the case in developing countries. This work was theoretical article that uses secondary sources of data including weather events that occurred recently to appraise climate change and agriculture in Nigeria. The results showed that human activities are largely responsible for climate change experienced in different parts of the globe today. These activities have led to increased concentration of greenhouse gases into the atmosphere and they are associated with the industrialised countries and some emerging nations. Agriculture in Nigeria is entirely dependent on climate and changes in climate are bound to affect it. This study found that climate change has already had a negative impact on agriculture in Nigeria especially in the last few years. It was recommended that conscious efforts should be made towards mitigating the impacts of climate change on agriculture in Nigeria.

## 6. DISCUSSIONS

In the developing countries, one of the biggest effects of climate change on agricultural products is very unpredictable rainfall which affects the growth pattern of rain-fed crops such as maize and rice. In Southern Katsina State in Northern Nigeria for example, maize and rice are planted on farmlands at the beginning of the 2014 rainy season to take advantage of early harvest but there was a long delay in the rains for one month; this makes the crops to start drying which affects yield in the harvesting period. The farmers are experiencing an unusual situation where there is shortage of rainfall in the month of July and August (Mahmud, 2014). This situation primarily caused by climate change will affect maize and rice productivity both in terms of quality and quantity.



Due to climate change, temperatures are higher and it is in higher temperatures that most diseases thrive. New diseases are appearing at vegetables at alarming rates, a rate so fast that scientists find it difficult to keep up with tracking, naming and classifying them. The bird flu is a great example of this problem (Epperson, 2014). The increase in temperature due to global warming has resulted that some food crops like wheat which was previously cultivated in Northern Nigeria at the Hadejia-Jamaare River Basin Development Project could not be produced today as the crop cannot get the lower temperature it requires for its growth. This situation of non-cultivation of wheat has resulted in shortage of wheat in the region and has prompted importation of the crop from foreign countries to meet up domestic demands within Nigeria.

The effects of climate change have already been felt in many parts of the country with the modification of intensity and seasonal nature of the rains, elevation of average annual temperatures, and intense frequency of wide-spread, high impact weather phenomena including drought and flooding. These effects of climate change directly have an impact on agriculture in Nigeria. Agricultural activities in Nigeria such as rain fed agriculture, livestock rearing, fisheries and forest products extraction are sensitive to climate change (Salami, 2010).

## 7. CONCLUSION

Climate change is now a reality and its effects are felt all over the globe. These effects are largely negative and have serious repercussion for human beings, their source of livelihood and the environment. It is due to this that climate change is the single biggest environmental issue facing the world today. Nigeria is one of the most vulnerable countries to climate change in Africa due to her varied climatic zones, coastal location and more people are living and working in climate change prone areas. Agriculture in Nigeria is largely dependent on the climatic conditions and changes in these conditions can have impact on agricultural activities. Based on the discussions in this article it could be observed that climate change has brought negative impacts on agriculture in Nigeria. However, conscious efforts must be made towards mitigating the impacts of climate change on agriculture in Nigeria.

Within contemporary global challenge of climate change and its adverse effect on food security and agricultural productivity, measures must be taken towards adaptation and mitigation. One successful path to tread is to boost agricultural production. Projections based on population growth and food consumption patterns indicate that agricultural production will need to increase by at least 70 percent to meet demands by 2050. Most estimates also indicate that climate change is likely to reduce agricultural productivity, production stability and incomes in some areas that already have high levels of food insecurity. Developing climate-smart agriculture is thus crucial to achieving future food security and climate change goals. Each country should develop and implement a viable national action plan, which takes into account future development paths, expected climate change impacts, and adaptation and mitigation costs. National governments can play a crucial role in assisting with climate mitigation and adaptation in five major ways: provide information and advice about climate risks and available strategies, provide guidance and training on design and implementation of measures, promote desirable adaptation measures through public policy, mandate adaptation to safeguard public health and safety and institutionalize adaptation capacity and policy and promote interdepartmental cooperation (Yohe, Burton, and Rosegrant, 2008)



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