Indicators of Climate Change and their Effects on Livelihood and Biodiversity of Essien Udim Forest Akwa Ibom State, Nigeria

H. N Ukoima, F. A Chukunda & E.E Williams
Department of Forestry and Environment,
Rivers State University, Port Harcourt,
Rivers State, Nigeria

Abstract
The study examined climate change indicators and its effect on the livelihood and biodiversity of Essien Udim forest in Akwa Ibom State, Nigeria. Specifically, the study described the socioeconomic characteristics of the respondents in the study area; assessed the effect of climate change on the biodiversity of the forest, examined the effect of climate change on the livelihood activities of households and identified the mitigating strategies used to reduce the effect of climate change in the study area. Structured Questionnaires were used in extracting information from the 210 participants (heads of household) from seven communities whose households get their livelihoods using the purposive and proportionate sampling procedures. Data collected where analyzed using descriptive (percentages, frequencies, mean and standard deviation and inferential (correlation analysis and z-test) statistics. Findings revealed that majority of the respondents were male (56.7%), married (62.9%) and they are aware of climate change (95.7%). The effects of climate change on biodiversity include disease outbreak in the forest (2.97), die-back due to fungi disease outbreak as a result of flooding (2.86), chlorosis due to bacterial diseases in the forest (2.95) and disease symptoms on the trees (2.83) while the effects on households include increased rise in sea level (2.93), coastal erosions because of rise in sea level (2.67), increased cost of non-timber forest products NTFPs (2.95) and none availability of NTFPs (2.97). Some of the mitigating strategies used are the use of alternative energy sources such as solar panel, reduction in the burning of simple coal, stopped felling of trees, prompt weeding, and planting of trees. At the probability of 5%, climate change indicators like excess rainfall, excess sunshine and drought/flood had a positive effect on the biodiversity of the forest as it has caused die-back due to fungi disease outbreak and chlorosis due to bacterial diseases in the forest. This study concludes that climate change indicators have drastically impacted on the biodiversity of the forest and the means of livelihood of the people. It is recommended that increased information to rural households on switching away from fossil fuel energy sources to less damaging substitutes.

Keywords: *Climate Change Indicators, Livelihood, Biodiversity, Mitigating Strategies*

INTRODUCTION

Climate change is any change in climate over time whether due to natural variability or as a result of human activity (IPCC, 2001). It is a product of Natural events such as biogeographically and human activities which have contributed by adding CO_2 and other heat-trapping gases to the atmosphere. Greenhouse gas emission increases the greenhouse effect and caused earth's surface temperature to rise. The primary human activity affecting the amount and rate of climate change is greenhouse gas emissions from the burning of fossil fuels (Onokerhoraye, 2011).The most important GHGs directly emitted by humans include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and several others. Climate change is a threat to human existence and biodiversity. The negative effect of climate attracts attention beyond national boarder.

Climate change affects plants in natural and agricultural ecosystems throughout the world (Stern, 2007). Climate change directly impacts crops, as well as their interactions with microbial pests (Rosenzweig *et al.,* 2000). However, little work has been done to model the effects of climate change on plant disease epidemics (Garrett *et al*., 2006). Climate change affects shelter, health, livelihood and life in general. The negative impacts of climate change currently reflect on the dwindling natural resources, including food, which generally affect human environment, economy and health (Onokerhoraye, 2011).

The effects of climate change have also metamorphosed into some negative effects such as the decline in agricultural activities, migration, drought, crises among farmers and herds - men, erosion, flooding, poverty, and hunger among others and other numerous problems yet to surface. Climate change also affects agricultural productivities in several ways, including its direct impact on food production. Climate change, which is attributable to the natural climate cycle and human activities, has adversely affected agricultural productivity in Africa (Ziervogel *et al.* 2006). The major concern arising from the climate change issue is the impact it may have on biodiversity and its reciprocal interactions with the environment, which ultimately would pose the questions on the planet's ecosystem and human sustainability
Biodiversity is defined as "the variability among living organisms from all sources including, inter alia, terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species, and of ecosystems". Functional diversity describes the biological role of species or groups of species in an ecosystem. Soil biodiversity is often used as a synonym for a number of heterotrophic species below-ground (Hooper *et al.,* 2005), which makes it unfeasible in many ecological studies as it contributes little information about their role in ecosystem function.

There are many studies on the effect of climate change, past studies that have examined the impact of climate change on food production at the country, regional, or global scale failed to provide critical insights in terms of effective and future adaptation strategies (Nkomo *et al*, 2006; Stern 2007; Apata *et al*, 2009) . Studies on the impact of climate change (particularly rainfall and temperature) and climate-related adaptation measures on crop yield are very scanty. Furthermore while these studies were conducted using sub-regional agricultural data as well as household-level it did not identify the determinants of effective adaptation methods to predict efficient adaptive measures and the future effects on food production and population growth were not assessed. From the above gap, this study examined the effects of key climatic variables on livelihood and biodiversity of Essien Udim forest in Akwa Ibom State, Nigeria.

LITERATURE REVIEW

Concept of Climate Change

There is no pain stating the fact that man depends on his environment for existence and sustenance such that man's life is shaped by his environment and this warrants the need for environmental protection from all forms of degradation, especially those brought about by the activities of man. Realizing the importance and inevitability of the environment for of man's, survival, environmental experts have been arguing vehemently that without the environment man cannot exist since human activities are made possible by the existence of his environment, that is his immediate surroundings change (Pearce *et al.,* 1996).

Nowadays, environmental problems are receiving attention at international levels and the global communities are continuously making efforts geared towards ensuring that the world is a better place for human habitation (McCarthy *et al*., 2001). Climate change is principally a major problem caused by the increase of human activities or human mismanagement of the earth leading to several direct and indirect negative impacts on health. These climatic variations have wide-range harmful effects including increase in heat-related mortality, dehydration, widespread of infectious diseases, damages to public health infrastructure, migration of both man and animals among others (Onyeneke, 2010).

Climate Change and Agriculture Production

Agriculture remains the mainstay of the majority of households in Nigeria and is a significant sector in Nigeria's economy. The significance of the agricultural sector to Nigeria's economy cannot be overemphasized as it is catalyst for food provision, contribution to the gross domestic product, provision of employment, provision of raw materials for agro-allied industries, and generation of foreign earnings. Crop production takes a significant aspect of agricultural production and exports in Nigeria. Generally, there are many factors influencing crop production and these include soil, relief, climate and diseases among others.

However, food production could not keep pace with population increase. Food shortage is therefore linked with climate change. Today, climate change and food insecurity are twin devils that have been identified as urgent world problems. This is because food security which is mainly from agriculture threatened by the emergence of climate variability as agriculture serves as one of the sensitive sectors to this threat. Over 60% of the Nigerian populace depends so much on agriculturally related activities for sustenance and crop production takes significant aspect of agricultural related activities in Nigeria. For instance, crop production contributes more than 80% of Agricultural GDP and more than 48% of total non-oil GDP in Nigeria (CBN, 2011) opined that climatic fluctuation is putting Nigeria's agriculture system under serious threat and stress.

Climate Change and Forest Products

According to United State Department of Agriculture (2011) forests play a critical role in maintaining the climate, freshwater systems, soils and biodiversity, all of which are critical to food security and other key aspects of human well-being. Forest helps in combating climate change through absorption and reduction of greenhouse gas such as carbon dioxide in the atmosphere. Various kinds of wood and non-wood items are derived from the forest. Forest supplies many products in form of wood which serves as basic material for construction, furniture, paper; and non-wood items which include extractions such as bark, dye, fibre, gum, incense, latexes, oil resins, waxes, shellac and tanning compounds, food, bush meats, flowers, fruits, honey/nuts, leaves, seeds, spices as well as decorative, ceremonial and medicinal items (Adebayo, 2009).

Forest contributes to poverty reduction and agricultural stability by protecting the soil. The majority of the rural communities depend heavily on forest products for their livelihoods (MNRT, 2009). Livelihoods are the sum of ways in which people make a living. Thus, income generation from forests is supplementing the farm income although not many households have the capacity to take advantage of forest-based income generating activities. Increasing agricultural production costs in relation to product prices and increasing living costs in general have pushed people to exploit forest more intensely, particularly on the general lands to generate cash income, reported that forests support the livelihoods of 87% of the rural poor.

Climate Change and Pest Buildup in Forests

Forests provide critical refuges for terrestrial biodiversity, are a central component of the earth's biogeochemical systems, and are a source of ecosystem services essential for human wellbeing (Shvidenko *et al.*, 2005). Forests also have the potential to mitigate global climate change by serving as net carbon sinks (IPCC (2007). Global forest area has been reduced by 40% over the last three centuries, primarily as a result of human activities, particularly the conversion of forested land to agricultural usage.

Today, less than one-third of the earth's land area is covered by forests (FAO, 2001). Disturbance agents such as pathogens, insects and fire can decrease the ability of forests to provide goods and services, especially when the natural disturbance patterns or regimes of these agents are altered by human activities (Lewis and Lindgren). Climate has always shaped the world's forests, but today the world's climate has become warmer and will change further and at an unprecedented rate (Pachauri and Reisinger, 2007).

Plant Disease Epidemic

An epidemic is defined as a change of disease intensity in populations over time and space (Campbell and Madden, 1990), but the term is usually used to describe a widespread and severe outbreak. Plant disease epidemics may become more frequent as climate changes. Epidemics of insects and pathogens that are mobile or easily dispersed, and can kill their hosts relatively quickly, are examples of pests particularly likely to increase in frequency (Ayres and Lombardero, 2000). Many forest pathogens can take decades to spread and then to kill their hosts, yet their long-term, cumulative effects can be serious. Rates of spread of these agents and rates of tree mortality may be significantly altered by climate change. Climate influences the dynamics of host–pathogen interactions, so it is likely that climate change will have strong effects on the distribution (Pearson & Dawson, 2003) and behaviour of plant species and pathogens.

Climate Change Qualitatively and Disease Symptoms of Trees in Forests

Plant diseases play an important role in agriculture (Agrios, 2005). A limited amount of information on the potential impacts of climate change on plant diseases is available. Plant pathologists have long considered environmental influences in their study of plant diseases: the classic disease triangle emphasizes the interactions between plant hosts, pathogens and environment in causing disease (Grulke, 2011). Climate change is just one of the many ways in which the environment can move in the long term from disease-suppressive to disease-conducive or vice versa (Fuhrer, 2003; Perkins *et al*., 2011).

Therefore, plant diseases could be even used as indicators of climate change (Garrett *et al.*, 2009), although there may be other bio-indicators which are easier to monitor. Long-term datasets on plant disease development under changing environmental conditions are rare (Scherm, 2004), but, when available, can demonstrate the key importance of environmental change for plant health (Fabre *et al*., 2011).

Effects of Rising Temperatures

A change in temperature may favor the development of different inactive pathogens, which could induce an epidemic. Due to changes in temperature and precipitation regimes, climate change may alter the growth stage, development rate, pathogenicity of infectious agents, and the physiology and resistance of the host plant (Charkraborty and Datta, 2003).

As the temperature increases, the duration of winter and the rate of growth and reproduction of pathogens may be modified (Ladanyi and Horvath, 2010). Similarly, the incidence of vector-borne diseases will be altered. Climate can substantially influence the development and distribution of vectors. Changes may result in geographical distribution, increased overwintering, changes in population growth rates, increases in the number of generations, extension of the development season, changes in crop-pest synchrony of phenology, changes in interspecific interactions and increased risk of invasion by migrant pests. Temperature has potential impacts on plant disease through both the host crop plant and the pathogen. Research has shown that host plants such as wheat and oats become more susceptible to rust diseases with increased temperature; but some forage species become more resistant to fungi with increased temperature (Coakley *et al.*, 1999). Many mathematical models that have been useful for forecasting plant disease epidemics are based on increases in pathogen growth and infection within specified temperature ranges. Generally, fungi that cause plant disease at cold average temperatures are likely to experience longer periods of temperatures suitable for pathogen growth and reproduction if climate is warm.

Effect of Rising CO_2 Levels

Increased CO_2 levels can impact both the host and the pathogen in multiple ways. New races may evolve rapidly under elevated temperature and CO_2, as evolutionary forces act on massive pathogen populations boosted by a combination of increased fecundity and infection cycles under favourable microclimate within enlarged canopy (Chakraborty, 2013).

Some of the observed CO_2 effects on disease may counteract others, researchers have shown that higher growth rates of leaves and stems observed for plants grown under high CO_2 concentrations may result in denser canopies with higher humidity that favor pathogens. Lower plant decomposition rates observed in high CO_2 situations could increase the crop residue on which disease organisms can overwinter, resulting in higher inoculum levels at the beginning of the growing season, and earlier and faster disease epidemics. Pathogen growth can be affected by higher CO_2 concentrations resulting in greater fungal spore production. However, increased CO_2 can result in physiological changes to the host plant that can increase host resistance to pathogens (Coakley *et al.*, 1999).

Impact of Changing Soil Moisture

The soil moisture relationship to microbial community is more highly variable and complicated than that of temperature, and less studied. It is easy to understand intuitively that soil water content will vary negatively with temperature, and has been shown to be the case (Davidson *et al.*, 1998). However, the relationship is challenging to describe empirically. There is no consensus as to an equation describing soil respiration and moisture (Emmett *et al.*, 2004), or moisture and temperature.

As with other factors, interactions may be seen as a key reason that temperature relationships are not clear. The time scales and spatial scales of water change are different from those of temperature change. Moisture changes may come in the form of wet-dry cycles, drought, flooding, or smaller shifts. These different changes have different community structural and functional impacts, and are conditioned by a community's native regime. There are several mechanisms or physical processes affecting microbial communities that vary with moisture content (Rodrigo *et al.*, 1997).

Climate Change on Forest Plant Disease Symptoms

Forest plant diseases are strongly influenced by weather and climate. For forest pathogenic fungi, bacteria, viruses, and other microorganisms, the temperature and moisture conditions interacting with seasonal phenology, and stress on the host determine infection severity and distribution. Extreme weather, i.e., drought or typhoons, can kill large expanses of trees directly by overwhelming tree physiological capability and structural strength. Expected changes in climate coupled with the increasing stresses of invasive species and lack of fire are creating conditions conducive for many forest plant diseases. Patterns and rates of wood decay, caused by forest fungi, are also expected to change, which will influence forest carbon cycles. Warming, changes in precipitation, and weather extremes are already influencing forest plant diseases in western North America.

Climate Change on Fungal and Bacterial Population in Forest Soils

Soil is one of the most abundant, valuable and complex natural products of the earth and can be observed from different angles. Soil is the habitat for fungi, bacteria, plants and animals, resulting in an enormous biodiversity of belowground and aboveground soil microorganisms. Soil organisms are major drivers of biogeochemical nutrient cycles (carbon, nitrogen, phosphorous: C, N, P), and hence are indispensable for life on earth. Soil harbours an enormous diversity of life. A handful of soil can contain literally billions of bacterial cells, and tens of thousands of bacterial and hundreds of fungal species (Read, 1992). Changes in climatic conditions such as fluctuations in the abundance and seasonality of rainfall have important consequence at the ecosystem level.

Climate Change and Fungal Population and Distribution

One of the important effects of climate change on fungi is the change in phenology. The time and resources required for mycelial growth and subsequent fruit body production are unknown for the vast majority of fungal species. In particular, the July temperature and precipitation during August is found to promote an earlier average fruiting (Moore *et al*., 2008). Studying the effects of climatic predictors on the fruiting time during the study period 1960–2007, temperature is found to play an important role in influencing evapo-transpiration (ETP) processes, with rise in temperatures causing higher ETP rates. De Aragón *et al*., (2007), argue that it is the difference between rainfall and ETP which gives better estimation of the water available to plant and fungi than the rain gauge reading. ETP rates higher than the rainfall may pose threat of physiological drought to plant and fungal communities (De Aragón *et al*., 2007). Temperature not only has direct effects on microbial activity, but eventually it can also affect the temperature dependency of the community.

Climate Change and Bacterial Population and Distribution

Climatic change alters the relative abundance and function of soil communities because soil community members differ in their physiology, temperature sensitivity, and growth rates (Whitaker *et al.,* 2014). The direct effects of climatic change on microbial composition and function have been reviewed extensively (Chen *et al.*, 2014). Warming by 58^{0}C in a temperate forest, for example, altered the relative abundances of soil bacteria and increased the bacterial to fungal ratio of the community (De Angelis *et al.*, 2015).

Microbial communities respond to warming and other perturbations through resistance, enabled by microbial trait plasticity, or resilience as the community returns to an initial composition after the stress has passed (Allison and Martiny, 2008). Shifts in microbial community composition are likely to lead to changes in ecosystem function when soil organisms differ in their functional traits or control a rate-limiting or fate-controlling step (Schimel and Schaeffer 2012). For instance, specific microbial groups regulate ecosystem functions such as nitrogen fixation, nitrification. Change in the relative abundance of organisms who regulate specific processes can have a direct impact on the rate of at process.

Climate Change and Soil-Borne Pathogens

According to the IPCC (2007) report, climate change will alter patterns of infectious disease outbreaks in humans and animals. Soil pathogens are no exception which supports the claim that climate change is already changing patterns of infectious diseases caused by soil pathogens. For example, over the last 20 years, 67% of the 110 species of harlequin frogs (*Atelopus*) native to tropical regions in Latin America have gone extinct from chytridiomycos is the, a lethal disease spread by the pathogenic chrytid fungus (*Batrachochytrium dendrobatidis* (Willey *et al.*, 2009).

Research suggests that mid- to high-elevations provide ideal temperatures for *B. dendrobatidis*. However, as global warming progresses, *B. dendrobatidis* is able to expand its range due to increasing moisture and warmer temperatures at higher elevations (Muths*et al.*, 2008).

Climate Change and Plant Population

Because climate and vegetation are so strongly associated, it is assumed that the forecast rapid changes in climate will affect plant distributions and alter the makeup of forest communities. For example, climate change could cause regional rainfall patterns to shift, which would be accompanied by an increase in rainfall and wind intensity. Such shifts could impact existing rain shadow effects in some regions causing more precipitation on the windward side of mountain ranges while creating even drier conditions on the leeward sides. Fire patterns are likely to be altered as well, which could affect a variety of plant species, even those that are fire resistant or require the presence of fire to regenerate.
Climate change has impacted negatively on plant populations and distribution (Ukoima, 2018). Due to temperature increases, the limited availability of water, and other environmental factors, entire forests may disappear, and new ecosystems may take their places. Also, a global average of one third of the existing forested area could undergo major changes in broad vegetation types with the greatest changes occurring in high latitudes. Both plant and animal communities at high elevations and in high latitudes may have no place to migrate and could be lost completely. Alpine ecosystems are thought to be particularly sensitive to climate change largely due to their low productivity, tight nutrient cycling, and their position at a limit for many plant processes (Walker *et al.*, 1993).

Health Impact of Climate Change

Climate change impacts on health in many ways. Africa is particularly known for its vulnerability to many climate sensitive diseases such as malaria, tuberculosis and diarrhea (Thomson *et al.*, 2004). The health impacts of climate change include, inter alia, heat-related illnesses, extreme weather-related injuries, spread of infectious diseases such as water- and food- borne diseases, upsurge of respiratory disorders, vector-borne diseases and, stress-related and mental health disorders (Costello *et al.*, 2009). Mshelia (2005) and Adefolalu (2007), claim that climate change has affected agriculture and health in Nigeria. A swing in the cycle of rainfall and weather conditions will promote the prevalence of some diseases such as malaria, due to the increased incidence of pools and standing waters. Floods are also increasing in frequency and intensity in the region and may contaminate freshwater supplies, heighten the risk of water-borne diseases and create breeding grounds for disease-carrying insects such as mosquitoes (Guernier *et al.*, 2004).

MATERIALS AND METHODS

Study Area

The study was carried out in Essien Udim Local Government Area of Akwa Ibom State, Nigeria. Akwa Ibom State is one of the 36 states of the Federal Republic of Nigeria. It is located in the coastal southern part of the country, lying between latitudes 4°32′N and 5°33′N, and longitudes 7°25′E and 8°25′E. Akwa Ibom State currently covers a total land area of 7,249 square kilometers. It is the 10th largest state in Nigeria in terms of landmass. About 13.4 percent of the 960km of Nigeria’s Atlantic Ocean coastline runs through the State (Wikepedia, 20/06/2020).

Research Design

The study adopted Ex-post Facto descriptive research design because the study investigates the factors which are associated with certain occurrences such as climate change and its outcomes such as livelihood. Ex-post Facto descriptive research design establishes cause effect relationship without manipulation of variables.

Sampling Procedure

The study was carried out in Essien Udim LGA of Akwa Ibom. It has a tropical rain forest with two seasons – wet and dry. There are seven clans which include; (1) Adiasm, (2), Afaha (3), Ekpenyong Atai, (4) Ikpe-Annang, (5) Odoro-Ikot (6) Okon, and (7) Nsasak with 136 communities with population of 192,668 according to the Census, 2006. Two communities were randomly selected from each clan giving a total of 14 communities. Purposive sampling procedure was used to select thirty (30) households (equal proportionate) having their livelihoods from forests of the selected communities/villages giving a total of 210 respondents.

Method of Data Collection

The main source of information collection was primary data. The primary data was collected using self-structured questionnaire. The instrument was titled "Indicators of Climate change and their Effects on Biodiversity of Essien Udim Forest Akwa Ibom State, Nigeria"

Method of Data Analysis

A correlation analysis was used to determine the effects of climate change on the livelihoods of households in the study area whereas a t-test was used in determining the strategies used by households to reduce the impacts of climate change in the study area, while correlation statistical analysis was used to determine the causes of climate change, describe the socio-economic characteristics of the respondents, identify the level of awareness and indicators of climate change in the study area and finally to examine the effects of climate change on biodiversity of the study area.

RESULTS

Socio-economic Characteristics of the Respondents in the Study Area

The socio-economic characteristics of the respondent in the study area are presented in Table 4.1. The result showed that majority of the respondents was male (56.7%) while 43.3% were females. A high number of the respondents were in the age bracket of 30-39 years (33.3%) followed by those in the age bracket of 40-49 years (29.1%), 20-29 years (20.5%) while 50-59 years and 60-69 years was 10.0% and 7.1%, respectively. The mean age of the respondents was 44 years. Also, majority of the respondents were married (62.9%), 33.8% single, 2.3% were widow/widower and 1.0% were separated. A little less than half of the respondents had 5-6 household persons (48.6%), 40.5% had 1-4 persons and 10.9% had 9-12 persons. The mean household size was 5 persons. Most of the respondents had secondary school certificate (47.1%), 24.3% had primary certificate and 20.0% had tertiary degree. Only 8.6% had no formal education. About 45.7% of the respondents were into gathering of non-timber forest products (NTFPs), 38.6% of the respondents were into trading of forest products, 13.3% were into hunting of wild animals and 2.4% were involved in gathering of forest products. Furthermore, 46.7% of the respondents have been in forest activities for 11-20 years, 38.6% have been in it for 11-20 years and 14.7% have been having their livelihood from forest products. The mean forest activities experience was 12 years.

Effects of Climate Change on biodiversity of Essien Udim Forest

The effects climate change on biodiversity of Esien Udim forest are presented in Table 1 the results showed that the respondents in the study area were of the view that the effects of climate change on biodiversity of Essien Udim forest include disease outbreak in the forest (2.97), die-back due to fungi disease and damping off outbreak as a result of flooding (2.86), Chlorosis due to diseases in the forest (2.95), disease symptoms on the trees (2.83), buildup of pests in the forest (2.76), causes stunted growth of trees (2.57), causes poor yield of trees (2.60) and reduced tree canopies of the forest (2.51). All the variables were significant at a probability level of 0.05.

Effect of Climate Change on households in the study area

Effects of climate change on households in the study area as shown in Table 4.5. The results shows that increased rise in sea level (2.93±0.60), coastal erosions because of rise in sea level (2.67±0.62), increased cost of non-timber forest products NTFPs (2.95±0.66), none availability of NTFPs (2.97±0.68), flooding that has hindered harvesting of NTFPs (2.86±0.70), increased incidence of pests and diseases (2.83±0.71), low/poor yield of forest crops like okasi leaves (2.74±0.60), and change in rainfall pattern (2.66±0.66). The grand mean was 2.83. All the variables were significant at a probability level at 0.05.

Table 1: Effect of Climate Change on households in the study area

Effects N=210	Mean± SD	z-test z-score	p-value	SA	A	D	SD	Remark
Increased rise in sea level	2.93±0.60	2.101	0.155	97	40	35	38	S
Flooding has hindered harvesting of NTFPs	2.86±0.70	2.211	0.011	90	40	40	40	S
Coastal erosions because of rise in sea level	2.67±0.62	2.102	0.010	75	43	40	52	S
Increased cost of NTFPs	2.95±0.66	2.106	0.011	95	43	40	32	S
None availability of NTFPs	2.97±0.68	2.111	0.027	100	40	35	35	S
Increased incidence of pests and diseases	2.83±0.71	2.103	0.015	90	35	45	40	S
Low/poor yield of forest crops like okasi leaves etc.	2.74±0.60	2.114	0.010	80	35	55	40	S
Change in rainfall pattern	2.66±0.66	2.116	1.011	73	35	60	42	S

$\geq$ 2.50=Effective; P $\leq$ 0.05

Mitigating Strategies to Reduce Effects of Climate Change in the Study Area

The results on the mitigating strategies to reduce effects of climate change in the study area are presented in Table 2. To reduce the effects of climate change at Essien Udim Forest, some mitigating strategies have been adopted by households having their livelihoods from the forest. The results showed that the mitigating strategies are reduction in the burning of fossil fuels (2.84), use of alternative energy sources such as solar panel (2.80), reduction in the burning of simple coal (2.67), stop felling of trees (2.64), prompt weeding (2.97), planting of trees (2.63), introduction of agro forestry system (2.74), change in farming season (2.66) and the use of alley farming (2.66). These mitigating strategies are all significant at a probability level at 0.005. However, irrigation (2.48) and crop diversification (2.48) were not significant at a probability level at 0.05.

Table 2: Mitigating strategies to reduce Effect of Climate Change in the study Area

Effects N=210	**Mean± SD**	**z-test z-score**	**p-value**	**SA**	**A**	**D**	**SD**	**Remark**
Reduction in the burning of fossil fuels	2.84±0.60	2.101	0.155	91	40	35	44	**S**
Using alternative energy sources such as solar panel	2.80±0.70	2.211	0.011	88	40	35	47	**S**
Reduction in burning of simple coal	2.67±0.62	2.102	0.010	90	40	40	40	**S**
Stop felling of trees	2.64±0.66	2.106	0.011	73	43	40	54	**S**
Prompt weeding	2.97±0.68	2.111	0.027	95	43	40	32	**S**
Planting of trees	2.63±0.71	2.103	0.015	72	44	39	55	**S**
Introduction of agro forestry system	2.74±0.60	2.114	0.010	90	35	45	40	**S**
Use of alley farming	2.66±0.66	2.116	1.011	80	35	55	40	**S**
Irrigation	2.48±0.90	1.998	0.110	67	35	40	68	**NS**
Crop diversification	2.46±0.59	2.0002	1.002	62	34	45	68	**NS**
Change in farming season/ cropping pattern	2.66±063	2.116	1.011	73	35	60	42	**S**

≥ 2.50=Accepted; P ≤ 0.05

The relationship between climate change indicators and its effect on the biodiversity of Essien Udim forest, this was determined by using correlation analysis, the results, in (Table 2) showed that excess rainfall had a positive significance on disease outbreak in the forest (0.037), die-back due to fungi disease outbreak as a result of flooding (0.012), chlorosis due to bacterial diseases in the forest (0.025) and disease symptoms on the trees (0.010). Excess sunshine had relationship with die-back due to fungi disease outbreak as a result of flooding (0.040), excess fog had negative relationship on chlorosis due to bacterial diseases in the forest (-0.028), more drought/flood is significance with disease outbreak in the forest (0.042), die-back due to fungi disease outbreak as a result of flooding (0.026), chlorosis due to bacterial diseases in the forest (0.039) and disease symptoms on the trees (0.025). High wind had negative significance on reduced tree canopies of the forest (-0.025). Extreme longer day had significant on disease outbreak in the forest (0.033) and high humidity had positive significance on disease outbreak in the forest (0.048).Die-back due to fungi disease outbreak as a result of flooding(0.028), chlorosis due to bacterial diseases in the forest(0.036),disease symptoms on the trees(0.032) and reduced tree canopies of the forest(-0.022).

Table 3: Relationship between climate indicators and effect on biodiversity

Spearman's rho		Disease outbreak in the forest	Die-back due to fungi disease outbreak as a result of flooding	Chlorosis due to bacterial diseases in the forest	Disease symptoms on the trees	Buildup of pests in the forest	Causes Stunted growth on trees	Causes poor yield of trees	Reduced tree canopies of the forest
Excess rainfall	Correlation	-.144*	-.173*	-.155*	-.177*	-.057	.032	.038	.019
	Sig.	.037	.012	.025	.010	.408	.650	.580	.779
Excess sunshine	Correlation Coeff	-.119	-.142*	-.128	-.145*	-.044	-.062	-.058	-.075
	Sig.	.085	.040	.065	.036	.521	.369	.400	.282
Excess fog	Correlation Coeff	-.079	-.061	-.028	-.059	.024	.099	.097	.070
	Sig.	.254	.382	.684	.397	.730	.151	.162	.315
More drought/flood	Correlation Coefficient	.042	.026	.039	.025	.140*	.071	.078	.068
	Sig.	.548	.709	.572	.720	.043	.303	.262	.329
High wind	Correlation Coefficient	-.161*	-.182**	-.169*	-.184**	-.034	-.016	-.010	-.025
	Sig.	.020	.008	.014	.008	.622	.823	.885	.718
Less humidity	Correlation Coefficient	-.123	-.134	-.108	-.128	-.046	-.035	-.026	.054
	Sig.	.075	.053	.118	.065	.508	.614	.705	.439
Extreme longer night	Correlation Coefficient	-.096	-.121	-.088	-.119	-.053	-.067	-.058	-.029
	Sig.	.166	.079	.204	.085	.441	.337	.401	.679
Extreme longer day	Correlation Coefficient	-.147*	-.133	-.156*	-.129	-.064	.108	.098	.161*
	Sig.	.033	.055	.024	.062	.357	.120	.158	.020
High humidity	Correlation Coefficient	-.137*	-.152*	-.145*	-.148*	-.082	.092	.093	.157*
	Sig.	.048	.028	.036	.032	.238	.182	.179	.022

Source: *field survey 2020*

The result of the z-test conducted in Table 3 showed that the t-*tab* (4.8817)>*t*- cal (2.91764) at probability value of (P<0.05*: P-values*=0.034401 and 0.04554). Since t-tab is greater than t-cal, the null hypothesis rejected and the alternative accepted, indicated that there is a significant difference between awareness of the use of mitigating strategies to reduce effects of climate change in Essien Udim forest.

Table 3: Z-Test of awareness and mitigating strategies to reduce effect of climate change

	Mitigating strategies	*Awareness*
Mean	50.5	32.5
Variance	102.5	212.5
Observations	12	2
Hypothesized Mean Difference	0	
Df	2	
t Stat	4.881773	
P(T<=t) one-tail	0.033301	
t Critical one-tail	2.718786*	
P(T<=t) two-tail	0.04554**	
t Critical two-tail	2.917644	

(P<0.05*: P-values*=0.034401* & 0.04554**) *significant difference at 1% level

The socio-economic characteristics showed that age had a negative relationship with mitigating strategies on using alternative energy sources such as solar panel (-0. 30) and gender had no relationship with any of the mitigating strategies. Marital status had positive relationship on reduction in the burning of fossil fuels (0.006), using alternative energy sources such as solar panel (0.014), Reduction in burning of simple coal (0.006), irrigation (0.038), and use of alley farming (0.045). Education had a positive relationship with prompt weeding (0.044) and livelihood with irrigation (0.022), years of experience with reduction in the burning of fossil fuels (0.007), using alternative energy sources such as solar panel (0.030), reduction in burning of simple coal (0.007) and prompt weeding (0.003), and use of alley farming (0.045).

Table 4: Correlation Matrix between Socio-economic Characteristics of the Respondents and Mitigating Strategies on Climate Change at Essien Udim Forest

		Reduction in the burning of fossil fuels	Using alternative energy sources such as solar panel	Reduction in burning of simple coal	Stop falling of trees	Prompt weeding	Planting of trees	Intro of agro forestry system	Use of alley farming	Irrigation	Crop diversify cation	Change in farming season/ cropping pattern
Gender	Pearson	.066	.058	.049	.100	.061	.093	.040	.068	.099	.096	.102
	Sig. (2-tailed)	.343	.404	.476	.148	.379	.179	.568	.328	.153	.165	.139
Age	Pearson	-.078	-.030	-.086	.149*	-.107	.159*	-.073	.034	.086	.143*	.119
	Sig. (2-tailed)	.263	.669	.213	.031	.122	.021	.290	.619	.213	.039	.086
Marital status	Pearson	.190**	.169*	.191**	.098	.162*	.108	.179**	.138*	.143*	.124	.111
	Sig. (2-tailed)	.006	.014	.006	.156	.018	.118	.009	.045	.038	.074	.107
Educational	Pearson	.108	.070	.112	.060	.139*	.058	.092	.063	.092	.063	.192**
	Sig. (2-tailed)	.120	.312	.106	.390	.044	.406	.184	.361	.183	.364	.005
Livelihood	Pearson	-.087	-.117	-.115	.064	-.061	.078	-.121	-.059	.158*	.126	.125
	Sig. (2-tailed)	.208	.092	.096	.359	.377	.259	.081	.396	.022	.069	.070
Experience	Pearson	-.186**	-.150*	-.186**	-.116	-.207**	-.097	-.182**	-.130	-.063	-.025	-.067
	Sig. (2-tailed)	.007	.030	.007	.093	.003	.160	.008	.061	.362	.719	.330
	N	210	210	210	210	210	210	210	210	210	209	210

**. Correlation is significant at the 0.01 level (2-tailed), *. Correlation is significant at the 0.05 level (2-tailed).

Table 5: Effect of Climate Change on biodiversity of Essien Udim Forest

Effects N=210	Mean± SD	z-test z-score	p-value	SA	A	D	SD	Remark
Disease outbreak in the forest	2.97±0.64	2.107	0.016	100	40	35	35	S
Die-back due to fungi disease outbreak as a result of flooding	2.86±0.66	-1.016	0.155	90	40	40	40	S
Chlorosis due to bacterial diseases in the forest	2.95±0.62	2.271	0.011	95	43	40	32	S
Disease symptoms on the trees	2.83±0.70	2.261	0.010	90	35	45	40	S
Buildup of pests in the forest	2.76±0.76	2.271	0.011	85	35	45	45	S
Causes Stunted growth on trees	2.57±0.55	-1.930	0.027	70	35	50	55	S
Causes poor yield of trees	2.60±0.68	-2.105	0.015	70	35	55	50	S
Reduced tree canopies of the forest	2.51±0.64	-2.101	0.010	63	35	60	52	S

= Significant, >2.50=Effective; $P \leq 0.05$

SA - Strongly agreed
A - Agreed
D - Disagreed
SD - Strongly Disagreed
SD - Strongly Disagreed

Discussion of Findings

Effect of Climate Change on biodiversity of Essien Udim Forest

The respondents in the study area were of the view that the effects of climate change on biodiversity of Essien forest include outbreak of diseases in the forest, die-back due to fungi disease outbreak as a result of flooding, Chlorosis due to nutrient deficiency soil in the forest and symptoms on the trees, buildup of pests in the forest, causes stunted growth on trees, causes poor yield of trees and reduced tree canopies of the forest. Soil is the habitat for fungi, bacteria, plants and animals, resulting in enormous biodiversity belowground and aboveground micro-organisms, as earlier reported by Auclair and Revenga (1996) and Auclair *et al.*, (1992).Forests provide many social, economic and environmental benefits. They also provide an important defense against climate change (Manstrandrea and Schneider, 2009) in that they facilitate photosynthesis which produces Oxygen (O_2) and consumes huge amounts of CO_2 known for effecting global warming. The number of trees available to absorb CO_2 through photosynthesis has been greatly reduced through deforestation. Human beings cut down trees for timber or to clear land for farming or building. This is in consonance with the present findings.

Similarly, the ozone layer gets depleted when the atmosphere becomes impure due to the release of dangerous gases or repellents from industries, exhaust pipes of vehicles, air conditioning devices and refrigerators. These materials emit substances such as chlorofluorocarbons (CFC), carbon monoxide (CO_2), hydrocarbons, smoke, soots, dust, nitrous oxide and sulphur oxide which deteriorate the ozone layer (Ringius, 1996; Manstrandrea and Schneider, 2009).Greenhouse effect is the capacity of greenhouse gases for example, water vapour, carbon dioxide, methane, nitrous oxide, ozone, chlorofluorocarbons, hydro-chlorofluorocarbons, hydro-fluorocarbons, and per fluorocarbons) in the atmosphere to trap heat emitted from earth surfaces, thereby insulating and warming the planet in a blanketing manner or in a layer of greenhouse gases in the atmosphere. These atmospheric gases concentrate as a result of inventions that burn fossil fuels as well as other activities such as clearing of land for agriculture or buildings, and cause the earth's climate to become warmer than it would naturally (Hernes, 1998; Paehler, 2009). Agriculture is a contributor to climate change. Clearing forests for fields, burning crop residues, submerging land in rice paddies, raising large herds of cattle and other ruminants and fertilizing with nitrogen, all release greenhouse gases to the atmosphere (Rosenzweig and Hillel, 1995).

Warmer climates provide more favourable conditions for the proliferation of insect pests and diseases. Altered wind patterns may change the spread of both wind-borne pests and of bacteria and fungi that are the agents of crop diseases. Crop-pest interactions may shift as the timing of developmental stages of both hosts and pests may be altered. Livestock diseases may be similarly affected.

Several animals may be predisposed to higher instances of heat stress, increased disease transmission and possible resistance to disease control measures by economically important pests and diseases in most African regions (Manstrandrea and Schneider, 2009). Also, an increase in the frequency of extreme events such as sprolonged drought or intense flooding could create conditions that could be conducive to disease or pest outbreaks, and severely disrupt the predator-prey relationships that normally restrict the proliferation of pests (FME, 2003). This also agreed with the present results findings. Warmer and more humid conditions would enhance the growth of bacteria and moulds on many types of stored food, and this would increase food spoilage and create some specific toxicological health hazards. Temporal variations in soil physico-chemical properties pH, moisture, total organic matter and nitrogen as a result of effects of climate change like flooding and rise in temperature , influences the population status and their species composition of microorganism which results to diseases (Das and Dkhar, 2011).

IPCC (2007), projected temperature increases for several different scenarios, depending on the magnitude of future greenhouse gas emissions. For a "moderate" scenario-in which emissions grow slowly, peak around the year 2050, and then fall-the IPCC report projected further warming of 1.1 to 2.9^{o}C by the year 2100 (IPCC, 2007). For a "high-emissions" scenario-in which emissions continue to increase significantly and finally level off at the end of the century-the IPCC report projected further warming of 2.4 to 6.4^{o}C by the year 2100. The IPCC cautioned that even if greenhouse gas concentrations in the atmosphere ceased growing, the climate would continue to warm for an extended period as a result of past emissions, and with more dramatic effects than were observed during the 20th century. If greenhouse gas emissions continue to increase, climate scientists project severe climate changes. This does not differ from the present research findings.

The result on the relationship between climate indicators and its effect on the biodiversity of Essien Udim forest showed that rainfall had a positive significance on disease outbreak in the forest, die-back due to fungi disease outbreak as a result of flooding, chlorosis due to nutrient deficiencies in the forest and disease symptoms on the trees. Excess sunshine had relationship with die-back due to fungi disease outbreak as a result of flooding, excess fog had negative relationship on chlorosis due nutrient deficiencies in the forest, more drought/flood is significant with disease outbreak in the forest, die-back due to fungi disease outbreak as a result of flooding, chlorosis due to nutrient deficiencies in the forest and disease symptoms on the trees. High wind had negative significant on reduced tree canopies of the forest. Extreme longer day had significant on disease outbreak in the forest and high humidity had positive significant on disease outbreak in the forest, die-back due to fungi disease outbreak as a result of flooding, chlorosis due to nutrient deficiencies in the forest, disease symptoms on the trees and reduced tree canopies of the forest (Auclair *et al*., 1992). Indicating that climate change indicators like excess rainfall, flooding/drought and outbreak of pests affect the soil composition, crops growing in the forest and the trunk of trees thereby leading to poor/low yields of food products, stunk growth of tees and buildup of pests in the forest. This confirms the findings of Das and Dkhar, (2011) and Dyer (1995) that flooding and excess sunshine have affected the species composition of microorganism in the soil which results to nutrient deficiencies like chlorosis in the forest.

Effect of Climate Households in the Study Area

Effects of climate change on households and the study area revealed that it has led to increased rise in sea level, coastal erosions because of rise in sea level, increased cost of non-timber forest products (NTFPs), none availability of NTFPs, flooding that has hindered harvesting of NTFPs, increased incidence of pests and diseases, low/poor yield of forest crops like okasi (*Gnetum africanum)* leaves among others and change in rainfall pattern. The findings confirm with Deressa *et al.*, (2008) who stated that evidence has shown climate change has already affected crop yields in many countries. Also, Lobell *et al.*, (2008) stated that evidence have shown that global warming has influenced agricultural productivity leading to declining food production and high cost of food products.

To reduce the effects of climate change at Essien Udim Forest, some mitigating strategies have been adapted by households that get their source of livelihoods from the forest. The results showed that the mitigating strategies are, reduction in the burning of fossil fuels, use of alternative energy sources such as solar panel, reduction in the burning of simple coal, stop the falling of trees, prompt weeding, planting of trees, introduction of agro forestry system, change in farming season/ cropping pattern and the use of alley farming. However, irrigation and crop diversification were not accepted. This supports Slibodan (2012), who suggested the use of alternative energy sources such as solar panel, changing farming and cropping pattern and building new water projects for flood control and drought management.

CONCLUSION AND RECOMMENDATIONS

Conclusion

The study has shown that there are indicators of climate change in the study area such as excess rainfall, excess sunshine, excess fog, high cases of drought/flood, and high wind. Including less humidity, extreme longer night, extreme longer day and high humidity, these indicators of climate change were as a result of burning, burning of fossil fuel, use of agrochemicals to kill or dry up trees and changes in sun energy. These indicators have affected the biodiversity of the forest such as by causing outbreak of diseases in the forest, die-back due to fungi disease outbreak resulting of flooding, chlorosis due to bacterial diseases in the forest, disease symptoms on the trees, buildup of pests in the forest, causes stunted growth on trees, causes poor yield of trees and reduction of tree canopies. Not only was the biodiversity of the forest affected but also the livelihoods of households and the study area in general.

Climate change has led to increased rise in sea level, coastal erosions because of rise in sea level, increased cost of non-timber forest products NTFPs, none availability of NTFPs, flooding that has hindered harvesting of NTFPs, increased incidence of pests and diseases, low/poor yield of forest crops like okasi leaves among others and change in rainfall pattern. In order to reduce the effects of climate change, households adapted some mitigating strategies such as reduction in the burning of fossil fuels, use of alternative energy sources such as solar panel, reduction in the burning of simple coal, stop the falling of trees, prompt weeding, planting of trees, introduction of agro forestry system, change in farming season/ cropping pattern and the use of alley farming.

Recommendations

Based on the findings the following are recommended:

1. The use of agrochemicals to dry up trees should be discouraged among rural people as it increases the fast denegation of the biodiversity of the forest.
2. Rural people should be encouraged to plant trees instead of falling trees in the study area.
3. There is the need to increase climate change information to rural households' as such information when communicated effectively to them will enable them to understand its causes and how to reduce its impact.

Contribution to Knowledge

1. It was discovered that climate change has impacted negatively on the biodiversity of the forest thereby resulting to low yield of food crops in the area.
2. From the finding it has been proven that climate change has resulted in the reduction/none availability of NTFPs in the study area.
3. Finally, high cost of NTFPs in the study area was as a result of climate change.

REFERENCES

Adebayo, A.A (2009). Attaining sustainable rural development in Nigeria through effective management of forest based resources. *International Journal of Creativity and Technical Development*, 1(3), 32-45.

Agrios, G.N (2005). *Plant Pathology*, (5th edn) San Diego, CA, USA: Elsevier-Academic Press.

Allison, S. & Treseder, K.K. (2008). Warming and drying suppress microbial activity and carbon cycling in boreal forest soils. *Global Change Biology*, 14, 2898–2909.

Auclair, L.J.T & Revenga, C (1996).The role of climate variability and global warming in the dieback of northern hardwoods. *Water Air Soil Pollution*, 91, 163-186.

Auclair, L.J.T., Worrest, R.C., Lachance, D. & Martin, H.C. (1992).Climatic perturbation as a general mechanism of forest dieback. In: Manion PD, Lachance, D (eds). *Forest Decline Concepts*, APS Press, St. Paul, MN, 38-58.

Ayres, M. P. & Lombardero, M. J. (2000).Assessing the consequences of global change for forest disturbance from herbivores and pathogens. *Science of the Total Environment* 262, 263–86.

Campbell, C.L. & Madden, L.V. (1990). *Introduction to Plant Disease Epidemiology*. New York, USA: John Wiley & Sons.

Chakraborty, S. & Datta, S. (2015). How will plant pathogens adapt to host plant resistance at elevated CO2 under a changing climate? *New Phytology*, 159, 733-742.

Chen. (2014). The interaction between arbuscularmycorrhizal fungi and soil phosphorus availability influences plant community productivity and ecosystem stability. *Journal of Ecology*, 102, 1072–1082.

Das, B.B. & Dkhar, M.S. (2011). Rhizosphere microbial populations and physico chemical properties as affected by organic and inorganic farming practices. *American European Journal of Agricultural and Environmental. Science*, 10, (2), 140-150.

Deressa, T., Hassan, R.M., Alemu, T., Yesuf, M & Ringler, C. (2008).Analyzing the Determinants of Farmers' Choice of Adaptation Methods and Perceptions of Climate Change in the Nile Basin of Ethiopia. *International Food Policy Research Institute (IFPRI) Discussion Paper No. 00798*. Environment and Production Technology Division, IFPRI, Washington D.C.

Dyer, J. (1995). Assessment of climatic warming using a model of forest species migration. *Ecology Model*, 79, 199-219.

Federal Ministry of Environment (FME) (2003). Nigeria's first National Communication under the United Framework Convention on climate change. The Federal Ministry of Environment, Abuja, Landmark Publication Lagos, Nigeria.

Garrett, K. A., Dendy, S. P., Frank, E. E., Rouse, M. N &Travers, S. E. (2006). Climate change effects on plant disease: Genomes to ecosystems. *Annual Review Phytopathology*, 44, 489-509.

Grulke, N. E (2011). The nexus of host and pathogen phenology: Understanding the disease triangle with climate change. *New Phytology*,189, 8-11.

Hernes, H. (1998). A climate strategy for Africa towards environmentally sustainable development in Sub-Saharan Africa. AFTES Post UNCED series. Paper No. 10 world bank. Also available at http//www.worldbank.org/afr/findings/English /find120.htm.

IPCC (2001). Climate Change 2001: Impacts, Adaptation and Vulnerability. Working Group II. Contribution to the Third Assessment Report of the Intergovernmental Panel on Climate Change, "Chapter 18: Adaptation to Climate Change in the Context of Sustainable Development and Equity", Cambridge University Press, Cambridge, 877-912.

IPCC (2007) (Intergovernmental Panel on Climate Change).Summary for policy makers. In: Solomon S, Qin D, ManningM et al., eds. Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK: Cambridge University Press, 1–18.

IPCC AR4 WGI (2007). The report climate change 2007: The physical science basis. In S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor, H.I Miller (eds). Contribution of working group 1 to the Fourth assessment report of the International panel on climate change.Cambridge University Press, Cambridge UK and New York, USA, ISBN 978-0-521-880091. Also available at http://www.ipcc.ch/publications and data/ar4/wgl/en/contents.html (pb:978-0521-70596-7).

Ladanyi, M & Horvath, L. (2010). A review of the potential climate change impact on insect populations – general and agricultural aspects. *Applied and Ecology Environmental Resource*, 8, 143-152.

Lobell, D.B. & Marshall, B. B. (2008).Why are agricultural impacts of climate change so uncertain? The importance of temperature relative to precipitation. *Environmental Resource Letter*,3 (034007), 1-8.

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

Manstrandrea, M.D. & Schneider, S.H. (2009).Global warming. Microsoft ® Encarta ® Online Encyclopedia.

McCarthy, J., O. F. Canziani, N. A. Leary, D. J. Dokken, & C. White, eds. (2001). Climate change: Impacts, adaptation, and vulnerability. Contribution of Working Group II to the third assessment report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press.

Mshelia, A. (2005). Adaptation Strategies To Climate Change. *Journal Energy Environmental*, 18(3), 74-81.

Muths, E., Pilliod, D.S & Livo, L.J (2008). Distribution and environmental limitations of an amphibian pathogen in the Rocky Mountains, USA. *Biological Conservation*, 141, 1484-1492.

Nkomo, J.C., Nyong, A.O. & Kulindwa, K. (2006). The Impacts of Climate Change in Africa. Final draft paper submitted to The Stern Review on the Economics of Climate Change, July, 2006

Onokerhoraye, C. (2011). Climate Change And Sustainable Development In Nigeria; Conceptual And Empirical Issues. Enugu Forum Policy Paper 10. African Institute For Applied Economics, Nigeria.

Pachler, K (2009). Nigeria in the dilemma of climate change. Konrad Adenauer publications, Nigeria Office. Also available at http//www.kas.de/proj/home/ pub33/2/document_id-11468/index.html.

Read, D.J (1992). The mycorrhizal mycelium.102-133 *in* M. F. Allen, editor. Mycorrhizal functioning. Chapman and Hall, London.

Ringius, L. (1996). Climate change in Africa - issues and challenges in agriculture and water for sustainable development. CICERO Report, 1996.

Rosenzweig, C., Iglesias, A., Yang, Y. B., Epstein, P. R., & Chivian, E. (2000). Climate Change and U.S. Agriculture: The Impacts of Warming and Extreme Weather Events on Productivity, *Plant Diseases and Pests*. Boston, MA, USA: Center for Health and the Global Environment, Harvard Medical School.

Scherm, H. (2004). Climate change: Can we predict the impacts on plant pathology and pest management? *Canadian Journal of Plant Pathology*, 26, 267-273.

Slobodan, P. S (2012). *Floods in a Changing Climate: Risk Management*. *International Hydrology Series*. Cambridge University Press,

Spiegelberger, T., Hegg, O., Diethart, M., Hedlund, K. & Schaffner, U. (2006) Long-term effects of short term perturbation in a subalpine grassland. *Ecology* 87,1939–1944

Stern, N. (2007). *The Economics of Climate Change:* The Stern Review. Cambridge, UK: Cambridge University, Press.

Ukoima H. N. (2018). Effect on climate change on agriculture a paper presented during the World Environment Day organized by the Environment, my wealth in conjunction with the Rivers State Ministry of Environment. Academic Edu.

United State Department of Agriculture - USDA (2011).The Role of Forests in Sustainable Development. Retrieved from *https://www.fs.fed.us/speeches/role-forests-sustainable-development.*