JRAS

An International Journal

# Journal

## OF RESEARCHES IN AGRICULTURAL SCIENCES

Formerly known as Agricultural Sciences Research Journal

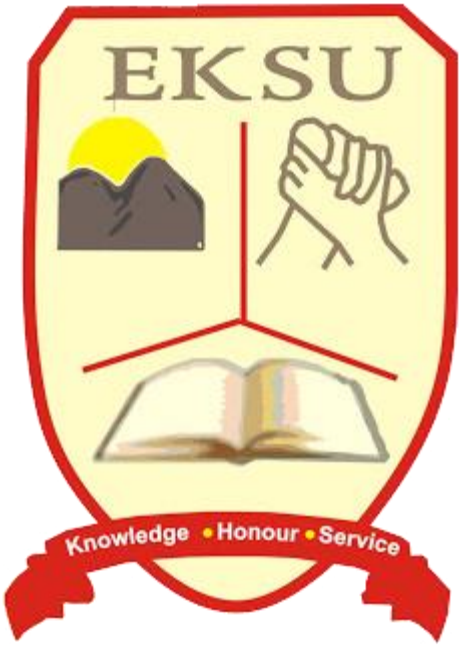
Volume 7, Nos 1 & 2

JOURNAL OF RESEARCHES IN AGRICULTURAL SCIENCES

Volume 7, Nos 1 & 2

# EKITI STATE UNIVERSITY

## FACULTY OF AGRICULTURAL SCIENCES




*JOURNAL OF RESEARCHES IN AGRICULTURAL SCIENCES*

VOLUME 7, NUMBERS 1 & 2, 2019

JRAS Editorial Office,
Faculty of Agricultural Sciences,
Ekiti State University,
Ado-Ekiti, Nigeria.
E-mail: foas.jras@eksu.edu.ng
jras.foas@gmail.com
Website:

ISSN: 2006 - 0041
Code: RAS 2008

Published by: *Journal of Researches in Agricultural Sciences*
JRAS Editorial Office
Faculty of Agricultural Sciences
Ekiti State University,
Ado-Ekiti, Nigeria.

Website:

# Journal of Researches in Agricultural Sciences

## CONTENTS

### MARCH



### SEPTEMBER




STEPHOL PRINTS

Journal of Researches in Agricultural Sciences Vol. 7


Journal of Researches in Agricultural Sciences

JRAS



Vol. 7(2), Sept. 2019 pp 31-42

# Climate Change Impacts on Ecosystem Services and Livelihoods of Fringe Forest Communities in Ondo State, Nigeria.

**O.V. Oyerinde and L.B. Adedoyin**

*Department of Forestry and Wood Technology,*
*Federal University of Technology, Akure, Nigeria.*

E-mail: ovoyerinde@futa.edu.ng

## Abstract

The changing climate from natural, but more from anthropogenic factors as indicated by global warming, unusual rainfall regimes and rising atmospheric carbon dioxide levels already affects agricultural production such that measures for climate change adaptation and mitigation are being emphasized. This study examined the impacts on of climate change on ecosystem services and livelihoods, and the adaptation and coping strategies in two forest communities of Ondo State, Nigeria. Primary data were obtained from 80 randomly selected respondents in four fringe communities of Ala and Akure Forest Reserves using a pre-tested and validated semi-structured interview schedule and subjected to quantitative statistical analysis. Sixty year-climate data obtained from Climate Research Unit of East Anglia, Norwich, UK showed that average temperature increased significantly while the increase in rainfall was insignificant and with high variability over the period for the study area. The forest communities derive provisioning, regulating, cultural and supporting services from the forest reserves with the most important ecosystem services being provisioning and supporting services at 63 and 53% ranking respectively. Almost all the respondents (95%) were aware of the changing climate and identified that crop farming was the livelihood most affected even as 49% attributed a reduction in soil fertility to it. Furthermore, climate change has reduced the natural ability of the forests to provide ecosystem services especially provisioning and regulating services in the study areas. Members of the forest communities have adopted various on-farm and off-farm adaptation strategies to cope with the changing climate and to improve their livelihoods.

**Key words**: Climate change, ecosystem services, forest communities, livelihoods, Nigeria

Cite as: Oyerinde, O.V. and Adedoyin, L.B. (2019). Climate Change Impacts on Ecosystem Services and Livelihoods of Fringe Forest Communities in Ondo State, Nigeria. Journal of Researches in Agricultural Sciences. Vol. 7(2), pp 31-42

## Introduction

Climate change is a serious challenge facing the world today with its impacts felt in all facets of life. According to Staudinger *et al* (2012), climate change has documented impacts on biodiversity with a focus on genes, species, and assemblages of species, ecosystem structural elements and functions of various ecological systems. These impacts are expected to increase as climate change continues and perhaps even accelerates. Climate change may be due to natural internal processes, external forcing and persistent anthropogenic changes in the composition of the atmosphere or in land use (IPCC, 2014). However, human activities such as burning of fossil fuels, deforestation and growing world population are the main causes of the changes seen in the climate today (IPCC, 2007). The emission of greenhouse gases (GHG) and global warming largely result from the industrial activities in developed countries but the effects are felt in developing countries where the livelihoods of the poor are severely at risk (McGuigan *et al.,* 2002). The impacts of climate change in developing countries could be dramatic, particularly with regard to marginal regions and highly vulnerable poor communities

(Boon and Ahenkan, 2011). For example, over 250,000 Nigerians were displaced by flood disasters that ravaged many communities across the country in 2010 (NEMA, 2010).

Human well-being and progress towards sustainable development are vitally dependent upon the earth's ecosystem services (IPCC, 2007). According to MEA (2005), the ecosystem services are the benefits people obtain from ecosystems which include provisioning services such as food and water; regulating services such as flood and disease control; cultural services such as spiritual, recreational and other cultural benefits; and supporting services, such as nutrient cycling, that maintain the conditions for life on earth.

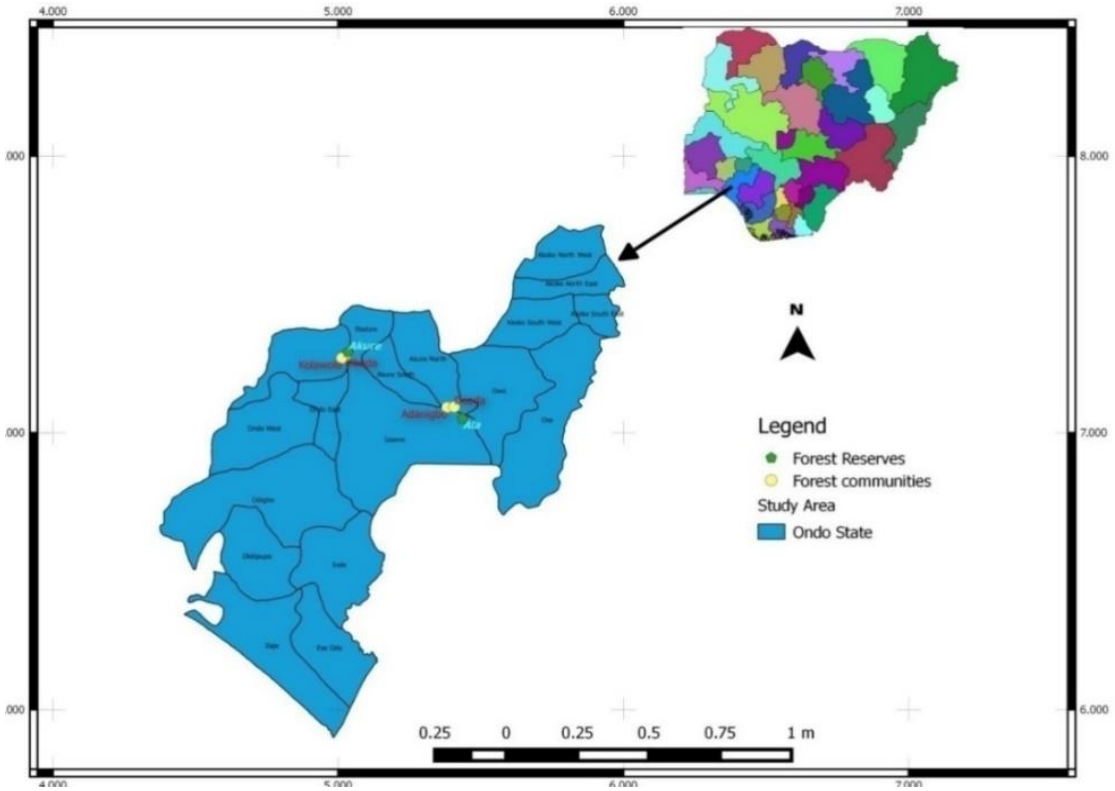



Fig. 1: Map of Nigeria showing the study area

Over one billion people rely heavily on forests and its services for their livelihoods (World Bank, 2004). The forests serve as carbon sinks and provide climate regulating services locally and globally (Bonan, 2008). However, the ecosystems, biodiversity and the services they support are intrinsically dependent on climate (Karevia *et al.*, 2012). The natural and agricultural ecosystems, including freshwater and coastal resources, are highly susceptible to the effects of climate change and the impacts of changing climate are already being experienced in Nigeria (NIMET, 2016). Ding *et al.* (2010) reported that the declining productivity and deterioration of forest ecosystems is a central concern to millions of people, whose livelihoods depend on them. There is the need to assess the impacts of climate change on the ecosystem services in order to explore the ecological, socio-cultural and economic values of the ecosystem services which, in turn, would facilitate planning and formulation of strategies and policies to safeguard valuable ecosystems, livelihoods, human well-being and environment at large (MEA, 2005). This study was carried out to assess the impacts of climate change on the ecosystem services and livelihoods in two forest communities of Ondo State, Nigeria, and the adaptation and coping strategies put in place to mitigate the negative effects.

## Materials and Methods

### *Description of study area*

This study was carried out in Akure and Ala Forest Reserves in Ondo State. The reserves are within the tropical rainforest ecosystem of Nigeria. Akure Forest Reserve (lat. 7.16°-7.29° N; long. 5.034°-

5.083º E) experiences humid tropical climate with seasonal variation. The mean annual rainfall is about 1600 mm with double maximum in July and September separated by a short relatively dry period in August while December-February constitutes the major dry season in which January and February as the driest months receive less than 30 mm rainfall (Akinyemi and Oke, 2014). Temperature ranges from about 20.6ºC to 33.5ºC which provides a conducive condition to the development of tropical rain forest. Ala Forest Reserve (lat. 6.75º-7.00º N; long. 5.00º-5.17º E) is 166 $km^2$ in size and divided into 100 annual coupes of productive forest for effective management (Adekunle, 2006). It was constituted as a government reserve by Order No.21 of 1950 and published in gazette No. 35 of 29th June, 1950.

## Method of data collection

This study made use of primary and secondary data. The primary data were collected from stakeholders and community dwellers in the forest communities with the aid of a semi-structured questionnaire and focus group discussions. Two communities in each forest reserve were purposively selected based on proximity to the forest reserve and accessibility. In all, four communities: Adanigbo, Daada, Kolawole and Obada were selected from within and around the forest reserves. The coordinates of each forest reserve and selected communities were obtained using a hand-held Global Positioning System unit. Pre-tested and validated semi-structured questionnaire were administered to 20 dwellers in each community (at 10 to men and women) for a total of 80 interview schedules while two forest officials in each reserve were interviewed. Only community members who were above 40 years old were interviewed based on the assumption that younger people have less experience on climate change impacts.

The secondary data were in form of climate data, literature, research reports and published articles relevant to the specific issues of the study. Climate data on the spatiotemporal pattern of temperature and rainfall of Nigeria were obtained from the Global Gridded Climatology (CRU TS 3.21) presented at a new high resolution (0.5º latitude /longitude) and made available by the Climate Impacts LINK project, Climate Research Unit (CRU), University of East Anglia, Norwich, UK (Mitchell and Jones, 2005). The 0.5º-resolution dataset of monthly surface-based climate parameters covered the 1953-2012 period (60 years). The reference CRU grid stations used for this study were Oba-Ile (lat. 5.25º N, long. 7.27º E) and Deji Camp (lat. 5.78º N, long. 7.20º E) for Akure and Ala Forest Reserves respectively.

## Data analysis

The interview schedules completed for each of the communities and respondents were scored to obtain quantitative values for statistical analysis. The quantitative information was analyzed using Statistical Package for Social Sciences (SPSS 16.0). Descriptive analysis in form of frequency, percentage distribution, tables and bar charts were used to analyze socio-economic and demographic variables of respondents. Quantum Geographic Information System (GIS) software package was used to produce the thematic maps of the study area. The climate data were subjected to time series and regression analyses using Microsoft Excel software. Temperature data were averaged while rainfall data for each gridded point stations were summed for the period of 60 years (1953-2012). The Mann-Kendall non-parametric test was used to analyze trends direction.

## Results and Discussion

### *Long-term temperature and rainfall patterns*

The temporal time series distribution and cumulative departures of mean annual temperature are shown in Fig. 2. There was a positive trend in annual temperature with ranges for the 60 year-period of 29.7º-31.9ºC and 31.4º-32.2ºC which indicate increases of 2.2º and 0.8ºC for Akure and Ala forest reserves respectively. Odjugo (2005) reported temperature increases of 1.2ºC in Port Harcourt, a coastal city in Rivers State, and 2ºC for Nguru, a semi-arid city in Yobe State, Nigeria between 1901 and 2005. This confirms the widespread increase in global temperature in recent decades but the values are higher than the global mean temperature increase of 0.74ºC recorded since 1860 when the scientific

measurement started (IPCC, 2007; Fan *et al.,* 2010) and exceed the increasing trend in air temperature of 0.036ºC in Nigeria from 1991-2000 (Akinsanola and Ogunjobi, 2014). There was no significant increase in the mean annual rainfall for the study locations. The minimum annual rainfall for Akure and Ala forest reserve was 1088.5 mm and 1231.3 mm respectively and the rainfall patterns showed very high variability in total precipitation volumes from year to year. The average negative deviation from the historical mean of 805.33 mm year$^{-1}$ was -105.3% while the average positive deviation was 120.9 percent. Anuforum (2010) had indicated established cases of approximately 1.2ºC increase in temperature and rainfall variability in the Niger Delta region which includes parts of Ondo State.

The rising temperatures can have adverse effects on crop growth and the irregularity of rainfall, even if total precipitation is sufficient, can affect yields adversely if the rains fail to arrive during the crucial crop growth stage and consequently affect the livelihoods of the forest community dwellers.

## Respondents' knowledge of ecosystem services

Out of the 80 respondents, 90% in Ala and Akure forest reserves had crop farming as the primary livelihood while 5 and 8% were into trading in Akure and Ala forest reserves respectively. The other primary livelihood activities in the study area were sales of Non-Timber Forest Products (NTFPs), sewing and teaching.

Ecosystem goods and services contribute significantly to the daily needs and livelihoods of the forest communities either directly or indirectly (Boon and Ahenkan, 2011). Table 1 shows the ecosystem goods and services identified to be very important to respondents in the study ar

a.

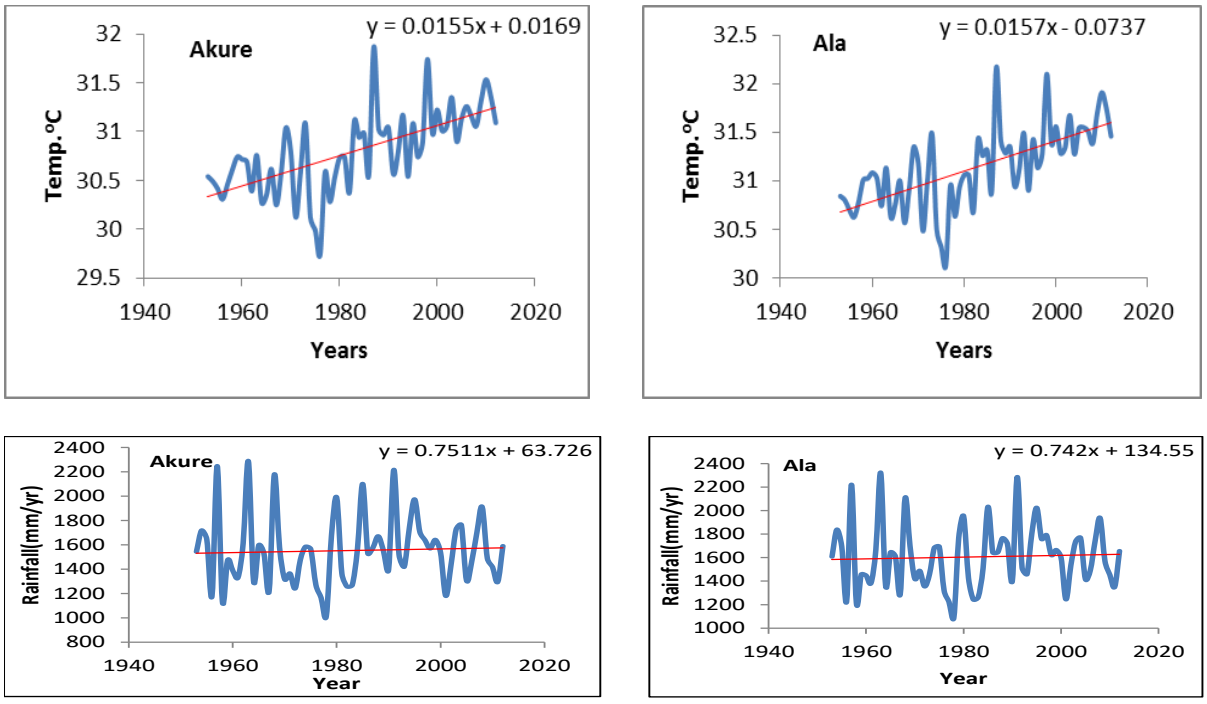



Fig. 2: Time series plot of mean annual temperature and rainfall between 1953 and 2012 for Akure and Ala forest reserves

Rain-fed agriculture (crop farming) constituted the primary and secondary sources of income in the forest communities indicating dependence on forest supporting ecosystem services for livelihoods which can be adversely affected by changes in the climate variables. Ozor (2009) noted that variations in rainfall pattern will affect crop production in different ways depending on the location and that changes in crop development and phenology as a result of climate change can

cause shortening or lengthening of crop cycles which could lead to decreases or increases in productivity.

Table 1: Ecosystem goods and services identified by the forest community dwellers

| Provisioning Goods | | |
|---|---|---|
| Foods | Medicine | Other goods |
| Bush meat | Barks | Fuel wood |
| Honey | Leaves | Timber |
| Wild fruits | Seeds | Grinders |
| Fish | Roots | Chewing sticks |
| Fresh water | Fruits | Building materials |
| Mushrooms | Animal products | Other goods |
| Snails | | |
| Spices | | |
| Kolanuts | | |
| Regulating Services | Cultural Services | Supporting services |
| Air quality regulation | Spiritual values, Religious values | Photosynthesis |
| Local climate regulation | Recreation | Soil formation |
| Erosion regulation | Tourism | Nutrient cycling |
| Water purification | Habitats for Gods | |
| Pest and disease regulation | Coronation materials | |

### *Use of provisioning ecosystem services*

A high dependence on provisioning forest ecosystem services was observed in the study area (Fig. 3) at 70 and 60% of the respondents in Akure and Ala forest reserves respectively. The provisioning ecosystem services were utilized for domestic purposes only by 25 and 37%, and for commercial purposes only by 5 and 3% of the respondents in Akure and Ala forest reserves respectively. Boon and Ahenkan (2011) reported high utilization of forest ecosystem services for both domestic and commercial purposes. Mamo *et al.,* (2007) and Tesfaye *et al.,* (2011) noted this direct-use value of forest provisioning ecosystem services in households as a key determinant of their value, both in consumption and as a source of income

.

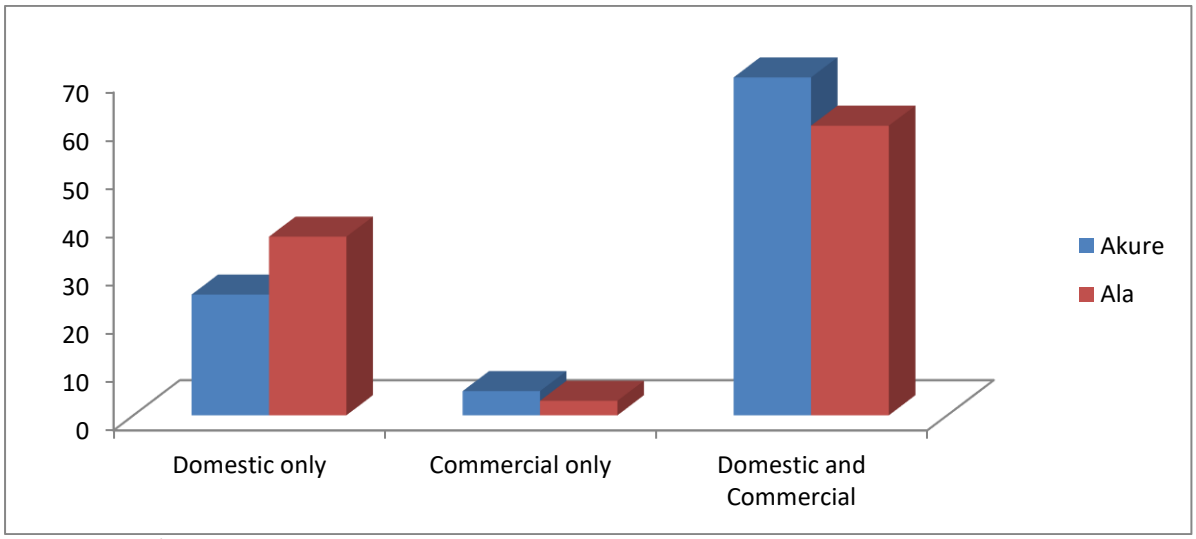



Fig. 3: Use of provisioning ecosystem service in the study area

### *Awareness of climate change impacts by respondents in the fringe forest communities*

Majority of the respondents, almost all (98%) and 88% of the respondents in Ala and Akure forest reserve respectively, were aware of climate change in the study area (Fig. 4) and had observed the effects of increasing temperature, higher intensity of rainfall and seasonal change in rainfall patterns. This high level of awareness is similar to reports by Falola and Fakayode (2014) and Oluwatusin (2014) which indicated 80.8% and 96.9% awareness of climate change among cocoa farmers in Ondo State respectively. The World Bank (2007) had noted that most farmers in Africa are aware of the effects and existence of climate change occurrence in their areas.

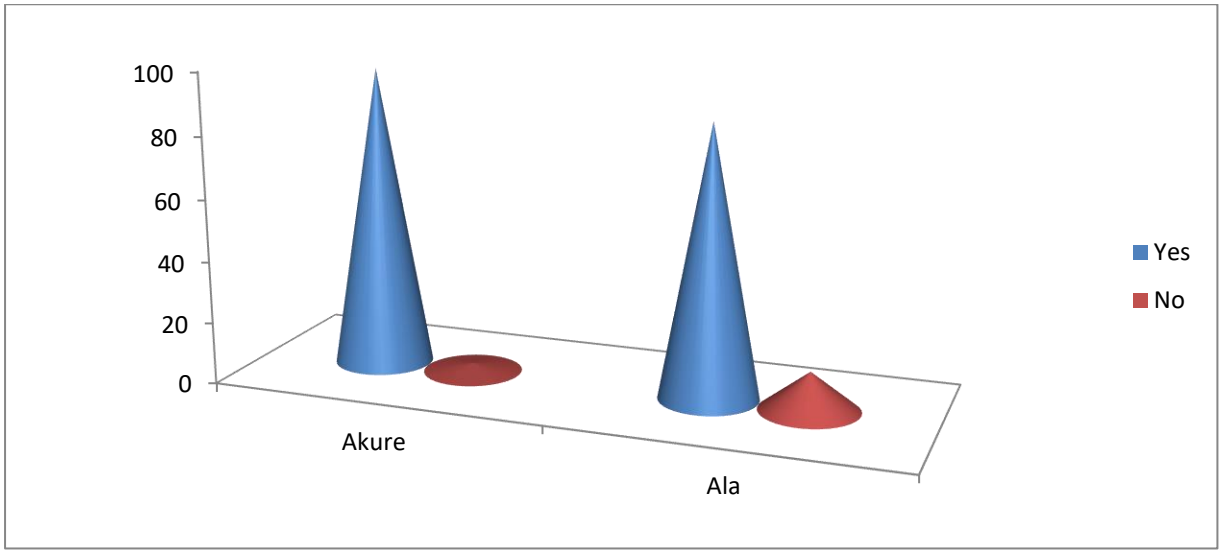



Fig. 4: Awareness of climate change in the study area

### *Perception of change in temperature by respondents*

The results show that majority of the respondents in the study area were aware of temperature change in the study area (Fig. 5). A high proportion of the respondents (68 and 65%) perceived an increase in the average temperature in their communities but 30% and 22.5% perceived a decrease in the average temperature while 2.5% and 12.5% of the respondents did not observe any change in the average temperature in Akure and Ala forest reserves respectively. This is similar to the report of a study by Adekunle *et al.* (2011) carried out in South-west, Nigeria. Also, Lyimo and Kangalawe (2010) observed that 90% of the farmers in Shinyanga rural District, Tanzania acknowledged that there had been a change in climatic condition.

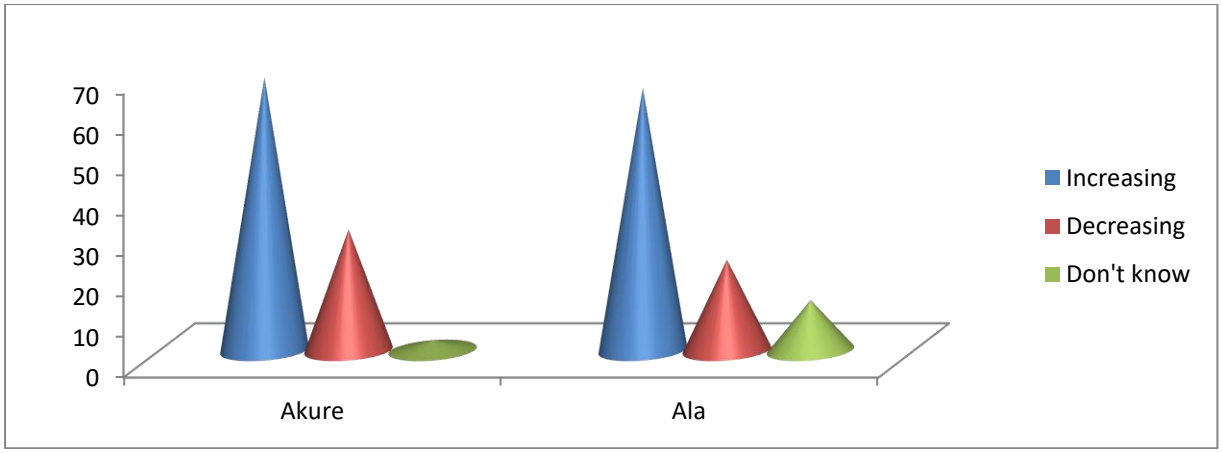



Fig. 5: Temperature change as perceived by respondents

### *Perception about length of rainy season and rainfall pattern*

The perception of the length of the rainy season is presented in Fig. 6. A larger proportion of respondents (55% and 82.5%) claimed experiencing longer rainy seasons compared to 43 and 5% of the respondents who perceived shorter rainy seasons in Akure and Ala forest reserves respectively). The perception of changes in rainfall patterns (Fig 7) was irregular as indicated by 53 and 63%, regular by 45 and 25% while 3% and 13% could not clearly state the current rainfall pattern in Akure and Ala forest reserves respectively.

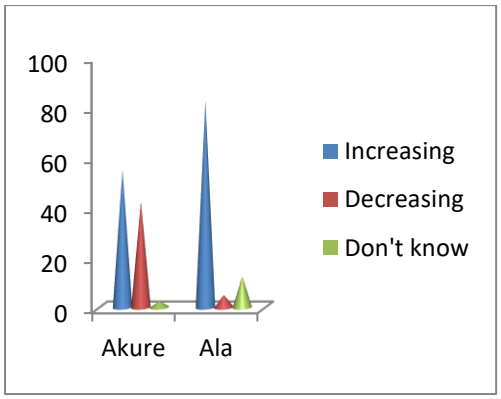



Fig. 6: Perception of rainy season lengths

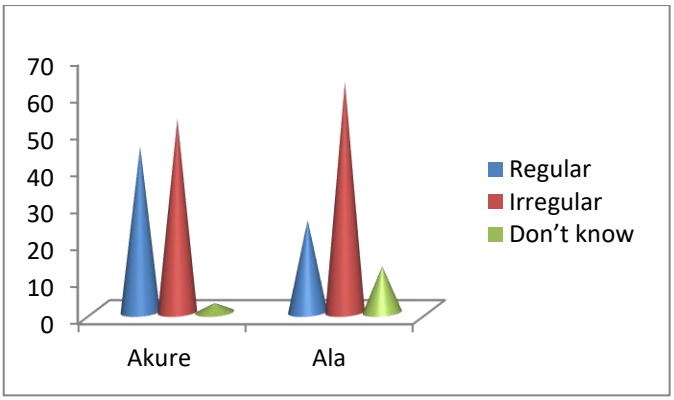



Fig.7: Perception of rainfall pattern

### *Perceived effects of climate change on ecosystem services in the study area*

Table 2 shows the respondents' perception of the effects of climate change on ecosystem services in the study area. Majority of the respondents (53% and 55% in Akure and Ala forest reserve respectively) attributed reduced soil fertility to the change in climate. This could have resulted from the irregular rainfall and increase in temperature. Conant *et al.* (2011) noted that high temperature increases the decomposition rate of soil organic matter which on the long run will adversely affect soil fertility. The reduction in water availability was attributed to climate change by 3% of the respondents in both forest reserves while 7.5 and 10% of the respondents in Akure and Ala forest reserves reported increase in incidence of malaria fever attacks respectively. The increased incidence of pest and diseases due to climate change was reported by 10 and 8% of the respondents in Ala and Akure forest reserves respectively. Dhillon and Sharma (2013) had noted that temperature increases tend to extend the geographic range of some insect pests. However, 8 and 5% of the respondents perceived that the change in climate brought about reduced bush meat availability whereas 7.5 and 2.5% of the respondents in Akure and Ala forest reserve respectively did not perceive

any effect of climate change on ecosystem services in the study area

.

Table 2: Perceived effects of climate change on ecosystem services

| | Akure | | Ala | |
|---|---|---|---|---|
| **Effect of climate change** | **Frequency** | **%** | **Frequency** | **%** |
| Reduced air quality | 2 | 5 | 4 | 10 |
| Increased incidence of pests and diseases | 3 | 7.5 | 4 | 10 |
| Reduced water availability | 3 | 7.5 | 3 | 7.5 |
| Reduced soil fertility | 21 | 52.5 | 22 | 55 |
| Reduced availability of bushmeat | 3 | 7.5 | 2 | 5 |
| Increased malaria incidence | 5 | 12.5 | 4 | 10 |
| No effect | 3 | 7.5 | 1 | 2.5 |
| Total | 40 | 100 | 40 | 100 |

### *Perceived effects of climate change on livelihood activities*

The livelihood activities of the forest communities are presented in Table 3. The most observed effect of climate change was crop failure which affected majority of the respondents which engaged in crop production as the main means of livelihood. Crop failure as a consequence of climate change was indicated by 18 and 30% of respondents while increase in the spoilage of stored produce was noted by 18 and 23 % of the respondents in Akure and Ala forest reserves respectively. The increased spoilage of crops such as cocoa and maize had a negative effect on the income generation of the forest community dwellers. A reduction in animal productivity was reported by 5 and 2.5% of the respondents in Akure and Ala forest reserves respectively while 17.5% of respondents in Ala forest reserve and 5% in Akure forest reserve attributed the decline in NTFPs to climate change effects. This crop failure and spoilage of stored produce were some of the deleterious effects of climate change on production reported by 80.8% of the cocoa farmers in Ondo State (Falola and Fakayode, 2014). The potential of climate change to bring about reduction in soil nutrient availability was reported by 10 and 17.5% of the respondents in Ala and Akure forest reserves respectively. Molua and Lambi (2006) had observed that performance of the agriculture sector depends largely on the return of good rains but which are not assured under changing climate scenarios in agreement with the projection of Assuncao and Feres (2008) that average agricultural output $ha^{-1}$ in Brazil could decrease by 18% due to climate change by the year 2040.

Focus group discussions also revealed the impact of changing climate on the adequate processing and storage of some crop produce especially the drying of cocoa beans, maize grains and cassava mash thereby lowering the quality and quantity of output for sale such that income generation from such sales would decline. Nhemachena *et al. (*2010) and Deressa *et al.* (2009) had observed that climate change would have adverse economic impacts on crop and livestock production systems. About 13% of respondents in Akure forest reserve agreed that climate change caused increase in crop productivity while only 5 and 2.5% of the respondents in Akure and Ala forest reserves respectively stated that the changing climate had no effect on their livelihood activities.

### *On-farm adaptation strategies employed in the study area*

Table 4 shows that various on-farm adaptation strategies have been employed by the respondents to cope with the changes in climatic conditions across the study area. Majority of the respondents (78 and 75% in Ala and Akure forest reserves respectively) changed the usual planting date of the main crops as a measure to cope with the impacts of climate change. Adekunle *et al* (2011) observed that the commonest adaptation method adopted by respondents in Southwest Nigeria was the choice of different planting dates for some crops

due to irregular rainfall. The control of pests and diseases through agrochemical sprays was adopted by 52.5 and 62.5% while fertilizer application was the practiced by 50 and 40% of the respondents in Akure and Ala forest reserves respectively.

Table 3: Effects of climate change on livelihood activities

| Effects of Climate change | Akure Frequency | % | Ala Frequency | % |
|---|---|---|---|---|
| Crop failure | 7 | 17.5 | 11 | 27.5 |
| Increased spoilage of stored produce | 7 | 17.5 | 9 | 22.5 |
| increased disease spread | 3 | 7.5 | 3 | 7.5 |
| Decline in NTFP'S | 2 | 5 | 7 | 17.5 |
| Reduced Soil nutrient availability | 7 | 17.5 | 4 | 10 |
| reduced animal productivity | 2 | 5 | 1 | 2.5 |
| Increased productivity of crops | 5 | 12.5 | 0 | 0 |
| Inability to process farm produce effectively | 2 | 5 | 4 | 10 |
| No effect | 5 | 12.5 | 1 | 2.5 |
| Total | 40 | 100 | 40 | 100 |

Agroforestry was adopted by 47.5 and 40% of the respondents in Akure and Ala forest reserves respectively while other on-farm adaptation strategies employed include application of manure, planting improved crop varieties, improved cultural services and mixed cropping. Ayanwuyi *et al.* (2010) and Falola and Fakayode (2014) observed that various on-farm adaptation strategies such as mixed cropping, planting different crop varieties, changing the planting and harvesting dates, crop protection with agrochemicals and water management among others are the practical measures used by farmers to mitigate the negative effects of climate change.

### *Off-farm adaptation strategies employed in the study area*

Table 5 shows the off-farm adaptation strategies used by the forest community dwellers to cope with the impacts of changing climate. Half of the respondents in Akure forest reserve and 62% in Ala incorporated other non-farm income sources to their livelihood's activity as an adaptation strategy. About 25% and 58% of the respondents adopted local networks for exchange of useful on-farm adaptation techniques in Akure and Ala forest reserves respectively. Also, 23% and 43% of the respondents in Akure and Ala forest reserves respectively claimed to have temporarily migrated while 48 and 60% changed to other sources of income as adaptation measures to the climate change. Only 5% of the respondents in Akure forest reserve and none in Ala forest reserve tried to reduce household consumption as an adaptation strategy to climate change because many already have very little to feed on as the forest communities are home to some of the poorest and most vulnerable people (World Bank, 2001).

Table 4: On-farm adaptation strategies employed by forest community dwellers

| | Akure | | Ala | |
|---|---|---|---|---|
| Adaptation Strategies | Frequency | % | Frequency | % |
| Agroforestry | 19 | 47.5 | 16 | 40 |
| Fertilizer application | 20 | 50 | 18 | 45 |
| manure application | 13 | 32.5 | 10 | 25 |
| Improved cultural practices | 20 | 50 | 14 | 35 |
| Mixed cropping | 9 | 22.5 | 10 | 25 |
| Change in planting date | 31 | 77.5 | 30 | 75 |
| Planting improved crop variety | 15 | 37.5 | 16 | 40 |
| Use of agro-chemicals | 21 | 52.5 | 25 | 62.5 |

Table 5: Off-farm adaptation strategies employed by forest community dwellers

| Adaptation Strategies | Akure Frequency | % | Ala Frequency | % |
|---|---|---|---|---|
| Local networks for exchange of useful on-farm adaptation techniques | 10 | 25 | 23 | 57.5 |
| Temporal migration | 9 | 22.5 | 17 | 42.5 |
| Changes to other forms of non-farm income sources | 27 | 67.5 | 24 | 60 |
| Incorporation of other non-farm income sources with farming | 20 | 50 | 25 | 62.5 |
| Reduction of household consumption | 2 | 5 | 0 | 0 |
| Listening to information about climate change | 5 | 12.5 | 5 | 12.5 |

## Conclusion

Climate change is no doubt one of the greatest environmental threats with social and economic impacts on the livelihoods of people especially forest dependent communities in developing countries. The observed climate change from the statistical analysis of 60-year rainfall and temperature records for the study area was consistent with the forest community dwellers' perception of climate change and variability. The changing climate was identified by the rising temperature, higher amounts of rainfall and their variability. The study shows that the forest reserves are providing ecosystem services, especially provisioning services in the form of food, medicine, building materials etc. to the forest communities. The major source of livelihood in the forest communities was rain-fed agriculture whose productivity is determined by climatic factors such that climate change, especially reduction in amount and unusual distribution of rainfall, were associated with low yields and crop failure. It was revealed that climate change is impacting on rural livelihood activities as well as bringing about changes in the forest ecosystem. Although the forest communities have adopted various on-farm and off-farm adaptation strategies, they are still very vulnerable due to their high dependence on forest ecosystem services and their low capacity to adapt to climate change impacts. Further studies should be carried out to ascertain the factors that determine the choice of adaptation strategies being used to cope with climate change effects in the study area.

## References


Adekunle, V.A.J. (2006). Conservation of tree species diversity in tropical rainforest ecosystem of South-west Nigeria. *Journal of Tropical Forest Science* 18(2): 91-101.

Adekunle, V.A.J., Okunlola, J.O. and Oke, D.O. (2011). *Management of Forest Ecosystem for Food Security and Rural Livelihood in South West Nigeria*. Final Project Report for 2011 START Grants for Global Research in Africa. 143 pp.

Akinsanola, A.A. and Ogunjobi, K.O. (2014). Analysis of rainfall and temperature variability over Nigeria. *Global Journal of Human-Social Science Research* 14(3): 230-240.

Akinyemi, D.S. and Oke, S.O. (2014). Floristic composition and structural diversity ofShasha Forest Reserve in Ile-Ife, Southwestern Nigeria. *Notulae Scientia Biologicae* 6(4): 433-440.

Anuforum, A.C. (2010). Demonstration and assessment of climate change in Nigeria and development of adaptation strategies in the key socio-economic sectors: meteorological approach. A paper presented at the *National Stakeholders Workshop on Developing National Adaptation Strategy and Plan of Action for Nigeria*, Abuja; 22nd March 2010.

Assunção, J. and Feres, F.C. (2008). Climate migration. Background Paper for *World Bank Flagship Report on Climate Change in Latin America, Low Carbon, High Growth: Latin American Responses to Climate Change*, World Bank Latin American and Caribbean Studies.

Ayanwuyi, E., Kuponiyi, E., Ogunlade, I. and Oyetoro, J.O. (2010). Farmers' perception of impact of climate changes on food crop production in Ogbomosho agricultural zone of Oyo State, Nigeria.

*Global Journal of Human Social Science* 10(7): 33-39.

Bonan, G.B. (2008). Forests and climate change: Forcings, feedbacks and the climate benefits of forests. *Science* 320: 1444-1449.

Boon, E. and Ahenkan, A. (2011). Assessing climate change impacts on ecosystem services and livelihoods in Ghana: Case study of communities around Sui Forest Reserve. *Journal of Ecosystem and Ecography* S3: 001. doi:10.4172/2157-7625.S3-001

Conant, R.T., Ryan, M.G., Ågren, G.I., Birge, H.E., Davidson, E.A., Eliasson, P.E. and Bradford, M.A. (2011). Temperature and soil organic matter decomposition rates-Synthesis of current knowledge and a way forward. *Global Change Biology* 17(11): 3392-3404.

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

Dhillon, M.K., and Sharma, H.C. (2013). Comparative studies on the effects of Bt-transgenic and non-transgenic cotton on arthropod diversity, seed cotton yield and bollworms control. *Journal of Environmental Biology* 34(1): 67-73.

Ding, H., Silvestri, S., Chiabai, A., and Nunes, P.A.L.D. (2010). A hybrid approach to the valuation of climate change effects on ecosystem services: Evidence from the European forests. *FEEM Working Paper*, No. 2010.050

Falola, A. and Fakayode, S.B. (2014). Awareness and effects of climate change on cocoa production in Ondo State, Nigeria. *International Journal of Applied Agriculture and Apiculture Research* 10 (1-2): 91-97.

Fan, Z., Brauning, A., Thomas, A., Li, J. and Cao, K. (2010). Spatial and temporal temperature trends on the Yunnan Plateau (Southwest China) during 1961-2004. *International Journal of Climatology* doi:10.1002/joc.2214

IPCC, 2007: Climate Change 2007: Impacts, Adaptation and Vulnerability. *Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Parry, M.L., Canziani, O.F., Palutikof, J.P., van der Linden, P.J. and Hanson, C.E. (Eds.), Cambridge University Press, Cambridge, UK, 976pp.

IPCC, (2014). *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Core Writing Team, Pachauri, R.K. and Meyer, L.A. (eds.)]. IPCC, Geneva, Switzerland, 151 pp.

Karevia, P., Tallis, H., Ricketts, T., Daily, G., Polasky, S, editors. (2012). *Natural Capital: Theory and Practice of Mapping Ecosystem Services.* Cambridge (UK): Oxford University Press.

Lyimo, J.G. and Kangalawe, Y.M. (2010). Vulnerability and adaptive strategies to the impact of climate change and variability. The case of rural households in semi-arid Tanzania. *Environmental Economics* 1(2): 89-97.

Mamo, G., Sjaastad, E. and Vedeld, P. (2007). Economic dependence on forest resources: A case from Dendi district, Ethiopia. *Forest Policy and Economics* 9: 916-927.

McGuigan, C., Reynolds, R. and Wiedmer, D. (2002). Poverty and climate change: Assessing impacts in developing countries and the initiatives of the international community. http://www.odi.org.uk/sites/odi.org.uk/files/odi-assets/publications-opinion-files/3449.pdf. (Retrieved on July 6, 2014).

MEA (2005). *Millennium Ecosystem Assessment. Ecosystems and Human Well-being: Synthesis.* Island Press, Washington, D.C., 137 pp. doi:10.4172/2157-7625.S3-001

Mitchell, T.D. and Jones, P.D. (2005). An improved method of constructing a database of monthly climate observations and associated high-

resolution grids. *International Journal of Climatology*. 25: 693-712.

Molua, E.L. and Lambi, C.M. (2006): Climate, hydrology and water resources in Cameroon, *CEEPA Discussion Paper* No. 33, 37pp.

National Emergency Management Agency (NEMA), Nigeria (2010). *Daily trust newspaper*, 14th October 2010.

NIMET (2016). *Seasonal Rainfall Prediction (SRP) Report*, Nigerian Meteorological Agency Report. 58pp

Nhemachena, C., Hassan, R. and Kurukulasuriya, P. (2010). Measuring the economic impact of climate change on African agricultural production systems. *Climate Change Economics* 1(01): 33-55

Odjugo, P.A.O. (2005). An analysis of rainfall pattern in Nigeria. *Global Journal of Environmental Science* 4(2): 139-145.

Oluwatusin, F.M., (2014): The perception of and adaptation to climate change among cocoa farm households in Ondo State, Nigeria. *Academic Journal of Interdisciplinary Studies* 3 (1): 147-157.

Ozor, N. (2009) Implications of climate change for National development: The way forward. *Debating Policy Options for National Development; Enugu Forum Policy Paper* 10; African Institute for Applied Economics (AIAE); Enugu, Nigeria: 19-32. Available online at: *http://www.aiaenigeria.org/*Publications /Policypaper10.pdf (viewed 24 May, 2019).

Staudinger, M., Grimm, N.B. and Staudt, A. (2012). Impacts of climate change on biodiversity, ecosystems, and ecosystem services. Technical input to the 2013 National Climate Assessment. Washington, DC: *Cooperative Report to the 2013 National Climate Assessment*.

Tesfaye, Y., Roos, A., Campbell, B.M. and Bohlin, F. (2011). Livelihood strategies and the role of forest income in participatory-managed forests of Dodola area in the bale highlands, southern Ethiopia. *Forest Policy and Economics* 13: 258-265.

World Bank. (2001). World Development Report 2000/2001: Attacking Poverty. Oxford: Oxford University Press.

World Bank, (2004). World Development Report 2004: Making Services Work for Poor People. World Bank. © World Bank. https://openknowledge.worldbank.org/handle/10986/5986 License: CC BY 3.0 IGO."

World Bank. (2007). *World development report 2008: Agriculture for development*. World Bank.